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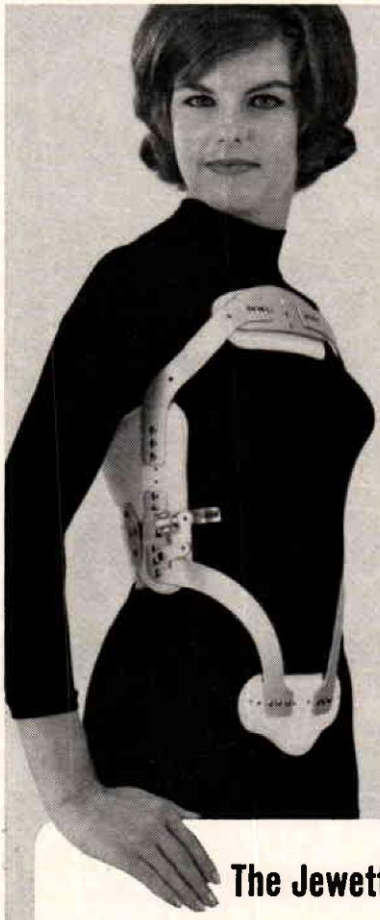

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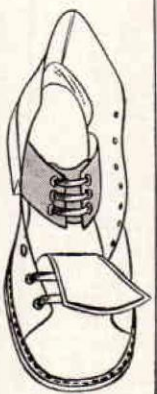

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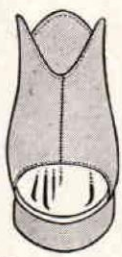

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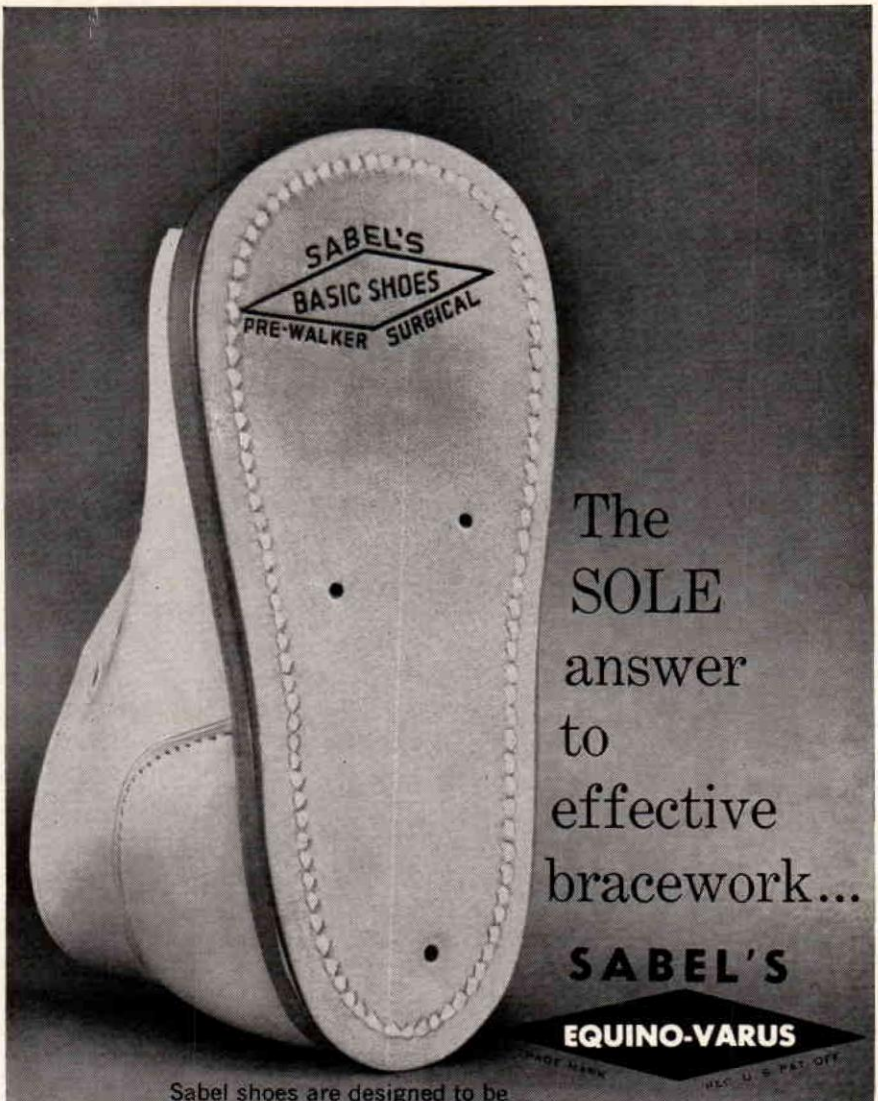

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PROCEEDINGS OF THE 1966 ASSEMBLY OF THE AMERICAN ORTHOTIC AND PROSTHETIC ASSOCIATION

This issue of the Journal includes three papers delivered at the 1966 Assembly in Palm Springs, California:

1. Immediate Post-Surgical Prosthetics, by Ernest M. Burgess, M.D., and Joseph H. Zettl, C.P.
2. Upper Extremity Orthotics: A Project Report, by Thorkild J. Engen, C.O., and Louis F. Ottnat, C.O.
3. Plastisol Coatings and Application Techniques, by David H. Harden, and Richard D. Koch.

Immediate Post-Surgical Prosthetics

by ERNEST M. BURGESS, M.D.,
Principal Investigator
and
by JOSEPH H. ZETTL, C.P.
Associate Director

Presented at the 1966 AOPA Assembly, Palm Springs, California

GENERAL CONCEPTS

The fitting of lower extremity amputees with a temporary prosthesis immediately following surgery constitutes a dramatic departure from conventional amputation surgery and management. The closed wound of an amputation can be subjected to firm, even, controlled pressures by use of a rigid dressing, carefully applied with relief for bony prominences and by avoiding proximal restriction. With this immediate post-surgical dressing properly applied and contoured, it is feasible to incorporate into it a light, adjustable temporary prosthesis and foot. General condition permitting, the amputee can bear controlled weight the day following surgery and ambulate with minimal weight bearing a day or two thereafter. Continued increases in weight bearing in both stance and gait phase are feasible and desirable throughout the wound healing period to the fitting of the definitive prosthesis. Immediate post-surgical prosthetic management of the amputee provides a number of benefits not obtained by conventional amputation surgery and prosthetic management. The technic provides:

1. Accelerated wound healing and stump maturation.
2. Decrease of post-operative pain (often only mild opiates and sedatives required.)
3. Absence of post-operative edema.
4. Marked reduction in phantom pain.
5. Earlier weight bearing (first post-operative day, general condition of patient permitting.)
6. Earlier ambulation (second or third post-operative day, general condition of patient permitting.)

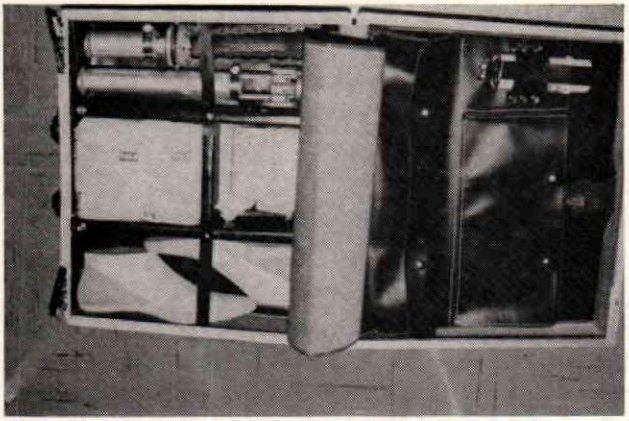

Figure 1—Prosthetic kit including AK & BK pylons, SACH feet, elastic plaster bandage, and AK suspension belt. On the right, adhesive spray, and compartments for felt strips, stump socks, and BK waist belt.

7. Shorter hospital confinement of the patient (average discharge between ten to twelve days.)
8. Earlier fitting with a definitive prosthesis (average 28 days post-operatively.)
9. A more stable stump (reduced changes due to muscle atrophy especially if tension myodesis was performed in surgery.)
10. An improved general physical condition of the patient due to reduced bed confinement.

Successful immediate post-surgical prosthetic fitting and ambulation also provides psychological and financial benefits and make the technic, whenever possible, the one of choice. The technic can be applied to any level of lower extremity amputation, and with proper attention to the details of the technic, extremely gratifying results can be obtained.

CASE SELECTION

The technic of immediate post-surgical fitting of lower extremity amputees is by no means restricted to selected cases of a particular category of disability or age group. Except for severe burns, the technic can be used successfully even if the patient is for some reason temporarily non-ambulatory. In this study to date, well over 100 cases have been treated in this manner and include the following amputation levels: Chopart, Syme, below knee, knee disarticulation, above knee, and hip disarticulation. No hemipelvectomy or upper extremity amputations have been carried out using this method. The patients' ages ranged from 3 to 86 years and covered practically the entire scope of standard lower extremity amputation surgery. The majority have been vascular amputees, many with gangrene and diabetic conditions.

SURGICAL AND PROSTHETIC EVALUATION

Whenever possible, it is standard procedure for the surgeon and prosthetist to evaluate the patient one day or more prior to surgery. At this time, a level selection is in order. In cases showing a poor circulatory status of the extremity, arteriography, oscillometry, plethysmography and

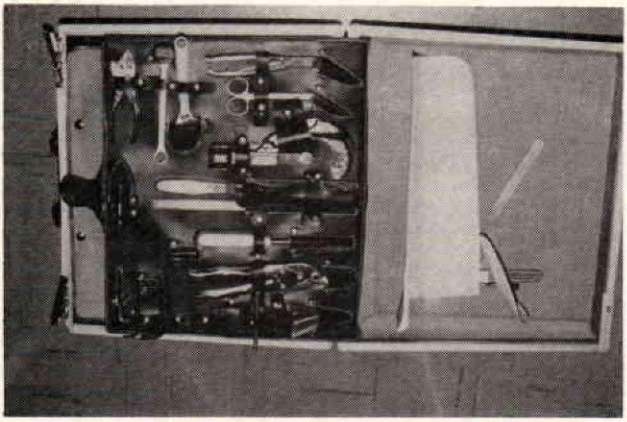

Figure 2—Prosthetic kit including required tools and PRS above knee casting fixture.

skin temperature readings will aid in level selection. However, it may be necessary to make the final decision at the time of surgery. Absence of a popliteal pulse is by no means a final indication for amputation at an above knee level. Satisfactory results have been obtained in below knee amputations without demonstrated blood flow through the popliteal artery, providing collateral blood supply was present to the skin flaps.

The procedure and the technics are fully explained to the patient to make him aware of his role and to insure his cooperation. It is good practice at this time for the prosthetist to secure a shoe from the patient, to note any contractures that may be present, and to take a waist measurement for the preparation of the suspension belt. This will insure the prosthetist to have the proper and fitting parts ready in surgery and to avoid any unnecessary confusion or delay. It is extremely valuable to have a complete assembled kit ready at all times, for just this purpose. (Fig. No. 1 & 2)

SURGICAL PROCEDURE

In surgery the departure from conventional amputation surgery whenever possible is in the form of the so-called tension myodesis. After the tibia is divided and beveled anteriorly, the periosteum is stripped back approximately 3/8″ and a series of small drill holes are placed through the distal end of the tibia. The major opposing muscle groups, i.e., the ankle dorsiflexors and plantar flexors in below knee amputations, and the flexor extensor and adductor muscle groups in above knee amputations, are sutured under tension to the bone near its terminal end. This retention of the musculature, in its functional position and being subject to voluntary control, avoids excessive stump shrinkage, and decreases stump and phantom pain. It also provides an improved circulatory status of the stump with a proprioceptive feedback sensation due to a more intimate prosthetic fit. Tension myodesis results in a cylindrically shaped stump capable of contracting powerfully during gait, resulting in a more stable relationship between prosthesis and amputee stump.

Contraindictions for tension myodesis are few, but it should be noted that in a severe vascular involvement, the additional trauma of the technic might jeopardize the success of the amputation. However, it is still advantageous to use the benefits of the immediate post-surgical prosthesis even if conventional surgical procedure is selected.

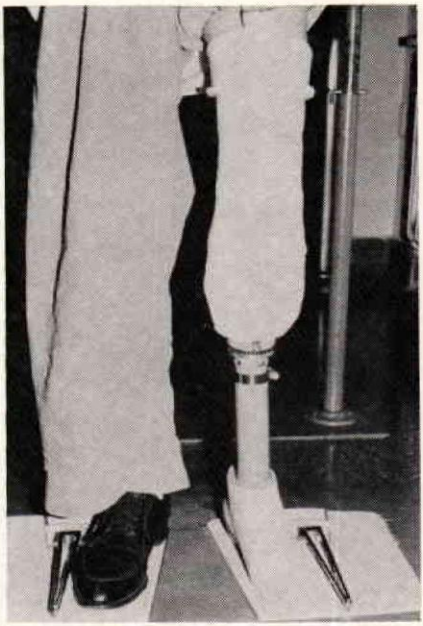

Figure 3—BK cast socket with adjustable wedge disk pylon and SACH foot.

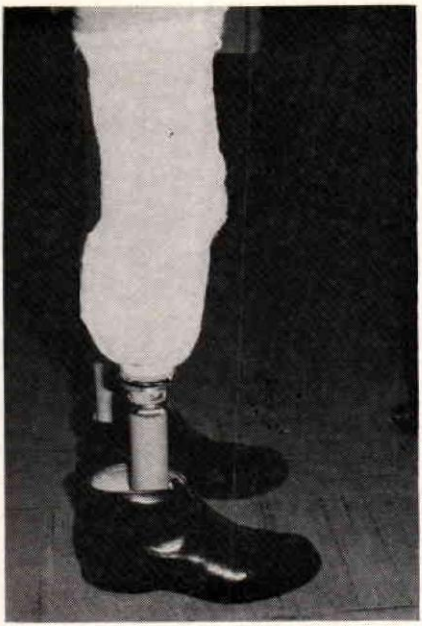

Figure 4—Lateral view of BK cast socket.

The wound is closed with interrupted sutures without excessive tension to the skin. A Penrose or suction drain is used in all cases to avoid the possibility of hematoma. The wound and sutures are then covered with a nonadherent Owens gauze dressing. Lambs wool or fully fluffed gauze is placed over the distal stump end and a special three ply Orlon/Lycra stump stocking of a corresponding size is gently rolled over the entire dressing and held in place with firm proximal pull to provide even, firm, but gentle pressure over the entire distal aspect of the stump and amputation site. The stump is now ready for the application of the cast-socket.

THE CAST-SOCKET

It is of utmost importance that the stump sock is suspended throughout the entire casting procedure to achieve adequate, continuous pressure relationships between the wound and the post-operative dressing. Felt strips 1½" wide, ⅜" thick, skived and beveled, are placed along both sides of the tibial crest and with the medial felt strip extending posteriorly to fit into the flare of the medial tibial condyle. An additional skived felt piece corresponding to the shape of the patella is fashioned, and all pieces glued in place with Dow Corning adhesive spray. The stump, held in 10° of flexion, is now wrapped beginning distally with firm controlled pressure and wrapping proximally to midthigh with decreasing tension to avoid proximal restriction. Elastic plaster of Paris is recommended because of its inherent quality to control desired tension, and its ability to conform to stump contours without tugging. Because of structural weakness, the elastic plaster must be reinforced with conventional plaster of Paris incorporating a 1½" safety buckle proximally to be used to suspend the cast-socket to the waist belt. Before the plaster wrap has hardened it is compressed slightly with

Figure 5—Syme cast socket with adjustable wedge disk pylon and SACH foot.

both hands proximal to the femoral condyles to provide additional cast suspension. A waist belt is applied to the patient and connected to the safety buckle on the cast. The prosthetic unit to be used is aligned in neutral position on the cast and attached with an additional roll of plaster of Paris. To allow for dynamic alignment changes, the unit selected should be adjustable in all planes. Next, the pylon is cut to the corresponding length of the sound extremity, the foot is attached, and the entire completed unit disconnected from the attachment plate. At this time the felt piece placed over the patella is cut out of the cast-socket and removed. This insures against possible abrasions and aids in determining if excessive piston action occurs during gait as a result of a loose cast.

In Syme and forefoot amputations, the knee joint is not included in the cast.

Due to the anatomical circumstances, of course, no felt reliefs are required in knee disarticulations and above knee casting procedures. However, after the initial wrap is completed, with the plaster of Paris still wet, the PRS developed casting fixture is applied to the stump to give the plaster socket a quadrilateral shape. Again, extreme care must be exercised to avoid proximal restriction. Since the previously used hip spica for cast suspension showed definite disadvantages, a suspension method was developed which allows the patient relative freedom of movement with increased comfort. The suspension consists of a 5″ wide webbing belt with a felt apron, and is attached to the socket by means of Bowden cables traveling through a housing incorporated into the cast. This arrangement suspends the cast-socket equally well regardless if the patient is supine or in a sitting position. The above knee unit for immediate post-surgical prostheses should incorporate the same features as the below knee and in addition include a manual knee locking mechanism with an adjustable friction device.

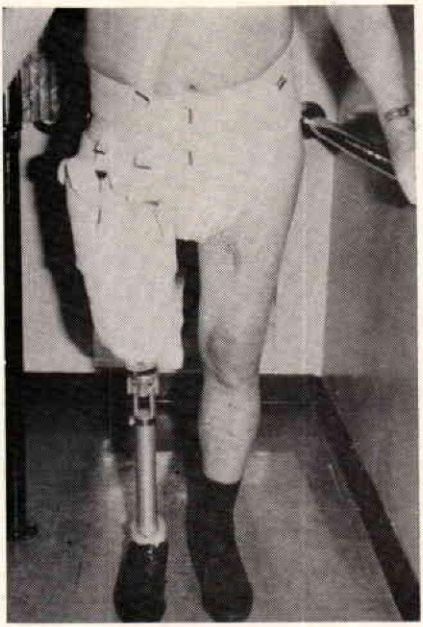

Figure 6—AK cast socket with adjustable wedge disk pylon, manual locking knee with adjustable friction. PRS Above Knee suspension system.

Figure 7—Same as Figure 6 as applied to knee disarticulation.

POST-SURGICAL AMBULATION AND MANAGEMENT

Circumstances and general physical condition permitting, it is standard practice to have the patient stand for a short period of time the day following surgery. At this time any necessary alignment changes will be corrected and attended to by the prosthetist. It is not unusual for the patient to experience relative freedom from pain, requiring little more than a mild medication for relief. The standing activity is attended and supervised by the physical therapist who will be in charge of the patient's post-operative course under the supervision of the attending surgeon. Progressively increasing weight bearing activities are continued twice daily for the next two or three days depending on the patient's motivation and general physical condition.

On the second post-operative day the drain is removed by cutting a window into the cast. The window is repacked with sterile fluff gauze and wrapped in place with a few layers of plaster of Paris.

Ambulation is initiated and increased progressively twice daily depending again on the patient's tolerance and motivation. However, actual weight applied at this time should not exceed 30 pounds. Because the technic and post-operative management usually provide a remarkable degree of post-surgical comfort, it is sometimes difficult to limit ambulation activities in patients, particularly in children. It is therefore extremely important that ambulation be supervised by a qualified physical therapist and practiced in accordance with pre-established instructions. The patient should ambulate between parallel bars with a gradual increase in duration and weight applied. Prosthetic alignment must be checked frequently and corrected if necessary in accordance with accepted biomechanical principles. Improper

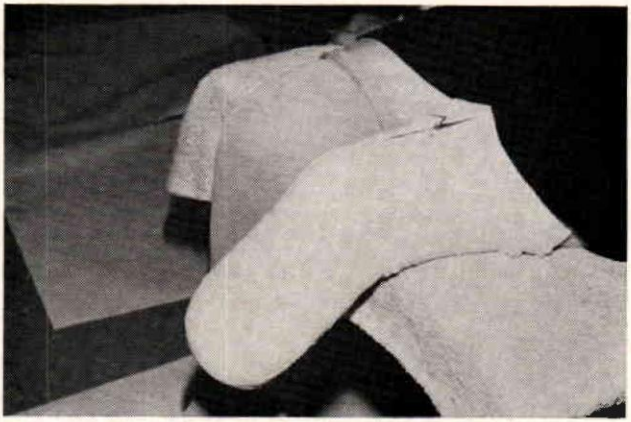

Figure 8—Rigid stump protector.

alignment will result in poor and painful gait and cause eventual damage to the tissues.

Unless clinical findings dictate otherwise, the initial cast change is usually between 10 to 14 days depending on the patient's age and general disability. In most instances, the sutures are removed at this time and the stump is recast in the same manner as previously. The day following the initial cast change, progressive ambulation activities are continued with the prosthetist present to reestablish dynamic alignment of the prosthesis. The patient can now proceed to crutch walking. However, at no time should the patient be allowed to ambulate without the prosthetic extension in place. The danger of the cast sliding distally will destroy the effectiveness of the entire concept of proper continuous pressure relationships, edema will develop, blistering can occur and with it, loss of the value of the entire technic.

The second cast-socket is generally left in place for an additional week to ten days. In most instances it is then possible to take the cast and measurements for the definitive prosthesis. The stump is rewrapped in a short removable plaster cast allowing knee motion and is to be worn whenever the definitive prosthesis is removed. This procedure will control possible stump changes until full stump maturation is achieved. It also guards against improper use of tensor bandages or stump shrinkers. (Fig. No. 8 Rigid stump protector)

It is absolutely necessary to fit and deliver the definitive prosthesis to the patient within a few days after the final cast change so as not to interrupt his ambulation, and to quickly complete his full rehabilitation cycle.

SUMMARY AND CONCLUSIONS

Immediate post-surgical prosthetic fitting of lower extremity amputees provides many definite improvements and benefits over conventional amputation surgery and management. With the ever increasing number of amputees, many can partake in the advantages the technic provides, with minimal disability time and financial hardship to the individual. The method can be adopted and used successfully at any modern medical center, providing meticulous attention is given to the details in the application of the technic. A thorough understanding of each team member, the surgeon,

prosthetist, and physical therapist, as to what is to be accomplished is of essence, but should provide final, gratifying results inherent in this method.

In closing, a word of caution: While the technic in its present stage as outlined above, is mature and sufficiently standardized to be used successfully by others, no attempt is made here to teach it or encourage its use. This is a report only on the current technic of immediate post-surgical prosthetic fitting and should be considered as such.

For clarification, the technic described here represents the current practices of the research team of the Prosthetics Research Study in Seattle, Washington, Ernest M. Burgess, M.D., Principal Investigator.

The work is conducted under Veterans Administration Contract No. V5261P-396.

Upper Extremity Orthotics: A Project Report †

by THORKILD J. ENGEN, C.O.*, LOUIS F. OTTNAT, C.O.**

Houston, Texas

The Department of Orthotics of the Texas Institute for Rehabilitation and Research (TIRR), in affiliation with the Baylor University College of Medicine, has conducted a clinical research program over the past four years to develop upper extremity orthotic systems that meet the complex requirements of simplicity, functional efficiency, and cosmetic acceptability. Existing components have been modified or redesigned and new components have been created in the process of developing individualized systems to meet a variety of patient needs. This paper will summarize improvements and innovations that have come about during the project period.

Engen Plastic Hand Orthosis

A promising achievement has been the development of a systematic method of hand splinting. A plastic hand orthosis, first described in 1959,[1] has been further developed and clinically evaluated during the project. It is

† Based upon a paper presented at the National Orthotic and Prosthetic Assembly, October 16-20, 1966, Palm Springs, California. The project was supported in part by Vocational Rehabilitation Administration Grant RD-1564. The facilities of the General Clinical Research Center for Chronic Illness were used in part for this project. The Center is supported by PHS Grant FROO-129 and Grant RT4 from V.R.A.

* Project Director; Director of Department of Orthotics, Texas Institute for Rehabilitation and Research; Assistant Professor, Department of Rehabilitation, Baylor University College of Medicine.

** Research Assistant and Orthotic Shop Supervisor, Texas Institute for Rehabilitation and Research.

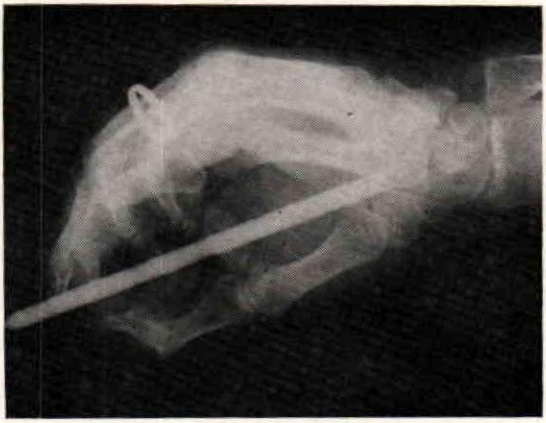

FIGURE 1

designed to serve as a standardized, mass-produced base unit that can be individually adapted. Various components can be added to meet the individual patient's requirements.

The present design of the plastic hand orthosis evolved from cineradiographic analysis [2] of normal hands in motion holding common objects (e.g., writing with a pencil (Fig. 1), self-feeding with an eating utensil, manipulating papers, pliers, and scissors, and using larger objects such as a drinking glass). This analysis provided a clearer understanding of the integrated musculoskeletal functions as they relate to normal activities and served to indicate where support could be given with the least hindrance to normal functional patterns.

With knowledge gained from the cineradiographic study, a standardized module was developed to serve as a foundation for various orthotic systems (Fig. 2[1]). Made of laminated polyester resins, this orthosis provides basic support to the metacarpal arch and the opponens muscle group, yet it allows passive digital mobility. The composition of the plastic permits the unit to be heat-reshaped to conform to the contour of the patient's hand. The orthosis is made in four sizes from master molds for both right and left hands.

Improvements have been made recently in the manufacture of the orthosis. A modified casting technique yields an extremely smooth inner and outer surface, eliminating the need for spray-paint finishing. Reinforcing pieces, made of fiberglass instead of Monel as formerly used, are laminated with epoxy resin into the radial side of the hand orthosis to assure structural stability and good joint surfaces.

Clinical experience verifies that the plastic hand orthosis is a practical way of meeting the patient's needs with minimum equipment. It can be adapted for the prevention or correction of deformities and can be incorporated into systems which utilize dynamic or external power (Fig. 2). The use of the prefabricated orthosis has greatly simplified individual fitting procedures. Although many problems were encountered in the early phase of its development, the practicality and soundness of the concept of using a prefabricated hand orthosis has been demonstrated in approximately 500 clinical applications.

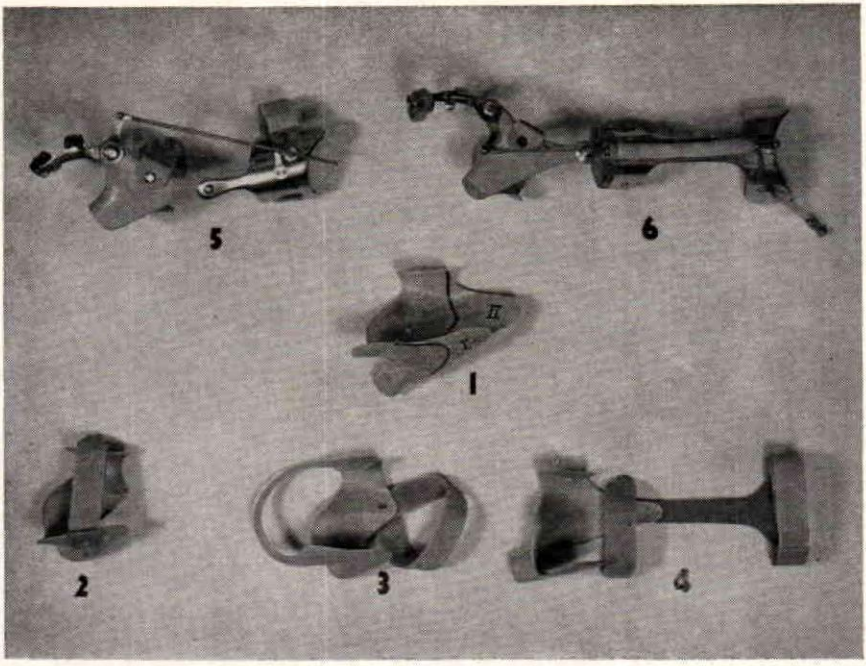

FIGURE 2

Illustrative Uses of the Plastic Hand Orthosis

Muscle imbalance due to neuromuscular disorders often results in malpositioning of the thumb and hyperextension of the metacarpophalangeal joints. Correction of this deformity may require permanent orthotic assistance, although temporary therapeutic or functional assistance during retraining is often adequate. By a simple trimming procedure, the plastic orthosis can be adapted into a short opponens and metacarpal support to realign the metacarpal arch and thumb opposition, thus preventing undesirable deformities and restoring useful function of the hand (Fig. 3).

Because of its form-fitting characteristics, the orthosis can be used for attachment of additional devices, such as a lumbrical support, or in conjunction with dynamic finger-extension assistance (Fig. 4). It can correct existing problems while preventing others, a factor that is vital to the patient's total program.

Figures 5 and 6 illustrate the plastic hand orthosis adapted to a patient presenting severe ulnar deviation of the metacarpalphalangeal joints due to rheumatoid arthritis. Passive volar and dorsal phalangeal support is incorporated for the purpose of correcting and preventing further deformity. The orthosis provides an excellent foundation for these corrective forces.

Another example of the systematic use of the plastic hand orthosis is seen in the patient with peripheral nerve injuries such as radial palsy. During the recovery and retraining period of such a patient, dynamic assistance is usually needed in thumb abduction, wrist extension, and the proximal volar phalangeal joints. This impairment may be either a temporary or a permanent condition, but in either case the type of device shown in Figure 7 is extremely helpful in maintaining or recovering hand and forearm functions.

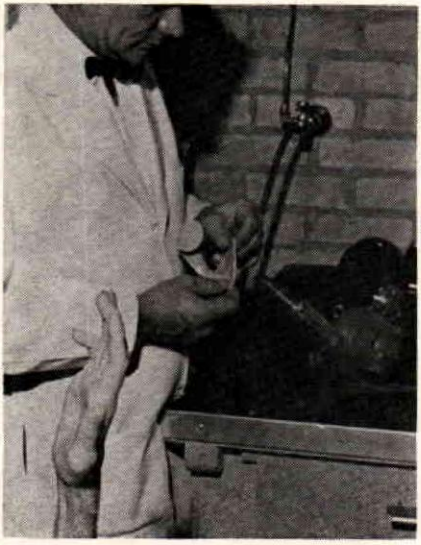

FIGURE 3

When the problem is one of restoration of function, it is important as always to utilize the patient's residuals as much as possible. For example, the patient with active wrist extension but no finger movement can have hand functions restored by reciprocal wrist extension-finger flexion orthosis. The action of wrist extension is utilized to bring about finger flexion by a simple mechanical linkage. Again, the plastic hand orthosis forms an integral part of the system.

The reciprocal unit has been improved as a result of knowledge and experience gained in the present research project. The functional limitations of the original orthosis were a confined range of motion within a fixed structural alignment of the hand in relation to the forearm. The cineradiographic analysis mentioned above served to emphasize the importance of the hand-to-forearm relationship in functional activities and resulted in the design of an adjustable telescopic rod which was developed in 1963 and described in 1964.[3] This orthosis gives the patient prepositioning ability and permits finely adjusted finger prehension so that a wide range of activities can be performed from holding a cup to picking up paper (Figs. 8 - 9). The adjustable telescopic unit is activated by the patient's opposite hand or by pressing the activating button against a stable object such as a lapboard. This releases the telescopic rod and enables new positioning of the hand. Release of pressure locks the rod in the new position. Approximately 375 adaptations of this orthosis have been applied and clinically evaluated. At ties can be performed from holding a cup to picking up paper (Figs. 8 - 9). TIRR, the patient who is a candidate receives his finger prehension orthosis as early as possible, even while in bed or in a reclined position. This has proved to be of great psychological value by permitting the patient to be engaged in purposeful activities during some part of the day.

Patients can be divided into three categories which typify the objectives of application of the reciprocating finger flexion orthosis. In the first group, the orthosis is applied in an early stage of convalescent care, and the patients gain enough residual movement so that eventually the orthosis is not needed. The second category use the orthosis for therapeutic value and

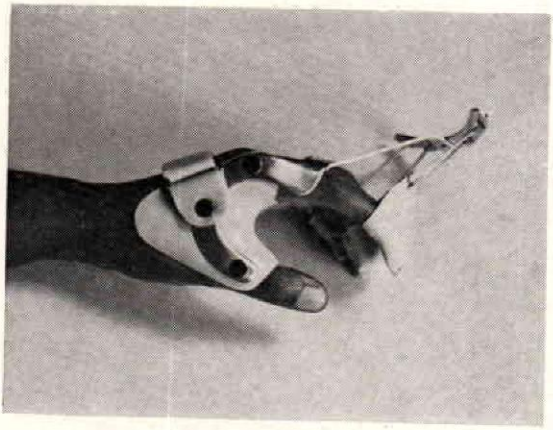

FIGURE 4

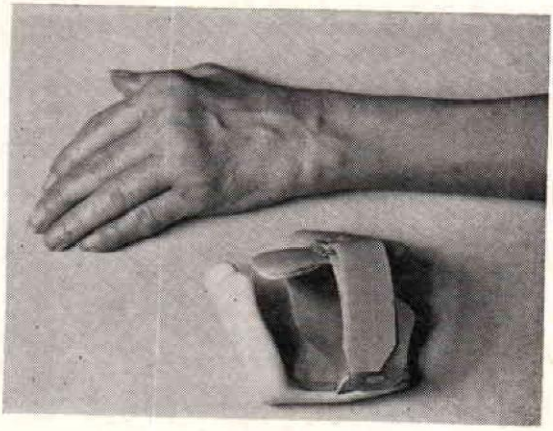

FIGURE 5

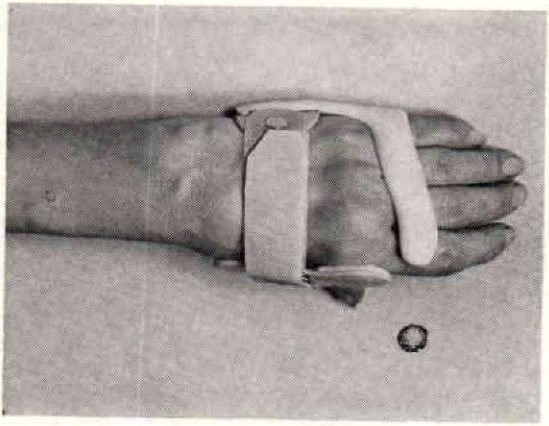

FIGURE 6

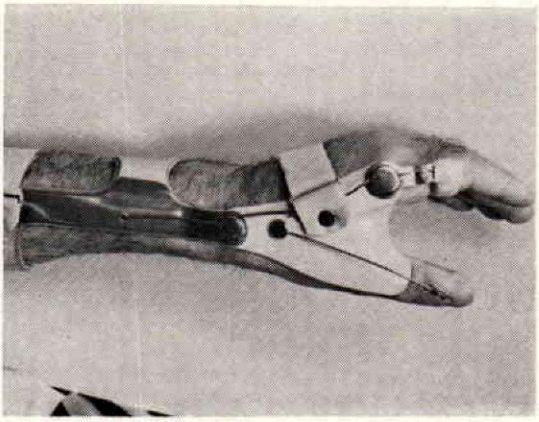

FIGURE 7

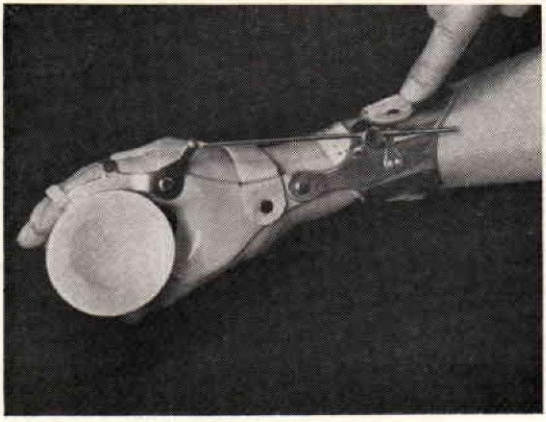

FIGURE 8

FIGURE 9

FIGURE 10

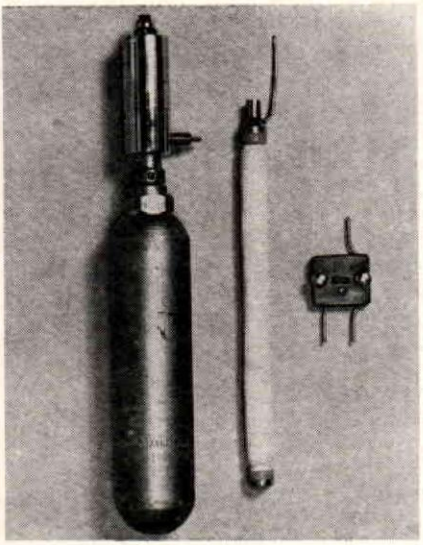

FIGURE 11

find that while they have enough residual function to carry out gross activities, they depend upon the orthosis for writing and manipulating small objects. The third group of patients, which constitute the majority, remain totally dependent upon the orthosis for all functional activities (Fig. 10).

In all the applications it is imperative that the patient be thoroughly trained in the practical use and limitations of the equipment. This essential phase of the rehabilitation program is carried out at this institution through close collaboration of the Orthotics Department with Physical Therapy and Occupational Therapy.

External Powered Orthotics

Many patients survive with severe functional deficit of the upper extremities as a result of trauma in the cervical region of the spinal cord, polio, or other pathological reasons. The only practical method of dealing with the functional problem in these cases is by the use of external power. Several extremely promising and significant programs in the development of externally powered systems are being conducted, nationally and internationally, in the fields of both orthotics and prosthetics.[4, 5, 6, 7, 8, 9, 11, 12] The project discussed here has dealt exclusively with the development of orthotic systems employing pneumatic power.

Patients with spinal cord severance at the C-5, 6 level maintain almost normal movement in the shoulder and upper arm but have a chronic functional deficit of the hand and wrist. An externally powered finger prehension orthosis with wrist friction joint has proved beneficial in restoring function to this group of patients. The major components of the system (Fig. 11) consist of the power actuator in the form of the McKibben Muscle Substitute,[10] compressed carbon dioxide as a source of energy, and a specially designed control valve for activation.[4] The activating mechanism is a simple mechanical valve consisting of a spring-loaded arm which occludes a small silastic tube to stop or permit the flow of gas under pressure. The control is located wherever the patient can operate it with the least conscious effort.

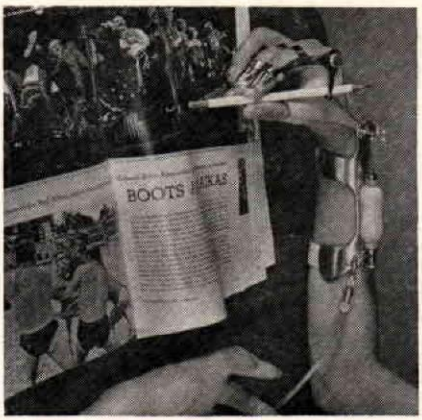

FIGURE 12

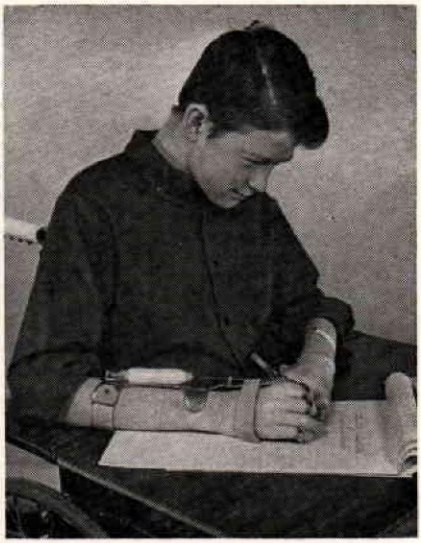

FIGURE 13

This system permits the patient to obtain smooth, gradual, and finely controlled movements of the powered functions that approximate normal motion. Four years of experience with this system has given convincing evidence that it provides the patient with substantial and reliable functional gain with minimal mechanical complexity, an important factor in meeting the requirements of cosmesis and acceptability by the patient.

The standardized plastic hand orthosis is routinely used as a Foundation for this finger prehension device. Versatility is increased by incorporating a friction joint at the wrist, permitting the patient to pre-position his hand voluntarily. The power actuator is located on the radial side and is attached by a cable to the distal end of the spring-loaded finger unit (Fig. 12). Upon contraction of the power actuator, the index and second fingers are moved toward the opposed stabilized thumb, resulting in a chuck-type prehension. This externally powered prehension orthosis has been adapted to 40 patients (Fig. 13). The unit is generally applied to the dominant extremity, though some have been used bilaterally.

An externally powered arm orthosis has been developed for patients who have lost all function in the upper extremities except the motion of raising and lowering the shoulder girdle. This situation occurs in patients with spinal cord lesions at the C-4, 5 level. Again, the patient's musculoskelatal structure is utilized as the biomechanical part of the device. Two power actuators are used in this system, one to flex and supinate the forearm and another to abduct the extremity. These are activated by the patient separately or in combination, depending on the movement he wishes to perform. The abduction unit utilizes the vector parallelogram principle, permitting horizontal movements independent of the powered elevation movement. A coil spring which minimizes the gravity forces imposed by the extremity is incorporated into the system to assist the power actuator in attaining maximum efficiency. The elbow flexion unit is linked to the abductor by a swivel arm. The proximal end of the power actuator is located slightly above the fulcrum of the elbow joint, and the distal end is attached near the radial side of the orthosis. When contracted, the orthosis produces the combined motion of elbow flexion

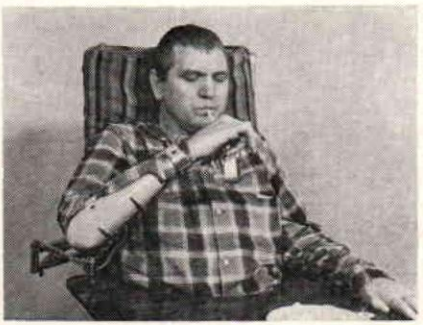

FIGURE 14

and supination (Fig. 14). Twelve arm units have been adapted and are being evaluated.

Patients will usually respond favorably to treatment programs while hospitalized, using their devices under supervision. It was desirable, however, to ascertain whether the equipment was being used as intended in their home environment. Questionnaires were therefore devised requesting information from patients at home regarding the powered equipment. Questions concerned functional use and acceptance of the system, problems encountered with the unit, and suggestions for improving the orthosis in design or usefulness. The questionnaires were mailed to 30 patients, and the replies strongly indicate the soundness of the external power concept.

Reported activities employing the orthosis include self-feeding, personal hygiene (brushing teeth, washing face, shaving, applying make-up, combing hair), and avocational activities such as playing cards, checkers, or dominoes, typing with electric or manual typewriter, turning pages, writing with ball point pen or pencil, and handling a telephone. Four patients are employed. Their occupations include account executive, computer programmer, office assistant, and housewife. Six others are attending school. Two of these are in high school and the rest are in college studying art, computer science, civil engineering, and electrical engineering.

The average length of wearing time at home is approximately five hours a day. Suggestions for improvement made by questionnaire respondents reflect individual needs and desires, since the goals the patient wants to accomplish determine the aid he expects from the unit. For example, one patient suggested that the lapboard be designed more individually to meet work requirements by adding a small drawer for utensils and other articles. It was gratifying to note that no one mentioned problems with discomfort or skin breakdowns.

Just a few years ago, restoration of worthwhile function to individuals with severe upper extremity impairment was mere wishful thinking. Today, although further research is needed to improve them, powered systems have already proved to be of great usefulness. External power has enabled the majority of quadriplegics seen in this project to at least perform activities of living from a wheel chair level. Many of them can perform avocational activities and some have become gainfully employed.

We have reached a plateau with our adaptations where numerous functions can be restored by these devices; but in order to establish a foundation for further progress, more knowledge is needed of joint relationships that occur in musculoskeletal action during normal upper extremity movements.

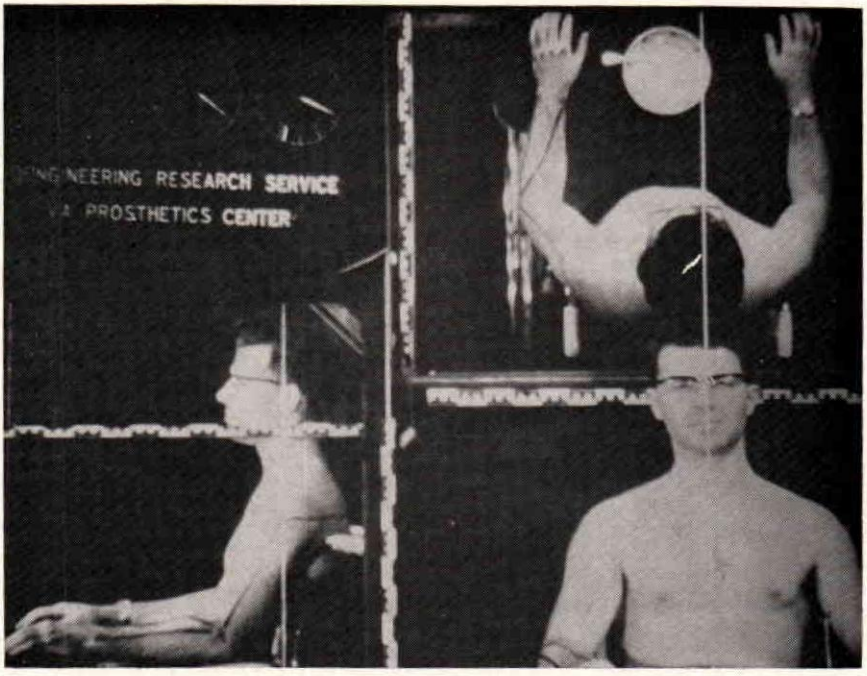

FIGURE 15

It is questioned whether our present designs incorporate sufficient degrees of mechanical range of motion and whether these motions are as well coordinated as in normal movements. Furthermore, lack of knowledge concerning head and upper torso involvement in these normal movements may result in the supplantation rather than maximum use of residual body functions. Attention to these issues will facilitate continued progress in the fields of orthotics and prosthetics.

Kinematic Studies

To investigate the aforementioned issues, the Department of Orthotics at TIRR is conducting studies of velocity and acceleration of the biomechanical functions of the upper extremities while purposeful daily activities are being performed. The objective is to study the functional coordination between the eye and the hand to obtain a better understanding of the requirements of orthotic components for maximum integration with residual body function.

In collaboration with the Bio-Engineering Laboratory of the Veterans Administration in New York, nine normal subjects have been photographed performing the five basic motions of table-to-mouth feeding, hair grooming, page turning, writing, and diagonal reaching from a sitting position. These activities involve three of the most important levels of hand movement: table, mid-torso, and head. To obtain a fairly representative sample of human physiology, subjects ranging from slightly obese to tall, thin individuals were used in the study. To determine whether the equipment hinders normal upper extremity movement, two identical sequences were taken of each subject, first without orthotic equipment and then with the arm orthosis without external power.

A 35 mm. movie camera was placed 20 feet from the subject. The addition of two mirrors positioned at 45-degree angles to the subject, one above the head and one at the side, made it possible to obtain three visual perspectives simultaneously: front, side, and top. Time clocks calibrated to one second and one hundredth of a second provided references for determining the velocity and acceleration of each motion. A black felt pen was used to identify the landmarks on the subject at the metacarpophalangeal joints, the styloid processes, the lateral epicondyle of the elbow, and shoulder joint (Fig. 15).

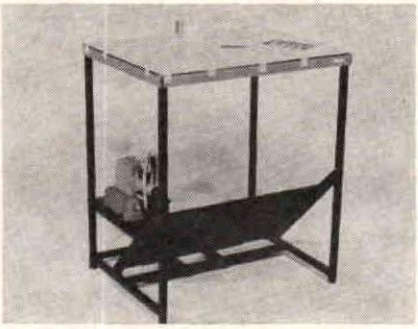

FIGURE 16

In analyzing the volume of film data, a special mirror arrangement and a standard film strip projector are used to project the three perspectives of the subject onto a glass screen covered with translucent acetate for plotting (Fig. 16). As the film is advanced frame by frame, the selected landmarks in each view are identified in black on the acetate. Once the action is completed, the plotted points are connected with lines to delineate the pattern of movements and the related angulation and acceleration between successive points.

The analysis utilizes only those motions whose points of reference are clearly visible in each view from beginning to end of the sequence. Figures 17 and 17a show the beginning and ending views of the diagonal reaching activity. The head movement is visible throughout the sequence, as are shoulder flexion and adduction and elbow extension. The plotted diagram, superimposed on both the beginning and ending view, graphically illustrates the sequential pattern of biomechanical activity. One notes the correspondence of acceleration and terminal deceleration between the head and forearm. The forearm accelerates rapidly in the beginning of the action and slows as it reaches the terminal point. The head moves similarly, while the hand remains in a neutral position throughout the activity. As the detailed analysis of these diagrams continues, measurements will be taken of the degree of angulation of the lines at each point of reference separated by equal time intervals but varying distances.

Another function being studied is hair grooming. This activity was separated into two phases, phase one showing the activity being performed on the right side of the head and phase two showing the subject grooming the left side. The beginning and ending motions of phase two are shown in Figures 18 and 18a with the interim movement pattern superimposed. In the begining motion, the hand is in the middle of the forehead; the shoulder is adducted horizontally, flexed and elevated; the forearm is slightly supinated; and the head is turned slightly to the right. It is evident that most of the activity occurs in the shoulder joint, but significant participation of the head and upper torso is also readily apparent, indicating the important

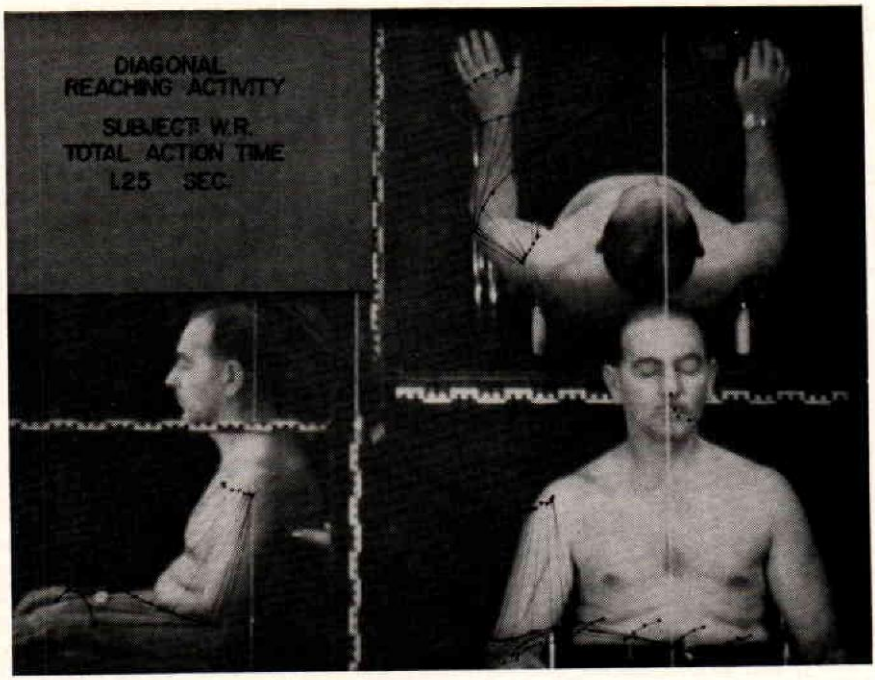

FIGURE 17

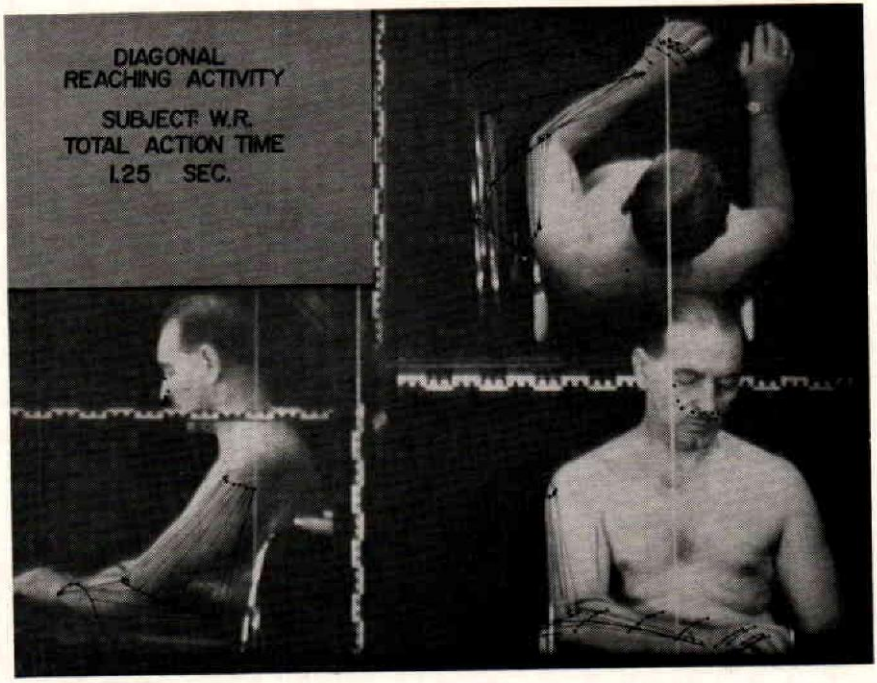

FIGURE 17A

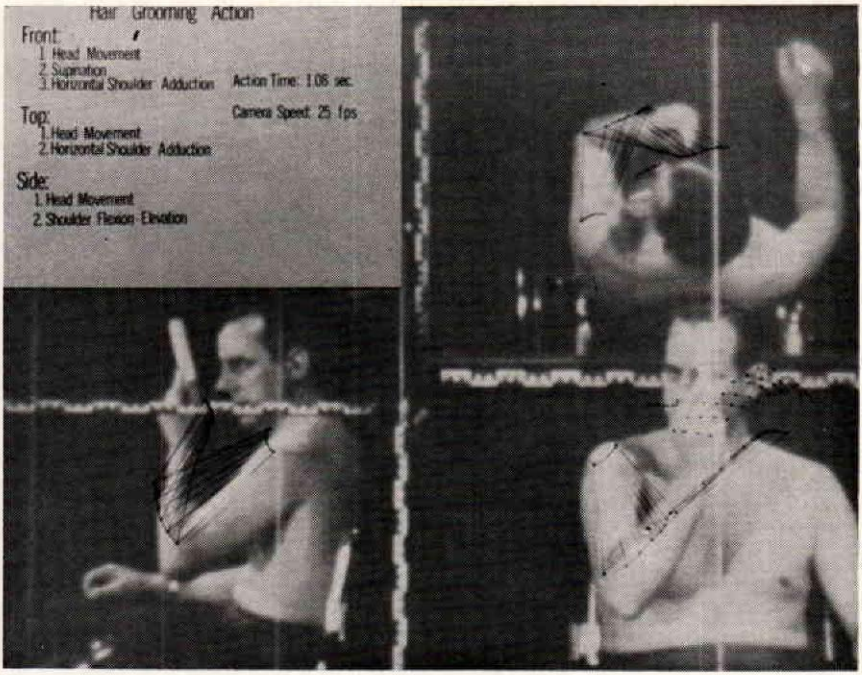

FIGURE 18

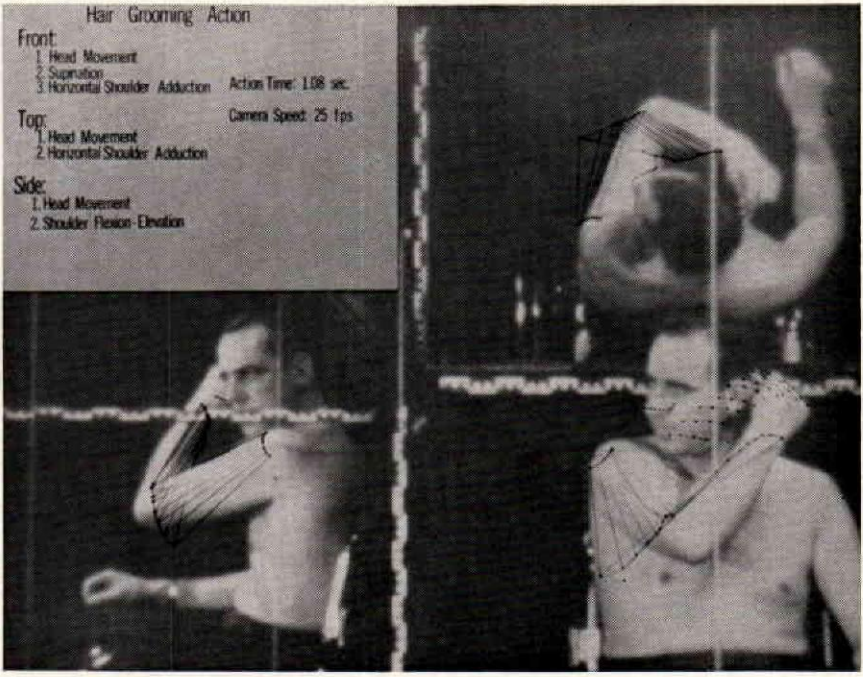

FIGURE 18A

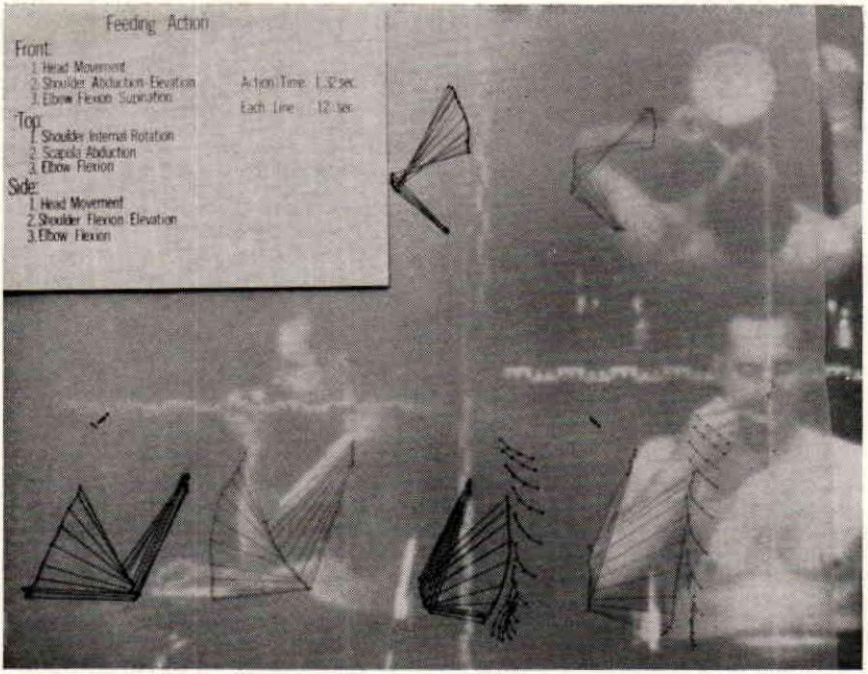

FIGURE 19

correlation of these functions. The head and torso movements are often overlooked as a part of the total pattern in this activity.

One of the functions most important to the severely impaired individual is self-feeding. This action is a combination of more synchronized joint motions than any other activity being studied. Head movement, abduction and elevation, internal rotation, and shoulder flexion are combined with elbow flexion, humeral rotation, and supination of the hand in this action. Figure 19 shows complete diagrams for two subjects performing self-feeding, the diagram for one subject superimposed adjacent to that of the other. Comparison of the two diagrams shows that the pattern of sequential movements is nearly identical in acceleration, velocity, and angulation. The only difference is in size of the diagrams, a factor determined by differences in the subjects' physical stature.

Analysis of the film data on three of the nine subjects has been completed. Analysis of the remaining data should establish a reasonably stable mean for each of the five patterns of movement. The same procedure will be followed in filming patients using powered assistance, and the diagrams thus obtained will serve as the basis for comparative analysis. Although this motion analysis is still in the preliminary stage, the evidence indicates that it will broaden our understanding of the biomechanical relationship between joints as purposeful activities are performed. It should identify the mechanical changes and design revisions needed to improve the overall function of the more sophisticated orthotic and prosthetic systems.

Adjunctive Developments

The plastic hand orthosis and its application in various upper extremity systems was selected by the National Research Council of the National

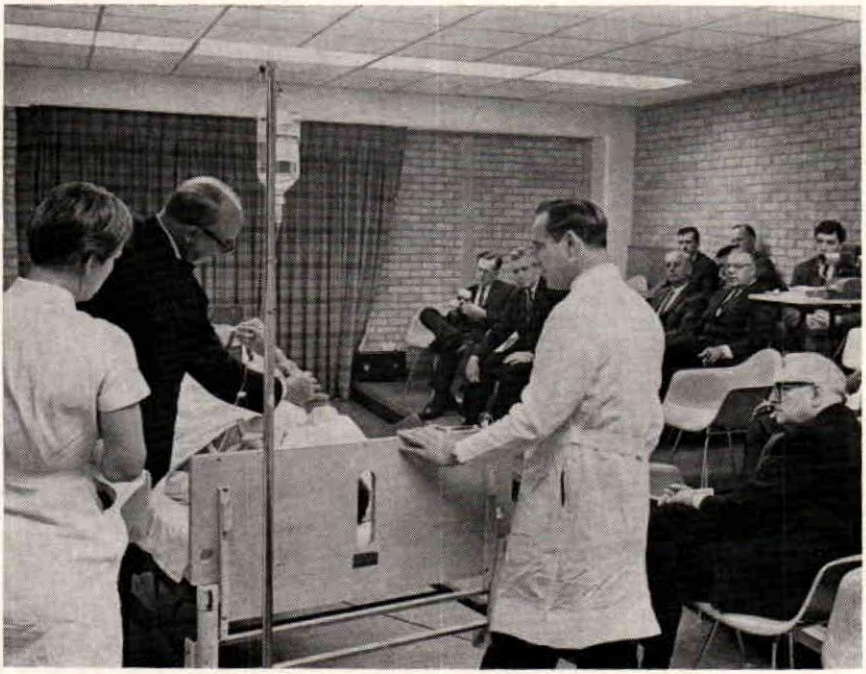

FIGURE 20

Academy of Science for inclusion in its field evaluation of research developments in orthotics and prosthetics. An orthotics course was held at TIRR in the Department of Orthotics in December, 1966. Four clinic teams of physicians and orthotists, selected by NRC, were given orientation to the clinical use of the plastic hand orthosis (Fig. 20). Detailed instruction was given in the fitting techniques for three devices in which the plastic orthosis is used: the short opponens, the long opponens, and the reciprocal wrist extension-finger flexion orthosis. These clinic teams were provided with a written project evaluation plan and components of orthotic systems to be applied and evaluated in their own institutions. At this writing the evaluation is still in process.

In August, 1965, a preliminary draft of an instruction manual was prepared which gave detailed instructions for utilizing and fitting the plastic hand orthosis and necessary components for a reciprocal wrist extension-finger flexion unit. This manual is now being revised because of recent equipment modifications and in the light of experience gained during the instruction course for the four clinic teams. This revision will involve expansion of the systematic approach to include application of the plastic hand orthosis as a foundation for numerous other orthotic systems. In addition, illustrations will be greatly improved through use of line drawings (Fig. 21).

Acknowledgments

This project could not have been conducted without the assistance and cooperation of the staff of Texas Institute for Rehabilitation and Research, especially the members of the Department of Orthotics. Special appreciation is extended to Dr. W. A. Spencer, Dr. P. R. Harrington, and Dr. L. A. Leavitt for their continued encouragement and technical advice at critical points

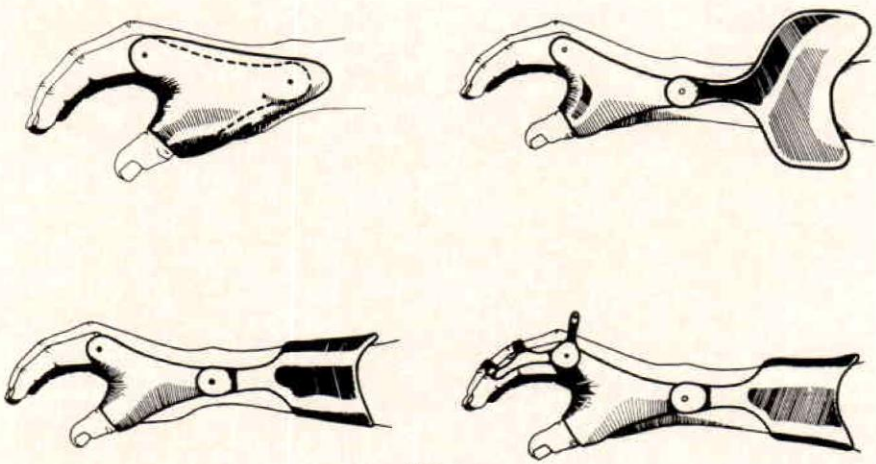

FIGURE 21

during the project, and in their consultative function on the TIRR Orthotic Committee. The editorial assistance of Dr. Kenneth E. Ware in preparation of the manuscript is gratefully acknowledged.

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Plastisol Coatings and Application Techniques

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and

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Braces and splints that apply supporting and corrective forces to the human body have traditionally been covered with various types of leather. At present, however, good leather hides are becoming very expensive and difficult to obtain. The problems involved in using leather have motivated research in the use of plastic materials and new covering processes to replace leather coverings. Ten years ago a polyvinylchloride-based material called plastisol was introduced as a covering material for hand splints. Since then this process has been used both experimentally and clinically at the University of Michigan Medical Center.

The effectiveness of a plastisol covering on hand splints led us to investigate the use of this material on other items such as back braces and leg-brace bands. Our first coating formulation was limited in application because of its high coefficient of friction and uncontrollable density, and the fact that no well-defined criteria for the coating process had been established. However, there remained the desirability of a smooth, encapsulating covering that could be applied simply by dipping the heated brace in the liquid material. Therefore a study was undertaken to characterize plastisol in detail and to perfect the dipping process. The resulting procedure is being effectively used on back braces, leg bands, pelvic bands, mouth sticks, hand splints, and brace straps. Clinical applications over the past five years tend to confirm the usefulness, acceptability, and advantages of this plastic covering.

I. PLASTISOL MATERIAL DESCRIPTION

A. *Chemical Composition and the Fusion Process*

Plastisol consists of a dispersion of fine vinyl resin particles in a plasticizing oil. Vinyl dispersion describes the nature of the material and the process by which the liquid plastisol is made. The resin particles absorb some of the plasticizer at room temperature and are held in suspension. When the resin is heated, the absorbing action is rapidly increased. Plasticizers remain in the plastisol material after fusion and import a flexible nature to the material.

These vinyl dispersions have additives such as light and heat stabilizers, pigments if color is desired, fillers, and other modifiers. Since plastisols have no solvent or water to evaporate, they are relatively simple to use and do not

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require elaborate venting of the curing oven. The plastisol formulations are stable for long periods at room temperature. Cans of liquid plastisol will not dry out or "skin over" during long periods of storage, even if left uncovered.

Dipping, i.e., immersion of an object in the liquid, is one of the oldest production methods used with vinyl dispersions. Dipping is divided into two types: hot dip and cold dip. Hot dipping is usually the simpler of the two methods and has been used in this study. Cold dips are generally used for objects such as wire baskets which will not hold as much heat as is required in the hot dip method. A special formulation is required if the material is to be cold dipped.

In hot dipping, heat transfer from the heated metal piece to the room temperature liquid causes the formation of a gel coat on the metal part. The thickness of the gel coat depends on the amount of heat transfer. The gel coat thickness can thus be controlled by the thickness and temperature of the object being coated. This gel coat has little or no mechanical strength because it is formed by swelling of the resin particles by absorption of the surrounding plasticizer. The swollen resin particles are then held together by physical contact only. Because the resin particles are not fused together, the gel coat is weak and crumbly, much like a piece of cheese. When the coated part is placed in the curing oven, however, the particles of resin fuse into a tough thermoplastic material, with the plasticizer acting as a lubricant between the vinyl molecules. The relative amount of plasticizer in the composition determines the flexibility of the product. Insufficient curing time or temperature will not fuse all the resin particles, leaving part of the plastisol in the crumbly gelled state. Over-curing due to excessive temperature or prolonged curing times causes a partial degradation of the material and alters its appearance and physical properties.

B. *Physical Properties of Plastisol*

Because the strength of the foamed plastisol is much lower than the regular plastisol, care should be taken to use this material only when a compressive force situation exists. The foamed material is not suitable for a tensile or shear force situation.

Cost and weight are two additional factors affecting the practicality of plastisol as a brace covering. Several brace parts were covered with leather or plastisol and the part weights compared. A band from a leg brace required 40 grams of regular plastisol to give the same covered size as 25 grams of sewn leather and felt. Thus, a plastisol covered brace is heavier than a leather covered brace if the covering volumes are equal since regular plastisol is more dense than leather. A brace properly covered with plastisol, however, will have less volume of covering than a leather covered brace. The plastisol need not extend $\frac{1}{4}$" to $\frac{1}{2}$" beyond the load bearing metal framework to allow for stitching as does leather. A narrower band may be used with plastisol because of the excellent surface continuity compared with the rough broken surface produced by stitching of the leather covering. Therefore, a plastisol covered brace can be equal in weight or only slightly heavier than a similar leather covered brace.

The cost of plastisol is approximately $10.00 per gallon or $1.00 per pound. The material cost for the leg band previously mentioned is thus less than 10 cents, only a fraction of the cost of leather covering. The time required for applying the plastisol to a single band is similar to that required for sewing of a leather covering. Plastisol's labor saving advantage becomes highly significant when an assembled brace is coated. It requires no more time to heat, dip and cure a complete brace than a single part. The

leather covering time, however, increases in proportion to the area covered. Plastisol covering thus offers an economic advantage from both the material cost and labor cost aspects. In addition, plastisol offers longer life which reduces replacement costs.

C. *Toxicity**

Certain materials when placed in contact with the skin may produce a reaction, either through the mechanical action of the two surfaces rubbing together, or by chemical reaction between the substance and the skin. A "patch test" was used to check for reactions souch as redness, irritation, inflamation, or eruption. Samples of plastisol and horsehide were placed on 53 subjects, 28 in the lumbar area of the back over the erector spinae muscle, 3 in the upper back between the scapulae, and 22 in the shoulder region over the deltoid muscle.

After 47 to 50 hours the patches were removed and the skin examined for evidence of irritation. Of the 53 subjects, three showed a reaction. One subject developed erythema under the leather patch, the plastisol patch, and the tape which held the patches in place. The erythema in each of these areas lasted 4 to 6 hours. Another subject developed mild erythema localized to the area under the plastisol patch. In this case the redness disappeared in a few hours. Erythema developed under the leather patch in the third subject. Twenty-four hours later this reaction cleared up.

None of the plastisol patches discolored from the test, but in many instances the skin under plastisol was found to be moist. This is attributed to the nonporous and nonabsorbent nature of the plastisol. The leather, however, absorbed perspiration and became moist or saturated and discolored.

Forty-eight hours after the patches were removed the subjects were again examined and did not show any new signs of positive reaction or any residual signs of reactions. The major significance of this test is that it shows plastisol to be less affected by body contact and that plastisol patches produce no more skin reaction than did leather patches.

II. DETAILS OF THE BASIC COATING PROCESS

Essentially, the coating process involves the transfer of heat from the metal to the liquid plastisol, which forms a gel on the metal surface. This very weak, soft material then must be cured in a hot oven to fuse the resin particles in the liquid dispersion to form a tough coating on the metal part.

The six steps involved in coating a metal part are: (1) metal preparation, (2) preheating of metal, (3) dipping, (4) surface sealing, (5) curing, and (6) cooling and finishing. Proper control of each step is important in obtaining optimum results. Useful variations in results can be achieved by controlled alterations in the basic steps.

A. *The Six Basic Steps in Plastisol Coating*

1. Metal Preparation

Durability and appearance of the final coated product depend to a considerable degree on the care taken in preparing the metal part. Sharp metal edges give an internal cutting effect which causes a breakdown in the

* The authors are indebted to Michael Schermer, a University of Michigan medical student in the Class of 1969, for his assistance in conducting tests on toxicity and coefficient of friction.

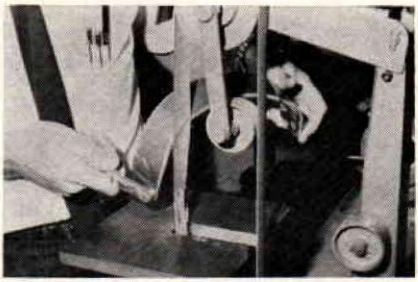


Figure 5—Preparing Metal.

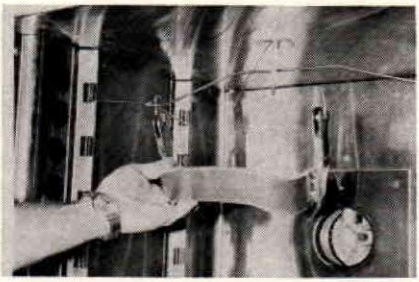


Figure 6—Preheating Metal.

coating from forces applied over the sharp edge; also the coating is thinner at sharp edges. Plastisol coating should not be used to cover poor metalwork. Well-rounded edges on the metal parts are easily produced by a fine belt sander, Figure 5, or filing or grinding. Contours and curves should be smooth and flowing to avoid abrupt changes in cross-section or configuration.

2. Preheating

Since gelling of the liquid plastisol on the metal part is caused by heat transfer, it is necessary to preheat the part to be covered, Figure 6. The thickness of the coating depends on the amount of heat transferred. The heat transfer rate in turn depends on the temperature of the metal part, its specific heat and conductivity, and the mass of the part compared to its surface area. Thus, the coating thickness is governed by the thickness of the part as well as the temperature to which it is preheated, Chart 1. Preheating is usually done in an oven at 190° to 220°C for five to fifteen minutes depending on the coating thickness and thickness variation desired.

Considerable time is required to heat a cold metal part to the desired dipping temperature even in a hot oven, and the thicker the part, the more time required. Chart 1 shows results of a thermocouple test in which various thicknesses of aluminum were placed in an oven at 195°C. It is desirable to use the same oven temperature for the preheat step as for the curing step so that the oven does not have to be adjusted between steps. A single setting is advantageous too, in that it allows preheating and curing of several pieces simultaneously.

3. Dipping

The preheated metal part is removed from the oven with appropriate tools such a pliers or hooks and immediately dipped into the liquid plastisol, Figure 7. Gelling of the plastisol on the part continues as long as sufficient heat transfer takes place between the object and the surrounding liquid, thus the amount of heat transfer determines the thickness of the coating, Chart 1. The gelling process usually terminates in about two minutes if the parts are of moderate thickness. If the part is removed before gelling is complete, the coating will sag and gel further as the part is drained, creating an irregular surface. When the gelling process is terminated, in one to three minutes, the part should be slowly lifted from the plastisol bath and suspended for draining, Figure 8. Several minutes should be allowed for the liquid material to drain off.

4. Surface Sealing

Next the surface must be sealed (surface molecules gelled to prevent further sagging) by rotating the dipped part above a soft Bunsen burner

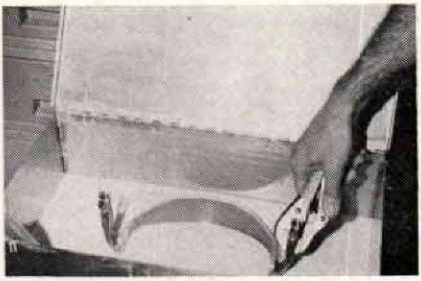


Figure 7—Dipping.

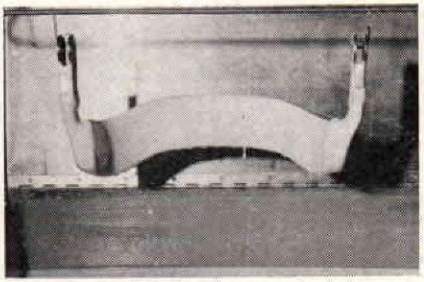


Figure 8—Dripping.

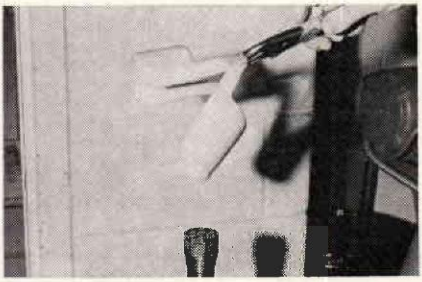


Figure 9—Flame Sealing.

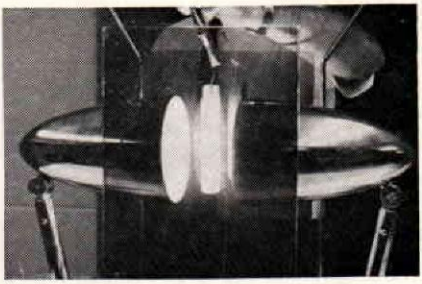


Figure 10—Light Sealing.

flame, Figure 9, or by rotating it between two infrared lamps, Figure 10. If the plastisol surface is not sealed, the coating will "melt" and drain away when the object is placed in the hot oven for curing. The dipping-and-sealing step is the most critical stage in the procedure, requiring considerable practice and skill.

5. Curing

In order to produce a tough, durable coating on a brace part, it is necessary to fuse the resin particles in what is called the curing step of the process. Since we are dealing with coating thicknesses of 1/16 to ¼ inch, considerable time is required for heat transfer from the curing oven to the inner part of the plastisol coating. This process depends on time and temperature, just as in roasting meat, which must reach a certain temperature at the center in order to be "done" to the desired degree. Chart 2a indicates the relationship between coating thickness, curing oven temperature, and curing time required to give the desired coating strength. Curing is best accomplished in oven temperatures ranging from 190° to 200°C for ten to twenty minutes, depending on the part and coating thickness. It should be noted that insufficient cure due to inadequate curing time or oven temperature results in a very weak coating. Since increased oven temperature reduces the time required for a complete cure, there is a tendency to increase the oven temperature beyond tthe recommended limit; however, while this may quickly cure the outer surface of the plastisol coating, the interior will be under-cured. Excessive oven temperatures may also cause discoloration of the surface before the inner part of the coating is completely cured.

6. Cooling and Finishing

After curing, the part is removed from the hot oven and either suspended for air-cooling or cooled in water. Because plastisol is a good

insulator, the coated metal part may take several minutes to cool even in cold water. The plastisol coating does not reach its full strength and firmness until it is fully cooled.

Following the cooling of the coated part, the plastisol material may be stripped from any portion of the brace which is to be left bare. Any hooks or supporting devices which were used during the curing process may now be removed and the plastisol trimmed to give a neat appearance. It has been found that a scalpel or heated knife is handy for trimming and removing surface imperfections. Light sanding with fine sandpaper is also good for removing surface imperfections. Roughened surfaces can be smoothed by application of heat, either a Bunsen burner or in the curing oven at a high temperature. Care must be exercised, however, to prevent breakdown of the plastisol by the high temperature.

COATING PROCESS REVIEW

1. *Metal Preparation*—Clean the surface and round all edges (polishing not necessary).
2. *Preheating of Metal*—The metal parts must be given sufficient heat content to pick up the desired coating thickness. Preheating is usually done in an oven at 190° to 220°C for five to fifteen minutes depending on the coating thickness and thickness variation desired.
3. *Dipping*—The preheated metal part is dipped into the liquid plastisol for several minutes until the heat has been dissipated and the desired coating thickness attained. The part is then slowly removed and the excess material allowed to drain off.
4. *Surface Sealing*—Next the part is rotated above a soft Bunsen burner flame or between two infrared lights to seal the coating surface quickly. Sagging during the curing step is thus prevented.
5. *Curing*—The dipped and sealed part is placed in the curing oven at temperature of 190° to 200°C for ten to twenty minutes depending on the part size and coating thickness. During this step the polyvinylchloride resin particles undergo fusion, to form the desired tough plastisol coating.
6. *Cooling and Finishing*—After removing the part from the curing oven the handling hooks are removed and the coating is trimmed and sanded to obtain a neat appearance. The part is then ready for use.

B. *Plastisol Coating Equipment*

The requirements outlined here involve equipment that will be needed in addition to that normally found in a brace shop equipped with metal-brace fabricating tools. Application of the plastisol coating requires additional equipment for heating the metal parts, dipping them, and sealing and curing the plastisol coating. Small tools for handling the hot parts are normally a part of brace ship equipment. A timer is a refinement which makes control of the process easier; otherwise a wristwatch or clock may be used.

Metal preheating and plastisol curing are best accomplished in a thermostatically controlled gas or electric oven, Figure 11, which has some sort of forced circulation and a vent for the slight fumes produced during the final curing process. The thermostat should be able to control the oven temperature to within 5° of the desired set-point since a larger variation will reduce controllability and thus affect the quality of the finished parts. A glass

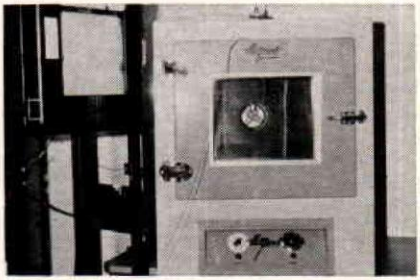


Figure 11—Preheating and Curing Oven.

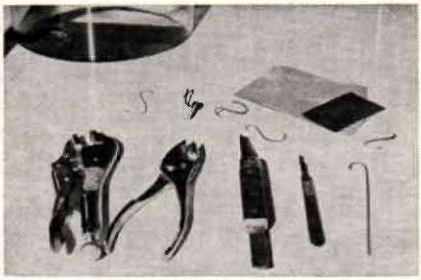


Figure 12—Small Tools Required.

panel in the oven door is essential for observing progress of the curing; the onset of discoloration that warns of overcure can be quickly detected. The oven should have rods or a rack near the top of the interior chamber for hanging the parts to be heated or cured.

Since the liquid plastisol does not evaporate or age appreciably under normal room conditions, it is not necessary to have an air-tight dipping container; however, the container should be covered when it is not in use, to prevent accumulation of dust or dirt particles on the plastisol surface. The can in which the material is purchased can be used as the dipping container, but a specially prepared tank or glass container may be more suitable in size and shape for the particular parts to be coated.

A Bunsen burner, Figure 9, or two infrared lamps, Figure 10, are required for the sealing process after the part has been dipped. Two gooseneck desk lamps can be set so that the two infrared bulbs face each other several inches apart; the part to be sealed can be slowly rotated between these lamps. If a gas supply is available and the open flame of a Bunsen burner is permissible, sealing can be accomplished by slowly rotating the part to be sealed over the top of the soft Bunsen burner flame. This method requires caution because the flame temperature is high enough to scorch the surface very quickly if the part is held in the flame.

Small tool and equipment requirements consist of simply fabricated wire hooks for hanging the parts in the oven or cooling rack, and tools such as pliers or vice-grip pliers for handling the hot parts, a sharp knife or a scalpel, sandpaper for trimming and finishing the final plastisol coating, and several hanging racks located both over the dip tank and in some appropriate cooling area, Figure 12.

III. EXTENDED APPLICATIONS

Several modifications of the basic coating process will give useful coating property variations. For example, the plastisol material may be bonded to the brace by a primer material; a soft layer of foamed plastisol may be applied before the final tough coating; coating thickness can be varied from one point to another on a single part; and plastisol straps can be fabricated as an integral part of the brace coating or mechanically attached to the brace.

A. *Bonding the Coating by Means of Metal Primer*

It is often necessary to apply the plastisol coating over an adherent primer so there will be no relative motion between the coating and the brace and so no moisture or dirt can get under the edge of any coating terminations.

We have found that plastisol coatings which did not adhere at points of maximum pressure, such as the edges of leg bands or upper thigh bands, were subject to internal failure by the cutting action of the metal edges, especially if these are sharp. Shifting of the plastisol coating also can be eliminated by causing the material to adhere to the brace part. A small amount of primer applied to the part where the coating is to terminate is very helpful in preventing foreign material from entering between the coating and the metal part.

Adhering of the plastosol coating to the metal can be obtained by dipping the part to be coated or by brushing small areas with a special primer furnished by the plastisol manufacturers. This primer should be applied before the preheating of the metal part. The normal preheating step will then evaporate the primer solvent and cure the primer so that it forms a very strong bond between the metal part and the subsequent plastisol coat. It should be noted, however, that a primed metal part becomes very difficult to strip for recoating. Because of this, it is suggested that limited areas be primed and that no primer be put in cracks or crevices formed by joining of two metal parts.

B. *Foamed Plastisol Underlayer*

It is often necessary to provide a soft padding or a built-up section on a brace. This can be produced by covering part of a brace with a soft, thick plastisol material of lower density. The effect is easily accomplished by first covering the metal part with a modified plastisol which expands by chemical foaming action during the curing process. This technique has been used successfully to produce up to 100% expansion of this underlayer on the metal parts.

The foamed underlayer of plastisol is obtained by dipping the preheated metal part first in the special foaming type plastisol and then proceeding through the sealing step and part of the curing step, as with the regular material. However, it should be noted that the foamed underlayer should be cured for three minutes only, at which time it should be quickly removed from the oven and dipped into the regular plastisol to obtain the tough outer layer. This outer layer should then be sealed and cured according to the normal cycle, being particularly careful to avoid extended curing periods which might cause a sagging of this much thicker coating. A good oven is essential for this step. If the oven does not have adequate circulation and becomes hotter at one point than another, the foaming action will be very uneven and the result will be unsatisfactory. It is usually desirable to apply a primer coat before preheating the metal part for the foamed underlayer. This foamed underlayer of plastisol has a much lower strength and thus should be used only when a cushion effect is desired under the tough regular plastisol coating.

C. *Variable Coating Thickness on a Single Part*

It is possible to have thin and thick sections on a single brace part by properly controlling the temperature of the part before it is dipped. As described earlier, the hotter parts or hotter sections of a part will pick up a thicker gel coat during the dipping step. The metal with a uniform cross-section can be given the required temperature gradient by either cooling part of a normally preheated part with small sections of wet toweling, Figure 14, or local heating of the part by a concentrated heat source. For example, one band of a brace requiring a thicker coating can be heated in the Bunsen burner flame for a few seconds immediately before the dipping step, Figure 15.

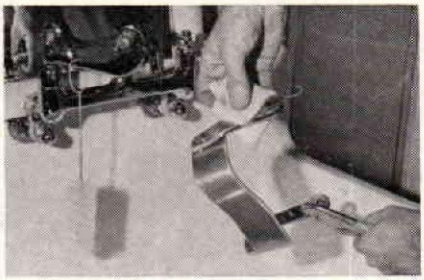


Figure 14—Wet Towel Cooling Uprights.

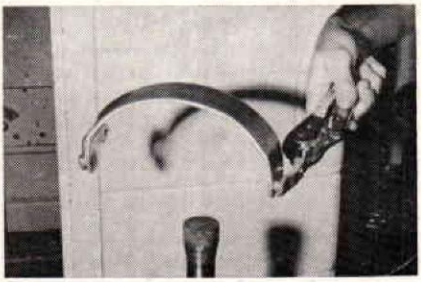


Figure 15—Heating Band in Flame for Thicker Coating.

Often a part to be coated must be given special preheating treatment in order to obtain a uniform coating thickness. An example of this requirement would be the coating of a leg brace which contains relatively thin bands attached to heavier cross-sectioned uprights. It is the natural tendency of a uniformly heated brace of this type to pick up a much heavier plastisol coating on the thicker cross-sectioned upright of the brace than on the thinner leg bands. Since it is usually preferable to have the reverse coating proportion, special treatment must be given to the brace during preheating to obtain the desired results. If the brace uprights are cooled with a wet towel, or the leg bands are heated for a few seconds in an open Bunsen burner flame, the coating thicknes on the bands can be equal to or thicker than the coating on the uprights. Another more subtle way of obtaining a similar temperature gradient can be accomplished by preheating the part for a shorter time at a higher temperature. Since thick parts heat more slowly, the preheat time and temperature can be adjusted to produce a much higher temperature in the thin band than in the thick upright, Chart 1.

Controlling the depth of submergence of the part in the dipping tank can often be used to control the coating thickness if one end or extremity of the brace requires a thicker coating. If partial insertion of a part into the liquid plastisol is followed by a complete submergence after the part cools somewhat, a variation in coating thickness is easily obtained. By controlling the rate of submerging the part into the liquid plastisol, a gradual variation in coating thickness and, consequently, a neat appearance will result. Some experimentation and practice are required to become familiar with this method of controlled coating thickness.

D. *Plastisol Straps*

Leather straps have normally been attached to braces by riveting or sewing, causing discontinuity in the brace appearance. When using plastisol as a brace covering material, it is possible to make the straps a continuous part of the plastisol coating, Figure 16. This is accomplished by attaching a temporary piece of metal to the brace for the dipping process in such a way that a continuous coating is obtained on both the brace and the attached metal. When the piece of metal is removed, an integral strap of plastisol will remain attached to the brace and brace covering. A little careful trimming and sanding give the strap and coating a neat appearance, and little or no trace of the special process is evident. Strap thickness can be controlled by selection of the thickness of the preliminary metal strap.

Another method of forming plastisol straps is to cut them from plastisol sheets which can be formed on metal plates. The sheets can be easily stripped

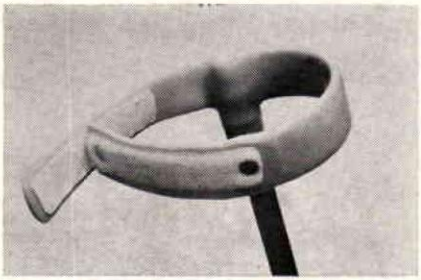


Figure 16—Continuous Plastisol Straps.

from the metal plates if no primer is used. The straps are then attached to the brace by normal procedures such as riveting and sewing.

IV. PRELIMINARY CLINICAL EVALUATION

During the past five years several hundred patients have been fitted with braces either totally or partially covered with a plastisol material. A large percentage of these patients have been enthusiastic about this new material; however, several common complaints were indicated by some of the patients when questioned about its acceptability. The complaints about the original plastisol were (1) high coefficient of friction, (2) hardness of the plastisol coating, and (3) failure of the plastisol coating due to splitting or crumbling.

Analysis of these complaints led to changes in the plastisol formulation. One change reduces the coefficient of friction. Another change gives a softer material by causing a foaming action during the curing cycle. Third, a study of the complete coating process pointed out necessary procedure improvements to reduce the causes of coating failures. Most of the coating failures were due to improper curing and improper metal preparation. In response to these initial patient complaints, Barley-Earhart Corporation developed the regular and foam type hot dip Plastisols BE 2-40 and BE 2-41. We then established the proper coating procedures for making full use of the properties of these new formulations.

At least 40 patients have been fitted with hand splints or leg braces covered with the improved plastisol formulations. Of these patients only 14 have been available for evaluation of this material, 9 of whom had previously worn leather covered braces. The format of the interview with the 14 patients is as follows:

A. Objective Information—Name; sex; age; height; weight; occupation; number of hours spent on feet per week; disability; type of brace worn; when first received braces; kinds of coating materials previously used; and how often coatings had to be replaced.

B. Evaluation (only for those who have worn both plastic and leather)—Which retains its original function longer; which is lighter; which has better original appearance; which maintains its appearance longer; which causes the least irritation; which is less sticky when not prespiring; which is less sticky when perspiring; which is easier to keep clean; which has the least tendency to pick up odor; which causes the most perspiring; and under what conditions do the braces irritate most.

Of the 9 patients who have previously worn leather braces, 7 were very pleased with the plastisol, one was indifferent, and one definitely preferred

leather. However, the patient who preferred leather showed a positive reaction to the plastisol in the patch test. On the other hand, one patient who had been reacting to his leather covered braces found no skin irritations from the plastisol. This patient also reacted to the leather in the patch test. All the patients indicated that the plastisol maintained its original appearance longer, was easier to keep clean, and had less tendency to pick up odor. The majority of the patients indicated that the plastisol had a better original appearance, was less sticky when perspiring, and was as light or lighter than the leather. Most of the patients indicated that the leather was less sticky when the skin was dry. All patients indicated that any brace causes irritation under hot and sweaty conditions, but the plastisol had less sticking effect.

Because of the limited number of patients who have been interviewed concerning this new material, the results of this survey are inconclusive and serve only as a guide for planning future clinical evaluations which will be contained in the final report on this subject.

V. SUMMARY AND CONCLUSIONS

Basic and clinical studies of plastisol, carried out at The University of Michigan Medical Center during the past five years, indicate that this polyvinlchloride-based material is a satisfactory replacement for leather as a covering for braces and splints, Figure 17. Clinical applications have shown that patients enthusiastically approve this change in most instances.

Plastisol-covered braces have the advantage of being nonabsorbent and nonreactive to body oils, waste, or detergent, Figure 18, 19. Although occasional erythema may develop from plastisol, as with leather, it will usually disappear shortly after the material is removed. Material tests show that the

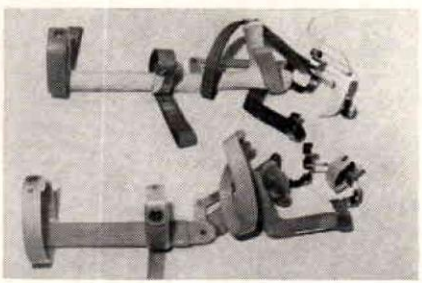


Figure 17—Felt covered and Plastisol covered Hand Splints.

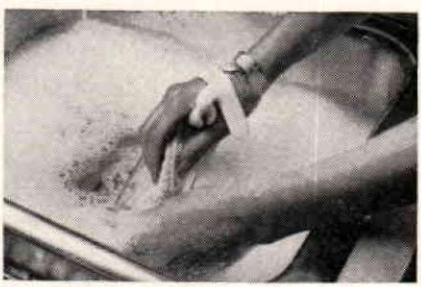


Figure 18—Plastisol in Dishwater.

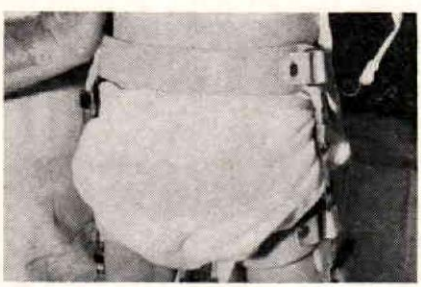


Figure 19—Plastisol Against Diaper.

thickness and density of the coating are easily controllable. In addition, plastisol requires no stitching. Clinical experience has shown the material to be cosmetically appealing to patients because of the pleasing color and neatness of the completely encapsulated brace sections.

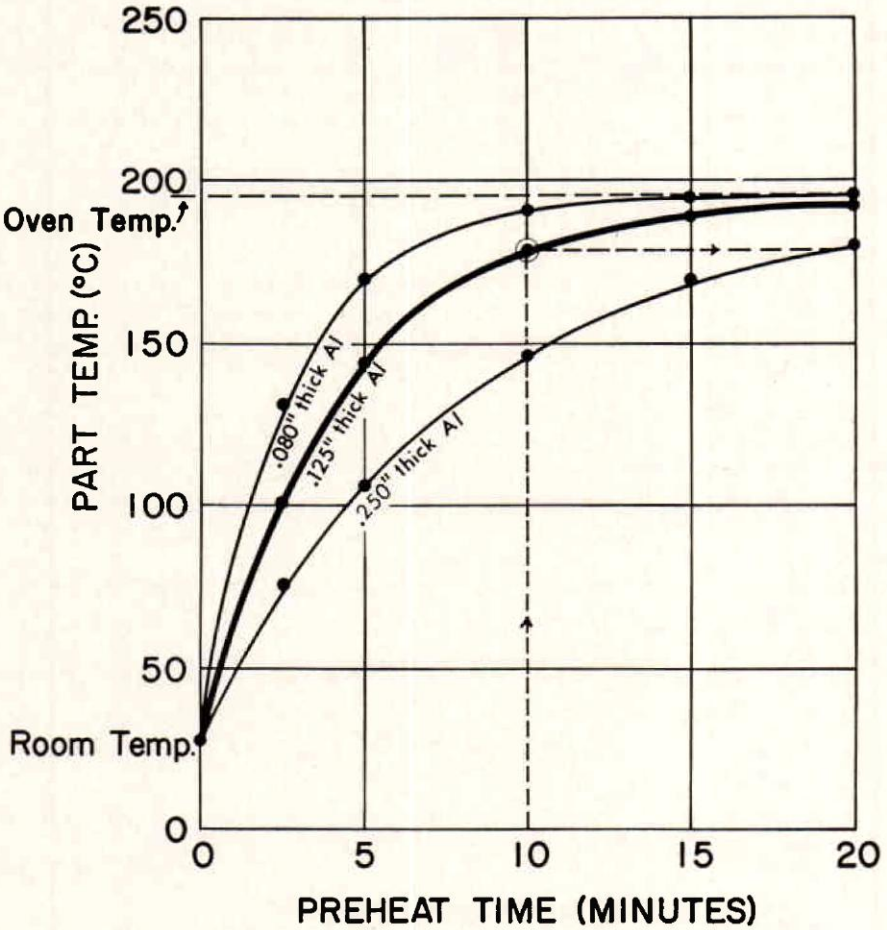
A simplified process for applying the plastisol coating to metal braces has been developed and standardized. Equipment requirements have been reduced to a few catalogue items easily chosen on the basis of size of the coated device; thus excellent results can be obtained even with a limited budget. Plastisol, then, offers lower initial cost, maintains its original appearance, and functions much longer than leather.

A disadvantage associated with a plastisol coated brace is that it does not "breathe," so that the skin it covers tends to become moist. On the other hand, this means that the plastisol coating will not absorb odor-causing perspiration, which is a significant problem with leather. Another disadvantage of plastisol is that a brace requiring a thick covering will be slightly heavier than the same brace covered with leather.

This study has shown that optimum results can be obtained on a wide variety of braces through the controllability of the various steps in the coating process. This ease of control makes it possible to vary the coating thickness, softness, and density, even in the coating of a single part.

On the basis of the lower cost of plastisol coating, the ease with which it is applied to assistive devices, and its ready acceptance by patients, this process is recommended for general use in rehabilitation centers elsewhere.

PART TEMPERATURES ATTAINED DURING PREHEAT in a 195°C oven

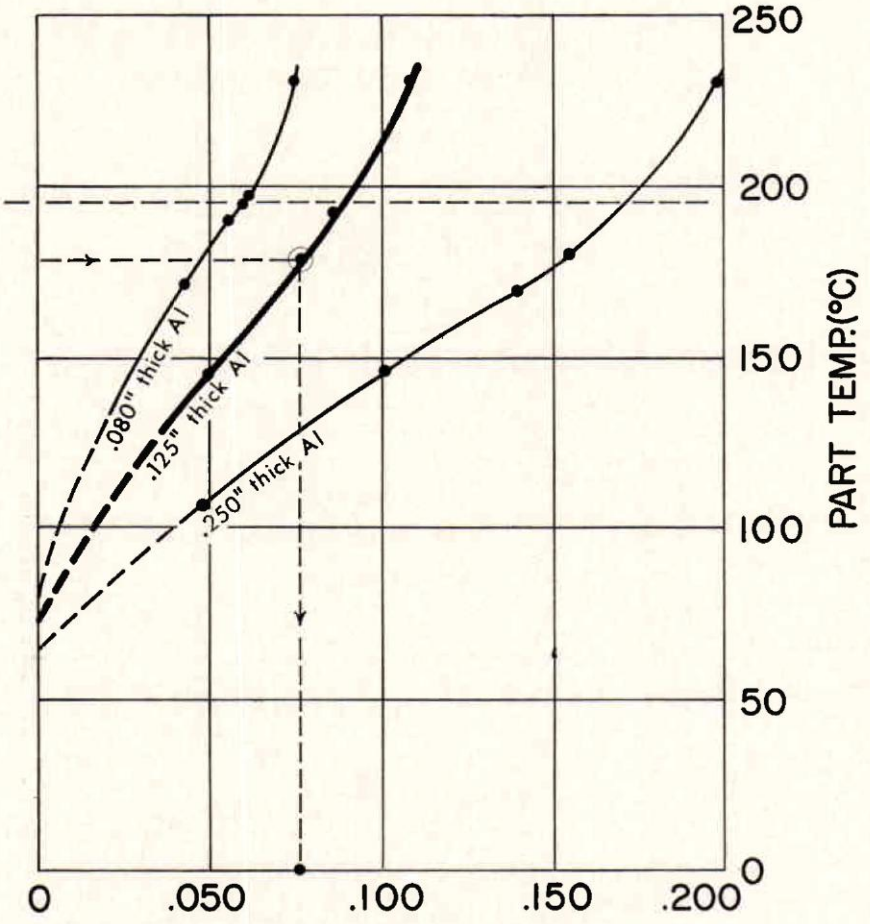


Examples of part temperatures attained

Aluminum Thickness	Preheat Time in 195°C Oven			
	5 min	10 min	15 min	20 min
.080"	168°C	190° C	194° C	195° C
.125"	144°C	177° C	188° C	192° C
.250"	105°C	145° C	168° C	180° C
	Part temperatures attained in given times			

CHART Ia

COATING THICKNESSES ATTAINED
for given part temperatures

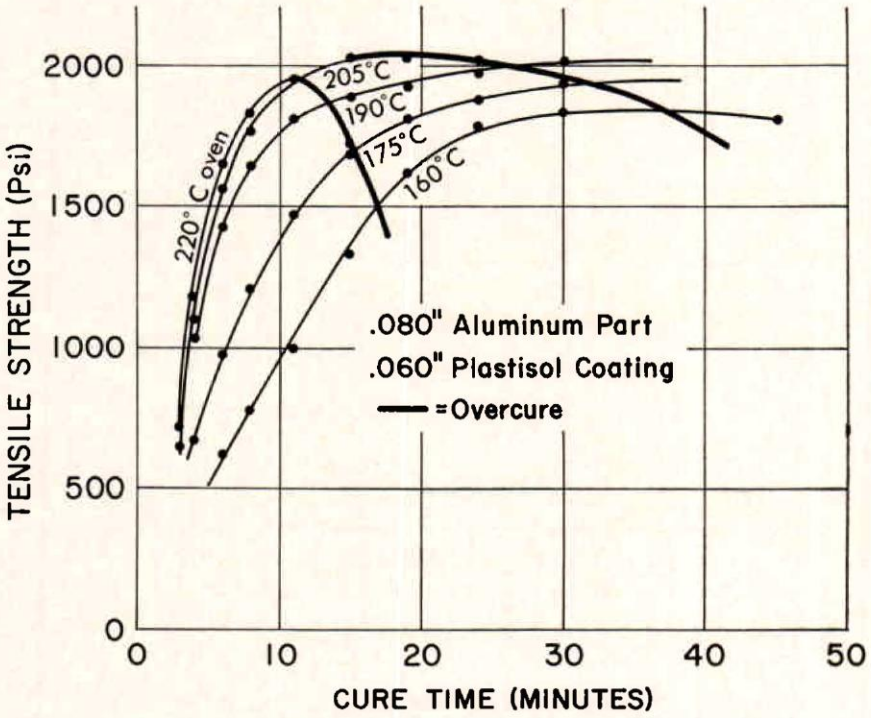


Examples of coating thicknesses attained

Aluminum Thickness	Preheat Time in 195°C Oven			
	5 min	10 min	15 min	20 min
.080"	.043"	.056"	.061"	.062"
.125"	.052"	.077"	.085"	.086"
.250"	.048"	.100"	.140"	.155"
	Coating thickness attained for given preheat times in 195°C oven.			

CHART 1b

PLASTISOL STRENGTH VS CURING TIME AT DIFFERENT OVEN TEMPERATURES



Note: Thicker coatings or metal parts require additional curing time. For example:

Aluminum Thickness	Coating Thickness		
	.040-.075"	.075-.100"	.100-.125"
.080"	8-12 min	10-15 min	-
.125"	9-15 min	12-17 min	14-20 min
.250"	10-16 min	13-18 min	15-20 min
	Cure time required in a 195°C oven.		

CHART 2a

DOUBLE DIP COATING THICKNESSES & CURE TIMES
(Foam Plastisol under Regular Plastisol Skin)

Coating thickness vs preheat time in a 195°C oven

Aluminum Thickness	Preheat Time in 195°C Oven			
	5 min	10 min	15 min	20 min
.080"	.120"	.160"	.190"	.195"
.125"	.125"	.170"	.210"	.230"
.250"	.110"	.180"	.230"	.280"
	Final coating thickness using a 195°C. Preheat oven.			

Higher preheat oven temperature gives a thicker foam underlayer.

Recommended curing time in a 185°-190°C oven

Aluminum Thickness	Final Coating Thickness		
	up to .100"	.100-.150	.150 & up
.080"	5-7 min	6-9 min	8-11 min
.125"	5-8 min	7-9 min	8-11 min
.250"	6-8 min	7-10 min	8-12 min
	Cure time required in a 185-190°C oven		

Note: Excessive cure time and/or temperature will cause sagging of the coating.

CHART 2b

Prosthetic Consideration for the Lower Extremity Child Amputee

by WILLIAM A. TOSBERG, C.P. & O.

Technical Director, Prosthetics Services
Institute of Rehabilitation Medicine
New York University Medical Center, New York, N.Y.

It is essential that prosthetic prescriptions are based on the requirements of the individual patient. This is equally true in the adult as well as in the child amputee. These requirements take into account the emotional as well as their functional needs. In the child amputee one has to consider also the emotional needs of the parents.

In prescription for a juvenile patient one has to distinguish between surgical amputation and the congenital absence of a limb. Amputations may be performed for accidents, disease, or for cosmetic purposes. Amputations for cosmetic reasons are generally not performed before the age of adolescence.

Prosthetic replacements for traumatic amputations in children are very similar to those for adults in design as well as in material. One has to consider, however, that a child is very active, and therefore prostheses should be constructed of sufficient strength and of a design which requires only minimal maintenance.

In a very young child, where no gait pattern is as yet established, it is advisable to provide a below-knee prosthesis with knee joints, side-bars, thigh lacer, hip joint, and sometimes even a pelvic belt. These additions may be removed as an acceptable gait pattern becomes established.

In above-knee amputations, suction sockets may be prescribed if the stump is well healed and only minimal stump changes are expected. An auxiliary suspension, however, is indicated—either Silesian belt or hip joint and pelvic belt. For children a SACH foot is preferred because it is considered to be stronger, water-proof, and requires less maintenance than an articulated foot.

Amputation resulting from disease is most often the result of malignancy because peripheral vascular problems are relatively rare in childhood. It is advisable that children be fitted at the earliest possible date at which a prosthesis is medically indicated. Immediate post-operative prosthetic fittings are generally very successful with children.

Growth is one of the predominant problems in the prosthetic fitting for children. One has to distinguish between circumferential growth and linear growth. In order to compensate for circumferential growth, extra wall thickness in lower extremity prostheses constructed from wood could make it possible to remove material as the circumference of the stump increases. In prostheses constructed of plastic, it is possible to fit the socket with one or two inserts, these to be removed as indicated. Linear growth is compensated for by cutting the prosthesis and adding to its length.

Figure 1—Right Amelia; left Syme.

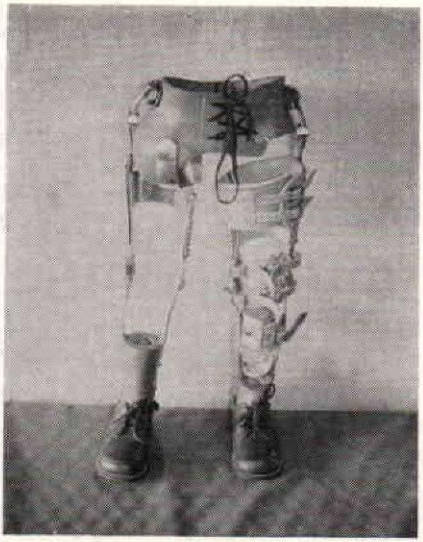


Figure 2—First set of Temporary Prostheses.

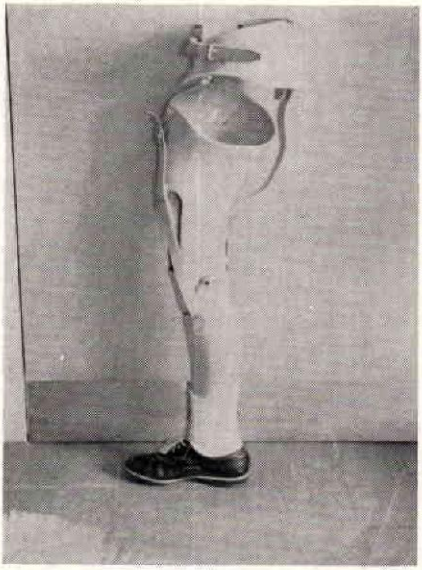


Figure 3—First set of Permanent Prostheses.

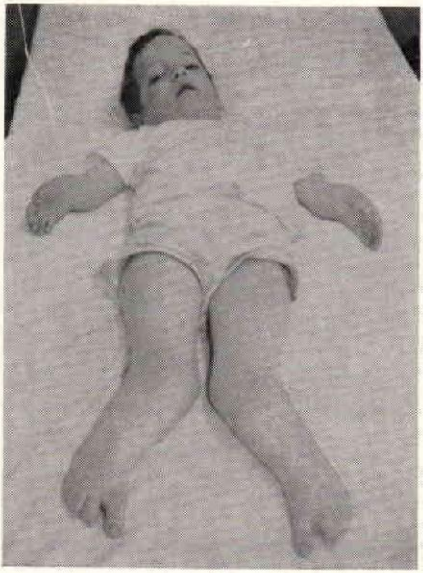
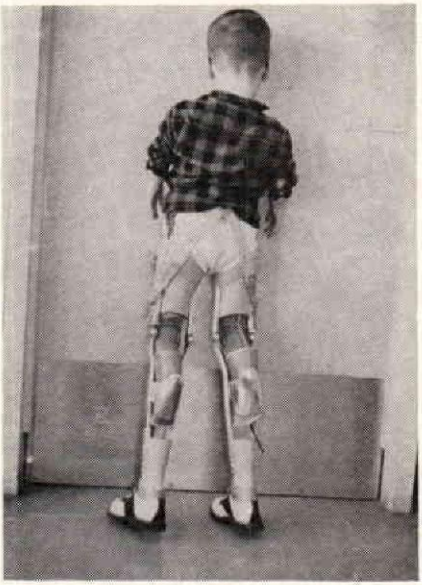
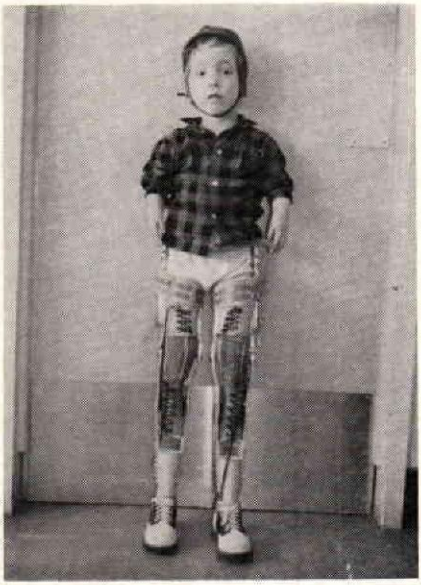


Figure 4—Bilateral Lower Extremity Hemimelia.





Figures 5 and 6—Posterior and Anterior views of Temporary Prostheses.

It has also been recommended, at least in early childhood, to elevate the shoe on the nonamputated side by approximately 3/8 inch and to fit the prosthesis to this increased length. The added length of the affected side could be removed gradually, until equal length is obtained. It is then possible to gradually add to the shoe of the affected side. In this manner growth of almost ¾ inch can be compensated for.

The Orthopedic and Prosthetic Appliance Journal of March 1967 carries an article by Howard V. Mooney which describes a different procedure to keep children's prostheses at the most functional length.

The majority of prostheses for children are constructed, however, to compensate for a congenital birth defect. Most of these anomalies are found in the upper extremities, the most frequent one being the absence of one hand or part of the forearm. Anomalies of the lower extremities often consist of either proximal or distal phocomelia, either unilateral or bilateral. Yet many other deficiencies are also seen. Dislocation of the hip joints are often associated with these disabilities.

There can be no standard pattern for prosthetic replacement since the clinical picture varies considerably. In the case of distal phocomelia with relatively little shortening of the extremity, a built-up shoe may be the best approach. Under certain conditions, the removal of a functionally useless foot allows construction of a standard below-knee prosthesis. The same is true in the cases of proximal phocomelia where standard above-knee prostheses can be utilized. Although a normal, or near normal foot may be present, end-bearing or accepted above-knee weightbearing principles often cannot be resorted to because of abnormal hip joints. Limited ischial bearing or exaggerated gluteal support has to be utilized. Wherever there is a freely movable ankle joint the remaining foot is fitted in extreme equinus to prevent unsightly protuberances in the prostheses. In order to insert the stump into the socket it is usually necessary to provide an anterior opening.

Time of fitting with prostheses depends upon the child's development.

Figure 7—Bilateral Acheiria; unilateral Terminal Hemimelia Transverse.

Fitting for functional upper extremity prostheses coincides with the ability of the child to sit erect. However, nonfunctional prostheses have been applied as early as the age of six months. Lower extremity prostheses are provided whenever the child shows an attempt to stand.

Since growth is rather rapid and anomalies vary considerably, it has been the practice at the Institute of Rehabilitation Medicine to provide brace-type appliances with ischial gluteal weightbearing at an early age. A non-articulated foot is used. These braces allow for a maximum adjustment. Replacement with a definitive prosthesis usually takes place before school age.

In cases of bilateral lower extremity amelia where sitting without a device is impossible or extremely difficult, a sitting device is constructed from a cast of the lower body part, which is attached to a board. Where body conformation allows, this is a closed socket; otherwise, there are lateral openings. The socket should be wide enough in its lower dimensions to allow for diapers.

Prostheses for bilateral amelia should allow for hip locks and knee locks in order to allow a swing-through gait, although Canadian hip-type prostheses have been successful in isolated cases.

One problem which is unique to the child amputee is the overgrowth of bony tissues, especially in the acquired amputation. Quite often multiple shortening of the bones have been resorted to in order to maintain a stump free of pain.

Training of lower extremity amputees is an important requirement because it is very difficult to correct faulty gait patterns once they are established.

Constant examination of skin in weightbearing areas is essential to determine need for adjustment or replacement.

It is also necessary to have periodic checks of all mechanical parts to determine wear and breakage.

Immediate Postsurgical Prostheses Past, Present, and Future

by JOSEPH E. TRAUB, C.P. *

Director, Prosthetics Research Study
Seattle, Washington 98104

On a sunny Sunday afternoon in June of 1963 just outside of Copenhagen, Denmark during the opening day's lectures of the Sixth International Prosthetic Course, the world of amputation surgery and rehabilitation was shaken to its very foundations by a tall distinguished surgeon from Poland. The title of his paper that afternoon was simply, "Electromyographic Studies." To be sure, the substance of this paper was a statistical analysis of his electromyographical study of approximately 200 amputation stumps. The results of these studies were in themselves very enlightening and interesting, but the conclusions and use this man had put his findings to were simply astounding. Those Americans, including the author, fortunate enough to be present for the lecture of Professor Marian A. Weiss, came away questioning their hearing senses. "Did he really say that he had amputees walking with a prosthesis on the first day following surgery?" was a common question. It was finally concluded that Professor Weiss had said just that, and that he must have been just a little crazy to make such a statement. "It is not possible for a patient to bear weight on an amputation wound so soon following surgery," was another commonly heard remark.

As the days passed, a few people, especially the Americans, began to be intrigued by the possibilities of such a concept. Maybe it could be possible to apply a prosthesis to a fresh wound on the operating table. After all, it had been possible to fit some amputees with open ulcerating stump wounds which healed quickly when total contact fitting techniques were used. Also, a French surgeon, Dr. Michael Berlemont had been treating so-called "septic" stumps with plaster casts and carefully controlled ambulation since 1957 with excellent results.

With these facts in mind, it was decided that we should attempt to get more information on the technique and possibly try his method in the United States. Mr. A. Bennett Wilson, Jr., Executive Director of the Committee on Prosthetic Research and Development, a unit within the National Academy of Sciences, contacted Dr. Weiss regarding the additional information.

Mr. Wilson learned that Dr. Weiss was scheduled to make a trip to the United States with a committee from the Polish Ministry of Health in the fall of 1963. This trip was funded by the Vocational Rehabilitation Administration which was supporting a portion of Dr. Weiss' research in Poland under a counterpart fund arrangement between the United States and Polish Governments. Although the travel schedule had already been confirmed, it was decided by both Mr. Wilson and Dr. Weiss that an attempt should be made to have Dr. Weiss visit some of the larger prosthetic research centers in this country.

* In July, 1967, Mr. Traub assumes office as Consultant on Prosthetics and Orthotics, Vocational Rehabilitation Administration, Washington, D.C.

Upon his return to the United States, Mr. Wilson contacted the Vocational Rehabilitation Administration and with their complete cooperation, arranged for Dr. Weiss to visit the Biomechanics Laboratory of the University of California at San Francisco, among others in October of 1963.

Following this visit it still wasn't completely clear to the U.S. experts as to just what Dr. Weiss' routine for immediate postsurgical fitting was. This lack of clarity was no doubt due to a slight difficulty Dr. Weiss had expressing himself in English. However, he had made enough of an impression on the experts at U.C. for them to want to try his technique as they understood it.

Accordingly in January of 1964, two below knee amputations were done by the U.C. surgeons with plaster of Paris sockets applied over newly amputated stumps in the operating room. These casts were applied by a Danish Research Prosthetist, Mr. Erik Lyquist, who was at that time on a research fellowship at the Biomechanics Laboratory of the University of California.

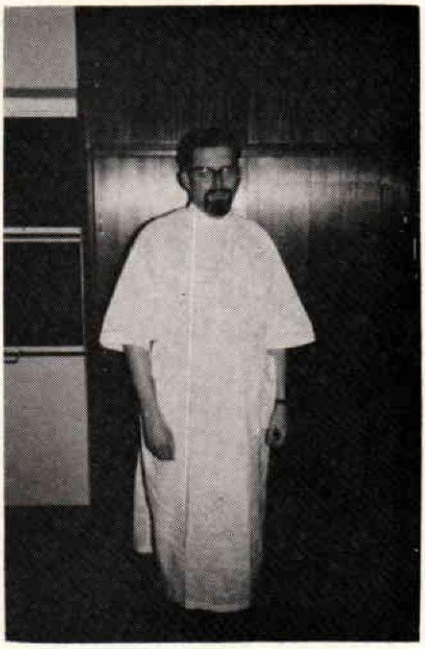
It was the author's privilege, together with Mr. Wilson, Mr. Anthony Staros, Director of the Veterans Administration Prosthetic Center, and Mr. Henry Gardner, Assistant to the Director, VAPC, to be present at the time of the second cast change on the second amputee which took place on the 13th day following surgery, the patient having been ambulatory from the first post-operative day. The appearance of the stump shape and wound healing when the cast was removed was spectacular, to say the least. The patient had experienced very little post-operative pain, and had progressed extremely well in his ambulation. Although we did not have an opportunity to see the other patient, we were told that the result with him was just as spectacular, and that he had been fitted with a permanent type PTB prosthesis on the 18th post-operative day.

These two cases were enough to convince those present that Dr. Weiss' theory was indeed a valid one. However, it was recognized that much more must be learned about a technique so different from conventional methods of post-operative amputation management before it could be released generally to the surgical and prosthetic professions.

Accordingly, during the winter and spring of 1964, several amputation centers embarked on a nationwide research program in immediate postsurgical prosthetic fittings. Principal among these centers were the U.C. Biomechanics Laboratory, the Navy Prosthetic Research Laboratory in Oakland, California, The Hospital for Special Surgery in New York City, and the Prosthetics Research Study in Seattle, Washington.

While the other centers undertook this program in addition to their other work, and in most instances without separate funding, the Prosthetics Research Study in Seattle was funded to study this technique by a contract between the Prosthetic and Sensory Aids Service of the Veterans Administration and the Principal Investigator, Ernest M. Burgess, M.D., an outstanding orthopedic surgeon.

The early results using the concept of immediate postsurgical prosthetic fitting were somewhat spotty in all centers. A few of the problems encountered were: pressure necrosis over bony prominences from inadequate casting, delayed wound healing from insufficient controlled pressure to the wound, intermittent edema from distal cast displacement, wound dehiscence due to the cast coming off or too tight a surgical closure, and wounds that would not heal at all due to insufficient blood supply to tissue at the elected level of amputation.



Dr. Marian Weiss of Poland.

The difficulties encountered during the first year of this study seemed in no way related to early ambulation or casting the fresh stump, but rather were thought to be purely technical in nature. The solutions to these problems required the development of considerable technical skill and a professional teamwork approach between the surgeon and prosthetist that did not as yet exist.

It was necessary for each specialist to work closely with, and understand as much as possible, the skills of the other. For example, the surgical fashioning of an amputation stump for the successful fitting of a prosthesis now became mandatory, since the post-operative course was to be one of weightbearing and ambulation with a prosthesis. It was also necessary for the prosthetic application to be such that the wound and remaining extremity would not be damaged or compromised by a continuous rigid dressing and the application of weightbearing forces to diseased or traumatically * involved tissues. Weightbearing and ambulation must be closely controlled and supervised to avoid trauma. Nurses must be trained to insure that the cast remains in place. The successful rehabilitation of a patient suffering an amputation then required true teamwork, so often spoken of but seldom achieved. The surgeon, prosthetist, physiatrist and/or physical therapist, and nurse, must coordinate their efforts continuously throughout the post-operative period in order to insure the successful completion of the rehabilitation process.

To be sure, the surgeon must be the leader of this team and make the decisions, but he also must recognize and utilize the talents of all other team members, especially the prosthetist.

In the beginning, it was generally assumed that wound drainage was

* Amputation is considered to be trauma.

not necessary if good hemostasis was achieved at the time of wound closure. However, in a few instances, hematomas were developed and the decision was made to drain all wounds to avoid as much as possible this painful complication. Also initially, it was felt that a cast should be applied that represented exactly the contour and fit of a prosthetic socket, providing unrestricted motion of the next proximal joint, i.e., the knee and hip joints. Suspension, or the lack of positive retention of the cast became the big problem. In only a few instances did the cast come completely off, but in a majority of cases, the cast could be displaced enough distally with motion of the next proximal joint to allow the rapid formation of edema.

At this point in the developmental research occurring in this country, it became apparent that a surgical-prosthetic research team should visit Dr. Weiss in Poland to determine exactly the technique he used, and to see his results firsthand. Dr. Burgess, Dr. Robert L. Romano, and the author, all of the Prosthetics Research Study in Seattle, Washington were chosen to make this trip with funds provided by the International Rehabilitation Activities Division of the Vocational Rehablitation Administration. Ths agency, as was mentioned previously, had been partially supportng the research of Dr. Weiss for some time with counterpart funds in Poland.

The trip to Poland was made in November of 1964. During the two weeks the U.S. team visited Dr. Weiss, a great deal of information was exchanged and much was learned. For example, Dr. Weiss was able to perform three amputations for our team and demonstrate his then current technique of Immediate Postsurgical Prosthetic Fitting on all three. One above knee, and two below knee patients were amputated with casts and prosthetic extensions applied immediately.

Upon the return of the Prosthetics Research Study team to the United States, both the surgical and prosthetic techniques were refined. Surgery to include tension-myodesis, or muscle to bone fixation, and Penrose drainage extending through and through the wound. The prosthetic technique was refined by immobilization of the next proximal joint for suspension and the addition of a soft compressible material (sterile fluffed gauze or lambs wool) over the end of the stump to produce constant gentle compression of the wound and adjacent soft tissues. In addition, felt pads were designed and included in the cast to provide pressure relief to pressure sensitive areas and to produce controlled pressure over pressure tolerant areas. Also, work progressed on the development of a good prosthetic pylon which would provide features of universal adjustability, light weight, proximal disconnect, and durability.

Thus refined and standardized the evaluation of Immediate Postsurgical Prostheses progressed in an extremely rapid fashion through the years 1965 and 1966.

During the summer of 1966, a preliminary manual titled, "The Management of Lower Extremity Amputees Using Immediate Postsurgical Fitting Techniques," was prepared by the Prosthetics Research Study with the assistance of Mr. A. Bennett Wilson, Jr. The preparation of this manual was requested by the University Council on Prosthetics Education, the members of which were interested in introducing this technique into the Prosthetics Education Programs at UCLA, Northwestern, and NYU. Further, a supplement to the manual describing a new approach to the management of above knee amputations was prepared in December, 1966. Both these publications, originally published in limited supply by the Committee on Prosthetic Research and Development of the National Academy of Sciences, have now been combined into one volume which is available from the Government

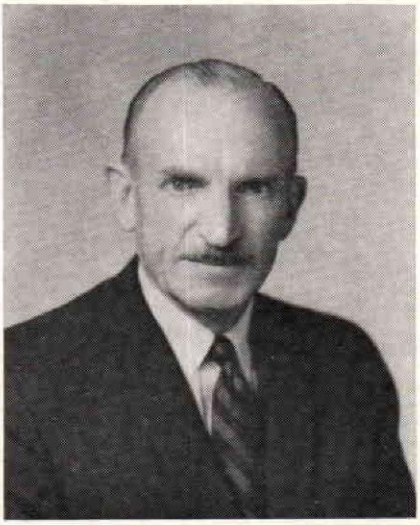
Printing Office. Courses on Immediate Postugrical Prostheses are now scheduled for all three universities.

Of course, not all the work done on this technique has been by the Seattle group. In addition to the prosthetic research centers mentioned previously, the Prosthetic Research Center, Prosthetic-Orthotic Department at Duke University Medical Center, the Department of Orthopedic Surgery at the University of Miami, Florida, and many others have contributed much to the growing knowledge in this field. The exchange of information between these centers was made possible by the appointment of an Ad-Hoc Committee on Immediate Postsurgical Prostheses by the Committee on Prosthetic Research and Development of the National Academy of Sciences. The members of this committee were Capt. Frank L. Golbranson, MC, USN, William R. Murray, M.D., and Ernest M. Burgess, M.D. Capt Golbranson served as the chairman of this ad hoc committee.

At this point in time with more than 500 cases having been treated by Immediate Postsurgical Prosthetic Fitting by the research centers mentioned above, the experiences have been such that it is desirable to release the knowledge gained for general application in rehabiltation practices for amputees. The techniques developed through the research program are conservative ones which if followed carefully, should prove successful in almost any setting—small hospital or large medical center. Of course, good clinical judgment still is of paramount importance both surgically and prosthetically. However, with the surgeon, prosthetist, physiatrist, physical therapist, etc., all working together as a team for the benefit of the patient, some spectacular results can be obtained.

As we look into the future, there is, of course, much still to be done. Improvements in surgery—level selection in vascular cases, improved tension myodesis, implants, etc., and in prosthetics—direct socket forming with plastics on stumps, improved permanent pylon designs, externally powered lower extremity prostheses, etc., are sure to come. The progress made over the past three years in the investigation of Immediate Postsurgical Prostheses has opened wide the doors for future improvement in the rehabilitation of amputees. We all look forward eagerly into the ever changing future and the continuing march toward the elimination of physical disability.

DR. GLATTLY HONORED BY THE AMERICAN ACADEMY OF ORTHOPAEDIC SURGEONS



Harold W. Glattly, M.D.

Doctor Harold W. Glattly, Executive Secretary of the Committee on Prosthetic-Orthotic Education, (the Committee on the Skeletal System and the Committee on the Genito-Urinary System of the National Research Council's division of Medical Sciences), was recently elected to honorary membership in the American Academy of Orthopaedic Surgeons, a most unusual distinction for individuals who are not orthopedists. The Certificate of Honorary Membership was presented to Doctor Glattly by Doctor Charles H. Herndon, President-Elect of the American Academy of Orthopaedic Surgeons, who is the retiring Chairman of the Committee on the Skeletal System, at a workshop on "Orthopedic Literature Information Services," sponsored by the Committee at the National Library of Medicine on May 19, 1967. At the same time, Doctor Herndon read a testimonial letter to the Committee members and the participants in this workshop, which the Committee had authorized him to send to the Secretary of the Army. In part, the letter reads: "Doctor Glattly has participated in generating the acquisitive and inquisitive curiosities of the Committee in the scientific area in many rewarding manners and thus significantly advancing the academic and research depth of American orthopedics. In the opinion of the Committee, such expertice merits comment and recognition. This letter simply serves to document these superior administrative and scientific accomplishments of Doctor Glattly. It is forwarded to you as a recognition and appreciation of the contribution of military medicine to civilian medicine at the highest level of national interest."

Doctor Herndon noted in his presentation that, as a result of Doctor Glattly's efforts, various accomplishments had been effected including the establishment of seminars for chiefs of training programs in orthopedic surgery and, in turn, the founding of the Joint Committee on Orthopedic Research and Education Seminars. He also noted that the National Institutes of Health have instituted a training program providing support for orthopedists who wish to go into academic and research careers. He stated that "information regarding the mechanics of funding research in orthopedics and musculoskeletal problems has been disseminated as never before. Seminars and workshops on specific orthopedic problems that have required development have been conducted with great success. He (Doctor Glattly) has a way of going neatly to the heart of the matter and bypassing the trivia, which has been a tremendous help to us in orthopedics."

A NEW SYMBOL FOR AOPA

A new symbol for the American Orthotic and Prosthetic Association appears on the cover of this issue, together with a change in the name of the *Journal.*

The symbol or logotype will hereafter be used on all publications and letterhead of the Association. It is the result of long study for a design which would reflect the professional image of members of the Association.

The design shows a handicapped person rising to his feet and able to walk through the efforts and professional skill of the orthotists and prosthetists shown on the right. It depicts the goal both are striving for—the restoration of the human function.

In approving the new design, the President of the Association, George H. Lambert, Sr., C.P.O., said "We wanted a symbol that is simple, striking, and—most of all—meaningful in conveying the essence of our work to the public."

Orthotics and Prosthetics

This is the first change since 1952 when the *Journal* of OALMA became the *Orthopedic and Prosthetic Appliance Journal.*

The format is unchanged and the volume numbering continues as in the past.

The name of the *Journal* has been changed to *Orthotics and Prosthetics.* The copyrighted sub-title, The Orthopedic and Prosthetic Appliance Journal, remains.

COVER DESIGN

A Bibliography on The Geriatric Amputee

Prepared by

The Research and Development Division

Prosthetic & Sensory Aids Service

Veterans Administration

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VITALI, M. and E. E. Harris — Prosthetic Management of the Elderly Lower Limb Amputee. *Clinical Orthopaedics*, No. 37, 1964, J. B. Lippincott Co., Pa.

NEWS NOTES

Robert O. Nitschke, C.P., of Rochester, N.Y., and Kurt Marschall, C.P., of Syracuse, N.Y., were guest speakers at the Annual Meeting of the New York Chapter of the American Physical Therapy Association, Inc. April 7-9 in Rochester, N.Y.

Mr. Nitschke covered the post-operative and early fitting methods and showed a film about special appliances. Mr. Marschall presented the patellar tendon supra-condylar prosthesis on slides and then demonstrated the new type of prosthesis on a bilateral amputee.

A display area with prefabricated and finished products gave the physical therapist an insight into the new developments in prosthetics and orthotics.

The article "University of Washington PTB Suspension System" which appeared in the March issue of the *Journal*, pages 58-60, describes work supported in part by U.S. Vocational Rehabilitation Administration Grant RT3. Reprints of the article are available from the Prosthetic-Orthotic Laboratory, University of Washington, Seattle, Washington 98105.

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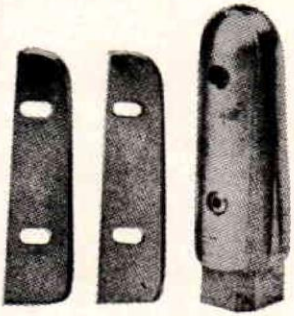

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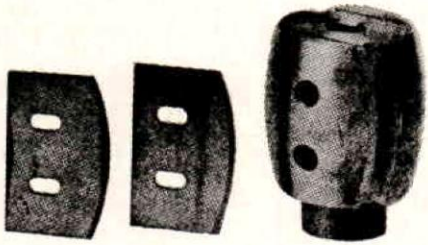
No. 2100AB Blades



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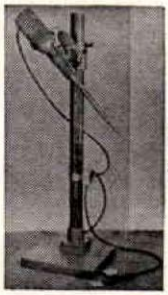

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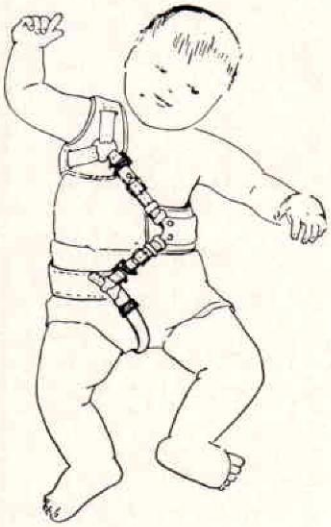

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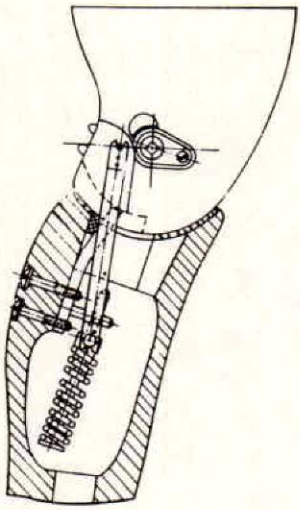

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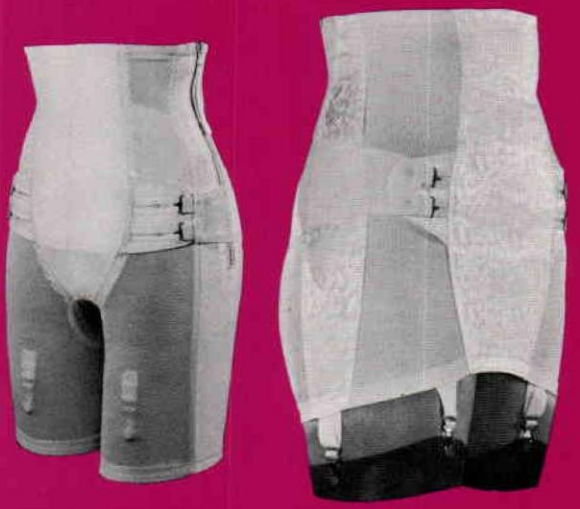

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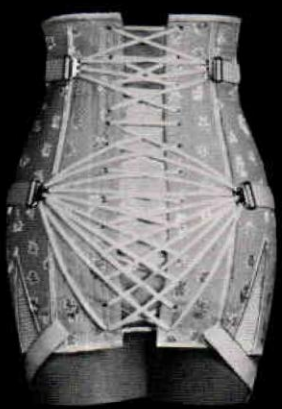
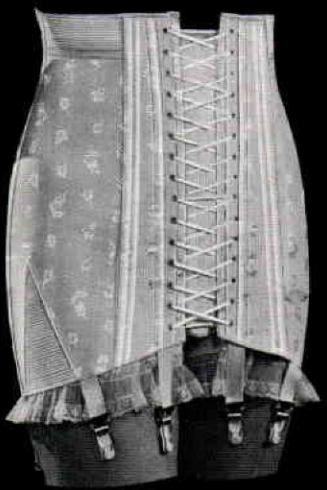


put patients back in shape



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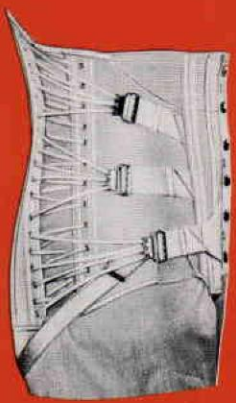

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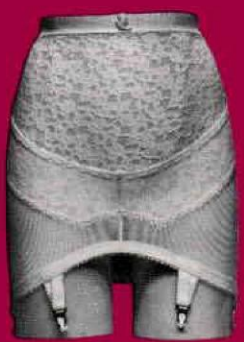

IF PENDULOUS ABDOMEN IS A PROBLEM

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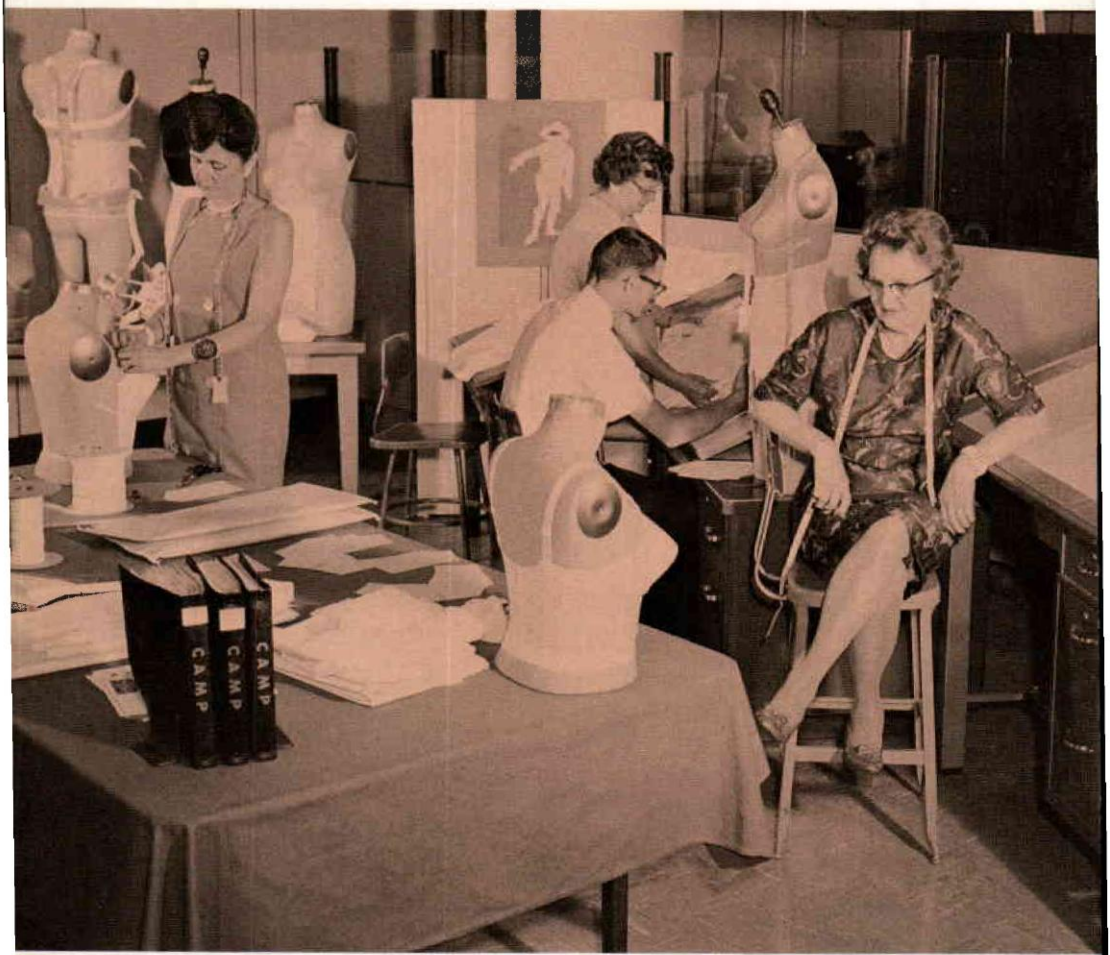

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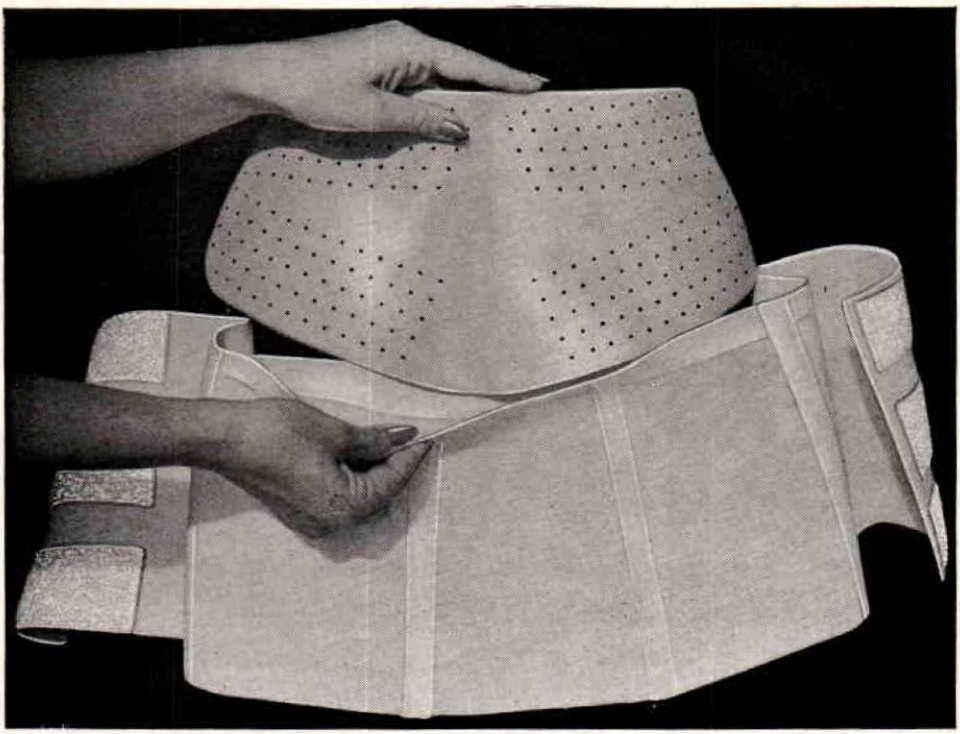

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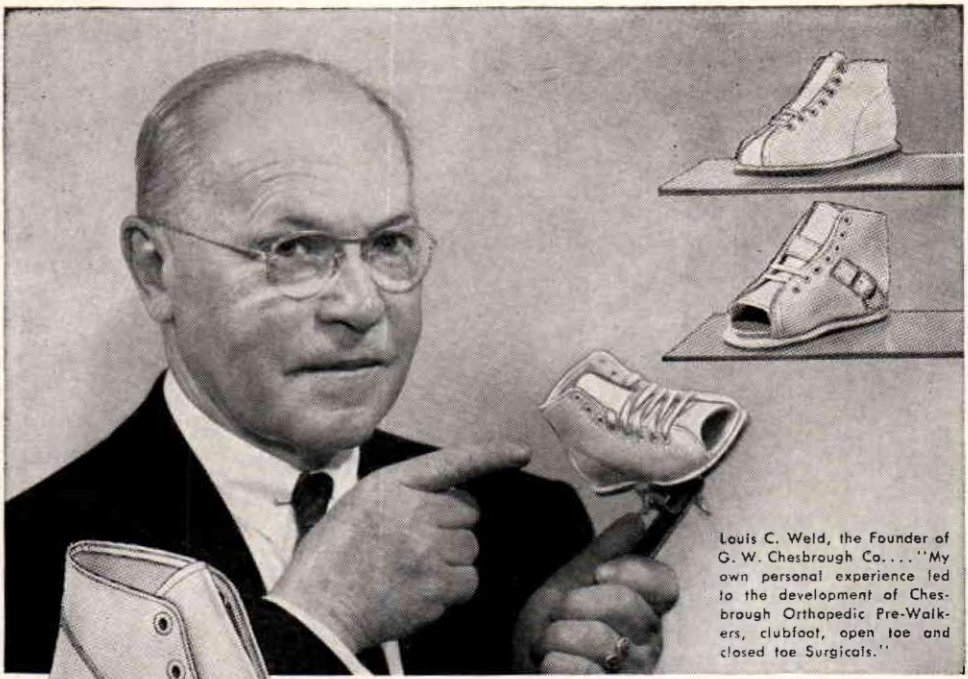

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