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SEPTEMBER 1972

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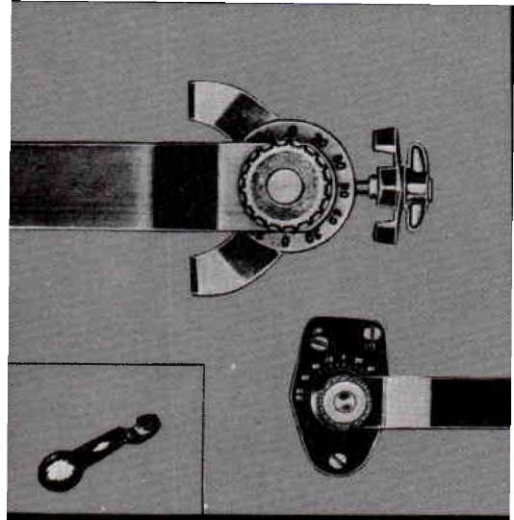

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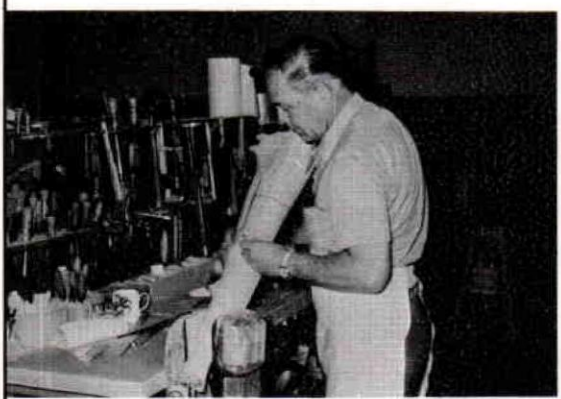

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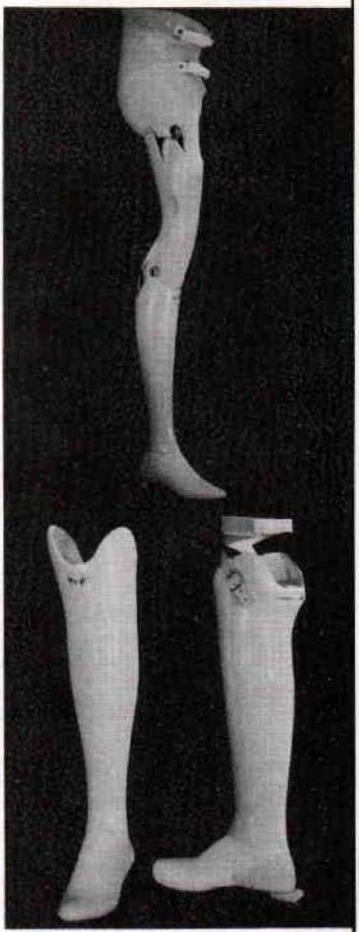

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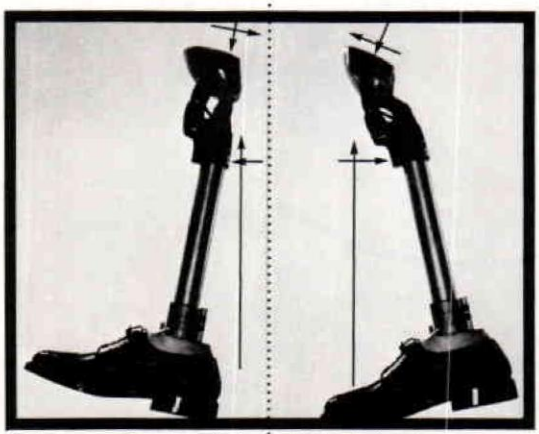

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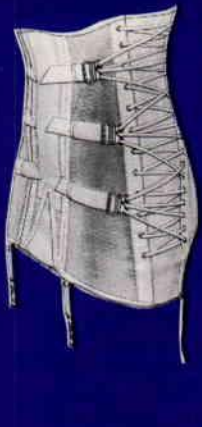

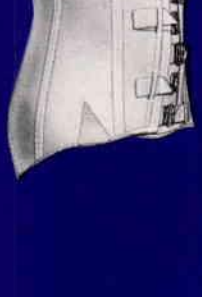

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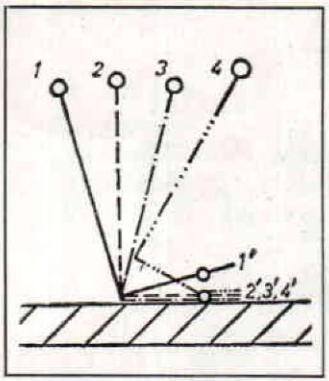

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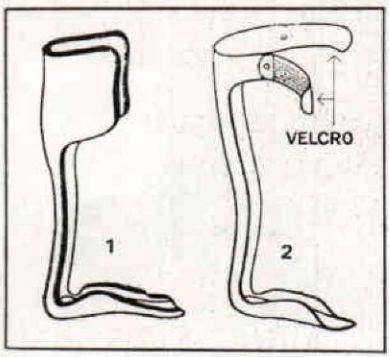

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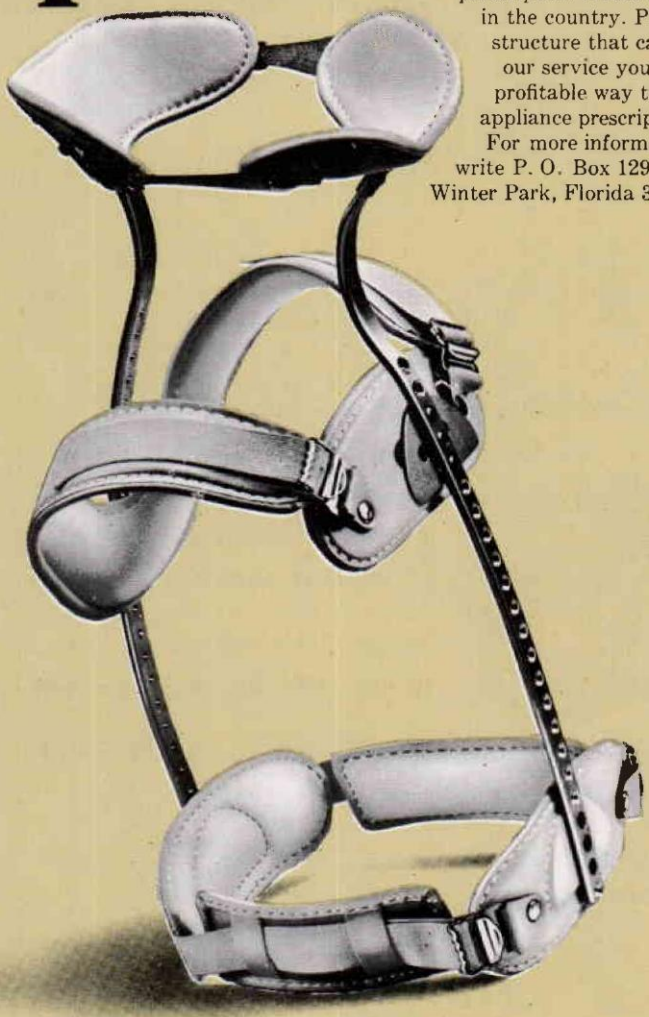

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The Fifth Interbor Congress

Siegfried W. Paul, C.P.O.

INTERBOR, the international Association of Orthotic and Prosthetic National Associations, held its Fifth Congress in Paris during the period April 26-28, 1972. The meeting was sponsored by the French Association.

The American Orthotic and Prosthetic Association joined the international organization in 1970 on the recommendation of its Board of Directors which was unanimously approved by the voting members at their Annual Meeting in Portland, Oregon. In the two years of its membership, the American Association has been represented by its Presidents and the writer. President Roy Snelson attended the Fourth Congress in Bonn, and President Mary S. Dorsch the one this year. Additionally, Mrs. Siegfried Paul, Vice President of the AOPA Women's Auxiliary, participated in the Paris meeting.

The organization of the Fifth Congress was managed by a Committee composed of Mr. Gilbert Pierron, Chairman; Mr. Marcel Oblet, President of the French Association; and Mr. Robert Neut, Congress Treasurer. The meeting, for which more than 600 persons registered, was held at the International Congress Center of Paris. Forty-three lecturers, representing Austria, Belgium, Denmark, England, France, Germany, Holland, Italy, Japan, Russia (USSR), Spain, Switzerland, Tunisia, and the United States of America, participated in the technical program. The lecture program was organized into related subject groupings followed by active question and answer periods, and simultaneous translation of the whole program into English, French, German, and Italian was provided. Thirty-one supplier companies from five countries including the United States presented outstanding exhibits of their products.

Among the papers that were presented those of particular interest dealt with Evaluation Tests for Upper Extremity Prostheses; CO-2 Powered Prosthesis for the Upper Extremity; The 4-P Waseda Hand;

A. Prosthesis with Myoelectric Control; The New Austrian Myoelectric Prosthesis; The Practicality of Externally Powered Above-Knee Prostheses; Orthotics and Prosthetics in Africa; Wheelchair Modifications for the Paraplegic; Orthotic Treatment of Spinal Fractures; Bracing in Myelomeningocele; Prosthetics and Orthotics in the USSR and Related Scientific Research; New Aspects on the Meccano Genesis of Scoliosis; and New Means of Ambulatory Traction in the Treatment of Scoliosis.

A number of field trips were included in the Congress program. Among the most interesting was a visit to the Centre de Reeducation et d'Appareillage. Located in the environs of Paris, the extremely modern facility is government financed and offers an interesting rehabilitation concept. Newly amputated patients referred to the facility are provided with temporary prostheses fabricated on the premises by unskilled personnel under the supervision of physical therapists. The permanent prostheses are assembled in much the same fashion, although great emphasis is put on the fact that a "private" facility will finish the prosthesis.

A full social program included a cocktail reception sponsored by the French Association, a boat ride on the Seine River with dinner served aboard, and the concluding banquet being held atop the Eiffel Tower. Among the activities provided for the ladies at the Congress were a bus sightseeing tour, a shopping trip to a Parisian department store, a visit to a porcelain manufacturing plant, a fashion show, and a tour of Versailles Palace.

Mrs. Mary Dorsch, President, The American Orthotic and Prosthetic Association, addressed the meeting. In announcing that the Association's quarterly journal, *Orthotics and Prosthetics,* is an affiliated publication of INTERBOR, she also advised that it had combined with *Artificial Limbs,* the publication of the Committee on Prosthetic Research and Development, National Research Council. Mrs. Dorsch extended the invitation to the member associations of INTERBOR to utilize the journal by providing manuscripts for publication as an effective way to increase communication among the member organizations.

Mrs. Dorsch pointed out that her participation in the Fifth INTERBOR Congress had emphasized that its members in Europe had the same problems and goals as the members of the United States association. She stressed the need for improved communication and unification of efforts to expand the educational opportunities for practitioners and to increase their professional stature in order to continually improve orthotic-prosthetic patient management.

At the conclusion of her remarks, President Dorsch extended an invitation to the representatives of the European members of INTERBOR to attend the American Orthotic and Prosthetic Association 1972 National Assembly and for INTERBOR to send an official representative to the convention. Mrs. Dorsch also invited INTERBOR to hold its Sixth Congress in the United States in 1976.

Cordo: A New Material in Prosthetics and Orthotics

Robert O. Nitschke, C.P.[1], Robert N. Brown, C.P.[1]
Gerald A. Tindall, C.P.[1]

Owing to inevitable changes that take place in the volume and shape of the stump, it is often more difficult to maintain a proper fit, than it is to achieve a proper fit initially. There is no instrument that tells a prosthetist exactly where and to what extent adjustments are necessary. However, it is well known today that pressure is not always the main source of discomfort, but that force and space can create more difficult problems. Many materials have been tried through the years and a number are being used in the fabrication of more acceptable sockets for lower-limb amputees.

It is our opinion that the "hard socket" for the below-knee amputee is most difficult to fit and adjust, and therefore is the least comfortable for many amputees, especially the older ones. A BK socket with a flexible liner has many advantages over the "hard socket." An insert can be considered to be a sort of "check socket" for locating trouble spots quickly and accurately. When the condition of the stump dictates, extra padding can be incorporated in any given area. In the case of the bulbous stump, the fleshy tissue may be "massaged" into the insert and then lowered into the socket for better displacement of the tissue. Most amputees in the United States are fitted by private prosthetists rather than in institutions, and therefore necessary adjustments very often require a long trip and loss of income for the amputee. We feel these are a few reasons a BK

[1] Rochester Orthopaedic Laboratories, Inc., 1654 Monroe Avenue, Rochester, New York 14618.

socket with flexible insert is a better means of achieving patient comfort and maintaining it over a longer period of time. The only major disadvantage of the liner as described originally for the patellar-tendon-bearing socket (3) seems to have been its deterioration in the presence of perspiration.

Since June 1970, we have been fitting BK amputees, except in a very few instances, with inserts made with "Cordo," a polyvinyl chloride compound (1) (2). During these years we have changed the technique and mixture and now are able to fabricate inserts to any thickness and density, and in some cases with pockets filled with either a gel or air. A Cordo insert does not absorb perspiration, and it is completely washable. We feel that inserts made from "Cordo" are also especially suitable for flexible liners of above-knee suction sockets, and for special prostheses and orthoses.

MIXING PROCEDURE

The Cordo solution we have found to be best suitable is a mixture of 65 percent Cordobond P-315-B2 and 35 percent Cordobond thinner P-371.[2]

The Cordobond and Cordobond thinner are placed in a covered container and heated to 180 degrees F. in an air-oven. Both materials are flammable and good ventilation is a necessary safeguard. When the solution has cooled Paraplex, 4 percent by weight, and the desired color are added.

[2] Products of the Ferro Corporation Composites Division, 34 Smith Street, Norwalk, Conn. 06851. These materials can be purchased in 5 gallon containers.

FABRICATION OF A FLEXIBLE LINER FOR A PTS SOCKET

The positive cast should be modified carefully to provide a very smooth surface. The cast is dipped into Cordo and allowed to dry fifteen minutes at 120 degrees F. in an air circulating oven. This first layer of Cordo acts as a sealer. A casting balloon is then applied over the cast to provide a smooth liner on the inside. Four coats of Cordo are then applied by dipping and allowing ten to fifteen minutes to dry between each dip. If the cast is rotated in front of a small fan after each dip, runners will be avoided. When the last layer of Cordo is dry, two layers of tube gauze are pulled over the mold loosely, each layer being saturated with Cordo and placed in the oven for 15 minutes. For extra protection of the anterior distal portion of the tibia, a ⅛-in. to ¼-in. thick piece of Plastazote is shaped and cemented on the insert. The edges are sanded to the contours of the cast. Additional Plastazote padding can be installed over any other sensitive, prominent areas.

For suspension, a Plastazote wedge is installed over the area of the medial femoral condyle. For the average insert, four additional layers of gauze are saturated and then allowed to dry over night. The insert is then taken off the cast and allowed to dry for two days. When dry, the insert is replaced on the cast, and the areas of the patellar-tendon and the popliteal are heated with a heat gun to mold them against the cast in order to avoid any bridging. No special procedure is used for lamination of the socket.

ADJUSTMENT

In our experience, adjustments to the Cordo insert can be made easier than with any other types of insert. Complete or partial liners may be added by applying tube gauze on the outside, and saturating with Cordo. In cases of drastic changes of the stump, other materials may be incorporated into the insert and covered again with Cordo. When a stump becomes enlarged, the insert can be stretched by heating with a heat gun, and pulled over the stump, or the change can be made by sanding the insert on the outside.

THE SYME'S SOCKET

Cordo inserts have proven to be very successful for the Syme's amputation. Because openings in the socket walls are not necessary when a Cordo liner is used, the socket can be made much lighter, yet stronger. The same procedure is used to fabricate the Syme's insert as for the BK prosthesis, except for configuration of the Plastazote build-up. The thickness of the Plastazote build-up is determined by the difference of the measurement of the bulbous distal end and the smallest circumference above it. The Plastazote may be thicker in places according to the contours of the stump. The measurement around the smallest area of the stump, after the build-up, should be ¼ in. less than that of the distal end to aid in suspension. After the build-up, the insert is finished in the standard manner and then laminated. To insure that there will be no damage to the insert, the cast must be broken out carefully.

At the fitting, the insert is pulled as far onto the stump as possible, and from the point the bulbous end has reached in the insert, it is slit distally as far as necessary to allow the stump to slide into position (Fig. 1). The patient then eases the insert into the socket. The ¼-in. difference in circumferences has proven to be such an effective means of suspension that it has sometimes been necessary to drill a small hole in the distal end of the socket to release the vacuum and allow removal of the limb.

The patient with Syme's amputation shown in Fig. 1 had an unusual amount of shrinkage because of loss of weight and the insert had to be built up three times with layers of tube gauze and Cordo. Although this finally pulled the material along the posterior slit apart, the amputee felt no discomfort.

ABOVE-KNEE ORTHOSIS

An above-knee orthosis with Cordo insert (Figs. 2 & 3) was developed to deal with three basic problems experienced by a polio patient who had very limited function of her right lower limb. The first problem was the inability to change shoes because of a two-inch shortage of the limb. A special shoe had been fabricated and fixed permanently to her orthosis. By casting the extremity in the degree of plantar flexion that allows the patient's toes to enter the shoe, but keeps the heel out of the shoe, it was possible to compensate for the length discrepancy. After the first lamination was made, the heel was built up to maintain the proper alignment under weight-bearing. Change of shoes was then practical, limited only by restrictions to heel height.

The second problem was pronounced unilateral muscle atrophy making the extremity unsightly. Better cosmesis was obtained by using a Cordo-Plastazote insert. The insert was fabricated so as to copy

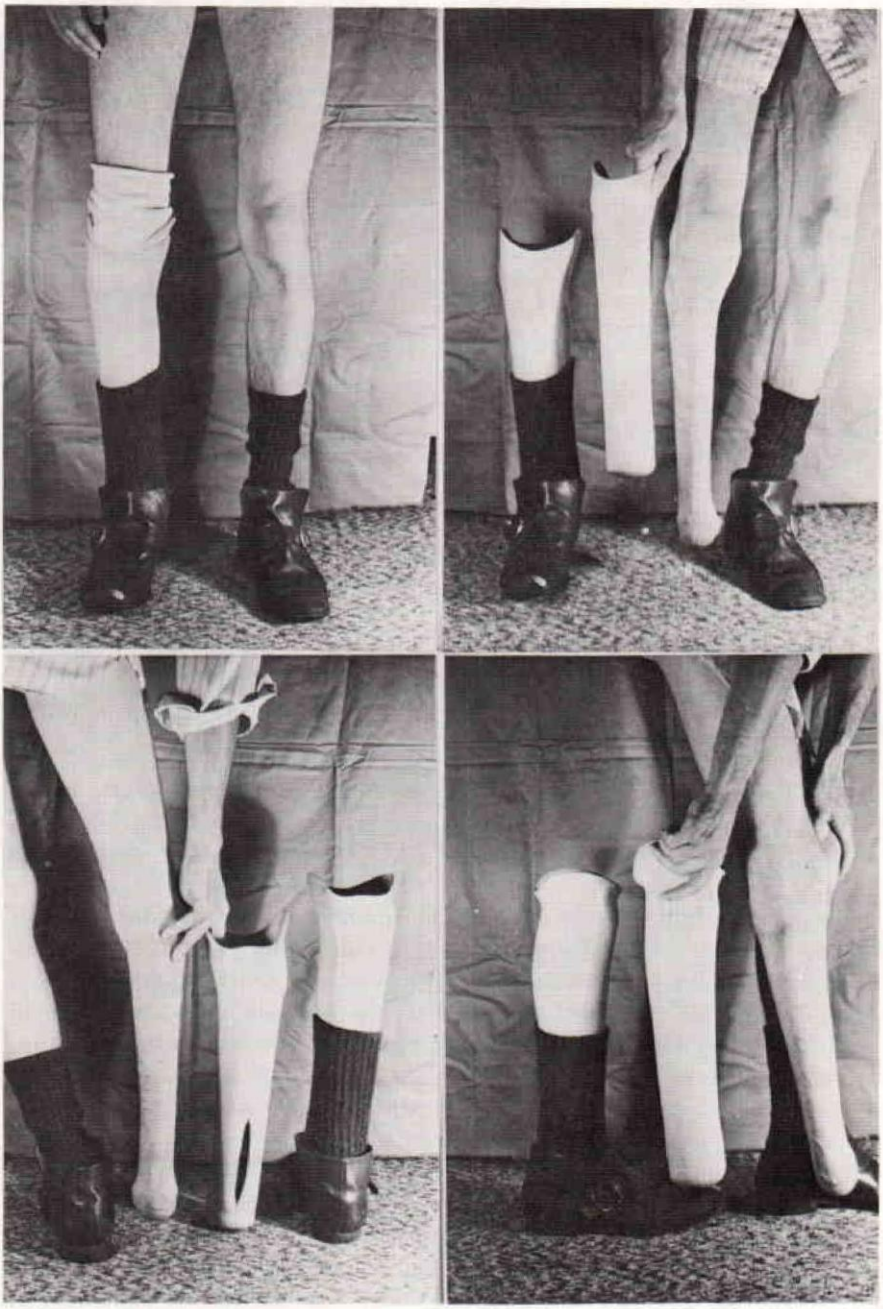

Fig. 1
Syme prosthesis using a Cordo insert.

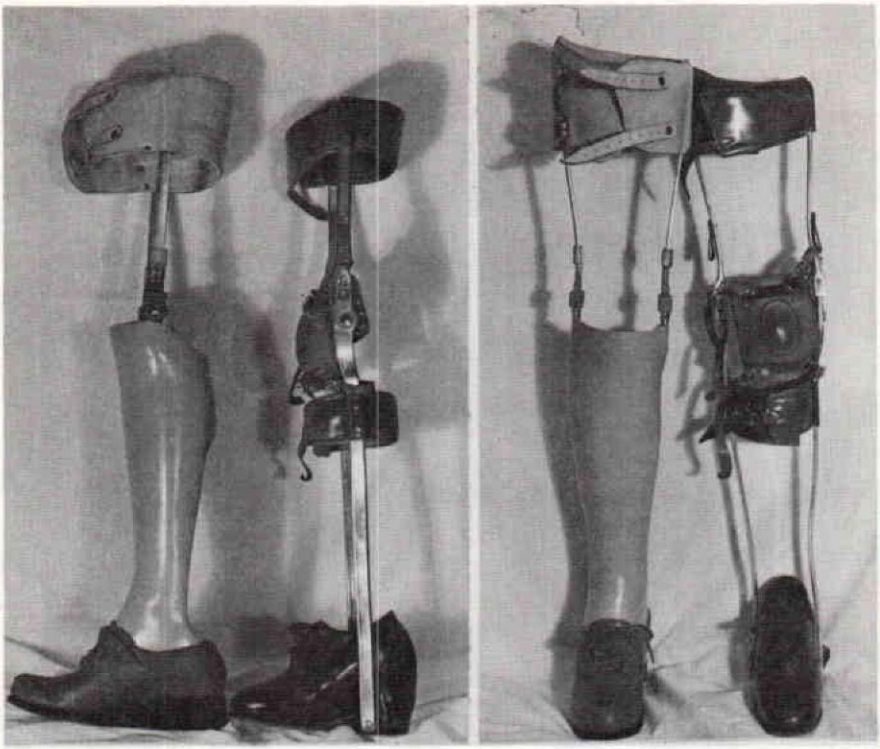

Fig. 2

Two views showing contrasts between the old and new orthoses for a polio patient with shortened leg.

the shape of the sound leg while at the same time maintaining a total-contact relationship between the extremity and orthosis.

This total-contact relationship brings us to the third problem, stability. The patient complained of a tendency to slide forward in the shoe, due mainly to the plantar flexion angle which was needed to compensate for the shortness and to obtain as much cosmesis as possible. Total contact provides stabilization of the extremity within the orthosis.

The insert fabrication was much the same as that for the Syme's prosthesis, taking care to copy the shape of the sound limb with the Plastazote buildups. An anterior slit was used in the insert, and a posterior opening in the laminated shell allowed the foot to pass into the socket.

After wearing the orthosis for several weeks, the patient complained of excessive perspiration, a condition which was to be expected. The front portion of the Cordo insert was eliminated and the patient became much more comfortable.

ABOVE-KNEE SOCKETS

Cordo inserts have proven to be very useful for many above-knee amputees as well. We have fabricated flexible liners for patients with very bony stumps, and added padding where very little natural pad-

ding is present in such areas as the lateral distal femur and the ischial tuberosity. This not only greatly increases patient comfort, but adjustment can very easily be made between the liner and socket.

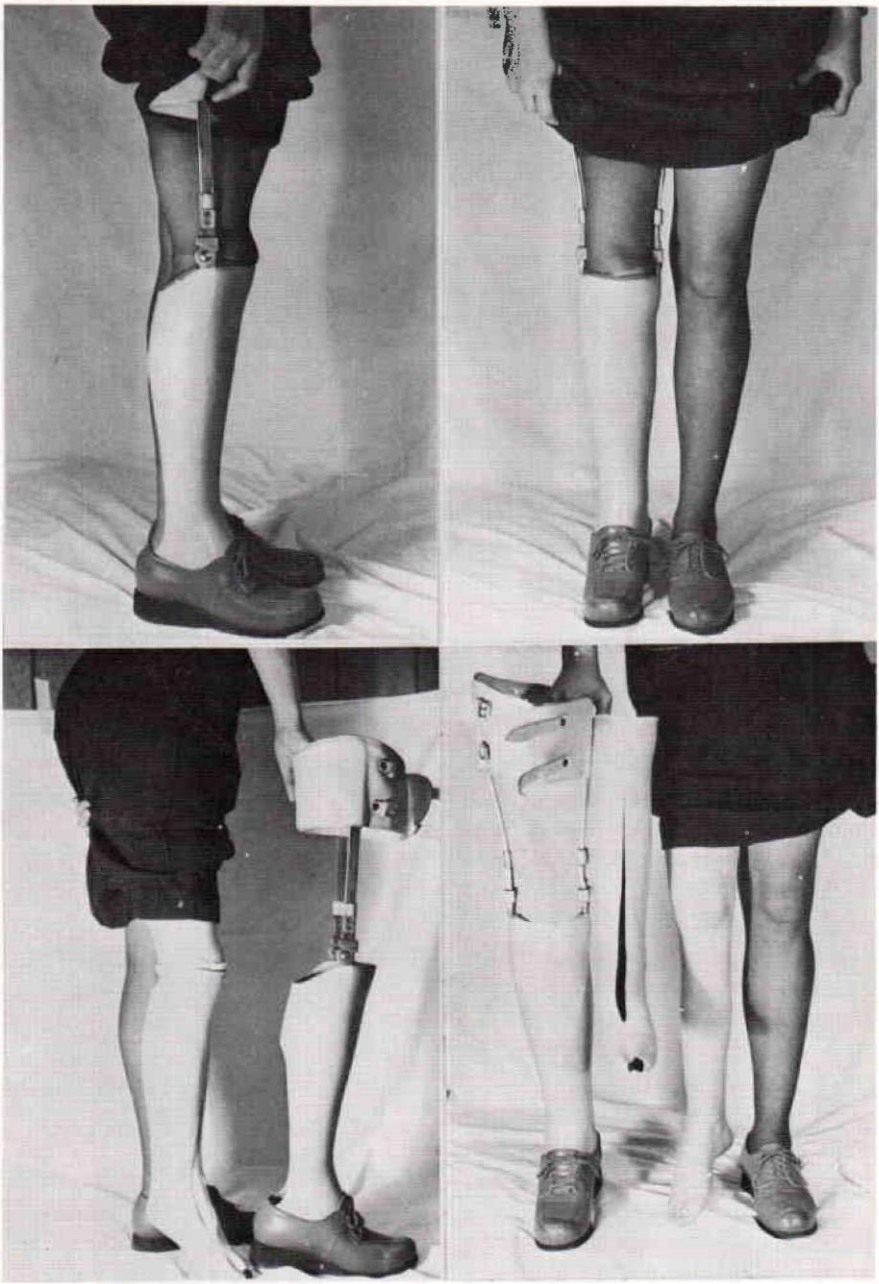

Fig. 3
Four views of an orthosis for a polio patient with leg-length discrepancy.

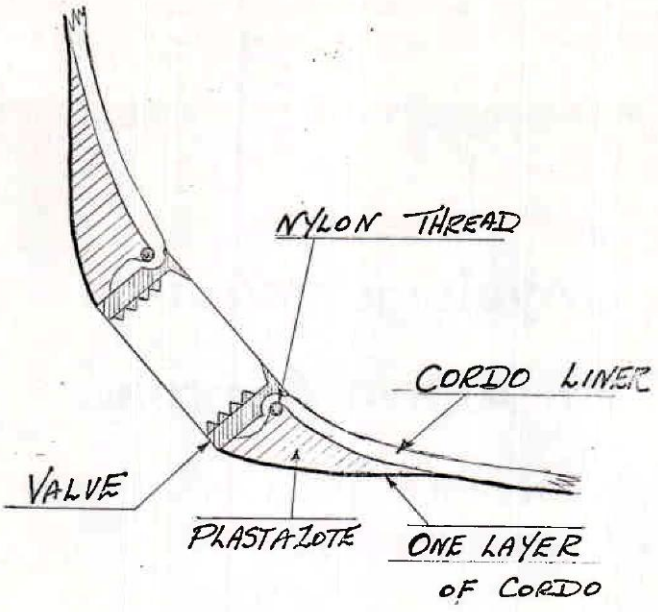

Fig. 4

Schematic view showing installation of a suction socket valve when a Cordo liner is used.

In cases where suction sockets are required, Cordo inserts are very useful. The largest obstacle is maintenance of the valve within the flexible insert. We found that when the valve is inserted into a hole ½ in. in diameter after the area around the hole has been heated, the flared portion of the insert can be tied off with a nylon cord in the valve's groove to make a permanent seal between the two (Fig. 4). The nylon cord is saturated later with Cordo to eliminate the possibility of slippage. The areas around the valve may then be built-up with Plastazote and blended into the contours of the stump. When desirable the last layer of Cordo may be left off until after the Plastazote has been added, and used to finish off the liner (Fig. 4).

IN CONCLUSION

It does not suffice to say Cordo has its place in prosthetics and orthotics. Cordo is a material with sufficient versatility to provide an answer to a problem that has long been the greatest complaint by the advocates of hard sockets, hygiene. It is not our contention that Cordo is the ultimate answer, but it most definitely provides an improvement.

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Myelomeningocele: An Active Approach[1]

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Children born with myelomeningocele present possibly the most rapidly increasing population needing orthoses. This rapid increase is attributed to improved life-saving methods introduced by neurosurgeons and urologists. At the same time there is an increased interest in maintenance and restoration of musculoskeletal function by orthopaedic surgeons.

All too often, however, the external support fits poorly, and procurement procedures delay delivery and repairs. Methods for decreasing requirements for support often are not used, and the patient is therefore, committed to prolonged, unnecessary bracing. Bulky supports that are difficult to apply may be discarded by older, heavier patients, thus negating previous efforts.

Our activities have been directed to the coordination of our orthotic and orthopaedic energies in the most aggressive, yet economical, approach possible for the care of these children. As a result, many hitherto heavily braced patients are ambulating with decreased support or no support at all; other, presumably, unbraceable children are able to use external supports; the overall drain on economic and physical resources of others seems to have been reduced; and a general optimistic attitude prevails in the families of our myelomeningocele patients.

THE PROBLEM OF MYELOMENINGOCELE

Myelomeningocele (spina bifida cystica, "open spine") afflicts approximately one of each 1,000 newborn babies. Its incidence is the

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highest in rural, white families, and is as much as 15 times higher in families with another myelomeningocele child.

Nature of the Disease

The lesions are located anywhere on the spine from the head to the sacrum, but most are in the lumbar spine. Neurologic deficit may range from minimal to complete distally from the level of the lesion. It is not uncommon for significant areas of neurological "escape" to occur, i.e., a child with a lumbar lesion whose one leg is normal while the opposite is severely involved, or the child with a lumbosacral lesion where the inverters of one foot are active and the dorsiflexors and everters of the other are active. In the case of high lesions there is often preservation of reflex function distally, so that the patient may have spasticity as well as paraplegia. (Occasionally patients resist passive motion quite consistently, and we have mistakenly "underbraced" them thinking that such a function was useful.)

Early Management

Significant progress has been made in two areas of prime neurosurgical interest: closure of the defect and management of hydrocephalus. Early closure of the neural defect reduces mortality, morbidity, and cost of nursing care. Its effect on motor function is not completely known. New techniques and improved devices have decreased the hydrocephalus problem to proportions that pose no significant threat to head control or to ambulation, at least from the point of view of size.

A number of urologic problems are common to myelomeningocele patients. The threat to life of hydronephrosis and pyelonephritis has been reduced considerably by urinary diversion procedures. Incontinence becomes more of a problem with increasing age. External infection of the genitalia, cystitis, and peroneal decubiti are recurrent problems in many of these children.

Strabismus, or squint, is present to some degree in most myelomeningocele patients, though not necessarily associated with vision difficulties. Management is best handled by an opthalmologist familiar with myelomeningocele patients.

Problems of the Parents

The physical complications of the myelomeningocele patient are just part of the problems faced by these children and their families. Divorce in families with a handicapped child is not uncommon. Proper counseling about the unknown cause of the defect and its incidence, we believe, could prevent some of these divorces.

Aside from conflict between the parents, myelomeningocele can cause other anxieties in the family. Early counseling and assistance by the visiting public health nurse can minimize the impact of urinary and rectal incontinence, sores, contractures, acute complications such as shunt dysfunction and urinary tract infection, and financial drain on the family.

Problems of Finance

The financial burden of this disease is onerous. Few of our patients could manage without the assistance of the Bureau of Crippled Children

Services. Moreover, the Bureau is concerned with the general welfare of the child, often in contrast to the compartmentalized views of medical specialists.

The logistics of transportation and time probably present the most difficult paramedical problem for families of these children. There are no funds to reimburse parents for loss of income, and few, if any, monies to pay the often sizable transportation bills for the typical, rural, low-income family affected.

Role of the Pediatrician

Myelomeningocele patients have the same pediatric problems as normal children, complicated by such medical problems as seizures, mental retardation, incontinence, and constipation. A pediatrician is the logical person to supervise and coordinate management of these children, preferably through a special clinic. Since patients often live far from the clinic, routine preventative and medical emergency needs may be handled most efficiently by a well informed medical person in the patient's neighborhood.

In a specialized clinic only a small number of patients can be handled effectively in a single day by a team of experts. Because of the large numbers (15 to 25) that attend our clinic at each session, only the neurologic, orthopaedic, orthotic, and acute social or medical needs can be handled in one session, and as a rule, general pediatric care is provided by practitioners near the home. Other problems, such as routine urologic and opthalmologic problems, often are approached at another time. The extreme complexity of the problems of myelomeningocele patients demands the highest degree of cooperation and coordination of efforts of all involved in the care of these children and their families.

GENERAL ORTHOPAEDIC CARE

Fewer and fewer children born with myelomeningocele die at birth or soon thereafter. They live and develop crippling and life-threatening musculoskeletal deformities, and therefore it is obligatory to include the orthopaedic surgeon in early evaluation and the consequent programming of care.

Evaluation

Generally speaking, orthopaedic problems are the most common ones for older children, but attention to these problems must begin at birth. In our institution, the orthopaedic surgeon is consulted as soon as the new-born is admitted for primary treatment. At this time, a general assessment of deficits and potential problems is made. Most important is a prediction of potential problems and a general decision about staging of procedures. Few operative procedures can be carried out early.

Our surgical approach is based on the following major principles: 1) removal of deforming forces, 2) alignment of joints in a functional position, 3) replacement of freed tendons to a place where they are most likely to be effective, 4) provision of immediate and continuous external support as deemed necessary, and 5) reduction of the amount of external support as much as possible by "internal bracing",

e.g., tendon transfer. When all procedures cannot be performed at the same time, the following general rule of thumb has been developed for priority of procedures that are obviously needed: 1) foot reconstruction is completed by six months of age, 2) hip surgery is completed by 14 months of age, and 3) spine procedures are completed by three years of age.

Management Programming

The expense of surgery can be appreciable. We have controlled this by two means. First, as many systems as can be serviced at one time are cared for. As an example, intravenous pyelograms, hearing tests, strabismus evaluation, tonsillectomy, herniorrhaphy, and circumcision are routinely carried out during the same admission. Second, more than one surgical procedure often is performed at one time. Most important, a given joint is completely repaired at one sitting. For example, the procedures for most dislocated hips consists of an iliopsoas transplant, an open reduction of the hip with modified arthroplasty, and a derotational femoral osteotomy to correct the inevitable anteversion, all carried out together. Both sides may be corrected at the same time, and when technically possible, knee and foot procedures are combined with hip surgery. In some cases as many as 12 procedures, when as many as 16 incisions are necessary, have been performed at one sitting. Such extensive operations may last as long as four hours, but with present-day anesthesia and aseptic techniques complications have been held to a minimum.

Procedures are staged so that the elapsed time in casts is minimal. For example, a spine reconstruction, requiring 16 weeks immobilization, may be planned along with hip reconstruction, requiring 6 weeks immobilization. The hip surgery, therefore, is performed 10 weeks after the spine procedure so that all trauma procedures will mature simultaneously.

Morbidity

Morbidity from surgery is minimal in anesthetic patients. We have yet to reach a limit of "tolerable" surgery, even though we are constantly made aware of the notion that a certain amount of surgery is all that a child can tolerate.

Morbidity is minimized by three means other than the reduction in the number of operative sessions. Hospitalization time is reduced as much as possible. Isolated knee or foot procedures are done on an out-patient basis. Patients with single or multiple major-extremity procedures are kept in the hospital only two or three days until fever is subsiding and they can be cared for by a well-informed parent. Major spine reconstruction is handled during a four- or five-day hospitalization period. It is our experience that routine procedures such as bladder credeing, rectal stimulation, cleansing, and routine care of the cast can be handled by the parents as well as by nursing personnel, and at a cost considerably lower.

Orthotics

External supports are applied early in life. In addition to the usual benefits, this approach enables us

to manage any fractures that might occur without the need for hospitalization. The use of orthoses also prevents recurrence of contractures.

NEONATAL CARE

All newborn babies with myelomeningocele are seen at or near the time of admission. Often an evaluation of the functional status of pre- and post-myelomeningocele closure can be obtained.

On the basis of our experience in the examination of these babies, we are convinced that 1) accurate assessment of individual muscles is impossible, 2) little change in gross function occurs with closure, 3) orthopaedic care, which consists primarily of exercises during this period, is facilitated by closure, and 4) a reasonably accurate evaluation of functional potential, particularly in terms of procedures which will be necessary, can be made at this time.

Neonatal cast correction of foot deformities has been abandoned. The feet that need correction most usually are rigid enough to resist correction and sufficiently anesthetic to develop pressure sores as well. Early operative correction is done only when frequent postoperative followup is possible, and when parents are interested and capable of carrying out an active stretching program. Otherwise, feet are corrected surgically at a time when adequate external support can be provided by shoes and orthoses.

We feel also that there is no place for closed treatment of dislocated hips in the neonate with myelomeningocele, because this type of dislocation will recur when the hips are straightened. Furthermore, in paralyzed or partially paralyzed patients, immobilization in a nonfunctional position is often followed by irreversible contractures in that position. In addition, external rotation, abduction and flexion contractures are the most difficult hip contractures to stretch, and this is the deformity produced by a contracted iliopsoas.

INFANT CARE

Most major reconstruction, in our opinion, should be completed before the child is ready to walk. For a nearly normal child this is within the first 18 months of life. Higher paralysis and more serious central nervous-system deficits extend the time before the child will want to walk. Indeed, certain children have no potential for walking. However, we do not accept significant contractures in any but the most completely decerebrate patients. Almost all have sufficient control of the trunk to sit, and most parents want to put shoes on their children.

Standing is often a very acceptable goal for a youngster, one which is most appreciated by the patient and parents. We often set this goal for patients under one year of age who have been given braces after surgery for severe instability of the spine or for rigid dislocation of the hips, knees, or feet.

SALVAGE PROCEDURES

We have been successful in preventing severe contractures in postoperative patients who wear their braces conscientiously. When braces are not worn, or when patients have not been relieved of contractures early in life, it is occasionally necessary to resort to such salvage procedures as joint resection, massive

release of contractures, particularly about the hip, resection of bones (e.g., talectomy), or osteoclasis, ostectomy, and arthrodesis to obtain functional alignment.

Results with such procedures are generally satisfactory, and often are appreciated more than the more prophylactic procedures done at an earlier stage. Seldom, however, can the patients be made as functional by late or secondary surgery as by early or primary definitive surgery.

SUMMARY OF EXPERIENCE

From 1968 through 1971, 497 procedures were performed on 133 patients during 166 operative sessions that averaged two hours each. By region there were:

40 spine procedures, primarily spine ostectomies with resection of deformed segments.

211 hip procedures, primarily iliopsoas transfers, open reduction, and proximal femoral osteotomies for anteversion.

207 foot procedures, primarily releases of contractures, tendon transfers, and Grice procedures.

39 other procedures, including hamstring transfers, tibial osteotomies, and others.

There were three operative deaths, all in patients undergoing spine osteotomy. Excessive bleeding was the cause. There were no major wound infections, but several foot wounds were delayed in healing.

The major complications consisted of failure to achieve the goals of surgery. Most important, it was discovered that femoral anteversion was always present when hips were dislocated, and therefore, the hip had to be reduced in internal rotation. A corrective osteotomy is also essential, because external supports cannot be applied effectively unless knees and feet face forward. The osteotomy is performed at the same time as the original surgical attack, and the small proximal fragment is held in the reduced position by an indwelling Kirshner wire until time for fitting of the orthosis.

The other major complication was recurrence of contracture, especially in the foot. Unless external support is applied immediately after surgery, and parents maintain a reasonable stretching program, it is not uncommon to have nearly complete recurrence within weeks.

Secondary and tertiary procedures are always more and more difficult. Occasionally, salvage procedures such as talectomy and joint fusion were necessary as a last resort.

ORTHOTICS

The key to success of a surgical program for treatment of the myelomeningocele patient is close cooperation between the orthopaedic surgeon and the orthotist. Needless to say, a large number of trials and errors has accompanied the evolution of our external support program. Many problems remain. These include the need for smaller, lighter, interchangeable components; the need for materials which resist excreta, and wear better; the need for supports which can be lengthened and enlarged in part rather than in toto.

Three major hurdles for external support programs have been cleared, however. First, through close coop-

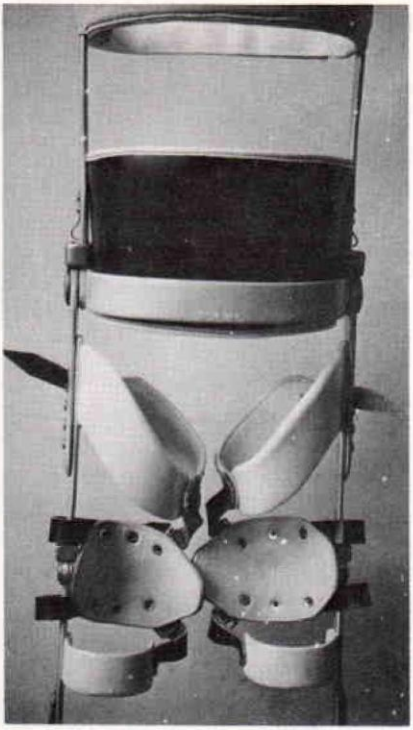


Fig. 1

Finished orthosis. A plastisol is used to cover the thigh and calf bands.

eration, prescription writing has been simplified. Special orders are given only when modifications are desired, but this is not often because our basic design incorporates smaller compact parts and because of the policy of treatment at an early age.

Some of the big changes made were in materials for covering the pads and cuffs, and in the fitting method. A nonabsorbent material that could be applied to the cuffs and pads was most difficult to find. In the pelvis and buttocks area we use Naugahyde instead of horse- or cowhide. The thigh and calf bands are covered with a plastisol and the anterior parts of the cuffs can be covered with either a plastisol or Naugahyde covered leather (Fig. 1).

Experience in fitting the orthoses prompted us to change our initial design somewhat. The original objectives were to help prevent recurrence of contractures and to control rotation. The area that had to be changed drastically was the hip-thigh complex. We were concerned primarily about anterioposterior control, and to a great extent overlooked the need for medial and/or lateral control. When iliopsoas transfers and proximal femoral osteotomies were carried out, it became apparent that a better lateral control was absolutely necessary to provide the best conditions for healing. We then redesigned the orthoses to provide a fit more snugly laterally at the hip-joint level, and more importantly, a tighter lateral fit on the shaft of the femur at the thigh-band level (Fig. 2). To provide an even,

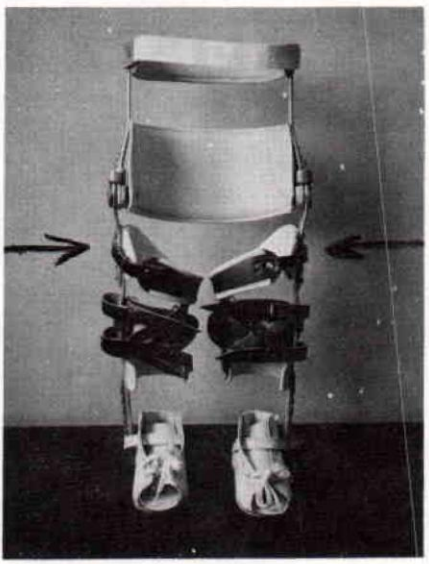


Fig. 2

View of a finished orthosis showing the snug fit along the lateral aspect of the thighs.

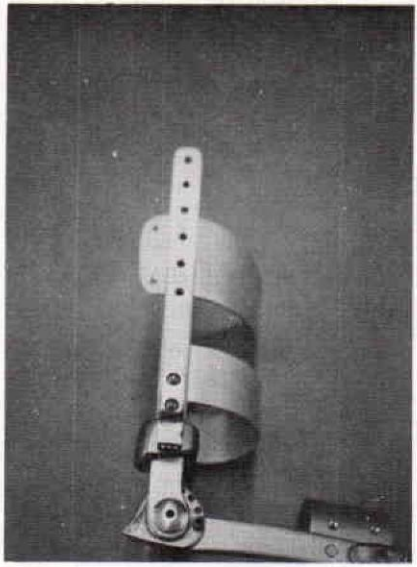


Fig. 3

View of thigh band showing the extension beyond the lateral upright to provide optimum stability.

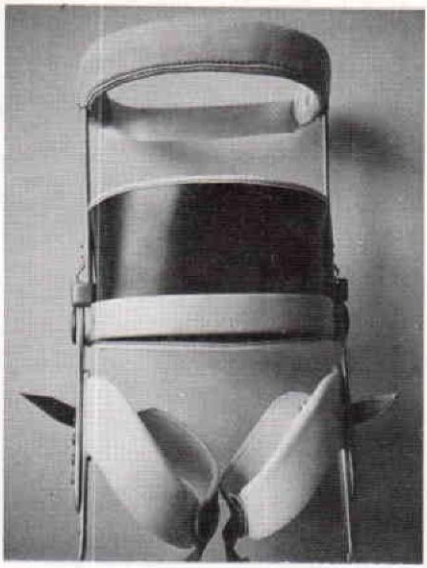


Fig. 4

Close-up view of thigh bands with lower medial sides to help with problems imposed by diapers.

firm force, the thigh band was redesigned so that it extends forward of the lateral upright by a distance equal to approximately the width of the femur (Fig. 3).

To help with the problems imposed by diapers the thigh band was designed to be much lower on the medial side than in conventional orthoses (Fig. 4).

We have found also that most orthoses for these children needed only lateral uprights for the legs (Fig. 5).

One big mistake that we made was in the method of attaching the ankle joint to the shoe. To make the orthoses easier to fabricate we used straight uprights with no joints from the calf area to the shoe. Continuous breakage and malfunction occurred. We reverted to the use of ankle joints, permitting a little anterior and/or posterior mo-

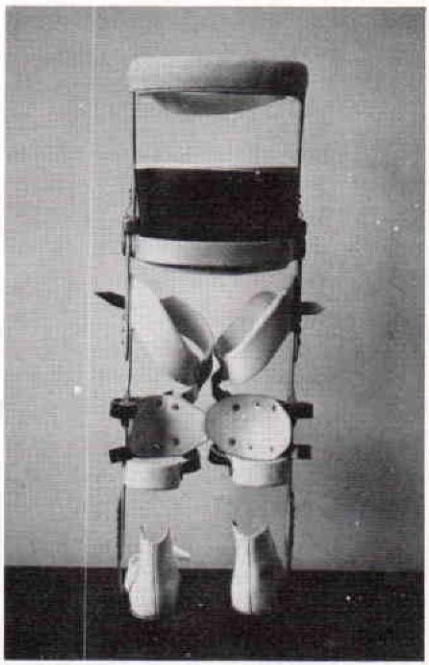


Fig. 5

Posterior view of the orthosis generally used in treatment of the child with myelomeningocele.

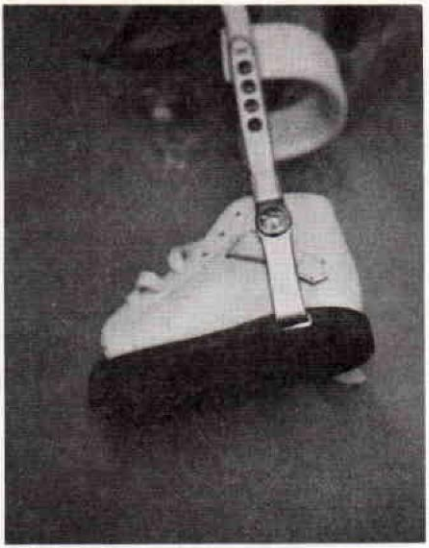


Fig. 6

Close-up view of the ankle joint and shoe attachment.

tion, and the breakage virtually ceased while function was excellent. Our big problem was finding a joint and shoe attachment small enough. These joints (Fig. 6) are now commercially available.[4]

Although many problems arise when a thoracic extension is added above the hip, the need for this is quite evident in myelomeningocele and cerebral palsy patients. When the earlier management procedures were employed, the thoracic extension required a thoracic band with chest straps, a lateral corrective strap, and a full abdominal front, in an attempt to correct lordosis and scoliosis. With the new and more advanced surgical techniques and the recognition of "surgically correcting" and "orthotically holding" the design of the thoracic extension has been simplified. We now use lateral extensions with only a thoracic band and chest strap. No pelvic or belly strap is necessary (Fig. 7). This is very handy and can be a conversion from a regular pelvic band and pad when the patient has to have an "iliostomy" or "Bricker Procedure" for kidney problems. Many times just a full chest strap of leather or cloth webbing is used with the lateral extension (Fig. 8). No band is necessary and the fitting of clothing is much easier. The important thing about the thoracic extension is the additional lever arm provided above the hip joint to approximate the lever arm below the hip joint.

The aluminum alloy parts that are commercially available result in a very light orthosis. Research is

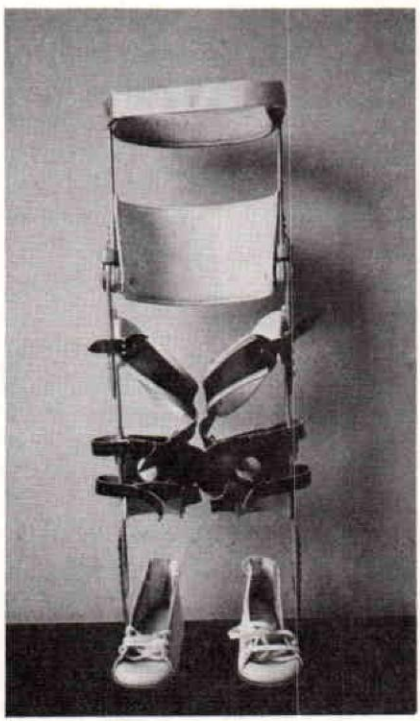


Fig. 7

Anterior view of the orthosis generally used in treatment of the child with myelomeningocele.

[4] Finnieston Laboratories, 1901 N.W. 17th Avenue, Miami, Florida 33125.

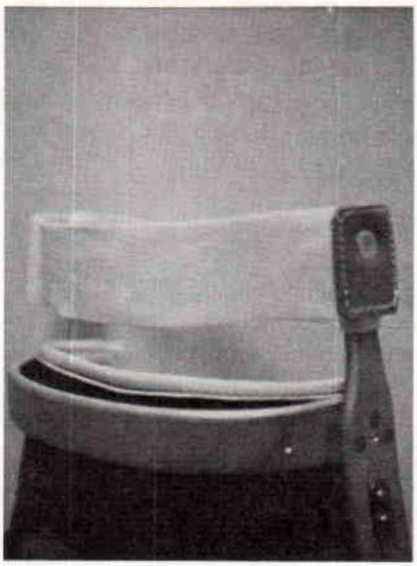


Fig. 8

Close-up view of lateral extension and simple chest strap of cotton webbing.

being carried out using plastics that we hope will help in further weight reduction.

Second, time between surgery and application of orthoses has been reduced. Patients are routinely measured just prior to surgery or during a postoperative cast change. Orthoses are then made available when the casts are removed. Unless the transition from casts to braces is immediate, the incidence of fractures and loss of correction rises at an alarming rate. This has been possible because we have utilized the New York University lower-extremity measurement and layout technique and when this procedure is followed no or very little adjustments are required.

And, finally, through the close cooperation of third party payers, especially the Bureau of Crippled Children Services, and the orthotists, supports are available exactly when they are needed. A system has been developed for fitting in the offices of the surgeons so that adjustments can be made at the time of primary fitting.

Overall Concept

Our general philosophy of bracing is as follows:

Early bracing enables children to stand and encourages attempts at ambulation. Early bracing also helps prevent fractures. Those uncomplicated fractures which do occur are treated on an outpatient basis. This results in significant savings of time and money. The major disadvantage to early bracing is the need for frequent revisions of the support system. This is overcome, at least in part, by inspection at least every three months. If revisions are needed, they are made the same day.

Orthoses are applied only to support weak parts or to maintain alignment. Treatment of contractures is, in our view, a surgical problem. It is our aim to have every support system applied by one person without any force. A minimum of corrective straps should be employed in order to minimize the complexity of the support system and thus encourage its use.

Bracing to permit standing is a legitimate goal. We believe that it enhances body tone and stimulates interest in the child's environment. Parents become more enthusiastic, and more activity occurs in the physical therapy area at home. Patients who have severely compromised trunk or head control cannot be braced effectively, and we delay application of external support in-

definitely unless it is required to supplement release of unmanageable contractures.

Every attempt should be made to remove external supports as soon as practical. Hip reconstruction has freed at least five patients from control braces. A few others have been able to abandon "long-leg" braces after hamstring transfers. Continuous efforts are being made to devise means to eliminate the need for external supports. The extreme value of rendering patients free of braces is two-fold. First, costs of care are reduced. Second, brace wearing becomes more and more difficult as children grow larger and/or become required to apply them without assistance. Few adults continue to wear control braces for these reasons.

ILLUSTRATIVE CASE REPORTS

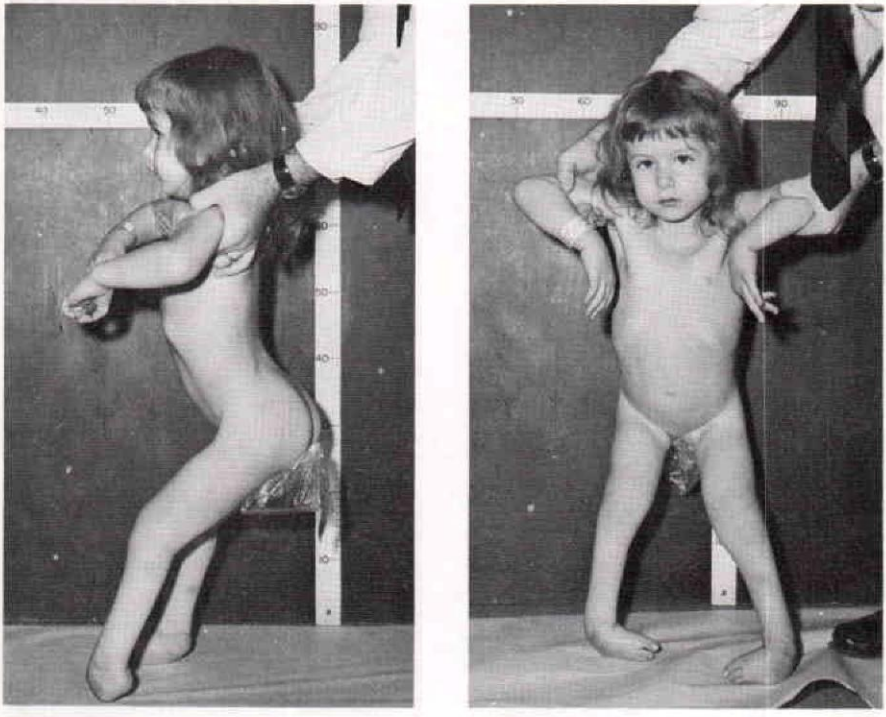
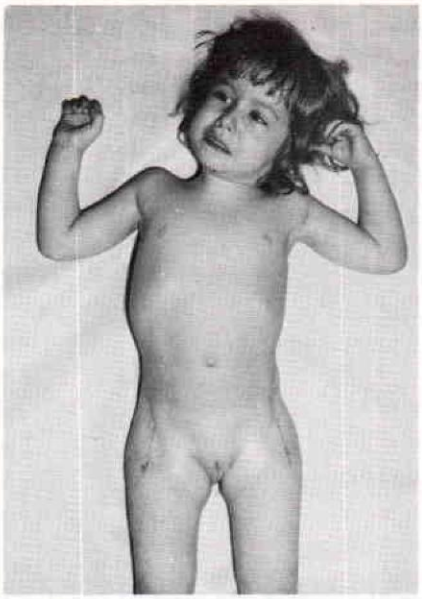


Fig. 9
Lateral and anterior views of Case 1.

Case 1: R.S., a six-year-old girl, was first seen at the age of three, at which time she had dislocated, contracted hips and feet (Fig. 9). She had been under nonoperative treatment for her entire three years



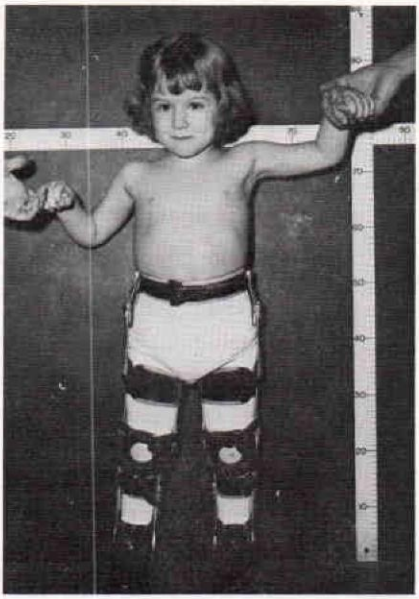


Fig. 10
Two views of Case 1 after treatment.

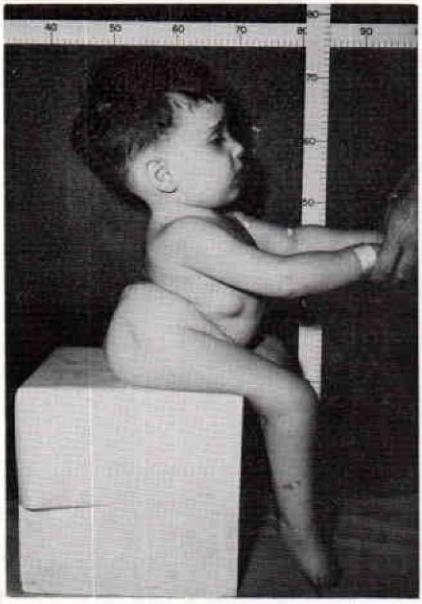


Fig. 11
Lateral view of Case 2.

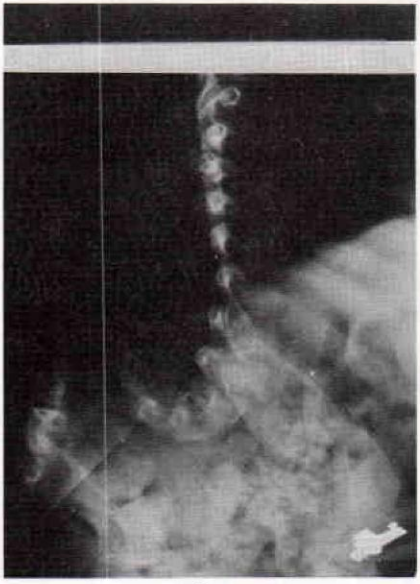


Fig. 12
X-ray of spine of Case 2 before operation.

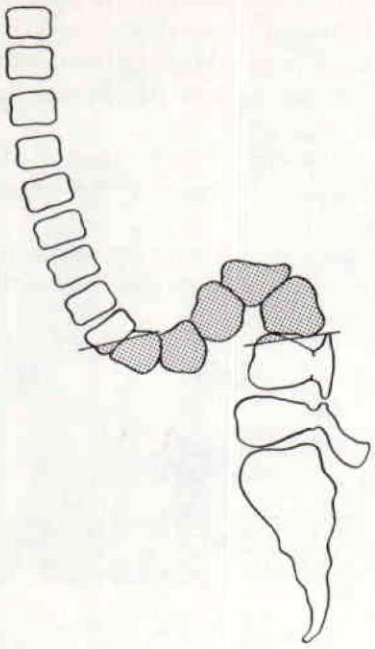


Fig. 13
Schematic view of spine resection carried out on Case 2.

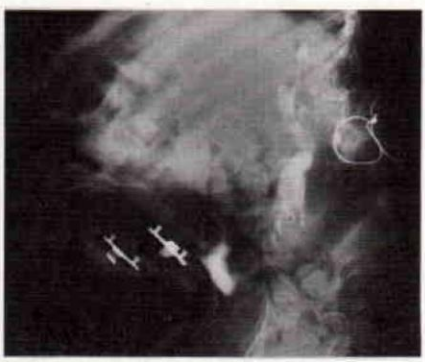


Fig. 14
X-ray of Case 2 after spine resection and fusion.

of life, with approximately 150 days having been spent in the hospital. The problem was unchanged by this therapy.

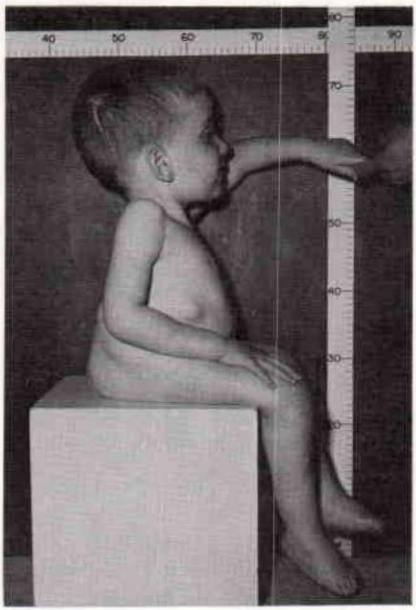


Fig. 15
Lateral view of Case 2 after treatment.

Bilateral iliopsoas transfers, acetabuloplasty, open reduction of hips, and femoral osteotomy were combined with bilateral foot releases. Control braces were applied one month later and ambulation began immediately (Fig. 10). After one year, braces were eliminated and the child now walks with crutches. Small knee-flexion contractures are present, but acceptable.

Case 2: T.K., a seven-year-old boy was seen at the age of four because he was unable to wear control braces. He had a large kyphosis over which the skin became ulcerated (Figs. 11 and 12). He could not lie on his back and ambulation, though desired, was not possible. An additional problem was impingement of his iliostomy bag on his thigh when he sat. The bag often

fell off. Spine resection (Fig. 13) and fusion resulted in a stable spine (Fig. 14) and the patient has been ambulatory with crutches and braces since five months after the operation. The problem concerning the iliostomy bag was solved also (Fig. 15).

SUMMARY

A team of interested specialists can provide effective care for patients with multiple birth defects.

An active surgical approach to orthopaedic problems can reduce cost and increase the average functional level.

Essential to the approach is close cooperation between the surgeon and orthotist.

New means must be sought continually to reduce costs and further increase function.

Advanced Designs of Plastic Lower-Limb Orthoses[1]

Jerry Casson, C.P.[2]

During the past several years, more and more effort has been placed on development of more advanced orthoses for the lower limbs. Many of the new ideas have been tried and put into use at the Spain Rehabilitation Center in Birmingham since the first of July 1971. Most of the patients fitted here have been paraplegics.

The patients were fitted first with a posterior-type plastic custom-molded orthosis of the type used by various universities and research centers around the country. The ankle is held in place by means of a plastic custom arch support molded as part of the orthosis. The proximal portion of the orthosis is trimmed to a point ¾ in. below the head of

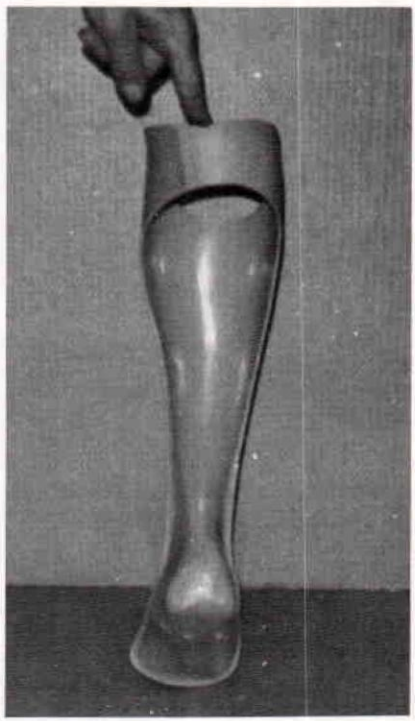


Fig. 1
Anterior view of the posterior-type plastic orthosis.

[1] This program was supported by the Research and Training Grant RT 19 from Social and Rehabilitation Services, Department of Health, Education, and Welfare.

[2] The University of Alabama at Birmingham, Spain Rehabilitation Center.

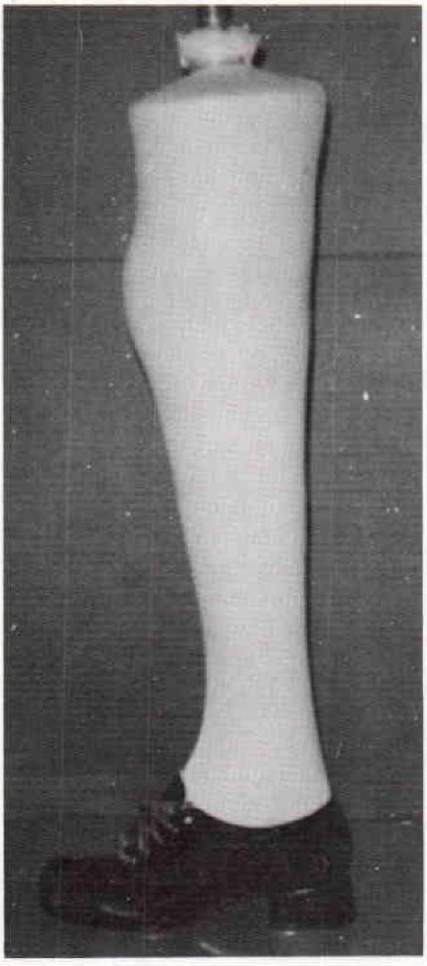


Fig. 2

Plaster cast set up in shoe to check alignment.

the fibula, as in the more conventional BK orthoses. To permit donning of the orthosis, the posterior wall is trimmed to a point about 1 in. below the lower anterior trim of the calf band (Fig. 1). The position of the ankle depends on the height of the shoe heel the patient is to wear.

While the cast is being taken the patient's knee is held in about 5-10 degrees of flexion, and the ankle is held in the corrected position until the plaster sets. Also, the foot is held in plantar flexion in order to provide normal alignment when the patient is standing with the shoe on (Fig. 2).

This orthosis is quite satisfactory for the paralyzed patient with "drop foot". In some cases, a strap is added to the ankle to prevent the foot from slipping forward in the shoe, and also to prevent valgus and varus (Fig. 3).

The orthosis seems to provide good ankle support and lateral stability during walking. The angle of the ankle in the shoe at heel strike showed that the patient's knee was forced into flexion. This action brought the foot flat on the floor, allowing normal action throughout the gait cycle.

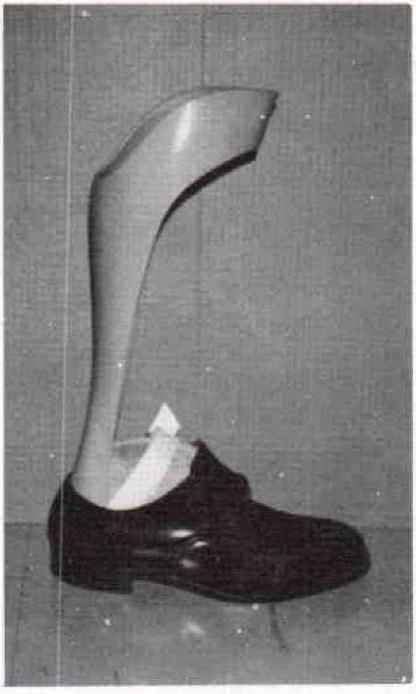


Fig. 3

Orthosis with strap added at the ankle to prevent the foot from slipping forward in the shoe.

Fig. 4
Side view of the anterior leaf-type of plastic orthosis.

THE ANTERIOR-LEAF TYPE

After many patients had been fitted and evaluated with the posterior-type BK orthosis, an entirely new approach was attempted. A new design using anterior support was developed to allow plantar flexion at heel strike, dorsiflexion at heel off, and transverse rotation throughout the gait cycle. The forefoot was enclosed with a flexible tunnel for the foot to slide into (Fig. 4). This stopped the anterior slipping of the foot on the foot plate. Valgus and varus are also controlled by the custom foot plate. The design of the anterior leaf at the ankle allows plantar and dorsiflexion; however, care must be taken in modification of the cast in this area.

A buildup of approximately ¼ of an inch must be added over the crest of the tibia along its entire length. The resulting space allows the orthosis to plantar flex and dorsiflex without rubbing the tibia (Fig. 5). Relief over the superior portion of the navicular may be needed in some cases.

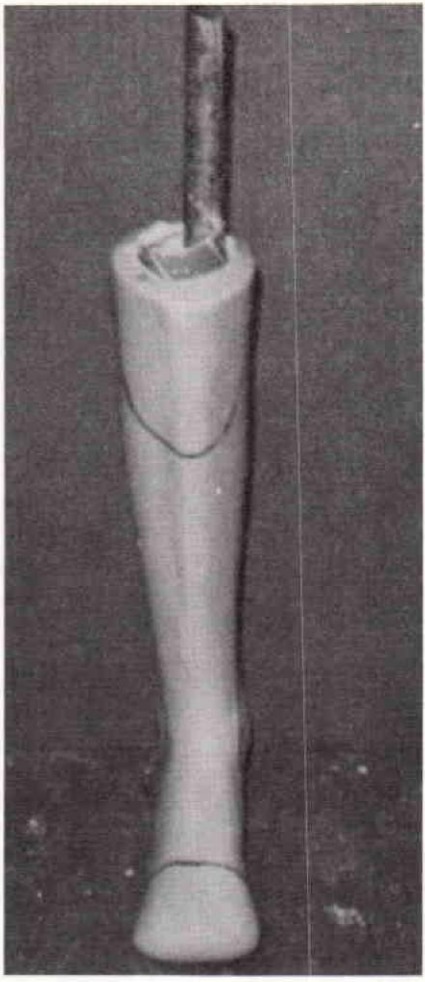


Fig. 5
Anterior view of cast for anterior-leaf orthosis showing buildup over the crest of the tibia.

FABRICATION OF THE NEW ORTHOSIS

1. Wrap and cast the patient's limb in the corrected position. Mod-

ify the cast along the tibial crest, and over the navicular, if necessary.

2. Place one layer of ½-oz. Dacron felt over the entire cast.

3. Add two layers of nylon stockinette over the Dacron.

4. Place a ½ in. by 6 in. by 1/16 in. piece of spring steel wrapped with one layer of fiberglass cloth in the curve of the ankle. It should extend proximally about 4 in. distally about 1½ in. to 2 in. (Fig. 6).

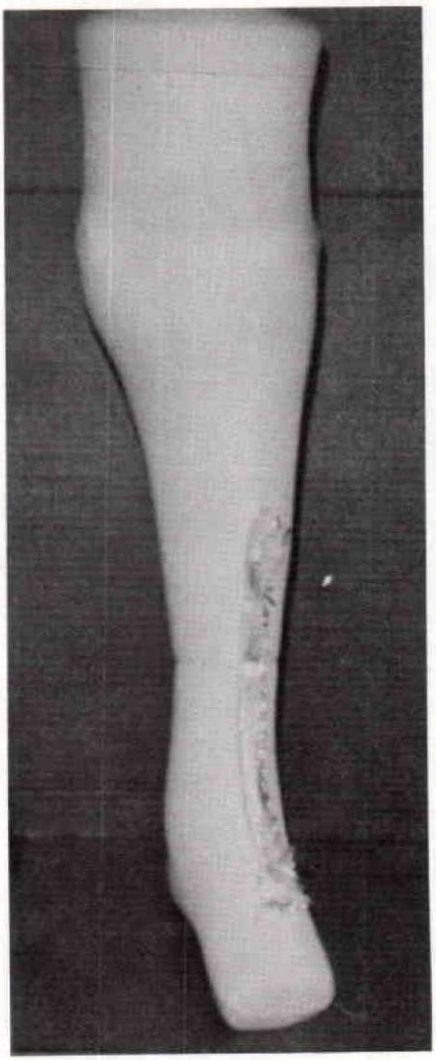


Fig. 6

Anterior view of cast for anterior-leaf orthosis showing placement of fiberglass covered spring steel leaf.

5. Two more layers of nylon stockinette are placed over the steel, starting at the ankle and reaching over the proximal portion of the cast. The foot portion should not be covered with these layers, in order to keep the foot plate as thin as possible.

6. Two more layers of nylon stockinette are placed over the entire model.

7. Add the PVA bag and laminate with a mixture of 70 per cent 4110 rigid polyester resin and 30 per cent flexible 4134 polyester resin.

8. After the lamination has cured, draw the outline of the orthosis on the model, and cut out with cast saw. Trim the edges and begin the fitting procedure with the patient.

ADVANTAGES AND DISADVANTAGES

1. The cosmesis provided by this orthosis is more acceptable to both male and female than is the more conventional types of orthoses. Shoes can be changed readily and knee socks or ladies' hose can be worn over the entire orthosis.

2. The weight of the orthosis is greatly reduced.

3. The disadvantage of the orthosis is the time and labor required for fabrication, thus increasing the cost.

ABOVE-KNEE VERSIONS

For CVA patients who require "long leg braces," we added knee

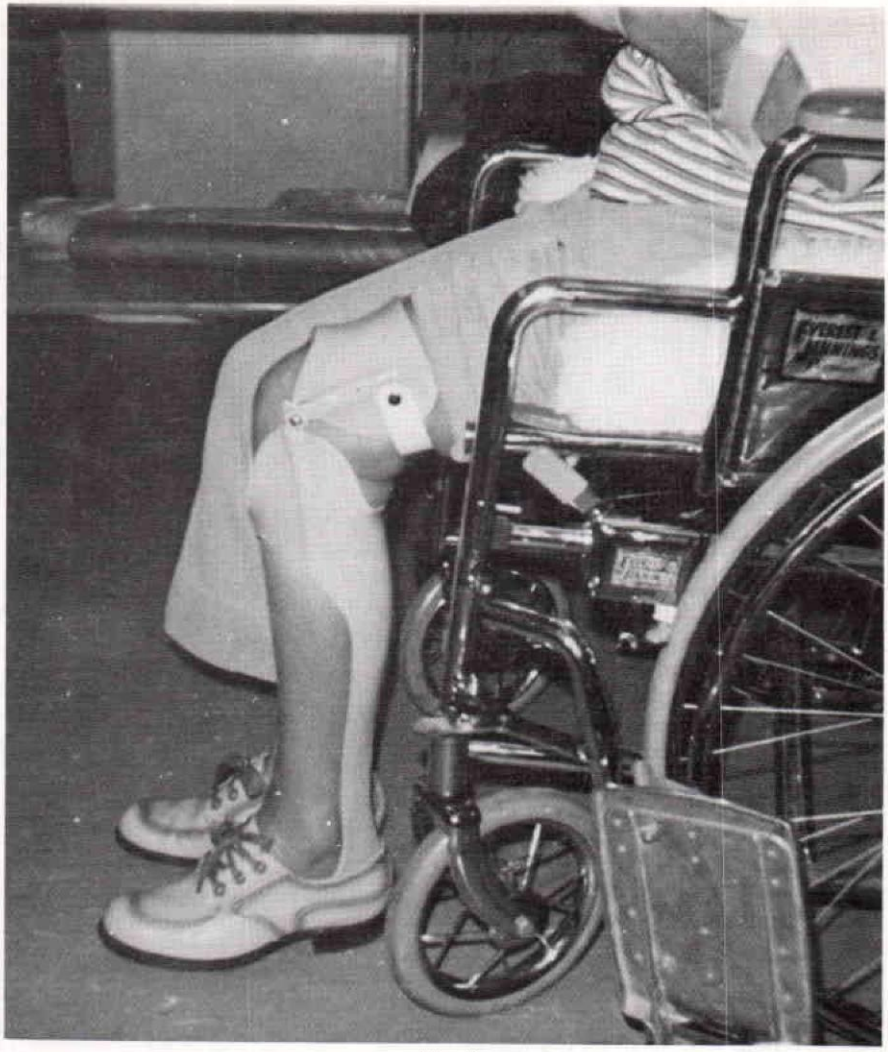


Fig. 7

Posterior-type below-knee orthosis modified to control recurvatum.

joints and anterior thigh bands to the posterior type (Fig. 7) to control drop foot and recurvatum of the knee.

Knee joints were used after trying orthoses made of one-piece lamination. The only reason for adding the knee joint was for cosmesis while the patient was sitting. After many patients were fitted with this type of orthosis, we found that the strap around the upper thigh band was not needed. A simple thigh band covering about ¾ of the circumference of the thigh just above the femoral condyles served just as efficiently (Fig. 8). Male patients wearing trousers, or females wearing hose over the orthoses automatically flex the thigh portion when sitting. This orthosis is being worn and accepted very suc-

cessfully by many patients here. The advantages and disadvantages are the same as with the below-knee orthosis.

Further development of above-knee orthoses has been undertaken for spinal-cord-injury patients. Orthoses for these patients must be strong enough to support the body and withstand the medial and lateral forces placed upon them during locomotion.

The orthoses shown in Figure 9 are for a patient with injury to the spinal cord at the T-10 level. Knee locks are used. The lower portion of the orthosis is constructed in the same manner as the posterior-type below-knee orthosis, having a custom footplate and posterior leaf. The thigh portion is made of a one-piece plastic laminate.

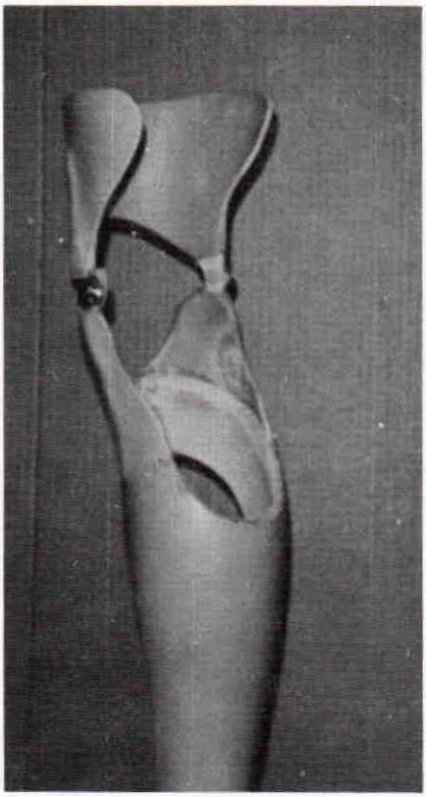


Fig. 8

Another view of the type of orthosis shown in Figure 7. Note that the posterior strap is not present in this later version.

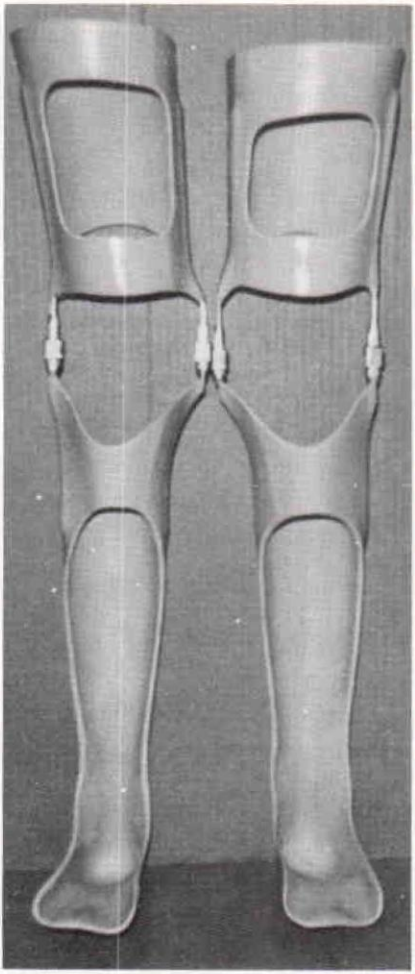


Fig. 9

Anterior view of plastic orthoses designed for a patient with an injury of the spinal cord at the T-10 level.

Donning the orthosis is made easy by cutting a window in the anterior portion of the thigh piece to form two solid bars. The top of the proximal bar is slightly lower than the top of the posterior section, and the lower posterior edge is higher

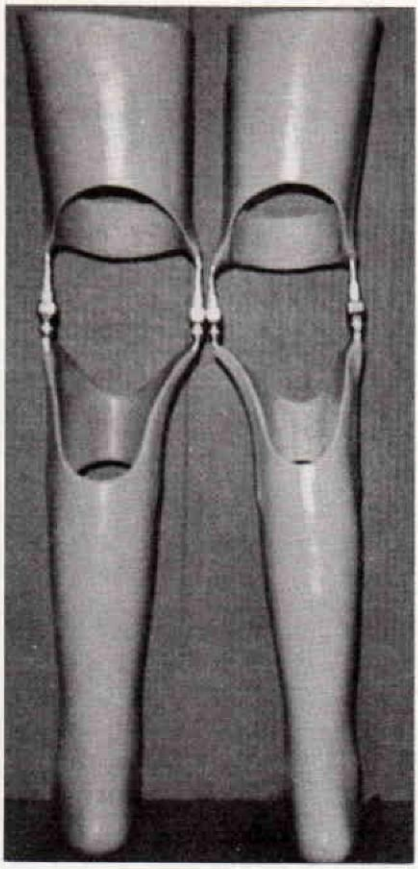


Fig. 10
Posterior view of orthoses shown in Figure 9.

than the top of the lower anterior bar (Fig. 10).

This type of orthosis is also being accepted and worn successfully at the Spain Rehabilitation Center. The advantages and disadvantages are the same as for the other plastic braces. While working with these patients, it has been demonstrated that genu valgus and genu varum can be held or corrected as in the double upright metal orthosis.

CONCLUSION

Observation of the patients wearing these new-type orthoses show that the control and action desired in most below-knee appliances can be obtained.

When fitting patients with these orthoses, care should be taken initially with the fit of the footplate. Patients with little or no sensory feedback are not aware of pinching, rubbing, or excessive pressure when such conditions occur. The patient should be allowed to walk or bear weight for only a short time before checking the area in contact with the footplate. The patients should be seen from week to week, or month to month, on an outpatient basis to check for wear and any further adjustments that might be needed.

New developments and concepts in orthotics are making it possible to reduce rehabilitation time. We are trying to add to this achievement through research and experimental procedures by developing the best orthotic prescription possible for the patient.

Clinical Evaluation of NASA Sight-Switch for Activation of Flexor-Hinge Splint

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Jack Conry, C.O.[1]
Sarah Gephardt, O.T.R.[1]

The well publicized sight-switch wheelchair control developed under the National Aeronautics and Space Administration program has been clinically evaluated at certain medical schools and rehabilitation hospitals. The conclusions drawn from these evaluations have been documented in both lay magazines and medical journals (1, 2, 3).

At the Hot Springs Rehabilitation Center (Arkansas), we adapted the sight-switch to the activation of battery-powered flexor-hinge splints (Fig. 1) to permit use of the splint for manipulation of the standard controls of a mechanized wheelchair and also to allow functional use of

Fig. 1
Sight switch attached to powered wheelchair.

[1] Hot Springs Rehabilitation Center, Hot Springs, Arkansas.

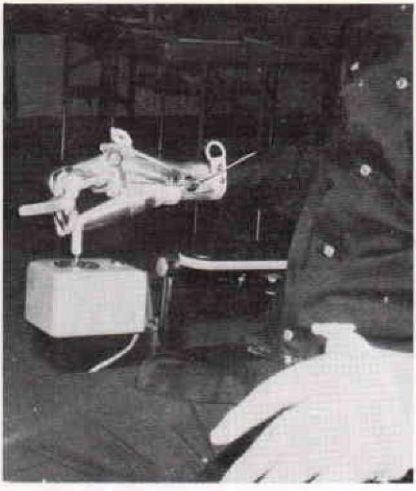

Fig. 2
Sight switch attached to Hot Springs flelexor-hinge splint.

Fig. 3
Extension stick on standard control of mechanized wheelchair.

the prehension device for hand activities once the target area was reached (Fig. 2).

The evaluation was carried out on five "high-quadriplegic" students over a period of four months and fractionated trials were made on normal individuals. The advantages and disadvantages were categorized empirically as major and minor advantages and disadvantages, and are listed below as such.

MAJOR ADVANTAGES

1. A simple extension stick on the standard control allows wheelchair operation by use of the motorized flexor-hinge splint (Fig. 3). Of course, the quadriplegic operator must have ball-bearing trough feeder or suspension-sling support of the arm (Fig. 4).

2. The externally powered flexor hinge splint can be used without the linear or curvilinear limitations imposed by the shoulder switch or the mouth switch which require the person to be sitting upright in his wheelchair. The sight switch permits trunk movement forward or laterally within the limitations of the feeder (Fig. 5).

MINOR ADVANTAGES

1. Only a relatively few hours of practice are required to attain proficiency.

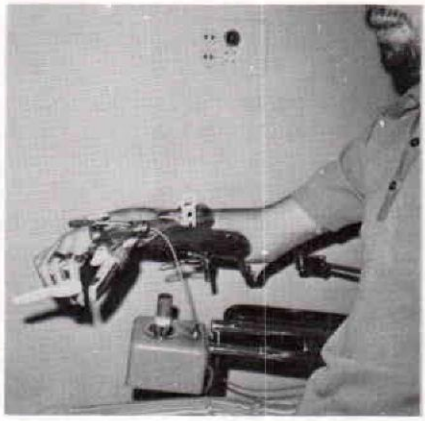

Fig. 4
Operator's arm in ball-bearing trough feeder.

Fig. 5
Operator using sight-switch to activate hand splint.

2. Acceleration and deceleration of the wheelchair do not affect the sight switch as they do the shoulder and mouth switches.

3. Rough terrain, doorjambs, and other floor obstacles which cause intermittent contact in the other switches do not affect continuation of current by the sight switch.

MAJOR DISADVANTAGES

1. The sight-switch required that the vision be turned away from the hand and object at the very instant it was most needed for effective prehension and monitored activity.

2. The equipment, particularly the control box, was a cumbersome accessory to attach to the frame of a mechanized wheelchair. Furthermore, this form of attachment made adjustment awkward.

3. The equipment needed fine and frequent adjustment in relation to posture, ambient light changes, and power fluctuations. The gain control almost required a rheostatic regulator.

4. Miscellaneous technical difficulties were encountered. The verbatim report of the orthotist, one of the authors, is as follows:

"The sight switch, Model SS40B, was received in nonoperable condition. It was carefully packed in a corrugated carton, but had not been secured internally. Both relays had come out of their sockets in transit, and banging around inside the case did considerable damage to wiring and other parts.

It was returned to Huntsville for repairs and, when it was returned, only one channel would function. Mr. Weaver from Hayes International came to the Center and worked on it. He replaced a transistor circuit board, rewired the indicator lights so they were driven directly by the transistors instead of the relays, and wired around the output jacks which were grounded to the chassis and not suitable for the application. After this, it could sometimes be made to function; however, it was very temperamental and inconsistent.

Until this time, I had maintained a hands-off attitude towards the device as far as the internal mechanism was concerned, but decided that, if it was to operate, some changes would have to be made. Following are some of the alterations:

1. Installed a four-prong output and two-prong input socket.

2. Removed 110 volt and six-volt-line cords.

3. Rewired chassis so that both

sight switch and hand-splint motor would operate from the input jack.

4. Added a variable resistor to drop twelve-volt input to six-volt required for sight switch.

5. Adjusted tension on relay return springs to operate with less current.

6. Wired indicator lights back into relay circuit as they seemed to be robbing too much current from the relay coil.

7. Went over entire unit looking for faulty solder joints and found several, especially on transistor boards.

8. The wiring harness on the glasses was too short and, although we requested longer leads or an extension, none was forthcoming.

The device now worked somewhat better but was still inconsistent and difficult to keep in adjustment. When the head was moved, light from the windows and overhead lights would fall on the photocells and require a change in the gain control. A considerable amount of fiddling was required each time to set the light so it would shine on just the right part of the eye."

MINOR DISADVANTAGES

1. Frequent changes in optic focus, secondary to activating the sight switch by looking away from the target area, caused an annoying dizziness or quasi-disorientation at times.

2. The glasses frames seemed to hinder peripheral vision moderately and, when worn for a protracted period of time, became an impediment to "unconscious awareness."

3. Evidence of irritative inflammation of ocular conjunctiva was noted, although somewhat inconsistently, after lengthy periods of sight-switch use.

4. The time and tediousness required in rigging and adjusting the equipment to the patient and the chair seemed to require more than help from the uninitiated layman. Needed were careful adjustment of the lights and sensors, insertion of several plugs, and adjustment of two gain controls.

BLACK-PATCH MODIFICATION

In an attempt to correct some of these problems, we devised the so-called black-patch modification. We moved the light source and sensor back along the temporal bone so that it shone on the skin approximately one-quarter of an inch behind the outer corner of the eye. (Fig. 6). We then stuck a small circular piece of black tape to the

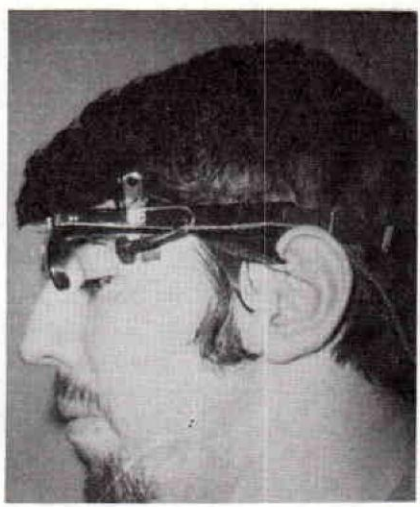

Fig. 6
"Black-Patch" modifications.

skin just beyond the lighted area. When the orbicularis oculi muscle was contracted tightly without closing the eyelids, the skin moved forward, positioning the tape in front of the light and thus triggering the switch. The steady contrast between the skin and black tape and the positioning of the light source close to the skin cut down on the effect of ambient light and made adjustment of the unit less critical. As a matter of fact, it required no changes over a three- or four-hour working period.

Another big advantage of this method was that the hand and object were visible at all times within this exaggerated squint. In addition, the demand for changes in optic refocusing were circumvented. Furthermore, we encountered less conjunctival reaction.

CONCLUSIONS

The sight switch is an intriguing idea. It has certain advantages over other switches in the realm of the *man* as compared to the realm of the *machine*. Thus, further development and emendations seem indicated.

It would appear, however, that in its present unmodified form it is not realistically applicable because:

1. It is too complicated for every-day use by laymen, i.e., donning, adjusting, and accommodating.

2. It is too cumbersome for portable application to wheelchair frame.

3. It is too prone to failure.

4. It has some inherent contrariety to optimum man-machine relationship.

We at HSRC appreciate the cooperation of Southwest Research Institute, NASA's Technical Utilization Section, and Hayes International, Incorporated, in making this evaluation possible.

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An Externally Powered Modular System for Upper-Limb Prostheses

By

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Charles H. Dankmeyer, Jr., C.P.[1]

Martin D. Massey, C.P.[2]

In the past, conventional harnessing arrangements in upper-limb prostheses have been used to provide both suspension and transmission of power to the prosthetic components. By encumbering an intact, contralateral, segment of the body, the prosthetist found a base for suspending the prosthesis and a semi-mobile anchor point for obtaining relative motion between body segments to provide cable-type functions. Obtaining function by this arrangement requires motion from either the intact side or the prosthetic side of the body, or by motion of both sides. Very little function can be provided in this manner to patients who have a high level amputation or restricted range of motion.

To improve the functional value of upper-limb prostheses, the Johns Hopkins Applied Physics Laboratory and the Johns Hopkins Medical School, working together, have developed a modular, externally powered system. A block diagram of the basic system is shown in Figure 1.

When body motion is not required to gain function, harnessing may be kept to a minimum and is needed only to provide suspension when necessary. Harnessing may be eliminated completely when the suspen-

[1] Dankmeyer Prosthetics Appliance Center, Inc., Baltimore, Md.
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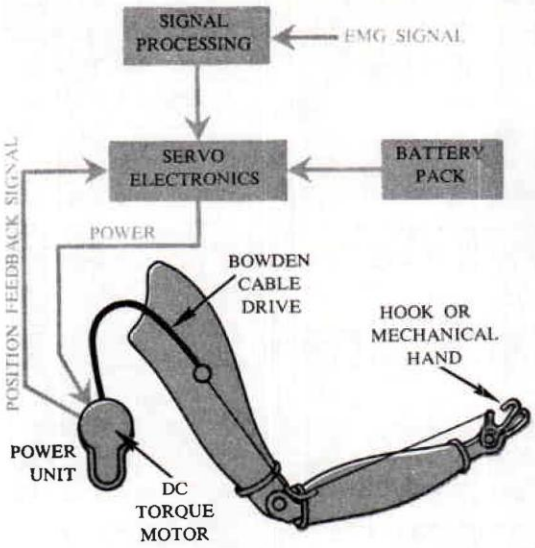

Fig. 1

Block diagram of the externally powered system for upper-limb prostheses developed at Johns Hopkins University.

sion function can be incorporated into the socket.

A special type of single-site myoelectric sensor can be used with the Johns Hopkins system. Most other myoelectric systems use two separate sensors and provide power in two directions. By using the basic design of conventional prostheses, only one sensor site is needed in the new design. The signal to open the terminal device is the only one necessary because the terminal device can be closed by elastic bands or springs in the conventional manner. And, only one signal is needed to lift the forearm, because gravity will produce extension when it is allowed to do so. The sensor and amplifier arrangement provides proportional control over all functions. The faster the amputee generates the signal, the faster the system operates. Because the amputee needs to learn to manage only one proportional control, the training time required is quite short. The system in operation is practically silent, and it is applicable to all types of upper-limb amputations.

One of the unique features of the Johns Hopkins externally powered system is that conventional prosthetic components are used. The only modification necessary is the provision of an opening in the wall of a standard socket for installation of the sensor electrode. The socket design can be modified so that suspension is the only objective that may challenge the prosthetist. The modifications for suspension have included use of single supraepicondylar cuffs with flexible hinges, figure-8 harness with triceps cuff, modified chest-strap harness, full suction

above-elbow sockets, and the Muenster designs.

Externally powered systems can provide the upper-limb amputee with a full range of motion in all planes without limiting the function of any of the other limbs. High-level amputees and those with limited range of motion may enjoy the full function of prosthetic devices through the use of external powered systems. For some patients prostheses have been made with battery, motor, or both incorporated into the hollow sections of the prostheses.

Power for the Johns Hopkins system is provided by small rechargeable electrical batteries. The actuator is a direct-current torque motor that has no clutches, brakes, or mechanical stops. A two-stage reduction gear is used, and the system is virtually silent. The motor will produce up to 30 pounds of force in the cable and will not be damaged if this force is held for several seconds. The system is activated by means of a single myoelectric signal sensor. The battery pack provides an average of eight hours use before recharging is necessary.

The modular aspect of the Johns Hopkins system provides a truly unique degree of versatility. The same power and control components can be assembled in different ways with conventional prosthesis components to create a variety of externally powered prostheses to satisfy the needs of individual patients with amputation at any level.

For example, a typical below-elbow prosthesis uses flexible hinges, triceps cuff, figure-8 harness, the se-

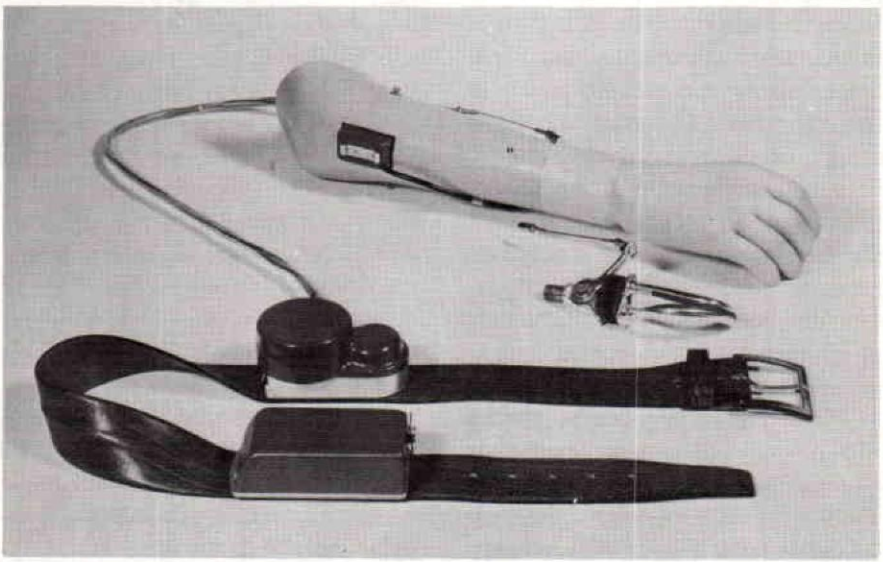

Fig. 2
Components for a below-elbow system.

lected terminal device, and is controlled by use of a Bowden cable. To convert this conventional prosthesis to an externally powered system, the cable is simply connected to the motor instead of being attached to the harness. Harnessing may then be modified to provide suspension only or it may be eliminated entirely if the Muenster type socket can be provided (Figs. 2 and 3).

The conventional above-elbow prosthesis components consists of a double-wall socket, Hosmer turntable-type locking elbow with lift assist, friction wrist, figure-8 or saddle harness, and a terminal device. Again the harness provides both suspension and a basis for function.

The typical cable system would be the fair-lead which allows the amputee to select either the elbow-forearm function or terminal-device function by locking or unlocking the elbow. To convert this system to the Johns Hopkins system, the prosthetist needs only to eliminate the control cable strap attachment. The cable then can control both the forearm position and the terminal device as the patient wishes. The cable is connected directly to the motor and all other components remain the same—one motor, elbow and terminal device powered. The same applies to the shoulder-disarticulation case. Figure 4 illustrates an attempt to provide suspension without straps.

Although the Johns Hopkins system does indeed permit conversion of a body powered prosthesis to an electrically powered prosthesis, each of the prostheses illustrated in this report was actually created as a dup-

Fig. 3
Patient wearing the system shown in Figure 2.

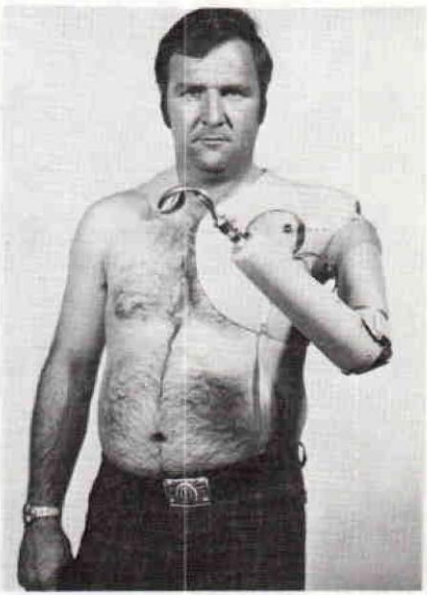

Fig. 4
The Johns Hopkins system applied experimentally to a shoulder-disarticulation patient. Note the absence of harness.

licate of the amputee's pre-existing body powered prosthesis. This was done in order to compare functions achieved with the two different power systems.

The principal research group for the Johns Hopkins system design are Gerhard Schmeisser, M.D. of the Johns Hopkins Medical School and research engineers Woodrow Seamone and C. Howard Hoshall of Johns Hopkins Applied Physics Laboratory.

The results of early clinical trials are discussed in the article that follows this one.

Early Clinical Experience With The Johns Hopkins Externally Powered Modular System For Upper-Limb Prostheses[1]

by

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Woodrow Seamone[3]

C. Howard Hoshall[4]

Eight amputees were selected to help provide data for evaluation of the Johns Hopkins system. In order to determine the range of applicability of this externally powered system, amputees who represented a broad range of upper-limb amputation levels were selected. Included in this program were one wrist-disarticulation amputee, two below-amputees, two elbow-disarticulation amputees, two above-elbow amputees, and one shoulder-disarticulation amputee. Following is a summary of the results of the evaluation program to date.

Unit #1 was fitted to a left-wrist-disarticulation amputee in February 1970. It has a laminated forearm socket suspended only by a supra-condylar strap. The motor, electronic control unit, and battery pack are worn on the waist. The EMG sensor is built into the fore-

[1] This work was made possible by fiscal support from the Prosthetic and Sensory Aids Service, U.S. Veterans Administration.

[2] Professor of Orthopaedic Surgery, The Johns Hopkins University School of Medicine.

[3] Supervisor, Missile Control Systems Group, Applied Physics Laboratory, The Johns Hopkins University.

[4] Engineer, Applied Physics Laboratory, The Johns Hopkins University.

arm socket in a "floating" arrangement, and is located over the junction of the common extensor tendon and the extensor muscle bellies. Proportional opening of the terminal device is controlled by varying the EMG signal. The unit was evaluated in three phases.

During the first, or break-in-phase, which lasted for several weeks, the amputee wore the prosthesis for graduated periods while performing increasingly demanding manual skills. By practicing various manipulations the amputee attempted to develop maximum dexterity. The causes of wire breakage and other mechanical and functional problems were identified and the design was corrected.

In the second, or comparison, phase, various physical and functional measurements were made so that the new prosthesis could be compared to the amputee's pre-existing body-powered (BP) prosthesis. These include the span, force, velocity, and fine control characteristics of the terminal-device grasp, the range of terminal-device placement, the bimanual work envelope, and grasp-placement coordinations as well as stability, weight, comfort, and speed of application. Test activities were recorded on movie film for review and further analysis.

In the third and final phase, the amputee used the new device as his primary prosthesis for all of his activities for several months in order to reveal undiscovered problems and to determine mechanical endurance and ultimate amputee preference.

After wearing the unit for one year, the amputee reported: For delicate work the body-powered prosthesis is superior to the externally powered (EP) one owing to (a) shoulder-muscle feedback, (b) the capability of setting the shoulders for steady force, (c) lack of lag time, and (d) higher speed. Because of the time lag and lower velocity, he is inclined to use his EP prosthesis primarily in a "bang-bang" mode. He dislikes battery and motor bulk and weight, especially at the end of the day. He has reported that the EP prosthesis is ideal for working above his head or within closely restricted space, such as when lubricating the underside of an automobile, or for conditions which render shoulder motion undesirable or difficult, such as when propped up to read in bed. The absence of a shoulder harness and lack of compression force on the end of the amputation stump are definite advantages of the EP system if and when the end of the amputation stump is tender. This amputee has been able to use a snugger socket with the EP system than with the BP system, because of this feature. He has no sensor skin-sensitivity problems despite a known sensitivity to nickel, the metal rivets in his lower-limb prosthetic socket, and his wrist watch. The net result of all factors is that he likes to have his externally powered system for special uses and for relief from his body-powered prosthesis, especially in hot weather. The average EP use is now two or three days per week.

Unit #2 (Fig. 1) was fitted to a right-above-elbow amputee in August 1970. One year prior to this time he had been fitted with a body-powered AE prosthesis with inter-

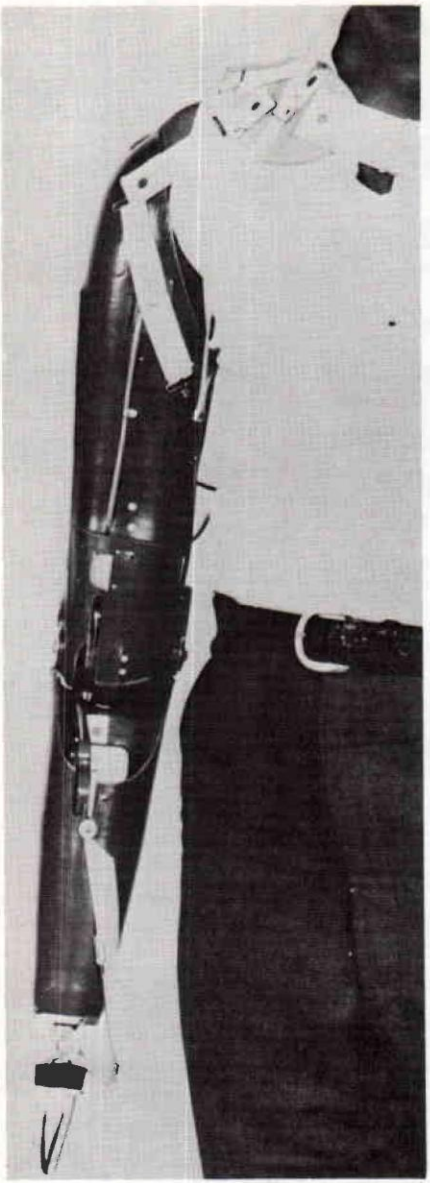

Fig. 1
Unit #2 fitted to an above-elbow case.

nal-locking elbow, AE figure-8 dual-control harness, quick-disconnect wrist, voluntary-opening (VO) hook, and an Army Prosthetics Research Laboratory (APRL) hand. He developed moderate facility with this equipment but never used the hook. The EP power unit is located in the elbow space and controls either the terminal device (voluntary-opening function) or elbow flexion, using a routine external locking cable and strap to the shoulder saddle in order to select terminal-device vs. elbow function. The battery for this system is located on the belt. The single-site EMG sensor is mounted in the socket over the biceps muscle.

The amputee clearly prefers the externally powered prosthesis to his body-powered system and uses it all the time. Some harness adjustment, repair of the elbow-locking cable attachment, and replacement of the rubber band which closes the hook have been necessary, but these were not related to the power system. There have been no breakdowns or adjustment problems in the EP system.

Although the patient states that he actually preferred the additional weight of his EP prosthesis compared with that of the BP, he also states that the weight becomes objectionable if his activities require him to be standing or walking and without additional support for his prosthesis for more than three hours.

For this reason he feels that this type of limb might be too tiresome for certain kinds of outdoor employment. However, when he is able to sit down and rest the prosthesis in his lap or on a table for a few minutes every couple of hours, the externally powered prosthesis causes him less fatigue than the body-powered one; therefore, he feels that the limb is especially suited to persons doing office work or to persons whose work activities entail occa-

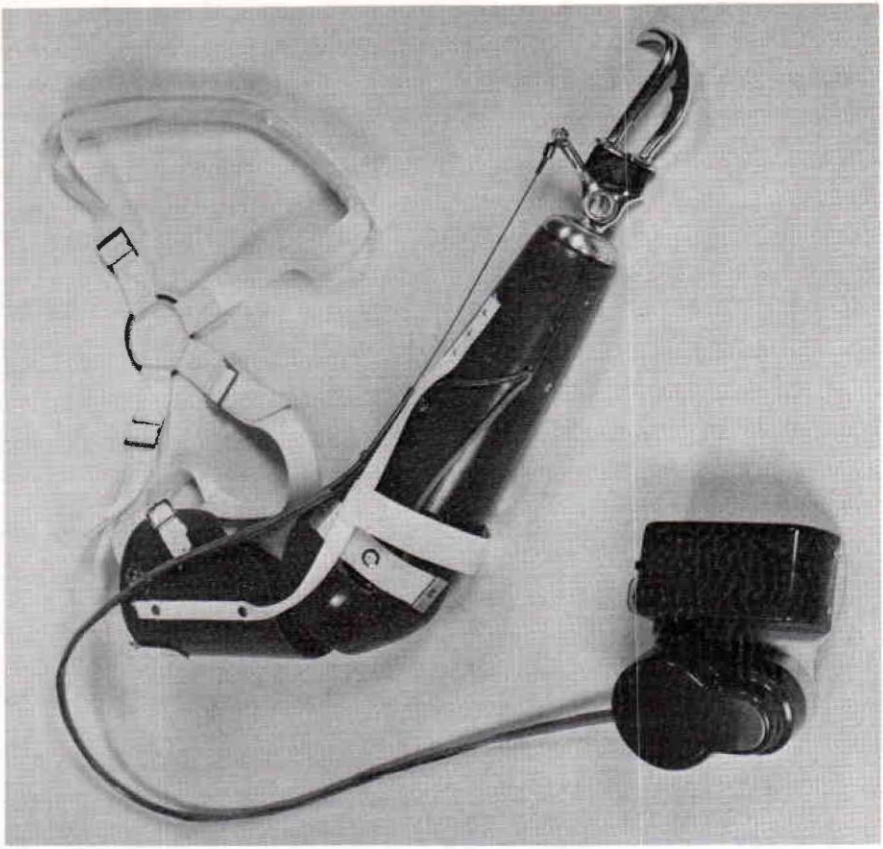

Fig. 2

Unit #3 for a right-mid-below-elbow amputee. In this case the power unit and battery case were designed to be clipped to the belt as a combined unit. A more convenient method is shown in Figure 3.

sional periods of sitting, as in driving a motor vehicle.

Preliminary analysis of experience with his EP system indicates that its advantages include ease of operation and an enlarged work envelope.

Unit #3 (Fig. 2) was fitted to a right, mid-below-elbow amputee during October 1970. His power unit and battery were initially designed to be clipped onto the belt with the power being transmitted to the prosthesis by a Bowden cable. A more permanent type of belt mounting, such as is illustrated in Figure 3, with the battery and motor on opposite sides, was subsequently found to be much more comfortable, secure, and less obstructive.

Reports by the patient of use time with the EP have varied from "most of the time" to "almost every day." This individual was fitted very snugly in order to obtain maximum stability of the socket on the stump, especially to facilitate playing the piano. It is not possible to fit the socket for his BP prosthesis as snugly as that for his EP without causing discomfort in the distal portion of the stump. This is believed to be

due to the development of comprehension forces in the end of the stump where the socket compresses it in reaction to the tension forces developed in the cable each time the terminal device is opened. In the EP prosthesis these compression forces are developed in the cable housing rather than in the soft tissues in the end of the amputation stump. This amputee has said that a significant reason for not wearing his EP prosthesis even more than he does is the extra time and effort required to apply the tightly fitting socket.

The subject had difficulty on some occasions with slow operation of the terminal device. He reported that it seemed to be dragging. The problem did not reappear when the prosthesis was examined and then reapplied to him. Ultimately, it was discovered that he was inadvertently twisting the cable as many as several revolutions in the process of donning the belt and prosthesis. This problem was solved by teaching him to use color-coded wires attached to the cable as an indication of twisting.

He had a very weak EMG signal when he was fitted initially. After the first week of wear, the strength of the EMG signal became about three times as strong as it was initially and a readjustment in the electronic-system gain became necessary. His EMG output has remained constant at this high level since that time.

The amputee is a student of the piano. He has been able to continue his piano lessons, and is developing

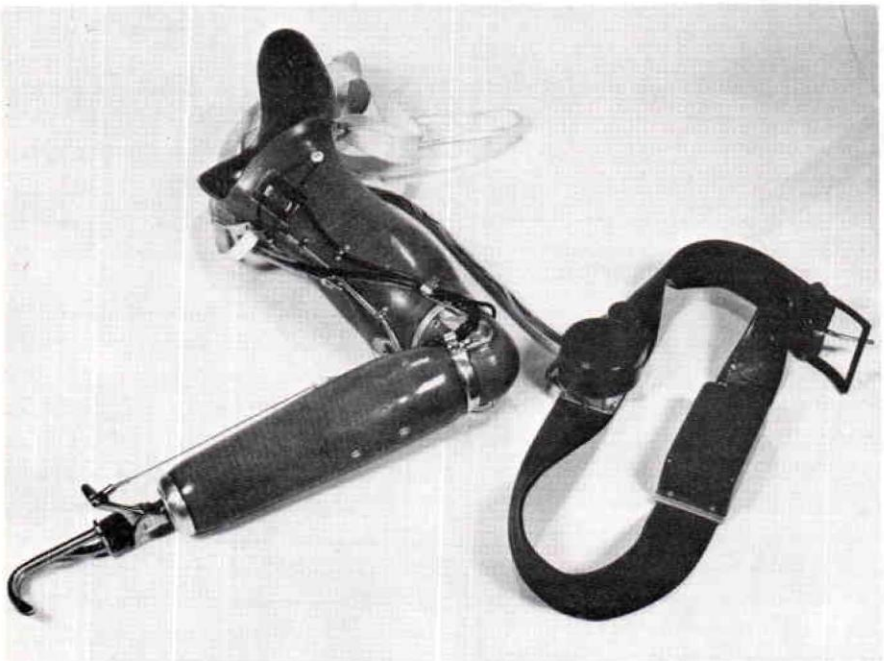

Fig. 3

Unit #4, for a right-elbow-disarticulation case. Note the location of power unit and battery pack on opposite parts of the belt. This arrangement was found to be more convenient than the initial design shown in Figure 2.

Fig. 4

Patient wearing Unit #4 playing the piano. Note the specially designed terminal device.

a good facility for the control of his EMG signal while playing the piano, using the specially designed terminal device shown in Figure 4.

Unit #4 (Fig. 3) was fitted in December 1970 to a right-elbow-disarticulation amputee who had only two months' experience with his body-powered prosthesis. A conventional Hosmer internal-locking elbow was used, the lock being activated in the traditional manner. The power unit and battery are mounted permanently on the belt in such a way that battery replacement is convenient. Force transmission between motor and terminal device is provided by a Bowden cable. The terminal device is of the voluntary-opening type.

This amputee's original injury was incurred while operating machinery used for processing soap. In January 1971 he returned to the same full-time job with the same employer.

The subject always uses his externally powered prosthesis from the time he gets up in the morning until he returns from work in the afternoon. Usually he takes the limb off at home, but puts it back on for any bimanual activities or to go out in the evening. He has worn the limb continuously as long as 14 hours.

On one occasion he dropped and broke the original battery case. Since delivery of his EP prosthesis, the only times he has worn his body-powered prosthesis was while this battery case was being replaced and on two other occasions when his EP prosthesis was in the laboratory for a check-out. The case was replaced

with one of a more durable material and no further breakage has occurred.

He has reported inadvertent openings of his terminal device in the washroom at his job when trying to hold wet toweling in order to wash and dry his remaining hand. In this situation he has resorted to switching off the power in order to maintain a grip on the toweling.

The sensor case was modified to improve electrode contact. He has had no other malfunction or mechanical or electrical breakdown. In reply to inquiry about speed he said that ideally he would like to have it a little faster. In reply to inquiry about the weight of his prosthesis he stated, "No problem. I guess I am used to it." Regarding the components on his belt he answered, "A little bulky, but they don't bother me none." He stated that, "The arm is working beautifully. It will do anything you try to do with it."

Unit #5 (Fig. 5) was fitted to a short-below-elbow amputee who had already learned to use a body-powered prosthesis with a Muenster socket and an APRL hook or hand. The externally powered prosthesis has a Muenster socket. There is no additional suspension or harness. The power unit and battery are permanently belt-mounted but the battery mount permits convenient battery replacement. Force transmission between motor and terminal device is by Bowden cable; hook and hand are of the voluntary-opening type. Prior to fitting with the EP prosthesis the amputee had stated that he was bitterly disappointed with the functional capabilities of his BP prosthesis. Although he usu-

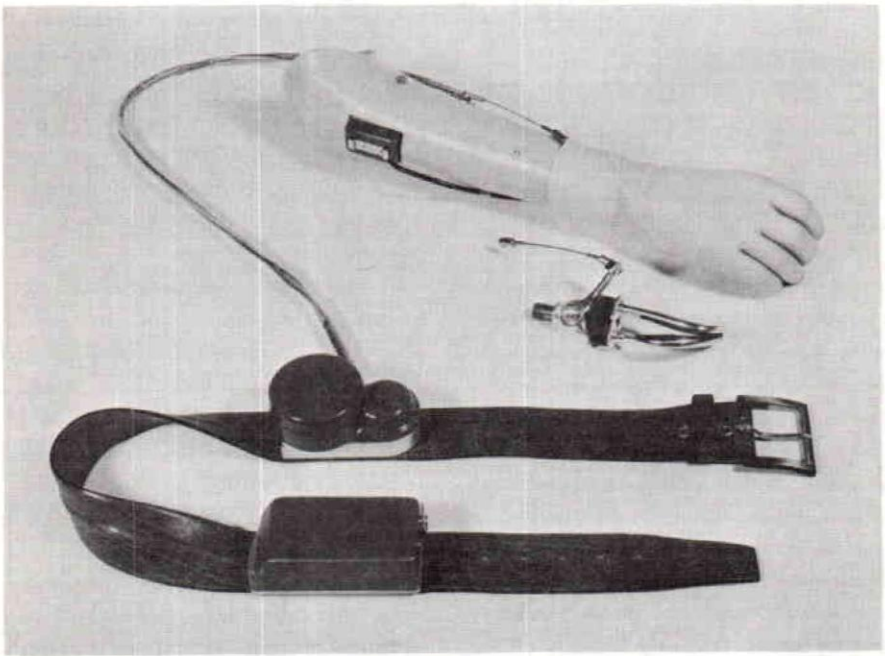

Fig. 5
Unit #5, for a short-below-elbow amputee. Note absence of harness.

ally wore this prosthesis, he did so almost entirely for appearance, and rarely used the hook.

This patient adapted immediately to the EP prosthesis without any special training. Since delivery of this system, he has used it exclusively, full-time, every day except on two occasions when he removed it for a few hours because of some skin irritation at the socket sensor port. In was felt that this problem was due at least in part to overzealous wetting of the skin in this area at the time of application of the prosthesis and to excessive pressure of the sensor. The condition improved with corrective action and no longer interferes with the use of the prosthesis. It is evident that this amputee is cycling his EP prosthesis more frequently than he formerly cycled his BP prosthesis. He reports that his battery lasts him about nine hours, and, in order to permit continuing function of his limb, he carries an extra battery with him when away from his house for the whole day.

The subject is a part-time farmer and mechanic. He likes to use the prosthetic hand in a work glove when working with farm hand tools. He prefers the hook when working with smaller metal objects. He reports that, although the belt-mounted components seemed annoying at first, he is no longer aware of them. When sitting, he rotates his belt slightly, thereby bringing the motor around to his side where it does not press against his back. The speed of operation is satisfactory, but he would like the hand to close a little faster. There have been no equipment breakdowns or malfunctions. He denies having any trouble with inadvertent openings but says that occasionally when applying high force to an object he switches off his battery to maintain the grip. He states that it will be terrible for him if the system is retrieved when the evaluation is completed, and he complains that he does not know how he will get along when he no longer has it.

Unit #6 is fitted to an above-elbow amputee who lost his left upper limb in an industrial accident six years ago and has been using a body-powered prosthesis for approximately five years. He is a full-time employee of an industrial contracting company where he works as a high-pressure boiler welder. He also raises horses. His BP prosthesis is of heavy-duty construction and has an internal locking elbow and a farmer's hook. He is very skillful with his BP prosthesis, subjects it to heavy use, and has been wearing it full-time, all the time.

Since he depends heavily on the humeral rotation turntable in his work and since his stump is fairly long, a special turntable was designed and constructed that occupies minimal longitudinal space and still permits placing the motor in the elbow region without undesirable lowering of the elbow center. The sensor is placed in a socket port over the biceps muscle. The remaining electronic components are placed in the forearm unit and the battery is worn on the belt.

One week after the externally powered limb was delivered, the amputee reported that the above-elbow figure-8 harness was uncomfortable, owing to the increased

weight of the prosthesis. The harness was then converted to a shoulder-saddle type with a cross-chest strap. The patient reports that this new harness system is more comfortable. He also reports that his work requires him to be standing or walking almost all of the time. He finds that under these circumstances the externally powered prosthesis is very tiring and that he must switch to his BP prosthesis in order to continue working efficiently for periods longer than five hours. He reports relief from tiring if he is able to sit, and he states that the prosthesis would be ideal for work which permitted resting its weight occasionally on a supporting surface such as a desk top or in his lap. He believes that part of his fatigue might be due to unaccustomed use of his biceps muscle.

He has had no malfunctions or breakdowns and denies inadvertent openings. A fresh battery pack lasts him five hours of work time. He states that the response of the limb is good and he hopes to develop an increased fatigue tolerance. Until the weight problem is solved, this amputee shows a clear preference for his BP prosthesis.

Unit #7 was fitted to a 56-year-old left elbow-disarticulation amputee about one week after delivery of his first body-powered prosthesis and nine months after his amputation.

The original injury to his left upper limb also resulted in severe permanent limitation of motion in his left shoulder. Owing to the limited muscle power and excursion available, the harness selected for the BP prosthesis consists of a shoulder saddle and cross-chest strap for suspension and a separate axillary loop for transmission force from the right shoulder to the main cable. This loop is designed to encircle the upper arm near the belly of the deltoid in order to exploit some sound-side shoulder motion to obtain maximum cable excursion. In spite of these special considerations and daily special-training efforts, the amputee is having great difficulty developing any useful function with his (BP) prosthesis.

The externally powered unit has a socket, forearm unit, wrist unit, and voluntary-opening terminal device which are identical to those of the BP unit. An identical shoulder saddle and cross-chest harness are used, but the axillary loop was omitted from the EP unit. In the EP unit the main cable is routed around a pulley in the forearm unit. The power unit and battery are mounted on the belt similar to the one shown in Figure 5.

The subject was able to operate both the elbow and terminal device with good control immediately after delivery of the limb and without special training. Since delivery no further adjustments have been necessary. There have been no malfunctions or breakdowns. Thus far, the amputee reports that he is delighted with all aspects of his EP limb, but that he is very discouraged with his BP limb.

Unit #8 (Fig. 6) was fitted to an 18-year-old right-shoulder-disarticulation amputee to replace the limb lost in a traumatic amputation secondary to a corn-picker accident.

The patient was fitted with a conventional body-powered prosthesis

approximately 3½ months after the amputation. This device provided negligible function and he wore it on special occasions for appearance only. Prior to being fitted with the externally powered prosthesis he had, for all practical purposes, totally rejected the conventional system.

No myoelectric signals suitable for control of the prosthesis were found when a thorough exploration was made of the muscles of the injured side of the amputee's body. However, more than one inch of transverse motion of the scar takes place when the pectoralis muscle is contracted. The patient has excellent voluntary control of the motion of the skin in this area.

A special transducer was developed to make use of this skin motion. The transducer utilizes a movable magnet and stationary semiconductor element that responds to changes in magnetic field strength. Approximately ⅜ inch of motion of the small string, which can be

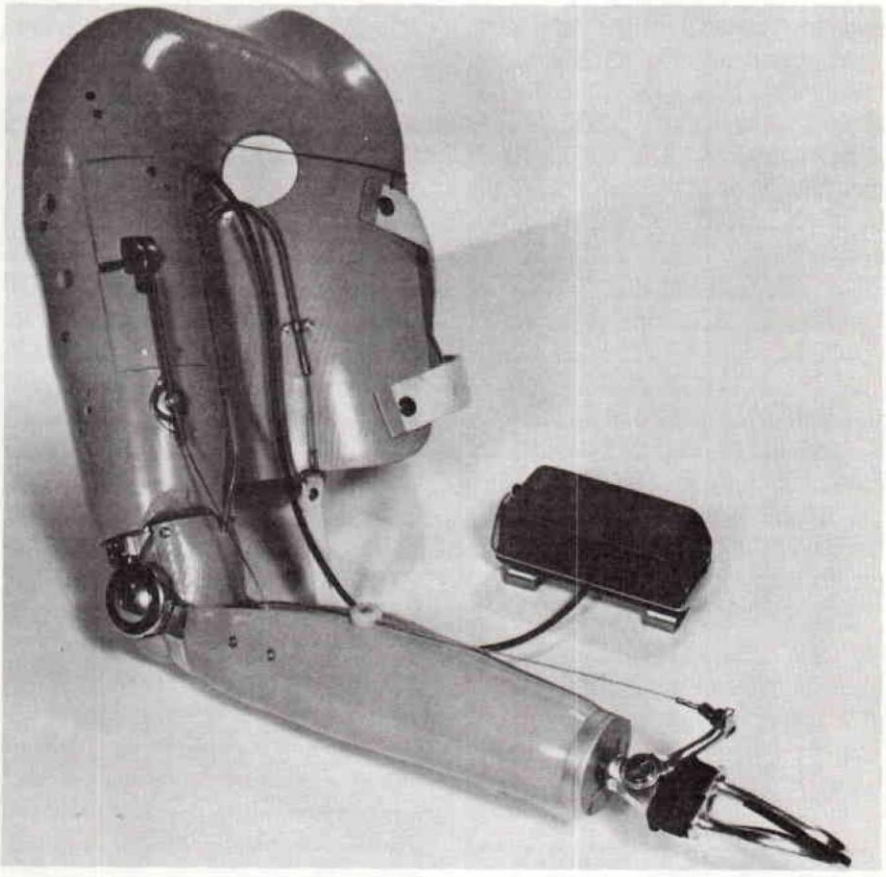

Fig. 6

Unit #8, for a shoulder-disarticulation amputee. The control of this prosthesis is provided by skin movement that provides relative motion between a magnet and a semi-conductor. A circular hole is provided in the socket over the pectoral area to permit connection between the skin and the string shown which is connected to the magnet portion of the transducer.

seen in Figure 6 emerging from the front of the shoulder of the prosthesis, controls the arm and terminal device. When the prosthesis is in use, the end of the string is passed through the large hole close to where it emerges from the prosthesis, and is attached to a button which is, in turn, attached to the skin with double-aided adhesive tape.

After using this prosthesis for approximately one month the amputee reports that he uses it 50% to 75% of the time. He uses it for bimanual operations, and for tasks like carrying empty buckets, but does not use it when he can do his work without it, such as when he drives a tractor. The adhesive attachment to the skin has remained intact up to two weeks without coming loose, and appears to be satisfactory for this evaluation. The battery is providing up to nine hours of operation on a single charge. The amputee has expressed a need for a "reach" capability, and is of the opinion that the prosthesis would be much more useful if the shoulder were movable.

Conclusions

Preliminary results of the evaluation of experimental models of the externally powered system on eight amputees indicated that this system has merit over body-powered systems in those cases where the following conditions exist:

1. The amputee is unable or unwilling to furnish the high force level and large excursions required to operate the body-powered prosthesis. Specific examples are: (a) high level of amputation; (b) tenderness in the end of the stump; (c) restriction of joint motion, especially in the shoulders; and (d) weakness of shoulder muscles.

2. The amputee needs a wider work envelope than is possible with a conventional body-powered prosthesis.

3. The amputee desires minimal harnessing for the prosthesis. As a trade off for this characteristic he must be willing to accommodate the additional weight/bulk of the electrical/mechanical subsystem of the powered system.

4. Training time must be minimal. Compared to other externally powered systems, the Johns Hopkins system offers advantages in that (a) it utilizes many standard, available prosthetic components, (b) it provides a powered elbow and/or powered terminal-device capability with a single motor and single EMG site, (c) it has demonstrated that proportional control is very "natural" and easy for the amputee to learn to use, (d) the system is versatile because powered components may be either located on the prosthesis or worn on the belt to suit the needs of the individual, and (e) donning is simplified by attachment of the sensor to the wall of the socket.

Versatility of component location is a particularly significant factor if the amputee is to be fitted in a manner consistent with his projected utilization of his prosthesis. The equipment-location criterion appears to be one of the critical factors in the ultimate acceptance or rejection of the powered system by

amputees. The Johns Hopkins concept allows maximum flexibility for equipment location.

This evaluation was based on the original experimental design to obtan data on the practicality of the basic concept. This initial design was limited in scope and did not include significant effort on miniaturization of components.

Further design refinements in packaging are planned to bring this design to a stage suitable for more extensive clinical testing and possible future availability to amputees.

ACKNOWLEDGMENTS

The authors wish to acknowledge the contributions of several who assisted in this collaborative effort. Messrs. (father and son) Charles Dankmeyer of Dankmeyer, Inc., Baltimore, and Mr. Martin Massey of J. E. Hanger, Inc., Baltimore, provided valuable counsel and, with the exception of the control units, fabricated these prostheses. Among the contributors at the Applied Physics Laboratory were J. H. Loveless, who contributed much in the design of the systems and who assembled and wired the prostheses, R. L. Konigsberg, who designed the sensor and control circuits, and E. R. Thompson who assisted him. J. L. Letmate designed the power-pack unit, and George Shoben laid out the printed circuit boards and assisted with their assembly. All of the volunteer test subjects have been most helpful and cooperative and their "inputs" have been valuable aids in the development of these systems.

Technical Notes

Crutch Grip Modification

Donald D. Strand, C.P.O.[1]

One year ago we had occasion to fit a 29-year-old female below-knee amputee who had severe limitation of both hands and her left elbow secondary to third degree burns. Both legs were also burned and a left BK amputation was eventually performed. The right foot was left deformed and stiff. Because both lower limbs were involved, it was essential that she use axillary crutches for an extended period during fitting and rehabilitation.

Inability to close her hands around the crutch hand grips presented a problem. Figure 1 shows her fingers in maximum extension. Maximum grip is shown in Figure 2.

To provide a comfortable and stable grip, Plastazote sheeting ¾-in. thick was heated in 310 deg. F.

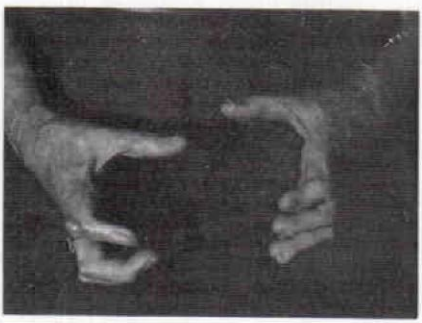

Fig. 1
Fingers shown in full opening postion.

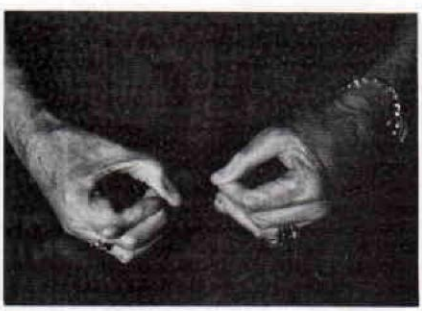

Fig. 2
Figures in closed position, showing maximum grip possible.

[1] Production Supervisor, Navy Prosthetics Research Laboratory, U.S. Naval Hospital, Oakland, Calif.

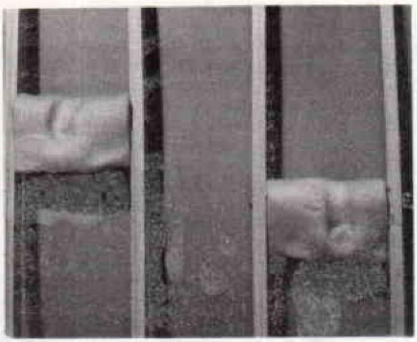

Fig. 3
Results of heating and molding Plastazote on crutch grips.

and then quickly pressed around the grips and molded by the affected hands and fingers while the patient was standing and bearing weight. The application and results are shown in Figure 3. The difference in height of the crutch grips was necessary because of the contracture of the left elbow.

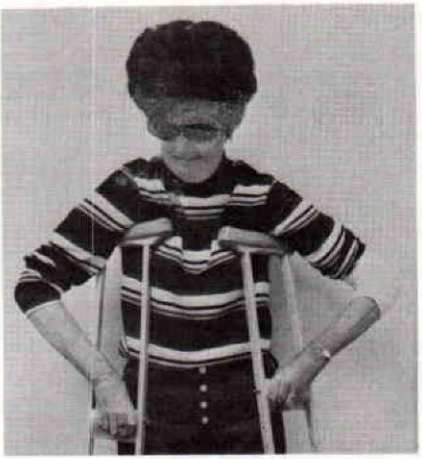

Fig. 4
The patient using the modified crutches.

The subject using the modified crutches, which proved to be both comfortable and functional, is shown in Figure 4.

Valve Housing for Use in Foaming and Finishing Above-Knee Suction Sockets

Harry N. Hughes, C.P.[1]
Gene Helmuth [1]

When foaming and finishing an above-knee suction socket much time is devoted to achieving an acceptable, finished socket. One of the problems has been to provide a neat cosmetic appearance in the valve area. Another problem has been to provide a properly tapered radius to the valve area so that the valve is easily accessible to the patient. A method used by the staff at the Navy

[1] Navy Prosthetics Research Laboratory, U.S. Naval Hospital, Oakland, Calif.

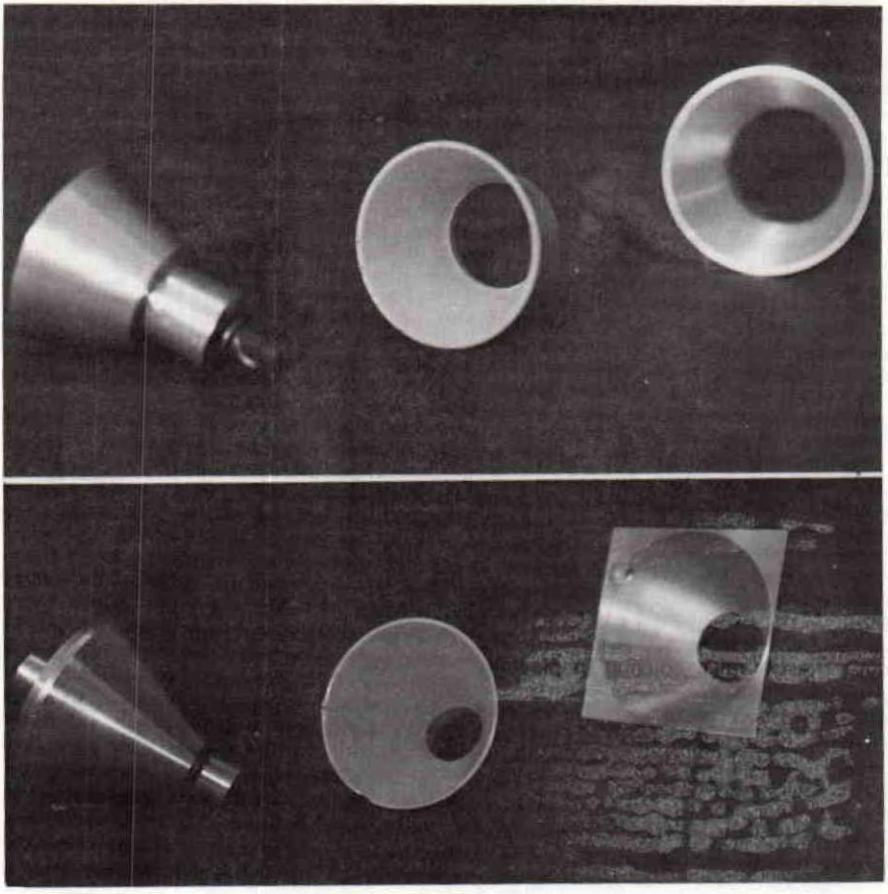

Fig. 1

Molds used in manufacture of plastic valve housings for above-knee sockets. The valve housing itself is shown in the center of both photographs. The upper photographs depicts the molds for the smaller size (3 cm. in length).

Prosthetics Research Laboratory has proven to be very satisfactory, and is described here.

A plastic valve housing has been designed and is made as a standard production item in two sizes. The larger size has a proximal diameter of 3 cm and distal diameter of 9 cm. It is 7 cm long with a 15-degree offset angle at the proximal end. The smaller housing measures 3 cm in diameter proximally, 5.5 cm distally, and is 3 cm long. The molds used in the manufacture of the plastic valve housing, along with the valve housings, are shown in Figure 1.

After the socket is laminated, approximately .5 cm of the laminate is removed around the face of the valve to allow placement of the plastic housing, which has been designed to fit snugly over the valve (Fig. 2). At this time, the prosthe-

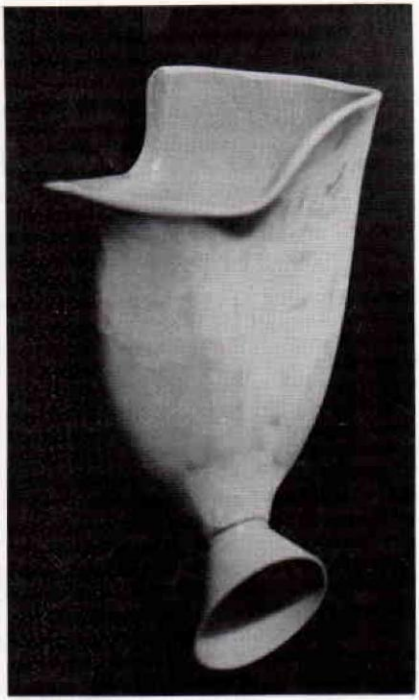

Fig. 2
Plastic valve housing in place.

tist visualizes the contour required for finishing, selects the appropriate size housing (depending upon the anticipated depth of the foam), and shapes the housing on the sander (Fig. 3). After shaping, the housing is filled with plaster-of-Paris or clay and plastic foam is introduced between the socket and the knee. After the foaming operation the thigh section is given its final shape (Fig. 4) and an outer laminate is applied. When the lamination has cured, the socket is trimmed, the filler is removed, and the thigh section is attached to the shin and foot. A view of the final result is shown in Figure 5.

This procedure eliminates the need for removing foam from around the valve and the filling in of this area with Cabosil, thus saving time while giving a much neater finish.

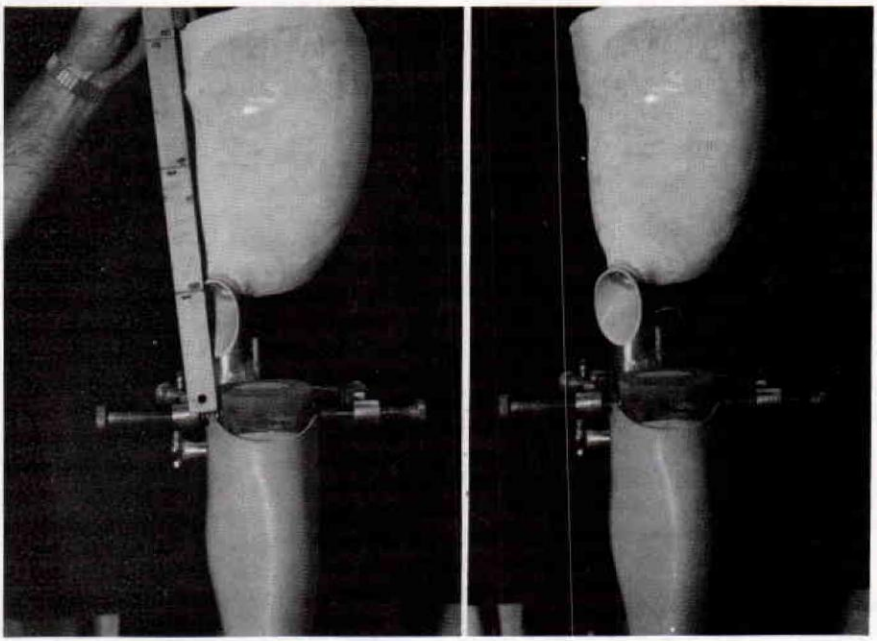

Fig. 3
Two views showing how valve housing is trimmed to come flush with exterior wall.

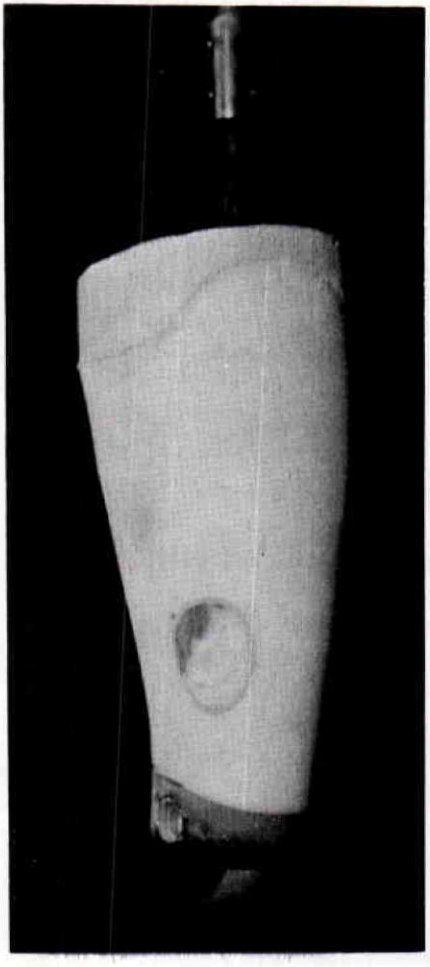

Fig. 4
A view of the process after foaming and before lamination of outer wall.

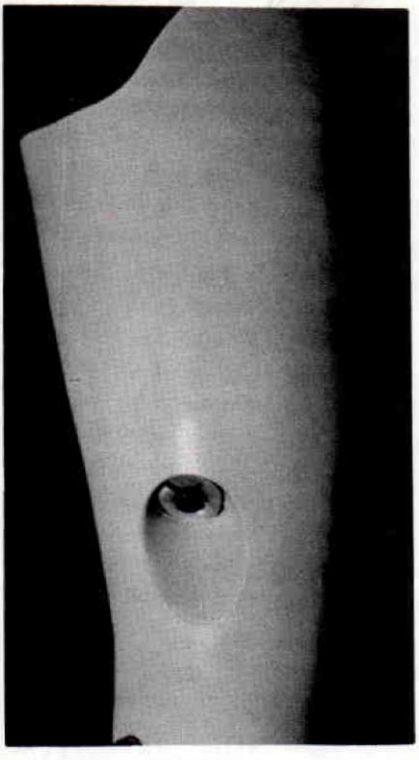

Fig. 5
The finished product.

The Navy Prosthetics Research Laboratory will be happy to provide samples of these plastic valve housings upon request.

Review of Current Literature

Beyond Plastic Surgery

By

Charles Beaver Edwards, Wayne State University Press, 1972

The title of this book on maxillofacial prosthetics is intriguing, and the author is knowledgeable in the subject with years of experience. However, it falls short of being a useful professional text and is too expensive ($12.95) for leisure reading.

In this relatively short book (135 pages), the author combines personal experiences and information of general interest with a how-to-do-it approach to cosmetic restorations of the face and body. Unfortunately, it is incomplete as a text book and too detailed for casual reading. Perhaps of more importance, the book does not reflect the advanced state of the art. The author is still using latex for skin and cotton for soft tissue rather than plastics, such as polyvinyl chloride skin and polyurethane foam.

The subject is a difficult one, and very little has been written about it. To deal comprehensively with cosmetic restoration, however, functional as well as passive prostheses must be considered. "Cosmesis" involves not only static appearance but how something looks in motion and how it feels, sounds, and smells. And as the author undoubtedly appreciates, it is the prosthetist-patient relationship as much as anything which helps to make people happy.

Maurice A. LeBlanc, C.P.

Moulds and Casts for Orthopaedic and Prosthetic Appliances

By

J. A. E. Gleave, Charles C Thomas, Publisher, Springfield, Ill.

170 pages, 108 illustrations.

Publication Date: May 30, 1972, Price $16.75

When someone pioneers by writing a book on a new technical subject, he assumes a great deal of responsibility with respect to research and other background information. To be valuable to students the material must be current, readily adaptable, and appealing in a productive sense. In "Moulds and Casts for Orthopaedic and Prosthetic Appliances" Mr. Gleave has met the test of the occasion, and compiled a text that will fill a very obvious void in the orthotics and prosthetics literature, for no one before has covered this subject in so much detail from the chemistry of plaster to the casting of a toe. Today, when more and more of our appliances are produced with a plaster reproduction of a body segment, we find that successful fittings relate to our ability to anticipate the biomechanical requirements of a suitable socket—patient contact. Furthermore, without an understanding of the principles described in this book, it is difficult for one to make a satisfactory cast that could be utilized reliably in the application of all of the new plastic materials and techniques available today.

Before outlining a variety of techniques for moulding and casting various body segments the author discusses a seldom considered element

in the moulding process, the displacement of soft tissue that can be voluntarily controlled or unknowingly permitted. Mr. Gleave makes the reader aware of the factors involved, and outlines methods for the technician to utilize body position, plaster bandage application, and other mediums to accomplish the goals dictated by the deformity or condition of the affected part.

Over the past ten years there have appeared on American programs complex and controversial approaches to "ideal" moulding procedures. These and others are described and well illustrated. Of particular interest to me was the inclusion and promotion of the laminated mould which seems to offer great potential for accuracy, especially for bony parts, e.g., foot, ankle and leg.

Whether the interest of the student lies in the trunk or in the digits, or in orthotics or prosthetics he will find helpful suggestions on all moulding problems. Last, but not least, we can well follow the author's opening remarks and standardize our terminology with the proper use of "mould" for the negative wrap and "cast" for the positive. We are indebted to our English colleague for his efforts and to all our European counterparts whose influence has contributed to the completeness of the work.

Carlton Fillauer, C.P.O.

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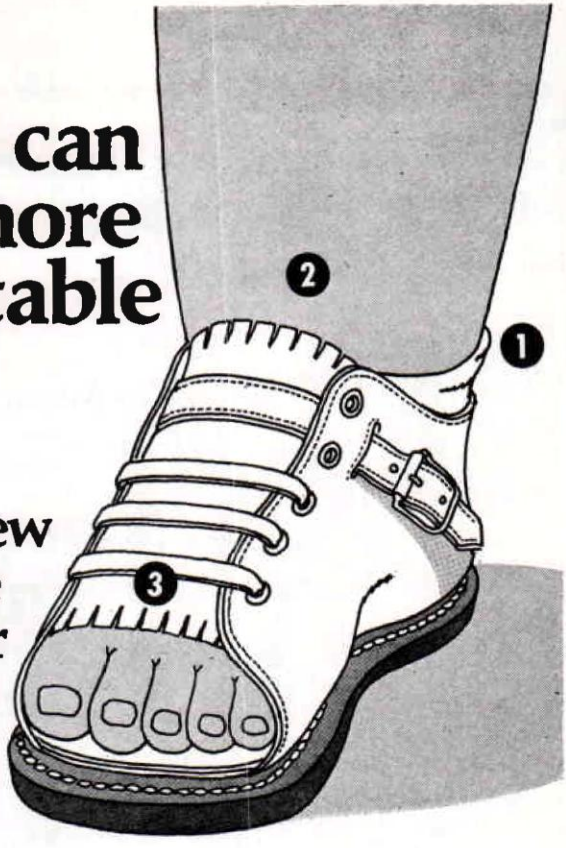

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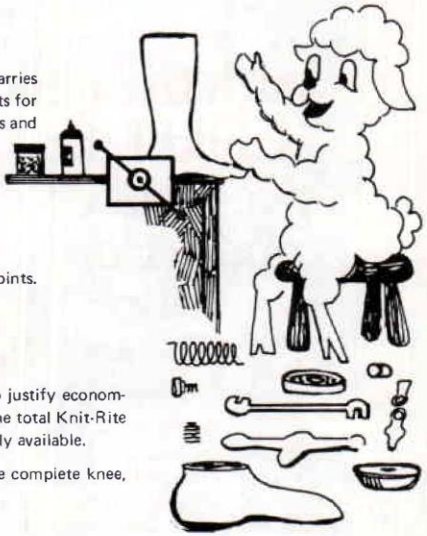
Pages 131 thru 143—Approximately 130 parts for knees.

Pages 144 thru 154—Lists prosthetic joints along with many parts.

Pages 176, 189, 191 and 192—Lists some of the parts for brace joints.



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1972 Certification Examination Results

The 1972 Certification Examinations were held at Northwestern University, Chicago, Illinois from August 6 to 9 inclusive. The following candidates successfully completed the examinations and have been awarded certification status in the disciplines indicated:

Certified Prosthetists

Allen, Harold R.
Allen, John L.
Araya, Walter D.
Arko, Geoffrey L.
Bardsley, Allan J.
Berndt, Bernhard
Booden, Jack, Jr.
Brelsford, Bill B.
Buckles, Donald W.
Carte, Michael A.
Clark, Richard L.
Cloud, James
Dickerson, Steven W.
Effinger, Norman
Eickman, Lawrence E.
Farrow, Bradley
Ferencik, Kenneth W.
Fessenden, Gary O.
Fillauer, Karl D.
Fornuff, Donald L.
Graham, Anthony L.
Hall, George H., Sr.
Hampton, Wade T.
Harshberger, Jack R.
Holen, J. David
Jay, Ronald W.
Jendrzejczyk, David J.
Karg, Otto
Leimkuehler, Jon P.
Lupo, Joseph N.
McVey, Max
Mason, Randy D.
Meltzer, Lewis N.
Mumm, Edward J.
Nunez, Rudy
O'Connor, John J.
Oertel, Horst
Pirtea, Ted
Pritham, Charles H.
Roberts, Patrick N.
Rodriquez, Francisco
Roman, Edward J., II
Sabolich, John
Schaefer, Robert F.
Simon, Sol
Smith, Aubrey I.
Staats, Timothy B.
Steele, Charles
Stepp, Ervin P.
Stewart, John S.
Swanson, Jerry O.
Trautman, Paul A.
Webb, William H., Jr.
Wines, Elmo T., Jr.
Yamate, Hideo

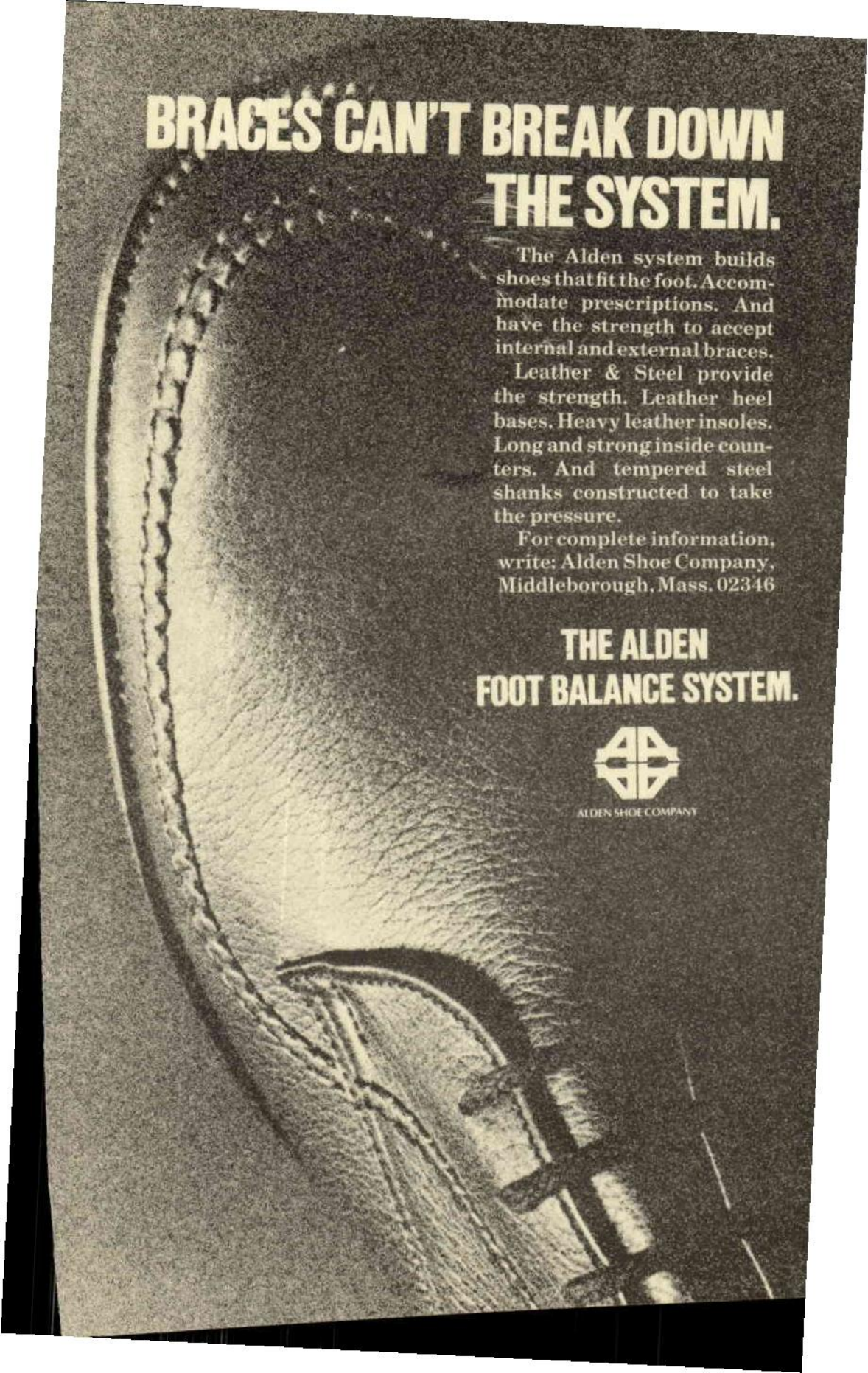
Certified Orthotists

Baldwin, Robert
Boe, Paul V.
Bulanek, James E.
Cannon, James R.
Davis, Charles
Gills, George
Goll, William
Hall, John T.
Hammer, Teddy J.
Hayhurst, Donald J.
Herron, Don
Hountha, Philip
James, Robert C.
Jimenez, Rudolph E.

Jones, Lloyd D.
Kuehnegger, Walter
Linck, Julius
Manfredi, Robert C.
Martin, Thomas A.
Mereday, Clifton S.
Meyers, Richard
Murphy, Michael P.
Murray, William T.
Myers, James
Peter, Gerhard
Picurro, Mark C.
Ramsey, Charles
Robbins, Arthur C.
Sankey, John A.
Schneider, Martin
Schultz, Jack
Snell, Frank E.
Spearman, Clarence
Stewart, Lloyd A.
Stills, Melvin L.
Teter, William E.
Torossy, Julius
Vitarius, George
Watson, Dan J.
Yanke, Mark J.
Zabaronick, Nicholas

Certified Orthotists-Prosthetists

Aycock, William R., Jr.
Barfield, Harold
Billock, John N.
Bindi, Rudy
Buckner, Martin L.
Casson, Jerry L.
Ceder, Loren R.
Cruz, Tony J., Jr.
Eldeb, Russell V.
Faulkner, Virgil
Kessler, Marion
LaBlanc, Kenneth P.
Lefton, Michael
Lewis, Michael A.
Martin, Richard E.
Pearl, Michael
Porter, David L.
Quigley, Michael J.
Roberts, John A.
Schlesier, Robert G.
Spring, Jack
Sweigart, James E.
Voner, Richard
Wilson, Michael T.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