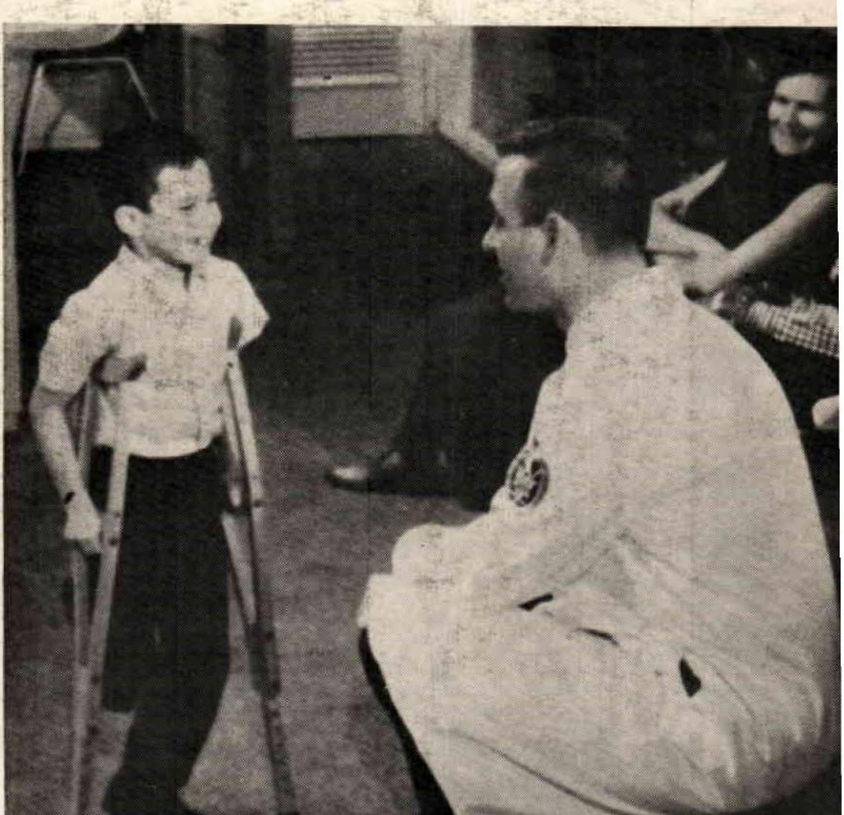
JUNE, 1966

ORTHOPEDIC & PROSTHETIC APPLIANCE JOURNAL

The Journal of the Limb and Brace Profession



"MEN AND MOBILITY"—Recruitment Film

(See Story on Page 152)

publisher: American Orthotics and Prosthetics Association

OFFICIAL NOTICE

The 1966 National Assembly of the
American Orthotics and Prosthetics Association
will be held October 16-20, 1966

PALM SPRINGS, CALIFORNIA

Reconvened Session

OCTOBER 21-28

HONOLULU, HAWAII

(AOPA Technical Mission)

FOR PROGRAM DETAILS AND REGISTRATION INFORMATION

write The American Orthotics and Prosthetics Association
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See pages 117-118

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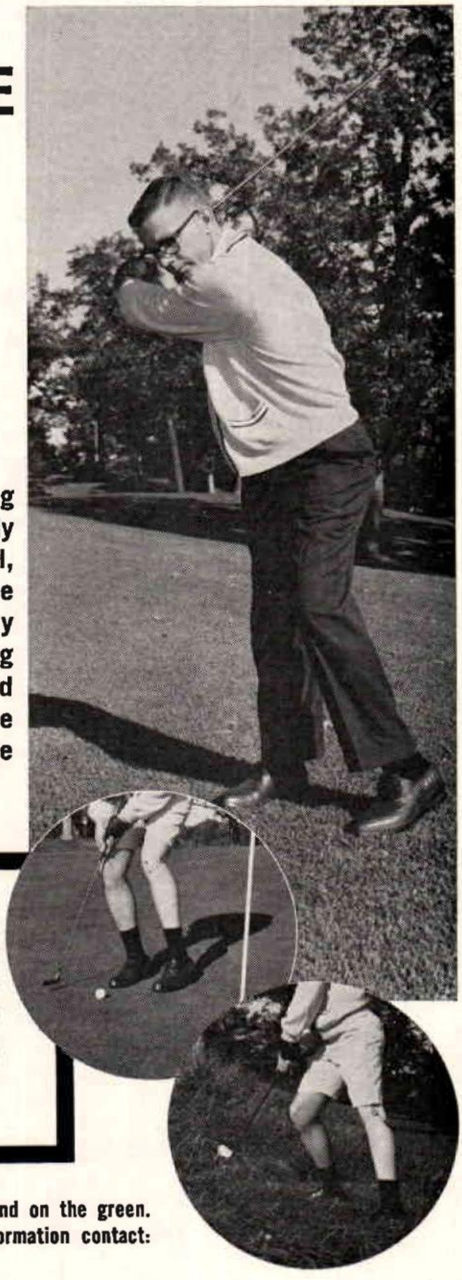

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CONTENTS

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THE AMERICAN ORTHOTICS AND PROSTHETICS ASSOCIATION

(Formerly the Orthopedic Appliance and Limb Mfrs. Assn.)

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INDEX TO ADVERTISEMENTS
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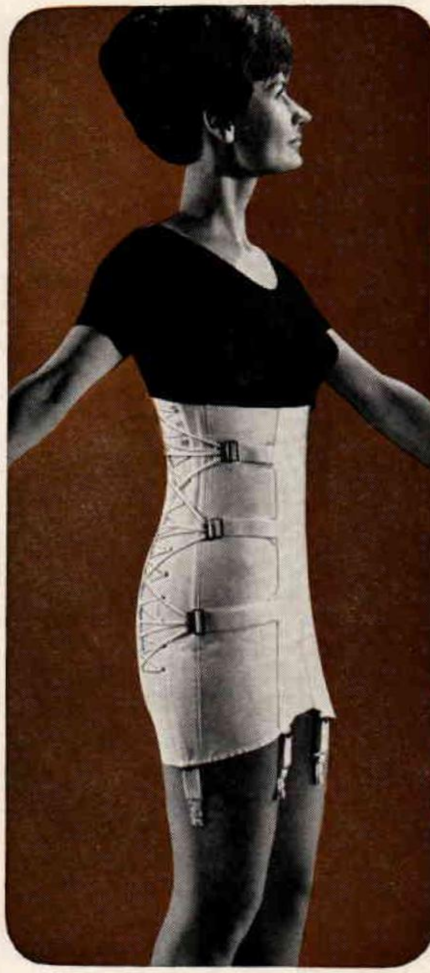

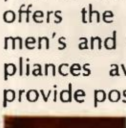
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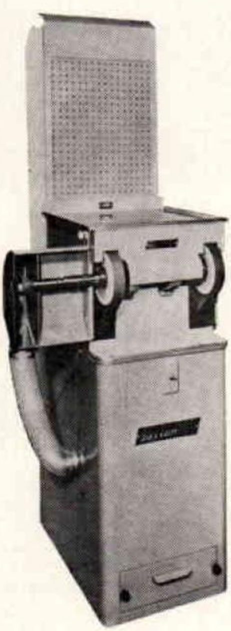

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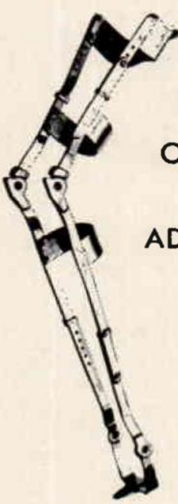

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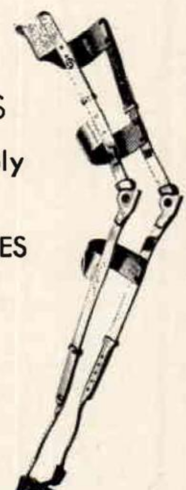

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The National Orthotics and Prosthetics Assembly: Official Notice

Since many readers of the Orthopedic and Prosthetic Appliance Journal *are physicians, surgeons, or rehabilitation officials who are not members of the American Orthotics and Prosthetics Association, the following information is given to acquaint them with the purposes and program of the Association's annual Assembly.*

The 1966 National Orthotics and Prosthetics Assembly will be held at Palm Springs, California, at the Riviera Holiday Inn, October 16 to 20. The first session will be followed by a reconvened session in Hawaii, which is to feature technical programs with the cooperation of Dr. Ivar J. Larsen of Honolulu and other physicians and rehabilitation officials of the state of Hawaii.

The Assembly is much more than the annual convention of the American Orthotics and Prosthetics Association. It is a technical and professional session of all persons concerned with rehabilitation of the orthopedically handicapped and includes program features of general interest to the medical profession and to rehabilitation officials as well as to Association members. Each session of the Assembly finds a larger registration of medical and paramedical officials attending.

Several related educational and research groups will hold their meetings in conjunction with the Assembly, including the University Council on Prosthetic-Orthotic Education (UCOPE).

Child Amputee Prosthetics Project, UCLA, and Rancho Los Amigos— One of the events planned for those arriving early at the Assembly is a tour on Friday, October 14, of the Rehabilitation Center and the Child Amputee Prosthetics Project at UCLA, with inspection of the Prosthetic-Orthotic classrooms there. Following luncheon, the tour members will visit the orthotic facilities at the Rancho Los Amigos Hospital in Downey.

Technical Exhibits—Displays and exhibits of the latest devices and orthotic-prosthetic supplies will be open to those registered at the Assembly from 10 a.m. to 5 p.m. on Sunday, October 16, and from 9 a.m. to 5 p.m. throughout the Assembly. These exhibits include displays from Universities which offer courses in orthotics and prosthetics, and from Government agencies concerned with rehabilitation, as well as from suppliers in the field. Information on the availability of exhibit space may be obtained from the Exhibits Chairmen, Kenneth Dodd and Cletus Iler, American Orthotics and Prosthetics Association, 919 18th St., N.W., Washington, D.C. 20006.

Program Highlights

Program Chairman Leroy Noble of Whittier, California, has reported some of the major presentations to be given at the 1966 Assembly, and a brief resume of these sessions follows:

Milwaukee Brace Session—A round table discussion led by persons who have taken the course offered at Milwaukee.

Higher Education for the Orthotic-Prosthetic Field—A panel discussion of the courses available at Chicago City Junior College, Northwestern University, University of California, Los Angeles, and Cerritos College.

Medicare—Question and answer session on State Medicare agencies, schedules, and the Association's Inter-Agency Committee.

New Techniques and Devices—Demonstration of new ideas and developments.

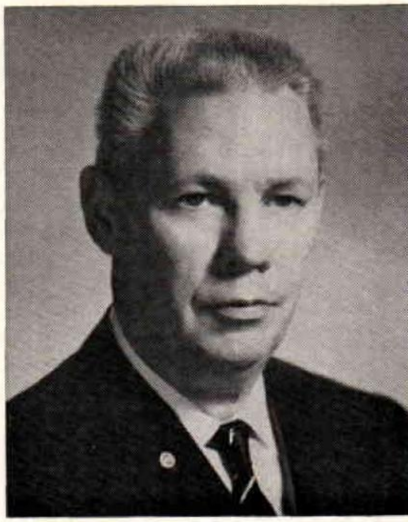
Fracture Splinting and Bracing.

End-Bearing Characteristics of Lower Extremity Amputation Stumps.

Immediate Post-Operative Prosthetics.

Cerebral Palsy: The California Approach.

Upper Extremity Prosthetics: Current Status and Developments.



LEROY NOBLE, C.O.

Assembly Exhibitors Announced

Applications for exhibit space have been received by the Association's Exhibits Committee from the following firms:

Americana Corporation (Encyclopedia Americana)
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Atco Surgical Supports, Inc.
Otto Bock Orthopedic Industry, Inc.
Encyclopaedia Britannica, Inc.
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"To Help Members Serve Physicians and Their Patients"

by FRED J. ESCHEN, C.P.O., *President*

The Programs and Activities of The American Orthotics and Prosthetics Association Conducted in the Public Interest

FRED J. ESCHEN, C.P.O.

It will be fifty years next Spring since a group of pioneer prosthetists and orthotists came to Washington, D.C. at the invitation of U.S. Council of National Defense. The American Orthotics and Prosthetics Association, which grew out of this 1917 meeting, carries on a wide variety of programs and activities. Although these, naturally, are planned primarily for the membership, their ultimate goal is to help these members serve physicians and their patients. Consequently, many of these programs are of direct as well as indirect public interest.

I am glad, therefore, to have the opportunity to report on these in this issue of the *Journal*. It is appropriate that I do so, since many readers of the *Journal* both in the United States and abroad are not members—they are physicians, officials, rehabilitation workers, and others who have an interest in the rehabilitation of the orthopedically handicapped.

In the years since the Association was founded, perhaps its most important activity of benefit to the public was the organization of the American Board for Certification in Orthotics and Prosthetics. I will exclude, however, an account of this important service from this article, since Mr. Durward R. Coon, President of the American Board for Certification in Orthotics and Prosthetics, will report on that activity in the next issue of this *Journal*.

Membership and Organization

The Association carries on its membership rolls some 548 companies, partnerships, institutions, and individuals. These Members provide orthopedic and prosthetic appliance service in 49 of the 50 states and in five Provinces of the Dominion of Canada.

Other Members are located in the Republic of Mexico and Venezuela in the Western Hemisphere, and in Sweden, Great Britain, Germany, Belgium, Norway, Lebanon, and Africa in the Eastern Hemisphere.

The voting members elect an eleven man Board of Directors and National Officers. The National Officers and Board of Directors direct the operations of a Washington Headquarters, staffed by an experienced group of employees who also carry on the activities of the American Board for Certification.

Serving the Veteran

Over 300 members of the Association have for many years carried on contractual relationships with the Prosthetic and Sensory Aids Service of the United States Veterans Administration. Working in close cooperation with the staff of the Veterans Administration, they provide the latest in prosthetic and orthopedic appliance service to the beneficiaries of the Veterans Legislation, both those service connected and others.

AOPA's record of assistance with this government program goes back many years. It is now carried on under the supervision of our Veterans Liaison Committee. Cooperative programs include the Suction Socket Schools and the Hydraulic Mechanism Seminar.

The field testing of new developments is one of the essential and important activities of the Veterans Administration and many members of the Association have taken part in these testing procedures, with resultant benefit to the civilian handicapped as well as the veterans.

Research

Research in the development of the new appliances, both orthotic and prosthetic, is a long time interest of individual members and of the Association. Currently, the Association's activities are channeled through its own Committee on Advances in Prosthetics and Orthotics (CAPO) cooperating with the Committee on Prosthetic Research and Development of the National Academy of Sciences—National Research Council.

Other research activity includes a project on Orthotic Terminology which has been developed by a sub-committee of CAPO and presented to the American Academy of Orthopaedic Surgeons for cooperative action.

Prosthetic-Orthotic Education

The Association's Committee on Education is now developing a study guide on anatomy and kinesiology planned specifically for the orthotist and prosthetist.

The Universities

Training in our field at the college level has been a long-term interest of the Association. Consequently, we have encouraged the development of courses at the University of California at Los Angeles, Northwestern University in Chicago, and New York University. From these short term or "refresher" courses intended originally for persons already in the field, there has grown (1) a four-year program leading to a Bachelor of Science degree in Prosthetics and Orthotics at New York University; (2) a certificate program at the University of California at Los Angeles; and (3) a series of courses at Northwestern University.

Northwesten University has also been closely related to the development of a two-year course at Chicago City Junior College leading to the Associate of Arts degree in Prosthetics. (An orientation course is given in Orthotics.)

A similar program has developed in both Orthotics and Prosthetics at Cerritos College in Norwalk, California.

These courses at Northwestern and Chicago City Junior College and Cerritos College have benefited from the cooperation of an Advisory Committee of Association Members.

Shop Training

This is an acute need. It has been estimated that four shop workers are needed for the optimum employment and backing up of a Certified Orthotist or Prosthetist. With this in mind, the Association is pursuing actively the development of shop manuals. These are now in preliminary edition and are being tested at institutional and private establishments, before final printing. At their present level, these manuals are being used in the training courses at New York University, at Cerritos and Chicago City Junior College and at Northwestern University.

Mention should be made of the ten-month training apprentice program at the Institute for Crippled and Disabled at New York City. Here again there is an Advisory Committee of Association Members selected from the New York City area.

Recruiting for the Profession

The orthotic and prosthetic profession has been advanced by the educational programs listed above. But there remains an urgent need to interest young people in orthotics and prosthetics as a career. With this in mind, the Association in 1964 developed and published "Careers in Orthotics and Prosthetics," an illustrated booklet, which is widely used in high schools and at career conferences.

To supplement it, in February of this year, the Association completed a color sound film, "Men and Mobility," financed by grant of funds received from the U.S. Vocational Rehabilitation Administration. A survey of the effectiveness of this film is under way now. Information about borrowing the film can be obtained from the American Orthotics and Prosthetics Association, Suite 130, 919 18th Street, N.W., Washington, D.C.

Publications

The Association is the publisher of the *Orthopedic and Prosthetic Appliance Journal*, now in its nineteenth year. With a circulation of over 4,000, the *Journal* is widely distributed throughout the world to Orthotists and Prosthetists, to rehabilitation agencies, and to government offices and physicians.

Other Publications

Other publications of interest to readers of the *Journal* include:

1. Facility Record Forms—these were developed by AOPA's Conference of Prosthetists in cooperation with the Committee on Prosthetic-Orthotic Education of the National Research Council. They were originally prepared for the use of the members of the Conference in collecting data for the use of the National Research Council. However, they have proven to be of great use to all prosthetic facilities and are now available. Copies may be purchased from the Association's Headquarters in Washington, D.C.

2. "Hygenic Problems of the Amputee" and "Stump Edema"—These pamphlets, originally prepared under grant from the Vocational Rehabilitation Administration, are now being handled by the Association.

3. "What Everyone Should Know about Orthotics and Orthotists" and "What Everyone Should know about Prosthetics and Prosthetists." These are scriptographic booklets, using the cartoon technique to acquaint the general public as well as the handicapped with our services.

Other publications available from the Washington Headquarters of the Association include:

Basic Principles of Lower Extremity Bracing.

Maintenance of the Prosthesis

What We are Trying to Brace in Cerebral Palsy

"The Inter-Change of Information"

A professional convention is the hallmark of a professional or scientific group and the Association has for many years developed its annual Assembly or Convention for this purpose. These meetings held once a year are a clearing house of information. They are attended by members of the Association, and a numerous group of related professions, medicine and paramedical, by invitation. In addition to a series of technical programs and discussions, the comprehensive group of exhibits covering materials, supplies, research, and education in this field, are a feature of the Assembly.

"At the Grass Roots Level"

Supplementing the National Association Meeting, there are a series of eleven Regional Meetings held in the Spring of each year at various parts of the United States. These are intended primarily for members of the Association, but physicians, therapists, Rehabilitation personnel, and allied medical groups are frequently in attendance.

"Medicare"

The adoption of Medicare Legislation by the United States has offered both a great challenge and an opportunity to the Association. To meet the obvious need for an exchange of information between members and those government agencies and intermediaries in the program, the Association has established an Inter-Agency Committee with jurisdiction in this field. And to assist with the state-wide program, the Association has established a subcommittee on Medicare. This is composed of fifty-two individuals who represent members of the Association in the fifty States. They are in contact not only with State agencies, but with the insurance companies and the Blue Cross-Blue Shield organizations which carry out this program. While this is relatively new, there are already signs that this cooperative effort will pay off in terms of better service to the handicapped.

The Future

The United States offers one of the few areas in the world where the private practice of Prosthetics and Orthotics exists. It can be asserted with pride that this has resulted in more comprehensive and efficient service to the handicapped than anywhere else in the world (to this list should be added some parts of Europe where the private practice of Prosthetics and Orthotics still exists). Yet, just as medicine in this country is in some danger of encroachment from institutional practice and government controls, there are some danger signs of proliferation of institutional facilities in prosthetics and orthotics. These appear to go beyond the natural bounds of research and education which were the original intent.

We value the competition of private establishments with each other. We believe that this is in the public's interests. However, when institutional facilities expand beyond their original purpose of research and education, their operations may erode the financial foundations of a private establishmen which is not endowed and which must pay taxes.

1966 sees the members of the Association on the verge of tremendous developments. The coming of Medicare, the development of educational training programs at the University level, the acceptance of total rehabilitation as a goal by the American people—all present challenges to the Association members, challenges to orthotists and prosthetists. The Association exists to help them meet these challenges and opportunities. That has been my constant concern as National President—a concern I know is shared by my fellow officers of the American Orthotics and Prosthetics Association.

The P. T. S. Prosthesis

(Complete enclosure of patella and femoral condyles in below knee fittings)

By KURT MARSCHALL, C.P., *Syracuse, N. Y.* and

ROBERT NITSCHKE, C.P., *Rochester, N. Y.*

The UCB prosthesis, or PTB prosthesis, as it is more commonly known, has undoubtedly enjoyed widespread popularity with patient and prosthetist in recent years. It has solved many problems which could not have been overcome with the conventional BK prosthesis, although it has not claimed to be the "cure all" for all types of amputations, especially not for extremely short stumps (4″ or less) or for patients whose work requires them to carry heavy loads over uneven ground (farmers, construction workers, etc.). A suspension strap is needed to hold the PTB in place and very often a light waist belt is used to minimize piston action.

Many attempts have been made to eliminate the suspension strap. It was two years ago, on a study trip abroad, that I first came in contact with two types of prostheses that utilize the suspensionless fitting method. One was developed by Dr. G. G. Kuhn at the Research Institute in Muenster/Westfalen, Germany, showing high enclosure of the femoral condyles but complete exposure of the patella (KBM Method).

The other type was first introduced in theory and practice by Guy Fajal of Nancy, France, at an International Seminar on Prosthetics in Copenhagen, Denmark in 1964. Fajal calls it a PTS prosthesis because of its patellar and supracondylar enclosure without any further suspension aid above the knee. It is his method we shall discuss here with due credit to Mr. Fajal for his pioneer work in and development of this particular type of prosthesis.

Before we present some of the cases that have been fitted by us at our prosthetic facilities in Syracuse, N. Y. and Rochester, N. Y., we should like to point out several specific advantages of the PTS prosthesis:

1. Relationship Between Socket and Stump

The socket of the PTS prosthesis encloses the patella frontally and the femoral condyles medially and laterally completely. The anterior brim line is brought in direct contact with the tendon of the quadriceps, thus eliminating the need for any suspension above this level.

2. Increased Knee Stability

It is this intimate, intricate and high enclosure that affords piston action free contact with the stump and a maximum of medial and lateral knee stability. It provides the patient with the incalculable comfort of not being restricted above socket level while standing, walking or sitting.

3. Normal Knee Flexion and Swing-Through

The correct fitting of the area of the quadriceps tendon as a main source of suspension can not be stressed enough. Its proper flare contributes to a smooth swing-through and normal knee flexion in the stance phase.

4. Ideal for Short Stumps

The high walls decrease the amount of pressure taken per square inch of stump surface. Stumps of extreme shortness, which frequently were rejected for fitting with a PTB, can be accommodated with the PTS prosthesis in most cases. Also, we found it advantageous to use this type socket for fitting the below knee amputee with the temporary prosthesis.

5. Cosmesis

Due to its high brim line and strapless suspension, the PTS is excellent in its cosmetic appearance and should appeal especially to young girls and women.

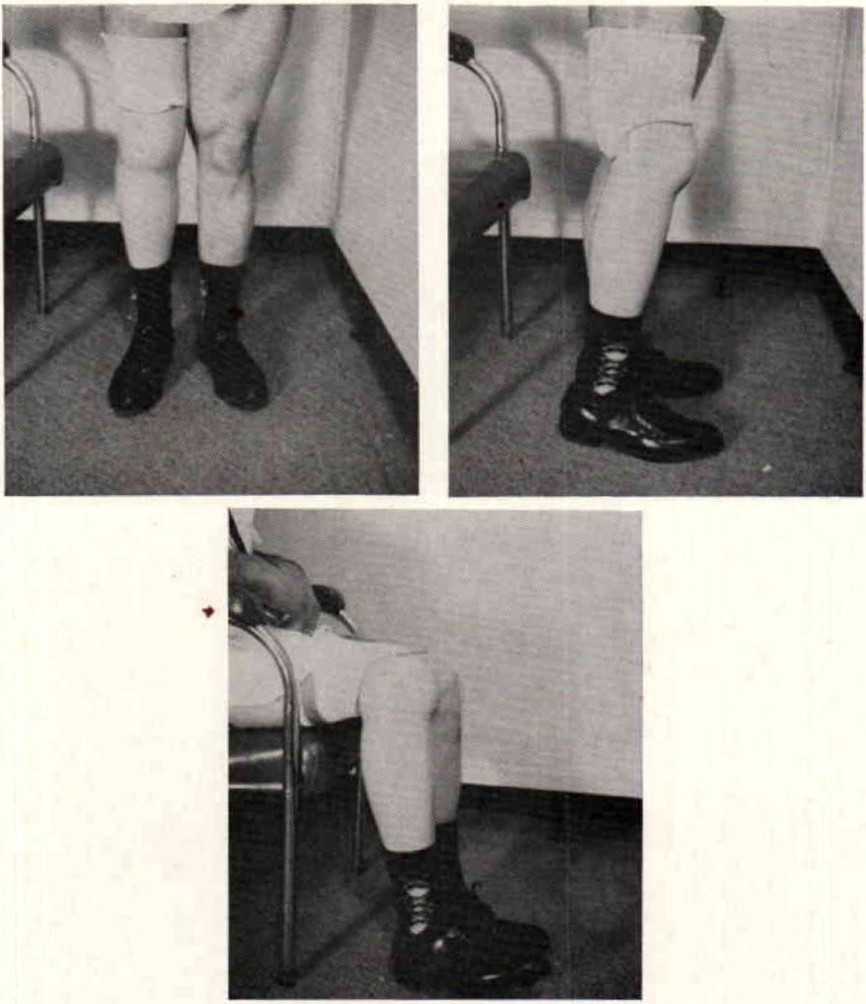
Success or failure in the construction of the PTS prosthesis hinges largely on the correct taking of the negative plaster mold. Very often we have taken two or three casts, using each one as a trial socket, retaining the one that proved the most satisfactory to us as well as to the patient.

Another point of equal importance while first experimenting with this

Case 1. Shows 58 year old female, housewife, amputated since 1965 with 6″ bulbous stump in standing and sitting position. She also has traumatic wrist disarticulation since age 16.

CASE #1

CASE #2

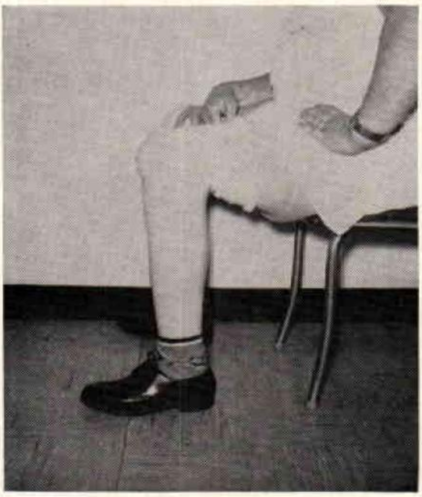


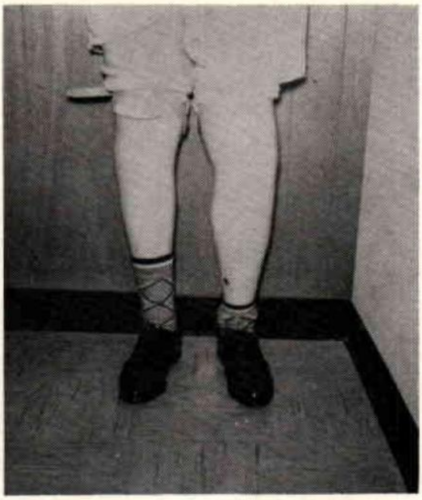
new type of prosthesis was communication with the patient. We made it a rule with every amputee, new or old, to explain to him what we tried to accomplish, what we were looking for and what he had to expect in the process of fitting. We did not use layman's language, but proper nomenclature, which was picked up readily by the patient, stimulated his interest and gave him a feeling of importance that assured us of his utmost cooperation.

The fabrication procedure of the PTS prosthesis is identical with the one used in fabricating a PTB. The purchase of new material or equipment is not necessary. The adjustable leg is still an important factor in proper alignment. A soft insert can be used for bulbous stumps (ease of donning the prosthesis) or a hard socket with soft end can be fabricated where excessive perspiration makes this kind desirable (ease of cleaning prosthesis).

Case 2. Shows 37 year old male, salesman, amputated since 1958 with 5″ stump, fitted first with standard BK prosthesis. Wore PTB since 1963. Note the normal knee flexion in standing position and excellent cosmesis despite 10° of abduction.

CASE #3





Case 3. Shows a 36 year old male bilateral Korean War veteran who wore conventional prostheses since 1952. Fitted in 1962 with PTB prostheses. Developed an extreme case of dermatitis at the distal end of his left stump after that. Due to patient's heaviness, reverting to the conventional prosthesis on that leg was thought able to correct this condition; however, this was not the case. Was recently fitted with the PTS prosthesis on the left leg and patient reported considerable improvement of his skin condition due to better blood circulation (no strap or corset restriction).

Summary

Like the PTB, the PTS prosthesis of Guy Fajal does not solve all the problems of every below knee amputee; however, it presents a valuable and welcome addition to the family of BK prostheses. Because of its outstanding advantages it should become in the near future an integral part of every prosthetic facility.

Braces for the Neurological Handicapped*

By WILLIAM A. TOSBERG, C.P.O.

Technical Director, Prosthetics Services,
Institute of Physical Medicine and Rehabilitation,
New York University Medical Center, New York City

Orthopedic appliances are an important adjunct in the treatment of neuromuscular and skeletal disabilities. Braces are designed for many different purposes. They are made from various materials, and there are unlimited types. The functional purposes of braces are:

1. To support body weight
2. To prevent deformities
3. To correct deformities
4. To control involuntary movements
5. To maintain correct alignment of body segments.

Braces may be divided into four major categories:

1. Spinal (including the Neck and/or Trunk)
2. Lower extremities
3. Upper extremities
4. Major debilitating neuromuscular syndromes which may affect more than one of the preceding categories.

The following are distinct medical indications for bracing of the neck and trunk:

Cervical Disc Rupture, Lesion, or Reduction of the Foramina, Postoperative Fixation, or Dislocation in the low Cervical area.

Torticolis or Wry Neck

Cervical Spinal strain or injury or Whiplash

Medical indications for bracing of the trunk are:

Kyphosis

Lordosis

Low Back Pain or Strain, with or without Disc Complications

Juvenile Scoliotic Spinal Curves (regardless of etiology)

Fracture or Postoperative Condition of the Spine.

Braces for the lower extremities are provided for:

1. Neuromusclar dysfunction, such as spasticity, flaccidity and athetosis.
2. Congenital or acquired joint dysfunction, deformation or malformation.
3. Fractures.

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** The line drawings which illustrate this article were prepared by Mr. Robert G. Wilson, Jr., of the Institute of Physical Medicine and Rehabilitation, New York, N. Y.

The principle neuromuscular symptoms requiring bracing are Paraplegia, Hemiplegia, Poliomyelitis and Cerebral Palsy.

The following joint dysfunctions may require bracing:

Pes Varus or Valgus
Genu Recurvatum
Knee Flexion Contracture
Legg-Perthes Disease
Upper Extremity Disabilities.

Another group of disabilities would be:

Congenital Muscular Weakness and Muscular Dystrophy
Non-union of long bones
Spina Bifida Vera

One of the first designers and constructors of orthopedic appliances who became well-known in Europe was Hessing, in Germany. Braces named after him were rather heavy and complicated. Their main advantage was the fact that they offered almost unlimited adjustment possibilities. These braces required plaster-of-Paris casts, from which positive molds had to be made. Screw plates were attached to the cast and a special type of leather was molded over it. Side-bars were provided with slots. As a result of this construction the brace could be lengthened or shortened; and the alignment of the lower, as well as the upper part, could be changed at will. This brace is rarely seen in its original form any more, since the indications for such constructions no longer exist.

Since the time of Hessing, the philosophy of bracing has changed considerably. Orthopedic appliances are now used to complement orthopedic surgery and not to substitute for it. Physical medicine in many instances has obviated, or at least greatly reduced, the need for orthopedic appliances. It is also now possible to make braces lighter in weight and less complicated in construction. In most cases bands can be substituted for closed cuffs, and straps and buckles replace long lacers. This makes it easier for the patient to apply his brace, and he can do so in less time.

Certain fundamental principles in the construction of braces must be observed, but these differ depending upon the disability, and also upon the sex and age of the patient. In a brace made for a patient in early childhood, the materials must be light and noncorrosive. One has to consider the need for proper nursing and also the sensitivity of the skin. With advancing age, conditions change. As the child becomes more active, the proper relationship between the required strength and the weight of the brace must be kept in mind. The brace should be simple and the need for extension, to accommodate for growth, must be considered. Frequent follow-up visits become necessary in order to determine whether or not the brace continues to fulfill its intended purpose.

In adolescent age, cosmesis quite often is of overriding importance. Complicated constructions may have to be resorted to in order to make braces acceptable to patients who are very self-conscious regarding their appearance.

For the adult, it is essential to consider the patient's social status, his occupation, and also his body weight. For a farmer, a leg brace without joints may be called for, whereas the same construction would be unsuited for a socialite woman with limited occupational needs.

Within its limits, a brace should be comfortable and wherever joints are required, the mechanical joint should correspond to the anatomical joint as closely as possible.

The question of overbracing or underbracing has been exhaustively explored. It seems to be the opinion of most physicians that it is wiser to apply extra bracing wherever there is any doubt. Parts may be removed as soon as this can be justified. To add bracing where originally insufficient support was provided is likely to induce a harmful psychological effect on the patient, whereas to remove a part usually has a beneficial effect.

The concept of teamwork has been firmly established in the approach to physical disability. It is practiced in prosthetics clinics all over the world. In the prescription and construction of braces, it is even more essential to have close cooperation between physician and orthotist. Basic requirements for an efficient brace clinic comprise:

1. Correct medical indication
2. Scientific orthotic design
3. Good workmanship
4. High grade materials
5. Careful fitting
6. Intelligent use by the patient

Brace shops should be in close proximity to hospitals or rehabilitation centers since frequent adjustments may be necessary to make a brace more functional, comfortable, and acceptable. Quite often adjustments are required to provide for changes in the degree of disability.

The following are some indications for appliances, as well as a brief description of their function.

Ankle braces are constructed for several purposes. If a foot has been operated on and the surgeon would like to keep the foot in the corrected position, he probably would prescribe a splint. Splints are generally made from plaster-of-Paris or plastics, and do not allow for any ankle motion.

If an ankle brace is required to correct imbalance of musculature between the anterior and posterior muscle groups, a brace with an ankle joint would be prescribed. It is essential that the mechanical joint is placed as close as possible to the point of rotation of the anatomical ankle joint.

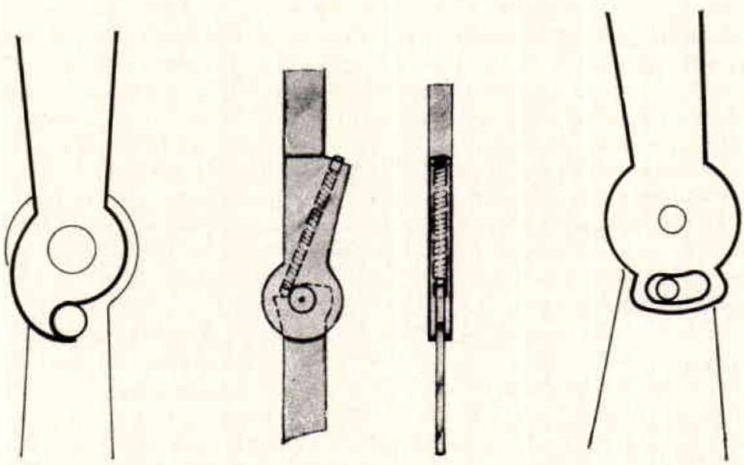


FIG. 1　　FIG. 2　　FIG. 3

FIG. 1—90° ankle joint stop. FIG. 2—Spring type assist, as in Klenzak joint. FIG. 3—Limited motion stop.

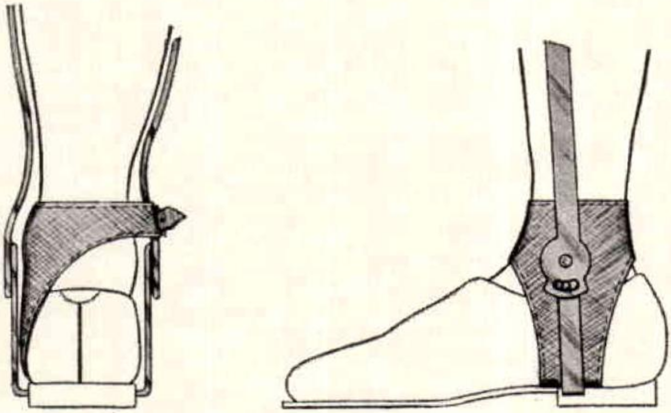


FIG. 4—T-strap to prevent pronation or supination of foot.

Many types of ankle braces are prescribed for dysfunction of the muscles of the foot and ankle. The purpose of such a brace is to prevent drop foot and to enable the patient to walk without toe drag.

If dorsiflexion or plantar flexion are to be controlled, the brace needs to be provided with an ankle stop. A 90 degree stop (fig. 1) will prevent plantar flexion beyond a right angle, but permits dorsiflexion. This type of stop is used wherever there is paralysis of the dorsal flexors. If one desires braces to assist dorsiflexion a mechanism to elevate the toes is required. This could be a spring type assist, as in the Klenzak joint (fig. 2), or elastic straps.

Limited motion stops (fig. 3) are occassionally prescribed in combination with a T-strap (fig. 4) to prevent either pronation or supination of the foot.

A different type of ankle brace to prevent drop foot is shown in fig. 5. This brace consists of spring steel without any ankle joint. Several types of ankle braces with single posterior bars have been constructed. These are attached to the shoe (fig. 6). This brace has limited indication, since the incongruency of the ankle motion between the brace and normal joint creates friction at the calfband. In some constructions this has been overcome by a slot in the posterior bar to allow motion between the upright and the brace. The constant bending forces create metal fatigue and failure. The main advantage of this type of brace is its superior cosmetic effect.

The reverse 90 degree stop (fig. 7) is used wherever there is paralysis of the plantar flexors, and for spasticity of the dorsiflexors.

Short leg braces can also be worn for night use, in order to prevent contractures or to maintain an improved position of the ankle joint which has been corrected through exercise, and where spasticity of the flexor or extensor muscles is present.

Short leg braces are indicated, too, for the correction of valgus or varus deformity of the ankle. Such construction would consist of a well-fitted molded sandal with a single bar on the outside for varus deformity, or on the inside for a valgus deformity. With the foot securely laced into the sandal, the long lever action permits a correction. Where such a brace is worn during the night, no ankle joint is required. The free ankle joint should be installed if the brace is to be worn during the day.

Long leg braces are required for any disability at or above the knee. They may be indicated for weak or paralyzed knee extensors, for hyperex-

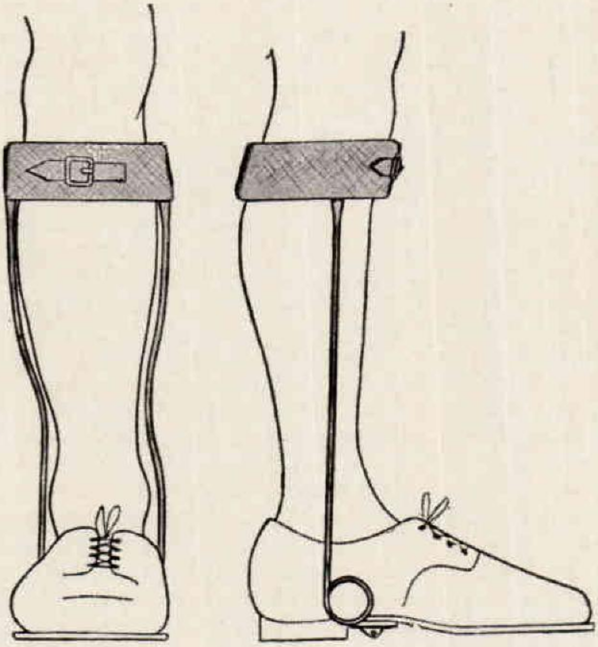


FIG. 5—Ankle brace to prevent drop foot.

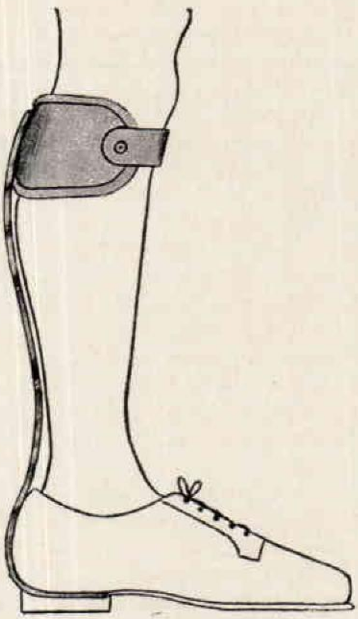


FIG. 6

FIG. 7

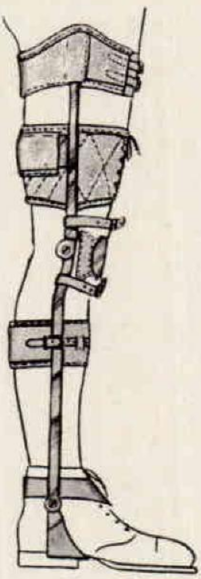


FIG. 8

FIG. 6—Ankle brace with single posterior bar. FIG. 7—Reverse 90° stop.
FIG. 8—Knee brace with calfband and two thigh bands.

tension of the knee, for either genu valgus or varus, for flexion contractions, or for involuntary motion. In some instances they are also used for tibial torsion. Again, these braces have to be accurately prescribed to fufill a specific need, and since there are many different types of disability, constructions for long leg braces differ considerably.

The simplest knee brace would be one to prevent genu recurvatum. Wherever the capsular ligament of the knee is overstretched, the danger exists that there will be progressive hyperextension of the knee. This can be prevented by a knee cage with anterior stops to prevent extension beyond 180 degrees. Simple side-bars with an anterior stop are frequently attached to an elastic knee cap to prevent such deformity. In more severe cases it might be necessary to construct braces which are attached either to a foot plate to be worn inside the shoe, or to a foot stirrup attached to the shoe. Such a brace should have a calfband as well as two thigh bands to keep it in position (fig. 8). The placement of the kneejoint is important in order to minimize any incongruous motion between the anatomical joint and the mechanical joint. There is, however, no true point of rotation in the knee joint and it is generally agreed that the least incongruency of motion takes place if the joint is located opposite the medial epicondyle of the femur. By slight deviation of placement of the knee joint from this point, different effects can be obtained. There are several knee joint constructions designed to duplicate the bending-sliding motion of the anatomical joint. Most of these constructions are rather complicated, however, and are resorted to only infrequently (fig. 9).

A long leg brace also has to be applied whenever there is weakness of the quadriceps. By placing the mechanical joint somewhat posterior to the anatomical joint, buckling can be prevented, although the quadriceps muscle might be paralyzed. Several constructions utilize an elastic extension aid (fig. 10).

Excessive genu valgus and genu varus require long leg braces. In these cases pads have to be attached to the medial bar for genu valgus and on the

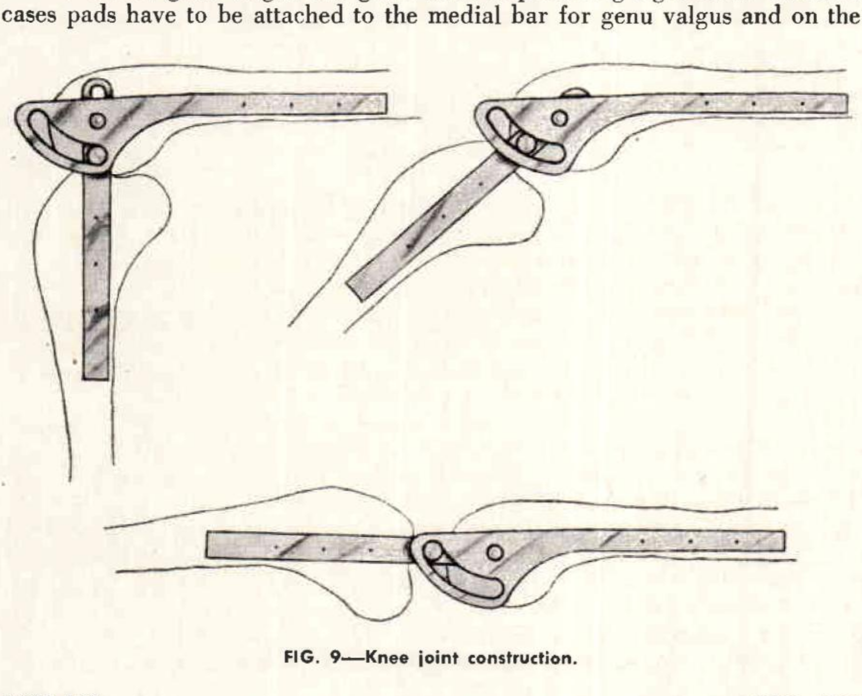


FIG. 9—Knee joint construction.

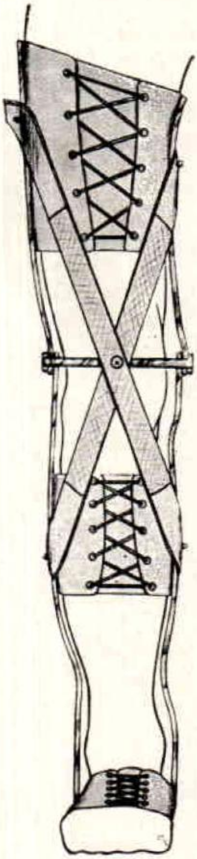


FIG. 10

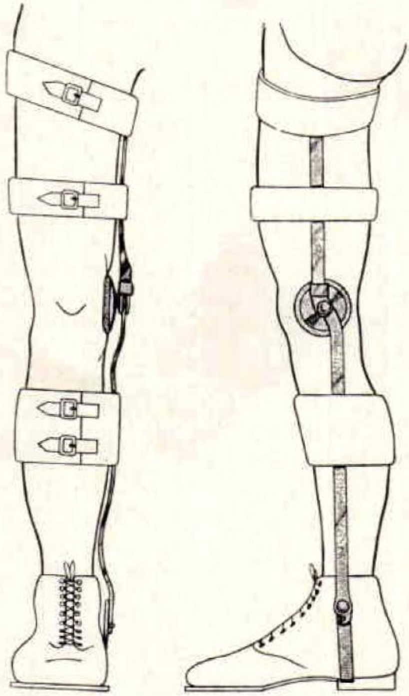


FIG. 11

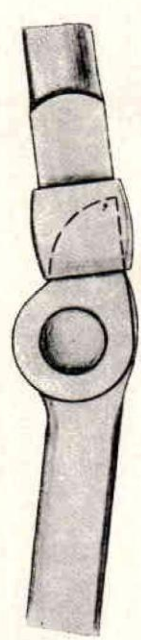


FIG. 12

FIG. 10—Long leg brace with elastic extension aid. FIG. 11—Single bar long leg brace. FIG. 12—Ring lock.

lateral bar for genu varus. The alignment of the brace combined with the pressure exerted on the soft tissues of the knee by these pressure pads will prevent progressive deterioration of the knee joint. Single bar braces as shown in fig. 11 serve a similar purpose.

Involuntary motions of the lower extremities, such as athetoid or spastic motions at ankle or at knee, are also controlled by long leg braces. Depending upon the disability, knee joints are constructed allowing free motion, limited motion, or are provided with a kneelock.

The simplest lock is a ring lock (fig. 12) which is normally applied to the lateral bar, except in a case of hemiplegia, where the lock is applied to the medial bar. In these cases the patient also has a disability of the arm on the same side, and therefore finds it difficult to operate a lock which is placed laterally. The ring lock is simple in construction and is dependable.

Bail locks (fig. 13) or Swiss locks (fig. 14) act on both side-bars at the same time. Such a double bar lock is preferred whenever high forces are transmitted through the medial bar. In those cases sheer forces would tend to break the bands or sheer the rivets.

Where supportive braces are required it is esential that they be pro-

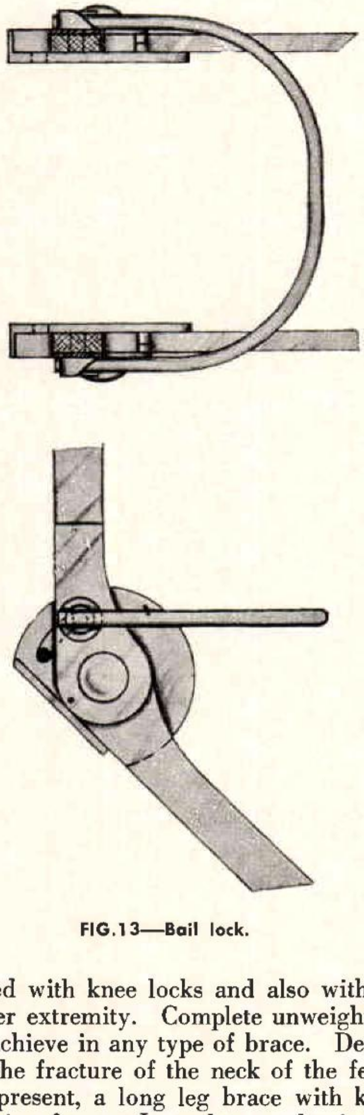


FIG. 13—Bail lock.

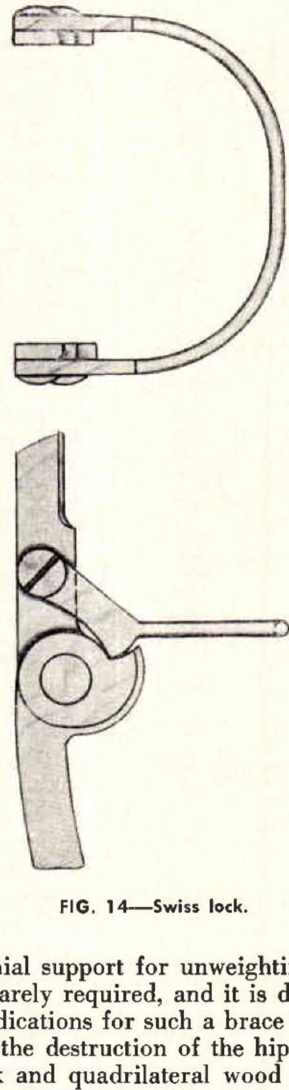


FIG. 14—Swiss lock.

vided with knee locks and also with an ischial support for unweighting the lower extremity. Complete unweighting is rarely required, and it is difficult to achieve in any type of brace. Definite indications for such a brace would be the fracture of the neck of the femur or the destruction of the hip joint. At present, a long leg brace with knee lock and quadrilateral wood top is gaining favor. In such a mechanism the wood top is constructed similar to the upper rim of a quadrilateral above-knee prosthesis.

Another possibility for unweighting the lower extremity is by means of an ischial seat or ischial band such as is found in the Thomas ring, or its many modifications. In the construction of a Thomas ring it is essential that the tuberosity of the ischium is fully supported, that the posterior weight-bearing area is parallel to the ground, that the lateral bar is at least two and one-half inches higher than the medial bar, and that no pressure is exerted on the pubic bone. The ring should be well padded to provide comfort. Wherever the contours of the leg make it possible, a closed ring is preferable to an open one. If an open ring is necessary, a strong leather strap should be provided to keep the tuberosity of the ischium accurately on the seat of the brace.

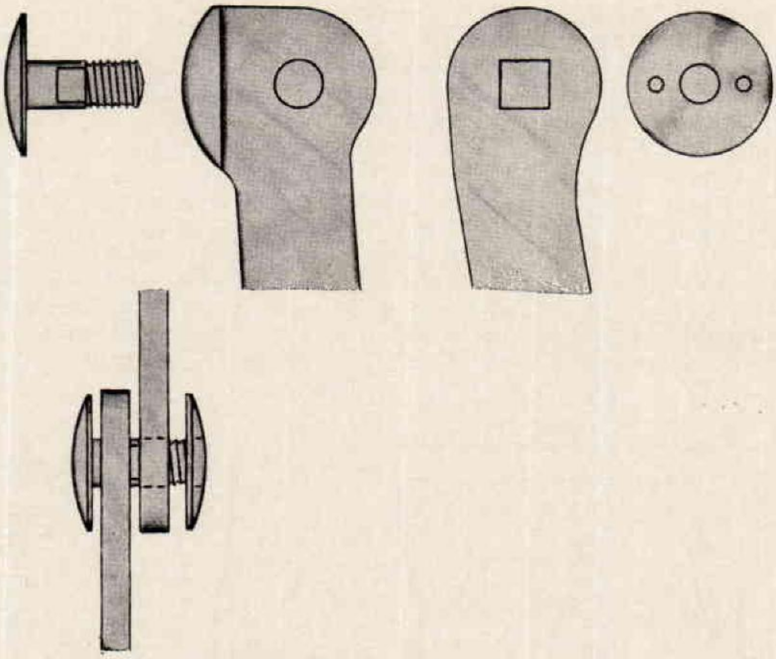


FIG. 15—Overlapping brace joint.

A weight-bearing brace in most cases requires to be provided with a hip joint and pelvic belt in order to maintain the alignment of the hip and to control the movements of the hip joints, such as flexion, extension, abduction, adduction, as well as internal and external rotation.

Hip joints, knee joints, as well as ankle joints may be the overlapping type or the box type. Where only minimal compression forces are applied, the overlapping type (fig. 15) will serve the purpose because it is less bulky and less expensive in construction.

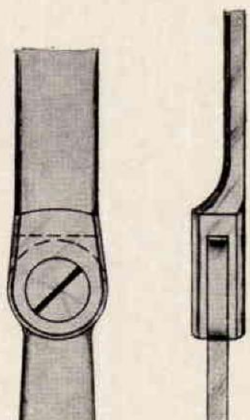


FIG. 16—Box joint for weight-bearing brace.

Weight-bearing braces should be made with box joints because the vertical forces are better distributed and the joints are more stable and more durable. (Fig. 16). Wherever duralumin is used it is essential that all friction surfaces are lined with steel, brass, or teflon to minimize friction.

Depending upon the disability again, the hip joint can be provided with free motion, with limited motion, with a stop at full extension, or with a lock. If only flexion and extension of the hip joint is required it is sufficient to provide a simple joint which allows this motion. In most cases, however, damage is serious enough to require a stop at 180 degrees to prevent hyperextension. Any hip joint should be constructed in such a way that hip flexion of at least 90 degrees is possible in order to allow the patient to sit comfortably. A pelvic band should be contoured to conform to the angle of the sacrum. The point of rotation at the hip is normally considered to be at the tip of the greater trochanter. In the case of bilateral braces, it is essential that both hip joints are parallel to each other in order not to restrict motion.

In the case of marked spasticity for contractures of the flexors, the metal bands have to be carried low over the sacrum and butterfly extensions are quite often resorted to (fig. 17). Wherever this becomes necessary it is essential that the hip joints are provided with locks, since otherwise no benefits are gained from butterfly or similar extensions. If there is a marked abnormal degree of abduction or adduction at the hips it becomes necessary to reinforce the pelvic band attachment considerably in order to control

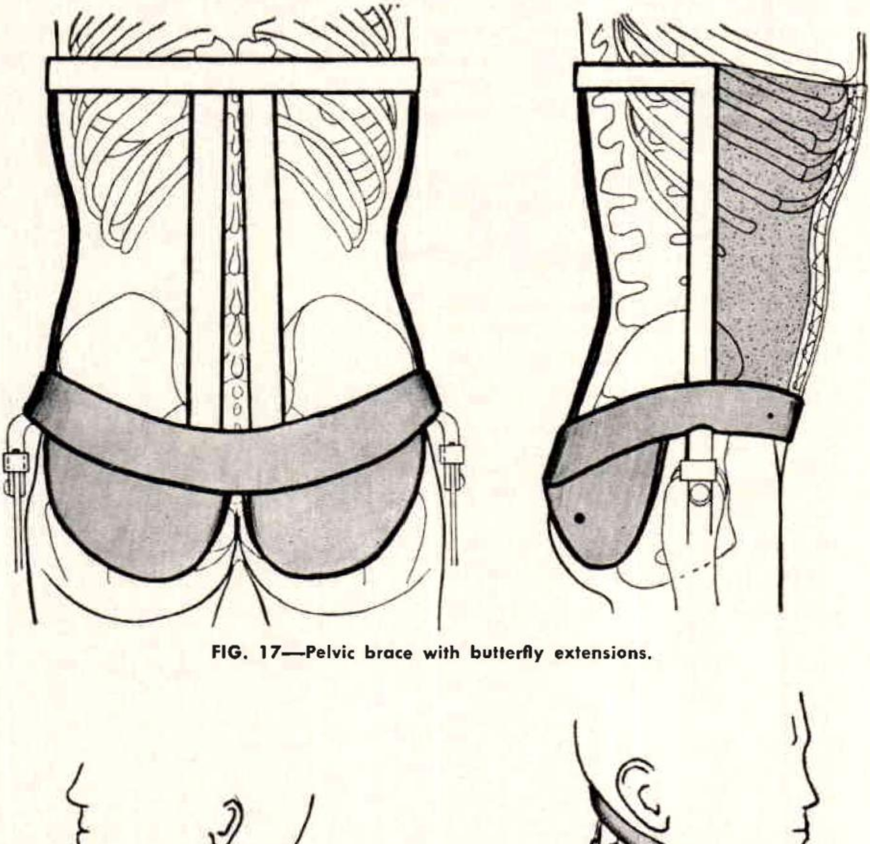


FIG. 17—Pelvic brace with butterfly extensions.

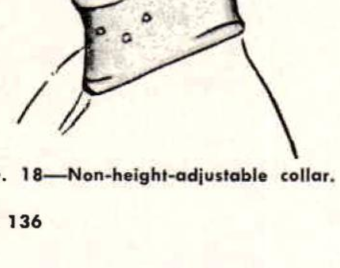


FIG. 18—Non-height-adjustable collar.

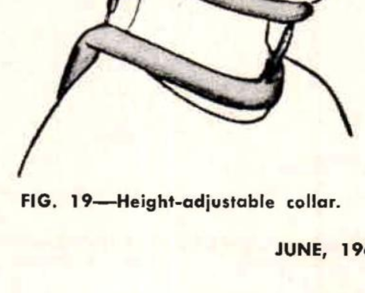


FIG. 19—Height-adjustable collar.

these motions, especially in case of spasticity. In severe cases it may become necessary to apply a spreader bar.

Bilateral long leg braces with pelvic belts are normally sufficient in all pathological conditions of the spinal cord with a motor level at T-10 or below. If the spinal cord is damaged above this level it becomes advisable to construct long leg braces to which a spinal brace is attached. In these cases a spinal attachment is used to support abdominal muscles to prevent lordosis and to maintain good body alignment.

There are innumerable constructions of spinal braces. They differ greatly in their constructions but all may be classified into two groups:

1. Passive or suporting
2. Active or correcting

The supporting spinal braces are used in symmetrical physiological conditions where the spine or trunk needs to be supported in an optional position for functioning, to alleviate discomfort, and for the fixation of fractures and post-operative conditions. In a corrective brace an attempt is made by mechanical means to overcome asymetry of the torso.

Orthopedic appliances for the neck most frequently used are of the following types:

1. Non-height-adjustable collar (fig. 18)
2. Height-adjustable collar (fig. 19)
3. Molded collars (fig. 20)
4. Open wire frame collars (fig. 21)

The first two types are generally prefabricated, whereas the third is molded to a plaster-of-Paris cast. The open wire frame collar is provided with turnbuckles for easy adjustment. Also used for pathology of the cervical spine are braces of either four-poster type, shown in fig. 22, or the two-poster type, shown in fig. 23. The last one is the most popular and versatile for cervical spine conditions.

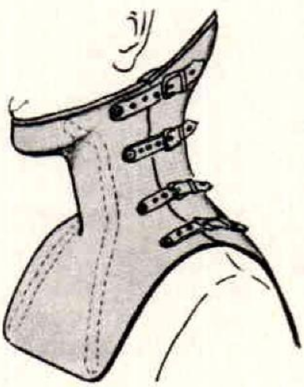
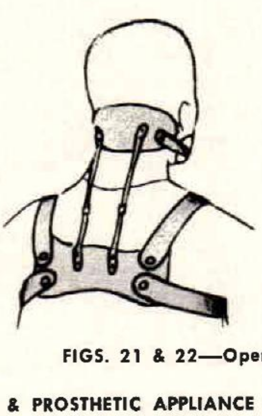
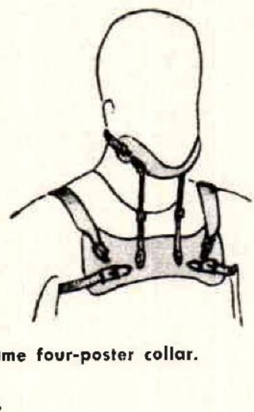


FIG. 20—Molded collar.





FIGS. 21 & 22—Open wire frame four-poster collar.

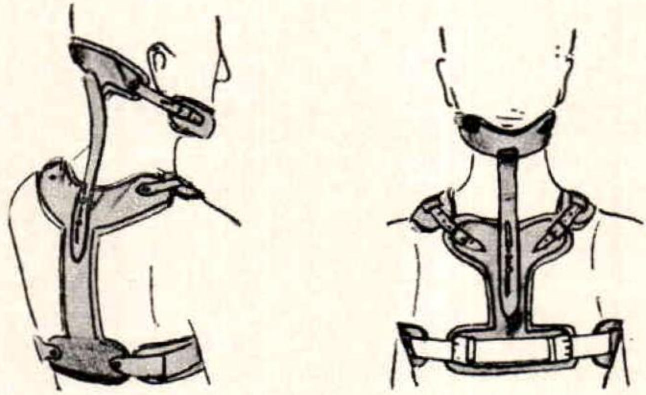


FIG. 23—Two-poster collar.

Braces for the dorsal and lumbar spine are prescribed for:

1. Kyphosis of the dorsal spine
2. Lordosis of the lumbar spine
3. Low back pain with or without disc complications
4. Fracture or post-operative condition of lower cervical and high dorsal spine
5. Fracture or post-operative condition of the middle low dorsal and upper lumbar spine
6. Fracture or post-operative condition of the lower lumbar or sacral region.

A lumbar and lower thoracic brace composed of a metal frame encircles the dorsal half of the body and is held in position by a corset or is strapped to an apron or abdominal pad. (fig. 24).

A lumbar and sacral brace is composed of a rectangular frame strapped to an apron or abdominal pad. (fig. 25).

A full back brace with a pair of uprights extends from a pelvic band at the level of the coccyx or lower sacrum to the upper third of the scapula or higher. In many variations the upper portion of the vertical bars turn laterally along the superior border of the scapulae. This brace also has a dorsal crosspiece which joins the two uprights at a position between T-10 and the lower third of the scapulae. The brace is attached by a corset pad or apron and by two shoulder straps which are attached to the superior terminus of the uprights and the dorsal crosspiece. (fig. 26).

A spinal hyperextension brace consists of a metal frame which rests against the anterior half of the body; a back pad which holds the brace against the body with varying degrees of pressure; and a sternal and a pubic pad which transmit counter pressure anteriorly. (fig. 27)

There are a number of braces for the correction of scoliosis. This condition is extremely difficult to correct since it consists of a combination of curvature as well as rotation of the spine. One of the more effective braces is the Milwaukee brace, as shown in fig. 28.

In addition there are molded body corsets made from different materials, such as plastics, molding leather, and others.

Although braces are generally known by the name of their designer, all of the braces fall into one of the above mentioned categories.

The following are some prescription criteria for definite disorders requiring braces.

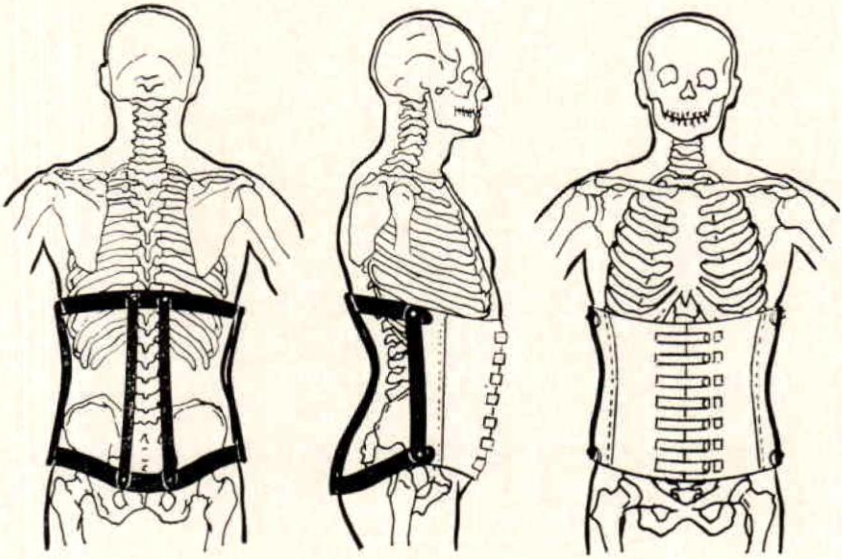


FIG. 24—Lumbar and thoracic brace with corset or apron

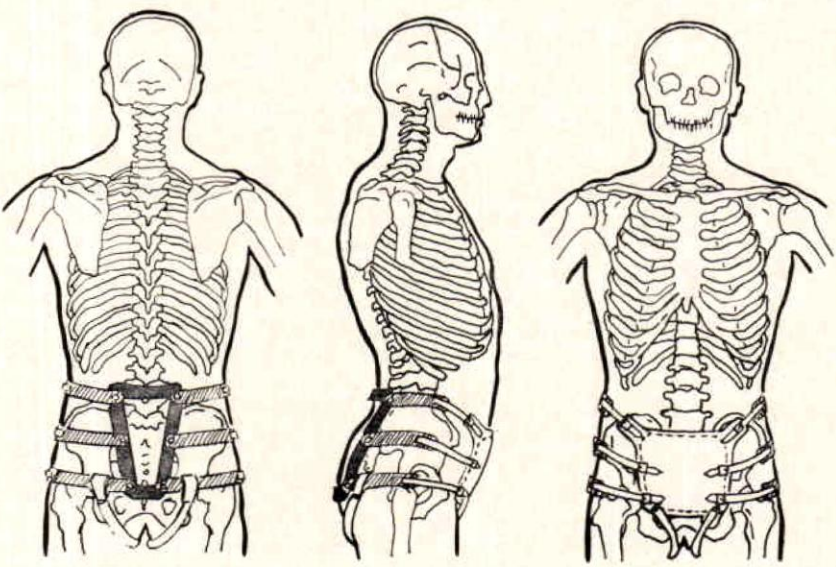


FIG. 25—Lumbar and sacral brace with apron

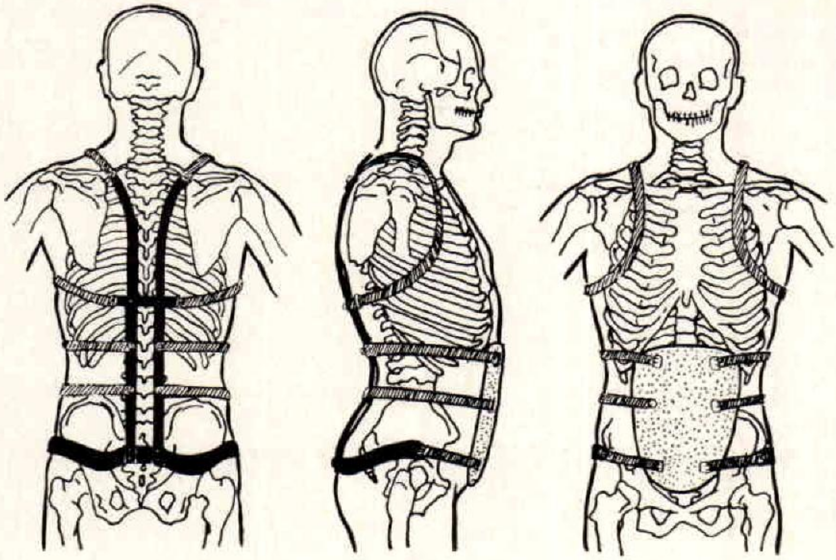


FIG. 26—Full back brace with corset or apron and shoulder straps.

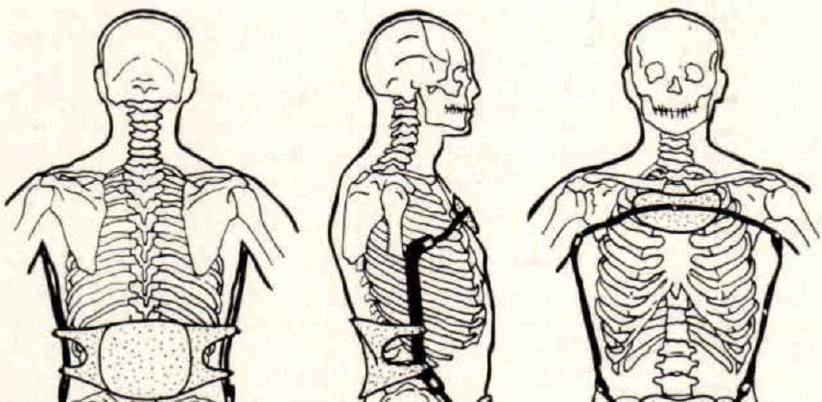


FIG. 27—Spinal hyperextension brace

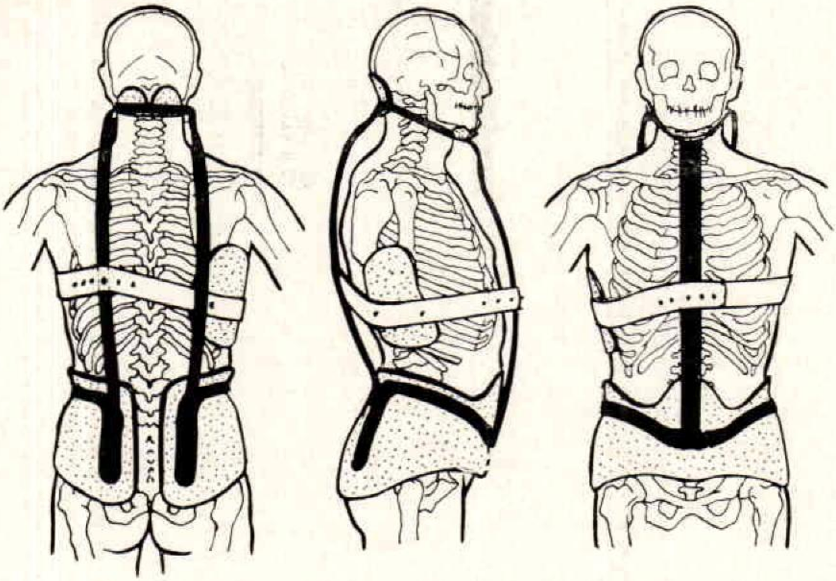


FIG. 28—Milwaukee brace

LOWER MOTOR NEURON DISORDERS

The brace should be of light weight in consideration of generalized limb weakness and lack of spasticity. Spring-loaded ankle joints are often used. Since there is full range of motion the congruence of the mechanical and anatomical joints is very critical.

As the result of paralysis of the anterior ankle musculature one may find a functional drop foot but there might also be a fixed deformity of the ankle, with equinus as result of a tight heel cord, as well as valgus or varus of the ankle and a combination of deformities of the foot. Any type of drop foot brace previously described may be indicated, depending upon the severity of the involvement.

Wherever one finds paralysis of the knee musculature causing weak knee extension, genu recurvatum or a flexion contracture, a long double bar leg brace as previously described is indicated, with the construction again depending upon the muscular involvement. If genu recurvatum or knee flexion contractures exceed 20 degrees, surgical correction is probably indicated, because knee bracing for such a condition becomes rather complex and heavy. The involvement of hip and/or knee extensors may require pelvic support either with or without hip lock, ischial seat, and knee locks.

Other muscles involved which might require bracing are the iliatibial band and the hamstring muscles. The type and amount of bracing depends upon the involvement of the musculature, as well as the deformity present. In the involvement of the hip one finds flexor paralysis, poor gluteus maximus, hamstring paralysis, or combinations of all three; as well as adductor and abductor paralysis. Bracing consideration is again guided by the involvement of the individual muscles or muscle groups and in some cases requires an addition of a pelvic belt, ischial seat, or even a spinal brace to standard long leg braces, with or without knee locks.

SPASTIC CEREBRAL PALSY

One of the most difficult physical disabilities to be braced is a case of spastic cerebral palsy where one finds not only motor deficit and impaired perception, but also functional and/or fixed deformity of the foot, knee, and hip. Motor deficit is usually bilateral volitional motor loss, and spasticity as an accentuation of antigravitational reflexes. Diffuse weakness may also be present.

One quite often finds the sensory deficit to consist of proprioceptive difficulties, visual field defects, and spatial disorientation.

In children with spastic cerebral palsy one finds almost any combination of the foot deformities. These should be corrected by surgical shoes. The more common deformities of the knee are either functional or fixed flexion contractures and genu valgum, which is sometimes combined with aptellar dislocation. Less common are genu varum, genu recurvatum, and ligamentous instability. Functional or fixed abduction flexion and internal rotation contractures of the hip are rather common, frequently combined with hip dislocation. As previously mentioned, the deformities of the feet are controlled by shoe corrections. Due to the severe deformities combined with spasticity, it is essential that the shoes are not an integral part of the braces, but are put on separately and the braces are connected by means of detachable stirrups.

Spring-loaded ankle joints are generally not recommended because they might induce spasticity. In a functional foot drop a plantar flexion stop is needed. Wherever there is a fixed equinus deformity, heel elevation has to be adjusted to such deformity. Surgical correction is often indicated in equinus as well as calcaneus deformities. Double bar long leg braces with knee caps as well as knee locks are indicated for functional flexion contractures. Fixed flexion contractures in excess of 25 degrees require surgical correction wherever possible. Where a fixed knee flexion contracture is unilateral, shoe elevation to equalize leg length is necessary. Genu valgum or genu varum require pressure pads medially or laterally. Genu recurvatum is prevented by extension stops at the knee joint in long leg braces.

In bilateral hip contractures a well contoured pelvic band with butterfly extensions maintains hip extension whenever the hip is locked.

Spreader bars as previously described may be indicated for extreme cases of adductor spasticity. Since it is very difficult to operate hip locks as well as knee locks against bending forces in spastic cerebral palsy, it is often necessary to provide locks where friction is reduced to a minimum by either ball bearings or roller bearings in connection with teflon linings at the friction areas. In the case of unilateral spastic cerebral palsy it is essential that the long leg brace with hip joint and pelvic band is anchored on the opposite leg by means of a thigh cage.

SPASTIC HEMIPLEGIA

Spastic hemiplegia normally involves the lower extremities distally and is usually treated by means of shoe corrections and short leg braces. Since a drop foot is almost always present there should be a plantar flexion stop in order to enable the foot to clear the ground during swing phase.

In a flaccid hemiplegia or wherever there is only minimal spasticity, a spring-loaded ankle joint is indicated as shown in figure 29. In the presence of a severe spasticity the standard prescription calls for a limited ankle joint. If there is minimal weakness of the knee musculature it is frequently sufficient to fit the short leg brace in slight equinus position. This will create a rotation movement around the knee to act as a stabilizing force. Wherever there is a severe lack of knee control a double bar brace with medial drop lock as previously described may be indicated. In case of such severity, limited gluteal bearing may be advantageous.

PROGRESSIVE MUSCULAR DYSTROPHY

No definite bracing pattern has been established. It is generally felt that wherever braces are used they should be of light weight and should provide extension assists in order to encourage motion around the joints. Only in the latter phases of this disease are locks indicated.

ATHETOID CEREBRAL PALSY

In this disease one generally finds involuntary movement of the trunk and all extremities with a varying degree of volitional motor loss. There may be deformities whenever athetosis is combined with hypertonicity. Those deformities, however, are rarely fixed.

There is considerable controversy concerning bracing of athetoids. Wherever bracing is recommended it is done for control purposes since bracing restricts involuntary motion, and increases the possibility of learning voluntary control. Bracing can be decreased as such control increases. Bracing normally starts with bilateral long leg braces combined with spinal bracing where hips as well as knees are initially locked. Locks are released progressively as voluntary control is achieved. It is essential that shoes can be independently removed for easier dressing. Ankle joints are most frequently provided with approximately fifteen degrees of motion in either direction. Locks at the knees, as well as at the hips, should be constructed in such a manner that both joints can be locked in full extension as well as in 90 degrees of flexion. Quite oftern weights are used to help control involuntary motion of the extremities.

Arthritic deformities and *fractures* are frequently braced. The type of braces, however, varies considerably and is determined by the functional disability. Bracing is applied in arthritis for restrictive motion of joints in order to prevent pain and deformities about the joints. In fractures, bracing is applied primarily for fixation.

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New Facilities Certified

By action of the Facilities Committee of the American Board for Certification, the following Facilities have been granted Certification since the publication of the 1966 *Registry of Certified Facilities and Individuals:*

CALIFORNIA

Los Angeles:

WESTWOOD ORTHOPAEDIC & SURGICAL APPLIANCE CO. — O
1571 Westwood Boulevard — 479-5720
Randall H. Hale, C.O.

San Francisco:

ORTHOPEDIC BRACE SHOP — O
Clark Air Force Base — 25236
(Private Patients Not Accepted)
**S/Sgt. James Smith,* C.O.

MICHIGAN

Kalamazoo:

AMTOWER ORTHOPEDIC APPLIANCES — P&O*
1817 Douglas Avenue — 345-5298
**Franklin H. Amtower,* C.O.

MINNESOTA

St. Paul:

GILLETTE STATE HOSPITAL FOR CRIPPLED CHILDREN — O
1003 East Ivy Avenue — 774-0301
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John H. Moe, M.D.

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BOAS SURGICAL — P&O*
1401 Turner Street — 432-6736
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Pittsburgh:

DE LA TORRE ORTHOPEDIC APPLIANCES — O
1035 Forbes Avenue — AT. 1-2870
Manuel De La Torre, C.O

* Extension of Title to Include Prosthetics

External Power in Upper-Extremity Prosthetics and Orthotics

By C. A. McLAURIN, B.A.Sc.
Project Director, Ontario Crippled Children's Centre
Toronto, Canada

After some twenty years of research and experimental fittings external power is being applied to upper-extremity prosthetics and orthotics in fairly large numbers, particularly in Russia and other parts of Europe. It is now becoming increasingly evident that in many applications powered devices have distinct advantages over conventional appliances, and it is the purpose of this brief paper to outline the characteristics of externally powered systems in the hope that it may help indicate where they may be used to advantage.

There are two fundamental differences in prosthetics and orthotics. Firstly, an orthotic device demands greater structural sophistication because it must lift and move the weight of the existing arm with all the joints and mechanisms external to the arm. The problem is somewhat eased in most cases since the device can be secured directly to a chair so that the weight is not critical. This is particularly significant with respect to the power supply. The second important difference is that in most prosthetic applications it is sufficient for the device to perform gross motions only since the fine positioning can be achieved by the remaining part of the body. For example, in the case of the bilateral shoulder-disarticulation amputee, the actual motions of writing are performed by the trunk to which the prosthesis is attached. Usually in an orthotic device the patient does not have this residual body motion and hence the fine positioning as well as the gross motions must be within the capacity of the orthosis. This suggests a highly responsive mechanical device and very difficult control problems.

Although there are many possibilities with respect to storage and conversion of energy the only practical solutions used to date, either experimentally or in service, are electrical systems and pneumatic systems. It is interesting to compare the characteristics of these two systems from a standpoint of energy storage, motors and controls. The commercial availability of nickle cadmium cells have made possible a reliable economical method for storing electricity. A pound of these cells can store 22,000 ft. lbs. of energy, enough to lift 1,000 lbs. to 22 feet. Unfortunately this isn't all available for use since the batteries should not be fully drained and since the motors and drive mechanisms usually have efficiencies of 50% or less. Thus if we use the batteries to one-third capacity we still have 15,000 ft. lbs. left, if the motor is only 50% efficient this is further reduced to 7,500 ft. lbs. and if the drive mechanism is only 50% efficient we are left with 3,700 ft. lbs. This is, however, a sizeable amount of energy to be carrying around in a pound pack. The cells can be recharged about 1,000 times and a service of a year or more is common. Other cells such as silver zinc have aproximately five times the energy storage per lb. but are not available in suitable sizes.

Other sources of electricity such as fuel cells although old in concept are still largely experimental and one cannot expect anything suitable for the prosthetic and orthotic field for many years to come. However, when better batteries are produced it is a very simple matter to connect them to any existing electrical system providing the voltage is suitable. Most systems used today require 12 volts. This was agreed to on two concurrent Panel Meetings of the Subcommittee on Design and Development of CPRD.* It is admittedly a compromise but does allow use of many types of commercial components.

In a typical pneumatic system carbon dioxide is stored in the liquid state in a high pressure cylinder which must meet rigid government specifications. The actual gas pressure available depends upon the temperature and is approximately 850 psi. at 70 degrees fahrenheit. According to Kiessling† at this temperature the theoretical energy available in a gram of carbon dioxide is 370 in. lbs. which is equivalent to 12,000 ft. lbs. per lb. However, since the container may weigh several times as much as the liquid contained therein and since energy is lost when the operating temperature is reduced to a safe level of 50 to 80 psi. the actual available energy is in the order of 2,000 ft. lbs. per lb. This is considerably less than the energy that can be stored in a 1 lb. battery pack and the re-charging process is much less convenient. Batteries can be recharged overnight with a small charger plugged into a household circuit. Carbon dioxide bottles can be re-filled from a larger container stored in the house or at most soda fountains or bars. Since there is considerable hazard in over-filling, some countries, such as Great Britain and Sweden, insist that bottles be refilled at a central station.

Other gases have been suggested, notably freon, which is used in aerosol cans. Freon contains less energy per lb. than carbon dioxide but since the pressure is low it can be stored safely in light weight containers. It is also more expensive than CO^2. From a standpoint of energy storage, batteries offer very definite advantages over CO^2 in terms of weight saving, convenience of recharging and safety.

One of the principle reasons for using compressed gas is the simplicity, light weight and high power of the motors or actuators. Although many of the original systems based on the Heidelberg pattern used a simple bellows, most systems use pistons for converting the gas into useful motion. The bellows are light in weight and can be easily fabricated using a rubber bladder contained in a fabric sack, but this is not durable, particularly in an industrial atmosphere, and can be used to exert a force in one direction only. Pistons can act in both directions and, with pressure on both ends of the piston, act as a lock. The McKibbon muscle (or braided pneumatic actuator) has received a lot of popularity because of its inherent simplicity but like the bellows is relatively vulnerable to corrosive atmosphere (smog) and acts only in one direction. Also because the volume of the muscle must be filled before any work can take place there is considerable wastage of gas. Variations on the piston have been utilized such as the

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* Committee on Prosthetic Research and Development, National Research Council, National Academy of Sciences, Washington, D. C.

† Edward A. Kiessling, American Institute of Prosthetic Research. (The Application of External Power in Prosthetics and Orthotics. Publication 874, Washington).

helical arrangement by Kiessling. In this device an oval piston moving in an oval cylinder causes rotation of the helix (something like a twist drill) mounted longitudinally through the piston. This rotation is coupled directly to an elbow joint or wrist unit. The motion provided by pneumatic devices is generally smooth and quiet and any associated sponginess is not detrimental to gross motions such as used in prosthetics. However, if a load is suddenly released while being lifted there is a corresponding jump in the lifting motion such as when a spring is released. One of the big advantages in using compressed gas is that it will do work much faster than most electrical systems. If you are lifting a weight with a piston the rate of lifting is limited only by the speed in which the gas can be conducted to the piston. Therefore, a gas system can not only be designed to lift a fairly heavy load but to lift it rapidly. In engineering this is termed horsepower. Electrical devices on the other hand have relatively low horsepower, so that even though they can be geared to lift similar loads, they will lift them much more slowly.

The usual method for converting electrical energy for useful work is the electric motor, although solenoids and other mechanisms have been proposed. The solenoid is useful only for a short stroke with a low force and hence has applications only for operating locks or brakes, and must be arranged so that they are used instantaneously only, to avoid unnecessary battery drain.

There are many types of electrical motors but the most common type and generally most effective type for use in this area is the permanent magnet D.C. motor. These are used in toys, household appliances such as shavers and tooth brushes, as well as in the aircraft and missile industry. Surprisingly enough there is very little difference in performance between a good toy motor and an expensive military type unit. However, the latter offers advantages in durability and convenience since usually they can be obtained complete with gear boxes with almost any ratio. A typical motor will weigh about 2 ounces and develop 1/400 horsepower at well over 10,000 r.p.m. The actual torque or turning effect of the motor is usually very small, about 2 to 7 inch ounces, thus before the motor can be used purposefully suitable gearing or other means of increasing the mechanism advantage must be employed.

Hydraulics have often been proposed as a means for converting the rotating motion of a motor to a useful purpose. Hydraulic systems are attractive because the pressure can be high without undue safety risks and therefore pistons can be quite small. The possibilities afforded by hydraulic transmission systems in prosthetics and orthotics are being investigated by General Electric.

Gears are heavy and noisy and, because of their flywheel effect, introduce a lag when starting or stopping the system. A common alternative is a screw mechanism wherein the motor rotates a shaft which is threaded, causng a nut to move up and down the shaft. This system is simple, quiet and rugged but wastes a lot of power through friction even though materials such as teflon and impregnated nylon are used for the nut. Ball bearing screws have a high efficiency, so high in fact that they will not hold against external forces. A promising alternative is produced by Roh'lix Corporation where the "nut" contains slightly canted roller bearings rotating on a plain shaft. This allows high efficiency and a fine pitch.

A further disadvantage of the electric motor system should be noted. If the load is increased until the motor stalls the current continues to flow, causing waste of electricity and possible damage of the motor. This can be overcome with suitably mounted cut-out switches, but this increases the complexity of the mechanism.

The actual lifting power of these small electric motors should also be noted. Horsepower is defined as the lifting of 550 lbs. a height of one foot in one second. Therefore, 1/400 horsepower motor will lift 550/400 lbs. (approximately 1.4) through one foot in one second. However, since the drive system is usually less than 50% efficient the actual lifting capacity would be somewhere around 0.7 foot lb. per second. It could be geared of course to lift ten times this much but it would take ten times as long to raise it through one foot. This must be recognized as a very definite limitation to small electric motors. Gas powered actuators offer very definite advantages over electric devices in size, weight, quietness and power.

CONTROLS

There are two aspects of controls—the mechanism by which the power is turned on and off and the means whereby the body can be harnessed for this function. The means of turning the actuator on and off in electrical devices is either a switch or rheostat. In most practical applications to date a switch is used. These are cheap, simple and reliable. In gas devices valves are used. These can be either on-off or variable. There is very little to choose between the two systems although valves tend to be noisy.

Electric wiring may be a little easier to employ as a transmission device than the flexible tubing that is used in pneumatics but it is interesting to note that the breakage of wires, particularly at the terminals, is one of the most frequent problems encountered in electrical devices in routine use.

By far the most significant aspect of controls is related to body application and there are two major classifications. First, bio-mechanical, in which an actual mechanical motion of the body is used to operate a switch or valve, and second, bio-electrical, where the electrical phenomena of the body is used through a suitable relay system to trigger valves or switches. Bio-mechanical control is usually the easiest to apply and the simplest to understand and is quite satisfactory for many practical applications.

One example of bio-mechanical control may be illustrated by a patient with a shoulder disarticulation, where the shoulder cap of the prosthesis is fitted loosely, allowing freedom of motion of the shoulder tip inside the cap. Valves or switches are arranged within the cap so that upward motion of the shoulder tip controls joint motion in one direction and downward motion of the shoulder tip controls the motion in the opposite direction. Similarly forward and backward motion of the shoulder tip can control motion about another joint. The use of the joy stick principle in this application allows simultaneous motion of the two joints.

Bio-mechanical controls also can originate from standard prosthetic harness systems, chin operated switches, finger switches for phocomelic fingers, chest and abdominal straps, in fact almost anywhere that convenient voluntary control is available. In quadriplegics the selection may be somewhat limited, but shoulder elevation and head control are obvious choices. The head control can utilize switches mounted in the back of a suitable headrest or by a light beam within an eyeglass frame directed to a photo sensitive keyboard as in the Case Orthotic Research Arm. Such things as ear-wiggling and eyebrow raising have also been shown to be useful but perhaps the most versatile is the tongue. In one system used at Rancho Los Amigos, the tongue operates seven switches in both directions.

The use of bio-electrical control systems introduces a great many possibilities and at least as many problems. The method usually used is myo-electrical (the electrical signal from a muscle). When a muscle is tensed an electrical signal is given off and this signal can be picked up with a surface electrode or inserted needle and amplified to a useful level in a similar way that a radio can pick up and amplify a signal. The signal is further processed so that when it reaches a pre-determined level it operates a relay controlling the flow of current to the actuator. This system is interesting because it makes possible the use of muscles which do not bulge enough to operate switches or valves. There are also indications that several independent signals can be generated from one muscle group with proper training.

The most prominent example of myo-electric control is the Russian hand. This has been fitted to more than 1,500 below-elbow amputees with the electrodes placed on the flexors and extensors of the forearm controlling the opening and closing of the hand. Experimental control units have been developed in Great Britain, Canada, Italy, Yugoslavia and Japan. Bottomley* indicated the feasibility of the control principle some 16 years ago and since then he and other researchers have demonstrated proportional control from a myo-electric signal.

The Philco Corporation is investigating a system whereby the prosthesis responds not to a single muscle signal but to a specific pattern of activity of six muscles. The control can be designed to respond to the "natural" activity of the individual thus minimizing training.

One of the interesting possible applications of myo-electrics in orthotics is the use of a signal from a muscle under voluntary control to produce a stimulating signal in a paralyzed muscle so that it may be usefully employed. This is in effect an external nervous system and is currently being investigated at Highland View Hospital, Cleveland, Ohio.

There are fundamental principles that apply to both myo-electrical and bio-mechanical controls. First of all, the muscles so used should be under control at all times (i.e., they work when you want them to and they don't work when you don't want them to). Second, the use of the muscles should not inhibit other activities. Third, if more than one muscle is used, and this is nearly always the case, then the muscles should be able to operate independently or together as required. Fourth, the muscle should be able to produce a variable signal so that the force or speed of the resulting motion is correspondingly varied. Fifth, the time required to train a muscle for a specific task should be minimal. Also it should be possible to do mental arithmetic or carry on an intelligent conversation while performing a task, without excessive concentration.

One important aspect in controls is feedback. This refers to the means of determining the results of the control motion. The most common cue is visual and often peripheral vision is satisfactory. Audio cues are also significant and this is why some noise is desirable. There are other methods that can be used as a substitute for the proprioceptive sense of the human body. The position servo system suggested by Simpson* is one example. In this instance the arm swings about the shoulder joint and the terminal device moves to and from the body controlled by a joy stick. Pushing the stick away from the body will cause the terminal device to move away, and moving it to the side will cause the arm to move to the side. The resulting motion is in turn coupled to the control stick so that the position of the arm can be determined by the position of the control stick.

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* Dr. Alastair H. Bottomley, Centre for Muscle Substitutes, West Hendon Hospital, The Hyde, London, N.W. 9.

Force reflecting servos have been applied in hands and hooks. An early example is the Vaduz hand where grasping is initiated by pressure on a small bladder, suitably located within a below-elbow socket. When the hand closes and grips an object the gripping force is transmitted back to the bladder indicating the strength of the grip by a corresponding back pressure. Marquardt† has demonstrated a control valve which similarly reacts to the actual gas pressure supplied to the actuator. Although feedback can be extremely complex, in practical applications there are a few considerations which may help to simplify the problem. In prosthetics the position of the arm can usually be determined by contact of the stump in the socket. The above-elbow amputee can tell when his arm is abducted because of the socket pressures. Also, if the elbow unit has a constant rate of speed, the amputee can tell by subconsciously timing the motions what angular change is occurring. AMBRL‡ has demonstrated a simple (from the standpoint of the amputee) method of controlling the grip of a terminal device. A Peizo electric crystal in the thumb generates a signal when an object starts to slip in a manner similar to the signal generated from a needle of a record player. This signal causes an increase in the grip of the hand until the slipping stops or maximum pinch is reached. This device not only eliminates the feedback problem but is a clever means of obtaining proportional control automatically.

Proportional control and feedback become very important when it is desired to operate two or more joints simultaneously. Using only visual feedback, simultaneous control of 2 joints has been successfully demonstrated, but the simultaneous control of three joints is extremely difficult. The problem in orthotics can be more acute since the orthotic device may be chair-mounted so that no proprioceptive sense is possible. Position servos would seem to be extremely valuable in this case especially when arranged in the polar co-ordinate system as illustrated by the Simpson* arm.

A complex control system can be avoided if the functional requirements of the appliances are accurately determined and the joints suitably arranged and coupled either mechanically or otherwise programmed to perform the task with the single control input. There are variations in the way in which a control input can be applied either to a single actuator or a complex system. The control can simply initiate motion of the device, which proceeds at a pre-determined rate until the control is released. The control may also be used in the same way but in a proportional manner so that increased pressure causes increased speed or displacement. Another alternative is to initiate motion and then utilize the control to steer the device similar to driving an automobile.

A quick review of applications both experimental and in service illustrates a wide variety of hardware. The Case Orthotic Research Arm has control motion about five joints, which can be suitably programmed by a tape recorder for many specific tasks. The joints can also be co-ordinated to respond to continuous inputs in the three co-ordinate directions. A more modestly powered electric orthosis developed at Rancho Los Amigos has similar mechanical function but the control is by tongue operated lever

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† Dr. Ernst Marquardt, Orthopadische Klinik der Universitat Heidelberg, 69 Heidelberg-Schlierbach, Heidelberg, West Germany.

‡ Army Medical Biomechanical Research Laboratory, Walter Reed Army Medical Center, Forest Glen Section, Washington, D.C. 20012.

* Dr. David C. Simpson, Dept. of Medical Physics, Edinburgh, Scotland. (Aug. 1965—British Vol. Journal of Bone and Joint Surgery.)

switches. A powered orthosis developed by Engen* at Baylor University is essentially a ball bearing feeder type arm rest, powered to provide elevation of the arm. This is a much simpler device, but does require residual function in the upper-extremities.

In prosthetics the most common devices in widespread use, are the Heidelberg type pneumatic arms consisting of elbow joints and locks, wrist rotators and locks, humeral rotators and prehensile hands or hooks. Originally these appliances were controlled with sequential valves, wherein one pull type control could operate the various actuators in sequence. This required considerable concentration to get the right one, and negated the possibility of combined motions. They are now usually fitted with a variety of controls placed where the operation is easiest, utilizing phocomelic fingers, chin switches, toe switches, shoulder elevation, scapular abduction, etc.

The Beograd hand illustrates some of the most advanced thinking in prosthetic devices. This electrically powered hand can grasp using the thumb in a pinching fashion, or with the thumb rotated outwards such as might be used in grasping a ball. The selection is automatically controlled by pressure sensitive pads in the fingers and palms.

In prosthetic use, it is seldom that one requires pure elbow flexion or pure wrist rotation in moving a terminal device from A. to B. There is therefore a trend to provide joint motions which are more closely related to the actual needs of the individual. The feeder arms developed by Northwestern and AIPR are an example of the latter, wherein the wrist and elbow are linked to keep a spoon level when lifting from plate to mouth.

It is apparent that there is no shortage of ideas and possibilities in the application of external power to orthotics and prosthetics. What is required is the realization of the actual needs of the patient which can be fulfilled with such devices and then to make available simple well designed hardware to fit these needs. It is apparent in severely handicapped cases, bilateral amelias, quadriplegics, etc. that the only practical solution is external power. This, of course, is not going to answer all their needs but can answer some. If an arm, for example, can be designed to provide feeding, writing, typing, book handling and toilet care with associated clothing manipulation then a great deal has been accomplished. These tasks are well within existing technical capacity, but there is perhaps need for greater comprehension of the way in which the man and the machine can best be combined for the needed tasks. This can be worked out in an experimental situation where engineer, prosthetist, therapist, doctor and patient can work together to establish the criteria in an informal manner. Once this criteria is established (and some already is) the real need is for a well designed product that is simple, light, and economical. This is somewhat similar to designing an electric shaver or carving knife. They are acceptable only if the product is reliable and attractive. The actual fitting, servicing and training are in no way more complicated than with harness powered devices and unlike the harness powered units there is greater possibility for future improvements in terms of power, speed and ease of operation. One of the biggest difficulties of course is that the sales volume is very small compared to household appliances, but proper orientation of the many competent people involved nationally in this programme could yield very real results in the near future.

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* Thorkild J. Engen, C.O., Director, Orthotic Department, Texas Institute for Rehabilitation and Research, Baylor University, 1333 Moursund Ave., Houston, Texas 77025.

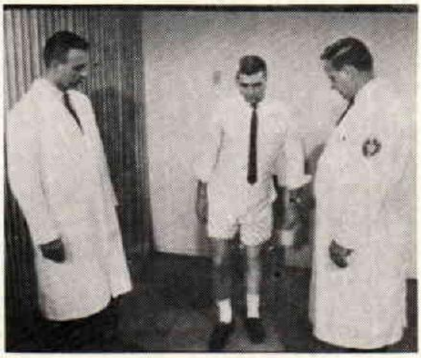
"Men and Mobility"—Recruitment Film

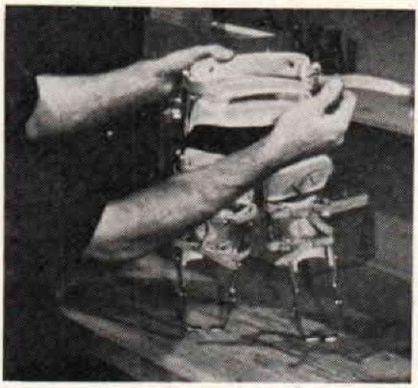
The cover picture for this issue of the *Journal* is from the new career film recently produced by the American Orthotics and Prosthetics Association under a grant from the Vocational Rehabilitation Administration. The Association contributed matching funds. Other scenes from this successful 17-minute color film appear on this page.

Association members who have seen the film at Regional Meetings throughout the country have praised it highly, and have recommended its use, not only as a recruitment tool, but as a means of describing the orthotic-prosthetic profession to physicians and laymen.

A five-member Advisory Committee evaluated the script of the film and supervised technical details of shop and clinic scenes. Members of this Committee were Jack D. Armold, Ph.D., Director of Prosthetic-Orthotic Education at Northwestern University; Isabel Robinault, Ph.D., formerly of the Institute for Crippled and Disabled; Arthur Guilford, C.O., Cleveland; Paul Leimkuehler, C.P., Cleveland; and LeRoy Nattress, Jr., then Executive Director of the American Board for Certification. Lester A. Smith served as Project Director for the film.

Copies of the films are available at a cost of $90, or on a rental basis at $10 for three days, from: Norwood Studios, 926 New Jersey Avenue, N.W., Washington, D.C.





Fabrication of Phocomelia Prostheses for Women

By DAVID G. WANNER, C.P.

Institute for the Crippled and Disabled, New York

Fabrication of a prosthetic device for Phocomelias to acquire a better cosmetic appearance, especially for women, may be achieved without cumbersome doors and straps (as in Figs. 1 and 2). But careful planning and accurate measurements and cast are a must. The use of fiberglass and epoxy makes it possible to fabricate a stronger and much slimmer prosthetic device than the conventional wood prosthesis.

The first step in this technique would be the application of a plaster cast. The cast must be taken with the patient standing and the limb fully extended and the foot in a plantarflexed position. In some cases, the foot tends to invert or go into a varus position. The patient should be instructed to hold the foot straight, or if need be, the prosthetist should hold the foot straight while the cast is setting.

For easy removal of the cast from the patient and to eliminate some cast modifications later, *the area of the Achilles tendon may be built up with heavy felt next to the skin under the cast sock.* The build up may be brought around both medial and lateral sides, especially if the ankle is thin. To remove the cast, a cut is made in this area, and the felt is pulled out. When taking the cast, it may be possible to keep high medial and lateral walls and,

FIG. 1

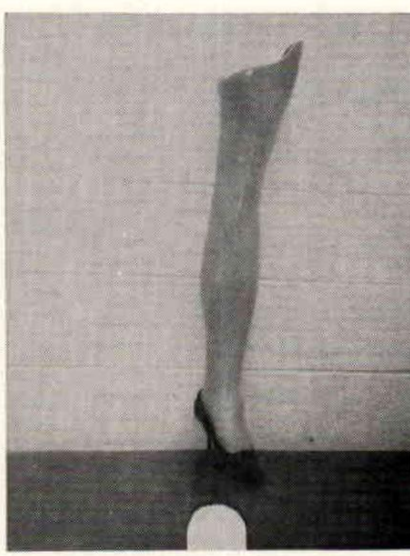


FIG. 2

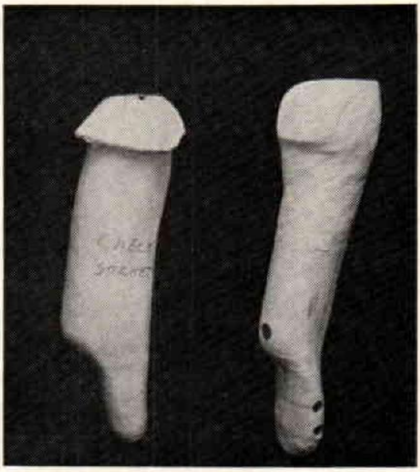


FIG. 3

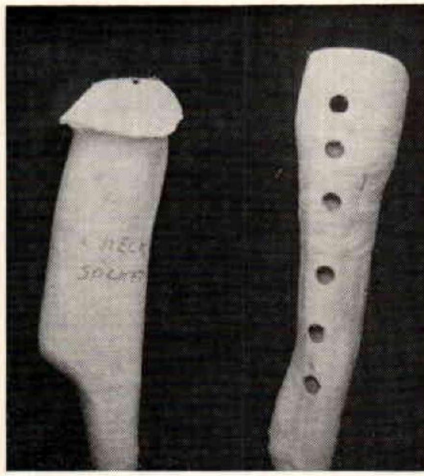


FIG. 4

if possible, to take some weight bearing on the patella tendon as on a regular patella tendon prosthesis. It may be possible on a slim patient to grip the thigh on the condyles with the high medial and lateral walls. In figures 3 and 4, the check socket on the right has high medial and lateral walls. The patient's knee joint was about mid-thigh. On the check socket on the left, the patient had very little femur left. The hip joint was weak, so for more lateral support, the lateral wall was made high as on an AK socket.

Girth measurements should be taken as usual at the proximal end of limb and every 2″ to the distal end. M.L. and A.P. caliper measurements should be taken at critical points, such as the widest point of the heel and foot areas and the width of the malleoli. These measurements are important in the modification of the cast to permit donning of the prosthesis.

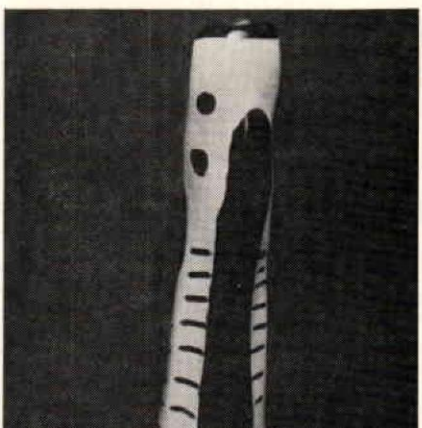


FIG. 5

FIG. 6

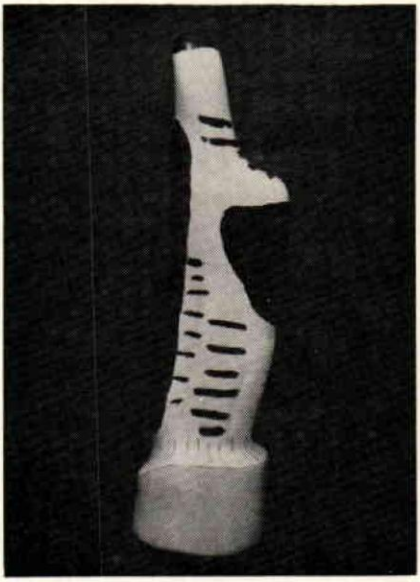


FIG. 7

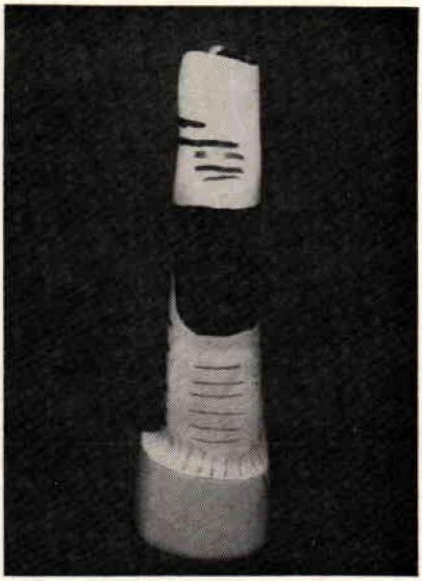


FIG. 8

Cast modification is achieved by proper evaluation of the limb. Also, by distributing weight wherever possible, such as below the medial condyle and under the heel of the foot, keeping in mind that the proximal portion of the socket may not be smaller than the widest part of the foot. It may be necessary to build up the cast on the tibial crest area to permit inserting of the foot in the prosthesis (as in figure 5). The cast should be built up at any bony areas. For example, the malleoli or bony prominences on the anterior of the foot, and ½" on the distal end of the foot, as in figures 5, 6, 7, 8. Build up areas are solid black and the lines indicate weight bearing areas.

A check socket should be fabricated of plaster of paris bandage (about 6 or 7 layers) and fit before the permanent socket is made (as in figures 3 and 4). The permanent socket will be as thin as possible and still be strong. This will *not* allow any major adjustments in fit later. Any relief or changes to be made should be indicated on the check socket. These changes are then made on the male mold before fabrication of the permanent socket. Changes for a better cosmesis may be made by making holes in the check socket to see if there is too much room for the leg, such as the foot on both medial and lateral sides, also anterior and posterior at heel level (as in figure 3). If there is too much room for the foot or toes, plaster on the male cast may be removed in these areas.

The male cast is prepared to be laminated in the same manner as any cast to be laminated, preferably with vacuum when possible. The vacuum will insure a thinner and stronger socket. The lay up for fabrication should consist of one layer of nylon first, then 5 to 7 layers of fiberglass followed by one final layer of nylon impregnated with epoxy resin. It is not recommended to use dacron felt as this just adds to the weight and makes a thicker socket.

When fabrication of the socket is completed, the distal end is set in a balsa block and set up on an adjustable leg if length permits. The static alignment of the socket to the foot should be set up in such a way as to permit a proper cosmetic shape. Although cosmesis is important, it should not interfere with dynamic alignment.

FIG. 9

FIG. 10

The choice of suspension and proximal shape of the socket may differ with each patient according to his or her anatomy. It is possible to use any one of the many P.T.B. cuff suspensions or to improvise on these techniques. A waist belt may be necessary in some cases or a silesian bandage. The choice of a SACH foot is also recommended as this eliminates mechanical maintenance and makes for a better cosmetic appearance.

When the limb is being finished, it is recommended that the patient be present for cosmetic shape. When filling areas of the limb, such as the calf area, the use of a light material, such as Hosmer plastic foam, is desirable.

The finishing procedure follows the conventional pattern with a lamination of two layers of nylon. The finished prosthesis should be much slimmer and shapelier and thus, more appropriate for women.

Prosthetic Services in Algeria

By DIETER MOZER

Centrallasarettet, Boras, Schweden

For about two years the Swedish Red Cross in Algeria, North Africa, has maintained a prosthetics project. The goals of this project are:

1. Construction of below and above-knee prostheses
2. Training of local personnel
3. Development of local industry

I should like to explain these three points in more detail because I realize that these and other questions will be discussed whenever it becomes necessary to start a similar project in a developing country.

According to different government offices, there are between four and eight thousand leg amputees living in Algeria today. Only several hundred of them have been provided with prostheses. It must be mentioned here that even today amputations have to be performed monthly. The reasons for these amputations are explosions of land mines. Several areas of the country are still covered with an unknown number of plastic mines which are extremely difficult to discover and defuse. It is the intention of the Swedish Red Cross to supply as many amputees as possible in the eastern provinces of Algeria with prostheses. For this purpose the Algerian Government has made shop facilities available. The Center of the Swedish project is in Constantine, an old but beautifully located city approximately 1900 feet above sea level, and 65 miles south of the North African Mediterranean seacoast.

The Swedish Red Cross has supplied the shop facilities with modern tools and machinery, at their own expense. Also, it employs presently, in addition to the Algerian apprentices, the following personnel: a shop supervisor, three orthopedic technicians, and a secretary. In addition to the prosthetics center, the hospital has made facilities available for an ambulation training center and inpatient care for our amputees. An orthopedic physician, a physical therapist, and a nurse are working in this part of the hospital. All are Swedish citizens. Altogether, this project involves eight Swedish employees.

The procedure is as follows. The Algerian Red Half-Moon, which is their equivalent of the Red Cross, has the task of registering leg amputees in outlying districts and transporting between 10 and 20 of these amputees to Constantine, whenever so requested. This is not always an easy process. Illiteracy is a widespread problem. The patients have to be sought out in the different mountain villages, because postal facilities and addresses are not available. The patients are transported to the hospital and then examined by the orthopedic physician. After casts and measurements are taken, the prostheses are constructed. Whenever necessary, stumps are revised. The average stay of a patient is two to three weeks. During this time, the legs are fitted and the amputee receives daily ambulation training and physical therapy. In this manner, between 20 and 35 patients are provided with prostheses and discharged.

The training of local personnel consists primarily of practical training in the shop. Several hours during the week are reserved for didactic teaching in anatomy, physiology, and hygiene. During my six-month stay as shop supervisor in Constantine, I had the opportunity to concern myself primarily with the technical training program. We recruited our trainees directly from a type of vocational school for mechanics, and obtained excellent results. At present there are four to six trainees employed in the shop. It is the primary goal of the project to enable the Algerians to run the prosthetics center on their own. During the time of training, the Swedish Red Cross assumes all expenses with the exception of the salaries of Algerian apprentices. These are paid by the Algerian Red Half-Moon. It is the present intention to gradually withdraw the Swedish personnel and eventually to turn over the project completely to Algerian hands.

It is essential that great stress be placed on the availability of materials. The currency conditions in Algeria are such that funds for the procurement of material in foreign countries cannot be obtained. It is necessary that European component parts, which can only be bought with foreign money—in this case, Swedish currency—must be replaced with Algerian materials that can be obtained within the country. These materials need to be up-graded eventually. This procedure, followed strictly, will be the best way towards self-help. It is hoped that, in the near future, the pressure from those who have been provided with prostheses will be utilized to prod the Government along these lines.

One cannot overlook the fact that in any of these under-developed countries there is a great deal of unemployment. The leg amputee, even if he is provided with the best prosthesis, will have difficulties in finding gainful employment if he is not able to take care of himself in his own agricultural environment. The State, as such, does not have a great interest in absorbing this group of disabled people in the economy. Algeria is not an industrial country.

However, we have found a number of raw materials and, by the use of these, we have come closer to the goal of independence from imports. For example: after considerable effort I was able to contact an international service organization (C.C.S.A.) whose goal it is to combat the progressive erosion of the soil on a large scale. Millions of small cedar seedlings are being planted in the bare and eroded areas of the Orest Mountains on the northern border of the Sahara. At the same time, cedar trees from two to three hundred years old, which have been damaged by Napalm bombs, are being cut down. This cedar wood has proved to be well suited for the construction of prostheses. Although it is 8% heavier than the generally used poplar or linden, the cedar wood is rather dense and has long fibers, thereby providing greater strength and increased elasticity.

It is not my intention to impress upon the readers that it is possible to conduct modern prosthetic services, using cedar wood, badly-tanned sheep and cow hides, and iron—so long as one has the will and energy. On the other hand, modern prosthetics does not have to be equated with plastics and other synthetic materials. Modern prosthetics also consists of certain fun-

The most prevalent type of prosthesis, model "homemade." This boy inherited his prosthesis several years ago from an older amputee. One can notice the flexed knee position. The amputee practically walks on his knee. It is surprising, however, that we rarely see fixed-knee contractures despite the fact that the patients in many cases have been walking on their knees for several years.

damentals which determine the indication for specific prostheses, the alignment, etc., in addition to materials. Considering all of this, we quite often see a type of half-modern prosthetics service which, in every case, is certainly better than no prosthetics service at all.

I would also like to discuss the area where one can use various types of prostheses. It is a generally accepted fact that in all countries of the world prostheses are constructed by following standard principles. Except for individual stump differences and also for financial considerations, these are always the same.

1. Under what conditions will the prosthesis be used? For example, for heavy manual labor, or for sedentary pursuits?

2. Under what external conditions will the prosthesis be used? For instance, what is the terrain? What are the climatic conditions? What are the possibilities for easy repair and adjustment?

In Algeria these questions can be answered when one realizes that:

(1) Sedentary employment exists only to a very limited degree;

(2) the amputees will live in most instances in small mountain villages without any road connections or, where roads do exist, they are in very bad condition.

(3) the median temperature is high.

(4) possibilities for repair of prostheses do exist but, for most patients, they cannot be obtained because a trip to Constantine is a very complicated and—for Algerian conditions—expensive undertaking.

For one who has for the past five years been following the development of the PTB prosthesis, as well as having actively worked on this, I could not fail to notice definite disadvantages in addition to the great and unquestioned advantages. Experienced European, as well as American, technicians have stated that follow-up examinations have revealed a fairly high percentage of amputees for whom PTB prostheses were definitely not the proper prosthetic type. Sweden and the United States, from a prosthetic point of view, are certainly sophisticated countries. It has been found that maintenance problems are higher and that the life expectancy of the PTB is lower than of conventional prostheses. It is also a fact that a badly worn shoe can create alignment problems within a PTB socket. This occurs to a higher degree than with conventional below-knee prostheses.

The vast majority of our Algerian patients walk on extremely poor shoes. Under existing climatic conditions, perspiration is a serious factor. Pressure and abrasions are more frequent where temperatures are above normal. We have found that these pressure and abrasion complaints can be minimized considerably when the PTB prostheses are converted to conventional limbs. I am not in a position to prove these points. However, I have had some experience in this field, and I had excellent opportunities during my time in Algeria to re-examine patients who had been fitted with PTB prostheses at an earlier time. In many cases, results of these re-examinations were depressing. I have come to the conclusion that the plastic closed-end PTB prosthesis is not indicated for most patients in Algeria.

For the above-knee prostheses, I feel that the patient who has gotten around for several years with a more or less homemade pylon is an extremely difficult candidate for modern prosthetic services. Many such cases have been complete failures. The explanation seems to be simple. The "civilized" experts just do not have in their armamentarium any place for observation of people living in really primitive conditions. These people

Soccer playing in the yard of the Hospital is part of the daily routine, and is a favorite gymnastic exercise.

depend upon the land for their living. They have to spend all of their lives on rocky, mountainous terrain, as shepherds. They have only the most primitive housing. Amputees depend upon their prostheses to a degree of which we just cannot possibly have any comprehension.

I had an opportunity to study several dozen of these homemade prostheses, and I would describe them as follows: strong wooden peg up to the knee, where it is divided and runs on a lateral aspect of the stump for about four inches past the hip joint. At this point there is a belt, a strap, or something similar which runs around the waist. By this means the prosthesis is suspended. Between the medial and the lateral fork one finds parts of a firmer leather socket which was either riveted, screwed, or bolted in, being open at the end. The whole is padded with pieces of cloth, old socks, and other textiles. The wooden fork may be broken in several areas and carefully reassembled by means of nails, screws, or wire. The general impression is that the peglegs are always too short, the gait is not aesthetic, the prostheses are unhygenic—but, no pressure sores, because the whole socket is soft; no complaints about heat because the air circulates about the stump freely; fairly rapid and uncomplicated ambulation, not only on level ground, but also up and down hill; maintenance problems minimum, and if some breakage occurs, the problem can usually be taken care of by the patient himself. The legs, as a rule, are extremely cheap and dependable. In other words, this is the almost-ideal prosthesis for this specific type patient. "Our" prostheses, in most cases (this concerns above-knee prostheses) give definitely inferior service. The foot was always a handicap. A SACH foot was out of the picture. The socket was too warm, and too hard.

What is one to do? Solutions can undoubtedly be found. Perhaps the "good old leather socket"—perhaps an exchangeable foot, which could then convert the pylon to a Sunday-and-holiday leg. There are many possibilities, but one has to spend some time to arrive at a good solution.

I would say that language difficulties don't exist at all—unless one is just lazy enough to pretend that they do. One can understand Arabic just as easily as German or English when a patient explains that his prosthesis is either too heavy or too warm, or too hard or too long, or whatever the problem might be.

Above all, one has to learn that, for example, in Algeria one does not automatically construct European or American prostheses, but primarily, Algerian ones. Once this fact is accepted, the greatest part of the problem has been solved.

Prosthetic Rehabilitation of a Patient With Bilateral Hip-Flexion Contractures: Report of a Case*

By JUSTIN ALEXANDER, R.P.T.† and GERALD HERBISON, M.D.‡
Bronx, New York

Prosthetic rehabilitation of the patient with hip-flexion contractures in excess of 30 degrees is difficult. Some of the problems which are frequently encountered are those of prosthetic fitting, of increased expenditure of energy in walking, and of cosmetic results. A case is reported in which these problems could be managed.

CASE REPORT

A 59-year-old man who had had ulcerative colitis for five years underwent herniorrhaphy in January, 1962. Subsequently, bilateral occlusion of the iliac arteries developed. In February, 1962, aortoiliac endarterectomy was performed and was followed by a *Staphylococcus aureus* septicemia. The infection responded to antibiotic therapy. Eight months later, a plan to bypass a rethrombosed aortoiliac segment was abandoned because of an infection involving the right retroperitoneal area. In March 1963, a dacron graft extending from the aorta to both common iliac arteries was implanted. Gangrene developed in both lower extremities in spite of the procedure. On May 1, 1963, a right above-knee amputation was performed, followed by a left below-knee amuntation on May 6, 1963.

On June 6, 1963, the patient was transferred to Bronx Municipal Hospital Center. Physical examination on admission disclosed bilateral inguinal draining sinuses, a right above- and left below knee stump which were in the process of healing. Roentgenographic examination accompanied by injection of contrast medium into both inguinal draining sinuses, performed on October 15, 1963, revealed a communication between the sinuses and the small bowel. The infected dacron graft was removed through the right inguinal sinus without difficulty. Subsequently, both fistulae closed. During this period the patient's wife died and his ulcerative colitis flared up.

By the time of his transfer to the Department of Physical Medicine and Rehabilitation, bilateral 60-degree hip-flexion contractures as well as a 90-degree knee-flexion contracture on the left had developed (fig. 1). Attempts to decrease the contractures by manual stretching and by use of pulleys were unsuccessful. Surgical release of the contractures was believed to be contraindicated because of the patient's impaired local circulation. The marginal circulation in the stumps, the severe contractures and the decreased mobility of the lumbar spine seemed to make the prescription of prostheses inad-

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† Chief, Physical Therapy, Bronx Municipal Hospital Center and Amputee Center; Instructor, Albert Einstein College of Medicine, New York; Associate Educational Director and Visiting Professor, Ithaca College, Ithaca, N.Y.

‡ Resident, Department of Physical Medicine and Rehabilitation, Bronx Municipal Hospital Center.

visable. An additional point was that the patient could not sit for more than an hour without developing numbness in the gluteal regions. The patient, however, insisted that he be given an opportunity to attempt ambulation.

It was, therefore, decided to try out the following plan: A bent-knee pylon was to be constructed for the left leg to allow the patient to stand between parallel bars. If he could tolerate weight-bearing pressure, a pylon for the right side was to be made. Because of the limited mobility of the lumbar spine, it was anticipated that both pylons would have to be aligned in sufficient initial hip flexion to compensate for the limited motion in the hips and in the spine.

Method—A plaster-of-Paris mold for the left below-knee stump was constructed. It enclosed the entire stump from the hip to the end of the stump. Padding material was incorporated into the mold. Reliefs for the rectus femoris muscle and for the adductor longus tendon were provided. The mold was allowed to dry on the patient for 24 hours and then a three-inch wide section of the anterior wall of the mold was cut out. The removed section extended from the proximal end of the mold to a point corresponding to the condyles of the femur, and it was re-attached on one side to the mold by means of moleskin. This arrangement allowed the stump to be placed into the mold from the front and it held the stump in place. A hollow, square, wooden pylon was constructed to serve as a shin piece. By resorting to this type of shin piece, we were able to increase the area of floor contact and at the same time keep the pylon light. The mold was attached to the shin piece by means of a medial and a lateral metal band. The alignment allowed for the hip-flexion contracture (fig. 2). As a result of this alignment, the weight was borne primarily on the knee and the posterior thigh. The patient was able to stand with this device without discomfort.

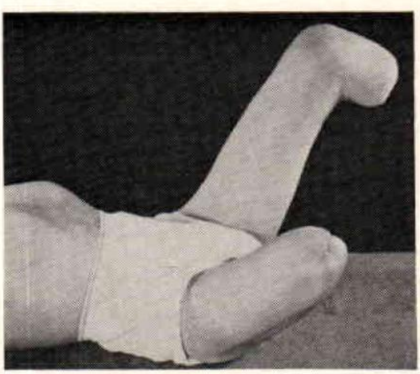

FIG. 1—Position of fixed contractures.

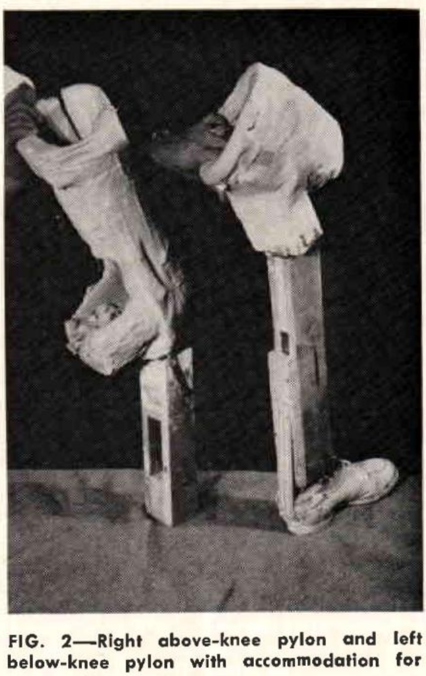

FIG. 2—Right above-knee pylon and left below-knee pylon with accommodation for contractures.

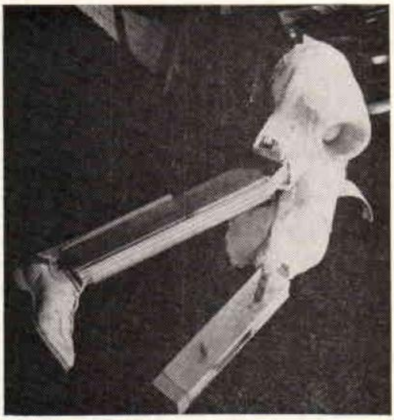

FIG. 3—Above-knee pylon with hinge knee and extension aid.

FIG. 4—Prostheses in the flexed position, above-knee alignment for cosmesis.

FIG. 5—Prostheses in extended position, above-knee showing modified Swiss lock and alignment for maximum function allowing for fixed contractures.

The right above-knee stump was then prepared as follows: A plaster-of-Paris socket was constructed with the patient in the standing position. Reliefs for the rectus femoris muscle and the adductor longus tendon were incorporated into the socket. Hollow shin and thigh pieces were made of wood and were joined by means of a strong metal hinge to allow for knee motion. The center of rotation of this joint was at the posterior border of the shin and thigh pieces (fig. 3). A strong elastic web strap bridged the knee joint anteriorly and served as an extension aid. A prosthetic foot with single axis ankle and anterior and posterior bumpers was attached to the shin piece. The plaster socket was attached to the proximal end of the wooden thigh piece at a 60-degree angle by means of a medial and lateral metal band embedded in plaster. The pylon was aligned so that the ankle joint fell under the greater trochanter and the knee joint axis was placed posteriorly to the trochanter-knee-ankle (TKA) line. A non-elastic web strap belt, attached to the lateral side of the socket, provided auxiliary suspension. Weight bearing occurred on the entire posterior aspect of the thigh.

The patient was able to ambulate between paralled bars and to progress to ambulation with a walker. It was therefore decided to prescribe permanent artificial limbs. The appliances followed the basic design of the pylons with a few exceptions. The below-knee prosthesis consisted of a molded leather socket with an anterior opening (fig. 4). The stump was held in the socket by means of Velcro straps. The prosthesis included outside knee joints with drop-ring locks, a single axis ankle, and a conventional foot with anterior and posterior bumpers. In the above-knee prosthesis, the thigh piece consisted of two separate parts: a wooden socket and a distal portion. The two were joined by means of hinges placed medially and laterally and could be locked with a modified Swiss lock in 60-degree flexion to enable the patient to stand upright (fig. 5). When the patient sat down, the lock could be opened to allow the socket and the distal portion of the thigh piece to be realigned into a straight line relative to each other, thus giving a more cosmetic appearance (fig. 4). A Bock knee with friction lock, pelvic band, single axis ankle joint, conventional foot with anterior and posterior bumpers completed the prosthesis.

Results—The patient was able to ambulate on his prostheses at first with a walker and subsequently with Lofstrand forearm crutches. Within a few days he was able to negotiate stairs, curbs and ramps. He was discharged from the hospital on May 29, 1964.

The patient has learned to drive a hand-controlled car since his discharge and he is independent in every way.

SUMMARY

The feasibility of prosthetic rehabilitation of a patient with a right above-knee and a left below-knee amputation in the presence of bilateral hip-flexion contractures of 60 degrees and left knee-flexion contractures of 90 degrees has been demonstrated.

Acknowledgements: The authors express their appreciation to Dr. Heinz Lippmann for editorial advice, and to Mr. John Marshburn of Henzel Artificial Limb Company, who translated their ideas into a finished product.

A Survey of Eight Wearers of the Veterans Administration Prosthetics Center Patellar Tendon-Bearing Brace

Prepared by HECTOR W. KAY, M.Ed. and
HEIDI VORCHHEIMER, A.B., R.P.T.
New York University Prosthetic and Orthotic Studies

A SUMMARY

I. Introduction

Bracing to relieve weightbearing stresses of the lower extremity has been achieved by loading the brace at the level of the pelvis, with the wearer essentially "sitting" on the proximal portion of the brace. Weight is then transmitted to the ground through an exoskeleton of sidebars and locked knee. The disadvantages of this type of brace are its bulk and the locked knee. When the pathology is located above the knee such disadvantages may be unavoidable. In the case of certain below-knee lesions, however, a weight-bearing brace which does not extend above the knee is desirable and appears theoretically feasible. Such a brace would be less bulky and would allow unrestricted knee motion and a more natural gait.

In 1958 the Veterans Administration Prosthetics Center (VAPC) designed a below-knee weight-bearing brace to meet the needs of a patient who was unable to bear weight on his foot.[1] This individual had previously been fitted with both a locked-knee ischial-bearing brace and a short leg brace with weight borne on the tibial condyles. He had rejected both of these devices.

The VAPC design is based on current below-knee prosthetic techniques. The primary weight-bearing component is a partial socket of laminated plastic similar to the proximal portion of a patellar tendon-bearing (PTB) below-knee prosthesis. A steel frame is laminated to the socket. Uprights anchored to this frame transmit the patient's weight, through rigid or limited motion ankle joints, to the heel of the shoe and the ground.

Conventional fitting and alignment techniques are used for the uprights, ankle joints and shoe attachment. A SACH heel wedge and a rocker bar are incorporated in the shoe to simulate plantar flexion and provide a more natural rollover from heel to toe.[2] These shoe modifications are designed to minimize the gait deviations imposed by limited ankle motion. The SACH heel wedge is also considered to function as a shock absorber, contributing to a smoother gait.

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[1] McIlmurray, William and Greenbaum, Werner, *A Below Knee Weight Bearing Brace*, ORTHOPEDIC AND PROSTHETIC APPLIANCE JOURNAL, June 1958, pp. 81-82.

[2] McIlmurray, William and Greenbaum, Werner, *The Application of SACH Foot Principles to Orthotics*, ORTHOPEDIC AND PROSTHETIC APPLIANCE JOURNAL, December 1959, pp. 37-40.

The Committee on Prosthetics Research and Development (CPRD) in December 1963 selected the VAPC design as a suitable item for evaluation under the Orthotic Evaluation Program to be inaugurated by New York University. The planned evaluation of the VAPC device will cover three phases:

(1) Review and examination of subjects fitted by the VAPC;

(2) Selection, fitting and evaluation of subjects by NYU;

(3) Selection, fitting and evaluation of patients by cooperating field clinics.

This report is confined to the procedures employed and the results obtained in the first stage of the evaluation.

II. Purpose

The primary objective of the review was to determine the value of the experimental device in relation to the conditions for which it had been prescribed. Three possible levels of findings were hypothesized:

(1) The brace made a positive contribution to the amelioration of the condition.

(2) The brace had a stabilizing effect: it neither improved nor aggravated the condition.

(3) The brace had a negative effect: it aggravated the condition.

As a secondary goal, criteria for the prescription of this type of weight-bearing brace were investigated to the extent permitted by the available data.

III. Methodology

The study was conducted by a research group composed of three physicians (one orthopedist and two physiatrists), an orthotist and a physical therapist. The following aspects of brace wear were investigated:

Medical. The group reviewed each patient's history, focusing on pathological status prior to fitting and at the time of the review. Conclusions as to effect on pathology were drawn, based primarily on comparative X-rays. The applicability of the brace to related pathologies also was considered.

Performance Evaluation. Patient-performance during level walking and stair climbing was rated subjectively, with neuromuscular deficit, habit patterns and brace characteristics considered as possible sources of deviations from normal gait.

Wearer Reaction. The braces were rated with regard to comfort and fit, functional characteristics, maintenance requirements and general characteristics. Where applicable, comparisons with previously used devices also were made.

Orthotic. The group investigated the types of braces worn previously, and the subjects' experiences with them. The experimental braces were examined to determine the types of components used, and to identify fabrication and alignment characteristics in relation to pathology.

IV. Sample

From 1958 to November 1963, the VAPC fitted the PTB brace to 22 patients, all of whom had defects of the below-knee weight bearing structures. Eight of the 22 patients participated in the evaluation procedures. The fourteen additional subjects did not participate in the review despite maximum efforts on the part of both NYU and the VA to secure their cooperation. The eight patients reviewed may constitute a select rather than random or representative sample, but this does not invalidate the findings of the review. However, broad generalizations from these findings would hardly be warranted without further study.

TABLE I

DESCRIPTION OF SAMPLE
(N = 8)

Subject	Age	Height	Weight	Pathology	Prior Braces
N.C.	44 y 8 m	5'7"	220	Nonunion, tibia	1. Ischial bearing 2. Short leg with condylar bearing
D.D.	46 y 7 m	6'0"	182	Traumatic and surgical ankle joint changes	1. Short leg, weight-bearing 2. Short leg, standard
R.M.	34 y 2 m	6'1"	180	Same	1. Ischial bearing
D.M.	33 y 11 m	5'6"	185	Malunion and joint changes	1. Ischial bearing with Hessing anklet
W.N.	44 y 10 m	5'10½"	192	Traumatic and surgical joint changes	None
A.R.	39 y 10 m	6'0"	155	Traumatic joint changes	None
A.S.	39 y 6 m	5'9½"	166	Absent os calcis	1. Short leg brace 2. Ischial bearing
W.T.	47 y 7 m	6'4"	153	Traumatic and surgical joint changes	1. Short leg brace

V. *Results*

A. *Medical.* The eight subjects reviewed exhibited clinical symptoms of skeletal and/or soft tissue intolerance to the stresses of weight bearing. The medical findings related to wear of the experimental brace are summarized below for each of the eight patients:

Subject N.C. The X-ray evidence indicated that the experimental brace, worn during the period 1958-1964, apparently produced a slight improvement in the patient's condition. No increase in the deformity was detectable, and although the tibial nonunion persisted, it was somewhat less marked.

Subject D.D. This patient's pathology apparently stabilized during the 5½ year period of experimental brace wear. No progression of bony pathology could be determined by comparison of reports of X-rays taken some time prior to fitting of the experimental brace and those taken for purposes of this review. The subject's pain had decreased.

Subject R.M. No objective evidence of change in the condition of the os calcis was apparent following 14 months wear of the experimental brace. Nevertheless, the subject's pain on weight bearing had decreased.

Subject D.M. The radiological data demonstrated a definite improvement in the status of the tibial malunion. The condition, which had persisted for nearly three years despite surgery, appeared to have healed during the 17 month period the experimental brace had been worn.

Subject W.N. The comparative X-rays showed no significant changes in condition. There was, however, a reduction in pain during the 5¾ years of experimental brace wear.

Subject A.R. This subject had worn the experimental brace for a period of 4 years 11 months. Initially, there had been marked reduction in pain with stabilization at a tolerable level. More recently, however, pain at the instep and metatarsals had increased, with associated pain in the hip. These symptoms were in conflict with the stabilized condition indicated by the X-rays. It was not clear, therefore, whether the experimental brace had contributed negatively or positively to the patient's condition.

Subject A.S. This subject was the first patient fitted with this brace design by the VAPC. He had worn the item continuously for 6½ years, with generally beneficial results. No progression of the arthritic process was evident radiographically, and osteoporosis had decreased. The subject's functional capacities had improved.

Subject W.T. Comparison of the patient's condition as reported in the medical history with his current status led to the conclusion that no increase of the bony pathology had occurred. Pain was apparently less. The three years of brace wear had seemingly stabilized the patient's condition.

B. *Performance.*

1. *Level walking:* The eight subjects exhibited a minimum of gait deviations. The only atypical characteristic common to all subjects related to knee motion, which differed from the "normal" cycle of: (1) extension at heel strike followed by flexion to foot-flat; (2) gradual extension from foot-flat through mid-stance, with maximum extension reached just prior to heel-off; (3) terminal flexion immediately following heel-off.

The deviation from normalcy varied in degree with different subjects, but the pattern was uniform. Typically, the knee was flexed at heel-strike, and flexion increased to foot-flat. The knee was then "snapped back," producing abrupt extension immediately after foot-flat, rather than gradual knee extension just before heel-off as in the normal cycle. Terminal knee flexion occurred later than normal and was abrupt. This gait characteristic, which is also typical of below-knee amputees fitted with Patellar Tendon-Bearing prostheses, is attributed to the flexed knee alignment of the device (up to 20°) which prevents complete knee extension.

Shortened stride length, shortened stance time and external rotation of the involved extremities are deviations of gait typically found in situations of limited ankle motion and pain. Even though the experimental brace incorporated rigid or limited motion ankle joints and had been prescribed for conditions of painful weight bearing, these characteristic gait deviations were not present. Apparently the SACH heel wedge and rocker bar application, which simulated plantar flexion of the ankle, had offset the typical effect of a limited motion ankle joint, while alleviation of the pain-producing stress of weight bearing had eliminated this cause of gait deviation.

The four subjects who had previously worn ischial-bearing locked knee braces did not exhibit any carry-over of the stiff kneed gait typical of such devices.

2. *Stair climbing:* Methods of stair ascent and descent varied widely among the eight subjects. The common element in all the variations was the reduction in use of the affected knee. Inability to bring the knee into full extension because of the flexion alignment of the socket was seen as the causative factor in all the variations in technique exhibited.

C. *Wearer Reactions.* Tables III, a-d, present a composite of the patients' ratings.*

* Tables II and IV have been omitted from this summary.

TABLE III

PATIENT REACTIONS TO THE EXPERIMENTAL BRACE
(N = 8)

IIIa—COMFORT AND FIT

	Responses				
	Excellent	Good	Adequate	Poor	Very Poor
Overall comfort	3	4	1	—	—
Overall comfort after prolonged sitting	1	2	4	1	—
Comfort in knee area after prolonged sitting	3	3	1	1	—
Comfort in weight-bearing area	2	3	2	1	—
Comfort with respect to perspiration	1	2	2	—	3
Comfort with respect to pain*	5	1	1	—	—
Estimation of fit	2	4	2	—	—
Percentage of responses	30.9	34.5	23.6	5.5	5.5

* One additional subject reported no pain with brace wear.

Findings in regard to comfort and fit were generally positive (approximately 65% in Good and Excellent categories.) Six of eight patients had little or no pain in the affected area.

IIIb—FUNCTIONAL CHARACTERISTICS

	Responses				
	Excellent	Good	Adequate	Poor	Very Poor
Limp	1	4	3	—	—
Impact shock	1	4	3	—	—
Heel-to-toe transition:					
a. as regards smoothness	2	4	1	1	—
b. as regards effort required	2	3	3	—	—
Contribution to security	7	1	—	—	—
Usability (extent of time)	6	2	—	—	—
Percentage of responses	39.6	37.5	20.8	2.1	0

These reactions were emphatically positive (77% in Good to Excellent categories.) Particularly interesting are the ratings accorded security of the brace and the extended periods of time the brace could be worn.

The subjects were also asked to estimate the percentage of body weight borne by the brace during stance phase. Estimates ranged from a maximum of 90 percent to a minimum of 40 to 60 percent.

IIIc—MAINTENANCE AND REPAIR

	Responses				
	Excellent	Good	Adequate	Poor	Very Poor
Durability (frequency of repair):					
a. Socket	3	4	1	—	—
b. Other parts	3	2	2	1	—
Maintenance of cleanliness	3	4	1	—	—
Percentage of responses	37.5	41.7	16.7	4.1	0

As indicated in Table IIIc, the repair and adjustment requirements of the VAPC brace were quite low. One subject required repairs every one to three months, but in all other cases the need arose less frequently.

IIId—General Characteristics

	Responses				
	Excellent	Good	Adequate	Poor	Very Poor
Weight of brace	—	1	4	3	—
Interference with clothing	2	3	—	2	1
Incidence of backache	2	4	—	1	1
Overall value of brace	4	4	—	—	—
Percentage of responses	25.0	37.5	12.5	18.8	6.2

The subjects' opinions concerning the relative merits of their conventional and experimental braces were reported by the patients on the same factors as their evaluations of the experimental braces.

On *Comfort and Fit*, 69.4% reported that the experimental brace was Much Better, and 19.4% that it was Better than the conventional brace.

On *Functional Characteristics*, 71.4% reported Much Better and 11.9% reported that it was Better.

On *Maintenance and Repair* the response was: Much Better, 30%; Better, 40%.

On *General Characteristics* the response was: Much Better, 60.9%; Better, 8.7%.

D. *Orthotic*. The subjects had used the experimental brace design for periods ranging from a minimum of ten months to a maximum of six and one-half years. As shown in Table V, the components incorporated in the eight experimental braces were reasonably uniform. All except the PTB socket are in common use. Four individuals were provided with a small amount of dorsiflexion ankle motion, while the other four had no ankle motion. Custom-made shoes with fillers were worn by five of the subjects to compensate for shortening of the involved extremity.

TABLE V

COMPONENTS OF PTB BRACE
(N = 8)

Subject	Socket	Brace-Shoe Attachments	Ankle Joint Type	Ankle Joint R.O.M.	Shoe Modifications SACH Wedge	Shoe Modifications Rocker Bar
N.C.	P.T.B.	Solid stirrup	Clevis	7° (D.F.)	Yes	Yes
D.D.	P.T.B.	Split stirrup	Clevis	None	Yes	No
R.M.	P.T.B.	Solid stirrup	Clevis	8° (D.F.)	No	Yes
D.M.	P.T.B.	Foot plate-molded sandal	Solid	None	No	No
W.N.	P.T.B. (modified*)	Solid stirrup	Clevis	6° (D.F.)	Yes	Yes
A.R.	P.T.B.	Solid stirrup	Lap (welded)	None	Yes	Yes
A.S.	P.T.B.	Solid stirrup	Clevis	8° (D.F.)	Yes	Yes
W.T.	P.T.B.	Solid stirrup continuous with upright	Solid	None	No	Yes

* Patellar and femoral condylar extensions missing.

Examination of the braces indicated that, in general, they were well constructed, functionally adequate and quite durable. However, not all of the braces fitted optimally and some deviations from standard orthotic practice were noted. These factors were apparently not of sufficient magitude to affect the adequacy of the brace as a whole critically.

SUMMARY AND CONCLUSIONS

The initial phase in the evaluation of the VAPC brace involved an examination of eight of the 22 patients fitted by the developer during the period 1958-1963.

Three possible levels of findings were hypothesized with respect to the effects of the experimental brace, viz., positive, stabilizing or negative.

The objective evidence obtained (comparative X-rays) indicated definite improvement in the skeletal condition of one subject; two showed slight improvement and five showed no change. The one subject exhibiting definite improvement also reported pain-free ambulation. Six of the remaining seven subjects reported that they still experienced some pain but significantly less than with earlier braces. One subject indicated that pain was recurring after several years of relief.

Insofar as the subject showing definite improvement is concerned, it is conceivable that healing of the tibial malunion might have occurred simply with the passage of time. However, this had not happened in the three year post-trauma and surgery period prior to fitting of the patellar tendon-bearing brace. Hence, wear of the experimental brace must be considered as having contributed to healing. Results with the six subjects who reported relief or decrease of pain and whose X-rays showed slight improvement or no change might also be considered positive. Progression of symptoms and arthritic pathology would usually be expected in such cases as those reviewed. Lack of progression, therefore, may constitute a second-order benefit attributable to reduction in weight-bearing stress. Thus, in seven of the eight cases the outcomes appeared to be positive or at least stabilized. In the case of the one subject who reported recurrence of pain, the outcome of the fitting might be interpreted as equivocal or negative, although there was no objective evidence of deterioration.

Thus the review data indicate that, in general, the brace design under study is an effective method of treatment for below-knee conditions that require unweighting of the limb. Use of this brace is considered to be indicated in situations of structural instability (including nonunion of the tibia), excessive pain on weight bearing, persistent infection or a combination of these factors resulting from trauma and/or surgery of the leg, ankle or foot. In cases of nonunion, use of this item would involve consideration of the extent of instability as well as the location of the fracture, since highly unstable fractures would generally preclude any mobility of the individual. In any event, an intact weight-bearing area below the knee is an essential prerequisite.

The patellar tendon-bearing socket has been used successfully with stirrup attachments (rigid and limited motion ankle joints) and with a foot plate-molded sandal attachment.

In the experimental brace as in prosthetic appliances, the PTB socket is fabricated to fit snugly with pressure applied to the prepatellar tendon and tibial flares with a stabilizing counter-pressure exerted in the popliteal space. The amount of weight taken on the proximal socket is influenced both by the intimacy of fit and by the degree of initial flexion in which the socket is set.

The length of the sidebars can also be varied to control the amount of contact between the foot and the shoe, thus changing the amount of weight taken on the brim. It is noteworthy that the subjects interviewed tended to loosen the strap fasteners on the socket for greater comfort; but by so doing, of course, they reduced the effectiveness of the weight-bearing characteristics of the socket.

Essentially, the orthotist attempts to fit the brace with provision for weight-bearing sufficient to eliminate or significantly relieve pain, and commensurate with the wearer's tolerance of pressure on the prepatellar tendon and tibial flares.

The intimate contact and stability of the socket in the knee area require that during fabrication provision be made for anatomical variations in the ankle and foot. Adequate compensation must be provided for toe-out, tibial bowing and foot malformation. The ankle motion limitations imposed by this type of brace reduce the need to compensate for excessive tibial torsion.

Ambulatory function with the PTB brace approaches the normal. The only significant deviations are related to knee action during stance phase (between heel-contact and mid-stance, and between heel-off and toe-off). In both instances, the deviations appear to be directly related to the flexion alignment of the socket. Variations in stair-climbing techniques also appear to be associated with this alignment factor.

The subjective reactions of the wearers to the brace were generally positive, reaffirming the medical and performance findings.

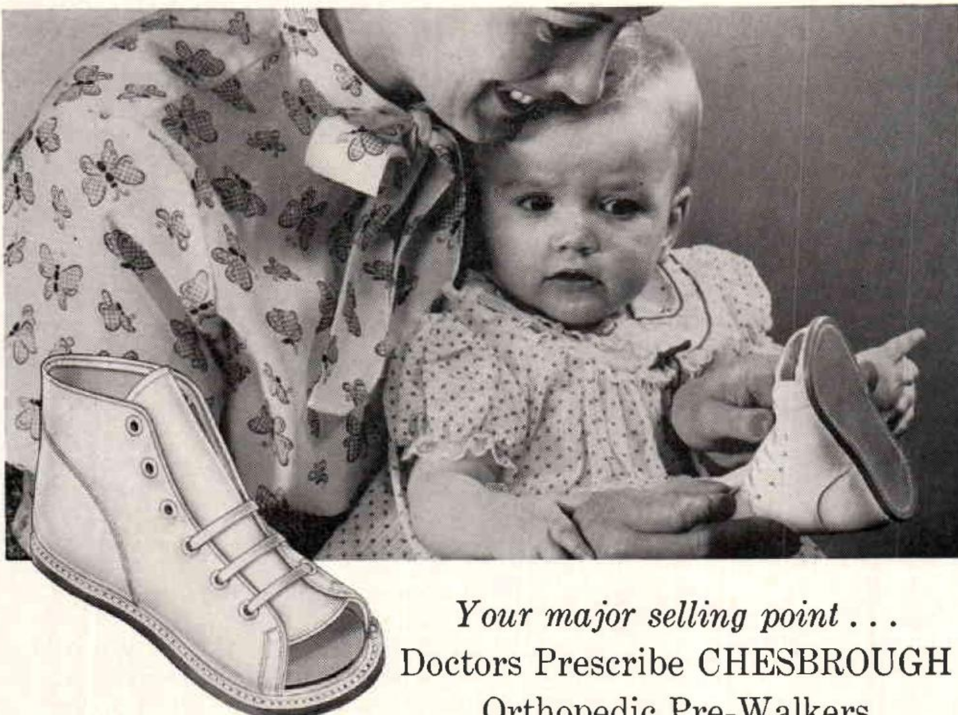
Since the results of the study to date indicate that the VAPC patellar tendon-bearing brace is an effective device from the medical, orthotic, functional, and wearer-reaction points of view, activation of the second phase of the evaluation program—fitting of subjects by New York University—appears fully warranted.

University of Miami Prosthetics Seminar Scheduled

The University of Miami will present, for the third consecutive year, a three-day seminar on "The Lower Extremity Amputee—Surgery and Prosthetics Management" on December 1-3, 1966 at the Americana Hotel at Miami Beach, Florida.

This seminar will include discussions on preventive and reconstructive surgery in peripheral vascular disease; new concepts in surgery; myoplastic procedures; immediate postoperative fitting; biomechanics of human locomotion; and basic prosthetic principles in the adult and juvenile amputee. Research and new developments will also be discussed.

A limited number of traineeships are available. For application and further information, write to Augusto Sarmiento, M.D., Division of Orthopaedics, Jackson Memorial Hospital, Miami, Florida.



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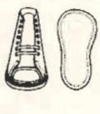

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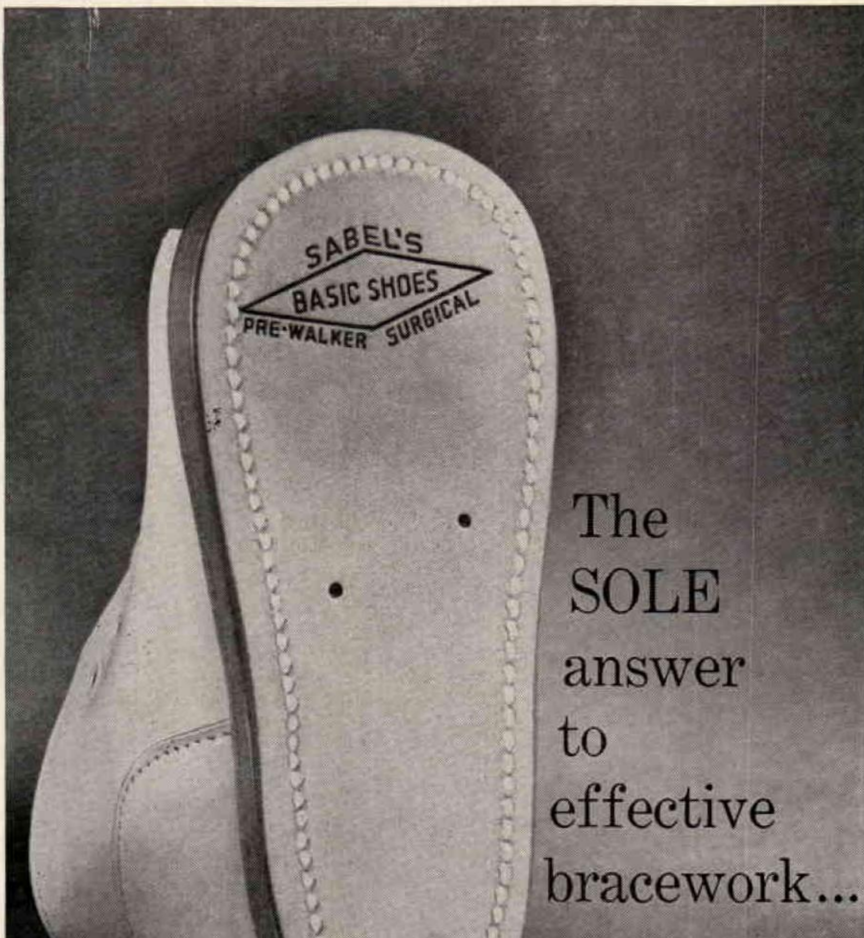
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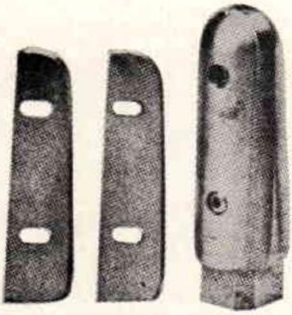

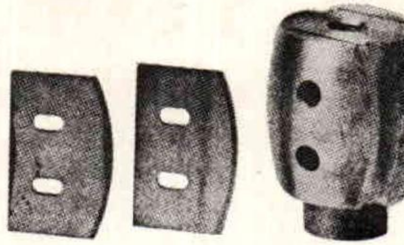

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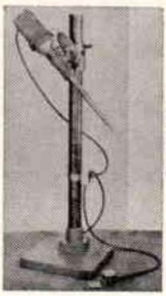

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