

Spring 1968

Artificial Limbs

*A Review of
Current Developments*

COMMITTEE ON PROSTHETICS
RESEARCH AND DEVELOPMENT

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DIVISION OF ENGINEERING

and

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The Ratio—Patients : Prosthetists

A. BENNETT WILSON, JR.¹

REPEATED attempts to determine the number of amputees in the United States have been to little avail. But perhaps it doesn't really matter whether or not we have an exact count of the amputee population, as long as every amputee, now and in the future, receives the service he needs. A knowledge of ratios between types of amputees and of trends in causes and levels of amputations is more important than over-all numbers. Glattly has given us some very illuminating figures that can and have been useful to those whose responsibility it is to plan for the future needs of amputees. From the Glattly reports we learned that during a period between 1961 and 1963 the ratio of lower- to upper-extremity cases fitted for the first time was about 6:1, and that 62 per cent of these lower-extremity patients were over 50 years of age (*Artificial Limbs*, Spring 1963).

Nearly everyone responsible for the treatment of amputees knows from his own experience that the number of patients needing artificial limbs is increasing, and that the great majority of patients responsible for this increase is in the lower-extremity category. This situation is largely the result of three factors. It would naturally be expected that the number of amputees would increase with over-all growth of the population. Another factor is that more people are now living long enough to develop some form of vascular insufficiency that often leads to amputation. Still another factor is that a higher percentage of the geriatric amputee population is now being fitted with a prosthesis than heretofore—following recognition of the fact that the time and effort spent in fitting most elderly patients are more than justified.

Unfortunately, the number of prosthetists in the United States has not increased. The number of prosthetists certified by the American Board for Certification in Orthotics and Prosthetics, Inc., has remained nearly constant for the past decade. Steps are currently being taken to encourage more young people to enter the profession, but a number of years must necessarily pass before these efforts can show results.

Yet, in spite of the fact that the prosthetist:patient ratio is declining, the prosthetists have managed to provide improved service to more patients. A highly respected prosthetist recently estimated that individual prosthetists are

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now serving twice as many patients as they did ten years ago. Yet these improved services are being rendered for less real money than was the case ten years ago. A recent study by the Veterans Administration, whose caseload increased 59.3 per cent between 1957 and 1967, showed that their cost per patient per year had actually decreased in spite of the decreased purchasing power of the dollar. Part of this saving no doubt is the result of improved management and administrative procedures by the VA, but the major portion comes from the application of better fitting and fabrication procedures by well-trained, efficient prosthetists. Not only have the man-hours necessary for fitting and fabrication been reduced but less time is being spent on adjustments and repairs.

Further development and application of pylon-type prostheses and plastic sockets offer much hope for further reducing the time necessary to fit and fabricate a prosthesis. More widespread use of immediate postsurgical and early fitting procedures will result not only in reduced hospitalization time, but in happier, healthier patients. Surgeons must be made aware that many knee joints that a few years ago would have been lost automatically can now be saved. And, we must develop sockets that can be adjusted or will adjust themselves to the ever-changing conditions of the stump.

These facts show that a great deal of progress has been made in limb prosthetics since World War II. Yet, with no signs to indicate any change, either in the trend toward more patients or in the number of people to provide services for patients, it is the responsibility of all of us involved—research groups, educators, clinical personnel, and administrators—to continue to develop and apply improved devices and procedures for management of amputees. At the same time we must encourage intelligent young men and women to enter the field. To do this the role of the prosthetist must be made more attractive—both economically and through recognition of the worthwhileness of the work performed.

The Acceptance and Rejection of Prostheses by Children With Multiple Congenital Limb Deformities

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CHILDREN with severe multiple congenital limb deformities associated with thalidomide are numerically few (22,48). Because of the severity of this disability, the associated deformities, and the psychological trauma to both parents and child, the thalidomide tragedy has served as a catalyst to study the congenital amputee in depth. There is still controversy concerning the appropriate prosthetic and rehabilitation program for these children, but the attention this tragedy has focused on other less-involved children perhaps will reap benefits far beyond our expectations (1,13,18,23,26,36,39,42).

The possible factors associated with acceptance or rejection of appliances may be inherent in the appliance, or they may arise from the child's own frustration, the parental reaction (15,20,43), or other environmental factors. Retrospective studies of children who attend the Nuffield Orthopaedic Centre for prosthetic management and a review of

the relevant literature have been carried out in an effort to establish a pattern of management and to delineate topics for future research.

SCOPE OF THE STUDY

During the past four years, 50 children with congenital amputations and limb deformities have attended the Disabled Living Research Unit at the Nuffield Orthopaedic Centre. Approximately half were deemed not to need prostheses or appliances at this time.

This article reviews 21 children with multiple congenital limb deformities who have been under continuous care for prosthetic management and general rehabilitation for four years. All the deformities were presumed to be due to thalidomide, and the lesions were characteristically bilateral (Table 1). Thirteen of the children have been fitted with upper-limb prostheses only, four with lower-limb appliances only, and four with both upper- and lower-limb appliances (Table 2). Henkel's classification (21) was used; other classifications are used in various parts of the world (4,10,16,30,47,51).

Each child has been fitted with appliances on more than one occasion. In considering acceptance or rejection of prostheses, attention has been focused on the type of prosthesis provided rather than actual numbers. A satisfactory design may well be repeated in different sizes or, after rejection of

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TABLE 1. CLINICAL LESIONS OF CHILDREN IN SURVEY

Upper limbs only involved	
Amelia	3
Short dysmelia	4
Long dysmelia	7
Total	14
Lower limbs only involved	
Short dysmelia	2
Upper and lower limbs involved:	
Upper amelia; lower, short dysmelia	1
Short dysmelia of all four limbs	3
Upper short dysmelia with lower amelia	1
Total	5

TABLE 2. APPLIANCES FITTED

Appliances Fitted	No. of Children	No. of Different Stages of Prosthetic Management
Conventional upper-limb prostheses only	3	3
Powered upper-limb prostheses only	2	8
Conventional and powered upper-limb prostheses	8	30
Lower-limb prostheses only	4	10
Upper- and lower-limb prostheses	4	19
Total	21	70

one type, a different pattern may be tried. On average, each child has passed through three stages of prosthetic management, but the number of prostheses made and supplied is in considerable excess of this (Table 2). The classification of type of prosthesis fitted is given in Table 3.

Some children had only conventional prostheses, and others only powered upper-limb appliances. The majority, however, started with conventional appliances and then "graduated" to the powered ones.

CRITERIA FOR PROSTHETIC MANAGEMENT

UPPER-LIMB APPLIANCES

The fitting of upper-limb prostheses at the Disabled Living Research Unit was governed

by various factors. In the early stages, the demands of the parents and the availability of materials and appliances were the most dominant factors. As this was a disability incurred by a man-made drug, the parents felt that they had the right to have the best treatment available. For the first year or so the Unit was dependent upon the availability of material and parts from within the United Kingdom, those imported from Germany, or what could be made locally.

When the children's rudimentary arms were long enough to grasp objects bilaterally, to reach the mouth, and to be within the child's vision, then an appliance was not considered appropriate (22). But when both arms were absent, or the rudimentary arms were so short that they could not achieve the basic function of feeding, artificial arms were fitted. However, these children were also deliberately encouraged to use their feet to enable them to acquire sensory perception of texture, temperature, etc., as well as dexterity in movement and achievement of toilet management (31).

The fitting of the upper-limb appliances attempted to follow the normal behavioral patterns. A cosmetic appliance fitted during the first few months of life helped them to get used to wearing such appliances and learn sitting balance.

TABLE 3. CLASSIFICATION OF ARTIFICIAL LIMBS FITTED

<i>Conventional Upper Limbs</i>	
C.1.	Conventional cosmetic upper limb
C.2.	Conventional upper limb with cable-operated hook
C.3.	Conventional upper limb with cable-operated hook and elbow flexion
<i>Powered Upper Limbs</i>	
P.1.	Simple "pat-a-cake"
P.2.	Gas-powered hook and single-acting wrist unit
P.3.	As P.2. but with added cable elbow flexion
P.4.	Oxford Metal Jacket, double-acting wrist unit, and powered hook
P.5.	As P.4. but with Otto Bock hand instead of hook
<i>Lower-Limb Appliances</i>	
L.1.	Caliper-type with rocker foot pieces
L.2.	Caliper-type with ski foot pieces
L.3.	Caliper-type with shoes
L.4.	Swivel walkers



Fig. 1. The first powered upper-limb appliances known as "pat-a-cakes" were fitted at the age of about one year. These are no longer issued.



Fig. 2. Child with bilateral amelia who was issued an appliance giving powered prehension and wrist rotation with passive elbow and shoulder movements.

In order to give the child some form of bilateral grasp, "pat-a-cake" appliances were fitted when the child was approximately one year old. These were the first type of appliances to be powered by compressed carbon dioxide, and were actuated by body movement (Fig. 1).

The next stage was the introduction of wrist rotation and externally powered hooks or hands, fitted as the materials became available and the needs of the child demanded (Fig. 2)(34).

LOWER-LIMB APPLIANCES

A child's development is directly dependent on the vertical positioning of spine. Sitting,



Fig. 3. Child with lower-extremity amelia placed in a "flower-pot" at the normal age of sitting.

standing, and walking at the normal age are important for the child's normal development. Therefore, it is important that babies with amelia or short dysmelia of the lower extremity sit up at the normal age of sitting; that is, at the age of six months in a "flower-pot" (Fig. 3), and at about one year they should be given some form of legs for mobility (Fig. 4) (22).

The type and height of the lower-limb appliances issued to the children depended on the degree of competence and confidence in balance (Fig. 5). The children were supplied appliances with "shoes" as soon as was practicable; in any case, before they commenced formal schooling.



Fig. 4. Some form of mobility should be provided during the child's second year.



Fig. 5. The type and height of a lower-limb appliance depend upon the child's competence and balance. Whenever possible, the height should be kept within the lower limits of normal growth.

Coping with appliances for all four limbs imposes a considerable physical and intellectual strain on small children. The physical maneuvers necessary to walk with bilateral lower-limb appliances are often considerably restricted by the presence of upper-limb appliances. The children's activities and needs

should be balanced and the training program phased to allow the children to obtain practice with both sets of appliances separately and together. For some children, upper-limb appliances are an aid to balance, whereas for others these appliances are an impediment.

METHOD

The children and parents were interviewed, schools were visited, and all available records and reports were reviewed. These records include functional activities of daily living, simple objective tests of skill, and school reports. The extent of the activities covered included those featured in other simple follow-up studies (32). All children were seen by a clinical psychologist.

In the analysis, notation was made of:

1. The children's preferences.
2. The parents' preferences.
3. The amount of cooperation from the child.
4. The amount of cooperation from the parent.
5. The amount of cooperation from the school and teachers.

Concerning mechanical aspects, comments were recorded concerning:

1. The weight of the appliance.
2. Delay in supply of the appliance.
3. Delay in supply of spare parts.
4. Speed of response of the appliance.
5. Limitation of reach.
6. Limitation of other movements.

Physical reactions noted included heavy perspiration (associated with the weight of the appliance), skin rashes, soreness from the harness, and restriction of the child's body movement.

DEFINITIONS

APPLIANCES

The appliances have been grouped into: conventional upper limbs; powered upper limbs; lower limbs; and then classified according to their functional features (Tables 2 and 3).

ACCEPTANCE AND REJECTION

"Acceptance" of prostheses by children is often more passive than active. "Acceptance"

of an appliance in this study means that the child uses the appliance for most of the day for various activities; for example, feeding, writing, or playing. "Acceptance" in this context does not necessarily indicate that the child prefers the appliance to his own limbs. Almost invariably, the children prefer to use their own body and residual limbs for most manipulative activities.

"Total rejection" implies complete refusal to wear the appliance. Some children have to be persuaded to wear the appliances even for short periods each day, but will do so with encouragement; this usually means periods of half an hour. This condition is termed "partial rejection"; it could equally well be termed "partial acceptance."

RESULTS

ACCEPTANCE AND REJECTION OF CONVENTIONAL UPPER-LIMB APPLIANCES

Undoubtedly, conventional appliances for this group of children have a poor record of acceptance. Of those fitted before the age of two years, 14 children fitted with 14 bilateral appliances rejected the appliances on nine occasions (64 per cent), whereas acceptance was recorded in five cases (36 per cent) (Table 4). But it is difficult to assess correctly whether a child of this age has accepted or rejected an appliance, as the observer's judgment is likely to be very subjective.

It was noted, however, that after the age of two years conventional appliances were totally rejected.

TABLE 4. ACCEPTANCE AND REJECTION OF 14 CONVENTIONAL UPPER LIMBS ON 14 CHILDREN

Type	Age Range (years)	Accepted	Rejected		Totals
			Partial	Total	
C.1.	1-2	5	4	3	12
C.2.	2-3	0	0	1	1
C.3.	3-4	0	0	1	1
		—	—	—	—
		5 (36%)	4 (28%)	5 (36%)	14 (100%)

TABLE 5. ACCEPTANCE AND REJECTION OF 39 POWERED UPPER-LIMB PROSTHESES ON 13 CHILDREN

Type	Age Range (years)	Accepted	Rejected		Totals
			Partial	Total	
P.1.	1-2	1	1	2	4
P.2.	2-3	3	5	3	11
P.3.	3-4	2	4	2	8
P.4.	4-5	2	7	0	9
P.5.	5½	4	3	0	7
		12 (31%)	20 (50%)	7 (18%)	39 (100%)

ACCEPTANCE AND REJECTION OF POWERED UPPER LIMBS

Thirty-nine powered upper-limb appliances were fitted on 13 children, and were rejected on 27 occasions.

The acceptance of the powered upper-limb appliances in this series is 25 per cent in children under four years of age and 38 per cent in those over four years (Table 5). Acceptance increased considerably when the powered hand was introduced.

However, partial rejection (or partial acceptance) occurs for 50 per cent of appliances, and total rejection of powered appliances has not occurred in children over four years of age.

ACCEPTANCE AND REJECTION OF LOWER-LIMB APPLIANCES

Seventeen lower-limb prosthetic appliances have been fitted on eight children; 13 of these were accepted, one partially rejected, and only three totally rejected. Ultimately, *all* lower-extremity prostheses were accepted.

One child rejected appliances during her second year, because any type of appliance restricted her mobility and she was able to progress well by crawling. One child rejected, when, at the age of five years, he was fitted with appliances and he found them cumbersome and restrictive. This child has now accepted caliper appliances. Another child preferred the ski-type of appliance rather than those with shoes, because the latter kept on breaking and she had little confidence in them.



Fig. 6. Swivel walkers are a distinct improvement over previous lower-limb appliances.

The swivel walkers were made according to the design principles described by Motloch and Elliott (33) (Fig. 6).

None of the swivel walkers fitted has been rejected. They are a distinct improvement over any previous appliance. The full details are given in Table 6.

ACCEPTANCE AND REJECTION OF APPLIANCES ACCORDING TO AGE

Acceptance and partial acceptance are clearly related to increasing age (Tables 7 and 8).

TABLE 6. ACCEPTANCE AND REJECTION OF LOWER-LIMB APPLIANCES

Type	Age Range (years)	Accepted	Rejected		Totals
			Partial	Total	
L.1.	1-2	1	0	1	2
L.2.	3-4	5	0	1	6
L.3.	4-5	4	1	1	6
L.4.	5-6	3	0	0	3
		13 (76%)	1 (6%)	3 (18%)	17 (100%)

TABLE 7. ACCEPTANCE AND REJECTION OF ALL UPPER-LIMB APPLIANCES ACCORDING TO AGE

Age Range (years)	Accepted	Rejected		Totals
		Partial	Total	
1-2	6	5	5	16
2-3	3	5	4	12
3-4	2	4	3	9
4-5	2	7	0	9
5-6	4	3	0	7
	17 (32%)	24 (45%)	12 (23%)	53 (100%)

TABLE 8. ACCEPTANCE AND REJECTION OF ALL LOWER-LIMB APPLIANCES ACCORDING TO AGE

Age Range (years)	Accepted	Rejected		Totals
		Partial	Total	
1-2	1	0	1	2
2-3	1	0	0	1
3-4	5	0	0	5
4-5	3	0	2	5
5-6	2	1	0	3
6-7	1	0	0	1
	13 (77%)	1 (6%)	3 (17%)	17 (100%)

MAJOR REASONS FOR REJECTION OF UPPER-LIMB APPLIANCES

There were many recorded reasons for rejection or partial rejection, and for each

child there were usually several contributory reasons.

When these were grouped together and all the different appliances were considered, it was found that the commonest cause for rejection was the mechanical inefficiency of the prostheses (76 per cent); the next most common cause of rejection was the child's preference for using his or her own residual limbs. In a relatively few cases, the lack of cooperation of parents or child was a major reason for rejection (Table 9).

CHANGE FROM REJECTION TO ACCEPTANCE

It is even more interesting to analyze the major factors that lead from a rejection to an acceptance (Table 10).

FAMILY ENVIRONMENT

The problem of parental cooperation is partly reflected in the families' general environmental background. Although the numbers are small, the review indicates that the better-educated, middle-class families are more likely to help their children accept appliances (Table 11).

TABLE 9. MAJOR REASONS FOR REJECTION OF UPPER-LIMB PROSTHESES*

Prosthesis inefficient for various reasons	38 (72%)
Child prefers own limbs	22 (41%)
Parents uncooperative	9 (53%)
Child uncooperative	7 (41%)

* This table refers to all rejections for all the children of all the appliances supplied; that is, it refers to 17 children, 17 parents, and 53 appliances.

TABLE 10. MAJOR REASONS FOR CHANGE FROM REJECTION TO ACCEPTANCE OF UPPER-LIMB PROSTHESES*

Hand fitted instead of hook	4
Parental cooperation improved	4
Increased understanding with increasing age	3
Increased function available from appliance	2
Hook fitted instead of hand	1
School cooperation particularly improved	1

* This table refers to seven children and 28 appliances.

TABLE 11. ACCEPTANCE AND REJECTION OF THE CURRENT POWERED UPPER-LIMB PROSTHESES BY 17 CHILDREN ACCORDING TO FAMILY BACKGROUND

Background	Acceptance	Rejection		Totals
		Partial	Total	
Middle class—urban	3	2	1	6
Working class—urban	0	2	3	5
Working class—rural	2	1	1	4
Adopted	0	2	0	2
	5 (29%)	7 (42%)	5 (29%)	17 (100%)

CLINICAL PSYCHOLOGISTS' ASSESSMENT

All the children in this series were of at least average intelligence, with three being distinctly above average. Two children of average intelligence developed aggressive tendencies and for a period would use their artificial arms almost entirely as weapons. Their aggression finally diminished after starting at normal primary schools.

Psychological testing was unable to delineate specific features helpful in predicting acceptance or rejection of appliances. Perhaps if the testing had been more comprehensive and more frequent, trends might have been exposed. However, the simple clinical psychological appraisal reflected the acknowledged situation rather than helping to elucidate the underlying motivation toward acceptance or rejection of prostheses (7).

SCHOOL

In this series, 13 children attended normal state schools, five attended day schools for the physically handicapped, and two were at residential schools for the physically disabled. One child was undergoing orthopaedic treatment during the period covered by this survey. From this small series, acceptance for upper-limb appliances was higher for children attending normal state schools than for children at special schools for the physically handicapped (Table 12).

DISCUSSION

The birth of a child with a congenital limb deformity is a domestic crisis and the parents need urgent help and advice on the total management of the child. The crisis intervention (2) is a critical function of the management team, but the personal approach and careful handling are also essential (5).

That there should be complex factors interacting to produce acceptance or rejection of the appliances is understandable. Goldner and Titus (14) noted that they have been uniformly unsuccessful in the upper-extremity amelia and phocomelia, particularly when the condition occurred bilaterally. It was only when external power was added that they were able to make significant progress. This experience has been true of other authors (5,19,27,36,44).

The outstanding findings in this study are that therapists, parents, and children partake in a mutual learning process, and very close cooperation between all concerned is essential for good rehabilitation (29,37). Brooks (2) emphasizes the importance of recognizing

TABLE 12. ACCEPTANCE AND REJECTION OF PROSTHESES RELATED TO TYPE OF SCHOOL*

Type of School	Acceptance	Rejection		Totals
		Partial	Total	
Normal state schools				
Upper-limb appliances	6	3	3	12
Lower-limb appliances	2	0	0	2
				14
Schools for physically handicapped				
Upper-limb appliances	0	4	1	5
Lower-limb appliances	5	0	0	5
				10

* This table is based upon an analysis of 20 children wearing 24 appliances, as follows: 11 children with bilateral upper-limb appliances, four children with bilateral lower-limb appliances, four children with bilateral upper-limb and lower-limb appliances, and one child with bilateral upper-limb appliances who was also deaf.

situations which are known to produce adverse reaction and aptly refers to this as "crisis intervention." Each stage of the child's development must be watched (12,40), and the value of the appliances should be frequently reassessed.

Many children have deformities which at first do not seem to need surgical or prosthetic intervention. However, as the child develops, function and environmental features change, and there is a need for continuity of supervision and repeated clinical and functional reappraisal. The need for aids to daily living, special aids, or, indeed, surgical management may become relevant at any stage of the child's development (11,17,35,45,46). Although surgery of the upper limbs should be approached with caution during infancy, arteriograms indicate that the blood supply, even in single-digit phocomelia, is likely to be adequate for major reconstructive surgery to be contemplated in later life (30).

Objective records of activity, writing, and performing other prearranged tasks which can be timed, or for which some degree of accuracy can be charted, are of more value than a "clinical impression" or answers to a questionnaire (25). This study has employed simple tests which can be timed, and from which "learning curves" can be constructed (24,38).

The assessment of a child's function is more than simple assessment of activities of daily living in a therapeutic environment. Assessment must be in "real life" terms, and the children, the teachers, and the parents need to be integrated into the assessment and therapeutic team. This is well illustrated by the comprehensive evaluation of a functional cosmetic hand carried out by New York University (9).

The teacher does not need to be particularly orientated toward the physically handicapped. The children in this study often appear to do better at normal schools than at special schools for the physically handicapped, unless they have all four limbs severely involved; and very often a normal school near home would seem to be more appropriate than a school for the physically handicapped that is located further away. Estimation of intel-

ligence should be an accepted method of evaluation of all children prior to entrance into school, and psychological evaluation may be of significant help (6,41).

However, it may be necessary to adapt the child's physical environment, so that he is not penalized by unsuitable classroom furniture or unduly physically fatigued. This can usually be overcome by relatively simple devices.

Gouin-Decarie (15) compared thalidomide children to the average population and found the mean I.Q. to be 98. Along with a delay in speech, there was retardation in development of the child's perceptual concept of space and movement.

The design and fitting of prosthetic devices for children with multiple limb deformities and the subsequent training and resettlement of the children at home and school are complex activities involving engineers, technicians, prosthetists, therapists, school teachers, social workers, and, not the least, the children and their parents. The establishment of objective and valid criteria for evaluating patient performance in the very young is difficult. The fact that the children are constantly changing as they grow and develop should emphasize the importance of reassessing goals of achievement as well as anticipated attainment.

There are three major factors of influence: the personality of the child, the parental influences, and the therapeutic unit managing the child (8).

Brooks and Shaperman (3) devised a "Prosthesis Adjustment Scale" based on the child's use of the prosthesis—the applied use, maintenance, and acceptance. In their experience with the below-elbow congenital amputee, acceptance was interrelated with wearing, use, and skill of applied use. Although they emphasize that the fitting of a unilateral congenital below-elbow amputee before the age of two tends to result in full-time wearing and good acceptance of the prostheses, they also note that the category most closely related to early fitting is full-time wearing. Although indoctrination for full-time wearing is possible for single amputees, it is much

more difficult to accomplish for multiple amputees.

The almost complete acceptance of lower-limb appliances from an early age reflects the point that if the appliance fulfills a real need, even if inefficiently, the appliance will be accepted.

In the case of upper-extremity appliances, there is a definite improvement in partial acceptance and a dramatic improvement with the development of more reliable appliances, less subject to mechanical failure (note the change from P.3. to P.4. in Table 5).

In this review, no differentiation has been made between mechanical failure, troubles with control mechanisms, or power packs. Interestingly enough, in this series there was no particular problem relating to the supply and recharging of the gas cylinders. As more function is derived from gas-powered appliances, the supply problem will increase and probably limit the use of this type of appliance (28).

Brooks and Shaperman (3) also note that the acceptance of a prosthesis is closely related to the ability to communicate, and that good communication between parents and child (that is, good family relationships) is probably the major factor in establishing acceptance of appropriate prostheses. Thus the home environment is critical, and in certain circumstances this may be the determining factor (50). In this series, the age of four appeared to be the "watershed." At this age, children can begin to understand the reasons for continuing to use appliances and become at least partially cooperative. They also tend to start to attend nursery school at this age. Children with severe multiple limb deformities may be educated in normal schools or special schools for the physically handicapped, depending upon their clinical or their social needs (39).

The decision to remove the child to a residential school for the physically handicapped is a major one, and not necessarily associated with improvement in physical function or acceptance of suitable appliances. In this study, it has been noted that normal state schools have accepted these severely disabled children as a personal challenge and have

usually gone to great lengths to encourage the children in their rehabilitation, collaborating closely with the hospital therapists and prosthetics departments. By treating the children in this way, they have been permitted, indeed encouraged, to face up to many of the normal challenges and experiences of school life. This seems to have helped the children to be integrated into community living.

In this series, a small number of children with limb deformities in special schools for the physically handicapped are not so adapted to their disability as those at normal schools, and prosthesis acceptance is relatively poor. The atmosphere of the schools for the physically handicapped is often more protective and necessarily geared to the most incapacitated. Furthermore, some of these schools have many children who are on the borderline of being educationally subnormal. Appliance training in these schools is usually the responsibility of the physical therapist and not the teachers, and the teachers are reluctant to divert individual attention to appliance training in the presence of more disabled children who are unable to use appliances, for example, victims of cerebral palsy. However, children with severe mobility problems, as well as severe upper-limb dysmelia, may find the special equipment, adapted environment, slower tempo, and special staff of particular help.

As a group, these children achieve remarkable levels of manipulative skills using their residual upper limbs, chin, shoulder tips, feet, and mouth. The wearing of an upper-limb prosthesis frequently hampers these skills while only providing a much cruder form of function. However, there has been no experience here in fitting a single multifunctional arm balanced with a cosmetic prosthesis, and there are certain advantages in this approach (42). For children with absent or deformed legs, almost any form of lower-limb appliance gives them an immediate advantage in standing, achieving reasonable height, and—as a bonus—walking short distances.

As a general experience, it can be said that patients must obtain an immediate advantage from the appliance for it to be accepted. It is

the immediate postfitting phase which appears to be of greatest importance. If the appliance looks unfinished, if the technicians have to make numerous adjustments in the fittings, if it is uncomfortable or scratchy, if mother's face registers horror at the appearance—all these factors have a long-term effect out of proportion to their immediate import. If the antagonistic features even slightly outweigh the advantages, then acceptance is unlikely, or at best partial, and becomes more a matter of deference to authority, or, for children, part of a game rather than a true integration of the appliance into the body image. The immediate advantage gained must outweigh all the antagonistic factors. If this occurs, the patient will persist through further stages of fitting, training, and redevelopment.

The swivel walkers are a striking example. These appliances were used experimentally at first because earlier caliper-type lower-limb appliances were breaking so frequently that the children were continually frustrated. The swivel walkers were both more reliable and more immediately efficient, and acceptance was immediate and universal.

Cosmesis is often a motivating force in acceptance of any appliance (9,49). In this series, there was a marked improvement in acceptance on the introduction of a powered hand in preference to a hook (Table 5) even though function might be less. The change from 25 per cent to 75 per cent acceptance associated with the use of a powered hand accentuates the urgent need for a sophisticated, cosmetically acceptable, functional terminal device. This confirms the experience of New York University (9). Children were also pleased when ordinary shoes could be fitted to their lower-limb appliances.

Frequently, however, it is the mothers' dominant influences which lead to cosmetic acceptance overriding function, whereas fathers are often more likely to be interested in function. In one instance, a powered prosthesis was frequently returned nonoperational because a father repeatedly attempted to improve its functions. Another father, often at home because of shift work or lack of work,

spent many hours training his son to use his upper-limb prostheses.

However, acceptance associated with cosmesis might occasionally extend to a pathological acceptance, and there is one child with bilateral upper-limb, unequal-length phocomelia, who insists on wearing a single upper-limb prosthesis in spite of the fact that it prevents him from undertaking many functions he could perform with his two phocomelic limbs. The initial supply was largely at the insistence of the parents, and in retrospect probably should have been refused.

One problem that was very unsettling for both child and parents was the involvement of more than one clinical center. Usually, this was due to geographical circumstances. The clinicians near the child's home were unable to provide certain facilities; for example, experienced training, or appropriate surgery or prosthetic devices. Furthermore, in some instances, there was a separation between the provision of upper-limb appliances and lower-limb appliances. In all instances, this diversification of clinical control and lack of unified approach led to difficulties in management and was, not infrequently, a contributory factor in rejection of appliances.

CONCLUSIONS

The object of any critical reappraisal of clinical management is to improve the treatment of patients in the future. On the basis of this study, it is possible to lay down some broad general principles for the management of children with congenital limb deformities.

In the initial stages, the parents' attitudes are dominant; therefore, early confident collaboration is essential. The parents should have faith in the doctors and should have a clear understanding of the individual responsibilities of the members of the pediatric and prosthetics team, which may vary according to local facilities. The child should be under frequent review by the same clinical team. Each member of the team—pediatrician, prosthetics consultant, therapist, technician, social worker, and psychologist—has contributions to make at all stages.

For severely disabled children, introduction to adapted clothing, aids to daily living, and training activities must be tailored to fit the individual child's expected development, and independent activities should, wherever possible, match the accepted "stepping stones" of child development.

Lower-limb deformities should be treated by appropriate surgery and prosthetics so that independent mobility is achieved as early and as efficiently as can be matched with normal progress. The size of the appliance should match natural growth as nearly as possible.

Upper-limb appliances present a more complex problem. Most children will alternate between accepting and rejecting appliances, depending on their development and needs.

Early fitting, at perhaps 12 to 18 months (or even earlier), has some relevance in that it accustoms the child to a somewhat uncomfortable appliance. But the child is unlikely to accept formal training in the use of a sophisticated appliance until more than four years of age. Once schooling starts, training in the use of an appropriate appliance should be part of formalized education, and this demands close collaboration between therapists and teachers, particularly in the school surroundings.

The prosthetists and technicians must be prepared to adapt and redesign frequently as the child's needs change. They must accept the need for adequate cosmesis even at an early age. Rejection of appliances must never be regarded as "naughty" or "ungrateful," but as part of natural development. Gentle insistence on regular training sessions may well tide a child over until in later years he understands and appreciates the need for the appliance and can make a reasonable personal decision regarding design and use.

There is an urgent need for the development of mechanically reliable, cosmetically acceptable, and functionally sophisticated upper-limb appliances.

This development of an awareness of the most suitable design and the appropriate uses of upper-limb prostheses should be the outcome of close understanding between the child, parents, doctors, teachers, and therapists.

SUMMARY

A group of 21 children with multiple limb deformities associated with thalidomide who have been supplied with various upper- and lower-limb prostheses is described. The acceptance and rejection of the appliances are analyzed according to age, family background, and the type of appliance.

ACKNOWLEDGMENTS

The powered upper-limb appliances and the swivel walkers were designed and made in the Research Workshops at Mary Marlborough Lodge.

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Immediate Postsurgical Prosthetics Fitting in the Management of Upper-Extremity Amputees

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In the experience of the authors of this article, immediate postsurgical prosthetics fitting has been the most satisfactory means of managing lower-extremity amputees (1,2,3,4,5). The procedure has allowed better control of postsurgical edema, reduced postoperative pain, permitted more rapid conditioning of the stump, and shortened the time between amputation surgery and definitive prosthetic fitting. These conclusions are based on the experiences gained with 200 below-knee amputations followed by immediate postsurgical fittings at Jackson Memorial Hospital, the main teaching hospital of the University of Miami School of Medicine. The underlying cause of amputation in 85 per cent of these patients was peripheral vascular disease, usually with diabetes

FOUR UPPER-EXTREMITY CASES

On four occasions there have been opportunities to apply temporary prostheses to upper-extremity amputees immediately after surgery. The patients in this small series showed a considerable reduction in postoperative pain, rapidly began to use their prosthetic appliances, and were impressive in their psychological adjustment to their disabilities.

Brief clinical and prosthetics histories of these four patients follow.

1. L.M. is a 32-year-old male who was struck in the right hand by a rattlesnake in November 1966. Despite a vigorous therapeutic regimen, extensive damage was sustained. The patient underwent several surgical

procedures in attempts to restore function to his hand. One year later, because of a functionless, partially anaesthetic, two-digit hand, a wrist disarticulation was performed, with immediate fitting of prosthesis (Fig. 1). Seventeen hours after surgery, with no instruction other than the preoperative demonstration of the harness and hook control, the patient was capable of operating the terminal device sufficiently well to feed and dress himself (Fig. 2). The patient was fitted with a permanent prosthesis three weeks after amputation. The surgical wound had healed *per primam* when the stump

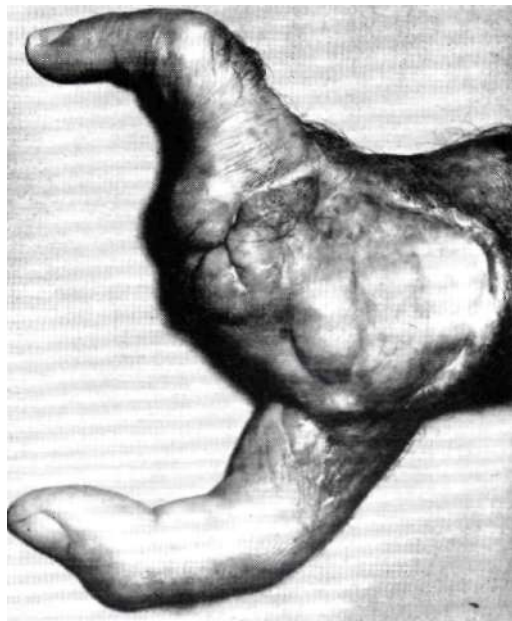


Fig. 1. Preoperative view of a functionless and partially anaesthetic hand resulting from the bite of a rattlesnake.

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Fig. 2. Photograph taken 24 hours after wrist disarticulation and immediate postsurgical fitting of prosthesis.

was first inspected two weeks after the surgical procedure.

2. A.S. is a 57-year-old male who severely injured his hand in a meat grinder, requiring a wrist disarticulation. Because of the nature of the injury, it was elected not to close the wound but to perform an open carpal disarticulation. One week later, in the absence of infection or other complications, a wrist disarticulation was performed by conventional means. The patient was fitted immediately postoperative with a below-elbow temporary prosthesis, complete with harness and controls. The patient left the hospital four days after surgery; when seen as an outpatient one week after surgery, he was capable of using the terminal device satisfactorily. He was fitted with the final prosthesis four weeks after surgical procedure.

3. L.D. is a 57-year-old male who underwent a right below-elbow amputation in December 1967 because of extensive metastases to the right radius from a hypernephroma (Fig. 3). The operation was performed by conventional methods and a temporary prosthesis, with harness and controls, was applied immediately after surgery. Convalescence was uneventful and the patient was discharged 22 days after surgery, at which time he was capable of controlling the elbow



Fig. 3. Metastatic lesion of right radius resulting from hypernephroma.

and terminal device in a relatively satisfactory manner. He was fitted with a permanent prosthesis 60 days after the surgical procedure.

4. F.M. is a 57-year-old male who sustained a severe sideswipe injury to the left upper extremity,

with multiple fractures and extensive arterial and nerve injuries. After approximately nine months and many surgical procedures, the patient was left with a functionless and nearly anaesthetic extremity. An above-elbow amputation was carried out by conventional means, with immediate fitting of the temporary socket. The postoperative course was uneventful. Harness and controls were added one week postoperative. Upon discharge four weeks after surgery, the patient was using the terminal device and elbow lock in a satisfactory manner.

DISCUSSION

The absence of severe peripheral vascular disease in the upper extremities appears to increase the possibility of successful immediate postsurgical prosthetics fitting even above that seen in the lower extremities. Since weight-bearing is not a factor, the possibility of stump damage as a result of excessive pressures is minimized. In all four cases reported in this article, primary healing took place and there were no complications. Phantom pain was not encountered in any instance. The four patients were fitted with plaster temporary prostheses with conventional harness and controls and were instructed to operate the terminal device as early as the first postoperative day. The two wrist-disarticulation patients were allowed to

move their elbows freely, and the two above-elbow patients were encouraged to move their shoulders as freely as possible. The psychological advantage of early rehabilitation has been apparent. Immediate postsurgical prosthetics fitting of the upper-extremity amputee appears to have significant advantages.

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Immediate Postsurgical Prosthetics Fitting of a Bilateral, Below-Elbow Amputee, a Report

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The application of immediate postsurgical prosthetics fitting procedures in the management of lower-extremity amputees has been reported as providing a number of advantages, notably control of postsurgical edema, a marked reduction in pain, and a material reduction of the period of hospitalization (1,2,3,4).

Although somewhat different considerations are involved in upper-extremity cases, immediate postsurgical prosthetics fitting of upper-extremity amputees is a logical progression in the application of these procedures. Upper-extremity amputations are considerably less frequent and are usually in a younger age group. Adequate wound healing is usually not a problem, local factors being the most important determinant. Still the application of a rigid dressing is a sound surgical concept.

Unilateral amputees have a high rejection rate for actual use of their prostheses. It is believed that immediate postsurgical fitting of prostheses to upper-extremity amputees permits rehabilitation from the earliest possible moment and, hopefully, a higher acceptance rate. As used in this report, the term "immediate fitting" means the application of a rigid surgical dressing with terminal device at the time of surgery or in the immediate postoperative period. This is in contrast with "early fitting," which is applied at some time after the removal of sutures.

During the past two years, the authors have

had the opportunity to apply immediate prosthetics fittings to three patients, with four upper-extremity amputations. The case reported here is that of a bilateral, below-elbow amputee.

CASE HISTORY

LMW, a 26-year-old employee of an electric power company, sustained electrical burns of both upper extremities on March 7, 1967, the result of receiving 19,000 volts of current through both wrists. One month later he was seen in the hospital by a consulting group (general surgeon, plastic surgeon, and orthopaedic surgeon) for consideration of possible reconstructive measures. It was the consensus of the group that no useful hand or part thereof could be salvaged (Fig. 1). As a result, on April 17, 1967, bilateral midforearm amputations were carried out. At the time of surgery extensive muscle necrosis was found—as expected—proximal to the apparent skin defect. This required loose closure of the amputations. Drains were placed in the wounds and compression dressings were applied. On April 20, 1967, the patient was returned to the operating room so that the wounds could be viewed, and they appeared to be clean. At this time rigid surgical dressings with terminal devices and harnessing were applied. From that time on, a marked improvement in the emotional status of the patient was noted (Fig. 2). The patient wore his temporary prostheses until May 26, 1967, when he was fitted with permanent prostheses. The patient made an excellent recovery, returning to full-time work in November 1967.

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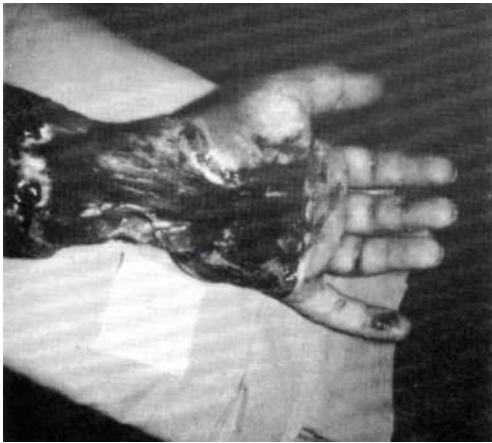


Fig. 1. Neither the left nor the right hand was considered salvageable.

APPLICATION OF TEMPORARY PROSTHESES

Some details in the application of the rigid dressings and temporary prostheses may be of interest.

Autoclaved lamb's wool was applied over the suture lines, and Orion Spandex socks were then rolled into place and held under tension.

To satisfy two somewhat conflicting considerations—that is, to ensure that the rigid surgical dressing would not be displaced when the patient flexed and extended his elbows, and to avoid immobilization of the elbow joint with plaster—Ace bandages were applied about 3 in. below the elbow and continued proximally to encase the elbow joint. Elastic plaster bandages were then applied, and the Ace bandages were incorporated into the plaster wrap. The plaster wrap extended to a point just below the condyles of the joint. Thus the rigid dressing was held in contact, and at the same time limited movement was permitted to the joint.

Steel straps attached to WE-500 wrist units were then applied to the rigid dressing with regular plaster for reinforcement.

A retainer plate riveted to an anchor plate was attached to the socket for cable attachment.

A standard bilateral ring harness with plastic triceps pad and flexible leather hinges completed the setup.

Two 5XA hooks were applied with one rubber band each.



Fig. 2. From the time of the application of the rigid dressings and temporary prostheses, there was an upturn in the patient's emotional status.

On April 25, 1967, sufficient atrophy had occurred to warrant new rigid dressings. The foregoing procedure was repeated. At this time, extra rubber bands were added to the terminal devices, and the patient demonstrated proficiency at a number of activities.

On May 9, 1967, the second cast change was made, and a wrist-flexion unit was applied to the right side. Again, more rubber bands were applied.

PERMANENT PROSTHESES

"Definite prostheses" were prescribed for the patient on May 18, 1967. The prostheses were fabricated and subsequently fitted on May 26, 1967. The prescription included:

Bilateral below-elbow plastic prostheses.
Double-wall sockets.
Flexible joints.
5XA hooks.
Dorrance No. 4 hands.
Two wrist-flexion units.
One driving ring.
One button hook.

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Experience with the Munster-Type Below-Elbow Prosthesis, a Preliminary Report¹

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The Munster technique, an attempt to obviate the traditional problems associated with fitting short and very short below-elbow amputees with split sockets and step-up hinges, has been described in some detail (1,2,3,4). However, individual clinic experience in fitting Munster-type prostheses to patients has not been well documented. Following publication of a manual of instruction for the Munster-type below-elbow prosthesis by New York University in 1965 (4), the Juvenile Amputee Clinic of the District of Columbia General Hospital undertook the routine fitting of short below-elbow cases with these prostheses. The principles of construction and fitting outlined in the New York University manual were followed very closely. This article presents an analysis of patients fitted with the Munster-type prosthesis at the Juvenile Amputee Clinic.

SCOPE OF THE STUDY

Fourteen patients were fitted with a total of 24 Munster-type below-elbow prostheses between 1965 and 1967. The group comprised

eight female and six male patients. The right upper extremity was involved in eight patients, the left in six. There were no bilateral cases. One ten-year-old boy had an amputation of traumatic etiology; the remaining 13 patients had congenital deficiencies. An 11-month-old infant is not included in the analysis because her family moved to another city shortly after her fitting, and no long-term follow-up data could be obtained. Stump length ranged from 1 1/4 in. to 7 in., with all but two stumps measuring less than 4 in. The distribution was as follows:

Number of Patients	Stump Length (in.)
1	1 1/4
1	1 1/2
1	1 7/8
2	2
1	2 1/2
2	2 3/4
1	3 1/4
2	3 3/4
1	4
1	7
Total 13	

¹ It is believed that this article will be of interest to our readers as a sequel to articles on the Munster-type below-elbow socket that appeared in the Autumn 1964 and Autumn 1965 issues of *Artificial Limbs*. This article will also appear in the July 1968 issue of the *Inter-Clinic Information Bulletin* of the Subcommittee on Child Prosthetics Problems, Committee on Prosthetics Research and Development.

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Seven of the patients had been previously fitted by conventional means, and seven had never worn a prosthesis. It is interesting to note that only one of the previous prostheses had been of the split-socket type, the others being preflexed.

During the study period, two patients received three prostheses, six received two prostheses, and six had single fittings. In the multiple fittings, the shortest period before replacement was five months, and the longest 26 months. The average for the entire 13 patients on whom adequate follow-up information was obtained was 11.8 months. The three patients

requiring replacement at five to six months gained weight rapidly or experienced spurts in growth.

FABRICATION AND FITTING PROCEDURES

Taking the wrap cast is one of the most critical steps in the preparation of Munster-type prostheses. Use of a proper molding grip is essential to the success of the technique. It was found that the stump of an infant is more difficult to cast than that of an older child because of the discrepancy between the size of the infant's stump and the hands of the prosthetist. Accentuation of the groove for the patient's ulna formed by the thenar and the hypothenar eminences of the prosthetist's hand seems to be less critical in casting the infant's stump than in casting the stump of the older child or adult. The difference is probably due to the generous layer of subcutaneous fat so characteristic of infancy. No special efforts were made to relieve the olecranon during casting, but a buildup was added to the positive model of the stump. Important factors during casting are pressure at the posterior distal surface of the humerus above the epicondyle level and the two-fingered pressure on either side of the biceps tendon. On small patients, the prosthetist's middle finger is slightly bent because of the different lengths of the index and middle fingers (Fig 1). A symmetrical socket brim which provides overall fit is the goal (Fig. 2). Aside from these minor differences, the casting and all the construction procedures followed the New York University manual exactly.

The simplified harness system commonly referred to as the figure-nine harness, with the cable reaction point located on the proximal posterior portion of the socket, was used in the series. For the nine-month-old patient a small triceps pad with conventional figure-eight harness was used, in order to make the prosthesis more secure (Fig. 3). It was believed that the nine-month-old patient might be able to remove the prosthesis without the additional suspension provided by the triceps pad and the anterior forked strap.



Fig. 1. Molding grip. Note slight flexion of middle finger.



Fig. 2. End view of symmetrical socket.

EVALUATION

The value of the prosthesis was judged on two bases. First, the reactions of the patient and his parents were considered. Second, patient response and performance were compared with the checkout criteria published in the New York University manual.

All patients and parents were pleased with the Munster-type prosthesis. The simplified harness and light weight were consistently mentioned as favorable features. It was interesting to note that the seven patients who had previously worn other types definitely preferred the Munster-type. The patient who had worn the split socket was even more emphatic in his approval, as were his parents.

Standard checkout forms were used in the clinic. However, for purposes of this study,

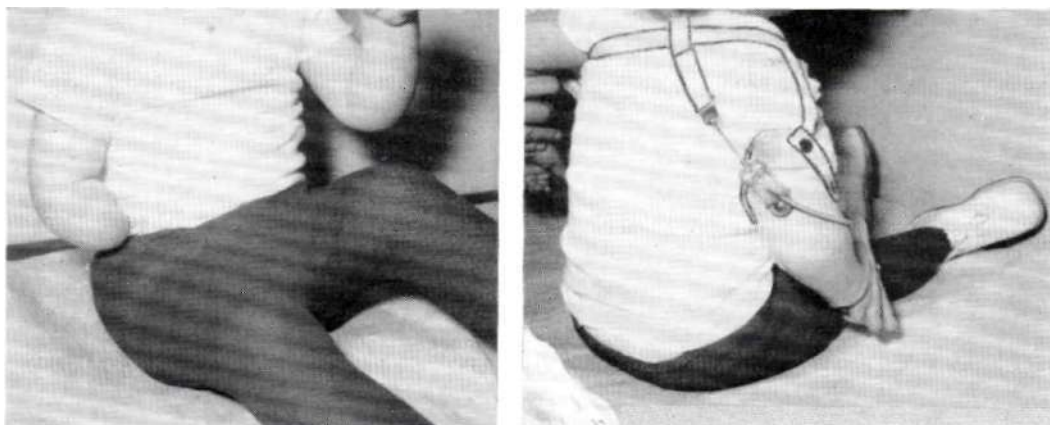


FIG. 3. Nine-month-old female infant (P.M.) with short below-elbow stump fitted with triceps pad and figure-eight harness for additional suspension.

special attention was given to certain specific items: range of motion with and without prosthesis, stability, and control-system efficiency. These data are summarized in Table 1.

Terminal-device openings were recorded for all patients within the limits of 30 deg. and 90 deg. of elbow flexion and were considered acceptable. The number of rubber bands varied between one-half a band to three, depending upon the functional requirements of the patients.

The recorded ranges of elbow motion without the prosthesis illustrate the hyperextension so characteristic of upper-extremity terminal transverse partial hemimelia. Maximum flexion varied from 80 deg. to 100 deg. with the prostheses for most patients. In all instances, full terminal-device opening was obtained at maximum forearm flexion. The test of full terminal-device opening at the mouth did not apply, because the terminal device could not be brought to the mouth. However, since all the patients were unilateral amputees, the flexion ranges were considered acceptable.

Retention of the prosthesis under axial load testing revealed suspension stability to be excellent, as most prostheses tolerated one-third of the child's weight without excursion of the socket. The greatest slippage recorded was one-half in.

Control-system efficiency was better than

80 per cent in one-half of the prostheses, and in no instance was the percentage less than the 71 per cent recorded in one case.

Perspiration has not been a problem even during humid summer days. All patients used cotton stockinette stump socks for insertion of the stump, with the ends tucked back into the forearm shell after donning. It is believed that the opening provided in the medial socket wall for this purpose may have been a significant factor in heat regulation.

SUMMARY

An analysis of experience in fitting a total of 23 Miinster-type prostheses to 13 patients has been presented. The prostheses were fitted, with very minor modifications in casting technique, according to the New York University fabrication manual. Actually, the differences were more quantitative than qualitative.

It should be mentioned that the clinic prosthetist attended the pilot course in Miinster-type fabrication technique at New York University. This technique is best acquired through firsthand instruction rather than by reading a manual.

The results have been gratifying. The parents and patients found the prosthesis acceptable, and in seven cases preferred it to other types that had been previously worn.

TABLE 1. FITTING DATA ON MÜNSTER-TYPE SOCKETS ($N = 13$)

Patient	Age at Fitting (yr.)	Length of Stump (in.)	Date of Fitting	Elbow Range without Prosthesis (deg.)	Elbow Range with Prosthesis (deg.)	Socket Displacement* (in.)	Control Efficiency (per cent)
S.M.	3	2½	10/10/67 3/14/68	0 to 135	30 to 80 20 to 80	0 0	75 91
E.B.	6	2	6/ 8/67	-15 to 125	28 to 100	¼	75
J.R.	3	3¼	5/18/66 12/ 7/67	-15 to 135	50 to 90 25 to 90	¼	75
T.P.	9	7	3/23/66 8/24/67	0 to 145	13 to 100 0 to 140	¼ ¼	71 75
A.L.	9	2¾	2/ 5/65 5/11/66	-15 to 135	35 to 105 35 to 105	⅛ 0	85 75
T.F.	4	2½	2/16/66	-10 to 128	36 to 96	0	75
M.C.	6	2	6/13/66	-28 to 90	27 to 82	¼	75
R.R.	3	1¼	10/11/67	-15 to 130	30 to 90	0	91
P.M.	¾	1½	10/ 5/67	-10 to 135	50 to 85	0	100
B.H.	6	3¾	8/24/67 3/ 8/68	-40 to 120	25 to 90 25 to 90	0 0	80 80
M R.	11	3¾	4/ 1/66 2/24/67 9/12/67	0 to 120	45 to 100 36 to 100 35 to 90	0 0 0	86 75 80
J.D.	11	1⅞	7/11/67 1/31/68	-10 to 135	15 to 85	½ ¼	78 100
S.P.	9	4	6/ 9/65 5/ 3/67 10/ 5/67	-28 to 125	50 to 102 30 to 76 30 to 76	¼ 0 0	75 94 94

* Socket displacement with axial load equal to one-third the weight of the patient

Although the range of motion in the prosthesis did not always equal the expected 70 deg. of active flexion, function was acceptable. The stability achieved was excellent. In no case was there more than 1/2-in. displacement of socket on the stump with one-third of body weight in axial pull.

The control-system efficiency was within acceptable limits in all cases, with one-half checking out at 80 per cent or better.

On the basis of this limited experience, it is believed that the Munster-type prosthesis is the fitting of choice for the child with a unilateral short or very short below-elbow amputation.

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The Army Medical Biomechanical Research Laboratory Porous Laminate Patellar-Tendon-Bearing Prosthesis

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In warm or humid climates, the problem of heat and perspiration within a nonporous plastic laminate prosthesis covering a substantial area of the body is particularly troublesome. The accumulation of sweat in a patellar-tendon-bearing (PTB) socket or a shoulder cap, combined with the inability of the laminate to permit evaporation or diffusion of water vapor, frequently causes mild to severe discomfort and even skin lesions sufficiently severe to require that the use of the prosthesis be suspended. Moreover, when a rubber (Kemblo) and leather liner is used, the sweat may cause it to deteriorate.

Initial efforts of the U.S. Army Medical Biomechanical Research Laboratory (AMBRL) to produce porous plastic laminates for prosthetic applications were well received when applied to upper-extremity devices (2,3); but, when the same technique was applied to PTB prostheses, the strength and durability of the material proved to be inadequate (4,5). In addition, problems of low porosity, nonreproducibility, and increased fabrication time were cited as serious deficiencies in the technique (8).

In 1966, AMBRL reported on the develop-

ment of an epoxy porous laminate which when fabricated according to the instruction manual (6) offered the following claimed advantages over prior techniques utilizing polyester resins:

1. The new laminates were two and one-half times stronger under laboratory test conditions.
2. The new technique produced laminates which were twice as porous as prior versions.
3. The fabrication procedure was simpler, required only one curing temperature, and could be reproduced more reliably.

DESCRIPTION OF THE TECHNIQUE

STUMP-CASTING PROCEDURES

The stump-casting and cast-modification procedures are essentially the same as those taught in the various prosthetics educational programs. However, the positive stump model is prepared for a suction lamination. This technique, which involves the use of a vacuum pump to make the PVA bag conform to the socket contours, is familiar to many prosthetists but is not a routine procedure in the fabrication of a PTB socket with soft insert.

FABRICATION PROCEDURES

The procedures for fabricating a porous epoxy laminate PTB socket with a soft distal end differ from those used in the polyester lamination system as follows: the utilization of Silastic Elastomer 385 and Foam Elastomer 386 to form the soft distal end, and the procedure of impregnating the Banlon and nylon stockinette with a predetermined quantity of resin mixture consisting of epoxy EPON, Versamid, pigment, and methylene chloride.

¹ Based upon *The AMBRL Porous Laminate Patellar - Tendon-Bearing Prosthesis*, published by Prosthetics and Orthotics, New York University Post-Graduate Medical School, New York, NY., in March 1968 (1). The study was conducted under the supervision of Sidney Fishman, Ph.D., Project Director, with financial support from a special grant from the Children's Bureau, Department of Health, Education, and Welfare.

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Preimpregnation of the stockinette and evaporation of the solvent prior to layup result in a stronger, more porous socket.

FINISHING PROCEDURES

Standard finishing procedures are not used because they would reduce the porosity of the socket. A procedure in which indexing pins are used to align the porous shank with the socket is detailed in the 1963 AMBRL instruction manual (4) and is incorporated in the NYU revision of the 1966 AMBRL manual (7).

The one variation from the AMBRL procedure that was introduced in the finishing process by NYU was the use of polyurethane as a buildup material over the socket instead of A.C. polyethylene wax (steps 51 and 52 in the 1966 AMBRL manual). Polyurethane foam was believed to offer the prosthetist a faster method for accomplishing the external buildup over the socket. The foam also permits the use of power equipment for shaping, which the wax does not.

PRELIMINARY EVALUATION

A preliminary evaluation completed at NYU in March 1967 (9) critically considered the epoxy porous laminate procedure in the following respects on the basis of four fittings on below-knee amputees: the fabrication process, amputee reactions, durability, and laboratory tests. The fittings were carried out in the New York metropolitan area during a period of very hot, humid weather in the summer of 1966, which afforded ideal conditions for investigation of amputee reactions to socket porosity.

In summary, the conclusions of the preliminary evaluation were:

That the May 1966 AMBRL instruction manual was generally clear and easy to follow. However, the finishing procedures lacked the completeness of those set forth in the June 1963 AMBRL manual. A revision of the former was prepared, incorporating details of this part of the technique. The procedures were consistent with accepted prosthetics practice, and no unusual equipment was necessary.

That the actual time required for fabrication was approximately one and a quarter hours longer than that required for fabrication of the conventional PTB prosthesis. The bench time can be reduced somewhat if

the suction hose is inserted into the oven, eliminating the necessity of setting up the undercut areas of the stump model prior to placement of the socket in the oven for curing.

That the coloring and the finish of the experimental prostheses were uniform, and the porosity was highly acceptable. Since no socket liner is used in this procedure, but rather a soft distal end, the amputee's tolerance to a "hard" socket was incidentally investigated. None of the amputee subjects in this preliminary evaluation noted any adverse reaction to the lack of a soft insert. All reported a significant reduction in discomfort associated with perspiration during the period of wear, remarking that the stump socks were much less saturated at the end of the day.

That the experimental prostheses were significantly lighter in weight, with an average reduction of 32 per cent. The prostheses showed no signs of breakdown or clogging of the pores over a six- to 12-month period of wear, and showed excellent retention of original conformation. All are still being worn satisfactorily after 18 months.

On the basis of this preliminary evaluation, the Subcommittee on Child Prosthetics Problems of the Committee on Prosthetics Research and Development recommended that a field study be initiated to evaluate the porous laminate technique on a broad sample of juvenile subjects.

SCOPE AND OBJECTIVES OF THE FIELD STUDY

Six clinics (Atlanta, Birmingham, Durham, Memphis, New Orleans, and Orlando), all located in hot, humid climates in the southern and southeastern sections of the United States, were invited to send a prosthetist representative to a three-day course in the fabrication of the AMBRL porous laminate PTB prosthesis, conducted at New York University in May 1967. Each clinic agreed to fit five subjects during the summer of 1967 with porous PTB prostheses fabricated by or directly under the supervision of the prosthetist attending the course.

The field study was designed to evaluate the AMBRL porous laminate used in the following respects:

1. Fabrication procedures.
2. Subjective reactions (comfort and cosmesis).
3. Medical considerations (stump hygiene and skin condition).
4. Durability and adjustments.

THE SAMPLE

The sample consisted of 20 subjects—11 males and nine females between four and 20 years of age. Five were from Atlanta, three from Birmingham, three from Durham, two from Memphis, and seven from New Orleans. There were seven right and ten left below-knee amputees, two bilateral amputees (one right below-knee and left Syme's; one bilateral below-knee), and one unspecified. Eleven of the amputations were congenital, ten acquired, and one unspecified. All subjects were experienced prosthesis wearers, the prior prosthesis having been worn for seven months to three years.

The types of prostheses worn by these subjects prior to the study are listed as follows:

PTB sockets	
With side joints and lacer, without liner	3
With supracondylar cuff, with liner	8
With supracondylar cuff, without liner	6
Syme's prosthesis	2
Other or unspecified	3
	22

METHODOLOGY

At least, five clinic visits by each amputee subject were required for the appropriate evaluations. An outline of the procedures follows.

FIRST VISIT (SCREENING AND PRESCRIPTION)

At the first visit, clinic personnel discussed the purpose of the study with patient and parents, indicating the type of data that would be requested. A porous laminate PTB prosthesis was to be prescribed at this time. For purposes of uniformity, all experimental limbs were to use supracondylar suspension. General biographical information was recorded, as well as subjective comments concerning the previously worn prosthesis.

SECOND VISIT (DELIVERY)

The porous laminate prosthesis was delivered at the second visit, and initial reactions of the subject and the clinic team were recorded. The prosthetist's report was initiated and retained by the prosthetist for submission at the termination of the study, as a means of

recording fabrication and maintenance problems.

THIRD VISIT (ONE MONTH POSTDELIVERY)

The child's stump was examined to ascertain if any dermatological changes had occurred which might be attributable to the porous socket. Subjective reactions to the experimental prosthesis and reactions of the subject to the prosthesis as compared with the previously worn prosthesis were recorded.

At this time the experimental prosthesis was rendered nonporous by the application of Saran Wrap, duplicating the procedure used in the preliminary evaluation at NYU. The prosthesis was then worn under these conditions for a two-week period of hot weather.

FOURTH VISIT (AFTER WEAR WITH SARAN WRAP)

The stump was examined for dermatological changes. Any differences reported by the subjects as a result of eliminating socket porosity were assessed. The Saran Wrap was then removed.

FIFTH VISIT (AFTER SIX WEEKS' WEAR OF THE POROUS PROSTHESIS WITHOUT SARAN WRAP)

Subjective and comparative reaction were once more elicited. The prosthetist's report was submitted.

FIELD STUDY RESULTS

During the NYU course of instruction in this technique, one prosthetist was adversely affected by the epoxy resin. The difficulty had been noted occasionally in earlier studies. The developer has recognized the potential hazard, and appropriate handling precautions must be carefully observed.³

³ Disposable gloves should be worn when handling all resins and solvents. Face shield or goggles are advisable when pouring or mixing the resins.

The epoxy resins (EPON 815) and curing agents (T-1) and, to a lesser extent, Versamid 140, are primary skin irritants. When in contact with the skin for a sufficient period of time, these materials are capable of producing a contact dermatitis in most individuals. In a relatively few hypersensitive workers, they can

FABRICATION PROCEDURES

Telephone contacts with the participating prosthetics facilities during the course of the field study indicated that, with one exception, the fabrication procedures posed no serious problems. One facility was unable to duplicate the procedures because of difficulties with equipment. (Adequate temperature control is mandatory for successful preparation; this facility's oven temperature could not be reliably maintained for precuring the layup material.) Prosthetists' fabrication reports were received from five of the participating clinics.

All reports indicated that two or three additional hours were required to fabricate a porous PTB prosthesis. Phases of the process cited as time-consuming were the weighing, processing, and curing; breakouts and re-assembly; finishing; and the preparation of the soft distal end.

No criticisms were made of the instructions contained in the manual. The process, however, was evidently more demanding than the conventional technique. Close attention to accuracy and detail is essential for successful preparation of the porous laminate.

produce an allergic type of dermatitis in a relatively short period of time.

Intermittent skin contact with these materials will not usually cause a dermatitis among normal workers; however, because of the occasional hypersensitive individual who cannot always be identified in advance, the precautionary measures suggested above should be used at all times.

In addition to the foregoing precautions, good general ventilation is highly recommended.

The first case of dermatitis usually indicates that proper handling procedures are not being observed, although in a very hypersensitive individual this is not necessarily true. The dermatitis should be treated promptly, and the source of contact should be ascertained and eliminated. The rash may be alleviated in most instances by soaking with warm Burow's Solution for 15-30 min., three or four times daily. Rashes that do not respond to treatment should be seen by a physician.

Based upon Handling Precautions for the Resin-Solvent System Used for Preparing Porous Laminates, an intramural memorandum issued by AMBRL in May 1967.

The increased fabrication time and effort, the need for some special materials, and the necessity for adequately ventilated work areas may result in some cost increases. One clinic expressed concern about the attitude of the local state agency in this respect, and one prosthetist suggested that the increased cost be borne in mind when the prescription is written.

REACTIONS OF SUBJECTS AND CLINIC PERSONNEL

The experimental limbs were generally considered superior to the previously worn prostheses in several respects. Initial reactions to the porous prostheses, elicited immediately after delivery, are shown in Tables 1 and 2. After a one-month period of wear, corresponding reactions of the subjects and the clinics were recorded; these results appear in Tables 3 and 4.

Examination of Tables 2 and 4 (comparative reactions) indicates few changes from the positive first impression as wear increased, with a trend toward more emphatic positive comments.

One month after delivery, the patient, his parents, and the clinic were asked their preference between the previously worn prosthesis and the experimental prosthesis. The results are shown in Table 5. In addition, the clinics were asked if they would prescribe a porous laminate prosthesis for other patients. Three clinics said "Yes," one said "No," and one said "Probably."

TABLE 1. REACTIONS OF PATIENTS AND CLINICS ON DELIVERY OF POROUS PROSTHESIS
(N = 22)

Rating	Patients' Reactions			Clinics' Overall Reaction
	Comfort	Weight	Appearance	
Very satisfactory	8	13	9	5
Satisfactory	14	9	10	13
Unsatisfactory	0	0	1	1*
Very unsatisfactory	0	0	1*	0
No response	0	0	1*	3

* Prosthesis not yet completed

After four weeks of wear, the prostheses were covered with Saran Wrap to eliminate the porosity of the sockets while leaving the prostheses intact. No change was made in fit, weight, alignment, or other factors that

TABLE 2. COMPARISON OF POROUS PROSTHESIS WITH PREVIOUSLY WORN PROSTHESIS
($N = 22$)

Rating	Patients' Reactions			Clinics' Overall Reaction
	Comfort	Weight	Appearance	
Better	9	13	9	7
Same	13	5	9	9
Worse	0	4	3	2
No response	0	0	1	4

TABLE 3. REACTIONS TO POROUS PROSTHESIS ONE MONTH POSTDELIVERY
($N = 22$)

Rating	Patients' Reactions				Clinics' Overall Reaction
	Comfort	Weight	Appearance	Heat	
Very satisfactory	9	12	8	3	7
Satisfactory	11	8	11	14	8
Unsatisfactory	1	0	0	1	2
Very unsatisfactory	0	0	0	1	0
No response	1	2	3	3	5

TABLE 4. COMPARISON OF PRESENT PROSTHESIS WITH PREVIOUSLY WORN PROSTHESIS
($N = 22$)

Rating	Patients' Reactions			
	Comfort	Weight	Appearance	Heat
Much better	12	14	8	10
Better	8	2	4	8
Same	0	5	5	3
Worse	0	0	3	0
Much worse	1*	0	0	0
No response	1	1	2	1

* Socket adjustments required

might affect reactions. The subjects were asked to wear the experimental limbs under these conditions for a two-week period of hot weather. Seventeen subjects reported data for this test period. The majority indicated that perceived heat within the socket increased and that perspiration became a problem (introducing dermatological problems and discomfort). Table 6 lists the reactions of the subjects regarding the test period utilizing the Saran Wrap.

Comparison of Table 6 with Table 2 shows a significant change in the perception of heat within the socket. Of those subjects offering opinions, 90 per cent considered the experimental prosthesis very satisfactory or satisfactory prior to the application of Saran Wrap, and 10 per cent considered it unsatisfactory. With the Saran Wrap, only 27 per cent reported the prosthesis satisfactory, and 73 per cent considered it unsatisfactory or very unsatisfactory—certainly a very dramatic reversal of reactions on the part of the wearers.

Since no changes were introduced in fit, weight, or alignment, it was not expected that perception of socket comfort would change significantly under the test conditions, except to the extent that comfort might be affected by heat in the socket. Prior to the test period 95 per cent reported satisfactory reactions to comfort, while 5 per cent considered the prosthesis unsatisfactory; with the use of Saran Wrap, 83 per cent considered the experimental limb satisfactory and 17 per cent unsatisfactory.

An uninterrupted six-week wear period followed the study of the effects of the Saran Wrap covering. At this time, subjects and clinic teams were asked to submit a non-comparative assessment of the experimental prosthesis and a separate questionnaire comparing the experimental prosthesis to the one worn before the field study. The results appear in Tables 7 and 8. These data were received regarding 17 experimental prostheses.

After a three-month period of wear, subjects and clinics were asked to indicate preferences as to the type of prosthesis to be worn in the future (Table 9). When clinics were asked if they would recommend the porous laminate prosthesis for other patients, three

TABLE 5. PREFERENCE FOR FUTURE USE BY PATIENTS, PARENTS, AND CLINICS

Respondent	Number Preferring Porous	Reasons for Preference	Number Times Mentioned	Number Preferring Prior	Reasons for Preference	Number Times Mentioned	No Response
Patients (N = 20)	16	Cooler	12	1	Durability	1	3
		Lighter	10				
		Appearance	3				
		Comfort	3				
		Better function	2				
		Soft end	2				
		Easier donning	1				
		Less irritation	1				
Parents (N = 20)	14	Child prefers	5	1	Porous hard to keep clean	1	5
		Lighter	4				
		Comfort	2				
		Cooler	2				
		Less perspiration	2				
		Alleviates skin problems	1				
		Function	1				
		Soft end	1				
Clinics (N = 5)	4	Alleviates dermatitis	4	1	Relief difficult Durability	1 1	0
		Lighter	4				
		Cooler	3				
		Function	1				
		Patient preference	1				

said "Yes," one said "No," and one said "Possibly."

MEDICAL CONSIDERATIONS

A definite decrease in stump hygiene difficulties was specifically reported for two subjects in the study, leading to a recommendation by one clinic that the porous laminate be considered in cases presenting dermatological problems. There were no instances of deterioration of stump condition that could be related to the porous laminate, although socket adjustments were required in some cases.

DURABILITY AND ADJUSTMENTS

Two clinic chiefs and their prosthetists expressed doubt that the porous laminate prosthesis would be sufficiently durable for patients who give their prostheses extremely heavy use. No such problems were encountered in an 18-month follow-up of the adult patients

TABLE 6. REACTIONS TO A TWO-WEEK PERIOD WITH SARAN WRAP
(N = 17)

Ratings	Patients' Reactions		Clinics' Overall Reaction
	Comfort	Heat	
Very satisfactory	6	0	3
Satisfactory	8	4	5
Unsatisfactory	1	3	2
Very unsatisfactory	2	8	3
No response	0	2	4

participating in the original NYU study of the epoxy porous prosthesis. The developer implies that adequate strength can be provided with this technique, even for heavy subjects, although only limited supporting data for this contention are available.

One prosthesis fitted with side joints and thigh corset, which compromised the requested supracondylar suspension, showed repeated

TABLE 7. REACTIONS TO POROUS PROSTHESIS
APPROXIMATELY THREE MONTHS POSTDELIVERY
(*N* = 17)

Rating	Patients' Reactions				Clinics' Overall Reaction
	Comfort	Weight	Appearance	Heat	
Very satisfactory	12	12	11	6	9
Satisfactory	4	5	5	8	4
Unsatisfactory	1	0	1	2	3
Very unsatisfactory	0	0	0	0	0
No response	0	0	0	1	1

TABLE 8. COMPARISON OF POROUS PROSTHESIS WITH
PREVIOUSLY WORN PROSTHESIS
(*N* = 17)

Rating	Patients' Reactions			
	Comfort	Weight	Appearance	Heat
Much better	10	12	8	10
Better	5	5	4	4
Same	1	0	3	3
Worse	0	0	1	0
Much worse	1*	0	1	0

* Socket adjustment required

breakdown. If side joints are to be provided, the porosity of a substantial socket area must be sacrificed in order to provide adequate strength. Consequently, porous lamination may not offer as significant an advantage for these patients. In view of this problem, reservation of the porous laminate procedure for the PTB-type of fitting without side joints may be indicated. This point merits further investigation.

One prosthesis was reported to have delaminated between the insert and the outer wall. However, it appears that this complaint referred to a failure of the bond between socket and shell and not to delamination *per se*. Two other prostheses showed marked wear during the period of study, although no functional problems were encountered.

Adjustments are more difficult to perform on the porous laminate socket, since it is

impossible to fill in an area without sacrificing porosity. It is also more difficult to relieve an area. Because the finished laminate is so much thinner than conventional products, reducing the area may render it too weak for normal use.

DISCUSSION

The high level of acceptance of the experimental prosthesis is supported by repeated references to three principal factors.

"Increased comfort" is a broad term which encompasses, both directly and indirectly, the decreased weight of the porous limbs compared to the previously worn prostheses, decreased perspiration (with concomitant dermatological improvement) and reduction of heat within the socket, and the added comfort of the soft distal end.

WEIGHT

To confirm the subjective impression of lighter weight, the weights of previously worn prostheses and experimental prostheses were compared. Table 10 indicates the percentage of weight reduction for the 14 prostheses where such data were available. It can be seen that the average reduction is approximately 25 per cent.

PERSPIRATION AND HEAT

Approximately one-third of the reasons cited for the preference of the porous laminate for future use related to the diminution of perspiration and the perception of the experimental limb as cooler. The results of the two-week test period (experimental socket covered with Saran Wrap) dramatically illustrate the importance of socket porosity in this regard.

SOFT DISTAL END

In their preliminary testing, both the developer and New York University found no serious problems occasioned by the change from an insert to a hard socket with soft distal end. The observation was borne out in the field study during which the incidental investigation of the soft distal end elicited several positive comments (one clinic, although

TABLE 9. PREFERENCES FOR FUTURE USE BY PATIENTS, PARENTS, AND CLINICS

Respondent	Number Preferring Porous	Reasons for Preference	Number Times Mentioned	Number Preferring Prior	Reasons for Preference	Number Times Mentioned	No Response
Patients	15	Lighter	8	1	Appearance	1	1
		Cooler	6				
		Comfort	3				
		Better function	2				
		Cosmesis	2				
		Better fit	1				
Parents	14	Better function	4	1	—	—	2
		Lighter	4				
		Cooler	2				
		Child's preference	1				
		Comfort	1				
		Cosmesis	1				
		No odor	1				
		Less skin problems	1				
Clinics	2	Lighter	5	3	Durability	3*	0
		Cooler	4		Experimental sockets	2	
		Better function	3		not adequately porous		
		Patient preference	2		Cosmesis	1	
		Comfort	2		Cost	1	
		Appearance	1		Porous harder to fit or modify	1	
		Reduction in skin problems	1				

* Despite preference for porous laminate in one case

TABLE 10. PERCENTAGE OF WEIGHT REDUCTION
(N = 14)

Weight of Prior Prosthesis (in pounds and ounces)	Weight of Porous Prosthesis (in pounds and ounces)	Percentage of Reduction
3 - 8	2 - 5	53
4 - 8	2 - 8	44
5	5	0
4 - 8	3 - 8	22
1 - 8	1 - 4	17
5 - 8	3	30
4	4 - 14	0
5	3	40
3 - 4	2 - 6	27
3 - 12	2 - 5	38
1 - 4	1 - 4	0
1 - 2	1 - 2	0
5 - 4	3	43
5 - 4	3 - 8	33

recommending a standard laminate in the future fitting of a patient to provide greater durability, would recommend that the new prosthesis incorporate the soft distal end procedure).

AMPUTEE AND CLINIC REACTIONS

Patients and their parents were almost unanimous in their acceptance of the porous prosthesis (nearly 95 per cent of the patients and their parents preferred the experimental technique), whereas the clinics exhibited much less enthusiasm. At the close of the study, only two of the five clinics would definitely prefer the porous laminate for future use. It is important to note that the two clinics which recommended the porous laminate for future use accounted for the fitting of 11 of the 17 subjects who completed this phase of the

study. Reluctance to prescribe the porous laminate resulted in extremely limited samples from the three clinics who preferred the standard technique.

Two of the clinics rejecting the porous laminate for the future use of the patients fitted in the study might, however, recommend the porous prosthesis for *other* patients. Therefore, only one clinic categorically rejected the experimental prosthesis.

Several suggestions may be advanced to help resolve this apparent discrepancy of opinion. During the study, as early as one month postdelivery, four reports were received which indicated dissatisfaction with the appearance of the experimental limbs. The poor appearance was specifically related to difficulties in keeping the comparatively rough surface clean. It was noted that the porous prostheses tended to appear dirty after only a short period of use, with one experimental prosthesis being rejected for this reason. Interrogation of adult patients involved in the preliminary laboratory study showed that the prostheses are in fact difficult to clean and that they gather varying amounts of dirt, but none of the patients spontaneously complained of this problem. It might be expected that children would be less sensitive to this problem than adults.

A further explanation for the clinics' less emphatic endorsement may lie in the increased cost factors (due to two to three hours' increase in fabrication time and materials), the need for some specialized equipment, and the occasional allergenic reactions of shop personnel to the uncured resin-solvent system. Therefore, the prosthetists' reluctance to utilize the technique may have been transmitted to the clinics.

SUMMARY

The AMBRL porous laminate technique as applied to the PTB prosthesis was evaluated over a three-month period on 20 children at five juvenile amputee clinics in the southern section of the country. Essential aspects investigated were the fabrication process, subjective reactions, medical considerations, adjustments, and durability.

The data indicated that porous laminate PTB prostheses were generally well accepted by patients and parents but less so by clinic personnel. The developer's claims of reduced perspiration, added comfort, decreased dermatological problems, and lighter weight were generally corroborated; weight reduction was the most consistently reported advantage.

Increased fabrication time and some increase in the complexity of the fabrication process were cited as problems. Cosmetic characteristics elicited both favorable and unfavorable remarks; the propensity of the porous laminate to collect and trap dirt particles caused some dissatisfaction, while the textured appearance of the porous laminate was preferred in some instances.

Concern was expressed regarding the durability of the porous laminate, particularly when applied to a prosthesis which was subjected to arduous use, although the experimental evidence was apparently insufficient for such concern.

Based upon patients' and parents' preference for the experimental limbs, including instances of improvement in stump condition, it appears that the porous laminate PTB is a significant and worthwhile addition to prosthetics technology. Other applications of the porous laminate may also be recommended, particularly for those patients with substantial body areas enclosed within a socket, with severe perspiration problems, or where a lightweight prosthesis is indicated. Shoulder caps, transthoracic sockets, above- and below-elbow sockets, or hip-disarticulation and hemipelvectomy applications may be considered. Informal observations of several upper-extremity fittings have again indicated that the porous laminate offers distinct advantages in terms of decreased perspiration and weight.

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Physical Properties of Silicone Rubber

JOHN W. HODGE, JR., B.S.M.E.,² AND
MARY H. YEAKEL, O.T.³

ROOM-TEMPERATURE-VULCANIZING (RTV) silicone rubber is a versatile material and easy to handle. The ingredients from which it is formed are thick liquids that vulcanize at room temperature within a short period of time after the catalyst is added. Depending upon the relative amounts of solid and foam ingredients, the consistency of the resultant rubber may range from a hard solid to a soft foam.

Increasingly numerous applications of silicone rubber are being made in prosthetics and orthotics; for example, in fabricating distal pads for above-knee and below-knee sockets, shoe fillers for certain types of foot amputations, finger pads for prosthetic hands, and pads for braces. The material has been used successfully in medical implants. It is also useful as an exercising medium for strengthening the hand grasp, because a wide range of compressive forces can be obtained by varying the consistency of the foam rubber.

An evaluation of the physical properties of silicone rubber made with varying proportions of ingredients was conducted at the U.S. Army Medical Biomechanical Research Laboratory. The results should enable users of this material to prepare foam specimens with predetermined characteristics to meet particular requirements. During this evaluation, samples were prepared and tested for density, compressive forces, and tear resistance. The material considered was a com-

position of RTV 385 solid elastomer, RTV 386 foam elastomer, and catalyst 386.⁴

EXPERIMENTAL PROCEDURES

Table 1 shows the sample formulations evaluated, the foam density of the samples, and the compression test and tear test results of the samples.

Each sample formulation is based on a 100-gram total of the elastomers plus six grams of the catalyst. The elastomers are combinations of the solid and foam components according to the weights shown in Table 1, except for the extremes (Samples 1 and 11), which are composed entirely of one or the other of the elastomers.

The samples were prepared in such manner that essentially a free rise was obtained. The dimensions were 1 3/16 in. X 1 3/16 in. X 3 3/16 in. for the samples on which density and compression observations were made. Tear test samples were 6 in. X 1 in. X 1 in.

Foam density was determined by dividing the weight of each specimen by the volume of the specimen.

Compression tests were conducted on a table model Instron Testing Machine (Fig. 1). Compressive forces were observed at 15 and 50 per cent deformation and reported as pressure in pounds per square inch (psi).

Tear tests were conducted in accordance with ASTM Method D1564-64T.⁵ The test rate was 2 in. per min.

The maximum density was found to be approximately 68 lb. per cu. ft. Figure 2 shows that density increases at a higher rate when the specimen composition is more than 50 per

¹ Based upon Technical Report 6802, Project 3A014501 B71P 06 045, *Physical Properties of Silicone Foam (RTV 385/RTV 386)*, U.S. Army Medical Biomechanical Research Laboratory, Walter Reed Army Medical Center, Washington, D.C. 20012, February 1968.

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⁴ Material supplied by Dow Corning Corp., Midland, Mich. 48641.

⁵ *Standards on Rubbers*, Part 28, American Society for Testing and Materials, April 1967.

TABLE 1. FORMULATIONS, FOAM DENSITY, COMPRESSION TEST RESULTS, AND TEAR TEST RESULTS

Sample No.	Formulation RTV 385 (grams)* RTV 386		Density (lb. per cu. ft.)	Pressure at 15 Per Cent Deformation (psi)	Pressure at 50 Per Cent Deformation (psi)	Tear Resistance (pi)
1	0	100	7.6	0.40	1.28	0.4
2	10	90	9.0	0.51	1.53	
3	20	80	10.0	0.61	1.66	
4	30	70	11.4	0.84	2.42	
5	40	60	13.4	1.02	3.11	0.7
6	50	50	15.5	1.28	4.21	
7	60	40	18.6	2.04	6.63	
8	70	30	22.8	3.31	11.48	
9	80	20	29.6	5.61	28.06	1.5
10	90	10	39.6	12.76	51.00	
11	100	0	68.3	42.86	Beyond instrument range	2.0

* To the 100-gram total of elastomers, 6 grams of catalyst was added for each formulation



Fig. 1. Using a table model Instron Testing Machine to test a sample formulation. The forces can be read on the graph.

cent RTV 385. Density ranged from 7.6 lb. per cu. ft. for a sample containing 100 per cent RTV 386 to 68.3 lb. per cu. ft. for a sample containing 100 per cent RTV 385.

Table 1 presents compressive forces at both 15 per cent and 50 per cent deformation of the foam specimens. At 15 per cent deformation, the compressive force was found

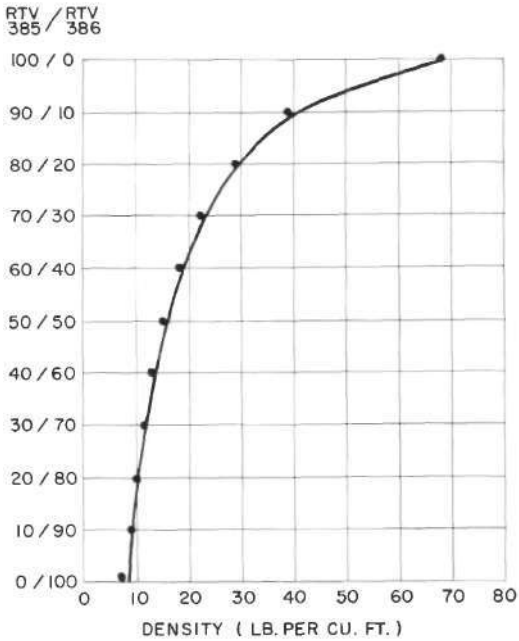


Fig. 2. Foam density. The density increases at a higher rate when the formulation contains more than 50 per cent RTV 385.

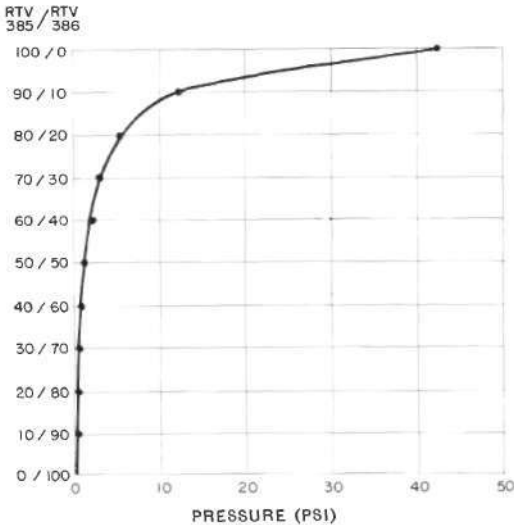


Fig. 3. Pressure at 15 per cent deformation. The more pronounced changes occur in samples containing more than 50 per cent RTV 385.

to be 0.4 psi on a specimen containing no RTV 385, while on a sample comprised 100 per cent of RTV 385 the compressive force increased a hundredfold to 42.86 psi. The

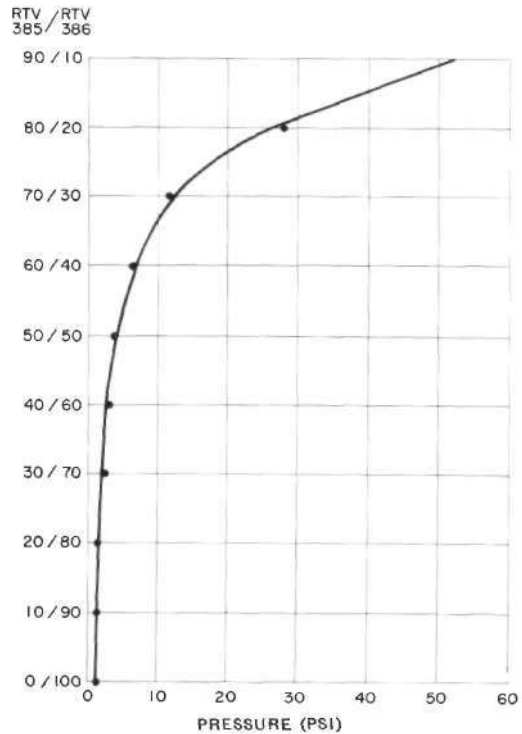


Fig. 4. Pressure at 50 per cent deformation. The test sample containing 100 parts RTV 385 exceeded the instrument load range.

graphical representations of these changes in Figure 3 and in Figure 4 show that samples containing more than 50 per cent RTV 385 exhibited more pronounced changes in compressive forces at both 15 per cent and 50 per cent deformations. In determining compressive force at 50 per cent deformation, it was found that a sample containing 90 parts RTV 385 and 10 parts RTV 386 gave results of 51 psi. The test sample containing 100 parts RTV 385 exceeded the instrument load range. However, if one assumes that the behavior of the material would follow a pattern similar to that at 15 per cent deformation, one could expect the compressive forces to exceed 128 psi; that is, 100 times the compressive forces on the test sample containing no RTV 385.

The tear resistance of this material (Fig. 5) was found to be very low. The maximum tear resistance was found to be 2 lb. per in. for a sample composed 100 per cent of RTV 385. A sample composed 100 per cent of RTV 386

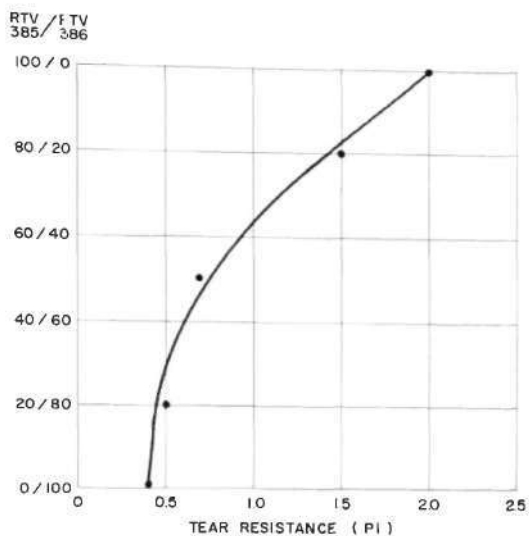


Fig. 5. Foam tear resistance. Tests for tear resistance were performed on Samples 1, 3, 6, 9, and 11.

showed a tear resistance of 0.4 lb. per in. Tear tests were performed on Samples 1, 3, 6, 9, and 11 only.

SUMMARY AND CONCLUSIONS

Observations were made of a number of the physical properties of silicone rubber pre-

pared from RTV 385 and RTV 386 with an appropriate amount of catalyst. The properties specifically considered were density, compressive forces, and tear resistance. These properties were considered because they can be changed by varying the proportions of the components in the formulations.

The results obtained show comparable changes and their magnitudes. These results may be used to choose a formulation which will give predetermined density and compressive-force results. Analysis of the results shows that the more significant changes in the physical properties occur when an amount greater than 50 per cent of RTV 385 is used in the formulation. It follows that fairly precise consideration must be given to weighing out quantities of RTV 385 for higher compressive forces, particularly in the region of 80 to 100 parts of RTV 385. Slight changes in the proportions of the components in this region produce very large changes in compressive forces.

The tear resistance of this material was found to be very low. This was to be expected, because foam materials in general offer little resistance to tension or tear.

News and Notes

Prosthetics-Orthotics Education

University of California, Los Angeles

In existence since July 1952, the UCLA Prosthetics-Orthotics Program has as its primary purpose the education of physicians, surgeons, physical therapists, occupational therapists, rehabilitation personnel, prosthetists, and orthotists in the fields of prosthetics and orthotics. Academically and administratively, the Prosthetics-Orthotics Program is a special project in the Department of Surgery, Division of Orthopaedic Surgery, UCLA School of Medicine. The instruction is presented largely through intensive short-term courses sponsored by University Extension.

All courses are presented in the new UCLA Institute for Chronic Disease and Rehabilitation, where ample space and equipment have been provided by UCLA. The teaching fac-

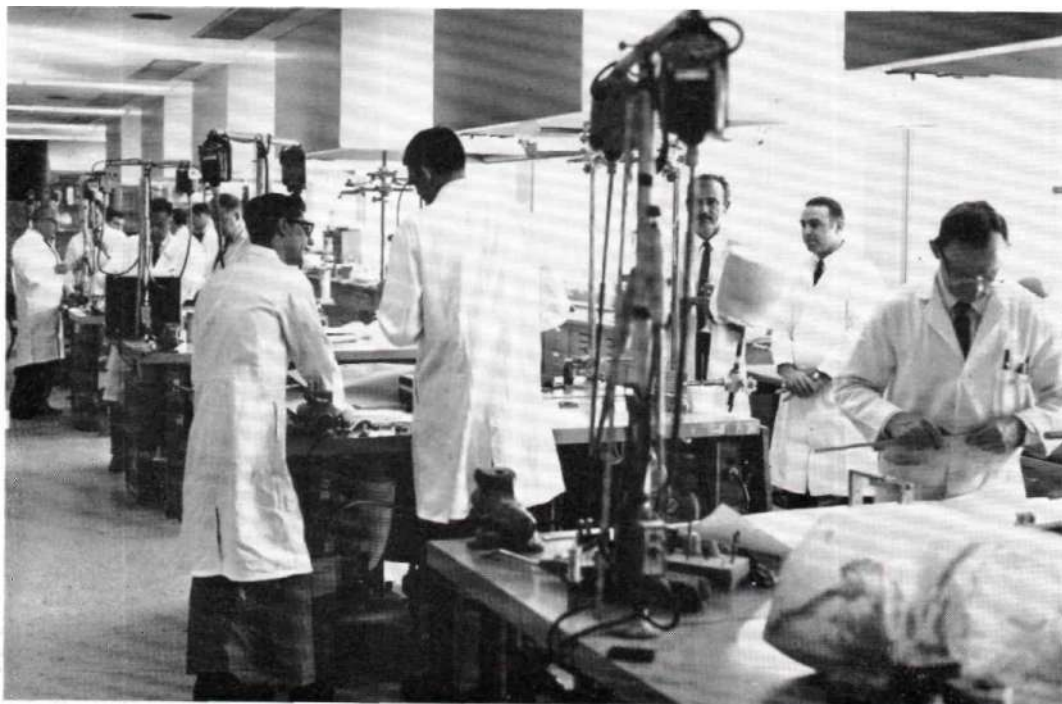
ulty includes individuals from several community hospitals and the Veterans Administration Hospital, representatives from the California State Vocational Rehabilitation Service, and members of the UCLA faculty.

Enrollments during the 1966-1967 and 1967-1968 academic years have been as follows:

	1966-1967	1967-1968
Orthopaedists (practicing)	32	33
Physiatrists (practicing)	6	7
Orthopaedists (residents)	97	102
Physical medicine (residents)	18	19
Other physicians	13	1
Physical therapists	52	60
Occupational therapists	14	20
Correctional therapists	3	1
Other therapists	2	0
Rehabilitation counselors	112	132
Insurance company representatives	5	3
Prosthetists and orthotists	84	92*
Totals	438	470

* Includes eight students enrolled in the two-semester certificate program.

The schedule of courses to be offered during the 1968-1969 academic year follows. Addi-



Members of the 1967-1968 UCLA Certificate Program in Prosthetics and Orthotics fabricate hip-disarticulation prostheses under the direction of the instructional staff.



Participants in the 1967-1968 UCLA Certificate Program in Prosthetics and Orthotics. Left to right: John Bray, chief instructor; Otis Pryor, laboratory technician; Richard Clark, student; Cherrill E. Crowe, student; Frederick P. Thranhardt, student; Fred Sanders, laboratory mechanic; Richard T. Voner, student; Robert W. Bakhvin, student; Keith Vinnecour, instructor; James S. Young, student; Bradd L. Rosenquist, student; John R. McHenry, student; Charles Scott, research prosthetist-orthotist.

tional information and application forms can be obtained by writing to Bernard R. Strohm, Director, Prosthetics-Orthotics Program, The Rehabilitation Center, University of California, Los Angeles, Calif. 90024.

Prosthetists

Upper-Extremity Prosthetics—Sept. 3-Oct. 4.
Below-Knee Prosthetics—Oct. 23-Nov. 27.
Above-Knee Prosthetics—Jan. 6-Feb. 7.
Hip-Disarticulation and Syme's Prosthetics—Mar. 3-21.

Orthotists

Lower-Extremity Orthotics—Apr. 28-May 23.
Upper-Extremity Orthotics—June 2-13.

Prosthetists and Physicians

Immediate Postsurgical Prosthetics Fitting—Dec. 16-18; Mar. 24-26.

Prosthetists, Therapists, and Physicians

Child Amputee Prosthetics—Apr. 14-18.

Therapists

Prosthetics Orthotics—Oct. 7-18; Dec. 2-13; Feb. 17-28; Mar. 31-Apr. 11; May 19-29.

Physicians

Prosthetics-Orthotics—Oct. 7-18; Dec. 2-13; Feb. 17-28; Mar. 31-Apr. 11; May 19-29.

Rehabilitation Personnel

Prosthetics-Orthotics Rehabilitation—Nov. 11-13; Jan. 6-8; June 16-18.

Brief descriptions of major research activities under way at UCLA follow.

Feasibility Study of Application of Pneumatic Structures to Orthotics. This is an investigation to determine the feasibility of using various types of inflatable structures as splints, braces, and body supports in orthopaedic management. Dr. Charles Bechtol and Charles Scott are the investigators.

Upper-Extremity Prosthetics Research. This is a study of the state of the art and an evaluation of current or proposed techniques, procedures, and devices to culminate in the publication of a manual.

Endoskeletal Upper-Extremity Prosthesis Feasibility Study. An endoskeletal artificial arm,



Patient evaluation during the course in lower-extremity prosthetics at UCLA.

if feasible, would have interior rigid structure and controls with a soft covering and skin corresponding to the bone, muscle, soft tissue, and skin of the human arm. It is anticipated that such a device would possess greatly improved appearance and feel.

UCLA Functional Long Leg Brace. Clinical research continues with this brace in the general areas of fitting, alignment, and gait training.

There have been some recent faculty and staff changes. Bernard R. Strohm has been appointed Director of the UCLA Prosthetics-Orthotics Program, effective July 1, 1968. Mr. Strohm has been an instructor in the Prosthetics-Orthotics Program at UCLA since 1959 and is a physical therapist by training. He is presently an administrator in the hospital and clinics organization at UCLA. Dr. Miles H. Anderson, the former Director of the UCLA Prosthetics-Orthotics Program, resigned on January 1, 1968, to accept a position with the School of Education, U~CLA. Bradd L. Rosenquist has been appointed to the instructional staff to replace Maurice LeBlanc, who is now engaged full time on the feasibility study on endoskeletal prostheses. Mr. Rosenquist has a B.S. degree in zoology and has spent one year at Rancho Los Amigos Hospital and one year in the certification program at UCLA.

New York University

During the 1967-1968 academic year, New York University's Prosthetics and Orthotics postgraduate education program registered an increase of 24 per cent in student enrollment over the previous year and an increase of 600 per cent since the program's inception,

12 years ago. During the program's first semester in the spring of 1956, six sections of courses in above-knee and upper-extremity prosthetics were offered to 152 physicians and surgeons, therapists, and prosthetists. During the 1967-1968 academic year, more than 900 students, who now include orthotists and rehabilitation counselors, attended 35 sections of 14 different courses. The student enrollment during 1967-1968 was:

Physicians and surgeons	423
Prosthetists	108
Therapists	236
Orthotists	23
Rehabilitation counselors	129

Total 919

Several new courses have been added to the postgraduate curriculum. As the culmination of more than two years of painstaking preparation, *Spinal Orthotics for Orthotists* was offered for the first time during 1967-1968. The extended period of curriculum development was required because of the lack of any logical, standardized approach to the field of spinal bracing. This lack extended from the matter of nomenclature through such areas as measurement, tracing and fitting of appliances, and even to the functions of spinal braces.



Instructor evaluates fitting of hyperextension brace during the course in spinal orthotics at NYU.

A course offering was therefore not possible until a coherent system, including both the theory and practice of spinal bracing, could be developed and evaluated.

In its final form, the two-week, full-time course included instruction in anatomy, biomechanics, orthotic components, measurement, tracing and fitting procedures, fabrication techniques, corsetry, and the medical aspects of orthotics management. Considerable time was spent in laboratory sessions, during which the students engaged in supervised practice in applying procedures which had been demonstrated.

The response of both observers and students to this first effort in a new area was most gratifying. Considerable enthusiasm was expressed both for the specific methods being taught and for the introduction of a logical approach into this previously unstructured field.

Immediate and Early Postsurgical Prosthetics for Physicians and Surgeons was also inaugurated this year. This three-day, full-time course included the rationale of immediate and early prosthetics fitting procedures, the application of rigid dressings, immediate postsurgical and preparatory prostheses for lower-extremity amputations, as well as recent developments in surgical techniques. Laboratory practice in wrapping rigid dressings and preparing immediate postsurgical prostheses was provided the students. Another course introduced in 1967-1968 was *Immediate and Early Postsurgical Prosthetics for Prosthetists*. This six-day, full-time course is twice the length of the prior one in *Early Fitting Techniques* which was offered last year. The increased time permitted the inclusion of lectures and laboratory experience in the application of immediate postsurgical prostheses, in addition to the previously taught preparatory prostheses.

The process of integrating instruction on immediate and early fitting procedures into *Lower-Extremity Prosthetics for Physicians and Surgeons* and *Lower-Extremity Prosthetics for Therapists* was also completed during the current year. Both courses now include lectures and demonstrations on both immediate and early fitting procedures. In the course for physicians and surgeons, two optional

evening laboratory sessions were provided for those students who wished to obtain supervised experience in applying rigid dressings for both below-knee and above-knee amputations. Information on immediate and early fitting procedures was also included in *Prosthetics and Orthotics for Rehabilitation Counselors*.

An extra session of *Lower-Extremity Prosthetics for Therapists* was offered in June 1968 because of oversubscription for the four scheduled sections.

A highlight of the 1968-1969 curriculum will be a course in *Spinal Orthotics for Physicians and Surgeons*, which will be offered for the first time. Although this course will be related to *Spinal Orthotics for Orthotists*, there will be substantial differences in content and emphasis. Less detailed information will be provided on fabrication procedures and more on fitting principles, prescription criteria, and the interrelationships between orthotics management and other forms of treatment. The new course is expected to require three days of full-time intensive instruction. A pilot offering will be given in the fall of 1968 and will be followed by two regularly scheduled sections, one in the fall semester and another in the spring.

The schedule of courses to be offered during 1968-1969 follows. Additional information and application forms can be obtained by writing to Sidney Fishman, Ph.D., Prosthetics and Orthotics, NYU Post-Graduate Medical School, 317 East 34th St., New York, N.Y. 10016.

Prosthetists

Below-Knee Prosthetics—Sept. 3-20.

Immediate and Early Postsurgical Prosthetics—Jan. 6-11; Mar. 31-Apr. 5.

Above-Knee Prosthetics—May 26-June 13.

Upper-Extremity Prosthetics—July 7-18.

Orthotists

Spinal Orthotics—Jan. 20-31.

Lower-Extremity Orthotics—June 16-27.

Physicians and Surgeons

Lower-Extremity Prosthetics—Oct. 7-12; Nov. 11-16; Feb. 3-8; May 12-17.

Immediate and Early Postsurgical Prosthetics—Jan. 6-8; Mar. 31-Apr. 2.

Lower-Extremity Orthotics—Oct. 14-18; Mar. 3-7; Apr. 14-18.

Upper-Extremity Prosthetics and Orthotics—Dec. 9-13; Mar. 24-28.

Spinal Orthotics—Nov. 25-27; Apr. 24-26.

Therapists

Lower-Extremity Prosthetics—Sept. 9-20; Oct. 21-Nov. 1; Feb. 10-21; Apr. 28-May 9.

Lower-Extremity Orthotics—Oct. 14-18; Mar. 3-7; Apr. 14-18.

Upper-Extremity Prosthetics and Orthotics—Dec. 2-13; Mar. 17-28.

Rehabilitation Counselors

Prosthetics and Orthotics—Oct. 28-Nov. 1; Feb. 17-21; May 5-9.

With the award of Bachelor of Science degrees to five students in 1968, New York University has now graduated 15 students from its four-year undergraduate program in Prosthetics and Orthotics. This year's graduates are George Hall, of Syracuse, N.Y.; Eugene Silver, of Leonia, N.J.; John Eschen, of Eastchester, N.Y.; Arthur Yellin, of Philadelphia, Pa.; and John M. Snowden, of Seattle, Wash. Instituted in 1964, the curriculum was designed to meet the pressing need for professionally trained personnel to provide leadership in the clinical, research, and teaching aspects of prosthetics and orthotics. The many job offers received by the present graduating class attest to the urgency of the need the program is meeting.

Several changes will be instituted in the 1968-1969 academic year. For the first time, all of the specialized courses will be offered on a yearly rather than an alternate-yearly basis, as in the past. This change is being made in anticipation of increased student enrollment, in order to eliminate the programing difficulties resulting from the alternating year schedule.

As a result of the impending move of the prosthetics-orthotics shop laboratories by September 1968 to the 11th floor of 317 East 34th St., the number of students who can be accommodated in each class will increase from 14 to 18. In addition, the move will provide the further advantage of making the undergraduate training contiguous to that of the physicians, surgeons, therapists, and counselors attending related courses. The resulting interaction, both formal and infor-

mal, should have distinct educational advantages.

In order to offer the required 55 credits of specialized prosthetics and orthotics instruction, two full-time prosthetist-orthotist instructors will serve on the faculty, supported by four part-time prosthetist-orthotists, one engineer, one specialist in biomechanics, and one psychologist.

Following are the course requirements for the four-year undergraduate curriculum:

Points

Liberal Arts

Social Science

Government and Politics
History of Western Civilization
Introduction to Psychology
Man and Society

15

Science and Mathematics

Man in Biological World
Algebra and Trigonometry
Nature of Matter

12

Humanities

Literary Heritage
Philosophical Analysis
Elements and Literature of Music
Painting in the Western World

3

3

3

15

English Composition

English Composition

6 6

Speech

Fundamentals of Speech

4 4

Electives

Introduction to Modern Chemistry
Development of Physics

4

4

8

60

Professional Education

Sociology of Education
Developmental Psychology

Specialization

Anatomy of Physiology I, II
General Metalworking
Prosthetic and Orthotic Techniques
Survey of Physical Defects
Biomechanics
Mechanics

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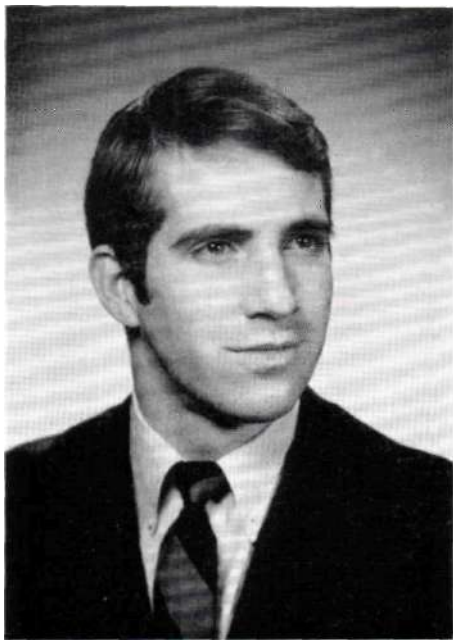
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Properties of Materials	
Above-Knee Prosthetics	
Below-Knee Prosthetics	6
Lower-Extremity Orthotics	6
Upper-Extremity Prosthetics	5
Upper-Extremity Orthotics	3
Spinal Orthotics	5
Professional Problems in Prosthetics and Orthotics	2
Clinical Affiliation—Prosthetics and Orthotics	4
Mechanical Drawing	2
	68
<i>Free Electives</i>	0 0
Total	132

In the case of some of the foregoing liberal arts courses, substitutions may be made in the same general subject areas.

In June 1968 the first presentation was made of the J. E. Hanger Award, which is to be awarded annually to the outstanding graduate of the four-year undergraduate curriculum. John Snowden, of Seattle, Wash., was the first recipient of the \$300 award, in recognition of his superior academic and technical performance. The award is being offered by J. E. Hanger, Inc., nationally prominent pros-



John Snowden, recipient of first J. E. Hanger Award at New York University.

thetics-orthotics facilities, in honor of the organization's founder, J. E. Hanger, who pioneered in the development of improved prosthetics techniques in the United States after he lost a leg during the Civil War. Its purpose is to accord recognition to the growing professional status of the practice of prosthetics and orthotics, which has developed from the efforts of New York University and other educational institutions. Following graduation, Mr. Snowden will join the firm of Lundberg's, Inc., in Seattle, as a prosthetist.

At the invitation of the Centro de Medicina de Reabilitacao in Lisbon, Portugal, NYU Prosthetics and Orthotics will offer a one-month course in above-knee prosthetics for prosthetists in Lisbon during July 1968. Four NYU faculty members (Dr. Fishman, Norman Berger, Ivan Dillee, and Clauson England) will organize and conduct the course. This will be the first formal instruction in prosthetics ever offered in Portugal.

During the past year, the NYU Prosthetics and Orthotics faculty assisted in the planning and setting up of a prosthetics-orthotics shop on board the hospital ship *Hope*, where none had previously existed. NYU provided prosthetists-orthotists on a rotation basis to staff the shop during its ten-month stay in Cartagena, Colombia. Ivan Dillee and George Hartmann, of the full-time faculty, and Charles Rosenquist and Carlton Fillauer, of the part-time faculty, each gave a month or more of service aboard ship. Sidney Fishman, Ph.D., Coordinator of Prosthetics and Orthotics, also visited the *Hope* to plan for the establishment of a permanent prosthetics-orthotics shop at the Santa Clara Hospital in Cartagena. At present, no prosthetics-orthotics facilities exist in this entire area of Colombia.

Under the sponsorship of the Social and Rehabilitation Service of the Department of Health, Education, and Welfare, Dr. Fishman spent 10 days in Yugoslavia during October 1967 inaugurating an evaluation program for the Belgrade Multifunctional Artificial Hand at the Serbian Institute of Prosthetics.

NYU Prosthetics and Orthotics is pleased to announce two recent staff appointments. In January 1968 Clifton Mereday, B.S., R.P.T., became a full-time staff member as



Clifton Mereday, B.S., R.P.T., new faculty member, Prosthetics and Orthotics, New York University.

an instructor and assistant research scientist. A member of the American Physical Therapy Association, Mr. Mereday was formerly Director of Physical Therapy for the Suffolk County Department of Health.

Mr. Clyde M. E. Dolan, B.A., M.S., has joined the staff as an assistant research scientist. Mr. Dolan formerly served as Administrative Officer of the U.S. Army Medical Biomechanical Research Laboratory. He is currently responsible for the clinical application phases of the research program, and serves as an instructor in prosthetics and orthotics.

During the 1967-1968 academic year, the courses for physicians and surgeons, therapists, and rehabilitation counselors were conducted in new classroom facilities at 317 East 34th St. The move provided the opportunity to plan the classrooms in accordance with the specific requirements of the various prosthetics and orthotics courses given. A central projection booth serves both classrooms, and the projection equipment can be operated by remote control by instructors in both rooms

simultaneously, without the need for an operator. A major advantage of the new facilities is the increase in the number of students who can be accommodated. The new teaching area also permits better control and supervision of students when they are divided into small groups for laboratory sessions.

To accomplish the same goals for prosthetist and orthotist students, the shop, classroom, and patient facilities, which have been located at 342 East 26th St., will be moved during the summer of 1968. The University has leased approximately 3,000 sq. ft. remaining on the 11th floor of the new quarters, and this area will be used for the new prosthetist-orthotist training facility. In addition to the benefits to be derived from consolidating all teaching facilities in a single area, the number of benches in the shop will be increased from 14 to 18, permitting a substantial (29 per cent) increase in prosthetist and orthotist enrollment.

Northwestern University

The reorganization of various research, evaluation, and educational programs in prosthetics and orthotics in the Northwestern University Medical School resulted in the establishment of the NU Prosthetic-Orthotic



Clyde M. E. Dolan, B.A., M.S., new assistant research scientist, Prosthetics and Orthotics, New York University.

Center on April 1, 1968. The overall objective was to achieve better coordination, administration, and direction.

The specific objectives of the Center are:

1. To transmit research findings more rapidly into instruction.
2. To involve the faculty in clinics for research, evaluation, and consultation.
3. To substantiate current instruction through research.
4. To establish effective liaison and mutual projects with the NU Medical Center, the NU Biomedical Engineering Center, the Rehabilitation Institute of Chicago, Case Western Reserve University, and national research, evaluation, and educational organizations.

The academic year 1967-1968 marked the ninth year of classes in prosthetics and orthotics offered at Northwestern University. A brief summary of the offerings, together with future plans, follows.

Lower-Extremity Prosthetics for Physicians and Therapists. Again, the 1967-1968 academic year showed a marked increase in attendance. Nine sections of this course will be offered during the 1968-1969 academic year to meet the increased demands. Several sections will be offered consecutively to allow students to take both a lower- and an upper-extremity course during a given two-week period instead of having to return to complete the cycle. In an effort to provide better programming for the lower-extremity instruction, a film was produced to assist in the presentation of children's cases during the course.

Upper-Extremity Prosthetics for Physicians and Therapists. The results of reducing this course from five to four days have been found to be satisfactory. During the 1967-1968 academic year, only four sections were offered.

Management of the Juvenile Amputee for Physicians, Therapists, and Prosthetists. Two sections of this four-day course were presented during the 1967-1968 academic year, and two are scheduled for 1968-1969. Fifty-five spaces have been requested by residency programs for 1968-1969. Reviews of the course continue to be favorable because of the superior quality of the instruction and the teaching-patient presentations.

Orthotics for Physicians, Surgeons, and Therapists. Three sections of this five-day course were offered during the 1967-1968

academic year as a result of increased demand during the 1966-1967 academic year, by both physicians and therapists.

Residency Training in Prosthetics and Orthotics. Eighty-five physicians-in-charge of residency training programs in orthopaedic surgery and physical medicine are coordinating the training of their residents in prosthetics and orthotics with Northwestern University, representing an increase of seven programs over the 1966-1967 academic year. During 1963-1964, 160 residents were trained; during 1964-1965, 357; during 1965-1966, 323; during 1966-1967, 376; and during 1967-1968, 415 are expected to be trained. Physicians-in-charge of residency training programs have requested 553 spaces for residents during the 1968-1969 academic year.

Immediate Postsurgical Prosthetics Fitting. Five regularly scheduled sections on immediate postsurgical prosthetics fitting procedures were offered during 1967-1968. In addition, there was a special section for prosthetics students in the Associate-in-Arts degree program. The total number of students trained



Richard Bidwell, C.P.O., teaching during a recent course in immediate postsurgical prosthetics fitting procedures at Northwestern University.

was 143, of whom 82 were prosthetists and 61 were physicians. Class size is limited to 27 students, who are formed into nine teams. Each team has at least one orthopaedist and one prosthetist. The course has received a superior evaluation.

Associate-in-Arts Degree Program in Prosthetics. Planning for the Associate-in-Arts degree program in prosthetics began in 1963, and it was the first program in which a university medical school cooperated with a community college in offering a two-year degree. The current enrollment is 30 prosthetics students. Six students have received their degrees in prosthetics, and 10 are expected to graduate in June 1968. All the graduates have been placed in private facilities, and all members of the 1968 graduating class have prospects for employment. An evaluation and follow-up study on graduates is in progress. Reports show that a graduate of this program possesses the requisite knowledge and skill to perform satisfactorily as a prosthetist, with some supervision.

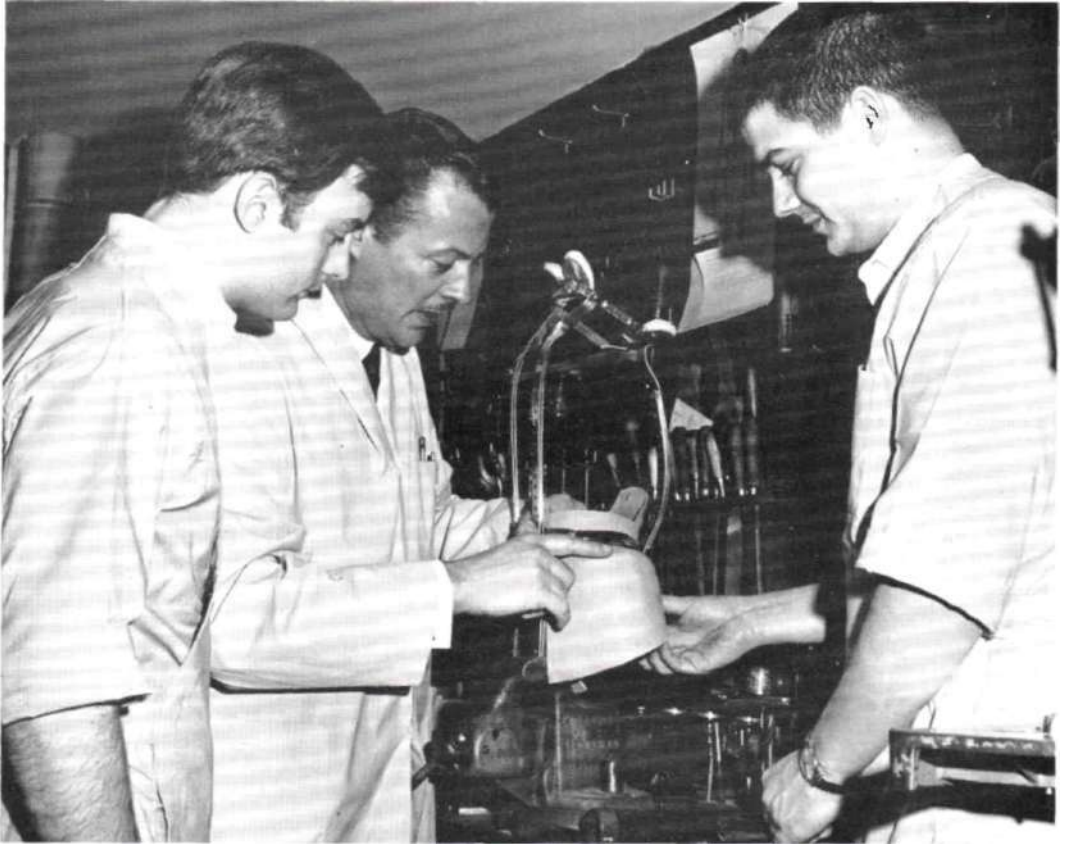
Continuing Education Courses for Prosthetists. Since 1963, there has been a decline in the demand for courses in below-knee, above-knee, and upper-extremity prosthetics, and special prosthetics courses for practicing prosthetists. Whenever there has been sufficient demand, courses have been offered in below- and above-knee prosthetics. One each was scheduled for the 1967-1968 academic year. The University Council on Orthotic-Prosthetic Education coordinates these course offerings nationally. It is believed that, in the future, the demand for continuing education courses for practicing prosthetists will be in advanced techniques and new developments. For example, practicing prosthetists have shown considerable interest in the immediate postsurgical prosthetics fitting courses.

Orientation in Prosthetics and Orthotics for Rehabilitation Counselors. Five sections of this course were offered during 1967-1968, representing the training of 173 persons from the Central States. Spaces for 207 students have been requested for the 1968-1969 academic year.

Associate-in-Arts Degree Program in Orthotics. There is abundant evidence that a

shortage of qualified orthotists deprives patients of proper care and impedes the operation of orthotics facilities in the United States. It is also clear that orthotics facilities are being called upon to provide increased services to patients. The projected future demands for orthotics care will require more than 1,000 orthotists to enter the field by 1975. In an effort to help meet these manpower needs, Northwestern University and Chicago City College are establishing an Associate-in-Arts degree program in orthotics. Beginning in September 1969, first-year orthotics students will follow the same general core curriculum of prosthetics students in their freshman year. Courses will include English composition, human structure and function, mathematics, figure drawing and composition, mechanics and heat, counseling, prosthetics-orthotics materials, metal fabrication, prosthetics-orthotics shop techniques, and physical education. The second year will continue the core curriculum with the following subjects: social science, fundamentals of speech, technical report writing, psychological aspects of physical disability, and business organization and management. In addition to these general education courses, sophomore orthotics students will devote most of their time to the design, fabrication, and fitting of orthopaedic braces for lower- and upper-extremity patients. Time will also be devoted to spinal orthotics. A general orthotics course will acquaint the student with medical and mechanical information necessary for performance as a clinical orthotist. Anatomy, kinesiology, and pathology will be taught for the upper extremities, lower extremities, spine, trunk, and neck. Affiliation with a certified facility has been recommended for all students after their first year. A clinical affiliation will be a required part of the curriculum during the student's fourth semester. Lectures and clinical experiences will be provided by the faculties and staff of the Rehabilitation Institute of Chicago and the NU Medical Center.

Short-Term Courses for Orthotists. It is planned to offer three special short-term courses for orthotists during the 1968-1969 academic year. *Lower-Extremity Orthotics* will provide the student experience in the design,



Loren Jouett, C.P.O., discusses the fabrication of an orthotic appliance with two students enrolled in the Associate-in-Arts degree program conducted by Northwestern University and Chicago City College,

fabrication, and fitting of below-knee braces (nonweight-bearing and weight-bearing) and nonweight-bearing above-knee braces. *Upper-Extremity Orthotics* will focus upon quadriplegic injuries, soft tissue deformities, and traumatic injuries. *Spinal Orthotics* will provide the student with experience in the design, fabrication, and fitting of spinal braces.

In cooperation with the American Academy of Orthopaedic Surgeons, XUPOC has completed three series of tape-recorded lectures coordinated with projection slides. The series are: *Upper-Extremity Prosthetic Training*, by Charles M. Fryer; *Congenital and Skeletal Deficiency Classification*, by Charles H. Frantz, M.D.; and *Amputation Surgery*, by Robert G. Thompson, M.D.

Work is progressing on the *Anatomical Study Guide for Prosthetists-Orthotists*, a

manual to assist persons preparing for the American Board for Certification Examination in Prosthetics and Orthotics. ABC is funding this project.

Upper-Extremity Harnessing and Control Systems, a handout booklet to accompany the film entitled *Upper-Extremity Harnessing and Control Systems*, will be completed by July 1968. The film and the booklet are a joint project of NUPOC and the Committee on Prosthetic Orthotic Education.

Planning continues on a biomechanics course for residents in orthopaedic surgery and physical medicine. Consultants from Case Western Reserve University' and the Veterans Administration Prosthetics Center are working with NUPOC faculty members in designing this course.

The Committee on Prosthetic-Orthotic

Education has requested NUPOC to develop a short-term course and film for nursing instructors in prosthetics.

CPOE has encouraged the development of three films on biomechanics. The first would be a core film of medical and mechanical terminology and information, the second film would relate the core information to prosthetics, and the third to orthotics. These films would be useful in continuing education courses and in degree programs in prosthetics and orthotics.

Minor revisions are being made in the film *Gait Analysis*, a Northwestern University—CPOE project.

During the 1967-1968 academic year, members of the NUPOC faculty and staff participated in meetings of the American Orthotic and Prosthetic Association, the Committee on Prosthetic-Orthotic Education, the Cook County Graduate School of Medicine, the American Academy of Orthopaedic Surgeons, the Biomechanics Seminars of Case Western Reserve University, the National School Boards Association, and the University Council on Orthotic-Prosthetic Education.

Workshop Panel on Lower-Extremity Prosthetics Fitting Convened by CPRD Subcommittee on Design and Development

The Seventh Workshop Panel on Lower-Extremity Prosthetics Fitting of the Subcommittee on Design and Development, Committee on Prosthetics Research and Development, met at Rancho Los Amigos Hospital, Downey, Calif., on January 6, 1968. James Foort, panel chairman, presided. Participants in the meeting were Francis A. Appoldt, Charles C. Asbelle, Leon Bennett, Ph.D., John Bray, Milo B. Brooks, M.D., Frank W. Clippinger, Jr., M.D., Ivan A. Dillee, Barbara R. Friz, Henry F. Gardner, J. Morgan Greene, Art Guilford, Fred Hampton, H. Blair Hanger, Robert Klebba, Herbert R. Kramer, Lewis A. Leavitt, M.D., David W. Lewis, Ronald Lipskin, Henry McClenney, Vert Mooney, M.D., Alvin L. Muilenburg, Robert T. Nethken, Vernon L. Nickel, M.D., Charles W. Radcliffe, John E. Rogers, Jr., Theron R. Rolston, M.D., Kenneth Schwarz,

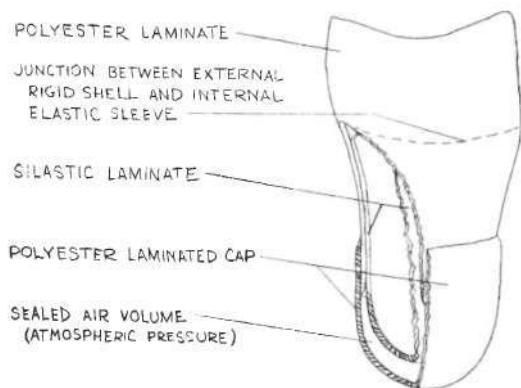
Charles Scott, R. N. Scott, Roy Snelson, Anthony Staros, Howard R. Thranhardt, Eugene F. Tims, Sc.D., Bert R. Titus, David W. Tope, Joseph E. Traub, Keith E. Vinne-cour, Leigh A. Wilson, and Joseph H. Zettl. Also present were A. Bennett Wilson, Jr., Executive Director of CPRD; Hector W. Kay, Assistant Executive Director of CPRD; and James R. Kingham, Staff Editor of CPRD.

Dr. Nickel, Medical Director of Rancho Los Amigos Hospital, extended a warm welcome to the participants and gave a brief account of the early history of Rancho Los Amigos. As a Los Angeles County institution it had served as a treatment center for alcoholics and, later, for victims of poliomyelitis. After World War II, a respiratory center was developed, and more than 9,600 respiratory poliomyelitis patients had been treated. Now the institution has a spinal cord center and a stroke service and maintains a 1,188-bed hospital. Dr. Nickel mentioned Rancho's orthotics research and development program, saying that the controls presently available are inferior to the assistive devices that have been developed. Work has been done on various types of controls—tongue controls, eye controls, and myoelectric controls.

At Dr. Nickel's request, Dr. Mooney briefly described Rancho's multidisciplinary approach to the care of amputees. He said that much of the work was being done by nursing personnel and extensive use was being made of plastics. In general, the program was conducted on an austere basis to conserve the expenditure of public funds.

In conclusion, Dr. Nickel mentioned that the nearness of Rancho to major activities of the national space program, coupled with the recent surge of interest in human engineering, had led to a considerable interchange of correspondence between Rancho and the space program. In general, he said, Rancho was eager to attract research and development programs that required room and patients—both being available at Rancho.

Consideration was given to the air-cushion socket developed at the University of California, Berkeley and San Francisco. Professor Radcliffe said that, in principle, the air-cushion socket is very similar to the standard PTB



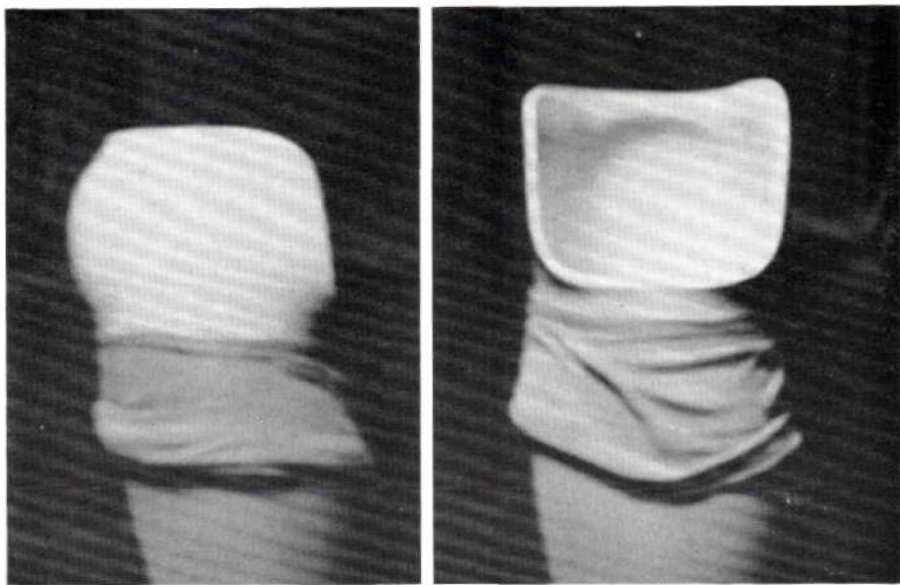
Schematic sketch of the air-cushion socket. Developed at the Biomechanics Laboratory, University of California, the air-cushion socket is very similar in principle to the standard patellar-tendon-bearing (PTB) socket. The laminate liner is free to move within the rigid socket, and a very small amount of air is trapped between the liner and the socket.

socket. The air-cushion socket consists of an external, rigid, polyester-laminated shell and an internal, elastic, silicone-rubber-laminated sleeve joined at the level of the tibial tubercle. The rigid socket shell provides direct support for the stump area proximal to the level of the tibial tubercle and extends distally on

the outside of the elastic sleeve to about one inch above the distal end of the tibia. The elastic sleeve encloses the distal part of the stump, beginning at the level of the tibial tubercle. A polyester-laminated cap bonded to the outside of the distal portion of the rigid socket shell provides an airtight seal distal to the elastic sleeve.

The laminate liner of the air-cushion socket is free to move within the rigid shell, and a very small amount of air is trapped between the liner and the shell. The sleeve tends to elongate and to close against the stump. Professor Radcliffe said that the air-cushion socket thus possesses obvious advantages in the control of edema. In fact, most of the early fittings were made to patients with chronic edema. But he believed that the socket offered other advantages to below-knee amputees.

Mr. Snelson showed the panel participants a number of Rancho patients who had been fitted with air-cushion sockets. In summary, Mr. Snelson said that 20 patients had been fitted with air-cushion sockets at Rancho—one by an outside shop. The fittings had been successful. However, the air-cushion sockets



Patellar-tendon supracondylar (PTS) socket. Views showing the trim lines. *Courtesy Prosthetics and Orthotics, New York University.*

required a longer period of time for fabrication than the hard sockets.

After a number of the other panelists had discussed their clinical experiences, it was the consensus that the air-cushion socket should be formally evaluated, with administrative assistance from the CPRD staff.

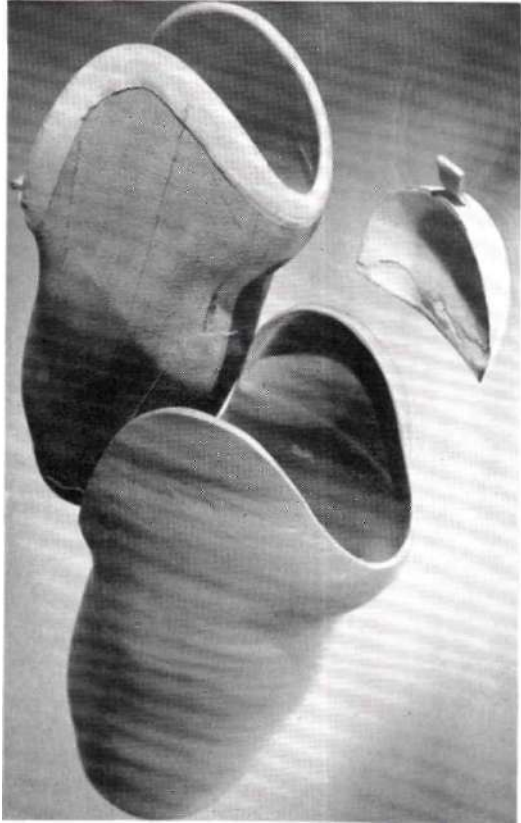
Mr. Kramer briefly summarized preliminary studies on the patellar-tendon supracondylar (PTS), below-knee socket that had been conducted at New York University. He described the supracondylar feature as a suspension adjunct to the PTB socket. He then showed projection slides depicting fittings made on the first three patients at NYU, pointing out the improved stability. The reaction of the patients was favorable, he said. Although only a limited number of fittings had been made, the results were encouraging. Mr. Kramer noted that the PTS socket was especially suitable for short stumps.

Mr. Hanger said that instruction on the PTS socket had been inserted in the course on the PTB socket at Northwestern University. Almost all the patients on whom fittings had been made reacted favorably. Mr. Hanger announced tentative plans to conduct a seminar at Northwestern University during August 1968 for the purpose of reviewing the variations in PTS socket procedures, with a view toward developing appropriate instructional procedures for the schools.

Mr. Gardner said that Dr. G. G. Kuhn of Germany and Monsieur Guy Fajal of France had been working on the PTS-socket concept for some time. In fact the Miinster below-knee socket and the PTS below-knee socket were based on the same principles.

Mr. Dillee commented on the condylar wedges used at Miinster and noted by Mr. Carlton Fillauer during his visit there in August 1967. Mr. Dillee said that Mr. Fillauer had used the wedges in some 14 fittings, with apparently satisfactory results. Advantages of the wedges included elimination of piston action and increased facility in donning prostheses. Mr. Dillee showed a number of projection slides depicting the wedges placed over the medial condyle.

Professor Lewis briefly described work being done at the University of Virginia to develop



Below-knee socket with condylar wedge for suspension (Miinster type). *Courtesy Veterans Administration Prosthetics Center.*

pressure transducers for use in the measurement of pressures between sockets and stumps. He said that two types of transducers were being developed: a capacitor-type, and an optical-fiber type.

Mr. Appoldt described studies being made at New York University on pressure differences resulting from differences in alignment. He said that there appeared to be considerable variability in the subjects. It seemed that in a quadrilateral socket most of the pressure is at the ischium.

The panel participants asked a number of questions concerning the fittings on the persons studied; that is, about the socket fit, the gait, etc. Mr. Appoldt said that the pressure transducers used in the studies had a number of limitations.

Dr. Leavitt briefly described studies of gait analysis being initiated at the Texas Institute for Rehabilitation and Research. A methodology for the studies was being developed. Dr. Leavitt showed projection slides depicting a prosthesis equipped with thermistors, pressure transducers, and goniometers, with recording devices for digital analysis. He said that if the methodology proves to be feasible it will be applied to a series of normal mature stumps for purposes of comparison with others.

Dr. Mooney said that an effort was being made at Rancho to develop a practical pressure transducer to meet clinical needs. He demonstrated a device being used at Rancho which provided indications in numbers of the pressures inside a prosthesis or a shoe. The exact placement of the device inside the prosthesis was critical, and unfortunately the device was pressure-sensitive and was capable of taking static measurements only.

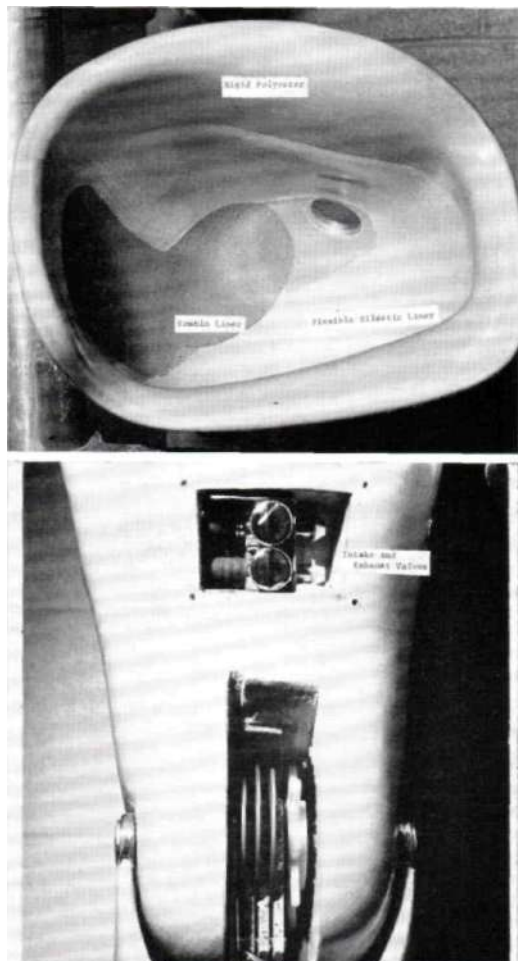
Mr. Snelson supported Dr. Mooney's comments regarding the usefulness of such a device in the clinic, saying that the patient's impressions of socket fit are likely to be inaccurate. Therefore, a good clinical tool was needed to measure socket pressures. He suggested that perhaps 20 psi was the maximum pressure that was tolerable.

Dr. Tims said that Louisiana State University is working with the USPHS Hospital, Carville, La., on pressure studies. The leprosy patient has anaesthesia of his extremities, with the result that he sustains damage to his hands and feet. Questions being studied are: What can live tissue tolerate in pressure and force? What is the time factor?

Mr. Foort described alignment studies that had been undertaken at Winnipeg. An instrumented pylon, with a transmitter and a recorder, was being used to study alignment moments anteroposteriorly and mediolaterally. But, he said, a clear definition of what constitutes good alignment is still lacking.

Mr. Appoldt showed charts and diagrams used in preliminary preparations for alignment studies being undertaken at New York University.

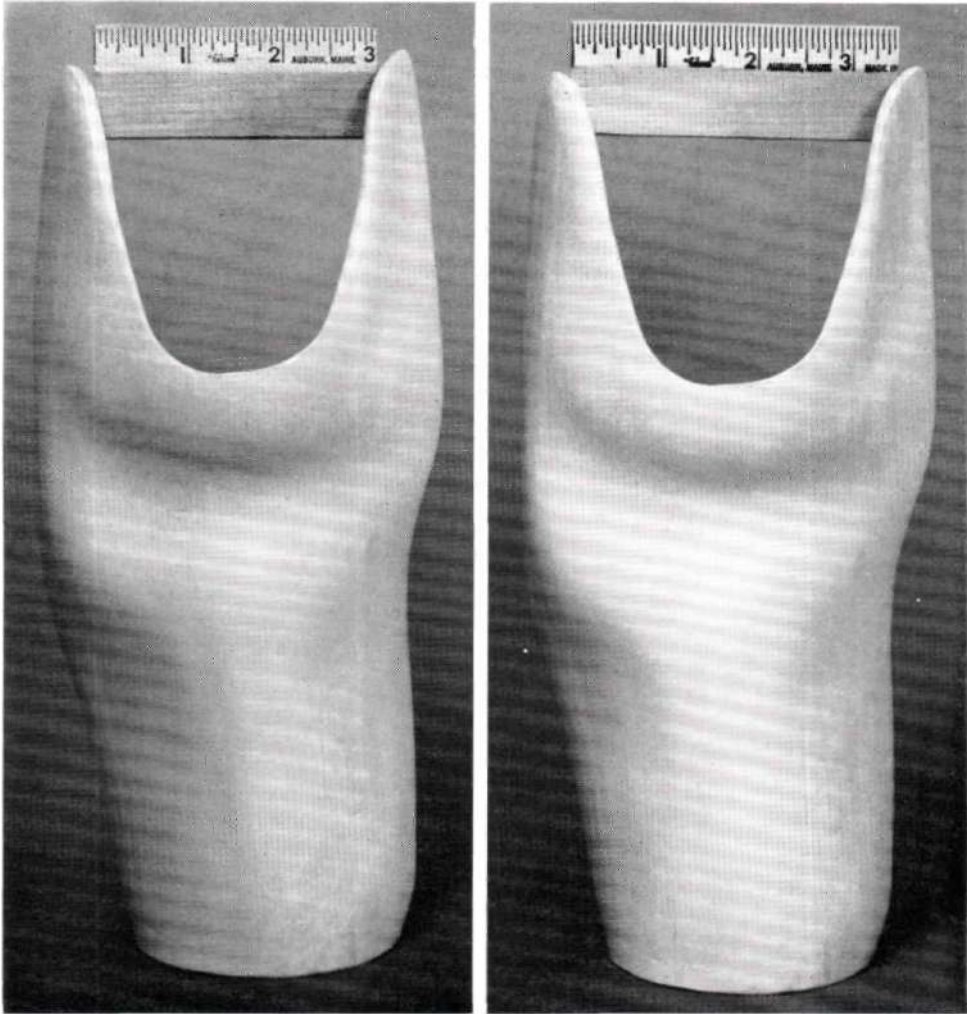
Mr. Hampton gave a status report on fluid-lined sockets under development at North-



Northwestern University above-knee, fluid-lined socket. *Top*, an interior view; a Silastic inflatable liner encompasses approximately three-fourths of the stump area. *Bottom*, an exterior view showing the intake and exhaust valves. *Courtesy Northwestern University Prosthetics Research Center.*

western University. The project had been embarked upon to take up the discrepancies between the stump and the socket. Three fluid-lined sockets were currently being worn. Air pressure within the linings was induced by a hand bulb, to suit the comfort of the amputee. It had been found that the amputee's requirements changed under different conditions.

Mr. Gardner described work at the Veterans Administration Prosthetics Center with the



Two views of a Polysar socket, illustrating its capacity to stretch. *Courtesy Veterans Administration Prosthetics Center.*

direct forming of sockets using Polysar, a new plastic material manufactured by the Polymer Corporation of Sarnia, Ontario. The Polysar sheets are formed in tubes of various diameters. When heated, the tubes can be pulled over the amputees' stumps and formed. Before application, the amputee's stump is prepared with a stump sock, and a cap is attached to the stump end. Then the heated Polysar tube is pulled over the stump, and a pressure bag, or sleeve, is placed over the tube. A bicycle pump and gauge are used to apply pressure through the sleeve, and an intimate total-

contact socket results. The patient is subjected to approximately 2 psi throughout the entire area of his stump. If the patient's stump shrinks, the socket can be reheated and shrunk to the new size of the stump. So far, the results were gratifying, but there were some patients who could not be fitted.

Mr. Foort said that four patients had been fitted with Polysar sockets at Winnipeg. With two mature stumps, Polysar had been very successful, and one patient chose Polysar over a regular fitted socket. Mr. Foort considered that the material was sufficiently promising

so that further use should be made of it. He suggested that possibly the Northwestern University casting technique could be used instead of the pressure sleeve technique described by Mr. Gardner.

Mr. Gardner said that a VAPC draft manual on forming Polysar sockets would soon be available.

Mr. Lipskin distributed copies of a draft fabrication procedure for transparent sockets. Using a motion picture film, projection slides, and photographs, he gave an account of preliminary work done with transparent sockets at New York University. He also briefly described a contour-tracing device developed at New York University to trace the circumference of stump models at various levels.

Planning Initiated for Specialized Child Amputee Fitting Centers

Action taken by the Committee on Prosthetics Research and Development on a recommendation by the CPRD Subcommittee on Child Prosthetics Problems resulted in the establishment of an *Ad Hoc* Committee on the Planning of Specialized Child Amputee Fitting Centers, which held its first meeting at the National Academy of Sciences, Washington, D.C., on February 23, 1968. Colin A. McLaurin, Project Director of the Prosthetic Research and Training Unit of the Ontario Crippled Children's Centre, presided as chairman of the *ad hoc* committee.

Participating in the meeting were George T. Aitken, M.D.; Herbert Elftman, Ph.D.; Charles H. Epps, Jr., M.D.; Sidney Fishman, Ph.D.; John E. Hall, M.D.; Warren G. Stamp, M.D.; and Howard R. Thranhardt. Arthur J. Lesser, M.D., represented the Children's Bureau, and Joseph E. Traub represented the Social and Rehabilitation Service. Also present were A. Bennett Wilson, Jr., Executive Director of CPRD; Hector W. Kay, Assistant Executive Director of CPRD; and James R. Kingham, Staff Editor of CPRD.

At the request of Mr. McLaurin, Dr. Aitken, as Chairman of the Subcommittee on Child Prosthetics Problems, reviewed the background for the establishment of the *ad hoc* committee. Dr. Aitken said that the Subcommittee on

Child Prosthetics Problems was greatly concerned with the problem of providing better care for the extremely handicapped upper-extremity child amputee. The Subcommittee had become aware of items—such as externally powered, coordinated feeding arms—that would greatly benefit such children, but which were not being widely applied. The idea of creating one or more specialized centers for the application of these items had evolved. At the same time, the Subcommittee realized that funds would be required to purchase the needed items. Representatives of the Children's Bureau had indicated the Bureau's interest in the problem, suggesting that a study be made and guidelines be developed. Dr. Aitken emphasized that the main concern was with the severely handicapped child, not the routine child amputee. He added that, although externally powered devices for upper-extremity amputees that had recently been developed had to some extent stimulated the present interest, there was no intention to overlook the severely handicapped lower-extremity child amputee.

At the request of Mr. McLaurin, Dr. Fishman discussed the severely handicapped child amputee population in the United States, pointing out that no precise figures for the entire population are available. He then distributed three analyses of data to the committee: an analysis of the Normative Survey conducted by New York University, an analysis based upon questionnaires sent to clinics affiliated with the Child Amputee Clinic Program, and an analysis based upon questionnaires sent to nonaffiliated clinics. Dr. Fishman pointed out that the first analysis indicated that, among child amputees, 22 per cent are severely handicapped, the second analysis indicated 26 per cent, and the third analysis indicated 25 per cent. Thus there was a consistency in the data pattern. In concluding his presentation, Dr. Fishman estimated that there are 3,600 to 4,000 severely handicapped children under treatment in the United States, of whom perhaps 900 require more specialized attention than they are now receiving.

Mr. Wilson suggested that a comparison be made between the data assembled by New

York University and the data assembled by the Committee on Prosthetic-Orthotic Education in connection with its Amputee Census.

Mr. McLaurin said that the ratio for the severely disabled among the Canadian child amputee population, as indicated at the Ontario Crippled Children's Centre, was essentially the same as the ratio derived from the analyses made by New York University.

Dr. Epps reported that about 10 per cent of the children served by the Juvenile Amputee Clinic at the District of Columbia General Hospital would benefit from a specialized center for externally powered devices.

Dr. Aitken said that, of the children treated at the Child Amputee Centers in Grand Rapids and at the University of Illinois, nearly 30 per cent of the congenital amputees have two or more limbs involved, and nearly 15 per cent have three or four limbs involved. A large proportion of the patients are under five years of age, and so they will continue to be treated by the Child Amputee Clinics for many more years.

Dr. Aitken distributed copies of an analysis of the patients treated at the Child Amputee Center at Grand Rapids, pointing out that the Grand Rapids center is a regional clinic with an average of 28 referrals per year coming to it from out of state. Dr. Aitken said that the administrative load for the handling of the out-of-state patients is assumed by the center in Grand Rapids. The method was successful because of the desire of the Michigan Division of Services to Crippled Children to operate the center at Grand Rapids as a regional center and the cooperation of the other states.

Dr. Stamp reported on the results of a study which he had made concerning the interrelationships with the surgical community in the event that specialized regional centers were established. Dr. Stamp said that the orthopaedic surgeons in the Shriners Hospitals reacted favorably to the notion of referring patients to regional centers. Other surgeons were generally favorable but expressed concern about the increased expense.

In the discussion which followed, it was the consensus that more than one regional center

would be desirable because of the size of the United States, the expense of transportation, the separation of members of families, etc.

Also brought out in the discussion was the probability that patients would continue to be seen at their local centers, in addition to being served by specialized centers. The point was made, too, that if regional centers were established and their existence became known the statistics concerning disabled children would alter; that is, more patients probably would appear at all centers, local and regional.

Dr. Hall and Mr. McLaurin presented information on the operation of the Ontario Crippled Children's Centre in Toronto. Dr. Hall described the existing relationships between government, industry, physicians, and patients, pointing out that control of the program has remained at the level of the unit and the individual surgeon. He spoke in some detail concerning the voluntary government-sponsored medical insurance program in effect in Ontario and the participation of service clubs in projects for raising and providing funds for braces and prostheses. He showed projection slides depicting the hospital facilities, the staff training program, and a number of the specialized fittings made in the Ontario Centre. Mr. McLaurin briefly described some of the specialized devices that had recently been developed. In conclusion, Dr. Hall said that approximately 70 per cent of the child patients seen at the Centre come from outside the Toronto area and 30 per cent from the immediate Toronto area. Cases are accepted only on referral from the patient's physician. In many cases, consultations with local physicians concerning special treatment or devices are conducted by correspondence.

Dr. Lesser, speaking for the Children's Bureau, said that from the governmental administrative point of view there appeared to be no obstacles to prevent the establishment of regional centers in the United States. He added that finances for the fiscal year commencing on July 1, 1968, could not be predicted, pending Congressional action. The present Administration had been generous and there had been an increase of 30 per cent in the funding for the crippled children's

program. If this increase became a reality, approximately 12 1/2 per cent would be available for new projects of a special nature. Grants from the Children's Bureau could be used for consultants' fees, travel, and devices, but not for food or clothing. Funds could be used for training programs. Dr. Lesser said that funds from the Children's Bureau could be made available to state crippled children's commissions or to institutions of higher learning. The Children's Bureau would look to the CPRD Subcommittee on Child Prosthetics Problems for technical assistance in selecting centers.

Mr. Traub, commenting on the interest of the Social and Rehabilitation Service in the possible establishment of regional centers, said that future funding for research and demonstrations is very uncertain. He said that SRS is definitely interested in the establishment of national centers of excellence to provide specialized medical care. He expressed the hope that the regional children's centers under consideration by the *ad hoc* committee, if established, could eventually develop the capacity to serve adults as well as children. He pointed out that children requiring special care eventually grow up and become adults who require special care. He said that SRS might be in a position to fund centers serving both children and adults. He also believed that SRS could join the Children's Bureau in supporting a training program in connection with such centers.

Dr. Fishman commented that a patient might be a child in the eyes of the law until he was 21; however, in many ways, for practical purposes that patient was an adult during the five years or so before he became 21.

Dr. Aitken pointed out that there is a vast difference in the care of very young patients and geriatric patients.

Dr. Elftman commented that if four or five centers were established each would probably develop its own special character.

Dr. Lesser commented that the selection of one center to serve as a pilot project out of 10 or 12 possible applicants could cause problems. Perhaps it would be best to consider geographical distribution and then determine which of the existing clinics were in a position

to assume the increased responsibility of operating as special centers with a minimum of additional staff and facilities. He emphasized that objective criteria should be used in making the selections. He added that Children's Bureau funds could not be used for construction, although they could be used for rent. He said that salaries could be committed for positions, and funds could be used for special manufacturing, but such use should be written into the proposals.

In summing up, Dr. Lesser said that a statement should be made of the problem and its dimensions, the complexity of the technical difficulties, some of the recent research and development that appeared to be promising, the fact that there are more developments for child patients than can now be applied, and the probability that increased applications would in turn lead to further developments. The statement should make it very clear that the principal use of the funds would be to ensure that more children would benefit from highly specialized prostheses.

Mr. Traub said that SRS has been given a mandate to integrate services for the entire population regardless of age. He thought it desirable that specifications include young adult patients as well as children.

Dr. Aitken recommended that the initial effort be concentrated on children.

The members of the *ad hoc* committee then turned their attention toward specific items in the development of a plan for the establishment of specialized centers for the treatment of extremely handicapped children.

Criteria. Dr. Aitken briefly summarized the existing criteria for Child Amputee Clinics. It was the consensus that these criteria could well serve as an initial requirement for groups seeking consideration as possible regional centers.

Engineering Personnel. Consideration was given to the desirability of requiring that professional engineering personnel be included on the staff of the proposed regional centers. One question raised was whether or not such an engineer would necessarily have to be an innovator; that is, could he not simply be a capable applier? It was realized that it is difficult to prescribe a requirement for creativ-

ity, but that there are certain routine things that a professionally trained engineer is qualified to do; for example, determining power requirements and efficiencies, and conducting stress analyses. Moreover, an engineer's knowledge of developments in other fields can serve to introduce new concepts as well as materials into the field of prosthetics. It was the consensus that at least one full-time engineer should be required, although his qualifications need not necessarily be described in terms of academic degrees.

Allied Health Personnel. With respect to allied health personnel, such as occupational therapists and physical therapists, it was the consensus that persons with these specialties should be full time at the center to meet the requirements of the center's special mission.

Prosthetists. It was the consensus that the prosthetists of the center should be certified and that the center should have a full-time prosthetist on its staff or some contractual arrangement with a commercial facility whereby full-time service would be provided.

Prosthetics and Other Shop Facilities. It was the consensus that a regional center should have some prosthetics shop facilities—at least, for fitting and alignment if not for fabrication—immediately available within the center. In addition to prosthetics shop facilities, it was considered that machine shop and electrical shop facilities should be immediately available, for purposes of hardware development and fabrication. Competent shop men should also be available, probably a machinist and a mechanic.

Medical Personnel. It was the consensus that the medical director of the center should be an orthopaedic surgeon with a proved competence in the area of child prosthetics.

Inpatient Facilities. It was considered that inpatient facilities were essential, with available beds for the special patients of the center.

Surgical Facilities. It was considered that it was not essential for the center to have surgical operating facilities within the center itself.

Differentiation between Specialized Center and Standard Amputee Center. It was the consensus that the clinic dealing with very seriously disabled children should be differ-

entiated from the clinic associated with the care and management of routine amputee patients. Such differentiation should include a difference in the meeting time of the two clinics.

Administrative and Other Supporting Personnel. It was recognized that the specialized clinic should have a competent staff of administrative, clerical, and photographic personnel to maintain adequate records. That is, the existing staff should be capable of expanding its activities to meet the additional need.

Purchase of Prototypes. It was recognized that the plan for the establishment of specialized centers should include a definite policy statement concerning money to be spent for the purchase of prototypes and on the letting of subcontracts if necessary.

Inter-Center Relationships. It was agreed that the plan should include a positive statement to the effect that close cooperation and coordination between the regional centers was presupposed.

Relationships between Specialized Centers and Routine Centers. During the discussion of relationships between specialized centers and routine centers, the thought was expressed that the severely handicapped child needed to be defined in order to provide a basis for referrals to the specialized centers. It was also thought that the specialized centers should provide a consultation service which could make recommendations for treatment that might be carried out at the child's home clinic. In general, it was believed that referral to the specialized centers should be from clinics already in the program. It was suggested that the home clinics would have an important role in the follow-up of patients treated at the specialized centers and that the specialized centers should be responsible for educating the home clinics in special procedures.

It was the intent of the *ad hoc* committee to have its completed plan ready for presentation at a Conference of Child Amputee Clinic Chiefs to be held at the National Academy of Sciences during June 1968.

Working Group Analyzes Data on Amputations

A working group to analyze data from the facility record forms submitted by members

of the Conference of Prosthetists of the American Orthotic and Prosthetic Association met in Washington, D.C., February 26, 1968. Dr. Frank W. Clippinger, Jr., who is the chairman of the group, explained that the purpose of the meeting was to identify items of information that could be retrieved from the taped data on 8,697 amputations. Several preliminary questions which can be answered by a computer were formulated, and it was decided to request an initial trial run which would correlate incidence with age, sex, site, and cause of amputation. This would be a simple correlation of data. Other information, such as relationships with training, the time of prosthetic replacement, and reamputation, would also become available.

Attending this meeting were Robert Keagy, M.D., Edward Peizer, Ph.D., Basil Peters, Bert R. Titus, Elizabeth Davies, Barbara R. Friz, and A. Hiram Simon, Staff Officer, Division of Medical Sciences, National Research Council.

Workshop on the Human Foot and Ankle Convened by CPRD Subcommittee on Fundamental Studies

In keeping with its major purpose of renewing familiarity with work that has been done in basic research and stimulating investigations in areas where knowledge is limited or lacking, the Subcommittee on Fundamental Studies, Committee on Prosthetics Research and Development, conducted a Workshop on the Human Foot and Ankle at Massachusetts General Hospital, Boston, Mass., March 1-2, 1968. Verne T. Inman, M.D., University of California Medical Center, San Francisco, presided as chairman. There were some 30 participants.

At Dr. Inman's request, Professor J. Raymond Pearson, Chairman of the Subcommittee on Fundamental Studies, reviewed the reasons for the formation of the Subcommittee. Professor Pearson said that this conference on the human foot and ankle was the first to be sponsored by the Subcommittee, and it was hoped that it would set a pattern for others to follow.

Dr. Inman noted that several participants in the conference had been delayed in their

travel to Boston by inclement weather. He also explained that, because of illness, Professor Gaynor Evans of the University of Michigan would not be able to deliver his paper on the *Mechanical Properties of Bone*. However, Professor Evans had prepared and submitted his paper, so that it could be included in the proceedings of the conference.

Dr. Clement B. Sledge, Department of Orthopaedic Surgery, Massachusetts General Hospital, made a presentation on the *Mechanical Properties of Cartilage*. He dealt with the functional role and the embryology of synovial joints, his theme being the interaction between synovial fluid and the cartilage itself. He stressed the avascular character of cartilage, pointing out the mutual antagonism between cartilage and a good blood supply. He showed projection slides depicting schematic and actual representations. He emphasized that from the first appearance of synovial fluid in the embryo it was important that there be muscle function to prevent fusion in the developing joint. He also showed the changes characteristic of degenerative arthritis and the effects of selective disease processes, experimental and pathological, which affect the mechanical properties of joints. The continuing importance of pumping action in the joint was stressed, both in the development of slipperiness and in nutrition. Without the pumping action, degeneration sets in and cysts develop. Slides depicting cysts resulting from excessive compression were also shown.

Dr. Inman commented that the subject dealt with by Dr. Sledge was very important so far as orthopaedists were concerned and briefly described three somewhat differing theories as to the lubrication of synovial joints: boundary lubrication, hydrodynamic lubrication, and hydrostatic lubrication. He also pointed out the incongruity between the parts of anatomical joints and the probable effects of this incongruity upon the lubrication of the joints.

During the discussion that followed, Dr. Sledge took the opportunity to stress the critical importance of placing the joint of an orthotic device in the same plane as the anatomical joint.

Dr. Herbert Elftman, Chairman of CPRD, made a presentation on the *Biomechanics*

of the Foot and Ankle. He showed projection slides illustrating the patterns of running strides and walking steps and the various axes of the foot in dorsiflexion and plantar flexion. He emphasized that malfunction of the hip or knee would affect the function of the foot. While briefly reviewing the parts of the foot, Dr. Elftman took the opportunity to stress the importance of the subtalar joint. He demonstrated the necessity for compressing the joints when attempting to obtain natural motions for purposes of measurement, and he described various methods of measurement. He also emphasized the importance of obtaining measurements while the subject was wearing shoes rather than barefoot.

Dr. Inman made a presentation on the *Influence of the Foot-Ankle Complex on the Proximal Skeletal Structure*. He mentioned a recent study of fatigue fractures of the foot among personnel undergoing basic military training. He also noted a rather widespread observation that patients who had had subtalar fusions frequently developed "ball-and-socket" ankle joints. He concluded his remarks with a plea that long-term studies be made of the subtalar joint.

Dr. Edward Peizer and Mr. Ernst Edel of the Veterans Administration Prosthetics Center presented, in sequence, three adult male patients, explaining data (case histories, gait films, projection slides, and barograms) that had been prepared on each patient. The orthopaedic shoes and orthotic devices that had been supplied were also shown and explained.

A similar presentation of data on three child patients of Massachusetts General Hospital was made by Drs. Donald S. Pierce and Peizer.

There was extensive discussion of all the cases, adult and child, during which it was brought out very clearly that there are large gaps in present knowledge. For example, it was considered that present methods of observation (films, barograms, etc.) are inadequate, and yet cineradiography and cinefluorography present difficulties and have many shortcomings. It was recognized that, because of inadequate knowledge and understanding of patients' conditions, many of the

methods of treatment in use are of questionable validity.

Dr. Augusto Sarmiento of the University of Miami Medical School showed motion pictures of a number of patients whose tibial fractures had been treated with the application of a cast permitting freedom of motion. Dr. Sarmiento said that some 250 patients had been treated by this method in Miami, with highly beneficial results in almost every case. Some of the casts were fitted with standard orthotic ankle joints, but more recently they had been fitted with steel cables at the ankle.

There was marked interest in the methods used by Dr. Sarmiento and general agreement that he had made a genuine contribution.

In concluding the conference, Dr. Inman posed two questions: What had been learned? What was to be done?

The answers to these questions, Dr. Inman said, are to be sought along three general lines:

First, it is apparent that there is insufficient knowledge concerning the axes and ranges of motion within the foot. The deficiencies of anatomical knowledge must be corrected by anatomists, whose studies of cadavers must be translated to living persons. The ranges of normal variations must be known. The normal must be better understood. The assistance of engineers in the application of instrumentation and engineering techniques is essential to the development of this information.

Second, when there is a better understanding of conditions, attention must be given to the development of better orthopaedic and orthotic appliances.

Third, it is apparent that there is insufficient information upon which to base evaluations. Simply gathering data for data's sake is pointless. Specific questions must be asked, and then answers must be sought. Standard techniques for evaluation must be developed.

NRC Division of Engineering Annual Meeting

As in past years, the annual meeting of the Division of Engineering, National Research Council, was scheduled as a part of the general program for the meeting of NRC, which met during the period March 10-12, 1968. Division of Engineering members, staff, and guests assembled at the Statler Hilton Hotel, Washington, D.C., during the afternoon and evening of March 11.

Presiding over the Division of Engineering program, entitled *Biomedical Engineering*

Today, was Dr. Murray Eden, Chairman of the Division's United States National Committee on Engineering in Medicine and Biology. Members of the U.S. National Committee, with assistance from the Chairman and Executive Director of the Division's Committee on Prosthetics Research and Development, and the Executive Secretary of the National Academy of Engineering's Committee on the Interplay of Engineering with Biology and Medicine, developed a most interesting program that was well received by the audience.

The initial phase of the afternoon session included a description of the current activities of the National Academy of Sciences-National Academy of Engineering-National Research Council in the field of biomedical engineering, presented by Dr. Murray Eden, Dr. Herbert Elftman, and Dr. John G. Truxal. Major features of the afternoon session were presentations by three guest speakers. Dr. Michael E. DeBakey, Chairman, Department of Surgery, College of Medicine, Baylor University, discussed and narrated a visual presentation of the technological aspects involved in the substitution of artificial organs and tissues. Dr. Morris F. Collen, Director, Medical Methods Research, Permanente Medical Group, Oakland, Calif., talked on the potential role of engineering in the development of equipment, techniques, and systems needed for health screening centers. This was followed by a movie and narration on the subject of man under the sea by Captain George F. Bond, Medical Corps, U.S. Navy, Assistant for Medical Effects, Deep Submergence Systems Project.

Dr. George T. Aitken, Chairman of the Subcommittee on Child Prosthetics Problems of the Committee on Prosthetics Research and Development, was the guest speaker following dinner in the evening. Dr. Aitken, an orthopaedic surgeon, is Medical Co-Director of the Area Child Amputee Program, Michigan Division of Services to Crippled Children, Grand Rapids, Mich. His subject was biomedical engineering program development, and he showed an orderly transition from basic research through development and evaluation to patient application, using as examples items that had been developed



Dr. George T. Aitken, Chairman of the Subcommittee on Child Prosthetics Problems of the Committee on Prosthetics Research and Development, addressing the evening meeting of the Division of Engineering, National Research Council.

in connection with the nationwide child amputee prosthetics program.

During the evening session recognition was given to Louis Jordan who, since 1942, has been a devoted and respected member of the staff of the National Academy of Sciences and the National Research Council. Mr. Jordan was Executive Secretary of the Division of Engineering from 1946 to September 1966. He continues to serve the Division as Special Consultant to the Chairman, Dr. J. A. Hutcheson. In recognition of his long and devoted service, Mr. Jordan's colleagues presented him with a sterling silver Revere bowl and an album of memorabilia. The album contained numerous letters from Academy executives and former Division Chairmen.

Meeting of CPOE Subcommittee on Special Educational Projects in Prosthetics and Orthotics

The Subcommittee on Special Educational Projects in Prosthetics and Orthotics of the Committee on Prosthetic-Orthotic Education met in Washington, D.C., on March 8, 1968. Dr. J. Warren Perry, who presided at the meeting, presented a brief report on the developing relationship between the American Medical Association's Council on Medical

Education and the allied health professions. Dr. Perry, a member of the Council's Committee on Education for the Allied Health Professions and Services, attended the Council's first meeting.

A major item of business before the subcommittee was a survey of the manpower needs of the prosthetics and orthotics professions.

The subcommittee decided that a representative of CPOE should appear at each one of the American Orthotic and Prosthetic Association's regional meetings for the purpose of encouraging participation in the survey. Distribution of the survey form will be made during June 1968.

Members of the subcommittee who attended the meeting were Jack D. Arnold, Ph.D., William M. Bernstock, Florence S. Knowles, Alfred E. Kritter, M.D., George Lambert, Alvin L. Muilenburg, and Herbert B. Warburton.

Meeting of CPOE Subcommittee on Orthotics

The Subcommittee on Orthotics of the Committee on Prosthetic-Orthotic Education met in Washington, D.C., on March 28, 1968. Chairman Jacquelin Perry, M.D., who presided at the meeting, distributed to members and guests the tabulations compiled from the results of the recently conducted survey on *Use of External Support in Low Back Pain*. Survey forms had been sent to 5,215 members of the American Academy of Orthopaedic Surgeons, and some 40 per cent had been completed and returned. Dr. Perry noted that the data were to be further analyzed according to geographic distribution. A final report is being prepared.

Respondents to the survey will be sent a brief checklist-type questionnaire in an attempt to determine what function they expect from the various supports they prescribe. Selected orthopaedic surgeons and orthotists will then meet to interpret and evaluate the findings.

The subcommittee plans to request the Conference of Prosthetists of the American Orthotic and Prosthetic Association to undertake a study to identify differences in device

construction as practiced today and to determine the extent of these differences, the study to be based on information received from orthotists and from comments appearing on the questionnaire forms.

Members of the subcommittee agreed that the results of the survey were extremely valuable for purposes of documenting current orthotics practices related to support of low back pain, providing guidelines for orthotic construction, and establishing basic information upon which further studies may be pursued.

Anthony Staros reported on the activities of the Committee on Prosthetics Research and Development in the area of orthotics and stated that these activities had been directed primarily toward lower-extremity bracing. The CPOE Subcommittee on Orthotics expressed a desire to cooperate in these activities.

Ralph A. Storrs, Co-Chairman of the Conference of Prosthetists, AOPA, reported that a subcommittee of the Committee on Prosthetics and Orthotics of the American Academy of Orthopaedic Surgeons had been working on development of a system of nomenclature in orthotics, relating it to biomechanical function and dysfunction. He noted that the system was primarily a teaching and research tool and was not expected to be universally adopted.

Members of the CPOE Subcommittee on Orthotics attending the meeting were Norman Berger, E. Burke Evans, M.D., Hans Lehneis, Charles W. Rosenquist, and Roy Snelson. Also present were Joseph E. Traub, Consultant, Prosthetics and Orthotics, Office of Research, Demonstrations, and Training, SRS; A. Bennett Wilson, Jr., Executive Director, CPRD; and Barbara R. Friz, Executive Secretary, CPOE.

Annual Meeting of the Committee on Prosthetic-Orthotic Education

The annual meeting of the Committee on Prosthetic-Orthotic Education was held at the National Academy of Sciences, Washington, D.C., on April 18, 1968, with Dr. Herbert E. Pedersen, Chairman of CPOE, presiding. Other members of CPOE attending the meet-

ing were Dr. Charles O. Bechtol, William M. Bernstock, Dr. Frank W. Clippinger, Jr., Dr. Clinton L. Compere, Dr. Roy M. Hoover, Mrs. Geneva R. Johnson, Alvin L. Muilenburg, Dr. J. Warren Perry, Miss Lena M. Plaisted, Colonel Ruth A. Robinson, Charles W. Rosenquist, and Dr. Walter A. L. Thompson. Dr. Charles L. Dunham, Chairman of the Division of Medical Sciences, National Research Council, was also present.

Others attending the meeting included Dr. Jack D. Arnold, Miss Audrey Calomino, Miss Elizabeth Davies, Dr. Sidney Fishman, Mrs. Barbara R. Friz, James R. Kingham, Mrs. Florence Knowles, Paul Leimkuehler, Chester Pachucki, Mrs. Jean E. Perrin, Dr. Elwyn C. Saferite, Mrs. Jean Schuerholz, Raymond E. Sollars, Dr. Robert E. Stewart, Bernard Strohm, Joseph E. Traub, Herbert B. Warburton, Captain Martin C. Wilbur, Dr. N. Elane Wilcox, Commander L. V. Willette, and A. Bennett Wilson, Jr.

After opening the meeting, Dr. Pedersen introduced Dr. Dunham, who welcomed the members of the Committee, explained the National Research Council's interest in CPOE, and outlined the activities of the Division of Medical Sciences. He stressed the importance of communications between the various committees with similar aims and goals.

Mrs. Knowles, Consultant in Physical Therapy to the Rehabilitation Service Administration, explained that the Vocational Rehabilitation Administration no longer exists as such. Because of the reorganization of VRA and other agencies during August 1967, the Training Division has become part of the Rehabilitation Service Administration (RSA) of the Social and Rehabilitation Service (SRS). She said that CPOE productivity is reflected in the conduct of the training programs supported by SRS.

Mr. Bernstock, Assistant Chief of the Research and Development Division of the VA Prosthetic and Sensory Aids Service, invited particular attention to the interest demonstrated by therapists in immediate postsurgical prosthetics and to the need for greater consideration of the role of the nurse in amputee management. He said that the

University Council on Orthotic-Prosthetic Education had been requested to consider the possibility of offering courses in immediate postsurgical prosthetic management to therapists. He also commended CPOE on the effective discharge of its responsibilities under the VA contract.

Mr. Wilson, Executive Director of the Committee on Prosthetics Research and Development, said that a major recent project of CPRD had been a Workshop on the Human Foot and Ankle, the proceedings of which would be published as one of the numbered series of the National Academy of Sciences publications. Other recent publications of CPRD included two issues of *Artificial Limbs*, monthly issues of the *Inter-Clinic Information Bulletin*, and a pamphlet entitled *Normal and Abnormal Embryological Development* which recorded the proceedings of a conference of Child Amputee Clinic Chiefs held during January 1966.

Speaking on behalf of the University Council on Orthotic-Prosthetic Education, Mrs. Knowles said that the need for different levels of practice in prosthetics and orthotics was being recognized in the implementation of various educational programs. Introduced by Mrs. Knowles as new members of CPOE who direct these programs were: Dean Saferite, Associate-in-Arts Degree Program in Prosthetics, Cerritos College; Dean Pachucki, Associate-in-Arts Degree Program, Chicago City College; and Dr. Wilcox, Orthotics Internship Program, Rancho Los Amigos Hospital.

Drs. Arnold and Compere briefly reported on new developments of the Prosthetics-Orthotics Education Program at Northwestern University. Of special interest was the increasing number of residents being trained, with 550 spaces allotted for the 1968-1969 academic year. They said that an informal survey of the Associate-in-Arts graduates of the Chicago City College—Northwestern University program showed that all were working in private facilities as "junior fitters" for \$5,400 to \$7,000 per year.

Drs. Fishman and Thompson reported on the Prosthetics-Orthotics Education Program at New York University. They said that the

1967-1968 academic year showed an increase of 25 per cent in the short courses, with a total of 900 students, 125 to 150 of whom were from foreign countries. NYU had been instrumental in setting up an orthotics shop aboard the hospital ship *Hope*. During July 1968, NYU will offer a course in above-knee prosthetics in Lisbon, Portugal, for 10 to 12 Portuguese-speaking students.

Dr. Fishman outlined two problem areas that deserved the attention of CPOE. First, training in immediate postsurgical prosthetics fitting should be directed toward the general surgeons who perform approximately 90 per cent of the amputations in the United States. Second, more—perhaps 75 per cent—of CPOE activity should be directed toward orthotics. Moreover, orthotics projects should be better coordinated.

Dr. Bechtol, reporting on the Prosthetics-Orthotics Education Program at the University of California, Los Angeles, said that Dr. Miles H. Anderson, the former Director of the Program, had been transferred to the School of Education at UCLA. Dr. Bechtol introduced Mr. Strohm, the new Program Director. Mr. Strohm is Coordinator of the Allied Health Professions at UCLA and Director of the Physical Therapy Department.

Speaking on behalf of the Committee on Orthopaedic Rehabilitation of the American Academy of Orthopaedic Surgeons, Dr. Compere said that the committee members were working actively with the American Physical Therapy Association, the American Occupational Therapy Association, and other groups involved in rehabilitation activities. AAOS had established a committee on continuing education. A very active committee of AAOS is the one on injuries, which is sponsoring 21 seminars during the coming year. It was agreed that co-sponsorship of seminars or workshops by CPOE and one of the AAOS committees could be a worthwhile arrangement.

Speaking on behalf of the AAOS Committee on Prosthetics and Orthotics, Dr. Pedersen said that the Committee would sponsor an instructional course in the management of the geriatric amputee at the AAOS meeting in January 1969. The course would be under

the direction of Dr. Pedersen. Another activity of the Committee is the development of a system of orthotics nomenclature in which orthotics terminology is being directly related to biomechanical functions and dysfunctions.

On behalf of the American Orthotic and Prosthetic Association, Messrs. Muilenburg and Warburton briefly reported on AOPA activities. AOPA's Conference of Prosthetists and Conference of Orthotists were working closely with the CPOE Subcommittee on Special Educational Projects in Prosthetics and Orthotics. Plans were being made for a much-needed recruitment program.

On behalf of the American Board for Certification in Orthotics and Prosthetics, Mr. Leimkuehler said that the chief activity of this group during the past year had been the restructuring of the certification examination and the review of definitions of prosthetists and orthotists to coordinate them with the definitions in the *Dictionary of Occupational Titles*.

The members of CPOE then decided:

To implement an educational program for geriatric amputees.

To dissolve the Subcommittee on Paramedical Education. Physical therapy and occupational therapy educators would be represented at CPOE annual meetings. An *ad hoc* committee to develop an educational program for nurses in the field of prosthetics and orthotics would be established.

To obtain information that will present a more accurate picture of the total amputee population of the United States.

To extend the survey on external support in low back pain by sending the initial respondents a brief questionnaire asking them to identify what they expect of the support prescribed.

To expedite the manpower survey of orthotists and prosthetists, an endeavor considered to be of vital importance.

To become more active in the solicitation of articles for *Artificial Limbs*.

To invite representatives from the Army and the Air Force to attend annual meetings of CPOE.

To consider means whereby activities concerned with the recruitment of prosthetists and orthotists can be better coordinated.

To establish an *ad hoc* committee to plan the geriatric amputee workshop. Present plans call for the workshop to be held during the latter part of 1968.

Eighteenth Meeting of CPRD

The Eighteenth Meeting of the Committee on Prosthetics Research and Development

was in Washington, D.C., on June 12, 1968. The Chairman of CPRD, Dr. Herbert Elftman, presided. The Vice Chairman of CPRD, Colin A. McLaurin, was present. Other members of CPRD attending the meeting were Dr. George T. Aitken, Dr. Cameron B. Hall, Dr. Robert W. Mann, Alvin L. Muilenburg, Professor J. Raymond Pearson, Professor Charles W. Radcliffe, Professor Robert N. Scott, Howard R. Thranhardt, and Bert R. Titus. Dr. Herbert E. Pedersen, who as Chairman of the Committee on Prosthetic-Orthotic Education is a liaison member of CPRD, was present. The Children's Bureau was represented by Donald Trauger, the Social and Rehabilitation Service by Joseph E. Traub, and the Veterans Administration by Dr. Robert E. Stewart, Dr. Eugene F. Murphy, Anthony Staros, and Dr. Edward Peizer. Others attending the meeting were Miss Audrey Calomino; Mrs. Barbara R. Friz, Executive Secretary of CPOE; Dr. George C. Sponsler, III, Executive Secretary of the Division of Engineering, National Research Council; A. Bennett Wilson, Jr., Executive Director of CPRD; Hector W. Kay, Assistant Executive Director of CPRD; James R. Kingham, Staff Editor of CPRD, and Mrs. Enid N. Partin, Administrative Assistant of CPRD.

Dr. Elftman convened the meeting and invited Dr. Sponsler to speak on behalf of the Division of Engineering. Dr. Sponsler extended a hearty welcome to CPRD from the Division and mentioned his special interest in the interplay of engineering with biology and medicine.

Professor Pearson, Chairman of the Subcommittee on Fundamental Studies, briefly reported on conferences conducted under the subcommittee's sponsorship.

Mr. McLaurin, Chairman of the Subcommittee on Design and Development, summarized the activities and plans of the various workshop panels organized by the subcommittee. Subjects to be considered at forthcoming panel meetings included powered elbows and terminal devices, components for knee-disarticulation and hip-disarticulation prostheses, fracture bracing, and lower-extremity prosthetics fitting.

Mr. Thranhardt, as Chairman of the Subcommittee on Evaluation, recommended that

the CPRD staff be expanded to facilitate the evaluation program. Items named as ready for evaluation included Polysar sockets, techniques of casting stumps, an AMBRL lower-extremity brace, the NYU electric orthosis, and the AMBRL electric elbow.

Mr. Traub said that the Social and Rehabilitation Service is vitally concerned with evaluation, which possibly had been somewhat neglected in the past. He said that SRS was prepared to give serious consideration to a nationwide evaluation program, preferably to be administered by CPRD.

Mr. Staros pointed out that the Veterans Administration possesses a bioengineering evaluation capability at the VA Prosthetics Center. VA also has a clinical evaluation capability in its hospitals, but in general the patients are limited to adult males.

Dr. Pedersen said that many suggestions had been made that CPOE and CPRD establish a coordinating committee, and evaluation might be an appropriate area for such a coordinating group.

Dr. Aitken, Chairman of the Subcommittee on Child Prosthetics Problems, reported on work of the *Ad Hoc* Committee on the Planning of Specialized Child Amputee Fitting Centers, saying that a plan for the establishment of such regional centers would be presented for discussion at the Conference of Child Amputee Clinic Chiefs to be held on June 13 and 14, 1968.

Mr. Traub reported that SRS hopes that, eventually, a system of specialized regional centers caring for persons at all age levels will be established. Such centers would be concerned with research, evaluation, and training.

Dr. Mann, Chairman of the Subcommittee on Sensory Aids, said that the report of a conference on sensory aids organized by the subcommittee will appear as a National Academy of Sciences publication. He said that he had made a presentation on sensory aids before the National Academy of Engineering's Committee on the Interplay of Engineering with Biology and Medicine. In conclusion, he expressed the view that the area of sensory aids was not sufficiently close to the central interest of CPRD, and he considered it desir-

able that a separate Committee on Sensory Deprivation be established.

Mr. Wilson then reported on a Workshop on Immediate Postsurgical Fitting of Prostheses held in Chicago on May 18, 1968. He said that educational programs in this subject are now being successfully conducted at the three universities affiliated with the Prosthetics-Orthotics Education Program. In general, there appeared to be satisfaction with the immediate fitting of prostheses, but a follow-up study on the experiences of the students would be desirable.

Dr. Elftman called upon the various liaison members and representatives for comments.

Mr. Trauger said that, owing to other commitments, it was not possible for Dr. Arthur J. Lesser, Deputy Chief of the Children's Bureau, to attend this meeting of CPRD. Dr. Lesser had asked that the good wishes of the Bureau be extended to CPRD.

Dr. Stewart expressed the appreciation of the Veterans Administration to CPRD for its many valuable contributions over the past 20 years. He said that VA sees a continuing need for a prosthetics research program.

Mr. Traub indicated that further reorganization within the Department of Health, Education, and Welfare may be in the offing.

He said that SRS was extremely pleased with the advisory services given by CPRD.

Dr. Pedersen said that CPOE activities were directly related to CPRD activities,



American scientists try Yugoslav equipment. During April 1968, Dr. Dudley S. Childress, Director, Systems Development Laboratory of the Northwestern University Prosthetic Research Center, and Hector W. Kay, Assistant Executive Director of the Committee on Prosthetics Research and Development, visited the Ljubljana Rehabilitation Research Project in Ljubljana, Yugoslavia. Dr. Childress is shown testing the myoelectric and functional electrical stimulation systems developed at the Center. Watching Dr. Childress (seated) are left to right: Eng. Borovsak, Eng. Jeglic, Mr. Kay, and Mr. Brodnik.



Dr. Marian Weiss explains his myoelectric research at Konstancin Rehabilitation Center to visitors from the United States. Listening attentively to Dr. Weiss are, from left to right: Dr. Ann Dubincheck, Dr. Martin S. McCavitt, Chief, International Activities Division, Social and Rehabilitation Service, Department of Health, Education, and Welfare, and Hector W. Kay, Assistant Executive Director, Committee on Prosthetics Research and Development.

and then briefly reviewed the activities of CPOE over the past 10 years. He said that planning was in progress for a workshop conference on geriatric patients, and it was intended that the outcome of the conference would be an authoritative new manual. He also described surveys on the design of orthopaedic braces and on the manpower needs in prosthetics and orthotics that were currently being conducted by CPOE.

Concerning international activities in prosthetics and orthotics research and development, Mr. Traub said that SRS has programs in a number of countries where counterpart funds are available under the provisions of Public Law 481. He said that CPRD had been asked to plan a conference to be held in the United States during the spring or summer of 1969, to be attended by representatives from the overseas projects. Mr. Staros said that a valuable outcome of such a conference would be a coordination of activities with respect to goals developed in the United States domestic research and development program.

Mr. Kay reported briefly on his recent trip to Europe, which had been made primarily to organize an evaluation program in Belgrade, Yugoslavia. He had had opportunities to visit rehabilitation centers in a number of countries.

Mr. Wilson outlined plans for a proposed Orientation Session for Engineers, Prosthetists, and Orthotists to familiarize them with medical and surgical concepts and procedures related to prosthetics and orthotics. A complete record would be made and might serve as a text in the educational program.

Mr. Wilson said that the Disabled American Veterans had expressed interest in sponsoring some project in limb prosthetics, and he had prepared a write-up offering a number of suggestions for their consideration.

Conference of Child Amputee Clinic Chiefs and Meeting of CPRD Subcommittee on Child Prosthetics Problems

A Conference of Child Amputee Clinic Chiefs was held, under the auspices of the Subcommittee on Child Prosthetics Problems

of CPRD, at the National Academy of Sciences, Washington, D.C., on June 13 and 14, 1968. Some 82 persons attended the Conference. Dr. George T. Aitken, Chairman of the Subcommittee on Child Prosthetics Problems, presided.

A major feature of the conference was a Symposium on Proximal Femoral Focal Deficiency, during which presentations were made by Dr. Aitken, Medical Co-Director of the Area Child Amputee Center; Dr. Harlan C. Amstutz, Hospital for Special Surgery, New York, N.Y.; Dr. John E. Hall, Ontario Crippled Children's Centre, Toronto, Ont.; Dr. Richard E. King, Georgia Juvenile Amputee Clinic, Atlanta, Ga.; and Dr. G. Wilbur Westin, Los Angeles, Calif. All of the presentations were extensively illustrated with projection slides and motion pictures. Publication of the papers presented for a National Academy of Sciences monograph was planned.

In opening his presentation, Dr. Aitken said that the nomenclature for congenital deficiencies proposed by Dr. Charles H. Frantz and Dr. Ronan O'Rahilly does not provide a specific descriptive term for the not uncommon anomaly referred to as "proximal femoral focal deficiency." Thirty-five patients with this anomaly had been treated at the Child Amputee Clinic in Grand Rapids, Mich. Dr. Aitken showed pictures and roentgenograms illustrating proximal femoral focal deficiencies which he divided into four categories. He pointed out that, since there usually were numerous associated skeletal deficiencies, the patients were frequently very severely handicapped. Dr. Aitken described types of prosthetic fittings that had been employed in the care of the patients both with and without surgery.

Dr. Amstutz presented a classification of proximal femoral focal deficiencies which differed slightly from Dr. Aitken's. Dr. Amstutz said that his classification was based upon analyses of the records of 60 patients. He said that certain morphological criteria were used in the classification to provide the basis for a more accurate prediction of later developments, particularly the prediction of inequality of leg length.

Dr. Hall confined his presentation to descriptions of surgical conversions (including

Van Nes procedures) and types of prostheses that had been provided to a number of patients with proximal femoral focal deficiencies at the Ontario Crippled Children's Centre. It was essential, he said, to make a radical differentiation between unilateral and bilateral cases. He also felt that early surgical procedures (including rotation osteotomies) and early prosthetic fittings were desirable so that the patients could become accustomed to use of their prostheses.

Dr. King said that the proximal femoral focal deficiency could be definitely recognized as an entity. He then reviewed its embryology and histology, identifying four types of the deficiency. In unilateral cases, he advocated early surgical conversion to obtain a prosthetic knee joint at the same level as the natural knee joint. Ideally, such surgical conversion would create a single skeletal lever to activate the prosthesis. Reasonable comfort, function, and cosmesis had been achieved for a number of patients through such surgical procedures.

Dr. Westin's presentation was based upon a review of the records of 165 cases treated at 17 Shriners hospitals. He said that the collective experience assembled for the review favored early surgical conversion. The review also showed that in general the rotation osteotomies performed to correct the condition had not been successful.

Dr. Charles H. Epps, Jr., Chief of the Juvenile Amputee Clinic at the District of Columbia General Hospital, then presented six patients undergoing treatment at the D.C. clinic who had proximal femoral focal deficiencies of various types. Roentgenograms were presented for each patient, and each was extensively discussed.

Current Activities

Brief reports were then made on the status of various activities being carried on under the sponsorship of the Subcommittee on Child Prosthetics Problems of CPRD.

Dr. Sidney Fishman, Coordinator of Prosthetics and Orthotics at New York University, described an ongoing census of the child amputee population being conducted by NYU.¹ Data for the census are obtained

from the 26 cooperating clinics affiliated with the cooperative child prosthetics program and from 14 clinics not presently affiliated. In the total census of approximately 4,000 children, 57 per cent were males and 43 per cent were females. With regard to the various etiologies and levels of amputation, males always outnumbered the females, the greatest difference appearing among unilateral lower-extremity amputees—61 per cent males and 39 per cent females. Congenital causes outnumbered acquired by a ratio of 2:1. In conclusion, Dr. Fishman said that the child amputee population appeared to be reasonably stable with respect to incidence and types.

At Dr. Fishman's request, Clyde M. E. Dolan, a staff scientist at NYU, reported on studies made of the Michigan feeder arm. Although subject to malfunctions, the arm had considerable merit. However, Dr. Fishman pointed out that the Ontario Crippled Children's Centre coordinated arm is now available and appeared to be superior.

Dr. Fishman reported that a field study of the porous laminate below-knee prosthesis conducted by NYU showed that the prosthesis provided increased comfort, particularly during hot and humid weather, and a weight reduction of 32 per cent. However, the additional labor required for its fabrication had produced criticisms from some of the clinics.

Dr. Fishman suggested that perhaps the next step should be a study of ways by which the clinics' objections might be overcome.

Dr. Fishman described a prosthesis evaluation scale developed at NYU, saying that a report on the scale is available and that the scale itself was available for clinical use. The scale is a questionnaire, and the score reflects the degree of patient satisfaction with his prosthesis.

Dr. Fishman and Mr. Dolan described a study being made of radiographic diagnosis of socket fit and Mr. Dolan discussed a study being made of transparent sockets and showed a film of a patient wearing a transparent socket. Dr. Fishman pointed out that although no relative movement between stump and socket was detectable at the brim, there was considerable piston action of the distal portion

and Orthotics, New York University Post-Graduate Medical School, May 1968.

¹ Munson, Nancy K., and Clyde M. E. Dolan, *Patient census at child amputee clinics—1967*, Prosthetics

of the stump within the socket. Dr. Fishman said NYU would soon publish a fabrication manual on transparent sockets.

Dr. Fishman and Dr. Yoshio Setoguchi of the UCLA Child Amputee Prosthetics Project showed a number of items developed at UCLA which will be available in the fall for clinical use. Included were elbow units, shoulder joints, and terminal devices for children. In addition, several UCLA electric carts (described in the Autumn 1964 issue of *Artificial Limbs*) would be available.

Films

The last hour of the session on June 13th was devoted to films of special interest. Dr. Aitken showed a film on sacral agenesis which presented three patients with a complete absence of the lumbrai spine and sacrum who had been treated at the Grand Rapids clinic. Mr. A. Bennett Wilson, Jr., Executive Director of the Committee on Prosthetics Research and Development, showed a Polish film dealing with training and fitting of a bilateral above-knee amputee, a boy with exceptional physical strength and coordination. Dr. Hall showed a film dealing with a patient on whom a rotational osteotomy (Van Nes procedure) had been performed.

New Devices

The session on June 14th was devoted to a presentation of new prosthetic devices, consideration of the report of the *Ad Hoc* Committee on the Planning of Specialized Child Amputee Fitting Centers, and a short executive session of the Subcommittee on Child Prosthetics Problems.

Mr. Colin A. McLaurin, Chairman of the Subcommittee on Design and Development of the Committee on Prosthetics Research and Development, conducted the presentation of new devices. Included were stable (polycentric) knees that were light and cosmetic and ankle units for the swivel walker.

Externally Powered Devices

Mr. McLaurin briefly reviewed the beginnings of externally powered prostheses in Heidelberg some 20 years ago, pointing out that, through the Otto Bock Company, a

complete line of components for carbon-dioxide-powered devices is now available. He added that at present only prototype components are available for electrically powered devices. At Mr. McLaurin's request, Dr. Maurice Mongeau of the Rehabilitation Institute of Montreal discussed the use of pneumatically powered devices for bilateral upper-extremity amputees. Mr. Bert R. Titus of the Duke University Medical Center demonstrated a three-function AIPR pneumatically powered arm that had been fitted to a child, saying that perhaps the wrist rotator was the most valuable additional function given to the patient. The work of Northern Electric on an electrohydraulic mechanism was described. In concluding the presentation of new devices, Mr. McLaurin said that hardware means nothing in itself; the components must be clinically directed and placed on patients to be of value.

Special Fitting Centers

Dr. Aitken said that, although precise figures for the entire United States are not available, it appeared that 25 per cent of the child amputee population falls into the severely handicapped category and would greatly benefit from care at specialized prosthetics centers, should such centers be established. For this reason, an *Ad Hoc* Committee on the Planning of Specialized Child Amputee Fitting Centers had been formed. At Dr. Aitken's request, Mr. McLaurin reported on the recommendations of the *ad hoc* committee of which he was chairman (reported in detail in another "News and Notes" item in this issue of *Artificial Limbs*).

Dr. Aitken said that the report of the *ad hoc* committee had been presented for discussion and consideration. He added that specialized prosthetics centers in Canada, Germany, and the United Kingdom caring for thalidomide victims have demonstrated that more sophisticated care can be given to severely handicapped children than is now being given in the United States. A motion was made, and carried unanimously, that the participants in the Conference of Child Amputee Clinic Chiefs accept the philosophy outlined in the report of the *ad hoc* committee.

SCPP Meeting

Dr. Aitken presided at the short executive session of the Subcommittee on Child Prosthetics Problems following the adjournment of the Conference of Child Amputee Clinic Chiefs. Members of the subcommittee present for the session were Sidney Fishman, Ph.D.; Claude N. Lambert, M.D.; Colin A. McLaurin; and Yoshio Setoguchi, M.D. Others present were Clyde M. E. Dolan; Charles H. Epps, Jr., M.D.; Shirley Furgerson; Hector W. Kay, Assistant Executive Director of CPRD; and James R. Kingham, Staff Editor of CPRD.

In connection with the cooperative clinic program, Mr. Kay reported that a number of prospective new member clinics had been visited. After some discussion, it was decided to invite the child amputee clinic of the Shriners Hospital, Greenville, N.C., to become a member, making a total of 27 affiliated clinics. It was noted that several other clinics were rapidly approaching the stage of meeting the criteria for membership.

It was tentatively decided to hold the next Conference of Child Amputee Clinic Chiefs during May 1969.

It was resolved that the *Inter-Clinic Information Bulletin* be continued, and that a schedule for contributions from the clinics be set up.

With respect to child orthotics problems, it was decided to defer action pending the outcome of a conference on orthotics being planned by CPRD.

Evaluation projects currently in prospect included an electric cart, two sizes of hooks, three sizes of Delron wrist units, and a manual lock for shoulder or elbow—all developed at UCLA. Other items included a polycentric knee, a cable recovery unit, and "ankle units" for the swivel walker.

The NYU child amputee census report was accepted for transmission to the Children's Bureau. Consideration was given to various ways by which the census could be carried on as a continuing project.

NYU was encouraged to explore the possibilities for obtaining 10 to 12 OCCC coordinated electric arms for evaluation.

It was tentatively decided that the next meeting of the subcommittee would be during the fall of 1968.

Vito A. Proscia Named Director of Center for Sensory Aids Evaluation and Development at Massachusetts Institute of Technology

The office of the Committee on Prosthetics Research and Development has been advised by Dr. Robert W. Mann, Chairman of the CPRD Subcommittee on Sensory Aids, that Vito A. Proscia has been appointed Director of the Center for Sensory Aids Evaluation and Development at Massachusetts Institute of Technology. Mr. Proscia succeeds John Kenneth Dupress, the Inaugural Director of the Center, who died on December 29, 1967.

Mr. Proscia is a native of New York. He was blinded while in elementary school and completed his preparatory education at the New York Institute for the Blind in the Bronx. He received his Bachelor of Science in physics at City College of New York and his Master of Science in electrical engineering at Columbia University, during which time he was employed by Columbia University's Electronics Research Laboratory as a research engineer on weapon systems and radar analyses. Between 1960 and 1962 he pursued doctoral level studies at the Brooklyn Polytechnic Institute. He was subsequently employed by the Fairchild-Stratos Corporation and then Grumman Aircraft Engineering Corporation as system analyst and in advanced systems engineering.

In 1967 Mr. Proscia came to the New England area as a staff member of the MITRE Corporation.

In concluding his announcement of Mr. Proscia's appointment, Dr. Mann said, "It is thus with some relief and with confidence in the future of the Center that I welcome Vito Proscia as Director."

Dr. Mann is Professor of Mechanical Engineering at MIT and Chairman of the Steering Committee of the Sensory Aids Evaluation and Development Center.

Conference on Engineering in Medicine to be Held in Andover, N.H., during August 1968

A conference on Engineering in Medicine will be held under the auspices of the Engineering Foundation at Proctor Academy, Andover, N.H., August 5-9, 1968. The conference theme will be *Physical Parameters in Multiphasic Screening*. Chairman of the Conference will be Dr. C. A. Caceres, Chief,

Instrumentation Field Station, U.S. Public Health Service, Washington, D.C. Gilbert B. Devey, Executive Secretary of the Committee on the Interplay of Engineering with Biology and Medicine, National Academy of Engineering, will be Co-Chairman of the Conference.

The Conference on Engineering in Medicine will bring together some 100 engineering scientists and representatives of medical science in a joint effort to define the optimal tests to separate normal and abnormal populations. This includes identifying the physiologic changes that characterize or foreshadow diseased states, selecting the tests that most reliably measure these changes, and defining the most economical and efficient means of conducting the tests.

Because physicians are rapidly becoming too scarce to examine asymptomatic populations, health screening clinics are seeking an ideal series of tests that technicians can administer and automated techniques can analyze.

This year's Conference follows a Research Conference sponsored by the Engineering Foundation on *Multiphasic Health Screening Tests* in Milwaukee, Wis., during July 1967, and will aim at defining the specific measurements and tests required in multiphasic examinations. It is hoped that the Conference can produce a report, based upon the five days of presentations and discussions, that governmental agencies, health administrators, and industrial developers will be able to use as a guideline in planning and equipping multiphasic health screening facilities.

A tentative program for the Conference follows:

Monday, August 5	One Year's Progress in Multiphasic Screening Scope for the Future Requirements in Medicine Industrial Perspectives The Engineers' Reply	Wednesday, August 7	Screening Parameters Required Dynamic Parameters Unobtrusive Parameters Requirements of Labor Unions, the Army, a telephone company, and air lines
Tuesday, August 6	Planning for the Physical Parameters Modeling Simulation	Thursday, August 8	Specifications for Physical Parameter Engineering Quality Control Instrumentation Redesign Transducers
		Friday, August 9	Selection of Physical Parameters in Ongoing Multiphasic Screening Projects: A Panel Discussion

The panel on Friday is to be moderated by Dr. Morris F. Collen, Director, Medical Methods Research, Permanente Medical Group, Oakland, Calif. The panel participants will include the project directors of four recently funded multiphasic clinics. The sessions on modeling will be presided over by Dr. Charles Flagle of Johns Hopkins Hospital, currently Special Assistant to the Surgeon General, U.S. Public Health Service. Other Conference participants will include Dr. Otto Schmitt, Professor of Biophysics, University of Minnesota; Dr. John G. Truxal, Provost of Polytechnic Institute of Brooklyn and Chairman of the National Academy of Engineering's Committee on the Interplay of Engineering with Biology and Medicine; and Dr. Donald R. Chadwick, Director of the National Center for Chronic Disease Control, U.S. Public Health Service. Industrial, medical, and other interested leaders in their fields are being invited to attend.

Correction

In the Autumn 1967 issue of the journal, page 67, the item "*Bilateral Hip Disarticulation: Casting, Fabrication and Training*" *Prosthetic-Orthotic Education, Northwestern University* was reported incorrectly. It should have read "*Bilateral Hip Disarticulation: Casting, Fabrication and Training*," *Northwestern University Prosthetic Research Center*. ARTIFICIAL LIMBS regrets the error.

NATIONAL ACADEMY OF SCIENCES—NATIONAL RESEARCH COUNCIL

THE NATIONAL ACADEMY OF SCIENCES is a private, honorary organization of more than 700 scientists and engineers elected on the basis of outstanding contributions to knowledge. Established by a Congressional Act of Incorporation signed by Abraham Lincoln on March 3, 1863, and supported by private and public funds, the Academy works to further science and its use for the general welfare by bringing together the most qualified individuals to deal with scientific and technological problems of broad significance.

Under the terms of its Congressional charter, the Academy is also called upon to act as an official—yet independent—adviser to the Federal Government in any matter of science and technology. 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 and its activities are not limited to those on behalf of the Government.

THE NATIONAL ACADEMY OF ENGINEERING was established on December 5, 1964. On that date the Council of the National Academy of Sciences, under the authority of its Act of Incorporation, adopted Articles of Organization bringing the National Academy of Engineering into being, independent and autonomous in its organization and the election of its members, and closely coordinated with the National Academy of Sciences in its advisory activities. The two Academies join in the furtherance of science and engineering and share the responsibility of advising the Federal Government, upon request, on any subject of science or technology.

THE NATIONAL RESEARCH COUNCIL was organized as an agency of the National Academy of Sciences in 1916, at the request of President Wilson, to enable the broad community of U. S. scientists and engineers to associate their efforts with the limited membership of the Academy in service to science and the nation. Its members, who receive their appointments from the President of the National Academy of Sciences, are drawn from academic, industrial and government organizations throughout the country. The National Research Council serves both Academies in the discharge of their responsibilities.

Supported by private and public contributions, grants, and contracts, and voluntary contributions of time and effort by several thousand of the nation's leading scientists and engineers, the Academies and their Research Council thus work to serve the national interest, to foster the sound development of science and engineering, and to promote their effective application for the benefit of society.

COMMITTEE ON PROSTHETICS RESEARCH AND DEVELOPMENT

COMMITTEE ON PROSTHETIC-ORTHOTIC EDUCATION

The *Committee on Prosthetics Research and Development* and the *Committee on Prosthetic-Orthotic Education*, units of the Division of Engineering and the Division of Medical Sciences, respectively, undertake activities serving research and education in the fields of prosthetics and orthotics, when such activities are accepted by the Academy as a part of its functions. Activities of the Committees are presently supported by the Department of Health, Education, and Welfare and the Veterans Administration. Information or reports developed by activities of the Committees are officially transmitted and published through the National Academy of Sciences.