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Artificial Limbs

*A Review of
Current Developments*

COMMITTEE ON PROSTHETICS
RESEARCH AND DEVELOPMENT

**National Academy of Sciences
National Research Council**

COMMITTEE ON PROSTHETICS RESEARCH AND DEVELOPMENT

Division of Engineering and Industrial Research

NATIONAL ACADEMY OF SCIENCES—NATIONAL RESEARCH COUNCIL

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NATIONAL ACADEMY OF SCIENCES—NATIONAL RESEARCH COUNCIL

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Transition

EUGENE F. MURPHY, Ph.D.¹

WITH this issue, *Artificial Limbs* embarks upon a new pattern of activity, changing from monographs covering major aspects to issues with articles on more diversified topics related to artificial limbs. A brief review of the philosophy and contents of prior publications may illuminate the logic of this transition.

In nearly every issue, stress has been laid upon the management of the amputee through a clinic team. This noble idea, arising from the follow-up of the cases fitted immediately after the suction-socket schools in 1947, was destined to have a profound impact not only upon prosthetics but also, through this program and many parallel developments, upon the management of other disabilities as well.

Early issues, many of them now out of print, were devoted to explanations of the total program of research, development, and evaluation in the fields of upper- and lower-extremity prosthetics. In a series of monographs, with copious references, *Artificial Limbs* has considered nearly every important level of amputation and has discussed the medical and psychological management of amputees, whether typical cases or those with special problems. Other related journals and reference books have become available to the clinician and to the research scholar.

With the establishment of this solid base of reference literature, both in previous issues of this journal and elsewhere, it now seems appropriate to deviate from the classic monograph style so as to permit relatively more rapid publication and greater freedom in pursuing timely yet widely varied topics. In the past, one of the major causes for frustrating delay in the publication of this journal has been the necessity to wait upon the last manuscript needed to round out a comprehensive monograph. Those concerned with the policy of the journal, of course, have long recognized that more rapid publication of a reasonably useful document could be obtained with far less effort and suspense. A series of manuscripts, each individually worthy yet not necessarily directly related to the others, could simply be accumulated until the bundle "weighed enough to print."

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The articles in this transitional issue, however, are related to the background of past issues and to other publications of the Committee on Prosthetics Research and Development. In the traditional role of the editorial or lead article, this is an attempt to correlate the articles in this issue, to comment on them, and to stimulate each reader to apply them to his problems.

Dr. Glattly's preliminary report on a survey of amputees, conducted with the cooperation of the prosthetics profession of this country, discloses a number of fascinating facts yet leads to interesting speculations. Obviously, the information in the article is related to the important considerations of methods of treatment for each level of amputation covered in past monographs and in the "case studies" issue of Spring 1957. Improved prostheses are available for every level of amputation; but perhaps more important are the principles of management valid for all levels which have evolved since World War II. The great preponderance of geriatric amputees in civilian practice points up the value of the report arising from a conference sponsored by CPRD in 1961—*The Geriatric Amputee*. At the other extreme, the number of child or juvenile amputees emphasizes the importance of the work of CPRD's Subcommittee on Child Prosthetics Problems and of the slowly growing number of special children's clinics engaged in a cooperative program. Fortunately, high-level and bilateral upper-extremity amputees are relatively limited in number, but they especially emphasize the need for auxiliary power, as discussed in the record of a conference held at Lake Arrowhead, California, in 1960 under the auspices of CPRD—*The Application of External Power in Prosthetics and Orthotics*.

Indeed, the entire problem of amputation emphasizes the role of the Committee on Prosthetics Education and Information in widely disseminating information to the medical and paramedical professions through their professional schools, and local and national meetings, and by exhibits, publications, films, and slides. In fulfilling its important role, CPEI will join CPRD in sponsoring *Artificial Limbs*, beginning with the next issue. Dr. William J. Erdman, II, a member of CPEI, will join the Editorial Board.

Mr. Colin A. McLaurin's article on independent-control harnessing for upper-extremity prostheses is clearly related to previous issues on the upper-extremity problem as a whole, harnessing for artificial arms, and discussions of problem cases. Elbow flexion independent of operation of the terminal device has long been sought, as shown by the patent literature in this country and by the German literature of World War I. Immediately after World War II, many of the amputees working with Northrop Aircraft in the relatively warm climate and casual atmosphere of Los Angeles preferred to sacrifice independent control in favor of simplicity of harnessing. However, the amputees fitted in the relatively cooler German climate by Professor Hepp after his return from his 1951 trip to the United States laboratories were more willing to accept his expert judgment that some form of "triple control" was important for function. Thus they were more willing to tolerate the more restrictive type of harness. As a

result of experience with problem cases seen at the Rehabilitation Institute of Chicago and at the Michigan Area Child Amputee Center at Grand Rapids, Mr. McLaurin and Mr. Sammons have decided that independent control is important for selected amputees. Their suggestions, presented in one of the major articles of this issue, deserve careful consideration.

The article on porous laminates in this issue, by Mr. Hill and Dr. Leonard of the Army Prosthetics Research Laboratory, is closely related to the discussion of perspiration and its consequences in a past issue on dermatological problems of amputation stumps. Readers of that classic will no doubt remember the cartoons of gremlins representing perspiration and bacteria attacking the stump within the typical air-tight socket. Porous sockets in the past have been only imperfectly approximated with porous, wicklike stump socks worn within wooden or metal shells, sometimes with numerous drilled holes, or in sockets molded of leather, which is slightly porous but undesirable from so many other hygienic aspects. The typical above-knee suction sockets of lacquered solid wood or of molded plastic laminate, both completely impermeable, have been worn without a stump sock. An early goal of the Sarah Mellon Scaife Foundation Fellowship on Orthopedic Appliances at Mellon Institute, in 1947 and following, was the development of a porous-plastic material. Though techniques of the time for attaining porosity were not satisfactory, the project made an important indirect step—the introduction to the orthotics and prosthetics field of epoxy laminate which later proved to be a key feature in the early development of porous laminates. After many years of effort, techniques only recently have been developed for the production of porous laminates of polyester resins as well as epoxy.

The adjustable coupling for alignment of lower-extremity prostheses, developed by Messrs. Staros and Gardner of the Veterans Administration Prosthetics Center, is obviously related to the early issue of May 1954 in which tools to aid in achieving alignment based upon biomechanical principles were discussed by Professor Radcliffe. The adjustable coupling is particularly useful in aligning prostheses containing special knee joints intended for better control of the limb, though it is also applicable in alignment of the patellar-tendon-bearing below-knee prosthesis. The present coupling, useful though it is, seems only a step toward a light, expendable coupling which may be left in the prosthesis, thus obviating the need for transfer of alignment.

Though amputees represent a relatively small fraction of the disabled of the country, the serious physical and psychological aspects of their problems demand special attention. Neglect of these severely disabled persons has sometimes, as at the end of World War II, been the cause of public criticism and emotional or even unjust reactions. It is gratifying that, since then, the systematic and steady work of many devoted individuals and organizations has led to the body of knowledge outlined in the literature now available and to many thousands of persons being trained through intensive short courses in

the field, and thus to the present happier state when this highly specialized publication may move from a series of monographs to the greater freedom enjoyed by other journals.

Eventually, it is hoped to cover such other problems as fluid mechanisms and children's prosthetics, to provide a review of clinical experience, and to enter the much broader and more complex field of bracing, or orthotics. Also, it will be a pleasure to consider for publication voluntary contributions, without placing continual pressure upon a few devoted contributors. In the meantime comments will be appreciated from our readers throughout the world.

A Preliminary Report on the Amputee Census

HAROLD W. GLATTLY, M.D.¹

WHAT is the magnitude of the amputee population of the United States? What is the composition of this group of physically handicapped individuals in terms of their sex, ages, and sites of amputation? What proportion of amputations is caused by disease? By trauma? By tumor? The answers to these questions are today more a matter of opinion than of documented fact since statistics relating to amputees that are based on large numbers of cases collected from all states of the Union have never heretofore been available.

In the interest of developing certain basic descriptive data concerning the amputee population of the United States, the Amputee Census was initiated in October 1961 as a joint project of the Committee on Prosthetics Education and Information and the American Orthotics and Prosthetics Association. The rationale of utilizing the limb facilities of this country as the data source for the Census is based upon the assumption that a relatively high percentage of new amputees visit these shops for the purpose of being fitted with a prosthetic device. It is believed that this percentage is materially higher today than it was in 1946, at which time a federally sponsored prosthetics research program was initiated. Since that date there has been a very marked improvement in the function and comfort of prostheses, and amputees who formerly were unable to pay for a replacement device now find that there are several Government agencies to assist them. These include the federally

supported State Bureaus of Vocational Rehabilitation, the Children's Bureau, the Veterans Administration, and the Workmen's Compensation programs. It has been variously estimated by both surgeons and prosthetists that between 80 and 90 per cent of all new amputees desire a prosthesis. It is hoped that some spot checks can be made in a few large medical centers to document this estimate.

The project title, Amputee Census, is strictly speaking a misnomer (although it is a concise expression of the hoped-for result), since no national or regional head count of amputees is involved. In that only new amputee cases are included in this study, it will be possible to establish annual rates of amputation by age and cause. By applying life-expectancy tables to these rates, it is hoped to develop information that will bear upon the size of our amputee population. For example, it is obvious that there is a very wide disparity in the life expectancy of a 55-year-old man in good health who loses a limb by reason of an accident as compared with a man of the same age who suffers an amputation of his leg as the result of vascular disease. This quantitative study will not be undertaken until the census has been completed in the fall of 1964.

Two simple data-collection forms were devised that can be executed in a matter of minutes by limbshop personnel (Figs. 1 and 2). The participating limbshops were provided with bound books of these serially numbered forms. The books consist of original data slips that are retained by the facilities and carbon copies in the form of self-addressed and stamped postcards to be mailed to the National Academy of Sciences. It will be noted in Figures 1 and 2 that the upper left-hand corners of the data cards are blocked out. It is in this space that the name of the amputee appears on the

¹ Executive Secretary, Committee on Prosthetics Education and Information of the Division of Medical Sciences, NAS-NRC. This Committee is jointly supported by the Training Division, Vocational Rehabilitation Administration, Department of Health, Education, and Welfare, and the Prosthetic and Sensory Aids Service, Veterans Administration.

State _____

Age _____ ☐ M ☐ F

No 43

XYZ

Date of Amputation _____

Date Prosthesis Furnished _____

Site(s) of Amputation

(____SD) (____AE) (____E) (____BE) (____W)

(____HD) (____AK) (____KB) (____BK) (____S)

Cause of Amputation

(____Trauma) (____Tumor)

(____Disease) (____Congenital)

Mail when complete

Fig. 1. Amputee Census Card No. 1. Data form for single amputations and multiple amputations that result from a single cause at the same time.

State _____

Age _____ ☐ M ☐ F

No 132

XYZ

Date of Amputation _____

Amputation

Date

Site

Cause

1st _____

2nd _____

3rd _____

4th _____

Mail when complete

Fig. 2. Amputee Census Card No. 2. Data form for multiple amputations that occur serially at different times from the same or different causes.

original forms retained by the facilities. Since the cards are serially numbered, it will be possible at some future time to identify certain types of amputees for further study. In the upper right-hand corner is a symbol consisting of three capital letters that identify each facility. The code to these symbols is known only to the staff of CPEI, and the limbshops have been assured that no information concerning their volume of cases will be disclosed to anyone.

The participating facilities were instructed to fill out a card on each new amputee case for whom an original prosthetic device of some type was provided. Amputees furnished with a replacement for a worn-out or otherwise unusable limb are not recorded in this study. The



Fig. 5. Actual case numbers in each decade of life.

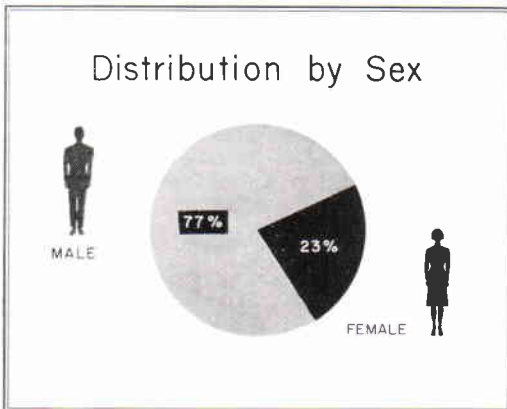


Fig. 3

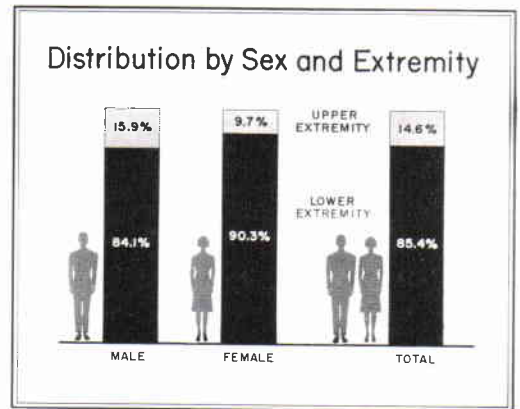


Fig. 6

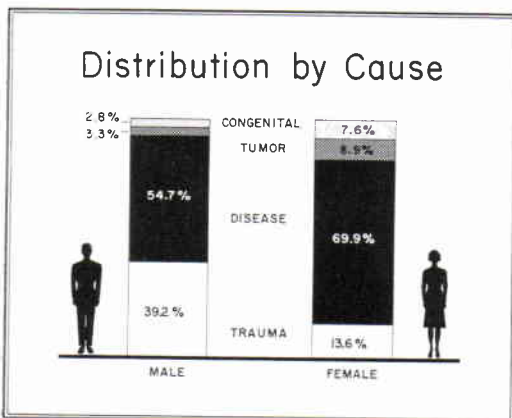


Fig. 4

card shown in Figure 1 is used for single amputations and for multiple amputations that occur simultaneously from a single cause. The card shown in Figure 2 is prepared for those cases that have had more than one amputation at separate times from either the same or different causes. Examples of this type of case include:

1. An individual who is a left, below-knee amputee due to an injury who, years later, becomes a right, above-knee amputee due to vascular disease.
2. An individual who is a left, below-knee amputee due to vascular disease and is converted into an above-knee case a year later.

Since this card amounted to only three per cent of the total data forms received, an analysis of

these cases will not be accomplished until the end of the project.

The following data items are entered on the census forms:

State of Residence.

Age.

Sex.

Date of Amputation.

Date Prosthesis Furnished.

Site of Amputation:

Upper Extremity:

(SD) Shoulder disarticulation (includes fore-quarter cases and very short above-elbow stumps that require fitting as an SD).

(AE) Above elbow.

(E) Elbow disarticulation.

(BE) Below elbow.

(W) Wrist disarticulation.

Lower Extremity:

(HD) Hip disarticulation (includes hemipelvec-tomies and above-knee stumps so short that they must be fitted as an HD).

(AK) Above knee.

(KB) Knee-bearing (includes knee disarticula-tions, Gritti-Stokes, etc.).

(BK) Below knee.

(S) Syme's operation or ankle disarticulation.

(Partial-hand and partial-foot amputations are not included in the census.)

Cause of Amputation:

Trauma—amputations due to physical and thermal injuries.

DISTRIBUTION BY SIDE OF AMPUTATION			
<i>Upper Extremity</i>			
Left	49.2%		
Right	50.8%		
<i>Lower Extremity</i>			
Left	49.2%		
Right	50.8%		

Fig. 7

RATIO MALES TO FEMALES OF AMPUTATIONS BY CAUSE			
Cause of Amputation	Males	Females	Ratio, Males-Females
Trauma	2330	243	9.2 to 1
Disease	3241	1250	2.6 to 1
Tumor	197	160	1.2 to 1
Congenital	168	136	1.2 to 1

Fig. 8

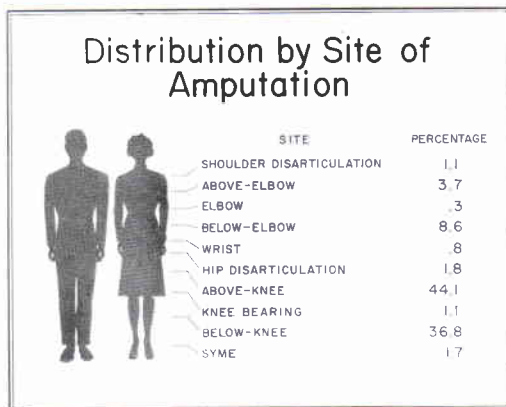


Fig. 9

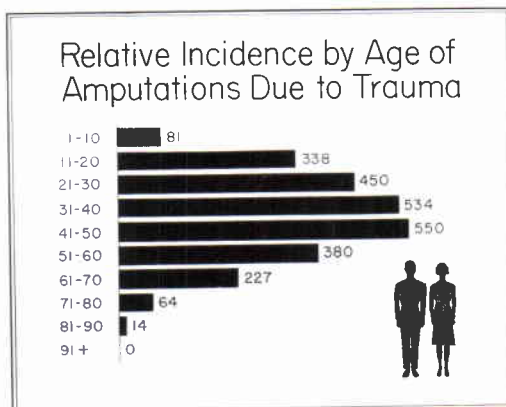


Fig. 10. Actual case numbers in each decade of life.

Disease—amputations due to vascular diseases and infections.

Tumor—refers to all types of growths for which an amputation is performed.

Congenital—only cases that are fitted with a prosthesis are included. The type of prosthesis is used to determine the level of "amputation." It is recognized that the data card is not appropriate for certain types of congenital amputees.

The statistical material that is presented in this preliminary report on the Amputee Census is based upon the data forms received from the prosthetics facilities during the 16-month period from October 1, 1961, through January 31, 1963. During this time, 8,416 new cases were reported. This sampling of the amputee population of the U. S. is sufficiently large so that the distribution by sex, age, side of amputation, levels of amputation, and causes of

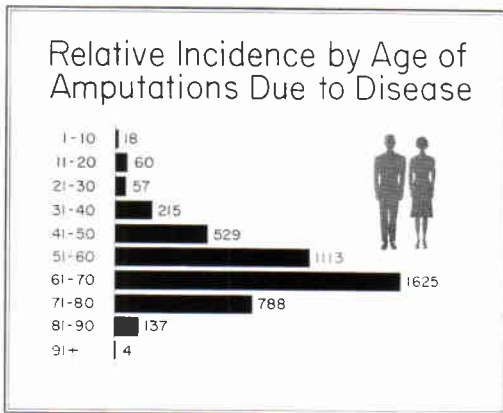


Fig. 11. Actual case numbers in each decade of life.

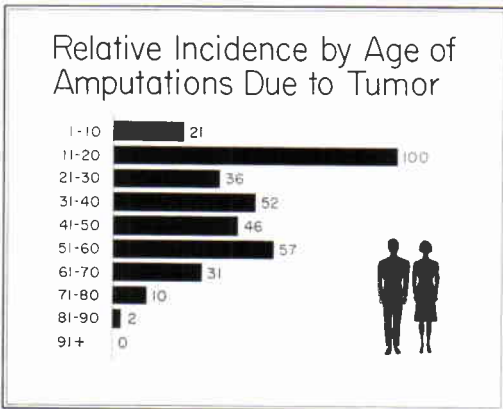


Fig. 12. Actual case numbers in each decade of life.

these new amputations is already well established. This conclusion is based upon the fact that the percentages presented in this report are almost identical to those that were obtained from an analysis of the first 5,000 cases. It is thus possible in this initial census report to present in graphic and tabular form (Figs. 3-13) a simple description of the group of individuals upon whom amputations are presently being performed. The following comments and observations on this statistical material are noteworthy:

1. The disparity in the amputation rates for males and females is due primarily to the facts that:
 - a. Amputations in males by reason of injury are nine times as frequent as in females. This is due to the vocational and avocational hazards to which males are more liable (Fig. 8).
 - b. Amputations in males by reason of disease are 2.6 times as frequent as in females (Fig. 8).

2. Amputations due to tumor are roughly comparable between the sexes (Fig. 8).
3. Congenital deformities of the extremities that are fitted with prostheses occur with almost equal frequency in males and females (Fig. 8).
4. There is no significant difference in the incidence of left- and right-sided amputations in either the upper or lower extremities (Fig. 7).
5. There is a surprisingly large number of lower-extremity amputees over 70 years of age who are being fitted with prostheses. In this series, they number 1,020, or 13.2 per cent, of the total number of reported cases. It will be noted that there are four who are over 90 years of age (Fig. 5).
6. The incidence of malignancy resulting in amputation is fairly constant for individuals between 21-60 years of age. The decade 11-20 years has an indicated rate of twice that of any other ten-year period (Fig. 12).
7. In this series there were 162 cases of multiple amputations that occurred from the same cause at the same time. Twenty-two were bilateral upper-extremity cases, 132 were bilateral lower-

DISTRIBUTION BY SITE, CAUSE AND SEX

S D		Trauma Disease Tumor Con- genital			
S D	Male	37	7	10	7
	Female	2	4	12	4
A E	Male	223	13	7	10
	Female	15	6	8	8
E	Male	13	0	0	5
	Female	1	0	0	6
B E	Male	494	14	2	52
	Female	21	6	4	54
W	Male	38	2	0	7
	Female	4	2	0	7
H D	Male	20	18	45	3
	Female	3	16	33	1
A K	Male	606	1858	99	16
	Female	88	662	68	11
K B	Male	29	29	2	4
	Female	5	13	1	3
B K	Male	818	1265	27	49
	Female	91	533	32	32
Syme	Male	52	35	5	15
	Female	3	8	2	10

Fig. 13

extremity amputations, and eight involved one upper and one lower extremity.

8. During the 16-month report period there were 1,798 cases of below-knee amputations for disease. It is believed that the vast majority of this group falls into the vascular insufficiency category. During this same period there were 2,520 cases due to disease in which the initial amputation was above the knee. There is no reason to doubt but that similar numbers of below-knee and above-knee amputations for vascular disease have been performed in years past during comparable periods of time. Although theoretically the site of amputation in vascular disease is based on the level of vascular sufficiency in the extremity, it may be that too many surgeons are overly concerned with the possibility that amputations at the below-knee level will later require re-amputation above the knee. This possibility is suggested by the fact that in this series there were only 12 instances in which below-knee amputations due to disease were re-amputated at a later date. This is an extremely low incidence, considering the number of below-knee amputations that are per-

formed annually for vascular conditions. A clinical study may be needed that is designed to define better the criteria that bear upon the decision as to the level of amputation in cases of lower-extremity vascular disease. The advantages of preserving the knee joint are obvious, especially in the older age group.

9. The reader must recognize that the foregoing statistical material relates only to new amputee cases. The statistics are not valid for the amputee population at large due to the wide variation in the life expectancy of various types of amputees.

ACKNOWLEDGMENTS

The Committee on Prosthetics Education and Information wish to express their appreciation to the owners and managers of the participating prosthetics facilities who made this study possible and to the officers, directors, and staff of the American Orthotics and Prosthetics Association for their full cooperation in this project.

Independent-Control Harnessing in Upper-Extremity Prosthetics

COLIN A. McLAURIN, B.A.Sc.¹ AND
FRED SAMMONS, B.A.²

FUNCTIONALLY, the well-designed and well-constructed body harness for an upper-extremity prosthesis serves a twofold purpose: first, it helps to hold the prosthesis in place; second, it transmits body power for operation of the prosthesis.

For shoulder-disarticulation amputees and for high above-elbow amputees, the provision of an adequate functional harness presents a challenging problem particularly with respect to power transmission and control. The problem is especially difficult in the case of shoulder-disarticulation amputees because of the lack of a control source from humeral motion, which is the major source of power and control in the case of above-elbow amputees. The typical prosthesis for shoulder-disarticulation amputees utilizes shoulder motions and chest expansion.

In the present limited state of the art of prosthetics, there are three minimal operations to be controlled in an upper-extremity prosthesis: lifting of the forearm, operation of the terminal device, and management of the elbow lock.

Here in the United States, the usual harnessing method for shoulder-disarticulation and above-elbow amputees utilizes the so-called "dual-control" system (1,2,3). Lifting of the forearm of the prosthesis and operation of the terminal device are so linked mechanically that a single control motion (shoulder motion

in the case of shoulder-disarticulation amputees, arm flexion in the case of above-elbow amputees) produces either operation, depending on whether the elbow is locked or unlocked.

In shoulder amputees, operation of the elbow lock must be managed by various special arrangements; for example, elevation of the shoulder, expansion of the chest, or use of the chin to nudge the elbow-lock control. In above-elbow amputees, operation of the elbow lock in a dual-control system depends upon extension of the humerus and depression of the shoulder.

In a triple-control system, operation of the terminal device is separated from lifting of the forearm of the prosthesis. Triple control has been a recognized method of harnessing upper-extremity amputees for many years, and standard harness patterns providing triple control can be found quite readily in prosthetics literature (1,2,3). However, triple-control harnessing in actual application is seldom seen in the United States, although it is used extensively in Germany and elsewhere. A possible reason for lack of use in the States is that in early trials it was difficult for the patients to operate the controls independently.

Recent experiments at Northwestern University in fitting bilateral shoulder-disarticulation amputees have resulted in a harnessing system that provides acceptable function using standard components. Success with some five or six cases renewed interest in "independent-control" harnessing for above-elbow amputees.

In describing this experimental harnessing for bilateral shoulder-disarticulation amputees and above-elbow amputees, the term "independent control," rather than "triple control," is used in order to avoid confusion with the standard harness patterns for triple control.

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² Research Therapist, Northwestern University Prosthetics Research Center, Chicago, Ill.

BILATERAL SHOULDER-DISARTICULATION AMPUTEES

The limited availability of control sites constitutes a serious restriction on the effectiveness of a harnessing system for bilateral shoulder-disarticulation cases. Shoulder motions are available on both sides, and chest expansion can be utilized. However, there may be only sufficient control motions to obtain acceptable function from one prosthesis. In this event, activities which require the use of two hands, such as eating with a knife and fork, are necessarily precluded.

Major consideration is given to operation of the terminal device and lifting the forearm of the prosthesis. In addition, the elbow lock must be operated and the functions of wrist and shoulder positioning should be supplied.

Although there is but one prosthesis, two shoulder sockets are used. On the side of the amputee on which the prosthesis is suspended,

the socket must provide weight-bearing at the top. This socket may be fitted well down toward the lower edge of the rib cage in order to provide good stability. The other socket, or shoulder cap, is designed specifically to provide independent control of the terminal device, and it is made as small and as light as possible (Figs. 1 and 2).

SHOULDER JOINT

A passively adjustable shoulder joint is essential for ease in putting on a coat, for positioning the prosthesis so that it does not interfere when sitting in an armchair, and for positioning the prosthesis for eating, writing, and similar tasks. Humeral abduction and flexion may be combined in a single axis joint. The friction plate shown in Figure 2 includes two wedge-shaped discs ("Wilson-Riblett wedges") which can be rotated during the preliminary fitting to provide the optimum plane of motion

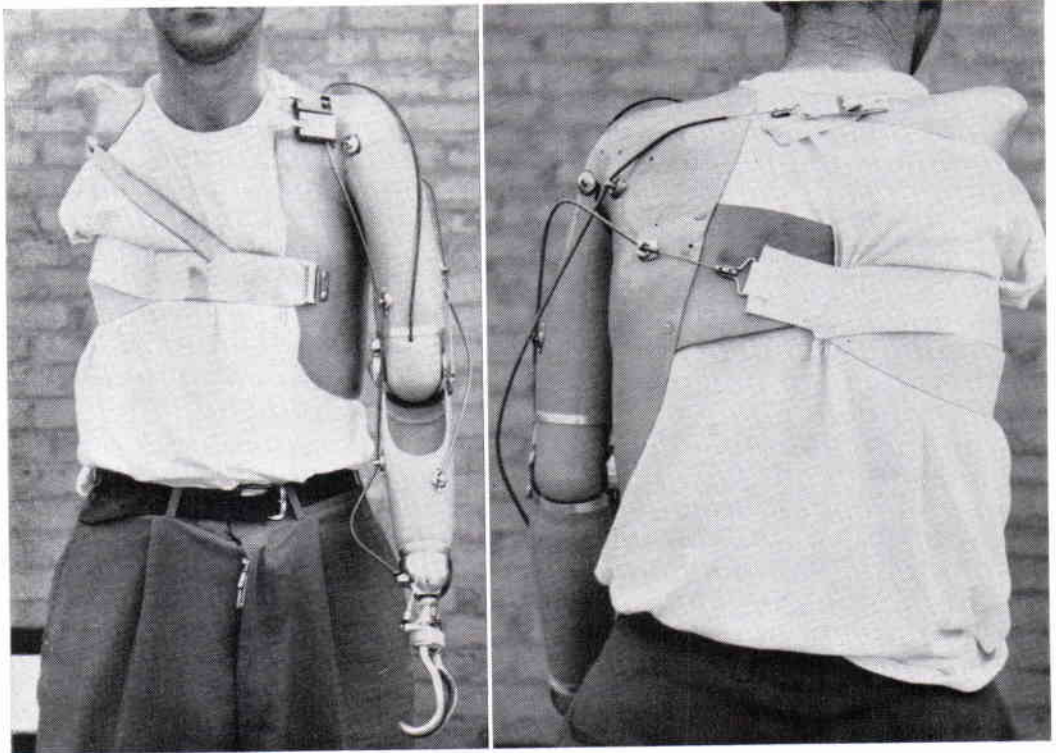


Fig. 1. Shoulder disarticulation on the right and humeral neck amputation on the left. Amputation followed electrical burns.

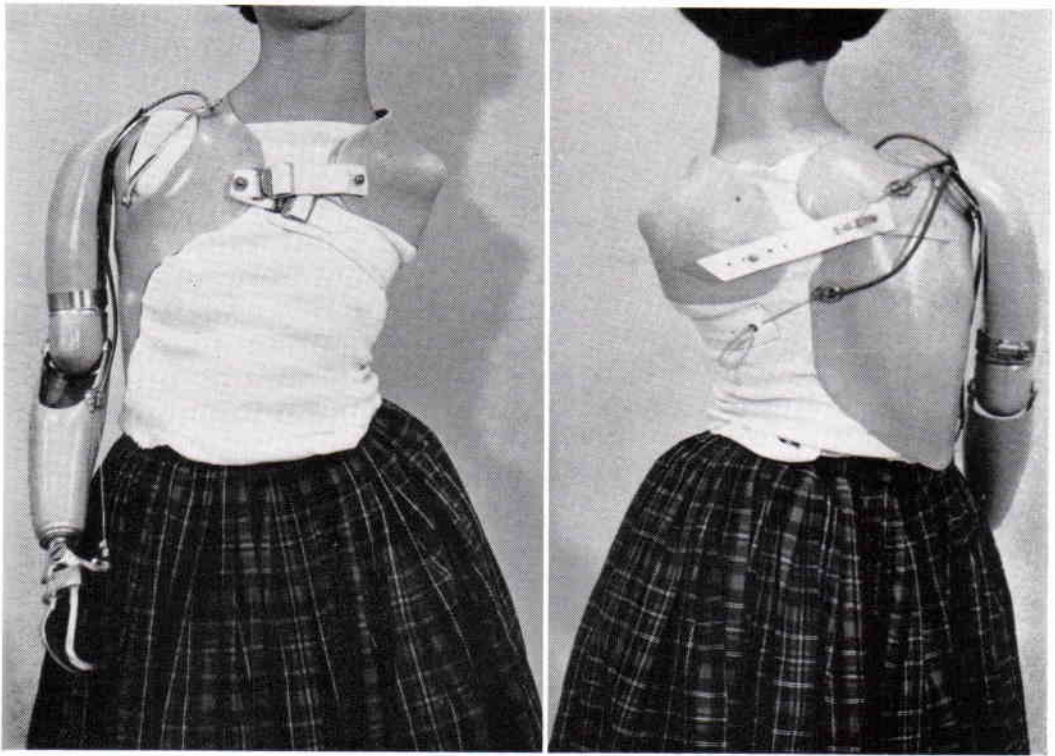


Fig. 2. Bilateral amelia with scoliosis and short left leg.

for the shoulder joint (Fig. 3). When this is obtained, they are locked into position. The amount of friction can be regulated by a self-locking nut and washer which hold the assembly together.

FOREARM LIFT

Because the weight-bearing socket has been extended downward over the rib cage, the chest strap may be positioned around the center of the rib cage where maximum excursion can be obtained. The harness pattern shown in Figure 1 uses chest expansion in series with scapular abduction of the prosthesis-fitted side to lift the forearm. The forearm lift cable terminates in a swivel fitting at the lift tab. Since excursion is usually limited, the lift tab should be positioned close to the elbow joint. If this is not possible, a pulley may be fitted to double the effect of the excursion. But, of course, such an arrangement doubles the input force requirement. In Figure 2, the forearm lift cable is fitted internally in a special

groove cut in the locking quadrant of the elbow unit.

TERMINAL DEVICE

With the chest strap fastened about the middle of his rib cage, the amputee is free to move the scapula of his nonprosthesis-bearing shoulder. Thus, a small shoulder cap, carefully fitted to the scapula, can provide independent control of the terminal device. An anterior elastic strap is usually required to hold the shoulder cap in position. In Figure 2, the available excursion was limited, and therefore a step-up pulley was necessary in order to achieve full opening of the terminal device.

ELBOW LOCK

Since operation of the elbow lock requires a relatively small amount of excursion and force, there are several ways in which it can be accomplished. The patient shown in Figure 1 originally was fitted with a cable which ran from the elbow lock, around a pulley high on the

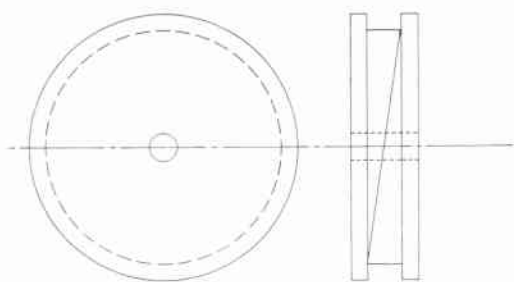


Fig. 3. Schematic drawing showing principle of "Wilson-Riblett wedges."

shoulder, and thence down to a waist belt, so that shoulder elevation was used, alternately, to lock or to unlock the elbow. Later, this was replaced by the nudge control (Fig. 1), which the amputee preferred.

For the patient shown in Figure 2, the prominent acromioclavicular joint was utilized by cutting a hole in the anterior part of the socket and positioning a lever so that forward motion of the clavicle moved the lever forward and downward to develop tension in the elbow-lock cable.

WRIST UNIT

A standard passive wrist-rotation unit, which permits pre-positioning by the amputee, was provided in both cases (Figs. 1 and 2).

For many tasks, such as toilet care, wrist flexion is important. Flexion can be provided by building it into the prosthetic forearm (Fig. 2), or by using a nudge control and Bowden cable to operate the lock on a standard wrist-flexion unit (Fig. 1). In the latter case the lock for the wrist-flexion unit is operated by relative motion between cable and housing. In this application the cable is stationary and the housing pushes to open the lock. To achieve this, the cable guides must be drilled out to allow the housing to slide freely. The inner cable passes through a hole drilled in the locking lever on the wrist-flexion unit and is anchored to a post screwed to the cover of the wrist unit (Fig. 4). When the wrist unit is unlocked by pressure on the nudge control, tension in the terminal-device cable will cause the wrist to flex. If the terminal-device cable is relaxed, gravity will cause the wrist to extend.

Thus a measure of active wrist flexion is obtained.

CAPABILITIES AND LIMITATIONS

The harnessing arrangement just described provides reasonably acceptable prosthetic function without the use of perineal straps. Independent control of the terminal device apart from operation of the elbow allows maximum opening of the terminal device in all positions of elbow flexion and improves the performance rate, since it is not necessary to lock the elbow before using the terminal device. Also, there is no tendency for the terminal device to open when the elbow is being flexed.

The amputee who is a skilled foot user may be able to put on or take off the prosthesis without assistance, particularly if Velcro straps are used (Fig. 2). If the amputee is not a skilled foot user, assistance is required in fastening the chest strap snugly.

The prime objective in fitting this type of prosthesis to a severely disabled amputee is to provide at least a minimum of self-sufficiency in public. Problems of self-dressing are complex, and their solution can scarcely be achieved without the use of external power and devices which have not yet been developed.

ABOVE-ELBOW AMPUTEES

The same three minimal operations (namely, operation of the terminal device, lifting of the forearm, and management of the elbow lock) must be controlled in the prosthesis for a unilateral above-elbow amputee. To avoid restric-

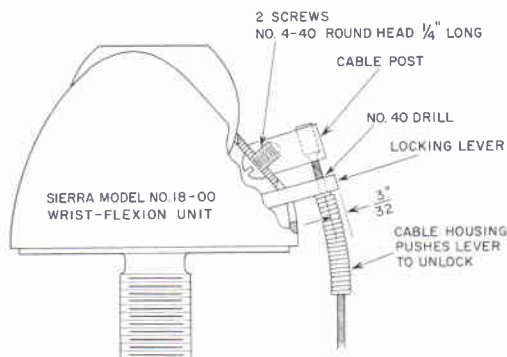


Fig. 4. Modifications of wrist-flexion unit for use with nudge control. Refer to Figure 1.

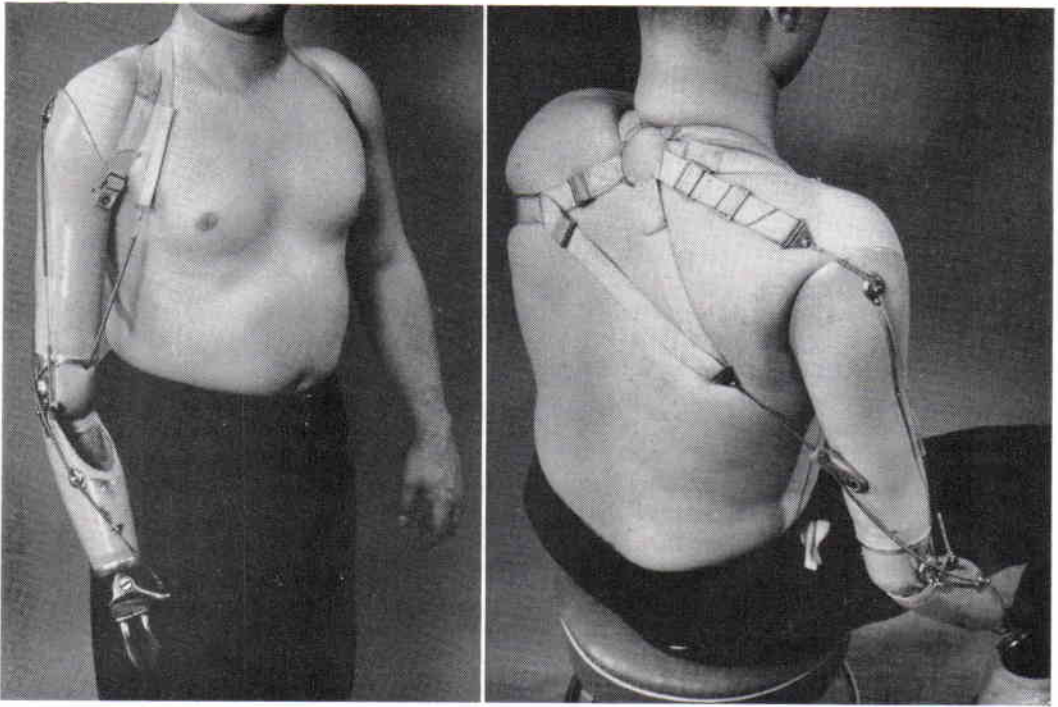


Fig. 5. Congenital above-elbow amputee fitted with independent control. Scapular abduction is used for forearm lift.

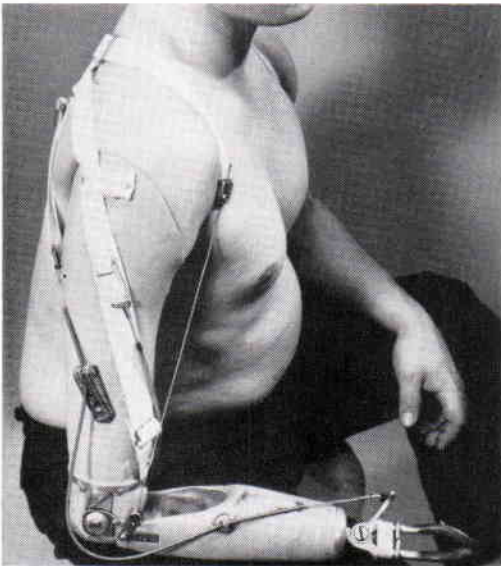


Fig. 6. Same amputee as shown in Figure 5 fitted so the shoulder depression is used to lift the forearm.

tion of the sound arm, the axilla loop of the harness should provide stabilization only. Hence the shoulder motions available for prosthetic use are those that remain on the amputated side. These are scapular abduction, humeral flexion, and humeral abduction. It is conceivable that humeral extension and humeral abduction could be harnessed, but an entirely different harnessing configuration would be required. As in the case of the shoulder-disarticulation amputee, shoulder elevation can be used only in conjunction with a perineal strap or a firm waistband. Most above-elbow amputees can separate scapular and humeral motion, and the harnessing described here is specifically designed to utilize this independent control.

In this harnessing system, lifting of the forearm of the prosthesis is activated by scapular abduction. The anchor point is a ring held in the center of the back by the axilla loop. The reaction point is attached high on the socket, so

as to be independent of humeral flexion. If the reaction point is placed centrally near the top edge of the socket, rotation is minimized and humeral abduction can be used to increase the excursion. The cable is passed through the reaction point and terminates in a swivel at the forearm lift tab, the length and position of which should be carefully adjusted to make full use of the available excursion. (The cable housing at the reaction point serves only as a cable guide.) The suspension strap and elbow-lock strap are attached as shown in Figure 5, the configuration being essentially the same as that used in the Northwestern University dual-control ring-type harness.

Humeral flexion and abduction are harnessed to provide operation of the terminal device. Experiments indicate that the harness pattern shown in Figure 5 is preferable to that in which the control cable is attached solely to the harness ring. A Bowden cable is used, with the housing anchored on the humeral section and on the forearm in a manner similar to that of a standard below-elbow fitting, so that operation of the terminal device is independent of flexion of the elbow.

Optimum results are obtained when the shoulder motions are used in combination. Maximum lift of the forearm is achieved when the humerus is abducted at the same time that the scapula is abducted. This means that the elbow is held close in to the body as the forearm is lifted—a motion that is not ideal for certain tasks, such as switchboard operation. Scapular abduction also tends to affect the terminal-device cable. Thus, when the elbow is held in full flexion, there may be some tension induced in the terminal-device cable, making it difficult to hold the hook closed without locking the elbow. Conversely, the hook is very easy to open fully in this position.

Three amputees have been fitted with this type of harness and have been wearing it rou-

tinely for several months. In addition, one bilateral amputee has been fitted with dual control on one arm and independent control on the other. All the subjects had been users of prostheses. They learned the basic controls with about an hour's training and became proficient at the end of a week.

This harnessing provides excellent terminal-device function throughout the full range of elbow flexion, without locking or even stabilizing the elbow. Since the terminal device is independent of the forearm lift, there is no tendency for the hook to open when the forearm is being raised. However, near the point of full flexion, the interaction of the harness straps does require considerable effort to avoid opening the hook. Moreover, the force available for lifting the forearm is adequate only for the lightest loads.

After several months' wear, one of the amputees rejected the harness and was refitted with a different type of independent control (Fig. 6). The operation of the terminal device was left unchanged, but the forearm-lift and elbow-lock straps were interchanged so that shoulder depression was used to raise the forearm, and scapular abduction to operate the lock. This seemed to provide greater force for lifting the forearm, provided the humerus is not flexed more than about 20 deg. Operation of the terminal device appeared to be slightly improved. The amputee is still wearing the prosthesis routinely.

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2. Pursley, Robert J., *Harness patterns for upper-extremity prostheses*, Chap. 4 in *Orthopaedic appliances atlas*, Vol. 2, Edwards, Ann Arbor, Mich., 1960.
3. Taylor, Craig L., *The biomechanics of control in upper-extremity prostheses*, Artificial Limbs, September 1955, p. 4.

Porous Plastic Laminates for Upper-Extremity Prostheses

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THE problem of perspiration and its removal from the amputee's arm and leg stumps encased in sockets has engaged the attention of the doctor and limb fitter for as long as limbs have been fitted.

In the early days of leather prostheses, a few months of wear during the summer were sufficient to cause the leather to rot and degrade because of perspiration. Since it was not possible to wash leather prostheses easily, severe hygienic problems were created. Efforts to coat leather with plastic films to overcome this difficulty were only partially successful for, in many instances, the adhesion of the coating was poor and frequent re-coatings were necessary. With the development of the all-plastic arm, it became possible to wash the socket thoroughly and virtually eliminate the hygienic problem. However, because the plastic did not permit diffusion of water vapor, sweat gathered profusely in the socket and became a source of discomfort and irritation. Efforts to permit diffusion of sweat by drilling gross holes in the plastic socket were not very successful. Although this practice permitted greater removal of sweat than in undrilled prostheses, the strength characteristics were seriously affected when a sufficient number of holes were cut to permit adequate removal. In addition, there still remained between the holes impervious plastic which could block large numbers of sweat pores—approximately 155 per square centimeter on the forearm (1)—and

permit puddling between the plastic and the stump.

It appeared that for optimum socket ventilation a porous-plastic socket should be developed which contained a large number of interconnected pores. Such a socket should permit rapid diffusion of sweat with minimal blocking of sweat pores. The porous laminate envisioned would consist of a layered fabric resin composite with unbridged voids between the filler strands. Such material should be easily cleaned by soaking in detergent, followed by flushing with water. The following design criteria were outlined for the desired socket material:

1. The socket material should have a uniform distribution of minute pores which would result in high porosity without blockage of sweat pores.
2. It should be easily cleaned.
3. Porous socket fabrication should conform as closely as possible with well-known fabrication techniques current in the practice of upper-extremity prosthetics.

Procedures for preparing porous upper-extremity prostheses were developed, utilizing the design criteria as a guide.

In general, the method comprised the use of a solvent or diluent with an epoxy resin. After initial cure had occurred, the solvent was permitted to evaporate by removal of the outer polyvinyl-alcohol (PVA) bag.

A series of experiments determined the combination of diluent, curing rate, and other factors necessary to produce a laminate with the optimum ratio between porosity and strength (3, 4). Evaluation at New York University indicated that the procedure initially developed by the Army Prosthetics Research

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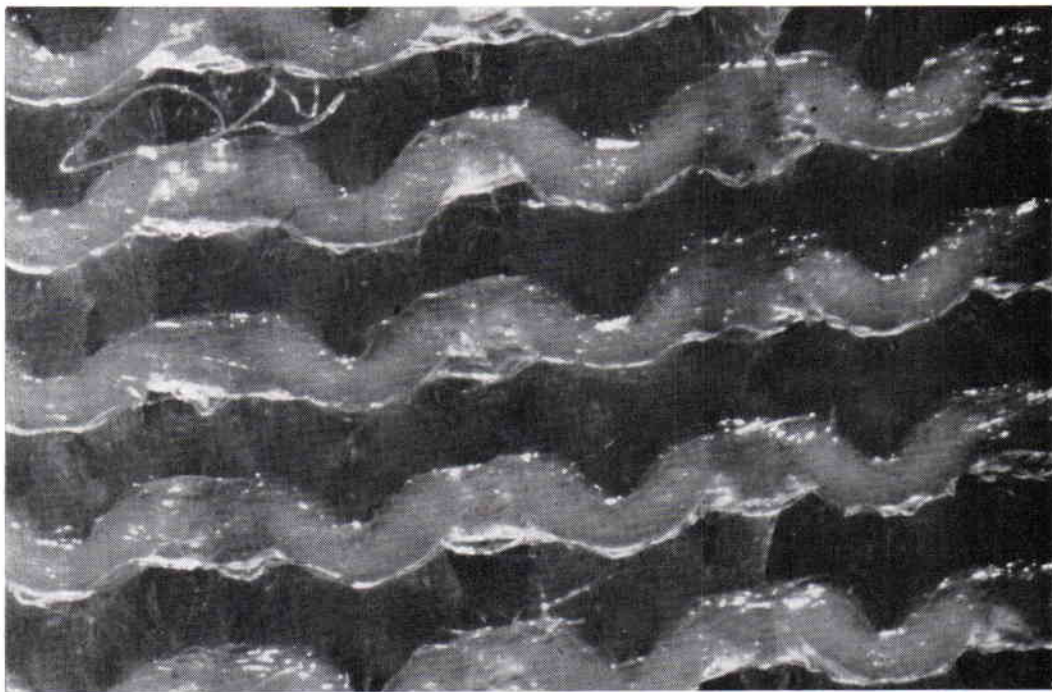


Fig. 1. Porous epoxy laminate made in accordance with the procedure developed at the Army Prosthetics Research Laboratory. Magnification approximately 21X. Courtesy *Veterans Administration Prosthetics Center*.

Laboratory produced a satisfactory material insofar as porosity and strength were concerned but that use of the conventional stockinet as filler produced rough surfaces that made cleaning difficult. Subsequent experiments at the Army Prosthetics Research Laboratory showed that this problem could be overcome by using a nylon stockinet of 200-denier Banlon knit (Fig. 1) for the outer and inner layers of the laminate and by the reapplication of a PVA bag at a critical time in the curing process. Further testing and development resulted in a practical technique which is described in detail in a manual prepared by the Army Prosthetics Research Laboratory (2). Sockets fabricated in accordance with this manual have smooth surfaces and high porosities. Patients fitted with porous sockets have reported a definite increase in comfort as a result of improved ventilation (6).

Laboratory tests have shown that porous epoxy laminates are not as strong in compression and tension as nonporous laminates, but that resistance to impact loads appears to

increase with the porosity and reach a maximum at approximately 17 per cent of effective porosity.³ In practice, the combination of physical properties possessed by the porous laminate which has been developed is satisfactory for use in arm prostheses. Experiments in the use of porous laminates for lower-extremity prostheses are under way.

If actual prosthetist working time is considered, the man-hours required for fabrication of porous laminates are somewhat longer than those required for the conventional plastic laminates. Depending on the technique employed, the porous laminating process may take up to one-and-one-half times as long as the conventional technique.

The components of the liquid resin system may elicit allergic reactions in certain sensitive individuals. Therefore, fabrication should take place in a well-ventilated area and protective gloves should be used in preparing the layup.

³ Effective porosity is the ratio of the quantity of water that flows through the laminate to the amount that flows through the stockinet alone.

No stump dermatitis or other adverse reactions have been reported from the use of the porous laminates to date.

Because the socket is porous, it is necessary that it be cleaned thoroughly and often in order to preclude an accumulation of foreign matter in the pores of the wall. It is recommended that ordinary soap and water be used for this cleaning.

Porous laminates may be considered for application to all upper-extremity amputation levels from below-elbow to shoulder-disarticulation. The technique is of particular value whenever perspiration presents a significant problem.

EPOXY-RESIN MIXTURE

The following epoxy-resin system has been found to produce a satisfactory porous laminate:

		Parts by weight
Epoxy resin	ERL 2795 ⁴ or Epon 815 ⁵	65
Curing Agent	Versamid 140 ⁶	35
Solvent	Trichloroethylene	43

The "pot life" of the liquid resin mixture resulting from this formulation is never less than 30 minutes and usually considerably longer.

The individual limb fitter can best determine the actual amount of resin mixture required for a particular lamination. Appendix A (page 29) contains a table which may serve as a guide in determining the correct amounts of materials for various applications.

FABRICATION

Briefly described here is the fabrication of a double-wall, below-elbow, porous prosthesis, utilizing a plaster-of-Paris (or wax) buildup; this account is followed by a brief description of the fabrication of a single-wall, below-elbow, porous prosthesis, based on the Mylar⁷ cone method.⁸

DOUBLE-WALL, BELOW-ELBOW, POROUS PROSTHESIS

For the fabrication of a double-wall, below-elbow, porous prosthesis, the stump model is prepared in accordance with common practice (9). As shown in Figure 2A, the model is then placed in a vise, distal end up, and coated with a lacquer such as Hi-Glo.⁹ When this coating has dried, a moistened sheet of PVA is stretched over the model and tied at the base (Fig. 2B). The next step in preparing the layup is to cut one length of tubular Banlon stockinet with a 200-denier weave¹⁰ and three lengths of tubular orthopedic stockinet so that each is at least 6 inches longer than the stump model (Fig. 2C). The end of each piece of stockinet is sewed in a curve to match the distal end of the model, and the excess stockinet is trimmed at the sewed end. The Banlon stockinet is turned inside out and pulled down over the model (Fig. 2D). Two of the orthopedic stockinets are pulled down over this. Then the remaining piece of stockinet is turned inside out and pulled down over the layup. The stockinet is smoothed, pulled down tightly, and tied at the base.

A PVA pressure sleeve is now prepared in the usual manner, pulled down snugly over the layup, and tied at the base rod (Fig. 3A). The layup is ready for impregnation, and it is time to mix the resin.

To measure the ingredients for the resin mixture, it is well to balance a disposable container, such as a paper cup, on a scale. The resin, curing agent, and solvent are then put in the cup in the proper amounts by weight. By referring to the table contained in Appendix A (page 29), it can be seen that the following quantities should be sufficient for a short below-elbow socket:

ERL 2795 (resin)	45.5 grams
Versamid 140 (curing agent)	24.5 grams
Trichloroethylene (solvent)	30.0 grams

from *A Manual for the Preparation of Above and Below Elbow Porous Prostheses* (2), published by the U. S. Army Prosthetics Research Laboratory, Walter Reed Army Medical Center, Washington 12, D. C.

⁹ Western States Lacquer, Dallas, Tex.

¹⁰ Wm. H. Horn and Bros., Philadelphia, Pa.

⁴ Bakelite Chemical Division, Union Carbide Chemical Company, New York, N. Y.

⁵ Shell Chemical Company, New York, N. Y.

⁶ General Mills Chemical Division, Kankakee, Ill.

⁷ DuPont Corporation Trademark.

⁸ Both accounts compiled for CPRD, NAS-NRC,

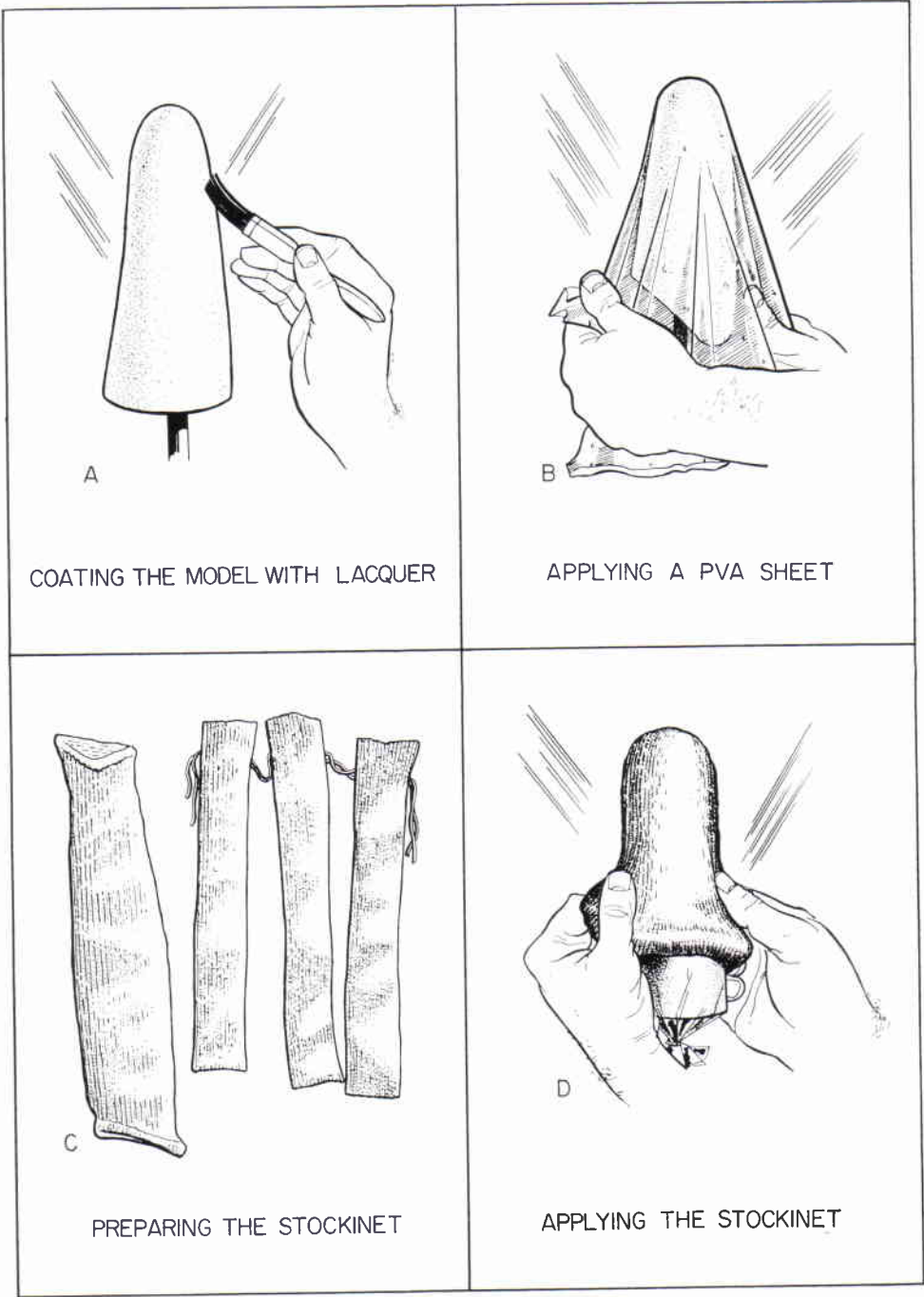


Fig. 2. Preparing the layup.

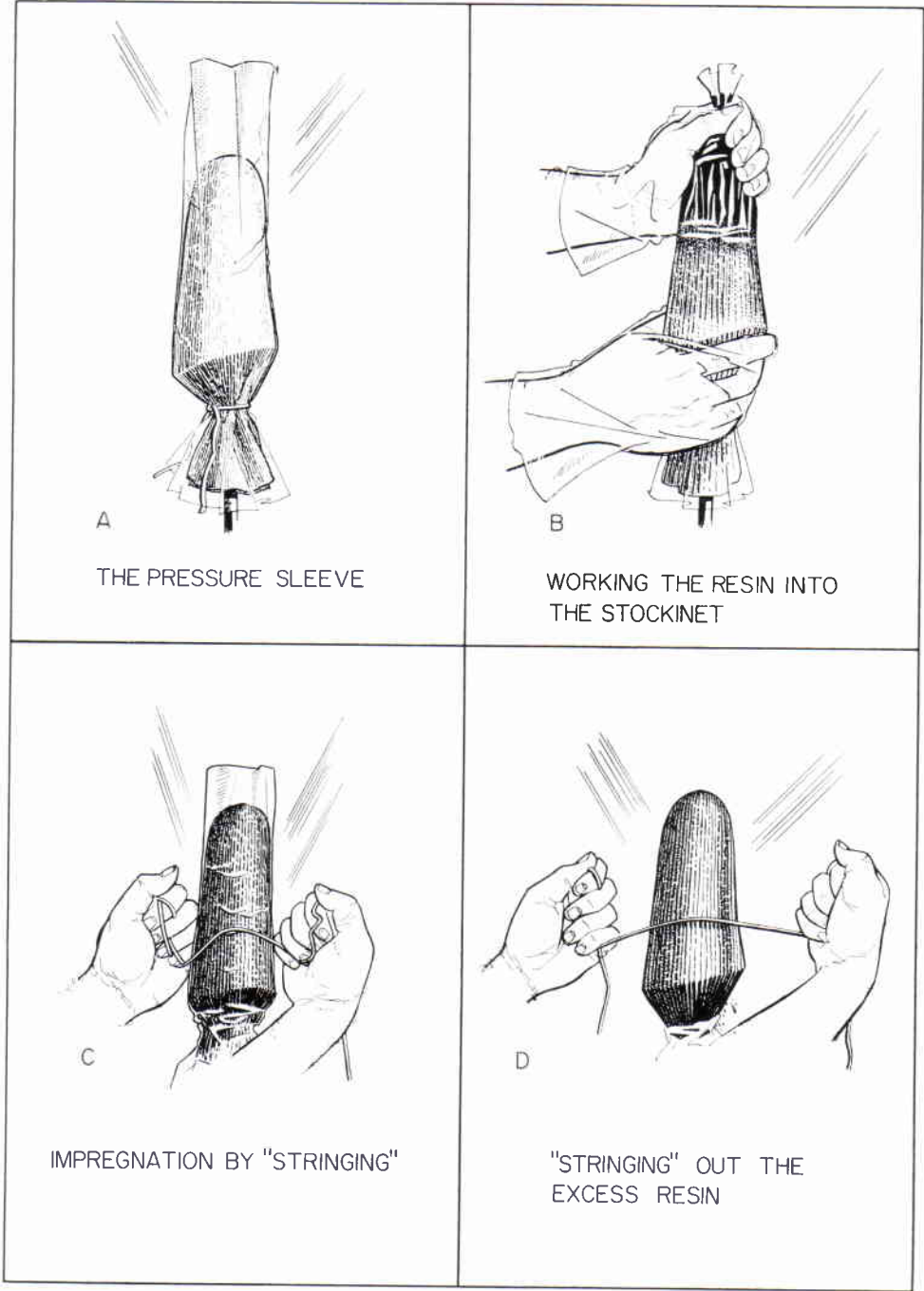


Fig. 3. Applying the resin mixture.

To this resin mixture should be added an appropriate pigment; for example, 2.5 grams of Caucasian epoxy pigment or 3.5 grams of Negroid epoxy pigment (Appendix A, page 29). The pigment is stirred into the mixture until it is uniformly blended.

The resin mixture is poured into the open end of the PVA sleeve and worked down into the stockinet. Twisting the end of the sleeve (Fig. 3B) develops considerable force and aids in the impregnation.

When the stockinet is fully impregnated, the PVA sleeve is pulled down, and the excess resin is "strung" down to the proximal end of the layup (Fig. 3C). Next, the PVA sleeve is cut and removed from the layup. Care should be exercised not to spill the excess resin contained in the bottom of the sleeve. The sleeve and the excess resin are discarded. Spilled resin may be cleaned off with isopropyl alcohol or trichloroethylene. The layup is "strung" with a heavy string until no further excess resin appears (Fig. 3D).

The layup is now placed for 30 minutes in a pre-heated oven set at 115 deg. F (47 deg. C), for what is known as the pre-cure. During this stage, the solvent evaporates from the layup, leaving it porous.

Upon completion of the pre-cure, the layup is removed from the oven, and the oven is set at 212 deg. F (100 deg. C) for the cure. At this step in the procedure, the solvent has evaporated and the resin has gelled slightly. If any areas of the laminate contain excess resin, the excess is "strung" to the proximal end. When the oven has reached a temperature of 212 deg. F (100 deg. C), the laminate is placed back in the oven for one hour. During this hour, the laminate will be cured sufficiently to permit the buildup for the outer socket.

At the end of the hour, the laminate is removed from the oven, and the oven is set at 115 deg. F (47 deg. C).

As soon as the laminate is cool enough to handle, a sheet of Saran-Wrap or rubber sheeting is placed over the laminate as a separating medium. This sheet will facilitate the release of the outer socket which is to be laminated over the inner shell.

For the forearm buildup, plaster of Paris is considered preferable rather than wax, for the

reason that wax may enter the pores of the prosthesis. The buildup is done in the usual manner (Fig. 4A). After the plaster has hardened, the paper cone is removed and the plaster of Paris is shaped to the desired contour. Any plaster on the knurled surface of the wrist unit is removed. The plaster is coated with Hi-Glo or some similar lacquer. A PVA sleeve is prepared, moistened, pulled down over the buildup, and trimmed at the wrist unit (Fig. 4B).

Next, a piece of Banlon stockinet and a piece of orthopedic stockinet are cut, each about 3 to 5 inches longer than the layup. Another piece of orthopedic stockinet is cut, a little more than double the length of the layup. (Additional lengths of stockinet may be used if additional strength is desired.)

The Banlon stockinet is turned inside out, pulled 1 to 2 inches over the distal end, and tied at the wrist unit (Fig. 4C). Excess stockinet that is proximal to the wrist unit is trimmed off.

The short piece of orthopedic stockinet is pulled over the longer piece so that both pieces meet at one end. The other end of the short piece should extend just past the middle of the longer piece.

These pieces of stockinet are extended and slipped, double end first, down over the wrist unit until the double thickness covers the entire layup (Fig. 4D). The double thickness of stockinet is tied at the wrist unit and pulled down and tied at the proximal end. The Banlon stockinet should be on the inside.

Two PVA pressure sleeves are now prepared in the usual manner, with the shiny surface of the material on the inside. One sleeve is set aside to be used later. The other is pulled down snugly over the layup and tied to the base rod at the proximal end.

Resin and pigment are mixed in the manner described previously. For a short or medium below-elbow forearm, the following quantities should be sufficient:

ERL 2795	68 grams
Versamid 140	37 grams
Trichloroethylene	45 grams
Pigment	As required to match the previous mixture.

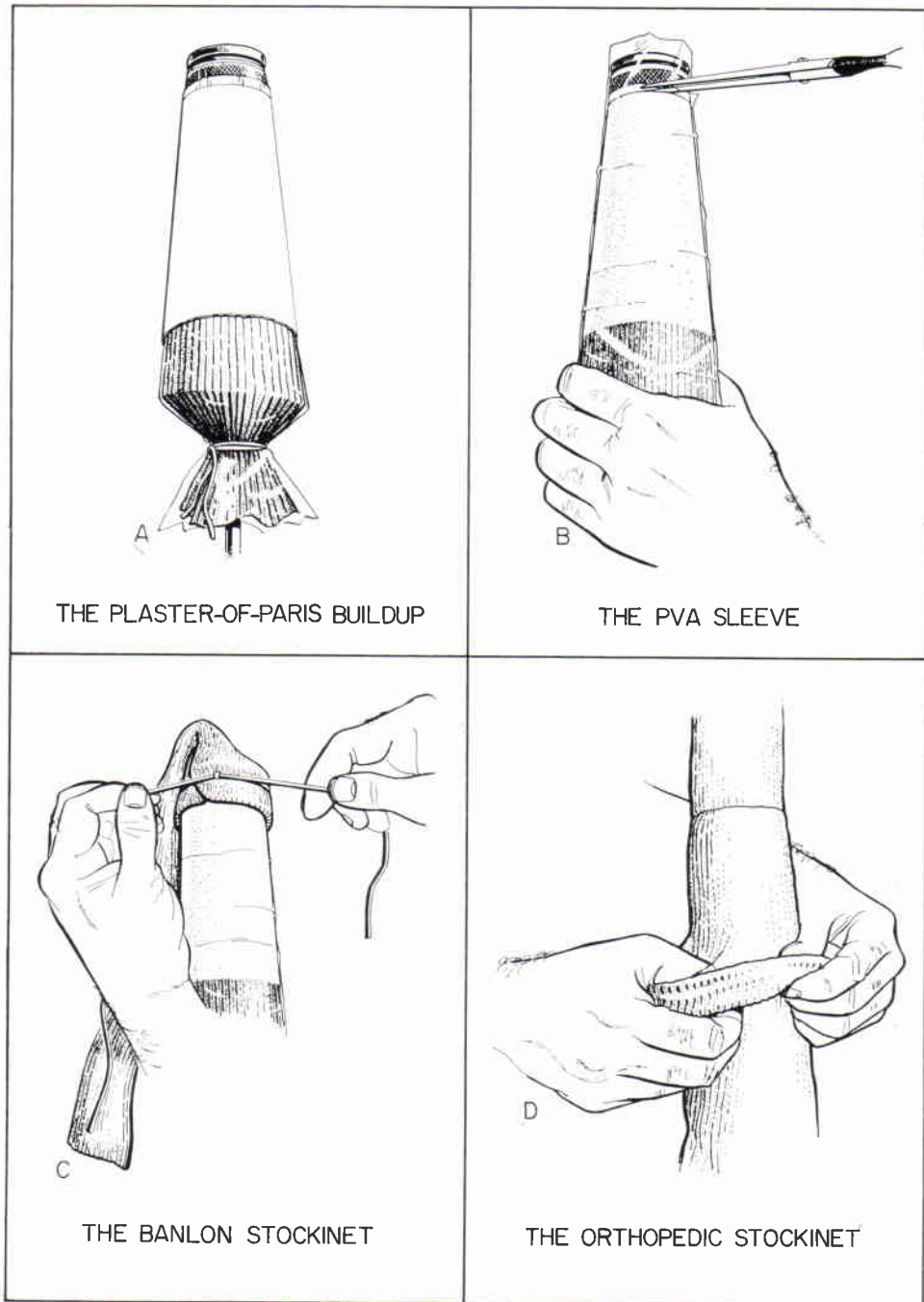


Fig. 4. The forearm buildup.



Fig. 5. Impregnating the forearm layup.

The resin is poured into the pressure sleeve (Fig. 5) and worked into the stockinet. When the stockinet is fully impregnated, the pressure sleeve is pulled down as far as possible, and the excess resin is "strung" down from the layup.

After the layup has been thoroughly "strung" down, the PVA sleeve is stripped off and discarded. The layup is "strung" once more to remove all excess resin.

There may be considerable resin in the stockinet around the base rod. This excess resin should be absorbed in the scrap stockinet wrapped around the base, so that it will not be drawn back into the laminate during the cure.

For the pre-cure, the layup is now placed for 30 minutes in a pre-heated oven set at 115 deg. F (47 deg. C), allowing the solvent to evaporate.

While the pre-cure is taking place, the second PVA pressure sleeve previously prepared should be moistened by wrapping it in a damp towel for 10 to 15 minutes. The next step in the procedure gives the prosthesis a smooth

surface, and it is essential that the PVA sleeve be thoroughly moistened.

Upon completion of the pre-cure, the layup is removed from the oven. The moistened PVA sleeve is pulled down until the entire layup is in contact with the sleeve. Light contact pressure is most desirable, for this will result in a smooth surface without reducing the porosity. It is important that the sleeve slide easily over the layup; otherwise, the force and pressure may cause pooling of the resin. At this point in the procedure, there should be no pools of resin on the stockinet. If there are, they should be "strung" out.

The PVA sleeve is taped around the wrist unit (Fig. 6); any severely undercut areas should also be taped.

The layup is now placed for one hour in an oven pre-set at 212 deg. F (100 deg. C). During this period the PVA sleeve shrinks around the layup, giving the surface a smooth gloss and aiding in molding the undercuts. At the end of

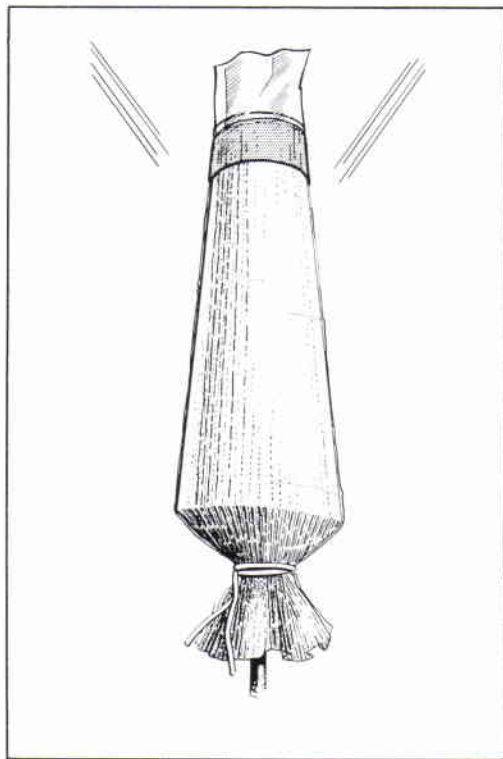


Fig. 6. Molding the surface.

the hour, the laminate is removed from the oven and the PVA sleeve is stripped off. At this point the laminate should be firm and free from tackiness.

The laminate is now ready for the final cure. It is replaced in the oven, set at 212 deg. F (100 deg. C), for 75 minutes to complete the final cure.

While the plastic is still warm, the layup is cut to the desired length. The outer socket will separate easily from the inner socket. The plaster may be removed by striking the socket with a rubber mallet. If necessary, a chisel may be used to dig the plaster out of the distal end of the socket. Remaining PVA film can be stripped off by hand or dissolved with hot water.

The prosthesis is held firmly on the amputee's stump, and the trim line is marked, after which the socket is removed and trimmed in the usual manner. After the socket and the forearm have been properly aligned, the edges are sanded and bonded together with liquid epoxy resin (ERL 2795, 65 parts; Versamid 140, 35 parts) (Fig. 7). The bond may be cured with a heat gun, or the prosthesis



Fig. 7. Bonding the socket and forearm.

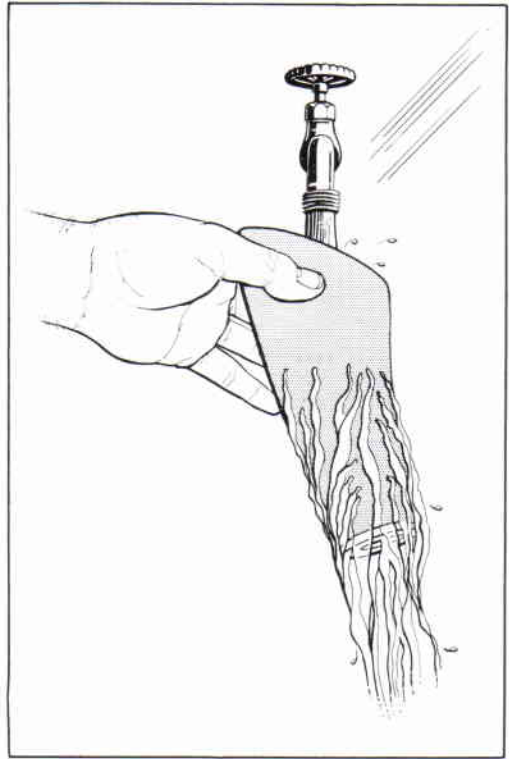


Fig. 8. Testing the porosity.

may be placed for one hour in an oven set at 212 deg. F (100 deg. C).

The porosity of the finished prosthesis can be tested by holding it under a water tap and allowing the water to run through the prosthesis (Fig. 8). If the prosthesis has been prepared properly, the laminate should show a uniform porosity.

The prosthesis is now ready to be harnessed in the usual manner.

SINGLE-WALL, BELOW-ELBOW, POROUS PROSTHESIS (MYLAR CONE METHOD)

For the fabrication of a single-wall, below-elbow, porous prosthesis, the stump model is prepared in the usual manner (9), placed in a vise, distal end up, and coated with lacquer. When the lacquer has dried, a moistened PVA sheet is pulled down over the stump model and tied at the base.

The stockinet layup, consisting of one length of tubular Banlon stockinet and three lengths

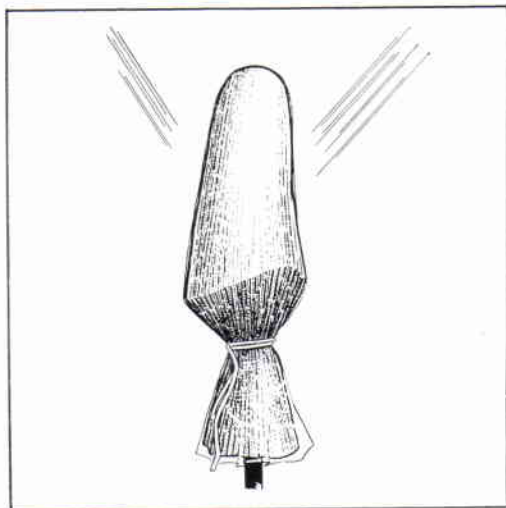


Fig. 9. The stockinet layup on the model. A PVA sheet is pulled down and tied at the base rod.

of tubular orthopedic stockinet, is prepared in the same manner as the stockinet layup for the socket of the double-wall prosthesis previously described.

When the stockinet layup is completed (Fig. 9), a sheet of PVA is pulled down over the layup and tied at the base rod. This PVA cover will protect the layup during subsequent steps.

Next, on an 8 in. $\times$ 12 in. sheet of Mylar (5-10 mils), a crayon mark is made halfway along one of the sides, about one-quarter in. from the edge. A second mark is made one-half in. inside the first mark. Then two final marks are made; one 3 in. above the first mark, the other 3 in. below the first mark. A curve is drawn from the edge of the Mylar sheet through the upper mark, through the inside mark, and thence to the edge of the sheet. A cut is made along the

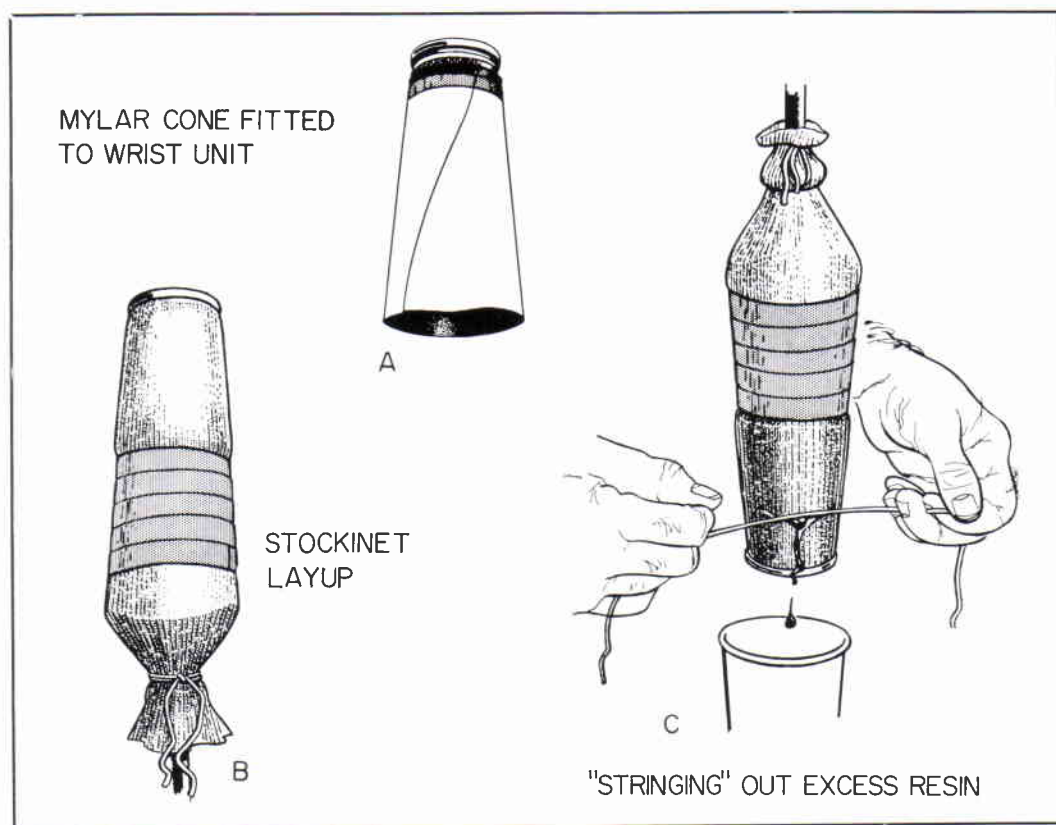


Fig. 10. The Mylar cone buildup and impregnation.

curve. This cut side will permit the standard adult wrist unit to fit squarely to the Mylar sheet when it is fitted into a cone (Fig. 10A). The wrist unit should be fitted a minimum distance into the cone.

The cone is placed over the stump model and adjusted so that the desired contour of the finished prosthesis will be obtained. Next, the prosthetist holds the cone and wrist unit in one hand, placing the unit flat on a table. With the other hand, he positions the stump model in the cone so that the distance between the elbow axis and the table surface corresponds to the required forearm length. The cone is adjusted at the proximal end, and the excess is trimmed off. The shortest cone that will give a desirable final shape to the forearm should be used, since it will provide the greatest bond area between the forearm and the socket. When the correct conical shape is obtained, the cone is closed with transparent tape, the proximal end of the cone is taped to the socket with transparent tape, the wrist unit is taped in place, all holes in the unit are closed with a sealer, and all seams are taped.

Next, a piece of orthopedic stockinet is cut so that it is at least 10 in. longer than twice the length of the layup. The stockinet is pulled down over the entire layup in such a manner that half of the stockinet extends above the wrist unit. The stockinet is tied at the wrist unit, and the extended half of the stockinet is pulled back down over the layup. The stockinet is pulled smooth and tied at the base rod.

The proximal edge of the Mylar is found by palpation, and a light line is drawn around the layup just distal to the edge of the cone. All the areas below this line are covered with masking tape (Fig. 10B).

A batch of resin is mixed as follows:

ERL 2795.....	45.5 grams
Versamid 140.....	24.5 grams
Trichloroethylene.....	30 grams

Sufficient pigment is added to give a slight color to the batch.

The entire layup is inverted and brush-coated with this resin mixture. The excess resin is "strung" down toward the wrist unit (Fig. 10C).

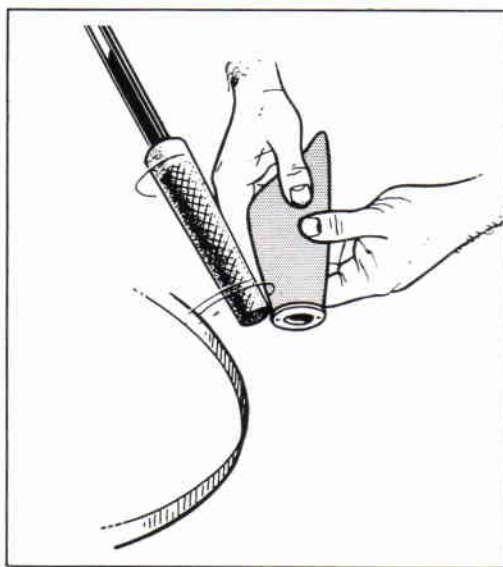


Fig. 11. Sanding the porous cone.

The layup is now placed for 30 min. in a pre-heated oven set at 115 deg. F (47 deg. C) for the pre-cure. After the cone has been pre-cured for 30 min., the oven temperature is increased to 212 deg. F (100 deg. C) and the cone is cured for 30 min. at this temperature.

The layup is then removed from the oven, the masking tape is removed from the layup, and the cone is separated from the inner socket. The Mylar sheeting is removed from inside the porous cone. The porous cone is sanded around the wrist unit until a smooth taper is obtained (Fig. 11).

With the table contained in Appendix A (page 29) as a guide, a 250-gram batch of resin mixture is prepared, including in it a suitable amount of pigment.

At this point the PVA sheet placed over the socket layup early in the procedure is removed, and a PVA sleeve is placed over the socket layup.

The inner socket layup is impregnated with resin in the usual manner. Excess resin is removed from the layup by "stringing," the PVA sleeve is removed from the layup, and any excess resin is "strung" out.

Now the porous cone is pulled down over the inner socket and aligned so that the wrist

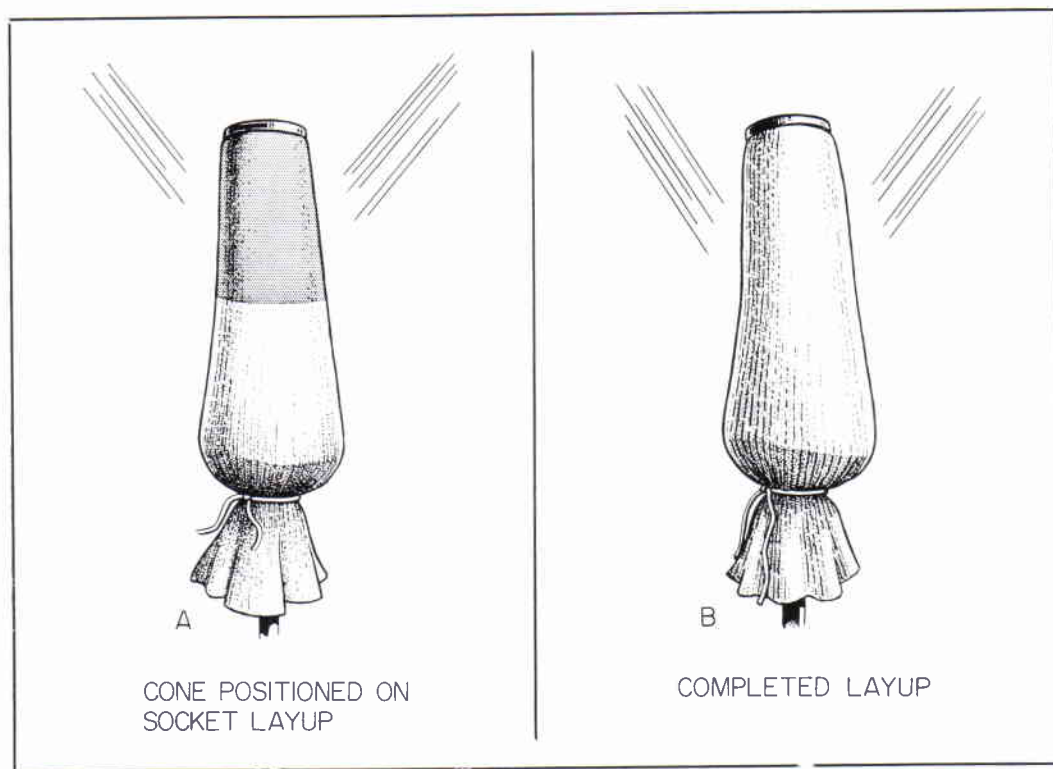


Fig. 12. Preparing the layup combining the socket and the porous cone.

unit is in the proper position. The stockinet is tied at the base rod (Fig. 12A).

A piece of Banlon stockinet is cut so as to be 3 to 5 in. longer than the layup, and a piece of orthopedic stockinet is cut so as to be twice the length of the Banlon stockinet. One end of the Banlon stockinet is tied around the wrist unit. The orthopedic stockinet is pulled over the Banlon stockinet and tied at the middle around the wrist unit. (Additional layers of stockinet may be used if greater strength is required.) All layers of stockinet are pulled down over the layup and tied at the base rod (Fig. 12B).

The layup is now thoroughly impregnated with the remaining resin mixture, with the use of a PVA sleeve and "stringing." It is very important that all the excess resin be "strung" down toward the proximal end, so that there will be no pooling of resin when a PVA bag is pulled down in a subsequent step. A few pieces of scrap stockinet should be wrapped around the base pipe to absorb excess resin.

The layup is now placed for 30 min. in an

oven pre-set at 115 deg. F (47 deg. C) for a pre-cure. While the layup is pre-curing, a PVA sleeve is prepared to fit the forearm. The PVA sleeve is wrapped in a moistened towel for 10 to 15 min. during the pre-cure. At the end of the pre-cure, the layup is removed from the oven and any excess resin is "strung" out. The oven temperature is increased to 212 deg. F (100 deg. C). Meanwhile, the moistened PVA sleeve is pulled down over the layup so that the entire laminate is in firm contact with the sleeve. If the sleeve is sufficiently moist, it will slide easily over the layup without causing any resin pools. However, if any resin pools do form, they should be "strung" out of the laminate. The PVA sleeve is taped around the wrist unit and any undercut areas to insure proper lamination.

The laminate is now placed for 60 min. in the oven, previously set at 212 deg. F (100 deg. C). At the end of 60 min., the laminate is removed from the oven and the PVA sleeve is stripped off. At this point, the laminate should be free from tackiness.

For the final cure, the laminate is replaced in the oven, still set at 212 deg. F (100 deg. C).

After the final cure, the laminate is removed from the oven and cut to the desired length. The laminate should separate easily from the mold.

The prosthesis is held firmly on the amputee's stump, and the trim line is marked. Then the socket is removed and trimmed in the usual manner.

POLYESTER-RESIN MIXTURE

Shortly after the initial success of the porous epoxy laminates, attempts were made to produce similarly porous polyester laminates. At first these attempts were unsuccessful. Although highly porous laminates were produced, their physical strengths were inadequate for prosthetic application.

However, because of significant improvements in the method of preparing porous epoxy laminates, particularly through the reapplication of a PVA bag at a critical time in the curing process, it was decided to reinvestigate the porous polyester system. The Army Prosthetics Research Laboratory has produced a series of cylindrical, porous polyester laminates which have shown when tested a strength sufficient for prosthesis (5). Preliminary results of the evaluation are promising. The fabrication procedures presently recommended are the same as have been described for porous epoxy laminates in this article and set forth in full in *A Manual for the Preparation of Above and Below Elbow Prostheses* (2), published by the Army Prosthetics Research Laboratory.

The following polyester-resin formulation is tentatively suggested for a medium below-elbow porous prosthesis:

Laminac 4110 ¹¹	80 grams
Paraplex P-13 ¹²	20 grams
Luperco ATC ¹³	3 grams
Trichloroethylene	43 grams
Naugatuck Promoter No. 3 ¹⁴	6 drops
Polyester pigment	1 gram (or as required)

¹¹ American Cyanamid Company, Plastics Division, 30 Rockefeller Plaza, New York 20, N. Y.

¹² Rohm and Haas Company, Philadelphia 8, Pa.

¹³ Wallace and Tiernan, Incorporated, Lucidol Division, 174 Military Road, Buffalo, N. Y.

APPENDIX A

RESIN MIXTURES REQUIRED FOR VARIOUS APPLICATIONS (2)

Amount of* Total Resin Mixture Needed	Amount of ERL 2795 Necessary	Amount of Versamid 140 Necessary	Amount of Trichloro- ethylene Necessary	Typical Applications
Grams	Grams	Grams	Grams	
50	23.0	12.0	15.0	Short BE
75	34.0	18.5	22.5	
100	45.5	24.5	30.0	
125	56.0	30.5	37.5	
150	68.0	37.0	45.0	Medium BE
175	79.5	43.0	52.5	Long BE
200	91.0	49.0	60.0	
225	102.5	55.0	67.5	Long BE
250	114.0	61.0	75.0	
275	125.0	67.0	83.0	Shoulder
300	136.5	73.5	90.0	

* Total resin mixture includes resin, curing agent, and solvent.

Color appropriate for the individual should be added to the resin mixture and stirred in until it is uniformly blended. For a 100-gram mixture, 1 to 4 grams of color is sufficient. Epoxy pigment, Caucasian, tan, No. 22826 (60% pigment) and epoxy pigment, Negroid, brown, No. 22831 (53% pigment) (Plastics Color Company, 22 Commerce Street, Chatham, N. J.) have been used successfully at New York University (7).

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Dynamic Alignment of Artificial Legs with the Adjustable Coupling

ANTHONY STAROS, M.S.M.E.¹

SINCE World War II one of the most significant advances in limb prosthetics has been the introduction of rational principles for fitting and aligning artificial legs (2,11). The University of California (Berkeley—San Francisco), sponsored by the Veterans Administration, has been primarily responsible for the steady improvement in methods and devices used by prosthetists in artificial-leg construction.

To assist the prosthetist in carrying out these principles, a number of mechanical aids or tools were devised. The two adjustable legs—one for above-knee cases (Fig. 1), the other for cases below the knee (Fig. 2)—and an alignment duplication jig (Fig. 3) were developed by the University of California, and are now recognized as important tools of the prosthetist (4). And dynamic alignment of artificial legs is a standard part of the curriculum of prosthetics schools (1) and standard operating procedure in most limbshops.

But there have been problems. For one, the limbshop must have a minimum of two adjustable legs for adult cases, and two smaller ones for child cases. A shop of any size requires multiple quantities because frequently a given unit must remain attached to a socket for a particular amputee for an extended period of time. And to make best use of the adjustable legs an alignment transfer jig is needed.

Other limitations in the above-knee adjustable leg appeared when knee units or knee-shank-foot units with fairly complex functions were introduced. Use of the UC adjustable AK leg, with its single-axis, constant friction joint for achieving alignment which is to be transferred to a permanent leg having a some-

what different type of function, is a questionable procedure; i.e., alignment suitable for a constant friction unit may not make proper use of the functions provided by more sophisticated devices. Some prosthetists have learned to accommodate for the required deviations by rules of thumb, but essential are some method and some tool for dynamic alignment to be made directly on the knee or knee-shank-foot mechanism to be used in the final prosthesis.

Ideally, the device should be of simple design and useful for both above-knee and below-knee cases. For the above-knee case, such a device should be inserted between the socket and permanent prosthetic knee for "functional" alignment.

If the unit were simple enough, it would be expected that more generalized use of alignment tools might result, and that facilities in other countries, where it is difficult to procure adjustable legs, could enjoy the advantages of dynamic alignment. Moreover, the alignment-transfer process needed scrutiny to see if simplifications in the equipment necessary might result.

For these reasons, the VA Prosthetics Center developed the Adjustable Coupling, sometimes termed the "Staros-Gardner Coupling."

DESCRIPTION OF THE ADJUSTABLE COUPLING

The adjustable coupling (Fig. 4) consists essentially of two plate assemblies held together by a central toggle pin. Mounted to a middle or intermediate plate but part of one plate assembly are four screw subassemblies, spaced 90 deg. apart, which contain independently adjustable, knurled screws used to "lock" the entire coupling as well as to provide

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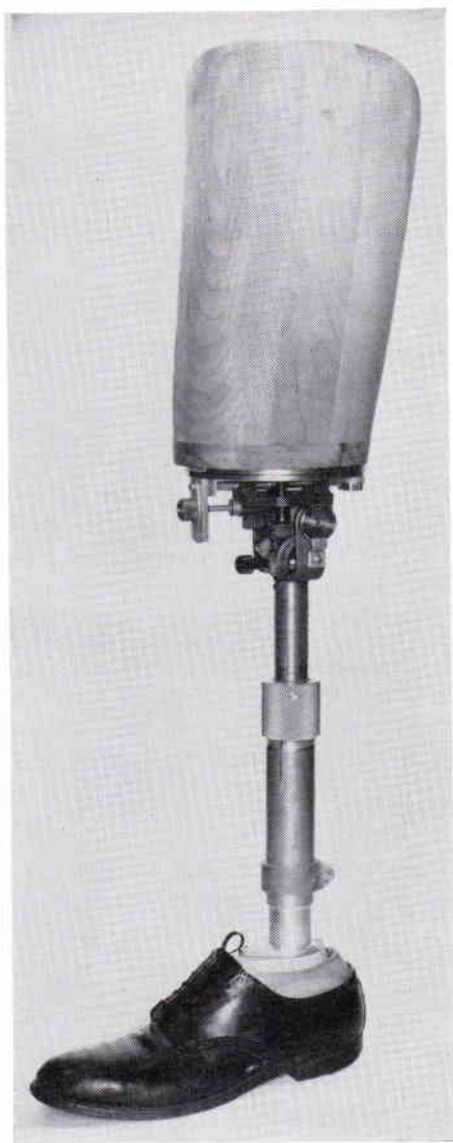


Fig. 1. An above-knee adjustable leg.

adjustment for adduction-abduction and flexion-extension.

In Figure 5 are illustrated the major assemblies of the coupling. The single-flange part of the toggle and the top plate constitute the top assembly. The bottom assembly contains the "box" part of the toggle, the bottom plate, the intermediate plate, the four tilt-screw subassemblies, and the toggle pin. The bottom

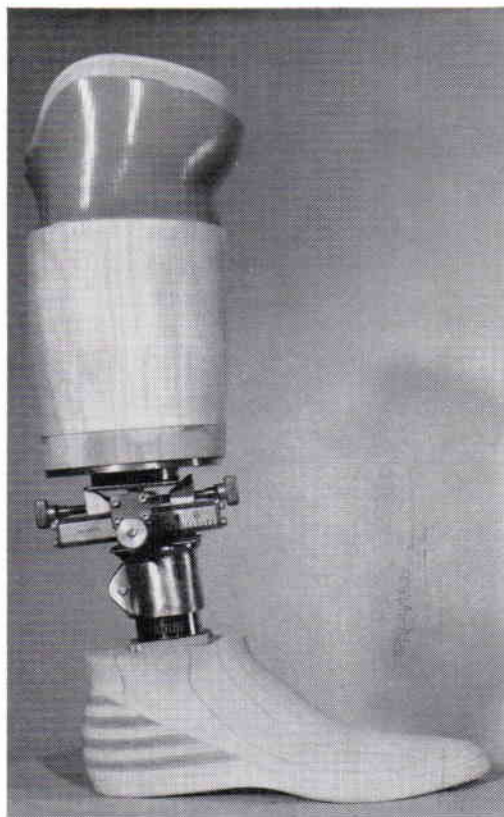


Fig. 2. A below-knee adjustable leg used in current practice.

and intermediate plates both contain "A" and "P" marks to indicate the anterior and posterior sides, respectively. The two assemblies contain countersunk holes for screws used for attachment to the prosthesis.

The top assembly, primarily offering medio-lateral and tilt adjustability, contains a $1\frac{1}{4}$ in., $\frac{1}{8}$ in. increment scale for gauging medio-lateral adjustments (with an index on the single-flange toggle which is free to slide with respect to the top plate). A tilt scale² is provided by markings on the threaded bushings of the four tilt-screw subassemblies. The

² All scales have "neutral" positions highlighted. The "neutral" positions on the tilt scales are most important in establishing the middle position of tilt, when top and bottom plates are parallel, or for disassembly, when it is important to "unlock" the coupling by having all four tilt screws down at least two increments below "neutral."

indexes for tilt scaling are the lower surfaces of the knurled screws. Scale sensitivity for tilt adjustment is 2 deg.

The bottom assembly provides rotation about the vertical axis and anteroposterior adjustability because the intermediate plate (and toggle "box") is free to move with

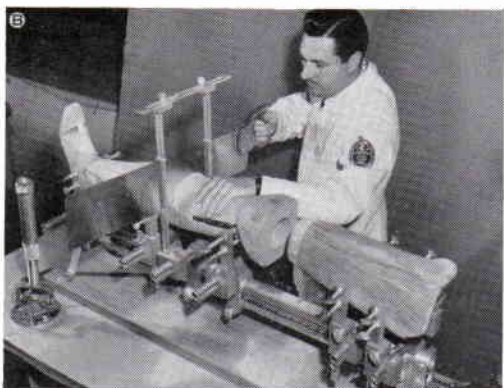
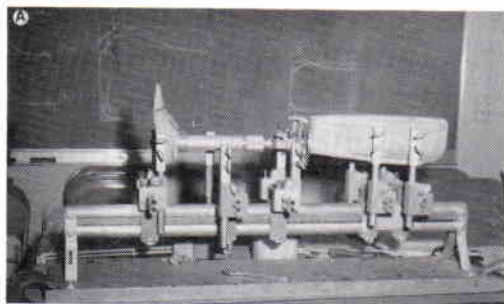


Fig. 3. Alignment duplication jig. A, Adjustable leg mounted in jig. B, Adjustable leg has been removed and wooden set-up substituted. Prosthetist is sawing shank to proper length.



Fig. 4. The adjustable coupling assembled.

respect to the bottom plate. On the anterior surface of the bottom plate is the 20-deg. (2-deg. increment) rotation scale. The index is located on the intermediate plate. The anteroposterior adjustment scale consists of a series of arcs, $\frac{1}{8}$ in. apart for $1\frac{3}{4}$ in., etched on the top surface of the bottom plate. The index for this scale is simply the outer contour of the intermediate plate.

The coupling, made primarily from an aluminum alloy (except for the toggle assembly which is steel), weighs 12 oz., is $3\frac{3}{4}$ in. in diameter, and is $1\frac{1}{8}$ in. thick when the plates are parallel. Ranges of adjustment are as follows:

1. *Mediolateral*: Total Range— $1\frac{1}{4}$ in.
Increment of Scale Markings— $\frac{1}{8}$ in.
2. *Anteroposterior*: Total Range— $1\frac{3}{4}$ in.
Increment of Scale Markings— $\frac{1}{8}$ in.
3. *Tilt*: Total Range—10 deg.
Increment of Scale Markings—2 deg.
4. *Rotation*: Total Range—20 deg.
Increment of Scale Markings—2 deg.

The coupling is disassembled by first lowering each of the four tilt screws two increments on the tilt scale. This operation loosens the entire assembly because it is held together as a result of the forces produced by tightening the force screws, and the toggle pin can thus be disengaged from the toggle box and flange. The top assembly and bottom assembly can then be separated.

Installation of the coupling into a prosthesis is made with the coupling so separated.

INSTALLATION OF THE COUPLING FOR DYNAMIC ALIGNMENT (10)

Figures 6 and 7 show the coupling in position for dynamic-alignment trials. When installed, the coupling should be located as close as possible to the distal end of the stump. A piece of material may have to be added to accommodate the wood screws without affecting the socket sealing plate itself. By so locating the coupling, small tilt adjustments on the coupling will produce major changes in the geometrical relationship of stump to prosthetic components distal to the coupling. When the "bench" or static alignment is reasonably close, the 10 deg. range of tilt adjustment is more than adequate.

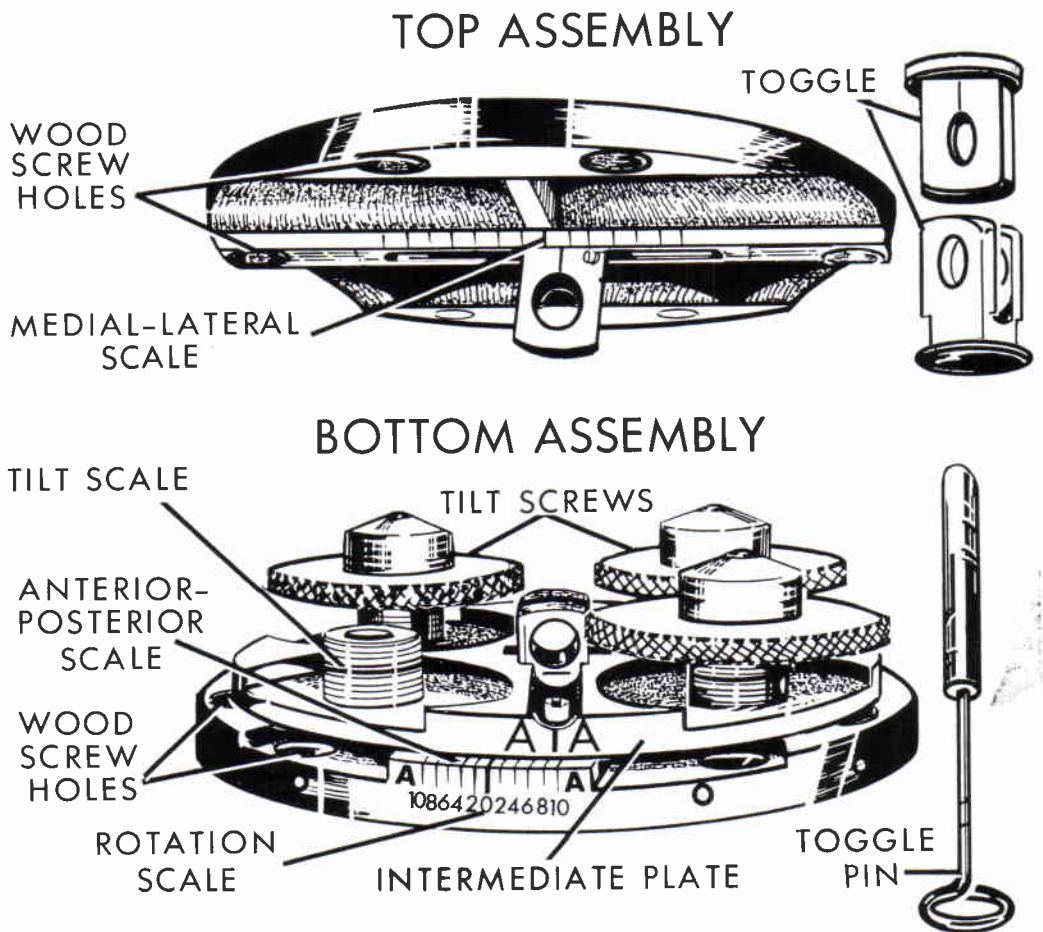


Fig. 5. Major assemblies and parts of the adjustable coupling. The toggle pin is permanently located in the semi-circular channel just above the AA marks on the intermediate plate. From (10).

After the socket is constructed and the components approximately dimensioned³ lengthwise, the top assembly of the coupling is attached to the bottom of the socket using as many wood screws as possible (Fig. 8). The bottom assembly then is attached to the top assembly by placing the single-flange part of the toggle within the "box" part and pushing the toggle pin through the holes in both toggle parts. One must make certain that the "A" marks (or "P" marks) are located properly

³ The over-all length of socket, knee unit, shank piece, and foot, plus $1\frac{1}{8}$ in. for the coupling, should be slightly larger than the amputee's dimensional requirements. Later sanding after a height check will produce accurate longitudinal dimensioning.

with respect to the socket. The coupling is then set with all adjustments on "neutral" so that top plate and bottom plate are parallel and coaxial, care being taken to ensure that the intermediate plate is not rotated with respect to the bottom plate.

The socket with the coupling attached is then temporarily placed on the above-knee setup (knee-shank-foot) or on the below-knee setup (shank-foot). A height check⁴ is made with the amputee standing on the prosthesis.

⁴ With especially long above-knee stumps, the knee center must be dropped during alignment trials because of the thickness of the coupling. Later, during transfer, true or near-true knee-center height can be restored.

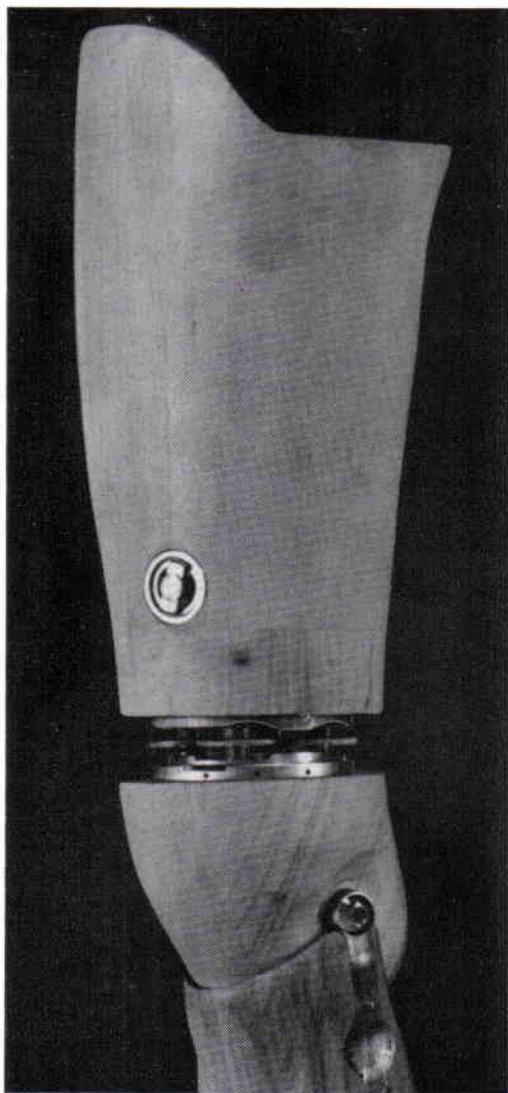


Fig. 6. The coupling installed in an above-knee prosthesis.

Since the coupling has not been fully assembled into the prosthesis, the prosthetist must, of course, assist the amputee in maintaining stability. After the height check has been made, the section of the prosthesis below the coupling (on the knee block or shank) can be sanded to obtain the correct height.

One must consider the desired static or bench alignment before fully attaching the bottom plate assembly to the prosthesis. A recently published chart (8) shows recom-

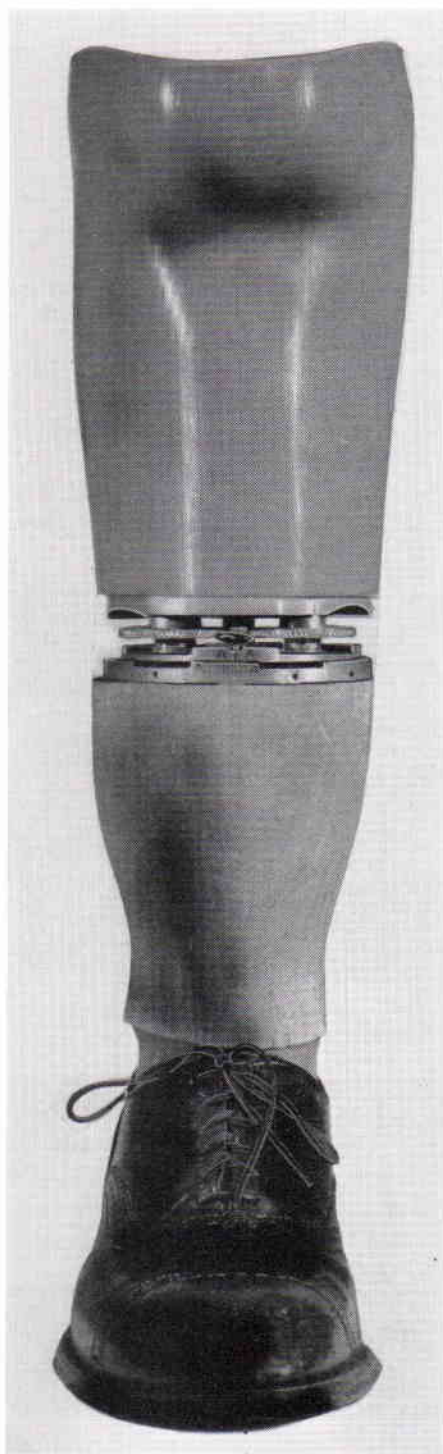


Fig. 7. The coupling installed in a below-knee prosthesis. From (10).

mended guides for "bench" alignment when the SACH foot is used. In any case, care should be exercised in locating the bottom assembly to assure that the ranges of adjustment available in the neutrally set coupling will not be exhausted during dynamic alignment.

When the bottom plate is being installed, the countersunk clearance holes are made accessible by shifting the intermediate plate with respect to the bottom plate (Fig. 9).

Dynamic alignment can begin when the coupling is reassembled and "locked" in the neutral position. This procedure should ordinarily be carried out in the following fixed sequence, making the linear adjustments first and the tilt adjustments second:

1. With the amputee *seated*, loosen only the two *front* tilt screws and make the ANTEROPOSTERIOR adjustment. Tighten the two front screws.

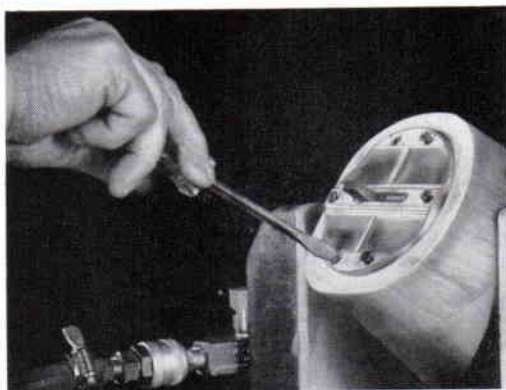


Fig. 8. Attaching the top assembly of the coupling to the bottom surface of the above-knee socket.

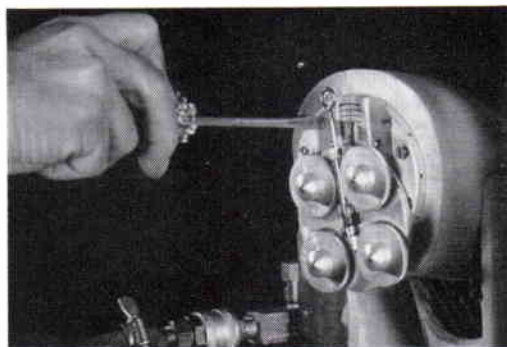


Fig. 9. Attaching the bottom assembly of the coupling to the top surface of the knee block.

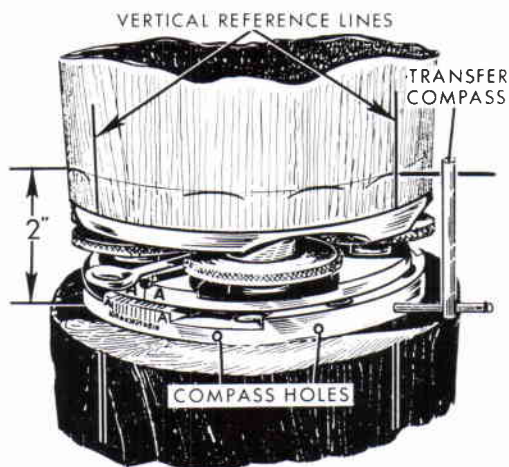


Fig. 10. Use of the special compass for an alignment-transfer reference. The vertical reference lines will be used to reestablish anteroposterior, mediolateral, and rotation positions. The horizontal line tangent to the tops of the compass arcs will reestablish tilt. From (10).

2. With the amputee *seated*, loosen only the two *front* tilt screws and make the MEDIOLATERAL adjustment. Tighten the two front screws.

3. With the amputee *standing*, provide TILT adjustment by turning down one of the two tilt screws *on the side to be depressed*. (The screw should be turned down only as far as needed for the angular adjustment desired.) Then tighten the tilt screw diagonally opposite to establish the angular adjustment desired. Next loosen (the same amount) the second screw on the side to be depressed and tighten the screw diagonally opposite to complete the angular adjustment and "lock" the coupling.

4. ROTATION may be established or reestablished before the screws are completely tightened in any of the above three adjustments. The rotation scale reading may be recorded before making any adjustment so that the position of rotation may be readily restored.

ALIGNMENT TRANSFER

No special jig is required for alignment transfer with the coupling. Actually, alignment is not "transferred" but rather "maintained" while the coupling is replaced with a permanent material.

Around the periphery of the bottom plate of the coupling, there are ten radial holes located 36 deg. apart that serve as centers for a special compass which is used for scribing reference marks on the socket after dynamic alignment has been completed. The alignment compass is inserted in each of the holes in the periphery of the bottom plate, and small arcs

are drawn or scribed on the socket base (Fig. 10). The *tops* of these arcs are then connected by a circumferential line which will be exactly

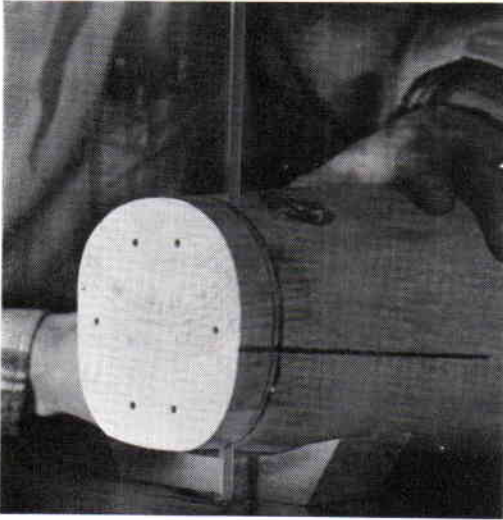


Fig. 11. Using the band-saw to cut the socket immediately below the horizontal-circumferential reference line.

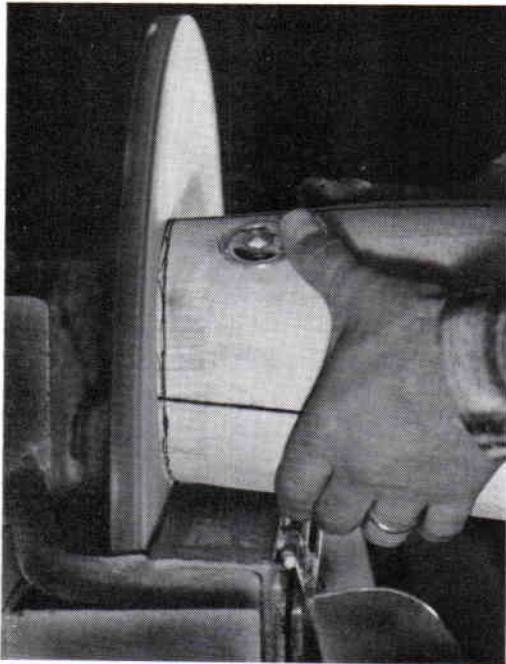


Fig. 12. Sanding of the socket to the horizontal-circumferential reference line.

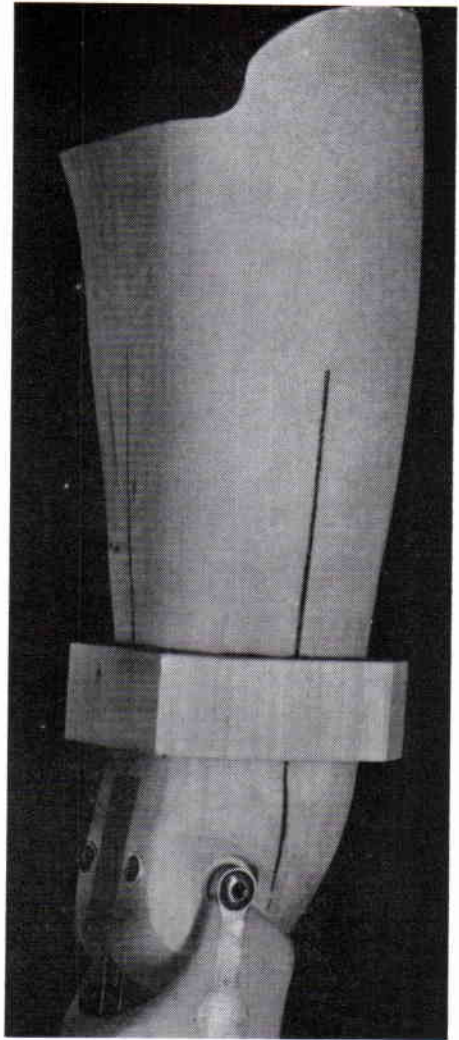


Fig. 13. Replacement of the coupling with a 2-in. wood block. Coincidence of the vertical reference lines must be restored in the alignment-transfer process.

2 in. above the bottom surface of the bottom plate and parallel to it.

At least four vertical reference lines (90 deg. apart) are made on the socket and continued onto the distal component (knee block or shank).

The toggle pin of the coupling is removed and the top and bottom plate assemblies are detached from the socket and from the knee block (or shank).

A saw cut is then made in the socket base⁵ just below the horizontal circumferential line (Fig. 11) and the socket base is sanded to the line (Fig. 12). A 2-inch-thick wood or foam block (with parallel top and bottom surfaces) is then placed between the socket and the knee block (or shank). The wood or foam block is then firmly attached (with cement, resin, and/or other fastening media) to both socket and knee block (or shank), care being taken to restore the coincidence of the vertical reference lines on the assembled components (Fig. 13). Although not necessary, an apparatus for holding the parts together during cement or resin cure can be used.

If one wishes, the standard alignment transfer jig may be used instead. Following standard procedures, the prosthesis with the coupling may be fixed in the jig and then the coupling removed. Saw cuts through the socket base and knee block (or shank) and substitution of an appropriately sized block of wood will be needed. In the above-knee limb transfer, one saw cut in the socket base will be sufficient if the prosthesis is mounted in the jig with the bottom plate of the coupling perfectly perpendicular to the long axis of the jig.

EXPERIENCE WITH THE COUPLING

The coupling, although primarily designed as a simple device for alignment of "permanent" lower-extremity prostheses, can also be used for temporary, or interim, prostheses.

The coupling has been in routine use in the Limb and Brace Section of the VA Prosthetics Center since March 1961. The numbers of permanent prostheses aligned with the coupling in the 22-month period ending December 31, 1962, were as follows:

Hip-disarticulation	13
Above-knee	130
Knee-bearing	16
"Bent"-knee	3
Below-knee	192

⁵ Normally, if there is enough material here for the wood screws to attach the coupling, there will be enough material for this saw cut and the subsequent sanding without disturbing the socket itself.

In addition, 34 above-knee and 22 below-knee sockets were replaced on existing prostheses by use of the coupling.

Experience indicates some economic benefits in use of the adjustable coupling. Starting at the same point in an above-knee prosthesis fabrication (with the socket roughly fitted), the adjustable leg—transfer jig procedure takes, on the average, slightly over 1/2 hr. more than the coupling-compass procedure. The end point for this time measure, in both procedures, is completion of alignment transfer with the prescribed prosthetic components assembled.

A more significant advantage of the coupling accrues from its use in aligning above-knee prostheses when special knee or knee-ankle mechanisms have been prescribed. A prosthesis system with functional features providing more than just a mechanical-friction control at the knee may require some deviation from that alignment which might be used with only mechanical friction. Even an extension bias strap will affect the alignment to be used. Thus, for such devices as the Bock Safety Knee, the Hydra-Cadence (with a relatively free plantar-flexion control), the Mauch hydraulic devices, polycentric linkages, and others, it is well to align the prosthesis with the prescribed special-function system installed. The coupling is designed primarily for dynamic alignment of such systems.

Added to the economic advantage of one device for both below-knee and above-knee use is the simple and inexpensive process for alignment transfer. For a new shop, this means that investment in an expensive jig is not mandatory. Also, because of the comparatively low cost of the coupling itself, many more alignment devices can be available in the shop. Thus, shifting alignment apparatus already installed in a setup awaiting an amputee trial may not need to be as frequent as formerly.

The coupling also facilitates the alignment of replacement sockets. Fitting problems often require the fabrication of a completely new socket before the remaining parts of the prosthesis need replacement. The new socket and coupling can be installed on the "old" prosthesis for dynamic alignment and replacement-

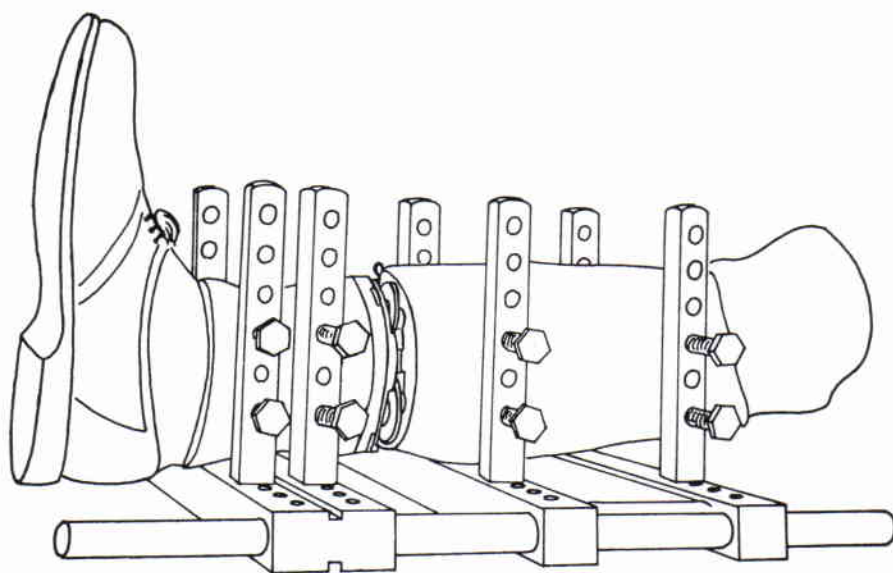


Fig. 14. Special band-saw jig used by Danes during alignment transfer. This jig holds components of the prosthesis in a fixed position to allow parallel band-saw cuts on both sides of the coupling. Subsequent clamping after cementing of wood block to replace coupling is also facilitated by this device.

socket fitting. This process is more expeditious than one in which the adjustable leg is used and then transfer is made to the "old" components. Also, proper fairing of new socket to "old" components can be assured by the coupling method of realignment because fairing problems can be readily observed and immediately corrected. When the adjustable leg is used, fairing problems can be noted only at the time of transfer. Major corrective procedures may then be necessary.

Many foreign practitioners have read and appreciated the various United States' documents which have emphasized the importance of dynamic alignment. But also, many have felt frustrated for, even though they have realized the value of dynamic-alignment apparatus, economic or technical handicaps prevented them from enjoying the use of the devices the practitioners in the United States had readily available. The coupling, therefore, because of its simplicity, can make a significant contribution to the benefit of the disabled all over the world, particularly in developing areas.

The coupling was introduced into Yugo-

slavia in 1961 (7). At about the same time, Denmark became interested in its use. E. Lyquist of the Orthopaedic Hospital, Copenhagen, has published a report on the coupling⁶ and on the apparatus he designed for clamping the prosthesis on a band-saw bed for alignment transfer (3). See Figure 14. Dr. B. Zotović of Belgrade has kindly offered the photograph (Fig. 15) of a prosthesis with the coupling now in use in Yugoslavia. In 1962, the coupling was introduced into Argentina. Still more applications to foreign use are anticipated.

Many clinicians have realized the importance of temporary or interim prostheses (9) for preliminary trials by an amputee. When temporary limbs which have alignment adjustability are used, dynamic stump conditioning and, especially for geriatric cases, evaluation of an amputee's ability to cope with a prosthesis are possible before a final prosthesis is ordered. Of utmost importance in temporary limb use is that prosthesis "*function*

⁶Lyquist (in November 1962) reported that the coupling was being used in all patellar-tendon-bearing fittings at the Orthopaedic Hospital. Some above-knee use was also reported.



Fig. 15. A Yugoslav above-knee prosthesis incorporating the adjustable coupling for dynamic alignment.



Fig. 16. The adjustable coupling used with a plaster-of-Paris above-knee temporary socket and an unfinished knee shank. The three straps are each $\frac{1}{8}$ in. by $\frac{3}{4}$ in. low-carbon steel. From (9).

not be seriously compromised" (9). A well-fitted, soundly designed socket must be used, and all parts should be continually maintained in proper alignment. Straps provide additional

reinforcement of socket to coupling assembly—mostly for horizontally directed loads. For plaster sockets, they are especially helpful since they can be contained within an outer, reinforcing plaster wrap.

There are now available several devices which might be used for temporary prostheses (9). Among these is the coupling. Figure 16



Fig. 17. The adjustable coupling used with a plaster-of-Paris below-knee temporary socket and unfinished shank. The three straps have the same cross-section as those used with the above-knee socket. The position of the carbon steel straps in both the above-knee and below-knee sockets should be reinforced with an extra plaster-of-Paris bandage wrap, as illustrated.

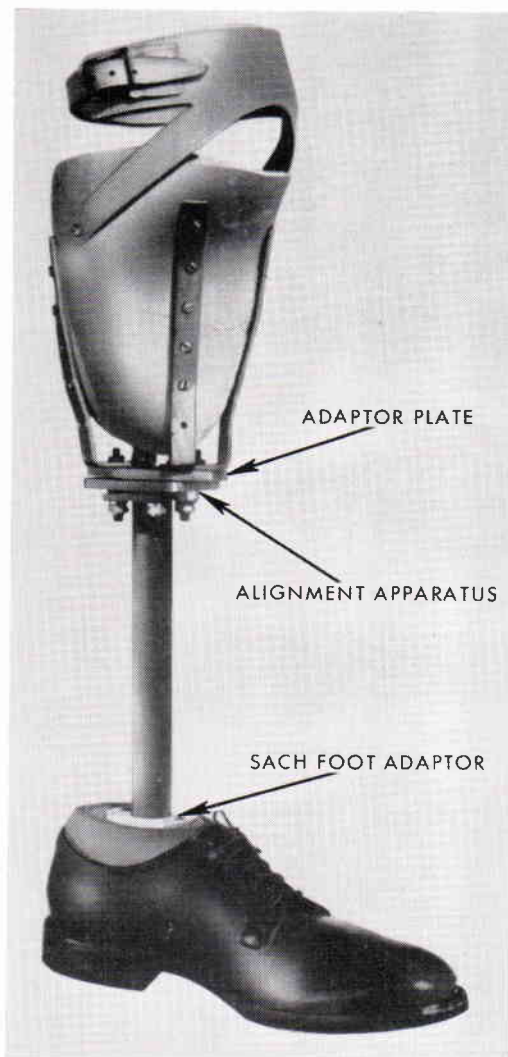


Fig. 18. A temporary or interim prosthesis with the Northwestern adjustable below-knee pylon, plaster-of-Paris patellar-tendon-bearing socket and SACH foot. The three straps are similar to those of the previous two illustrations. An adaptor plate must be provided to attach the straps to the pylon. In addition to the alignment adjustability available in the pylon, the position of the socket can still be altered if necessary.

illustrates a temporary or interim above-knee prosthesis incorporating the coupling and making possible the use of the type of knee (and function) anticipated for a permanent prosthesis. Now, not only fit and alignment can be "tuned" to each other, but both can be "tuned" to function. And, if necessary, function can possibly be altered by a rather

rapid change from one knee-shank mechanism to another.

Figure 17 shows the coupling used in a below-knee temporary, or interim, prosthesis. For this level of amputation, the practitioner has the choice of the coupling or the Northwestern Adjustable Below-Knee Pylon shown in Figure 18. This apparatus also has sufficient alignment adjustability available for most below-knee applications in both temporary and permanent prostheses. When attached to a "permanent" (plastic or wood) socket, its advantage is that it can remain in the prosthesis after the dynamic-alignment process is complete.

FURTHER DEVELOPMENT

The Northwestern Adjustable Below-Knee Pylon demonstrates a design principle long sought in alignment apparatus. With it, adjustments needed for dynamic alignment can be made as usual during the early stages of prosthesis fabrication, but the adjustable apparatus is now made a part of the limb obviating a transfer process but sometimes causing a slight increase in limb weight. At a later date, if the cosmetic-shank design allows it, readjustment of alignment can be made without a complete alteration of the prosthesis. Use of a relatively flexible cosmetic cover will probably be best for this purpose; if a plastic-covered foam shank is used, only destruction of the shank before realignment and a foam replacement and plastic finishing after realignment will be required.

Most desirable would be one apparatus, perhaps coupling-like, which could be used in above-knee and below-knee prostheses alike. The present adjustable coupling is both too heavy and too expensive for this purpose. A. B. Wilson, Jr.⁷ and Victor T. Riblett⁸ have designed a simple and inexpensive plastic, tapered-disc device which might remain in the prosthesis after the primary alignment trials (Fig. 19). At present the device usually

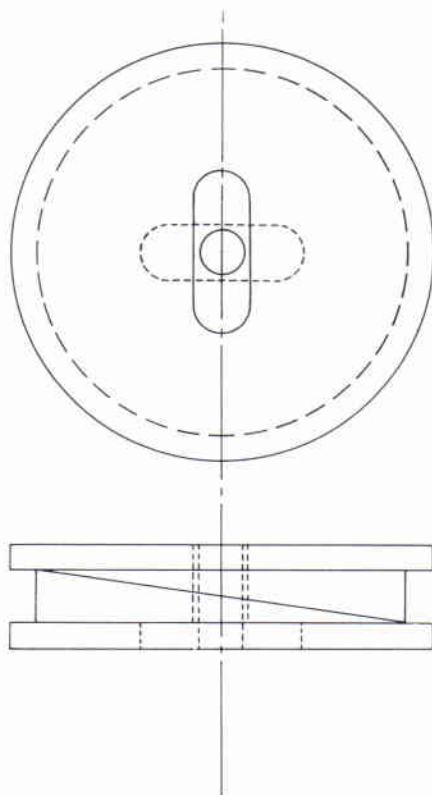


Fig. 19. Schematic drawing of the "Wilson-Riblett wedge," as applied to the VAPC coupling.

must be partly trimmed during the shaping of the limb for cosmetic finishing. Therefore, it could probably not be used at a later date for realignment purposes. But still this device will obviate transfer after initial alignment.

In eliminating only the primary-transfer process, a so-called "leave-in" alignment device must be priced at a level which would offer some gain to the prosthetist-user. If, at least with the regular coupling, alignment transfer involves an investment of approximately \$5.00 in labor and materials by the limbshop, then the *one-time*, "leave-in" alignment device should cost somewhat less. But even so, possible saving per prosthesis or additional profit is of a very low order of magnitude.

Needed is a device (and prosthesis design) which would allow realignment at a later date without major reconstruction of the prosthesis.

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⁸ Supervisor, Mechanical Development Branch, Army Prosthetics Research Laboratory, Walter Reed Army Medical Center, Forest Glen Section, Washington 12, D. C.

Economic benefits would accrue to prosthetist and amputee alike; at least some of the major cost-saving in the realignment process can be passed along to the customer. Perhaps many prostheses now condemned for alignment reasons would not need to be.

But most of all, such a device would offer convenience, allowing almost immediate accommodation to an amputee's needs. Instead of major delays in receiving a new alignment in a new or grossly altered older prosthesis, rather prompt prosthetist attention can be focused on an alignment problem in the existing limb. The prosthetist, if uncertain of an amputee's over-all fitting problem, can start with realignment of the existing prosthesis in his progressive analysis of the situation. He might be able to overcome what may seem to be socket-fit difficulties without major changes there. But, in any case, he would have readily available the mechanism for study of the problem and the problem's dependency on alignment.

Prosthesis design must of course be changed to accommodate the permanent installation of such a unit. A below-knee shank should preferably be a pylon—cosmetic-cover type, somewhat similar to the Northwestern device. Preferably, the lower part of the above-knee limb thigh (where this device would be placed) should have an easily removable cosmetic cover. Perhaps a simple plastic finish over foam forced into the spaces around a lightweight, inexpensive coupling would be adequate. The foam would need to be cut away (or possibly dissolved by appropriate chemical means) when realignment was necessary. But

even with present plastic-laminate finishing methods, realignment would involve only destruction of the laminate and then re-finishing.

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News and Notes

Ninth Meeting of CPRD

The Ninth Meeting of the Committee on Prosthetics Research and Development was held in the National Academy of Sciences building in Washington, D. C., on September 10 and 11, 1962. The objective of the meeting was to review administrative procedures and other nontechnical matters to determine in what ways the work of the Committee might be made more useful. The occasion for such review was the recent change in chairmanship of the Committee (Dr. George T. Aitken vice Professor Howard D. Eberhart), and the session was purely executive in nature. Evaluation procedures were discussed at length. Two *ad hoc* committees were appointed: one, under the chairmanship of Dr. Robert L. Bennett, to study the report of the 1962 Conference on Orthotics Research and Development to recommend the steps that should be taken in the development of an integrated orthotics program; the other, under the chairmanship of Mr. Colin A. McLaurin, to study the report of the 1962 Conference on Design of Upper-Extremity and Knee-Bearing Prostheses to recommend to the Committee on Prosthetics Research and Development the next steps that should be taken with respect to recommendations set forth at the Conference.

Meeting of *ad hoc* Committee on Orthotics Research and Development

The *ad hoc* committee to study the report of the 1962 Conference on Orthotics Research and Development met in Chicago, Illinois, on December 1, 1962. The members of the *ad hoc* committee were: Dr. Robert L. Bennett, Chairman; Dr. Herbert Elftman, Dr. Eugene F. Murphy, Dr. Jacquelin Perry, Dr. James W. Rae, Jr., and Mr. A. Bennett Wilson, Jr.

The committee considered the draft report

of the Conference on Orthotics Research and Development and was of the opinion that the report reflected the deliberations of the Conference but required some revisions. (The report of the 1962 Conference on Orthotics Research and Development, entitled *Orthotics Research and Development*, was published by the National Academy of Sciences—National Research Council in March 1963.)

The *ad hoc* committee considered that a number of orthotic items are ready for formal evaluation and recommended that evaluation be carried out by a number of clinics using predetermined procedures.

Meeting of *ad hoc* Committee on Design of Prostheses

The *ad hoc* committee to study the report of the 1962 Conference on Design of Upper-Extremity and Knee-Bearing Prostheses met in Chicago, Illinois, on November 13 and 14, 1962. The members of the committee were: Mr. Colin A. McLaurin, Chairman; Dr. Fred Leonard, Dr. John Lyman, Dr. James B. Reswick, Mr. Anthony Staros, and Mr. A. Bennett Wilson, Jr.

The discussions of the *ad hoc* committee were concerned with the methods by which the design and development of prosthetic devices could be most satisfactorily and rapidly achieved.

The consideration of a design includes many details of materials and structure and mechanism, as well as functional and aesthetic requirements. These details are too complex to be handled by a committee, and the over-all design must be the responsibility of the person actually engaged in the work. However, the *ad hoc* committee considered that there is much useful information that is not always readily available to the designer. Such information includes clinical experience, results of fundamental studies, and technical knowledge of advanced systems such as external power. In the opinion of the *ad hoc* committee, the most efficient way for this information to become available to the designer is through participation in workshop conferences with those persons who are familiar with this information.

Accordingly, the *ad hoc* committee recommended that the Committee on Prosthetics Research and Development sponsor such workshop conferences at the working level and establish a permanent Subcommittee on Design and Development to supervise and schedule the conferences.

Tenth Meeting of CPRD

The Tenth Meeting of the Committee on Prosthetics Research and Development was held at the University of California and the Sir Francis Drake Hotel in San Francisco, Calif., on December 6, 7, and 8, 1962. All members were present and, except for the executive session on December 8, the meeting was also attended by a number of other persons interested in prosthetics research and development.

Presentations on current projects were made before the Committee on Prosthetics Research and Development by the Biomechanics Laboratory of the University of California (San Francisco and Berkeley), the Biotechnology Laboratory of UCLA, the Child Amputee Prosthetics Project of UCLA, and the Navy Prosthetics Research Laboratory.

Evaluation procedures were again discussed at length and are now well formalized. To assist the Committee on Prosthetics Research and Development in making evaluations of prototypes, production-model items, and techniques, it was decided to form a Subcommittee on Evaluation.

The members of the Subcommittee on Evaluation are: Professor Herbert R. Lissner, Chairman; Dr. Charles O. Bechtol, Dr. Robert L. Bennett, and Dr. Verne T. Inman. The first meeting of the Subcommittee was held on March 5 and 6, 1963, at the Veterans Administration Prosthetics Center in New York City.

Pursuant to the recommendation of the *ad hoc* committee which studied the report of the 1962 Conference on Design of Upper-Extremity and Knee-Bearing Prostheses, the Committee on Prosthetics Research and Development decided at its Tenth Meeting to form a Subcommittee on Design and Development with the following functions and responsibilities:

1. To promote the interchange of information between development laboratories by arranging for workshop meetings at the working level.
2. To study and define the needs to be met by engineering design in prosthetics and orthotics.
3. To be aware of and to assess activity, capability, and talents wherever they exist.
4. To provide leadership in utilizing design and development resources most effectively on critical problems.
5. To evaluate new design ideas and suggestions from the point of view of engineering feasibility.
6. To encourage competent designers.

The members of the Subcommittee on Design and Development are: Mr. Colin A. McLaurin, Chairman; Dr. Fred Leonard, Dr. John Lyman, Professor Charles W. Radcliffe, Dr. James B. Reswick, and Mr. Anthony Staros. The first meeting of the Subcommittee was held at the University of California at Los Angeles on February 18 and 19, 1963.

The Subcommittee on Design and Development exists to be of service to designers of prosthetic and orthotic devices. Persons who have a design to be considered or who are in need of advice in developing a design should communicate with the Chairman of the Subcommittee: Mr. Colin A. McLaurin, Project Director, Prosthetics Research Center, Northwestern University, 401 East Ohio Street, Chicago 11, Ill.

Eleventh Meeting of CPRD

The Eleventh Meeting of the Committee on Prosthetics Research and Development was held in the National Academy of Sciences building in Washington, D. C., on March 28, 29, and 30, 1963.

Guests attending the meeting included Brigadier N. A. M. Swettenham and Dr. M. Vitali, both of the British Ministry of Health's Limb Fitting Centre at Roehampton in London.

Presentations on current projects were made before CPRD by the Northwestern University Prosthetics Research Center, the Veterans Administration Prosthetics Center, New York University, and the Army Prosthetics Research Laboratory. Dr. Vitali made a presentation on thalidomide babies in Great Britain and showed a motion picture depicting child-amputee patients under his care in England.

In addition, there were reports from the liaison members of CPRD: Dr. Eugene F. Murphy, for the Veterans Administration; Mr. Robert E. Jones, for the Vocational Rehabilitation Administration; and Dr. Harold W. Glattly, for the Committee on Prosthetics Education and Information. Dr. J. Warren Perry, of the Vocational Rehabilitation Administration, made a presentation on the University Council on Orthotic and Prosthetic Education, summarizing its purposes and objectives as the "3 Cs"—coordination, cooperation, and communication—among the three universities offering prosthetics and orthotics education.

Reports were received from the three standing subcommittees: the Subcommittee on Child Prosthetics Problems, the Subcommittee on Design and Development, and the Subcommittee on Evaluation.

The report of the Subcommittee on Design and Development described working panels being formed to cover the following areas: Upper-Extremity Components; Upper-Extremity Fitting, Harnessing, and Power Transmission; Lower-Extremity Components; Lower-Extremity Fitting; and External Power in Prosthetics and Orthotics. Membership on the panels will be kept fluid.

The report of the Subcommittee on Evaluation covered progress in the evaluation of pneumatic upper-extremity prostheses developed by the American Institute of Prosthetic Research and the Sierra Engineering Company, a porous-laminate lower-extremity socket being developed by the Army Prosthetics Research Laboratory, Münster techniques for fitting upper-extremity sockets, intermittent friction knee units developed at Northwestern University, and a number of other items. The Subcommittee strongly recommended that CPRD wholeheartedly support a long-term investigation of swing-phase control units for above-knee amputees, a study in which the Veterans Administration has a special interest. The Subcommittee also recommended that CPRD regard the New York University casting technique as an acceptable method for achieving a total-contact socket for above-knee prostheses.

It was decided by CPRD that the member-

ship of the Subcommittee on Evaluation should be expanded to include the Chairman of the Subcommittee on Design and Development and a prosthetist-orthotist member of CPRD. Accordingly, Mr. Colin A. McLaurin and Mr. Bert R. Titus were added to the membership of the Subcommittee on Evaluation.

In its executive session, CPRD reviewed proposals to the Vocational Rehabilitation Administration and the Veterans Administration for research grants and contracts, upon which these Government agencies desired the Committee's recommendation.

Annual Meeting for 1962 of CPEI

The annual meeting of the Committee on Prosthetics Education and Information of the Division of Medical Sciences, National Academy of Sciences—National Research Council, was held under the chairmanship of Dr. C. Leslie Mitchell in Phoenix, Ariz., on October 14, 1962.

The place and time of the meeting were selected to coincide with the annual assembly of the American Orthotics and Prosthetics Association to enable members of the two organizations to become better acquainted and in the interest of furthering joint objectives and programs.

Prominent among the joint projects of the Committee on Prosthetics Education and Information and the American Orthotics and Prosthetics Association is the systematic collection of data on the amputee population of the United States; that is, an accurate amputee census. (See p. 5).

Representatives of certain other organizations concerned with the rehabilitation of the orthopedically handicapped were also invited to participate in the meeting of the Committee on Prosthetics Education and Information so that all might benefit by the exchange of information.

The proceedings of the meeting were as follows:

1. Opening of the Meeting
Chairman of the Committee, Dr. C. Leslie Mitchell
2. Chairman's Report
3. Subcommittee Chairmen's Reports
 - a. Prosthetics in Medical Education—

- Dr. J. Hamilton Allan, Chairman, Department of Orthopedic Surgery, University of Virginia School of Medicine
- b. Prosthetics in Paramedical Education—Miss Dorothy Baethke, Director of Physical Therapy, University of Pennsylvania Hospital
 - c. Prosthetics Clinical Studies—Dr. Roy M. Hoover, Medical Director, Woodrow Wilson Rehabilitation Center
 - d. Advisory Committee on Prosthetics in Pennsylvania—Dr. William Erdman, Chairman, Department of Physical Medicine and Rehabilitation, University of Pennsylvania School of Medicine
4. Interests of the Training Division, Office of Vocational Rehabilitation
Dr. J. Warren Perry, Assistant Chief of the Training Division of OVR, Washington, D. C.
 5. Interests of the Prosthetic and Sensory Aids Service of the Veterans Administration
Mr. William M. Bernstock, Assistant Chief, Research and Development Division, Veterans Administration, New York City
 6. American Board for Certification and Education Committee, American Orthotics and Prosthetics Association
Mr. LeRoy Wm. Nattress, Jr., Executive Director, American Board for Certification in Orthotics and Prosthetics, Inc.
 7. Report of the Committee on Prosthetics Research and Development of the National Academy of Sciences—National Research Council
Mr. A. Bennett Wilson, Jr., Technical Director
 8. Interests of the American Academy of Orthopaedic Surgeons
 - a. Committee on Braces and Prostheses—Dr. Cameron B. Hall
 - b. Committee on Orthopaedic Rehabilitation—Dr. Vernon L. Nickel
 - c. Seminar on Orthopaedic Rehabilitation—Dr. Vernon L. Nickel
 9. Interests of the Committee on Rehabilitation of the American Medical Association
Dr. Ralph E. DeForest, Executive Secretary
 10. Interests of the American Academy of Physical Medicine and Rehabilitation
Dr. Frederick E. Vultee, Jr., Chairman, Department of Physical Medicine and Rehabilitation, Medical College of Virginia
 11. Interests of the Liberty Mutual Insurance Company
Dr. Melvin J. Glimcher, Assistant Director, Liberty Mutual Rehabilitation Center, Boston
 12. Reports of the Directors of the Prosthetics Schools
 - a. University of California at Los Angeles—Dr. Miles H. Anderson
 - b. New York University—Dr. Sidney Fishman
 - c. Northwestern University—Dr. Jack D. Arnold
 13. University Council on Orthotic and Prosthetic Education
Dr. J. Warren Perry, Executive Secretary
 14. Film on Locomotion
Dr. Cameron B. Hall, Department of Orthopedic Surgery, University of California at Los Angeles
 15. Orthotics Education
Mr. W. Frank Harmon, Certified Orthotist, Atlanta
- Upon the close of the regular meeting of the Committee on Prosthetics Education and Information, the members joined the main assembly of the American Orthotics and Prosthetics Association for the purpose of presenting before the attending orthotists and prosthetists an orientation program on activities and projects of the Committee.
- Meeting of CPEI Subcommittee on Prosthetics in Paramedical Education**
- A meeting of the Subcommittee on Prosthetics in Paramedical Education of the Committee on Prosthetics Education and Information was held in Chicago, April 8-9, 1963, with Chairman Dorothy Baethke presiding. For the first time, the fields of social work and rehabili-

tation nursing were represented on the subcommittee. The new members were Mrs. Enolia Archinard, Associate Professor, School of Social Work, Tulane University, and Mrs. Barbara Madden, Associate Director of Nursing, Rancho Los Amigos Hospital, in Los Angeles. Also present at the meeting were the recently appointed ex-officio members, Miss Margaret Kobli, representing the Council of Physical Therapy Directors, and Miss Martha Matthews from the Education Council of the American Association of Occupational Therapists.

Currently under study by this subcommittee are the educational needs of nursing, social work, and occupational and physical therapy in the fields of prosthetics and orthotics.

Annual Assembly for 1962 of AOPA

The annual assembly of the American Orthotics and Prosthetics Association was held in Phoenix, Ariz., during the period October 14-17, 1962. The President of the Association, Mr. Fred Quisenberry, of Los Angeles, presided. Registered attendance numbered 480.

Representatives from the Committee on Prosthetics Education and Information briefed the members of the Association on current developments in education in prosthetics and orthotics. Representatives from the Veterans Administration Prosthetics Center in New York City demonstrated new materials, chiefly plastics and titanium, that are becoming available to the orthotist. They also demonstrated the technique developed at the Center for making and applying a total-contact above-knee socket. Complementing this demonstration was one by representatives from the Biomechanics Laboratory of the University of California, San Francisco, of the socket-brim technique developed at the Laboratory to achieve a total-contact above-knee socket. Dr. Robert G. Thompson, of the Medical School of Northwestern University, and Mr. Colin A. McLaurin, of the Prosthetics Research Center of Northwestern University, made a detailed presentation on the problems of the geriatric amputee. Dr. J. M. Morris, of the School of Medicine of the University of California, San Francisco, reported on an extensive study made

of stresses on the spinal column. Exhibitors were well represented.

The assembly concluded with a banquet, at which Senator Barry Goldwater was the principal speaker. Mr. Carlton E. Fillauer, of Chattanooga, Tenn., was installed as the new President of the Association of 1962-63. Serving with him are President-Elect Robert C. Gruman, of Minneapolis; Vice - President Herbert J. Hart, of San Francisco; and Secretary-Treasurer M. P. Cestaro, of Washington, D. C.

Meeting of SCPP

The Subcommittee on Child Prosthetics Problems of the Committee on Prosthetics Research and Development, Division of Engineering and Industrial Research, National Academy of Sciences—National Research Council, met under the chairmanship of Dr. Charles H. Frantz in Phoenix, Ariz., on October 11 and 12, 1962. Dr. Frantz is Medical Co-Director of the Area Child Amputee Program of the Michigan Crippled Children Commission.

Other Subcommittee members present for the meeting in Phoenix were Dr. Milo H. Brooks, of the Child Amputee Prosthetics Project of the University of California at Los Angeles, and Dr. Sidney Fishman, of Prosthetic and Orthotic Research at the College of Engineering of New York University. Dr. Fred Leonard, Scientific Director of the Army Prosthetics Research Laboratory at the Walter Reed Army Medical Center; Mr. Hector Kay, of Prosthetic and Orthotic Research at New York University; and Mr. A. Bennett Wilson, Jr., Technical Director of the Committee on Prosthetics Research and Development, also participated in the discussions. Also attending the meeting was Dr. John E. Hall, of the Amputee and Prosthetic Clinic of the Ontario Crippled Children's Centre in Toronto, Canada, who is a member of the Canadian Government's Expert Committee on the Congenital Malformations Associated with Thalidomide.

Dr. Fishman and Mr. Kay discussed a normative data study being made of child amputees, based on data collected by 17 clinics cooperating with the Subcommittee. There was discussion concerning Canadian participation

in the survey by the Amputee and Prosthetic Clinic of the Ontario Crippled Children's Centre.

Dr. Brooks discussed the possible expansion of the services of the Child Amputee Prosthetics Project of the University of California at Los Angeles to serve other western states. The Subcommittee encouraged the expansion of services to cover other geographic areas.

The State Hospital for Crippled Children in Elizabethtown, Pa., and the Crippled Children's Hospital in New Orleans, were officially admitted as cooperating clinics.

The Subcommittee approved for commercial distribution a Size 1, Model A, prosthetic hand for children and a cosmetic glove for the hand, both of which were reported on by Mr. Kay. The Subcommittee also encouraged the further development of a nylon prosthetic hand which was reported on by Dr. Leonard. The nylon hand appeared to possess advantages over a comparable metal hand in reduced weight and in reduced cost for assembly. The Subcommittee referred a child's prehension device (a scaled-down hook) developed by the Army Prosthetics Research Laboratory to New York University for evaluation. The Subcommittee went on record as encouraging the commercial manufacture of a child-size upper-extremity prosthetic ring harness developed by Northwestern University. The Subcommittee recommended that the technique for this harness be introduced into the prosthetics school courses on management of the juvenile amputee.

Dr. Frantz and Dr. Brooks reported on recent studies of congenitally deformed children in West Germany who are the victims of thalidomide. Dr. Frantz said that, as a result of the currently large demand, German manufacturers of artificial limbs are becoming highly efficient in the manufacture of devices for infants. Of particular interest were devices utilizing carbon-dioxide gas to supply external power.

The Subcommittee on Child Prosthetics Problems went on record as desiring to encourage the development and application of external power to prosthetic and orthotic devices in the United States.

In considering its goals and mission for the

future, the Subcommittee decided that its scope included not only prosthetics *per se* but also the etiology of congenital malformations. In connection with the latter, the Subcommittee showed interest in the development of a nation-wide statistical data study of anomalies apparent at birth. Such a study would necessarily be based upon a standardized recording of anomalies on birth certificates.

Report by Dr. Charles H. Frantz on Thalidomide Babies in West Germany

In October 1962, Dr. Charles H. Frantz, Medical Co-Director of the Area Child Amputee Program of the Michigan Crippled Children Commission, and Chairman of the Subcommittee on Child Prosthetics Problems of the Committee on Prosthetics Research and Development, completed his report on the increase in the incidence of malformed babies in West Germany during the years 1959-1962. The report was made under a grant from the National Society for Crippled Children and Adults.

A popular account of Dr. Frantz's trip to Germany and his studies was given in an article entitled "The Untold Story of the Thalidomide Babies," by Steven M. Spencer, in the October 20, 1962, issue of the *Saturday Evening Post*.

To make his report, Dr. Frantz visited municipal hospitals, state hospitals, university centers, and rehabilitation centers in 10 large German cities. Physicians in the institutions visited have seen, examined, and are currently caring for some 1,800 cases.

Sociologically, the situation in West Germany presented an interesting phenomenon. The great majority of the congenitally malformed children were born to middle-class families; that is, businessmen, clerks, doctors, lawyers, veterinarians, and dentists. Many German physicians stated that the tensions of daily living for this group made them "pill-takers."

Figures available from the Ministry of Health at Bonn indicated that, of the officially reported 5,000 malformed babies born in West Germany since 1959, approximately 50 per cent died within a few weeks after birth. Of the surviving malformed children, about 25 per cent are so severely deformed as to require

special prosthetic devices. The rest can be fitted with more or less conventional devices.

Dr. Frantz reported that none of the registered malformed children wanted for care. The pediatric, surgical, and orthopedic facilities are well-organized and staffed by competent physicians and surgeons. Out-patient clinics are active and well-equipped. Many of the children are in hospitals under active surgical, orthopedic, or physical-therapy régimes. The physicians and surgeons in Germany have taken positive and definitive action in analyzing individual problems and have initiated early corrective measures.

Dr. Frantz noted that there are many amputees in West Germany from two World Wars, and the art of prosthetics is well-developed. There are some 600 artificial-limb and brace shops. For many years, children have been fitted with prostheses. In recent years particularly, under the stimulus of Professor Oskar Hepp of Münster, the practice of fitting children with prostheses has become almost universal.

Functionally, the complete phocomelic upper extremity offers many difficulties. Very little of the extremity is available for a prosthetic socket, and no significant power source is present. Consequently, special prosthetic techniques must be utilized. Plastic shoulder caps are fitted over the child's shoulder. In some clinics, cables utilized to operate the hook and elbow devices are anchored to belts around the waist or to straps encircling the thighs. This technique demands that the child understand the somewhat complicated system of operating the artificial limbs. The control "tricks" are difficult for young children to master. The system requires an excess of body motion to obtain elbow flexion or extension, and a considerable amount of energy is expended.

It is apparent that the application of external power to prostheses for phocomelics is desirable. In Heidelberg, external power for prostheses has been under development for some time. Professor Kurt Lindeman and Professor Ernst Marquardt have fitted externally powered prostheses to patients for the past 10 years. The source of power is carbon-dioxide gas under pressure. The gas is contained in a small tank carried in a sling. From the tank,

miniature plastic or rubber tubes lead to small pressure-control valves. The valves release gas to operate the elbow in flexion and extension and to open or close the terminal device. Children as young as 18 months have been fitted with such prostheses.

Initially, the children's maneuvers are crude and clumsy. However, under the instruction of well-trained therapists, the children soon learn what the devices can do for them. The opening or closing of the valves on the devices is accomplished by a slight pressure by one or two small phocomelic fingers. The valves rest on the shoulder caps immediately below an aperture for the fingers. The external power is available for activation of the elbow and opening and closing of the hand without excessive body motion.

Phocomelic children with involvement of four extremities offer difficult problems. The application of lower-extremity artificial limbs articulated to the pelvic wall offers a poor possibility of independent ambulation when good arms to handle crutches are lacking. German orthopedic surgeons and prosthetists are working on this problem, hoping to develop more satisfactory appliances.

Incomplete phocomelics have short arm segments which may be suitable for prosthetic sockets; however, these children have deficient muscle power. For these patients, modified types of standard above-elbow and shoulder-disarticulation types of prostheses are utilized. The phocomelic fingers are used to operate the positive-locking elbow units located on the humeral section of the appliance. This technique is well-developed at the University of Münster and is standard practice in the United States.

The birth of a malformed child into a family is received with emotional shock, especially on the part of the mother. In Germany, it was found that in about three months' time most mothers became resigned to the fact that they had a problem and responded more rationally than emotionally. It appears that generally the families have adjusted well to their problems.

For the future, German physicians do not expect additional malformed infants as the result of the ingestion of thalidomide by mothers during pregnancy. Many newspaper articles

have informed the public of the problem and the consequences, although the news coverage has not been in the nature of tabloid sensationalism.

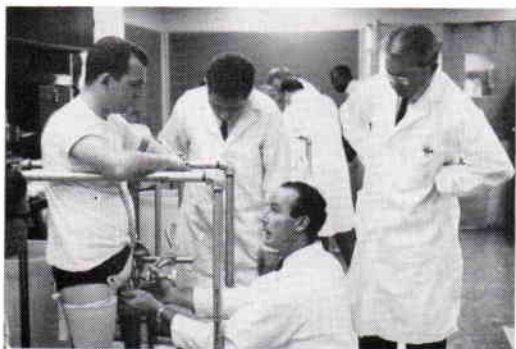
The tragic occurrence in Germany of malformed children whose mothers took thalidomide during a critical stage of early pregnancy has opened up an entirely new field in the area of drug-testing and has challenged the ingenuity of prosthetics research.

In the conclusion of his report, Dr. Frantz noted that, as a result of the experience in Germany, one would expect three major efforts:

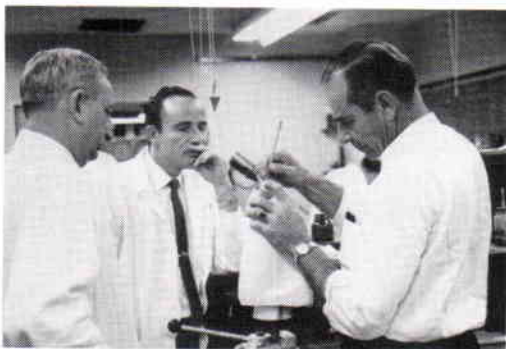
1. Broader scope of drug-testing and control.
2. Acceleration in the utilization of external power in prosthetics research and development.
3. Broader scope of genetic research relative to causes of malformations in human beings.

Prosthetics and Orthotics at UCLA

Enrollment in the program for "semester students" in Prosthetics-Orthotics Education at the University of California has doubled during the current academic year. Six students are enrolled for the entire spring semester, during which they will take the following courses: Below-Knee Prosthetics, Above-Knee Prosthetics, Upper-Extremity Prosthetics, Hip-Disarticulation and Syme Prostheses, and Functional Bracing of the Upper Extremities. The "semester students" are: Mr. James R.



Demonstrating the use of the VAPC casting jig during a Total-Contact Plastic-Socket Course at UCLA. Left to right: Amputee John Creech of DuPaCo; Fred Karg, Student; John Bray, Instructor; Dr. Miles H. Anderson, Director, UCLA Prosthetics-Orthotics Education Program.



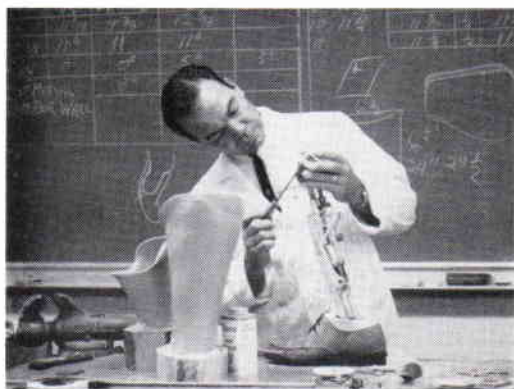
John Bray, UCLA Instructor, critically analyzes Student Charles A. Hennessy's model during the Total-Contact Plastic-Socket Course while Student Blair Hanger of Northwestern looks on.

Fenton, Fenton Brace and Limb, Miami, Fla.; Mr. James C. Hennessy, Peerless Prosthetics, Los Angeles, Calif.; Mr. Paul T. Lindbergh, and Mr. Patrick J. Marer, Rancho Los Amigos Hospital, Downey, Calif.; Mr. William F. Sinclair, of Arthur Finnieston, Inc., Miami, Fla.; Mr. Gordon P. Thanos, Saskatchewan Council for Crippled Children and Adults, Saskatoon, Sask.

All UCLA classes in Prosthetics-Orthotics Education are filled to capacity and over-subscribed for the spring semester. Plans are being made for the 1963-1964 academic year.

Included in the plans for the 1963-1964 academic year is an offering of a two-week course for physicians and therapists. The two-week session will include a field trip to Rancho Los Amigos Respiratory Center for special presentations on devices for the "totally disabled." In addition, there will be ample demonstrations and laboratory practice with patients. This new comprehensive course is being organized and presented in response to requests from the Veterans Administration, from various medical societies, and from the faculties of several of the nation's larger teaching institutions.

Twenty-four instructors in schools of physical and occupational therapy have enrolled in the special UCLA Workshop for Faculty Members of Schools of Physical and Occupational Therapy to be conducted during the period of July 8-19, 1963. This will be the third such



Don Colwell, UCLA Prosthetics Instructor, demonstrates the installation of the new VAPC coupling on a Hydra-Cadence unit.

workshop offered at UCLA. Upon its completion, faculty members from almost all the schools of physical and occupational therapy in the United States and Puerto Rico will have participated in this program. Promoted initially by the Subcommittee on Prosthetics in Paramedical Education of the Committee on Prosthetics Education and Information, National Academy of Sciences—National Research Council, the workshops are designed to indoctrinate instructors in the schools of physical and occupational therapy in prosthetics and orthotics so that they in turn might include more such material in their school curricula.

A representative advisory committee was set up by the American Physical Therapy Association and the American Occupational Therapy Association to assist UCLA with the curriculum, class schedule, selection of students, and other matters connected with the workshops. Known as the Paramedical Education Prosthetics Advisory Committee (PEPAC), the committee is headed by Miss Dorothy Baethke, of the University of Pennsylvania. The curriculum was prepared by Dr. Miles H. Anderson, Director of Prosthetics-Orthotics Education at UCLA, in close cooperation with the advisory committee.

Because of the success of the two-week workshops for physical and occupational therapy instructors, a similar program for physicians and therapists in general is being planned at UCLA for 1963-1964. Persons enrolling for the

program will be enabled to take a two-week course covering the latest developments in upper- and lower-extremity prosthetics and upper- and lower-extremity orthotics. Instruction will be given by men well-versed in both fields. Among the instructors will be Dr. Charles O. Bechtol, Dr. Cameron B. Hall, Dr. Ralph E. Worden, Mr. John J. Bray (prosthetist-orthotist), Mr. L. Roy Snelson (prosthetist-orthotist), and Mr. Bernard Strohm (physical therapist). Tentative plans are to offer one such course in the fall semester and another in the spring, although more may be arranged if the demand warrants it.

Present plans call for the UCLA Prosthetics-Orthotics Education Program to move into new and spacious quarters in the new Physical Rehabilitation Center on the West Medical Campus in February 1965. Meanwhile, Vice-Chancellor Stafford E. Warren has arranged to make a large area available for the use of the Prosthetics-Orthotics Education Program in the recently completed Marion Davies Pediatrics Wing of the Medical Center. This area will be used for the classes for physicians and therapists. It features a "burlesque hall runway" on which amputees and brace patients can walk while the students study gait faults.

Working in close cooperation with the research prosthetists of the Veterans Administration Prosthetics Center, the prosthetics staff of the UCLA Prosthetics-Orthotics Education Program has developed a five-day intensive course for prosthetists in the use of the VAPC casting jig for fitting total-contact,



Physical Therapist Bernard Strohm demonstrates the gait problems of a polio patient wearing a functional long leg brace, using the "burlesque-house runway" in the new Prosthetics-Orthotics Education quarters in the UCLA Marion Davies Pediatrics Wing.

plastic, above-knee sockets. Only prosthetists who have completed the regular above-knee course are permitted to enroll in this course. Three sections of the course have been given, with a fourth tentatively scheduled for April 1963. Forty-two prosthetists have been trained in this technique, and additional courses will be scheduled for 1963-1964.

Dr. Cameron B. Hall, of the UCLA Prosthetics-Orthotics Education Program, has been invited to participate in an international conference on the problems of the congenital child amputee to be held under the auspices of the International Society for Rehabilitation of the Disabled at The Hague, Netherlands, during September 11-13, 1963. Dr. Hall is a member of a five-man team invited from the United States.

Prosthetics and Orthotics at NYU

The spring semester marked the seventh anniversary of the Prosthetics and Orthotics Education Program at New York University with a total registration for courses exceeding 2,900. When courses were first inaugurated in 1956, the offerings were limited to courses in upper-extremity prosthetics and above-knee prosthetics for physicians and surgeons, therapists, and prosthetists. Since that time the following offerings have been added:

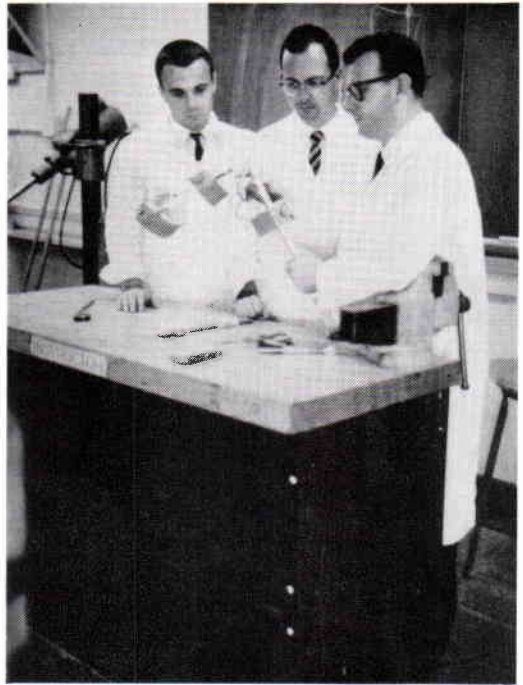
- Below-Knee Prosthetics (for prosthetists, physicians and surgeons, and therapists).
- Prosthetics and Orthotics (for rehabilitation counselors).

- Four-year curriculum leading to the degree of Bachelor of Science in Prosthetics and Orthotics.

- Lower-Extremity Orthotics (for orthotists).
- Fluid-Controlled Mechanisms for Above-Knee Prostheses (for prosthetists).

- Total-Contact Above-Knee Sockets (for prosthetists) (to be offered in the spring semester).

The four-year course leading to the degree of Bachelor of Science in Prosthetics and Orthotics has attracted considerable interest as a result of traineeships being offered by the U. S. Vocational Rehabilitation Administration. The traineeships provide assistance in the amount of \$1,800 for the junior year of study and \$2,200 for the senior year. To make the traineeships more widely applicable, students may



Mr. H. R. Lehneis, Coordinator of the courses for orthotists, explains and demonstrates a point pertaining to alignment of a long leg brace during a recent orthotics course at NYU.

transfer from other institutions to the prosthetics and orthotics program any time before the end of their sophomore year and in that way become eligible for traineeship assistance in their junior and senior years.

This is the second year that courses in Lower-Extremity Orthotics for orthotists have been offered. While the major part of this course is devoted to practical exercises in measurement, layout, and fitting of lower-extremity braces, a substantial amount of theoretical information is included in the course to provide the student with a firm foundation for his practical and clinical work. During the current academic year, the faculty has developed new written material on measurement, layout, and alignment of braces. In particular, this new material gives special consideration to tibial torsion in relation to brace alignment.

The interest in parallel courses in orthotics for physicians and surgeons, and therapists has made it necessary to intensify preparation for such courses. Conferences have been held fre-

quently during the past year to establish prescription criteria for braces and related course content. Participants in these conferences, which continue to be held at the Institute of Physical Medicine and Rehabilitation, are drawn from the faculties of the departments of Orthopedic Surgery, Physical Medicine and Rehabilitation, and Prosthetics and Orthotics Research and Education. A pilot course is planned for the latter part of the spring semester to which a group of leading physicians and surgeons will be invited. The course will include material on basic biomechanics, normal human locomotion, pathomechanics, shoe modifications, orthotic components and materials, brace layout and fabrication, check-out procedures, medical management, and training and prescription considerations.

Eleven courses in prosthetics and orthotics were offered during the fall 1962 semester. These offerings included courses in Lower- and Upper-Extremity Prosthetics for physicians and surgeons, courses in Below- and Above-Knee Prosthetics and one course in Fluid-Controlled Mechanisms for Above-Knee Prostheses for prosthetists, courses in Lower- and Upper-Extremity Prosthetics for therapists, and courses in Lower-Extremity Orthotics for orthotists.

The course in Fluid-Controlled Mechanisms for Above-Knee Prostheses that was offered for the first time during the fall semester was



Mr. Herbert Kramer, Research Prosthetist on the NYU staff, explains new and experimental devices currently undergoing tests to a combined group of physicians, therapists and prosthetists.

designed to meet the needs of prosthetists who may be called upon to provide these devices for patients. The course was scheduled so that students enrolled in the above-knee prosthetics course could stay another week to take the training in fluid-controlled prostheses. This same arrangement is being followed in the spring semester. The course includes material on techniques of alignment, duplication, adjustment, and finishing of fluid-controlled prostheses, with each student fitting and adjusting several prostheses to amputees.

Listed below is a schedule of the courses offered during the spring semester:

January 7-18

Prosthetics and Orthotics (for rehabilitation counselors).

February 4-15

Below-Knee Prosthetics (for prosthetists).

Lower-Extremity Prosthetics (for therapists).

February 11-16

Lower-Extremity Prosthetics (for physicians and surgeons).

February 25-March 8

Lower-Extremity Orthotics (for orthotists).

Prosthetics and Orthotics (for rehabilitation counselors).

March 25-April 5

Upper-Extremity Fitting and Harnessing (for prosthetists).

Upper-Extremity Prosthetics (for therapists).

April 1-5

Upper-Extremity Prosthetics (for physicians and surgeons).

April 22-May 3

Lower-Extremity Prosthetics (for therapists).

April 22-May 10

Above-Knee Prosthetics (for prosthetists).

May 6-11

Lower-Extremity Prosthetics (for physicians and surgeons).

May 13-17

Fluid-Controlled Mechanisms for Above-Knee Prostheses (for prosthetists).

May 13-24

Prosthetics and Orthotics (for rehabilitation counselors).

May 27-June 1

Total-Contact Above-Knee Sockets (for prosthetists).

June 3-7

Total-Contact Above-Knee Sockets (for prosthetists).

June 10-14

Total-Contact Above-Knee Sockets (for prosthetists).

The scheduled courses for physicians and surgeons, and for therapists, particularly in lower-extremity prosthetics, have been oversubscribed. Efforts will be made to schedule extra sections of these courses for applicants who cannot be accommodated in the regular courses.

The courses in Total-Contact Above-Knee Sockets, listed above, constitute a new offering. The desirability of total-contact sockets for below-knee amputees has been amply demonstrated by the successful experience of the last five years with the closed-end patellar-tendon-bearing socket. More recently, several groups have developed techniques for fabricating total-contact sockets for above-knee amputees. Though experience to date with this new application has been somewhat limited, results have been extremely encouraging. The evaluation of these fabrication techniques is now in progress at New York University Prosthetic and Orthotic Studies, and three five-day courses scheduled in late May and June will offer instruction in the fabrication, fitting, and alignment of these sockets. Prerequisite for the course is successful completion of the Above-Knee Prosthetics course or its equivalent.

In addition to their regular teaching duties, the faculty members of Prosthetics and Orthotics Education have been engaged in a number of related projects.

Miss Joan Erback represented Prosthetics and Orthotics, New York University, at the annual conference of the American Physical Therapy Association in San Francisco. At this conference, Miss Erback presented a report on "Developmental Activities of Amputees," and her paper on hydraulic prostheses will be published in a forthcoming issue of the Association's journal. Miss Erback is also coordinating a program on recent ad-

vances in prosthetics and orthotics for the Association.

Mr. H. R. Lehneis, in addition to preparing new written materials on lower-extremity bracing, has attended both the pilot course at UCLA in total-contact sockets and the pilot course in Principles of Spinal Orthotics at Northwestern University.

Mr. Ivan Dillee has appeared under the auspices of the Committee on Prosthetics Education and Information of the National Academy of Sciences—National Research Council to discuss prosthetic principles at professional meetings in Pennsylvania, Indiana, Ohio, and Iowa.

Mr. Warren Springer served as guest lecturer at the Institute of Physical Medicine and Rehabilitation, as well as the New York University School of Education, and is functioning as coordinator of a course in engineering biomechanics being planned for presentation at Brooklyn Polytechnic Institute.

Mr. Norman Berger recently served as chairman of the committee to study above-knee fitting problems for the University Council on Orthotic and Prosthetic Education. Mr. Berger also participated as a guest lecturer at the New York University School of Education and the Institute of Physical Medicine and Rehabilitation.

Dr. Sidney Fishman continues to serve as a member of the Committee on Prosthetics Research and Development and, along with Dr. Walter A. L. Thompson, represents New York University at the meetings of the Committee on Prosthetics Education and Information and the University Council on Orthotic and Prosthetic Education. During the last several months, Dr. Fishman has presented papers at the meetings of the International Conference of Occupational Therapists, the American Psychological Association, and the Association of Medical Rehabilitation Directors and Coordinators.

Prosthetic-Orthotic Education at NU Medical School

In December 1962, Prosthetic-Orthotic Education, Northwestern University Medical School, offered two pilot courses to the limb and brace professions. One course taught



Pilot Course—"Business and Administrative Procedures for Owners, Managers, Employees and Suppliers of Prosthetics-Orthotics Facilities," December 3-7, 1942. First row: Mr. Bidwell, Miss Hastings, Mr. Karaba, Dr. Arnold, Mr. Stoehr, Mr. Reiter, Mr. Smith, Mr. Denison, and Mr. Brownfield. Second row: Mr. Rosenquist, Mr. Hanicke, Mr. Pulizzi, Mr. Nattress, Mrs. Crowell, Mrs. Gillespie, Mr. Coon, and Mr. Sabolich. Third row: Mr. Martino, Mr. Scheck, Mr. Lambert, Mr. Gitlin, Mr. Cestaro, Mr. Quisenberry, Mr. Smith, Mr. Hedges, and Mr. McKeever. Fourth row: Mr. Bindi, Mr. Fillauer, Mr. Floyd, Mr. Leimkuehler, Mr. Guilford, and Mr. Harmon. Fifth row: Mr. Bartels, Mr. Storrs, Mr. Hart, Mr. Muilenburg, Mr. Hanger, and Mr. McGraw.

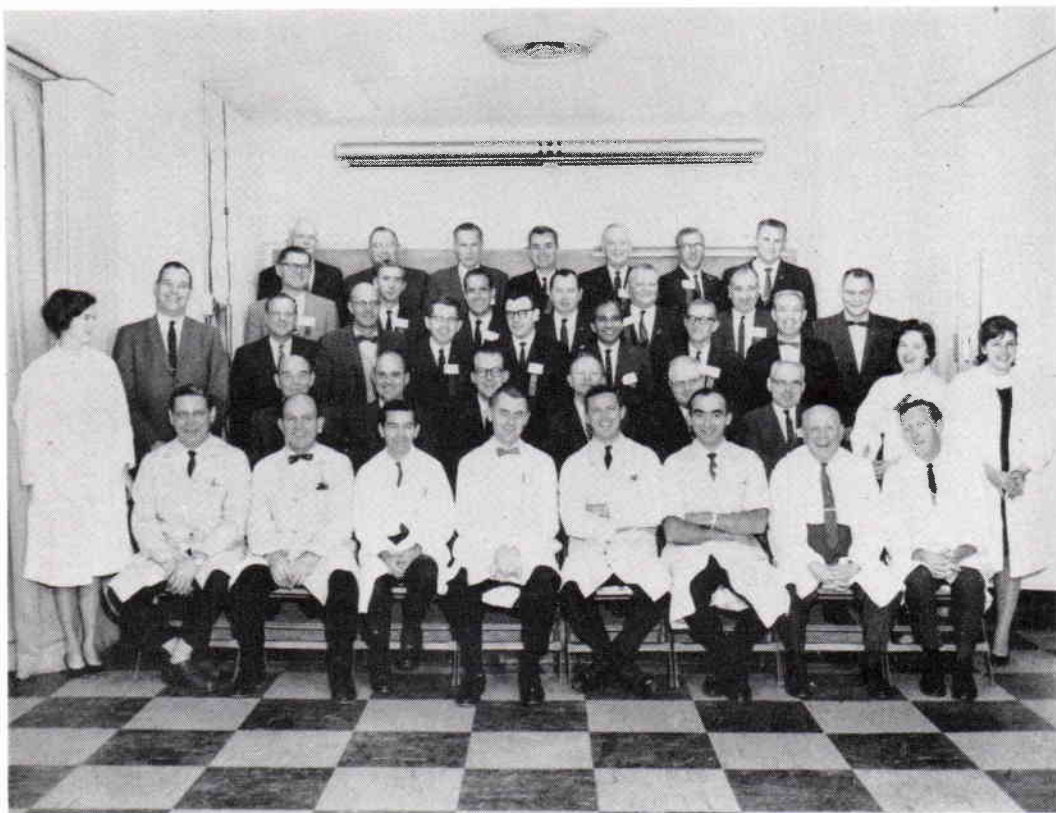
"Principles of Spinal Orthotics for Orthotists"; the other was "Business and Administrative Procedures for Owners, Managers, and Employees of Prosthetic and Orthotic Facilities."

"Principles of Spinal Orthotics" was developed by the faculty in order to instruct members of the orthotic profession in the medical and mechanical problems associated with disabilities of the spine, neck, and trunk. The course also attempted to survey the current practice of the art of bracing the spine. Thirty-one orthotists, engineers, and educators attended the pilot course to aid the

faculty in evaluating the material for future students.

The course in administrative procedures was planned and taught by the faculty of the Northwestern University School of Business in cooperation with Prosthetic-Orthotic Education. Thirty-two prosthetists and orthotists attended classes in accounting, office management, public relations, and legal aspects of medicine and business at Wieboldt Hall on the Chicago campus. A regular course was offered during February 11-15 of 1963.

Northwestern continues to offer courses



Pilot Course—"Principles of Spinal Orthotics," December 10-14, 1962. First row: Miss Hastings, Mr. Bidwell, Mr. DeBender, Mr. McIntyre, Dr. Keagy, Dr. Arnold, Mr. Jesswein, Dr. Boyland, Mr. Fryer, and Miss Rosen. Second row: Mr. Buschenfeldt, Mr. Bohnenkamp, Mr. Nattress, Mr. Brenner, Mr. Coon, Dr. Murphy, and Miss Moulder. Third row: Mr. Storrs, Mr. Guilford, Mr. Fillauer, Mr. Hanicke, Mr. Lehnies, Mr. Venkatranan, Mr. Glaubitz, Mr. Scott, and Mr. Bartels. Fourth row: Mr. Friedrich, Mr. Glancy, Mr. Engen, Mr. Lambert, Mr. Pease, and Mr. Goldstine. Fifth row: Mr. Benjamin, Mr. Titus, Mr. Rosenquist, Mr. McIlmurray, Mr. Ferrick, Mr. Peach, and Mr. Snelson.

for physicians, surgeons, therapists, prosthetists, and rehabilitation counselors. During the second semester of 1962-63 classes were offered in upper-extremity prosthetics, lower-extremity prosthetics, and juvenile-amputee prosthetics. The curriculum also included courses on total-contact plastic-socket techniques and the patellar-tendon-bearing below-knee prosthesis. The orientation course for counselors teaches management of patients requiring prosthetic and orthotic devices. Registration is open to other rehabilitation personnel.

Film—"Gait Analysis"

At the request of the Committee on Prosthetics Education and Information of the National Academy of Sciences—National Research Council, the faculty and staff of Prosthetic-Orthotic Education at Northwestern University Medical School have produced an outstanding teaching film entitled "Gait Analysis." This film demonstrates the most common gait defects which may be seen in an above-knee amputee, including circumduction, abduction, vaulting, medial and lateral whips, instability of the knee, long prosthetic step and others. These gait defects

are shown by a subject wearing an adjustable above-knee prosthesis, and are described in detail, then discussed as to possible causes, considering the amputee, the stump and the prosthesis. Normal gait is also demonstrated so that easy comparison between normal and abnormal gait can be made. The narration is conducted by a physician, a prosthetist and a physical therapist, all faculty members of the Prosthetic-Orthotic Education program at Northwestern University Medical School. Technical Consultants for the film include: Frederick E. Vultee, Jr., M.D.; Robert G. Thompson, M.D.; Hildegard Myers, R.P.T.; H. Blair Hanger, C. P.; William Sobbe, C. P.; and Edwin A. Bonk, Medical Photographer. A small pamphlet that summarizes the material presented in the film is available as a handout for those viewing the film.

This audio-visual teaching aid is recommended for all medical and paramedical groups concerned with management of the lower-extremity amputee, including physicians, therapists and prosthetists, both at the student and graduate levels. Chiefs of prosthetics clinics, facility owners and managers will find this film to be a valuable teaching device for their personnel. Since the release of this film in May 1962, it has been viewed in some 130 hospitals, university clinics, rehabilitation centers, schools of physical therapy, and limb facilities. In addition, the film has been shown at a number of national meetings of medical and paramedical associations. It is estimated that over 8,000 individuals have seen the movie. The film and handouts are available without cost to all groups who would benefit by its showing. Requests for the loan of the film should be addressed to: American Academy of Orthopaedic Surgeons, 29 East Madison Street, Chicago 2, Ill.

Course in Orthotics and Prosthetics in Argentina

At the request of the National Commission for the Disabled (Comision Nacional de Rehabilitacion del Lisiado) of the Republic of Argentina, a three-man team from the United States visited the National Center for Re-

habilitation in Buenos Aires to assist in conducting the First Technical Course in Orthotics and Prosthetics in Argentina.

The team consisted of Mr. Henry Gardner, of the Veterans Administration Prosthetics Center; Mr. Howard R. Thranhardt, of J. E. Hanger, Inc.; and Mr. A. Bennett Wilson, Jr., Technical Director of the Committee on Prosthetics Research and Development of the National Academy of Sciences—National Research Council. They visited Argentina during September 1962. In addition to serving on the faculty, they consulted with leaders in the rehabilitation field concerning their plans for strengthening the rehabilitation program in Argentina.

The course was attended by 68 physicians, 29 physical therapists, 27 occupational therapists, and 19 prosthetists. The students were from Government-sponsored rehabilitation units, private rehabilitation centers, private hospitals, private limbshops, and military hospitals. In addition to students from Argentina, there were students from Uruguay, Colombia, El Salvador, and Chile.

Serving with the team from the United States to form the faculty were Dr. José Cibeira, Director, Dr. Juan Luis Govi, Chief of the Amputation Service, and Mr. Edmundo Vaamonde, Chief of the Department of Psychology, all at the National Center for Rehabilitation. Both Dr. Cibeira and Dr. Govi have studied prosthetics practices in the United States.

Although labeled First Technical Course in Orthotics and Prosthetics, it was not possible to devote any significant amount of time to orthotics. A keen interest in the subject matter was evidenced by the students. Even a three-day military revolution which occurred midway in the course failed to reduce the student attendance appreciably.

The team considered that Argentina has the potential for establishing and operating a rehabilitation program as effective as any in the world. A nucleus of well-trained physicians is present. The materials required in fabricating artificial limbs and braces are available. Factories and "know-how" for production of prefabricated components are present. However, education in prescription, fabrication,

fitting, alignment, and prosthetics training is urgently needed.

It is the plan of the National Commission, with technical assistance from the United States, to conduct a three-month practical course for prosthetists during 1963, with the hope that it will provide the foundation for establishing an apprentice-type school for prosthetists.

**CPRD and UC Biomechanics Laboratory
Sponsor European Sabbatical of Professor
Charles W. Radcliffe**

Professor Charles W. Radcliffe, of the Department of Engineering, University of California at Berkeley, has recently reported on his activities in Europe during 1962 under the joint sponsorship of the Committee on Prosthetics Research and Development and the Biomechanics Laboratory of the University of California at San Francisco. Professor Radcliffe was on sabbatical leave from his regular duties as Professor of Mechanical Engineering.

Professor Radcliffe has been active in the Artificial-Limb Program almost since its beginning; in connection with the program, he has served on numerous committees and panels sponsored by the National Academy of Sciences—National Research Council.

During the first part of his sabbatical leave, Professor Radcliffe made a series of visits to a number of European centers of research in the field of orthopedic appliances and artificial limbs. The latter part of the leave was spent at the Orthopaedic Hospital in Copenhagen, Denmark, studying bioengineering principles associated with the design of specialized artificial limbs for geriatric amputees.

As an observer, he attended the annual meeting of the German Orthotist-Prosthetist Association in Wiesbaden during the period May 17-19, 1962.

At Bologna, Italy, Professor Radcliffe presented three lectures at an international symposium on prosthetic devices held at the Rizzoli Institute, the orthopaedic clinic of the University of Bologna, on June 18 and 19, 1962. Titles of the lectures were "Biomechanics of Above-Knee Prostheses," "Biomechanics of Below-Knee Prostheses," and "Design of

Improved Prosthetic Devices for Lower-Extremity Amputees."

In Copenhagen, Professor Radcliffe spoke to the British-Scandinavian Orthopaedic Congress on "A New Dual-Axis Orthopaedic Ankle Brace" on August 21, 1962. In Frankfurt, he presented a three-hour lecture-demonstration before 300 graduates of the German Technical School for Orthopaedic Technicians attending a symposium in connection with the annual meeting of their alumni association; his subject was "Biomechanics of Lower-Extremity Prostheses."

In addition, Professor Radcliffe made a number of informal presentations on similar subjects before groups of interested physicians, therapists, technicians, and engineers at the Limb Fitting Centre, Queen Mary's Hospital (Rochampton), London, and at the Orthopaedic Hospital in Copenhagen.

At the invitation of the Grupo Nacional de Ortopedicos Tecnicos (the Spanish Prosthetics Association), Professor Radcliffe participated in a four-day course of instruction in Below-Knee Prosthetics in Madrid during the period April 9-12, 1962. Dr. Pedro Prim of Madrid served as interpreter and co-instructor. The course was attended by 20 prosthetists and was the first sponsored by their association. It was considered successful and should serve as a stimulus to further activities of this type in Spain.

A similar course was conducted for six days in Bologna, Italy, during November 1962. The Italian course was sponsored jointly by the Rizzoli Institute of the University of Bologna, the Italian National Industrial Accident Insurance Company, and the Italian National War Veterans Association. This pilot course was successful, and it is hoped that it can serve as the first of many similar educational activities in Italy.

In addition to giving lectures and courses of instruction on the principles and techniques of prosthetics, Professor Radcliffe had a number of opportunities to give technical assistance in supplying information concerning the sources of supply of plastic resins and laminating materials, recommendations on the use of materials locally available, and recommendations for the design of a plastics

laminating laboratory for prostheses at the Rizzoli Institute in Bologna.

At the Orthopaedic Hospital in Copenhagen, Professor Radcliffe participated in a series of weekly seminars of interdisciplinary groups consisting of members of the departments of orthopedic surgery, physical medicine, prosthetics research, and engineering design. The meetings provided considerable guidance to research in lower-extremity prosthetics, an area of primary concern to Professor Radcliffe. The research program started in Copenhagen is being continued as part of the activity of the University of California Biomechanics Laboratory in San Francisco.

VA Clinical Application Studies

The Prosthetic and Sensory Aids Service of the Veterans Administration has recognized the desirability of conducting clinical studies of selected major devices or techniques prior to a decision as to their acceptance on a routine contractual basis. Such clinical application studies are designed to gather further information on significant factors regarding the device or technique, including advantages, prescription criteria, fabrication and fitting problems, maintenance problems, training considerations and check-out procedures. Besides affording broad clinical experience under a wide variety of conditions, these studies serve as an effective educational medium for participating clinical personnel.

The first clinical application study undertaken by the Prosthetic and Sensory Aids Service involved the Hydra-Cadence Above-Knee Prosthesis. This study drew upon the experiences, over a period of one year, of 100 above-knee amputee subjects and the observations and reports by 27 VA Orthopedic and Prosthetic Appliance Clinic Teams. The first fitting of the Hydra-Cadence prosthesis under the study took place on July 25, 1960, the last on September 5, 1961. Two interim reports were distributed, the first as of March 15, 1961, on a limited scale, and the second as of April 2, 1962, on a wide basis. Based on a significant trend of the study, a decision was made by the Veterans Administration to accept the Hydra-Cadence prosthesis as a contractual item beginning in January 1962. Prostheses

incorporating the Hydra-Cadence hydraulic system are now being prescribed when indicated for eligible veterans. A final report of the study is being prepared.

On February 11, 1963, it was announced that the Prosthetic and Sensory Aids Service will conduct clinical application studies of the Henschke-Mauch Swing-Phase Control Unit (Model "B") and the DuPaCo knee unit for controlling above-knee prostheses during swing phase. Approximately 116 amputees will serve as subjects for a six-month period under the supervision of 16 VA Clinic Teams. Besides evaluating the Mauch Model "B" and the DuPaCo systems on amputees who have never worn a hydraulic system, comparative data will be obtained from subjects who have worn the Hydra-Cadence prosthesis and the Mauch Model "B" units during previous tests.

ASME Hears Evaluation of Energy and Power Requirements for UE Prostheses

At the winter meeting of the American Society of Mechanical Engineers held in New York City during November 1962, Mr. Igor Paul, Research Assistant in the Engineering Project Laboratory of the Massachusetts Institute of Technology, presented a paper entitled "Evaluation of Energy and Power Requirements for Externally Powered Upper-Extremity Prosthetic and Orthopedic Devices" (paper number 62-WA-121). Professor Robert W. Mann, of the Massachusetts Institute of Technology, was co-author of the paper.

The paper evaluated the energy, power, and torque requirements for externally powered prosthetic and orthotic devices for different levels of disability. The frequency and range of human upper-extremity movements were determined by reducing 100 different activities to their constituent basic motions. The average energy and power and the maximum torque developed by the basic motions during maximum effort were evaluated for the most frequently used range of the motions. The total energies required by different upper-extremity disability levels to perform all basic motions associated with one elbow flexion were determined. The average power developed by simultaneous performance of basic motions

was estimated for different disability levels. Finally, the paper gave an example of how the determination of energy and storage requirements could be applied in the evaluation of alternative storage and conversion systems.

Copies of the paper may be obtained from the American Society of Mechanical Engineers, 345 East 47th Street, New York 17, New York, at \$1.00 per copy (50 cents per copy to members of the Society).

NU Publication on Distal Pads for LE Prostheses

The Northwestern University Prosthetics Research Center has recently issued a publication entitled "Silicone Rubber for Distal

Pads in Above-Knee and Below-Knee Prostheses." The publication was prepared by Mr. Fred Hampton, under a contract from the Veterans Administration.

The publication describes in detail the use of silicone rubber for making distal pads for above-knee and below-knee sockets. The silicone rubber can be in either foam or solid form.

Silicone rubber has similar application in the Syme, knee-disarticulation, and hip-disarticulation prostheses and can be used as shoe filler in certain types of foot amputations.

Requests for copies of this publication should be addressed to: Prosthetics Research Center, Northwestern University, 401 East Ohio Street, Chicago 11, Ill.

IN MEMORIAM



Frederick Edward Vultee, Jr.
1925-1962

The untimely death of Dr. Frederick Edward Vultee, Jr., on December 4, 1962, of a heart attack at the age of 37, left a host of close friends and associates shocked at the passing of such a man in the prime of his life. He was a most respected and admired member of the medical profession.

He is survived by his wife, Mrs. Janet Harlow Vultee, two daughters, Victoria Judith and Janet Elizabeth, and a son, Frederick E. Vultee, III, all of Richmond, Virginia. He was most devoted to his family.

At the time of his death, Dr. Vultee was Chairman of the Department of Physical Medicine and Rehabilitation and Director of the School of Physical Ther-

apy, both at the Medical College of Virginia.

Dr. Vultee received his B.S. and his M.D. degrees from Yale University. Until 1957, Dr. Vultee was on the staff at Walter Reed Army Hospital in Washington, D. C., where he also served his internship and residency in physical medicine and rehabilitation. While in Washington, he served, in addition, as clinical instructor in physical medicine and rehabilitation at Georgetown University. He was a veteran of World War II and a member of the Episcopal Church of the Redeemer in Richmond, Virginia.

Doctor Vultee was born in Fremont, Ohio, on February 10, 1925. He first came to the Medical College of Virginia in 1957 as Associate Professor of Physical Medicine and Rehabilitation. He left to become Associate Director of the Rehabilitation Institute of Chicago and returned in 1960 to the Medical College of Virginia, where he assumed the posts he held at his death. Although he left the Rehabilitation Institute of Chicago, he still actively engaged in teaching at that Institute and was a much valued member of the teaching faculty.

Doctor Vultee was a man of vibrant personality, both in his professional duties and in his social activities. His masterful and deeply concerned treat-

ment of patients was a model of medical proficiency, and in his handling of child patients he was without peer. Possessing an infectious smile, dynamic energy, and a marvelous sense of humor, Dr. Vultee was extremely popular with his patients, friends, and students. His philosophy and demeanor were those of the old-time favorite family doctor, enhanced by modern medical procedures.

During Dr. Vultee's tour of active duty with the Army at Walter Reed Army Hospital, he was an inspiration not only to the physical medicine section of the hospital, but to the other services as well, and particularly to the Army Prosthetics Research Laboratory at Forest Glen. There he enthusiastically participated in the rehabilitation of amputees and aided immeasurably in the design and development of all children's prostheses, training in their use, and the evaluation of devices. He also pioneered in the extensive research and development evaluation of cineplasty or surgically created muscle-motors for powering artificial hands. His keen and honest approach to the problems of amputees won for him the undying admiration of these patients and all of his associates.

Doctor Vultee's exceptional ability and extraordinary talent for teaching earned for him the highest regard and respect of the people in the professional and technological fields to which he was so devoted. He was also a prolific writer and made many notable contributions to medical literature.

Doctor Vultee leaves behind many who grieve for him. All of us who were accorded the privilege and the very great pleasure of knowing and serving with Fred feel that we have lost an irreplaceable friend. The loss is immeasurable to society and to the field of medicine, where his strength, magnetic personality, enthusiasm, and astute wisdom were a constant source of encouragement and comfort. His sudden passing leaves an unfillable void and has cut short a brilliant career that would have benefited all mankind. I wish I could have known him for a lifetime.

MAURICE J. FLETCHER
Col., U. S. Army (Ret.)



NATIONAL ACADEMY OF SCIENCES—NATIONAL RESEARCH COUNCIL

The National Academy of Sciences—National Research Council is a private, nonprofit organization of scientists, dedicated to the furtherance of science and to its use for the general welfare.

The Academy was established in 1863 under a Congressional charter signed by President Lincoln. Empowered to provide for all activities appropriate to academies of science, it was also required by its charter to act as an adviser to the Federal Government in scientific matters. This provision accounts for the close ties that have always existed between the Academy and the Government, although the Academy is not a governmental agency.

The National Research Council was established by the Academy in 1916, at the request of President Wilson, to enable scientists generally to associate their efforts with those of the limited membership of the Academy in service to the nation, to society, and to science at home and abroad. Members of the National Research Council receive their appointments from the President of the Academy. They include representatives nominated by the major scientific and technical societies, representatives of the Federal Government, and a number of members-at-large. In addition, several thousand scientists and engineers take part in the activities of the Research Council through membership on its various boards and committees.

Receiving funds from both public and private sources, by contribution, grant, or contract, the Academy and its Research Council thus work to stimulate research and its applications, to survey the broad possibilities of science, to promote effective utilization of the scientific and technical resources of the country, to serve the Government, and to further the general interests of science.

