*Autumn 1964*

# Artificial Limbs

*A Review of Current Developments*

COMMITTEE ON PROSTHETICS RESEARCH AND DEVELOPMENT

COMMITTEE ON PROSTHETIC-ORTHOTIC EDUCATION

**National Academy of Sciences**

**National Research Council**

# Artificial Limbs

VOL. 8 AUTUMN 1964 NO. 2

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COMMITTEE ON PROSTHETICS RESEARCH AND DEVELOPMENT
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# Collaboration for Rehabilitation

MARY E. SWITZER[1]

I WELCOME the opportunity to express my appreciation for the wonderful cooperation and assistance that the Vocational Rehabilitation Administration has enjoyed in our many close relationships with the National Academy of Sciences—National Research Council. Our associations with the Committee on Prosthetics Research and Development and the Committee on Prosthetic-Orthotic Education have been long and fruitful, and the contributions of these committees have been substantial in the development and coordination of the research and informational programs for the fields of prosthetics and orthotics.

VRA is glad to be associated with the National Institutes of Health—which is another agency of the Department of Health, Education, and Welfare—and with the Veterans Administration in supporting the CPRD program; and, naturally, we look with special pride on the CPOE program since we are its primary support.

In our search for the judgment of the most knowledgeable people in each field which we support, the members of our National Advisory Council on Vocational Rehabilitation and the consultants on our Medical Advisory Committee have come to respect the professional competencies of the engineers, physicians, therapists, prosthetists, and orthotists who serve on CPRD. The professional advice and recommendations available to the Academy—Research Council on this basis assure impartial excellence in judgment and accessibility to professional skills that are not readily available from any other source in this country.

I have been particularly impressed with the extensive informational program that CPOE has developed, especially the brochures, films, and slides for use in schools of medicine, physical therapy, and occupational therapy and for the work that has been initiated in the development of new amputee clinics in several of our State programs.

There are special reasons why the functions of the Committees continue to hold special significance to our total rehabilitation program: State-Federal, research and demonstrations, and training activities.

[1] Commissioner, Vocational Rehabilitation Administration, Department of Health, Education, and Welfare, Washington, D. C. 20201.

A recent study was made of the 120,000 persons who were rehabilitated in the State-Federal program during 1964, and it was found that the classifications of amputations, absence of extremities or other orthopedic deformities, accounted for a total of 42,352 persons rehabilitated. Approximately 35 per cent of the total group, therefore, were orthopedic rehabilitants. Thus, it is obvious that, even with the changing emphases in disability groups needing service, the thread of orthopedic disabilities runs through the entire program of rehabilitation, and orthopedic cases are almost four times as large as the next largest category of disability.

The VRA program of research and demonstrations, which began with a trickle ten years ago, has broadened into a flow of new ideas, methods, and patterns of service to facilitate and improve the restoration of the disabled to worthwhile lives. There have been approximately 850 VRA research projects approved during the period 1955–1964, and about seven per cent of these projects have been for studies primarily concerned with problems caused by or related to orthopedic disability. Thirty-one universities, hospitals, or rehabilitation centers have sponsored 55 research projects relevant to this field of work.

During fiscal year 1964, VRA awarded research grants to 13 new projects relating to the orthotic-prosthetic field and an additional 14 ongoing projects received continuation grants.

Some of the most imaginative and creative work in our total program is going on in this field of research, and we are constantly aware of the dramatic advancements that are taking place. The collaboration of medical rehabilitation and engineering with some of the discoveries in the space program should bring a whole new dimension to the war on disability.

So naturally we are pleased that CPRD has followed our recommendation to hold a conference on the Control of External Power in Upper-Extremity Rehabilitation so that leading engineers, physicians, and scientists can come together to formulate and coordinate their programs and assist us in developing future plans for support of their efforts.

Our training program, which continues to pour a steady stream of new professional rehabilitation workers into the ranks, has expanded so that professional training in all of the fields that contribute to rehabilitation has been influenced by VRA training grants: medicine, nursing, physical therapy, occupational therapy, rehabilitation counseling, social work, speech pathology and audiology, rehabilitation of the blind and deaf, the mentally ill and the mentally retarded, and recreation for the ill and disabled.

Since 1953, over 600 short-term courses in prosthetics and orthotics with a total enrollment of about 9,500 trainees have been attended by physicians, surgeons, therapists, counselors, prosthetists, orthotists, and related rehabilitation personnel. Last year alone, over 1,500 persons were enrolled in 90 courses which were a part of the extensive offerings in upper- and lower-extremity prosthetics and orthotics, management of the juvenile amputee, and general orientation courses for these fields. The work of the University Council on Orthotic-Prosthetic Education has done much to achieve a more uniform approach in curriculum offerings, teaching materials and methods, and evaluation procedures for the courses.

The semester courses at UCLA and Northwestern, the Associate in Arts courses proposed at Cerritos College and Chicago City Junior College, and the undergraduate curriculum at New York University—all these attest to the professionalism that is developing in prosthetics and orthotics.

CPRD's and CPOE's paramount asset to us is a technical proficiency while ours is a resource of public funds and a wealth of experience which we try to combine through the State-Federal partnership and our research and training projects into a comprehensive program for helping the disabled to reach their physical, economic, social, and personal goals. Our task, as public servants, is to administer these Federal funds as wisely as we can, always bearing in mind the true function of the law and purpose of our program: to convert dependency into competence and independence. As we work together along the paths of rehabilitation, exchanging our knowledge and our resources, perhaps we can all share in the conviction expressed on the seal of the Department of Health, Education, and Welfare which reminds us constantly that Hope is the Anchor of Life.

Artificial Limbs, Vol. 8, No. 2, pp. 4–14, Autumn 1964

# The Münster-Type Below-Elbow Socket, an Evaluation[1]

SIDNEY FISHMAN, Ph.D.,[2] AND
HECTOR W. KAY, M.Ed.[3]

SHORT stumps have always presented fitting problems in both upper- and lower-extremity amputation sites for the obvious reasons of small attachment area and a lack of useful range of motion. In an attempt to alleviate these problems for upper-extremity amputees, Drs. O. Hepp and G. G. Kuhn (*1*) of Münster, Germany, developed fitting techniques for the below-elbow and the above-elbow amputee, respectively, that provide a more intimate encapsulation of short stumps.

For the below-elbow amputee, the general characteristics of this technique (Fig. 1) are:

1. The elbow is set in a preflexed position (average 35 deg.). Because of the reduced range of useful motion, the socket is flexed so as to position the terminal device in the most generally useful area.
2. A channel is provided at the antecubital space for the biceps tendon to avoid interference between socket and biceps tendon during flexion.
3. The posterior aspect of the socket is fitted high around the olecranon, taking advantage of this bony prominence to provide attachment and stability to the socket.

For the above-elbow amputee, the characteristics of the technique are:

1. The socket is fitted high on the acromian, utilizing this bony structure to retain the socket in position and provide stability.
2. The axillary section of the socket conforms closely around the tendons of the pectoralis major and latissimus dorsi muscles to enable the patient to exert the force of these major muscles in moving his prosthesis.

In an earlier study (*4*), amputee clinics reported a favorable experience in fitting preflexed arms (that is, arms bent to provide a certain amount of preflexion) to children with short and very short below-elbow stumps. Since the Hepp-Kuhn technique seemed to represent an improvement in fittings of the preflexed type, New York University initiated a preliminary investigation of the procedure for adult amputees of this type. This study took place in the early part of 1961 and was limited to two short-below-elbow subjects. This exploratory study yielded generally positive outcomes in terms of function and comfort. One short-above-elbow amputee was also fitted with encouraging results.

The present evaluation is an extension of the initial study with major emphasis given to below-elbow fittings. Concurrently, further exploration of the above-elbow fitting technique was undertaken and is continuing, although not reported in this article.

For lack of a better term, the fitting procedures employed in this study are referred to as the "Münster-type" techniques. It should be emphasized that no claim is made that the techniques are identical to those followed by Drs. Hepp and Kuhn. New York University

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[1] Based upon *The "Müenster" Type Fabrication Technique for Below-Elbow Prostheses*, published by Adult Prosthetic Studies, Research Division, School of Engineering and Science, New York University, New York, N.Y., in June 1964 (*3*). The study reported was conducted under the auspices of the Subcommittee on Evaluation of the Committee on Prosthetics Research and Development, National Academy of Sciences—National Research Council, 2101 Constitution Ave., N.W., Washington, D.C. 20418. The research was sponsored by the Vocational Rehabilitation Administration, Department of Health, Education, and Welfare.

[2] Project Director, Orthotics and Prosthetics, New York University, 252 Seventh Ave., New York, N.Y. 10001.

[3] Associate Project Director, Orthotics and Prosthetics, New York University, 252 Seventh Ave., New York, N.Y. 10001.

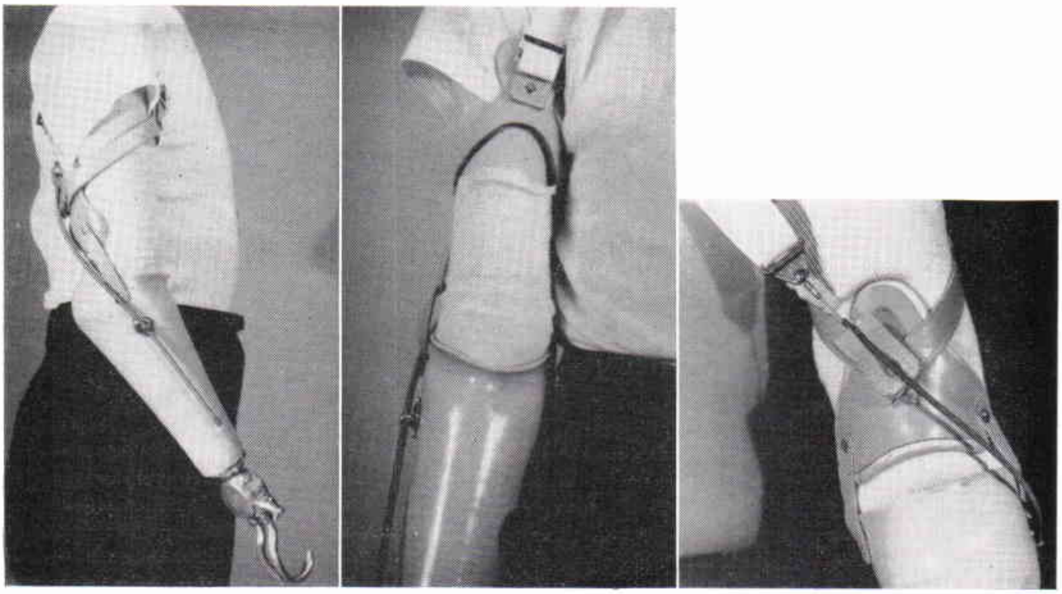



Fig. 1. Münster-type fitting for below-elbow amputee. *A*, Lateral view indicating the preflexion angle; *B*, anterior view indicating high trim line; *C*, posterior view indicating high olecranon fit and the small triceps pad.

personnel witnessed a demonstration of the techniques given by Dr. Kuhn in 1960 and had available the cited reference. However, none of the New York University fittings were either directly or indirectly supervised or checked by the developers.

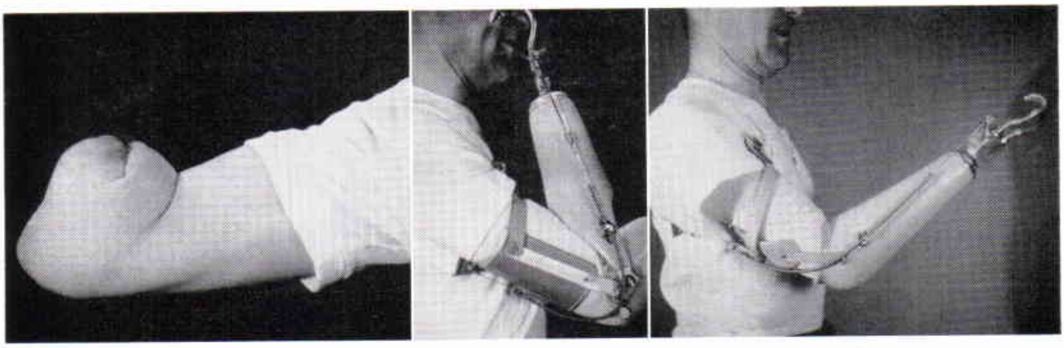
Both logic and prior experience suggest that the greatest benefit from the Münster-type below-elbow fitting technique may accrue to subjects with short and very short below-elbow amputations in that the step-up hinges and split sockets characteristic of typical United States fittings for these categories could be eliminated. Historically, step-up hinges have lacked durability. Moreover, a price is paid for the step-up characteristic by a corresponding decrease in lifting power. Contrariwise, it is apparent that the range of elbow flexion is reduced by the Münster-type fitting. This reduction may or may not be significant in terms of amputee function (Fig. 2).

## The Sample

The sample in this study consisted of eight adult below-elbow amputee subjects (including one bilateral amputee) whose stumps were relatively short—from 3¼ in. to 5½ in. measured from the medial epicondyle to the end of the stump. The physical characteristics of the sample and a description of their previously worn prostheses are given in Tables 1 and 2.

## Methodology

The Münster-type techniques for fitting below-elbow prostheses, as understood by New York University personnel, were followed in fabricating experimental arms for the eight subjects in the sample. In one case (WP), however, the anterior trim line (channel for biceps tendon) was reduced in order to provide this bilateral amputee with a greater range of elbow flexion. All prostheses incorporated triceps pads, leather hinges, and figure-eight harnesses. Six of the eight subjects (OB, PL, TM, WP, ES, and PW) were fitted with polyester porous sockets fabricated in accordance with the technique developed at the Army Medical Biomechanical Research Laboratory (formerly the Army Prosthetics Research Laboratory) (*2*). The other two subjects (DC and QS) were fitted with nonporous plastic sockets.



A B C

Fig. 2. Comparison of split socket and Münster-type fitting of very short below-elbow case. *A*, Very short below-elbow stump—3-¼in.; *B*, split socket with step-up hinge provides 140 deg. of elbow flexion; *C*, Münster-type fitting permits less elbow flexion but enables the amputee to carry considerably greater weight with flexed prosthesis unsupported by harness.

TABLE 1. CHARACTERISTICS OF THE SAMPLE ($N = 8$)

| Subject | Sex | Age | Site | Stump Length (in.) | % of Sound Side | Occupation |
|---|---|---|---|---|---|---|
| OB | M | 64 | LBE | 5⅜ | 54 | Salesman |
| DC | M | 35 | RBE | 3¼ | 34 | Administrative Research Assistant |
| PL | M | 60 | RBE | 4⅞ | 51 | Unemployed |
| TM | M | 41 | RBE | 3½ | 33 | Public Relations Representative |
| WP | M | 40 | LBE | 5½ | 52 | Social Worker |
| | | | RBE | 4 | 37 | |
| ES | F | 38 | LBE | 4 | 47 | Teacher |
| QS | M | 53 | LBE | 4¼ | 40 | Unemployed |
| PW | M | 45 | LBE | 5½ | 56 | Attorney |

TABLE 2. CHARACTERISTICS OF CONVENTIONAL PROSTHESES

| Subject | Terminal Device | Wrist Unit | Socket | Hinges | Harness |
|---|---|---|---|---|---|
| OB | APRL Hand | Friction | Plastic Porous Laminate | Single Pivot | Half-Cuff Figure-8 |
| DC | Sierra 2-Load Hook | Friction | Plastic Split-Socket | Step-up | Half-Cuff Figure-8 |
| PL | Becker Hand | Friction | Wood | Single Pivot | Full Cuff None |
| TM | APRL Hook | Quick Disconnect | Plastic Porous Laminate | Single Pivot | Half-Cuff Figure-8 |
| WP | | | | | |
| R | English Hook | Quick Disconnect | Leather | Single Pivot | Half-Cuffs |
| L | English Hand | Friction | Leather | Single Pivot | Modified Bilateral Figure-8 |
| ES | Passive Hand | Friction | Wood | Single Pivot | Half-Cuff No Harness |
| QS | Dorrance Hook | Hosmer FM-100 Quick Disconnect | Plastic | Polycentric | Half-Cuff Figure-8 |
| PW | APRL Hand | Friction | Plastic Porous Laminate | Flexible Leather | Half-Cuff Figure-8 |

The evaluation consisted essentially of a "before" and "after" comparison of status. The prosthetic status of all subjects in this study was assessed prior to their fitting with the Münster-type prosthesis in order to obtain a basis for later comparison. At one month and at six months after delivery of the experimental prosthesis, the prosthetic status of the subjects was reevaluated and comparisons between the conventional and experimental prostheses were drawn.

The stumps of all subjects were examined prior to the experimental fitting in order to identify their condition (scars, irritations, discolorations, etc.). This examination was repeated at the specified intervals to see what effect, if any, the experimental socket had had on the physical condition of the stump.

Two self-administering rating scales completed by all subjects elicited their opinions regarding prosthetic comfort, function, and cosmesis. A questionnaire was administered prior to the experimental fitting to assess the amputees' opinions regarding their conventional prostheses. A comparative questionnaire was administered in the post-fitting evaluations to compare the experimental and the conventional prosthesis in the factors previously rated.

A prosthetic-usefulness schedule (*3*) was applied to the six subjects who had previously worn a functional prosthesis to investigate their opinions concerning the relative value and comparative ease of performance of the conventional and experimental prostheses in the areas of work, home tasks, social life, dressing, and eating.

Three evaluation procedures were administered to the six subjects who had previously worn functional prostheses, as follows:

1. The angles of preflexion and maximum flexion were measured on both conventional and experimental prostheses, as well as the amount of vertical downward force the amputees could resist with their elbows flexed at 90 deg. (live lift) and fully extended (axial load).
2. The accuracy of positioning control exhibited by the amputees was measured with both conventional and experimental prostheses. Scoring of performance on the positioning control test (*3*) was in terms of accuracy and speed.
3. The amputees' ability to perform a series of 12 bimanual practical activities was rated on a seven-point scale. For each activity, six factors were rated independently but simultaneously by two experienced examiners. This evaluation was administered initially to the amputees with their conventional prostheses and then repeated with the experimental prostheses at the one-month and at the six-month post-fitting evaluations.

## Results

### STUMP EXAMINATIONS

In all cases a period of two to three weeks was required for the subjects to become adjusted to the more intimate fit of the Münster-type socket. During this initial wear period, the usual complaint was of an irritation in the medial epicondylar area, which was corroborated by visual examination. However, after this adjustment period, the experimental socket had no observed or reported effects on the amputation stump, although amputees were generally aware of increased pressure on the olecranon when the forearm was flexed.

### AMPUTEE REACTIONS

Comparative reactions to the conventional and experimental prostheses were obtained from the eight subjects in the sample. The factors investigated and the amputees' ratings are presented in Table 3.

It is clear from Table 3 that, with few exceptions, the amputees reacted very favorably to the Münster-type prosthesis. Sixty per cent of the responses were favorable toward the experimental item while only five per cent were unfavorable. The two factors which brought forth negative reactions were comfort (two subjects) and adjustments (two subjects). These negative reactions reflect difficulties experienced by these two amputees in adjusting to the intimate fit of the Münster-type socket. However, all seven subjects in the sample who had previously worn rigid hinges of one type or another cited the elimination of these hinges as a definite contribution to comfort.

No differences in reactions which could be attributed to socket porosity, or lack of it, were noted. The fact that the wear period for most of the subjects was confined to the winter months may explain this lack of difference.

The data on effort and control are of particular interest. All subjects in the sample reported improvement in these factors as a result of wearing the experimental prosthesis. Further questioning revealed that the ampu-

TABLE 3. AMPUTEE REACTIONS, EXPERIMENTAL VS. CONVENTIONAL ($N = 8$)

| Factors Compared | Composite Opinions | | | | |
|---|---|---|---|---|---|
| | Much Better | Somewhat Better | Same | Somewhat Worse | Much Worse |
| Comfort | — | 5 | 1 | 2 | — |
| Weight | 5 | 1 | 2 | — | — |
| Effort | 5 | 3 | — | — | — |
| Function | 5 | 2 | 1 | — | — |
| Control | 7 | 1 | — | — | — |
| Noise | 1 | 1 | 6 | — | — |
| Adjustments | — | — | 6 | 2 | — |
| Cosmesis | 2 | 4 | 2 | — | — |
| Activities | 4 | 1 | 3 | — | — |
| Durability | 1 | — | 7 | — | — |
| Totals | 30 | 18 | 28 | 4 | — |
| Percentage | 37 | 23 | 35 | 5 | — |

tees' opinions regarding improved prosthetic control with less expenditure of effort appeared directly attributable to the more intimate fit of the Münster-type socket. This reaction was commonly expressed by such statements as: "The prosthesis feels a part of me" and "I feel right-handed again." Several subjects reported that the Münster-type sockets did not tend to slip off their stumps under load, as was the case with their conventional sockets. One subject cited the more secure fitting of the Münster-type socket to be particularly advantageous in performing overhead activities because his stump did not slip out of the socket when he performed a pulling motion with the prosthesis.

The reactions of the two subjects (ES and PL) who had previously worn nonfunctional prostheses (for 15 and 20 years, respectively) are noteworthy. Neither became especially skillful prosthesis users in the course of the study, but both did come to use their terminal devices for grasp, which they had not previously done. Their highly positive responses to the experimental item and the fact that it changed their prosthetic status from that of nonusers to users after so long a period were considered quite unusual. Since both patients were fitted with porous laminate sockets, the role of the Münster-type fitting is not completely "pure" but, at least, must be regarded as contributory.

Of the six subjects who had previously worn functional devices, five were able to perform the same number of activities with the experimental prostheses as with the conventional, while one subject reported increased prosthetic function with the Münster-type prosthesis (for example, he was able to carry a coat on his flexed forearm and was able to use his prosthesis in steering a car). However, all six amputees indicated that activities were easier to perform with the experimental prosthesis because the close-fitting socket afforded better control and the elimination of the rigid hinges provided greater freedom.

In no case was there any evidence that the decreased range of motion with the experimental prostheses caused an appreciable decrease in prosthetic function. Since unilateral amputees routinely use their prostheses as assistive devices, there are few activities that are performed prosthetically at the extreme ends of the flexion-extension range. Bilateral subjects, however, are dependent on their prostheses for all upper-extremity functions and therefore require a greater range of motion. To provide the bilateral subject in our sample with an increased range of elbow flexion on his dominant side (40 deg. to 120 deg.), the anterior trim line was lowered. In addition, a wrist-flexion unit was provided to facilitate the performance of tasks close to his body.

## FUNCTIONAL EVALUATION

### *Biomechanical Data*

The Münster technique provides an intimate encapsulation of the amputated stump

Table 4. Comparison of Elbow-Flexion Range ($N = 9$)

| Subject | Preflexion | | Maximum Flexion | |
|---|---|---|---|---|
| | Conventional deg. | Experimental deg. | Conventional deg. | Experimental deg. |
| OB | 12 | 20 | 97 | 85 |
| DC | 15 | 34 | 135 | 95 |
| PL | 15 | 45 | 120 | 110 |
| TM | 15 | 32 | 105 | 97 |
| WP | | | | |
| R | 15 | 40 | 110 | 100 |
| L | 15 | 40 | 135 | 120 |
| ES | 30 | 35 | 125 | 116 |
| QS | 15 | 30 | 135 | 113 |
| PW | 15 | 35 | 135 | 104 |
| Means | 16.33 | 34.55 | 121.88 | 104.44 |

Table 5. Comparison of Holding Forces ($N = 7$)

| Subject | Live Lift (ft./lbs.) | | Axial Load (lbs.) | |
|---|---|---|---|---|
| | Conventional | Experimental | Conventional | Experimental |
| OB | 18 | 22 | 40 | 50 |
| DC | 2 | 10 | 35 | 70 |
| TM | 18 | 24 | 50 | 60 |
| WP | | | | |
| R | 4 | 12 | 35 | 30 |
| L | 9 | 31 | 40 | 29 |
| QS | 9 | 10 | 40 | 21 |
| PW | 14 | 23 | 30 | 45 |
| Means | 10.57 | 18.85 | 38.57 | 43.57 |

which results in a decreased range of motion. Forearm rotation is virtually eliminated, and the elbow flexion-extension range is significantly reduced. However, this type of fitting frequently increases the amputees' ability to resist moments about the elbow and to sustain axial loads.

A comparison of the flexion ranges of the conventional and experimental prostheses is presented in Table 4.

The preflexion angle of the Münster-type socket ranged from 20 deg. to 45 deg., with an average of 35 deg. The exact preflexion angle was planned for each subject contingent on such factors as stump length, natural elbow motion, and amputee preference. Maximum flexion of the experimental sockets ranged from 85 deg. to 120 deg. with an average of 105 deg.

Table 5 compares the maximum holding forces that amputees (the six who had previously worn functional prostheses) were able to maintain with both prostheses. "Live lift" refers to the amount of vertical downward force (applied at the terminal device) that an amputee can resist while maintaining his elbow at 90 deg. (Fig. 3). To allow for different forearm lengths, the data are expressed in foot-pounds. "Axial load" refers to the amount of vertical downward force applied at the terminal device that an amputee was able to resist with his elbow in an extended position. A complaint of pain or one-inch slippage

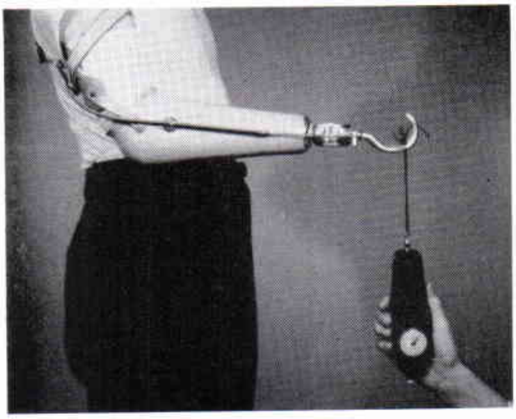


Fig. 3. Live-lift test.

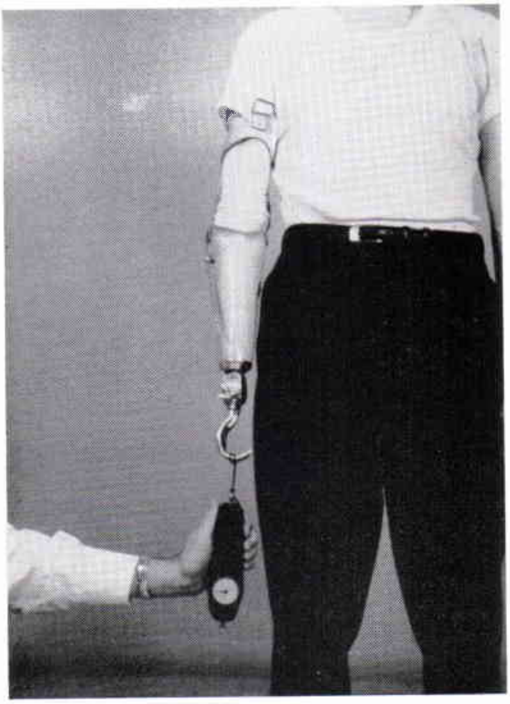


Fig. 4. Axial-load test.

of the socket on the stump was taken as the maximum tolerable load (Fig. 4).

In all cases the amputees were able to resist a greater force in the live-lift test with their Münster-type prostheses than with their conventional prostheses. For three subjects (DC, WP, and PW) the differences were very significant. In subject DC's case, this difference can be readily understood since he had previously worn a split socket and step-up hinge with an inherent mechanical disadvantage. For subjects WP and PW (prior single-pivot and flexible-hinge wearers, respectively), it is speculated that their improved lifting power was directly related to the more intimate fit of the experimental sockets. However, it is not clear why the same ratio of improvement did not obtain for the other subjects.

Four of the six subjects were able to resist a greater axial load with the Münster-type prostheses than with their conventional prostheses. The maximum axial load on the experimental prosthesis for the other two subjects was limited by stump pain, particularly in the epicondylar area.

*Positioning Control Test*

The positioning control test investigated the amputees' ability to control their prostheses; that is, to bring the terminal device to a desired location in space with measured speed and accuracy. Specifically, it tested the skill of the amputees in striking designated targets in the vertical (on the wall) and horizontal (on a table) planes. Three different sequences were applied in the vertical plane and two in the horizontal. Accuracy was measured by the distance of a mark (made by a pencil held in the terminal device) from the target. Superior prosthetic performance therefore is indicated by the lower scores and performance times. Tables 6 and 7 present the data for the three vertical and two horizontal sequences of the positioning control tests, respectively.

Analysis of the data of the positioning control test reveals minimal differences between the conventional and the experimental prostheses. In the vertical sequences, these differences favored the experimental prostheses slightly, with regard to accuracy, but the reverse is true regarding speed. In the horizontal sequences the experimental prostheses were slightly favored in both accuracy and speed. However, none of the differences proved statistically significant.

*Practical Activities Test*

Comparative performance data were obtained on five subjects in the sample. Two of

TABLE 6. POSITIONING CONTROL TEST SCORES (VERTICAL SEQUENCES) ($N = 7$)

| Subject | Sequence I | | | | Sequence II | | | | Sequence III | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Accuracy (in.) | | Speed (sec.) | | Accuracy (in.) | | Speed (sec.) | | Accuracy (in.) | | Speed (sec.) | |
| | Conv. | Exp. | Conv. | Exp. | Conv. | Exp. | Conv. | Exp. | Conv. | Exp. | Conv. | Exp. |
| OB | .23 | .23 | 14 | 15 | .20 | .28 | 30 | 40 | .19 | .29 | 34 | 43 |
| DC | .14 | .17 | 15 | 12 | .15 | .18 | 33 | 25 | .23 | .14 | 38 | 27 |
| TM | .18 | .12 | 17 | 14 | .21 | .14 | 32 | 39 | .28 | .15 | 37 | 47 |
| WP | | | | | | | | | | | | |
| R | .21 | .18 | 16 | 21 | .27 | .16 | 36 | 52 | .25 | .18 | 60 | 64 |
| L | .19 | .14 | 15 | 19 | .30 | .21 | 42 | 47 | .20 | .13 | 48 | 51 |
| QS | .20 | .24 | 10 | 9 | .17 | .22 | 26 | 19 | .27 | .21 | 30 | 40 |
| PW | .31 | .21 | 11 | 13 | .34 | .25 | 27 | 26 | .29 | .23 | 38 | 37 |
| Means | .20 | .18 | 14 | 15 | .23 | .21 | 32 | 35 | .24 | .19 | 41 | 44 |

TABLE 7. POSITIONING CONTROL TEST SCORES (HORIZONTAL SEQUENCES) ($N = 7$)

| Subject | Sequence I | | | | Sequence II | | | |
|---|---|---|---|---|---|---|---|---|
| | Accuracy (in.) | | Speed (sec.) | | Accuracy (in.) | | Speed (sec.) | |
| | Conv. | Exp. | Conv. | Exp. | Conv. | Exp. | Conv. | Exp. |
| OB | .15 | .16 | 22 | 22 | .25 | .26 | 21 | 22 |
| DC | .25 | .15 | 11 | 10 | .23 | .16 | 14 | 11 |
| TM | .10 | .19 | 17 | 17 | .07 | .10 | 21 | 21 |
| WP | | | | | | | | |
| R | .20 | .16 | 17 | 18 | .19 | .15 | 25 | 21 |
| L | .22 | .10 | 17 | 19 | .20 | .15 | 20 | 18 |
| QS | .15 | .15 | 15 | 11 | .25 | .23 | 18 | 18 |
| PW | .21 | .22 | 14 | 11 | .20 | .17 | 19 | 16 |
| Means | .18 | .16 | 16 | 15 | .20 | .17 | 20 | 18 |

the remaining three subjects were not tested because they had no prior experience with a functional prosthesis. The third subject (WP) had previously worn English-made components (terminal devices, wrist units) which it was not possible to duplicate in his experimental prosthesis. Since these different terminal devices would have introduced an extraneous variable into the experimental situation, the data from this subject are not included here.

Performance data were obtained on a 12-item practical activities test. The activities were: using a pencil sharpener, tying a necktie, tying a shoelace, carrying several packages, filing a fingernail, hammering a nail, opening a jar, putting on a glove, using a can opener, using a paper clip, using a telephone and taking a message, and removing bills from a wallet. Six factors, each rated on a seven-point scale, were considered for each test activity. The factors were: position of the prosthesis for use, grasp of the object (secure or insecure), position of object for use (efficient or inefficient), maintenance of position of object during use (efficient or inefficient), appearance of performance (natural or unnatural), adequacy of general performance (efficient or inefficient). The average scores for each subject in these six factors are presented in Table 8, with the higher scores reflecting better performance. The average performance times for each subject are shown in Table 9.

TABLE 8. COMPARATIVE PERFORMANCE RATINGS ($N = 5$)

| Subject | Prosthesis Positioning for Use | | Factors: Grasp Security | | Object Positioning for Use | | Maintenance of Object Position during Use | | Appearance of Performance | | General Adequacy of Performance | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Conv. | Exp. | Conv. | Exp. | Conv. | Exp. | Conv. | Exp. | Conv. | Exp. | Conv. | Exp. |
| OB | 5.3 | 5.5 | 5.3 | 5.5 | 5.2 | 5.5 | 5.3 | 5.5 | 5.1 | 5.5 | 5.1 | 5.5 |
| DC | 6.2 | 6.3 | 6.2 | 6.3 | 6.2 | 6.2 | 6.2 | 6.3 | 6.1 | 6.1 | 6.3 | 6.6 |
| TM | 5.9 | 6.1 | 5.9 | 6.1 | 5.9 | 6.0 | 5.9 | 6.0 | 5.9 | 6.0 | 5.9 | 6.0 |
| QS | 5.8 | 5.9 | 5.8 | 5.6 | 5.8 | 5.7 | 5.5 | 5.6 | 5.5 | 5.5 | 5.6 | 5.9 |
| PW | 5.8 | 6.0 | 5.8 | 6.0 | 6.0 | 6.0 | 5.8 | 6.0 | 5.8 | 5.8 | 6.0 | 5.8 |
| Means | 5.8 | 5.9 | 5.7 | 5.9 | 5.8 | 5.8 | 5.7 | 5.8 | 5.6 | 5.7 | 5.7 | 5.9 |

TABLE 9. COMPARATIVE PERFORMANCE TIMES ($N = 5$)

| Subject | Time (sec.) | |
|---|---|---|
| | Conventional | Experimental |
| OB | 12.8 | 10.8 |
| DC | 6.2 | 6.1 |
| TM | 7.0 | 7.6 |
| QS | 12.5 | 14.6 |
| PW | 6.8 | 7.6 |
| Means | 9.0 | 9.3 |

The data from Table 8 indicate that there were apparently no significant differences in performance between the Münster-type and conventional prostheses, and the time comparisons in Table 9 present no clearcut patterns. Two implications of these findings are of interest. First, the obvious and measurable decrease in range of forearm flexion imposed by the Münster-type fitting has no discernible effect on the bimanual performance of unilateral amputees. Second, the highly favorable reactions of subjects to the function and control aspects of the experimental arm were not corroborated by the performance-test data. This apparent lack of agreement may derive from two factors, either singly or in combination: some subtle but important differences in performance did exist but were not detectable by the observational testing procedures applied, or the more intimate and perhaps better fit of the experimental prosthesis (as compared to the conventional) created a "halo" effect which positively affected opinions concerning other aspects of the prosthesis. That is to say, since the prosthesis felt better, it must necessarily perform better.

## APPLICABILITY OF THE TECHNIQUE

Since it was hypothesized that the experimental item might have prime applicability to amputees whose stumps fell into the very short or short categories, attention was focused in the study on the fitting of such subjects. However, it was also of interest to investigate the range of stump lengths (or types) for which the Münster-type fitting might be suitable.

In the New York University sample the shortest stump fitted was 3¼ in. To investigate the possibility of fitting stumps *shorter* than this, a cast and check socket were made for a bilateral amputee with a 2½ in. below-elbow stump on one side (currently wearing a stump-actuated elbow lock) and an above-elbow stump on the other side. Since the below-elbow stump virtually disappeared at 90 deg. of flexion, it was thought that this was the absolute maximum flexion angle that might be obtained. This limitation was not considered acceptable for the dominant prosthesis of a bilateral amputee. It was also considered that this stump length was very near the lower limit for acceptable fitting, even for a unilateral amputee.

With respect to maximum stump length, two limiting factors are observed:

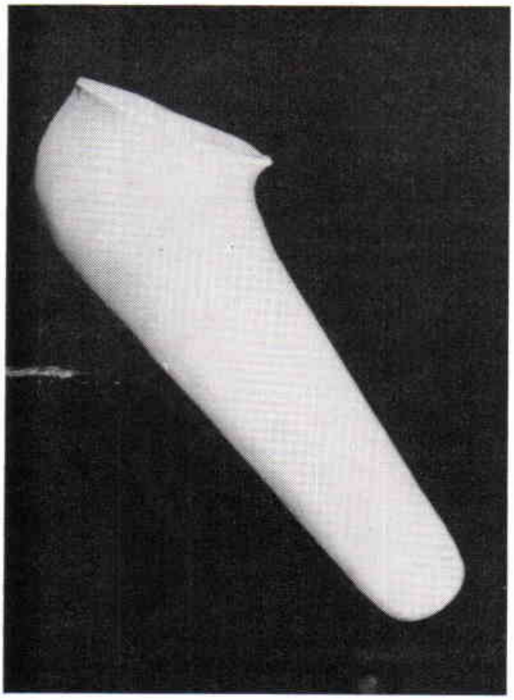


Fig. 5. View of Münster-type socket showing the sharp angle of the proximal opening in relation to shaft.

1. Stumps of mid-length and longer usually have some amount of pronation-supination which can be harnessed in a conventional below-elbow socket (with flexible hinges), but not in the Münster-type socket.
2. The configuration of the Münster-type socket (proximal opening at a sharp angle to the shaft) presents progressively increasing difficulty to donning and doffing as stump length increases (Fig. 5).

In the New York University series, in which the longest stumps fitted were 5½ in. (two subjects), neither of the above considerations was significant in either case. It is estimated, however, that the stumps of these two subjects were approaching the upper length limit to which the Münster-type socket could be applied without sacrifice of residual pronation-supination, or modification of the proximal socket to facilitate donning and doffing.

Subject to further study, therefore, it appears that the Münster-type socket can be applied to the range of below-elbow-stump types for which rigid hinges (step-up, multiple action, and single-pivot) are typically prescribed at present. Some consideration probably should be given to the development of a prosthesis that will permit stump-actuated pronation and supination of the terminal device, yet retain the stability afforded by the Münster-type socket.

## Summary and Conclusions

The applicability of Münster-type fittings was investigated by New York University. The sample for this study consisted of eight subjects with below-elbow amputations ranging from 3¼ in. to 5½ in. (34 to 52 per cent). The results of the evaluative procedures, which included interview techniques and performance testing, indicated the following:

1. A brief "breaking-in" period was required by all subjects to adjust to the more intimate fit of the Münster-type socket. After this initial period of adjustment, the experimental sockets had no observable or reported effects on the amputation stumps except a slight increase in pressure on the olecranon during lifting activities. The use of soft (Silastic) inserts over the epicondyles and olecranon to ameliorate these factors is under investigation at New York University.
2. The subjective opinions of all subjects were heavily in favor of the Münster-type prostheses.
3. The decrease in flexion range had no appreciable effect on prosthetic function for the unilateral amputees. For bilateral subjects, modification of the anterior trim line and provision of a wrist-flexion device may be necessary for performance of tasks close to the body.
4. The lifting and holding forces demonstrated by the amputees were generally better with the Münster-type prostheses.
5. The data from the positioning control and practical activities testing were inconclusive.

The evidence suggests, therefore, that the Münster-type prostheses are functionally advantageous with considerable cosmetic and comfort appeal for amputees with very short to medium below-elbow stumps.

## Recommendations

Based on the results of this study, it is recommended that:

1. The Münster fabrication technique be accepted as a satisfactory means of fitting below-elbow amputees. Prime applications would be for patients with unilateral losses whose stump lengths were classified in the short and very short categories.
2. Upon completion of the detailed fabrication manual now being prepared by New York University, the Münster below-elbow fabrication technique be introduced into the curricula of the Prosthetics Education Programs.

## Literature Cited

1. Hepp, O., and G. G. Kuhn, *Upper extremity prostheses*, Proceedings of the Second International Prosthetics Course, Copenhagen, Denmark, July 30 to August 8, 1959, Committee on Prosthetics, Braces, and Technical Aids, International Society for the Welfare of Cripples, Copenhagen, Denmark, 1960, pp. 133–181.
2. Hill, James T., and Fred Leonard, *Porous plastic laminates for upper-extremity prostheses*, Artificial Limbs, Spring 1963, pp. 17–30.
3. New York University, Adult Prosthetic Studies, Research Division, School of Engineering and Science, *The "Muenster" type fabrication technique for below-elbow prostheses*, June 1964.
4. New York University, Child Prosthetic Studies, Research Division, College of Engineering, *Final report, preflexed arm study*, November 1960.

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# Acceptability of a Functional-Cosmetic Artificial Hand for Young Children, Part II[1]

SIDNEY FISHMAN, Ph.D.,[2] AND
HECTOR W. KAY, M.Ed.[3]

IN THE study of the APRL-Sierra No. 1 right hand, which preceded that of the left, the results of comparative performance testing indicated that there was little difference between the hand and the hook on the various test activities. Statements of children participating in the study—and of their parents—indicated a relatively high level of performance with the experimental hand, but advantages and disadvantages were not clearly defined.

These results appeared to be at variance with past clinical impressions, which indicated that a hand was a significantly less functional terminal device than a hook. Hence, in the Left-Hand Study the performance tests were repeated to check the results of the earlier study. An attempt was also made to delineate more completely the relative usefulness of the two devices by obtaining data concerning their effectiveness in a wide variety of activities.

## PERFORMANCE TESTS

As indicated in Part I of this two-part series of articles, the child amputees participating in these studies were required to make four visits to the clinics servicing them, during a period of five months. The first visit was a screening session to select suitable candidates; on the second visit the child was fitted with the experimental hand; the third visit, two months after the fitting, was for the purpose of making evaluative comparisons between the old and the new terminal devices; and the purpose of the fourth visit, four months after the fitting, was to make a final evaluation.

A prosthetic performance test, utilizing the old terminal device, was given the child on the second visit. On the third visit the same performance test was administered, utilizing first the APRL-Sierra hand and then the old terminal device. The prosthetic performance test required the child to perform six activities, upon each of which he was timed and rated. The activities were:

1. Unscrewing and reassembling five small plastic barrels ("Kitty in the Kegs") (Fig. 1).
2. Drying a wet cup, saucer, and dinner plate, using a dish towel (Fig. 2).
3. Putting on a shirt or dress—as appropriate—and shoes and socks (Fig. 3).

[1] Part I appeared in the Spring 1964 issue of *Artificial Limbs*. Both Part I and Part II are based upon *Acceptability of a Functional-Cosmetic Hand for Young Children*, published by Child Prosthetic Studies, Research Division, College of Engineering, New York University, New York, N.Y., in January 1964 (*1*). Part I covered the history and purposes of the study, a description of the experimental hand (APRL-Sierra No. 1 hand), a description of the sample used in the studies, an account of the reactions of the children, their parents, and others to the hand, observations of classroom behavior during the period, and prescription considerations. Part II covers the children's performance of standard tasks with the hand and its functional capabilities and limitations. The studies reported were conducted under the auspices of the Subcommittee on Child Prosthetics Problems of the Committee on Prosthetics Research and Development, National Academy of Sciences—National Research Council, 2101 Constitution Ave., N.W., Washington, D.C. 20418. The research was sponsored by the Children's Bureau of the Department of Health, Education, and Welfare under a special grant.

[2] Project Director, Orthotics and Prosthetics, New York University, 342 East 26th St., New York, N.Y. 10010.

[3] Associate Project Director, Orthotics and Prosthetics, New York University, 342 East 26th St., New York, N.Y. 10010.

Fig. 1. "Kitty in the Kegs," a set of small plastic barrels, one inside the other. A picture of a kitten is in the innermost barrel.

Fig. 4. "Loony Links." The child is asked to assemble a jointed doll and stand it on its feet, using a preassembled doll as a model.

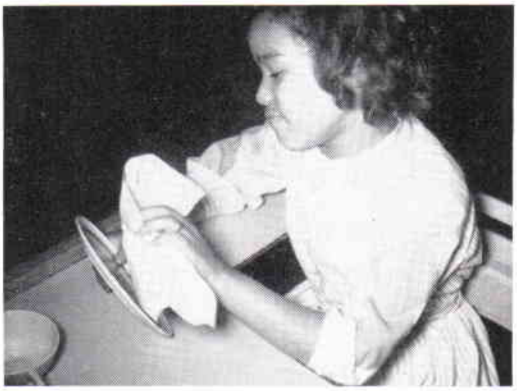


Fig. 2. Drying dishes.

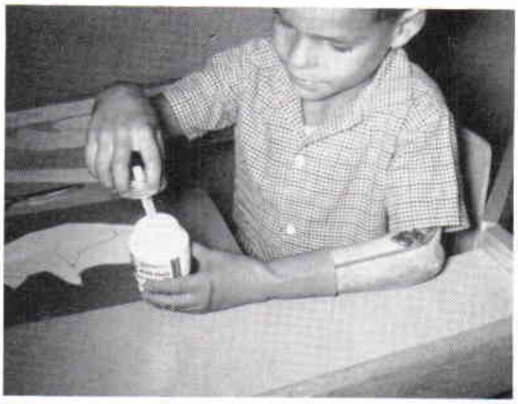


Fig. 5. Cutting and pasting.

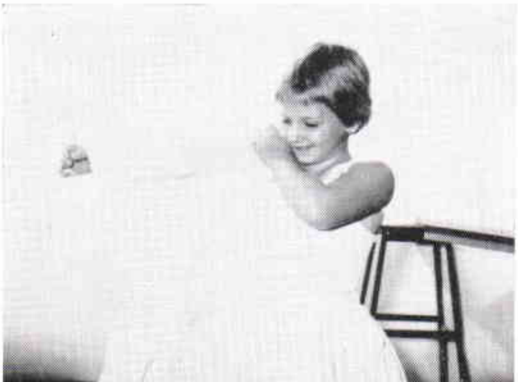


Fig. 3. Putting on clothes.

Fig. 6. Eating ice cream.

4. Assembling a jointed doll ("Loony Links") (Fig. 4).

5. Cutting out a printed figure and pasting it to a piece of paper (Fig. 5).

6. Eating ice cream from a paper cup, using a metal spoon (Fig. 6).

Typically, the test was administered by an occupational therapist. The rating scale employed ranged downward from a score of 5 for performance approximating that of a nonamputee to 1 for performance in which the terminal device was not used, in accordance with the following subjective criteria:

| Rating | Criteria |
|---|---|
| 5 | A nearly normal bilateral performance in which the terminal device seems essential; that is, it is used to perform active functions in addition to and more advanced than holding, such as grasp and transportation and manipulation of the object. |
| 4 | A bilateral pattern in which the terminal device is a significant aid in grasping or hooking. |
| 3 | The terminal device is used for occasional grasping only, alternating with passive use. |
| 2 | The terminal device is used passively for pushing, weighting, or support, but not for grasp. |
| 1 | The terminal device is not used, although the elbow and forearm may be used as an aid. Ratings of 1.5, 2.5, 3.5, and 4.5 were interpolated to indicate performance whose quality was between two categories. |

Each child's performances with hook and hand were compared on the basis of best scores obtained while utilizing each device. In the Left-Hand Study performance times with each device were also obtained. The comparative data are presented in Tables 1, 2, and 3.

Table 1. Comparative Mean Performance Ratings, Hook vs. Hands, Right- and Left-Hand Studies

| Activity | Right Hand (N = 32) | | Left Hand (N = 36) | |
|---|---|---|---|---|
| | Hook | Hand | Hook | Hand |
| Kitty in the Kegs | 4.23 | 4.05 | 4.42 | 4.00 |
| Dry Dishes | 4.06 | 3.62 | 4.19 | 3.60 |
| Put on Clothes | 3.45 | 2.77 | 3.83 | 2.94 |
| Loony Links | 3.87 | 3.75 | 4.01 | 3.46 |
| Cut and Paste | 3.58 | 2.87 | 3.95 | 3.03 |
| Eat Ice Cream | 3.16 | 2.72 | 3.35 | 2.68 |

There are obvious limitations to these data, in that the tests may have differed with individual children (the type of clothing donned, for example), and there were undoubtedly differences in the frames of reference employed by different therapists in rating a given performance. Since the data themselves are of doubtful precision, the application of tests of statistical precision is not indicated. Within these limitations, however, there is evidence that:

1. Mean performance ratings in all activities were higher for the hook (Table 1), which clearly appeared to be the better device functionally. Its superiority was most evident in the test activities of "Put on Clothes" and "Cut and Paste." The smallest differences in mean ratings were found in the "Kitty in the Kegs" and "Loony Links" tests. Both of these latter activities involve the grasping of objects for

Table 2. Comparative Effectiveness of Performance, Hooks vs. Hands, Right- and Left-Hand Studies

| Activity | Better Performance | | | | | | Hook and Hand Equal | | | Could Not Do or Not Reported |
|---|---|---|---|---|---|---|---|---|---|---|
| | Hook | | | Hand | | | | | | |
| | Right | Left | Total | Right | Left | Total | Right | Left | Total | |
| Kitty in the Kegs | 7 | 17 | 24 | 2 | 1 | 3 | 23 | 18 | 41 | 0 |
| Dry Dishes | 13 | 16 | 29 | 5 | 2 | 7 | 14 | 17 | 31 | 1 |
| Put on Clothes | 16 | 23 | 39 | 2 | 0 | 2 | 13 | 12 | 25 | 2 |
| Loony Links | 6 | 19 | 25 | 4 | 0 | 4 | 22 | 17 | 39 | 0 |
| Cut and Paste | 16 | 24 | 40 | 4 | 4 | 8 | 12 | 6 | 18 | 2 |
| Eat Ice Cream | 15 | 17 | 32 | 3 | 2 | 5 | 14 | 16 | 30 | 1 |
| Totals | | | 189 | | | 29 | | | 184 | |

TABLE 3. COMPARATIVE SPEED OF PERFORMANCE, HOOKS VS. HANDS, LEFT-HAND STUDY

| Activity | Better Performance | | Hook and Hand Equal | Could Not Do, or Not Reported |
|---|---|---|---|---|
| | Hook | Hand | | |
| Kitty in the Kegs | 25 | 8 | 3 | 0 |
| Dry Dishes | 26 | 7 | 2 | 1 |
| Put on Clothes | 23 | 10 | 1 | 2 |
| Loony Links | 24 | 6 | 6 | 0 |
| Cut and Paste | 17 | 3 | 15 | 1 |
| Eat Ice Cream | 26 | 9 | 1 | 0 |

which the active fingers and thumb of the hand are relatively well adapted.

2. In a total of 408 hook- and hand-performance comparisons shown in Table 2 (68 children performing 6 activities with each device), hook performance was rated as superior in almost half the instances (189 times). Interestingly enough, however, hook and hand performances were rated as equal almost as frequently (184 times), although hand performance was considered better in only a relatively insignificant number of cases (29). In this tabulation of the data also, the superiority of the hook appears less marked in the same two test items—"Kitty in the Kegs" and "Loony Links."

3. The comparative time data (Table 3) indicate that in the majority of instances hook performance was faster as well as more effective than hand performance, although again the results are by no means unanimous.

It is interesting to note (Tables 1 and 2) that in the Left-Hand Study the performance ratings more clearly reflected the functional superiority of the hook than was the case in the tests with the right hand. For example, only seven children of 32 were rated as performing the "Kitty in the Kegs" test better with the hook in the Right-Hand Study. In contrast, 17 of 36 children had better ratings utilizing the hook in this activity in the Left-Hand Study. A similar marked difference in comparative ratings is evident in the "Loony Links" task. In the other test activities, the differences diminished until in the "Eat Ice Cream" item the right- and left-hand data are almost identical.

The reasons for these differences are not clear. The subjectivity of the rating scale may, of course, have been a consideration. However, since the trend of the data is consistent, that is, favoring higher comparative hook ratings in the Left-Hand Study, it would appear that other than chance factors are operative.

Handedness might possibly be a factor, but unfortunately data on this variable were not obtained in the study. It is also possible that in the earlier Right-Hand Study the raters were affected by a "halo" factor which had diminished by the time of the later Left-Hand Study.

## FUNCTIONAL PREFERENCES

In studying child and parent opinions concerning the function provided by the No. 1 hand in comparison to that available in standard hooks, the task is complicated by the strong emotional factors involved. In many instances the excellent acceptance of hand appearance clearly tended to influence the answers to questions concerning its function. In interpreting the responses of children and their parents, therefore, it must be borne in mind that the hand was almost three times as heavy as the hook previously worn by the children; and although operating forces to initiate opening were only somewhat higher than for the hook, the forces required to obtain full opening were significantly higher—two factors which should make use of the hand more difficult.[4] Pertinent comparative data are presented in Table 4.

Thus, when children report, as some do, that the hand is lighter and easier to operate

TABLE 4. WEIGHT AND OPERATING FORCES OF HAND AND HOOK

| Terminal Device | Pinch (lbs.) | Weight (grams) | Operating Forces | |
|---|---|---|---|---|
| | | | To Initiate Opening (lbs.) | To Open Fully (lbs.) |
| No. 1 Hand | 2 | 170–173 | 4 ± 1 | 9 ± 1 |
| Dorrance 10X Hook | | | | |
| 2 Rubber Bands | 2 | 62 | 3 | 3.5 |
| 3 Rubber Bands | 3 | 63 | 4 | 5.75 |

[4] Actual pinch forces in the hooks worn by children in the study were not obtained. However, recommended forces for the age group are: below-elbow, 3½ lb.; above-elbow, 3 lb.

than the previously worn hook, the data must be questioned. Nevertheless, conservative interpretation of the available information does provide insight not only into hand usage but also into terminal-device function in general.

The presentation which follows is based primarily on data from the Left-Hand Study, but these are supplemented where appropriate by evidence from the preceding Right-Hand Study.

All 39 children and parents in the Left-Hand Study were asked, "With which terminal device is the child able to perform more activities?" The answers were:

| | Hook | Hand | No Preference |
|---|---|---|---|
| Children | 18 | 14 | 7 |
| Parents | 16 | 9 | 14 |

However, two children and two parents in the no-preference category added statements which suggested that the hook provided more function and that their no-preference choice was motivated by a balance between hook function and the cosmetic appeal of the hand either to the child or to the parent.

Furthermore, some children who rated the function of the hand as better than that of the hook made comments indicating the reverse. Joseph: "The hand is heavier and harder." Robin: "The hand can do a couple of things but not too many things." Linda: "The hand is heavier and harder but I like the way it works." The therapist said that this girl's answer was motivated by a strong desire to keep the hand.

However, several children who preferred the function of the hand were able to back up their choice by specific examples. Susan, a young above-elbow amputee, said the hand was easier to don, better for washing dishes, for holding paper, and to pick things up. Rodney, also an above-elbow amputee with an unfitted paraxial hemimelia (ulnar) on the contralateral (right) side, said the hand was heavier but easier to operate. His therapist said the hand did not afford Rodney greater function but he was much more eager to use it. This greater enthusiasm was also noted in Susan, the above-elbow amputee previously mentioned. The greater motivation to use the hand on the part of both these youngsters may have actually resulted in a higher level of functioning!

Fourteen of the 39 children fitted with the No. 1 left hand reported it to be as heavy as or heavier than their hook, and 17 found it hard to open or otherwise more difficult to operate than their hook had been. There seemed to be a significant relationship here with age, as indicated by the fact that of 17 children, ages 3 to 5, eight found the hand heavy, while of 22 children, ages 6 to 10, only six reported that the hand was heavy. Of those who stated that the hand was difficult to operate, ten were in the 4-to-5 age bracket and only five were in the 6-to-10 age group.

A relationship to amputation level was also apparent. The one shoulder-disarticulation amputee found the weight acceptable but the hand too hard to operate. He retained the hand, nevertheless, for cosmetic reasons. Of the five above-elbow amputees, four found the hand heavy and difficult to operate, and the remaining child rejected it after less than two months' wear. In contrast to these negative reports, two above-elbow amputees, only 5 years old, were among those who were most highly motivated to use the prostheses with the hand device.

The combination of youth and a higher level of amputation made the use of the hand much too difficult for the youngest child in the study, an elbow-disarticulation case who was barely 4 years old when fitted. Consequently, at the conclusion of the study he was wearing the hand only for special occasions. Of the four wrist-disarticulation amputees, the two 4-year-olds found the hand a little heavy and difficult to operate, while two 8-year-olds advised that both weight and operating forces were satisfactory.

### Specific Types of Grasp

In the Right-Hand Study a general comparison of the functional qualities of hand and hook, based on child and parent opinions, had yielded indecisive results. Therefore, in the Left-Hand Study children and parents were requested to rate the suitability of both the old terminal device (hook) and the No. 1

Fig. 7. Carrying a school bag.

hand, not only for grasping objects in general but also for eleven specific types of grasp or activity areas. Explanatory comments concerning terminal device use for each specific function were also solicited.

The eleven activity areas were:

1. Carrying objects, such as school bags, purses, lunch pails, etc.
2. Grasping or picking up very small elongated objects, such as pins, paper clips, etc.
3. Grasping or picking up small elongated objects, such as pencils, scissors, etc.
4. Grasping paper.
5. Grasping or holding soft objects, such as sandwiches, toothpaste tubes, etc.
6. Grasping or holding a drinking glass.
7. Using silverware while eating.
8. Grasping large bulky objects, such as paste jars, books, balls, etc.
9. Grasping objects such as bicycle handles, swing chains or ropes, etc.
10. Putting on clothes, such as shirts, blouses, etc.
11. Putting on shoes and socks.

Many of these areas involve the performance of a number of discrete activities. Hence, the data obtained not only provide bases for comparison of hand and hook functions but also supply considerable general information concerning the activities of children with upper-extremity prostheses. Since this information may be of significance to clinic personnel, especially to therapists and to persons concerned with the development of devices for children with arm amputations, the data relating to each of the activity areas are presented in some detail (Fig. 7).

*Carrying objects, such as school bags, purses, lunch pails, etc.*

| | Satisfactory | Unsatisfactory | Does Not Use | Not Reported |
|---|---|---|---|---|
| Children | | | | |
| Hook | 32 | 0 | 6 | 1 |
| Hand | 21 | 4 | 8 | 6 |
| Parents | | | | |
| Hook | 34 | 0 | 3 | 2 |
| Hand | 34 | 1 | 2 | 2 |

Approximately four-fifths of the children reported the hook as satisfactory for carrying objects with handles, while only half found the hand satisfactory. Parents, on the other hand, believed the hook and hand functioned about equally well for holding these objects. Where difficulty was experienced with the hand, it was usually because the objects carried were too heavy for the amount of "Bac-Loc" provided. Illustrative comments follow. Betsy: "The hand doesn't let me hold heavy things." Linda's mother: "Buckets, lunch pails, and anything of metal or plastic that is heavy slip from her grasp." Gabriel's mother: "The hand is satisfactory provided the handle is not too thick and the object not too heavy."

*Grasping or picking up very small elongated objects, such as pins, paper clips, etc.*

| | Satisfactory | Unsatisfactory | Does Not Use | Not Reported |
|---|---|---|---|---|
| Children | | | | |
| Hook | 23 | 4 | 9 | 3 |
| Hand | 15 | 13 | 6 | 5 |
| Parents | | | | |
| Hook | 20 | 11 | 6 | 2 |
| Hand | 12 | 16 | 10 | 1 |

More than half the subjects and parents rated the hook as satisfactory for picking up very small objects. The hand was considered adequate for this function by only about a third of the children and parents. Some children pointed out that the hand was satis-

Fig. 8. Holding a safety pin.

factory for holding very small objects but not for picking them up (Fig. 8). One parent suggested that the child's vision was blocked by the rest of the hand, another that the floating fingers were in the way. Some of the illustrative remarks are quoted. John: "Nails but not pins." Susanne: "I have to hold the object in the other hand to pick it up." Danny's mother: "Too much effort and concentration."

*Grasping or picking up small objects, such as pencils, scissors, etc.*

| | Satis-factory | Unsatis-factory | Does Not Use | Not Re-ported |
|---|---|---|---|---|
| Children | | | | |
| Hook | 30 | 1 | 4 | 4 |
| Hand | 26 | 7 | 2 | 4 |
| Parents | | | | |
| Hook | 32 | 2 | 4 | 1 |
| Hand | 28 | 6 | 4 | 1 |

Fig. 9. Holding a pencil.

Three-fourths of the children and parents considered the hook satisfactory for this function, while a slightly smaller proportion also found the hand satisfactory. The objects given particular attention within this category of use were scissors, pencils, crayons, hammers, and put-together toys.

It was apparently impossible to cut with ordinary scissors held in either a hook or an artificial hand. Thus, unilateral amputees held scissors in their good hand, while bilaterally involved children could not use them at all unless the scissors were especially modified.

Concerning pencils, the reports were mixed, with some children rating the hook better for picking up and holding pencils, but with more subjects preferring the hand (Fig. 9). Some illustrative comments follow. Jeff: "I can hold a pencil better with the hook." Danny: "The hand holds a pencil better for sharpening." Randy: "I can pick up pencils easier with the hand."

Only one or two of the children with unilateral amputations made reference to writing with the prosthesis, although this was, of course, necessary for bilateral amputees. In general, the hook was favored for writing. Gail: "I can write better with a hook." Randy's teacher: "He is more secure doing written work when he wears hooks." (Randy is a bilateral upper-extremity amputee.)

There were only two references to hammers, one favoring each terminal device.

Concerning put-together toys there were two statements, both favoring the hook.

Fig. 10. Grasping paper.

In summary, scissors appeared to be difficult, if not impossible, to grasp with either hook or hand, pencils somewhat easier to handle with the hand, and put-together toys easier with the hook, and possibly writing also.

*Grasping paper*

| | Satisfactory | Unsatisfactory | Does Not Use | Not Reported |
|---|---|---|---|---|
| Children | | | | |
| Hook | 37 | 0 | 1 | 1 |
| Hand | 30 | 4 | 1 | 4 |
| Parents | | | | |
| Hook | 34 | 1 | 2 | 2 |
| Hand | 34 | 2 | 1 | 2 |

Nearly all children rated both the hook and hand as satisfactory, with only four rating the hand as unsatisfactory (Fig. 10). Almost all the parents considered both devices satisfactory.

The comments indicated that grasping paper was not one function but several, each calling for a different application of the terminal device. Involved were such tasks as holding paper for cutting with scissors, holding paper on a desk for writing, picking up paper, selecting one sheet from many, holding playing cards for card games, etc.

Two children cited holding paper to cut with scissors to explain their rating of the hook as satisfactory, but in both cases they considered the hand also suitable for this purpose. The therapist of a third child (Susan) felt that the hand was less helpful: "When cutting paper, Susan usually places the paper in the hook. With the hand she seldom places the paper in the hand; it seems to crush the paper and hold it in an awkward position." Susan herself regarded both devices as satisfactory for grasping paper.

The hand was considered better for holding paper on a table or desk while writing (Fig. 11). Sean's mother: "With the hook the paper tends to slip—resulting in ragged print." Danny: "The hand holds down paper better for writing." Gail's mother: "School paperwork seems to be neater with the hand because the paper doesn't slip."

Several remarks seemed to indicate that the hand was better for picking up paper, but one bilateral amputee mentioned difficulty in selecting one sheet from many.

Concerning holding playing cards for various games, Susan's therapist made the following comment: "Playing card games is an activity which is performed better with the hand. It is in a better holding position and the cards come out easier when she is taking them from the hand."

*Grasping or holding soft objects, such as sandwiches, toothpaste tubes, etc.*

| | Satisfactory | Unsatisfactory | Does Not Use | Not Reported |
|---|---|---|---|---|
| Children | | | | |
| Hook | 20 | 9 | 9 | 1 |
| Hand | 13 | 10 | 12 | 4 |
| Parents | | | | |
| Hook | 21 | 10 | 5 | 3 |
| Hand | 24 | 9 | 5 | 1 |

Half the children rated the hook as satisfactory, but the number dropped to a third for the hand. Half the parents considered the hook as suitable and a slightly greater number rated the hand as adequate. More children than parents reported that neither device was used for grasping soft objects.

Picking up and holding a tube of toothpaste apparently presented no problem, but difficulties arose with sandwiches, cookies, candy bars, marshmallows, grapes, or raw eggs, all of which were usually held in the sound hand. The majority of the children experienced difficulty in holding soft objects with either device. Debra: "The hand squashes it and I can't eat it—the hand squashes the sandwich." Joseph: "The hook might squash them;

Fig. 11. Holding paper while writing.

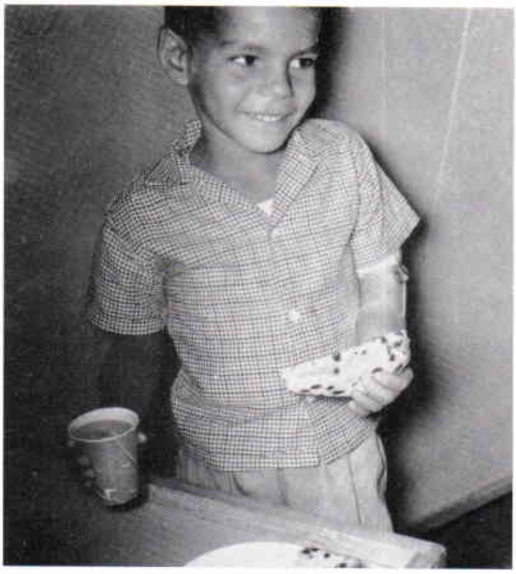


Fig. 12. Grasping a sandwich.

*Grasping or holding a drinking glass*

| | Satis-factory | Unsatis-factory | Does Not Use | Not Re-ported |
|---|---|---|---|---|
| Children | | | | |
| Hook | 8 | 8 | 18 | 5 |
| Hand | 7 | 12 | 16 | 4 |
| Parents | | | | |
| Hook | 13 | 8 | 13 | 5 |
| Hand | 12 | 11 | 15 | 1 |

Less than a fourth of the subjects rated either hook or hand as satisfactory for holding a drinking glass. The parents were slightly more positive, a third of them rating both hook and hand as suitable. Several of the children who gave a rating of satisfactory explained that they would use a terminal device only to hold a glass by the rim when filling it with water or to carry it while setting the table.

Comparisons between hook and hand were few. Some children stated that the hand did not open wide enough for available glasses or that the glass slipped. Two others, however, stated that the hand had a better grip and

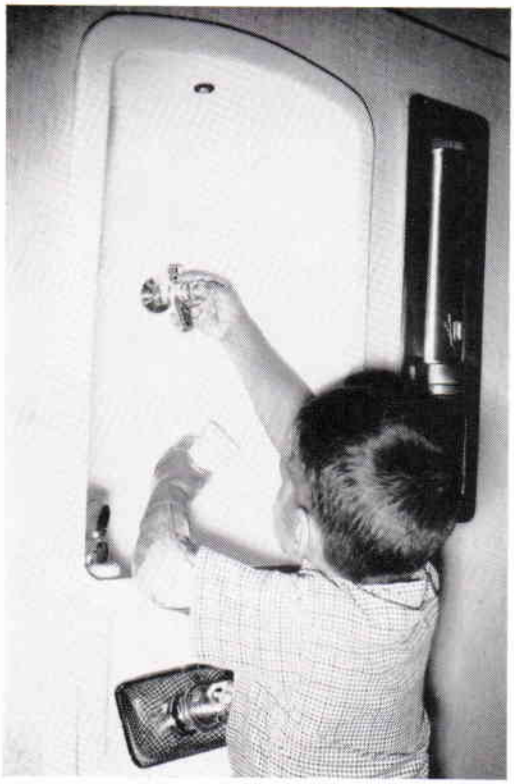


Fig. 13. Grasping a paper cup.

the hand can pick it up but I'll smash it." There were some children who made comments favoring the hand. Danny: "With the hand I can get a sandwich better without squeezing it" (Fig. 12). Mother of Randy (triple amputee): "Eating sandwiches is a treat which he was unable to do with hooks." However, a larger number preferred the hook for this purpose.

did not slip. Small opening and slippage were problems also reported with hooks. The general impression is that even children who rated a terminal device as satisfactory for holding a drinking glass were merely claiming they could hold a glass as a special feat, not as a commonly used skill (Fig. 13).

*Using silverware while eating*

| | Satis-factory | Unsatis-factory | Does Not Use | Not Re-ported |
|---|---|---|---|---|
| Children | | | | |
| Hook | 13 | 2 | 22 | 2 |
| Hand | 15 | 2 | 19 | 3 |
| Parents | | | | |
| Hook | 19 | 3 | 14 | 3 |
| Hand | 21 | 2 | 16 | 0 |

Approximately a third of the children and half of the parents rated both hook and hand as satisfactory for holding silverware, while half of the children and a third of the parents indicated that neither device was used for the purpose. The slight differences favored the hand. With the exception of three bilateral arm amputees, the children who answered this question were left-arm amputees. It appears likely that they used the terminal device only for holding a fork while cutting meat (Fig. 14), although one or two held a spoon in the terminal device also. Many children, even some who regarded a terminal device as satisfactory, reported that the parents usually cut their meat for them.

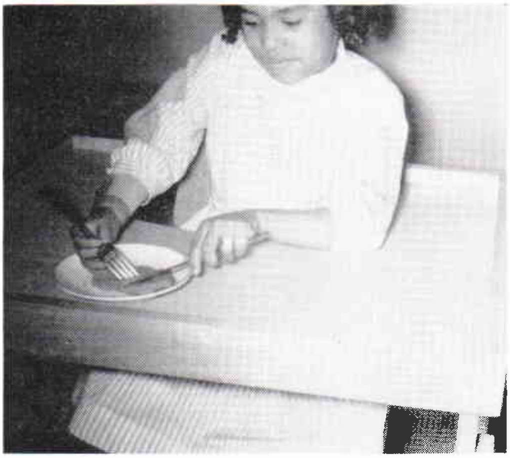


Fig. 14. Holding a fork.

Particular mention was made of problems of slippage, of difficulty of positioning, the better appearance of the hand performance, and the need for practice.

*Grasping large bulky objects, such as paste jars, books, balls, etc.*

| | Satis-factory | Unsatis-factory | Does Not Use | Not Re-ported |
|---|---|---|---|---|
| Children | | | | |
| Hook | 30 | 4 | 2 | 3 |
| Hand | 18 | 12 | 3 | 6 |
| Parents | | | | |
| Hook | 32 | 2 | 2 | 3 |
| Hand | 28 | 6 | 4 | 1 |

Fig. 15. Holding a large ball.

Fig. 16. Holding a doll.

Three-fourths of the children rated the hook as satisfactory, but only half found the hand so. The same proportion of parents rated both hand and hook as satisfactory.

The intention of the question was to determine whether the smaller opening provided by the hand was a disadvantage in actual use. The specifications of the No. 1 hand require that a minimum full opening of 2 in. be attainable with the thumb in the wide opening position, but most hands exceeded the specification to a maximum of approximately 2⅜ in. However, there were indications that several children utilized the small, 1½-in. opening only and did not bother to change the thumb position. A Dorrance 10X hook, by comparison, provided a 3-in. opening and the Dorrance 99X hook a 3½-in. opening.

A number of children and parents specifically mentioned holding baseball bats, balls, paste jars, books, boxes, dolls, and a see-saw. Curtis: "With the hand, I can hold the bat better when I play ball." Glenda's mother: "Bats the ball using both hands now." Comments indicated that the hook was superior for throwing balls, but the hand was satisfactory for catching them in two-handed fashion. In general, though, the children found it difficult to grasp balls with either the hook or the hand (Fig. 15). The hook was somewhat better for holding paste jars. Books, boxes, paper cups, and dolls (Fig. 16) were better held with the hook, but one boy said riding a see-saw was easier with the hand.

*Grasping objects such as bicycle handles, swing chains or ropes, etc.*

| | Satisfactory | Unsatisfactory | Does Not Use | Not Reported |
|---|---|---|---|---|
| Children | | | | |
| Hook | 34 | 1 | 2 | 2 |
| Hand | 24 | 3 | 7 | 5 |
| Parents | | | | |
| Hook | 36 | 1 | 1 | 1 |
| Hand | 33 | 2 | 2 | 2 |

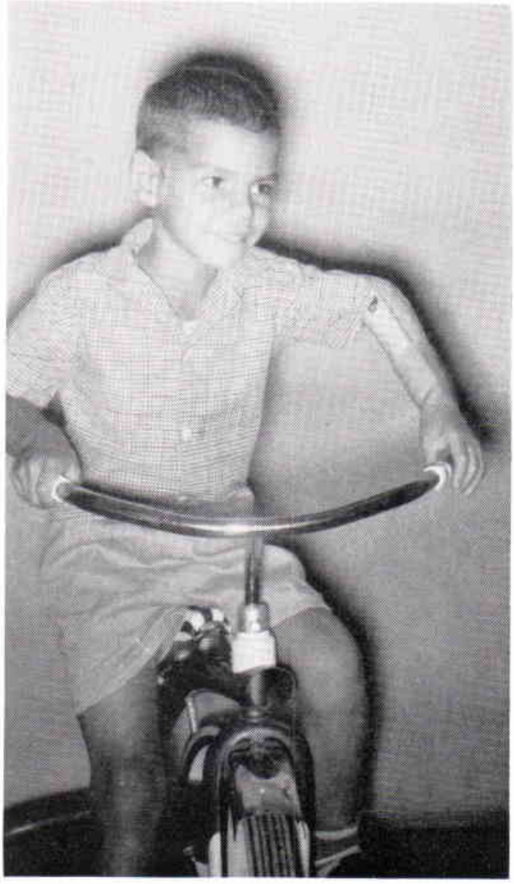


Fig. 17. Holding a bicycle handle.

Most children and parents rated the hook as suitable, but some children stated that the hand was unsatisfactory or not used for these activities. Confusion may have existed because of the separate uses; several of the children played on swings but did not ride a bicycle or tricycle. The hook was more often preferred for holding a swing chain, but preference was evenly divided for riding a bicycle (Fig. 17). Several parents felt that the hand grasp appeared more natural. There was concern about the danger of tearing the glove or breaking the thumb of the hand on a swing chain. Other activities mentioned under this heading were climbing monkey bars and holding a jump rope, a broom and a hoe, or a bow for archery.

*Putting on clothes, such as shirt, blouse, etc.*

| | Satis-factory | Unsatis-factory | Does Not Use | Not Re-ported |
|---|---|---|---|---|
| Children | | | | |
| Hook | 27 | 1 | 8 | 3 |
| Hand | 21 | 3 | 9 | 6 |
| Parents | | | | |
| Hook | 29 | 2 | 6 | 2 |
| Hand | 30 | 1 | 7 | 1 |

Two-thirds of the children and parents rated the hook as satisfactory, but only half the children considered the hand as satisfactory for this purpose. Several children who considered both devices as satisfactory commented that they were usually dressed, or were assisted in dressing, by their mothers. There were more comments favoring the hook than the hand; the glove tended to stick to cloth and there was glove discoloration attributed to contact with clothing, particularly from red dyes.

*Putting on shoes and socks*

| | Satis-factory | Unsatis-factory | Does Not Use | Not Re-ported |
|---|---|---|---|---|
| Children | | | | |
| Hook | 24 | 3 | 9 | 3 |
| Hand | 19 | 3 | 11 | 6 |
| Parents | | | | |
| Hook | 29 | 3 | 6 | 1 |
| Hand | 28 | 3 | 7 | 1 |

Two-thirds of the children and the parents rated the hook as satisfactory, but less than half of the former considered the hand satisfactory (Fig. 18). A fourth of the children stated that they did not use either device to put on shoes and socks, and the number who did not tie shoelaces with prostheses was undoubtedly much higher. Timothy, for example, said that he did not know how to tie shoelaces and that his mother dressed him, but he and his mother rated both devices as suitable for putting on shoes. Another reason given for parental assistance was that the child consumed too much time in dressing himself.

Fig. 18. Putting on shoes and socks.

## Conclusions

In spite of the wide differences in the opinions expressed by the children and parents participating in the study, it was apparent that:

1. The APRL-Sierra No. 1 hand was heavier and in most instances more difficult to operate than the previously worn hook, but for the majority of subjects in the sample these were not serious drawbacks. Those with shoulder-disarticulation amputations and to a lesser extent some of the younger children and above-elbow amputees were most likely to have difficulty with weight and operating forces. It is obvious, of course, that if the hand were lighter and had a more efficient operating ratio, it would be more acceptable to all.

2. The hand provided somewhat less pinch force than most of the hooks and a less precise grasp. The majority of children reported that they could perform more activities better with the hook; however, many could also specify a number of activities that were

performed better with the hand. The latter was preferred somewhat more often for tasks such as picking up a pencil, grasping paper, and holding silverware for eating. The majority of the children and their parents considered the hand as "adequate" to "very satisfactory" for a wide range of activities.

### Acknowledgments

In Part I of this series of articles, grateful acknowledgments were made to the clinics participating in the Child Amputee Research Program and to a number of persons for valuable cooperation and assistance in the conduct of these studies and in the preparation of the report. We again express our sincere appreciation.

### Literature Cited

1. Fishman, Sidney, and Hector W. Kay, *Acceptability of a functional-cosmetic artificial hand for young children*, Child Prosthetic Studies, Research Division, College of Engineering, New York University, January 1964.

Artificial Limbs, Vol. 8, No. 2, pp. 28–31, Autumn 1964

# Turntable Lock for Elbow Units[1]

FRED SAMMONS, B.A.[2]

IN THE conventional elbow unit (Hosmer E-400) for above-elbow and shoulder-disarticulation amputees, manual control of humeral rotation is permitted by virtue of cork and teflon gaskets providing mechanical friction between the top of the main portion of the elbow unit and the turntable to which the upper arm shell or socket is fastened (*1*). The amount of friction is determined by the tension maintained by the stud and attaching nut. Since humeral rotation is important for positioning the limb to obtain maximum functional usage, the friction must not be so

[1] Based upon *Elbow Rotation Lock* (*2*), published by Northwestern University Prosthetics Research Center, Chicago, Ill., in July 1964. The development reported was sponsored by the Veterans Administration.

[2] Research Associate, Northwestern University Prosthetics Research Center, 401 E. Ohio St., Chicago, Ill. 60611.

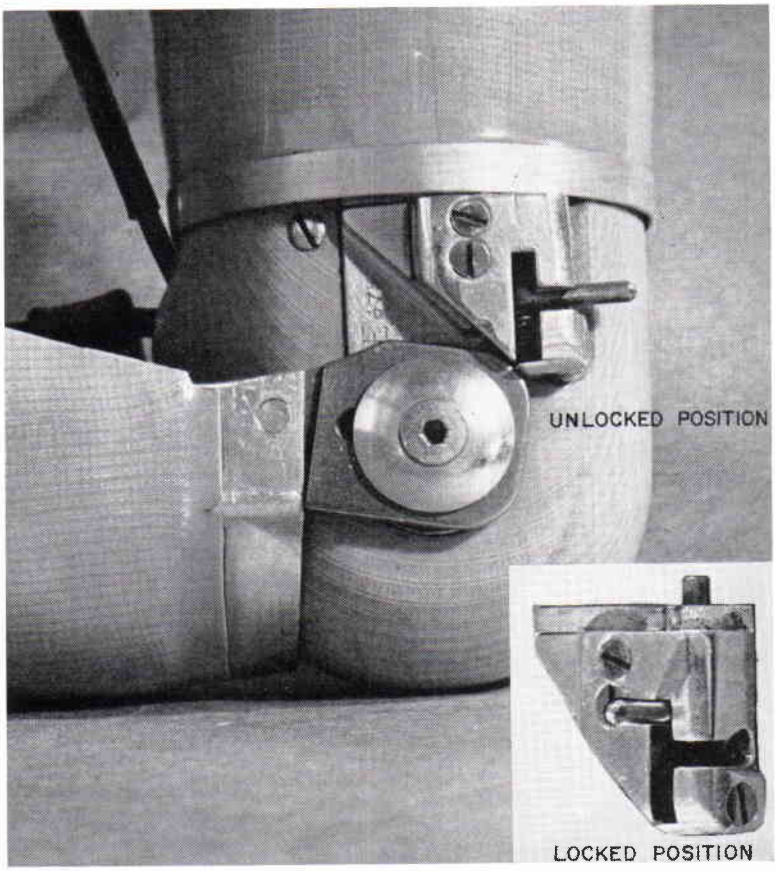



Fig. 1. Installation of lock.

great as to rule out easy adjustment. At the same time there must be enough resistance to rotation to accomplish most activities.

There are times when a rigid arm is desirable; for example, when climbing ladders, using a shovel for long periods, carrying an object balanced on the forearm, or carrying an object held away from the body. To provide rigidity for such demanding tasks, the Northwestern University Prosthetics Research Center has developed a manually controlled lock which can be mounted on the area provided for a forearm lift assist on the Hosmer E-400 elbow unit. A spring forcefully engages the locking pin in one of three holes drilled through the turntable for this purpose. Since the turntable possesses enough friction for most activities, the locking pin need only be used to overcome the tendency of the forearm to rotate gradually when shoveling, to provide the extra margin of safety when climbing vertical ladders, or to supply the rigidity needed in certain other tasks. The amputee returns the locking pin to the disengaged position when the task is completed.

Installation of the lock requires: first, drilling the indexing holes in the turntable; second, revising the plastic cap on the elbow unit and mounting the locking device; third, cutting a notch in the cork and teflon gasket to make room for the locking pin and regluing the gasket to the elbow unit.

Figures 1 and 2 are views of the locking device, and Figures 3, 4, and 5 show details of its installation.

The first prototype (not shown) of the lock was fitted to DM, a 38-year-old farmer who is a left above-elbow amputee. The lock was

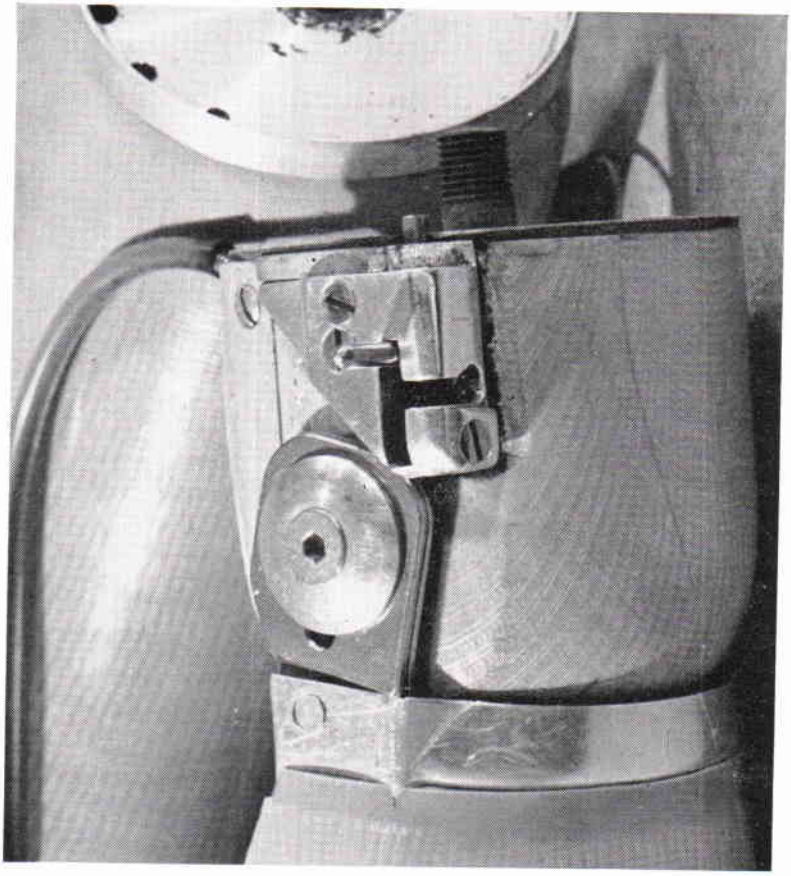


Fig. 2. View of modification showing indexing holes in turntable.

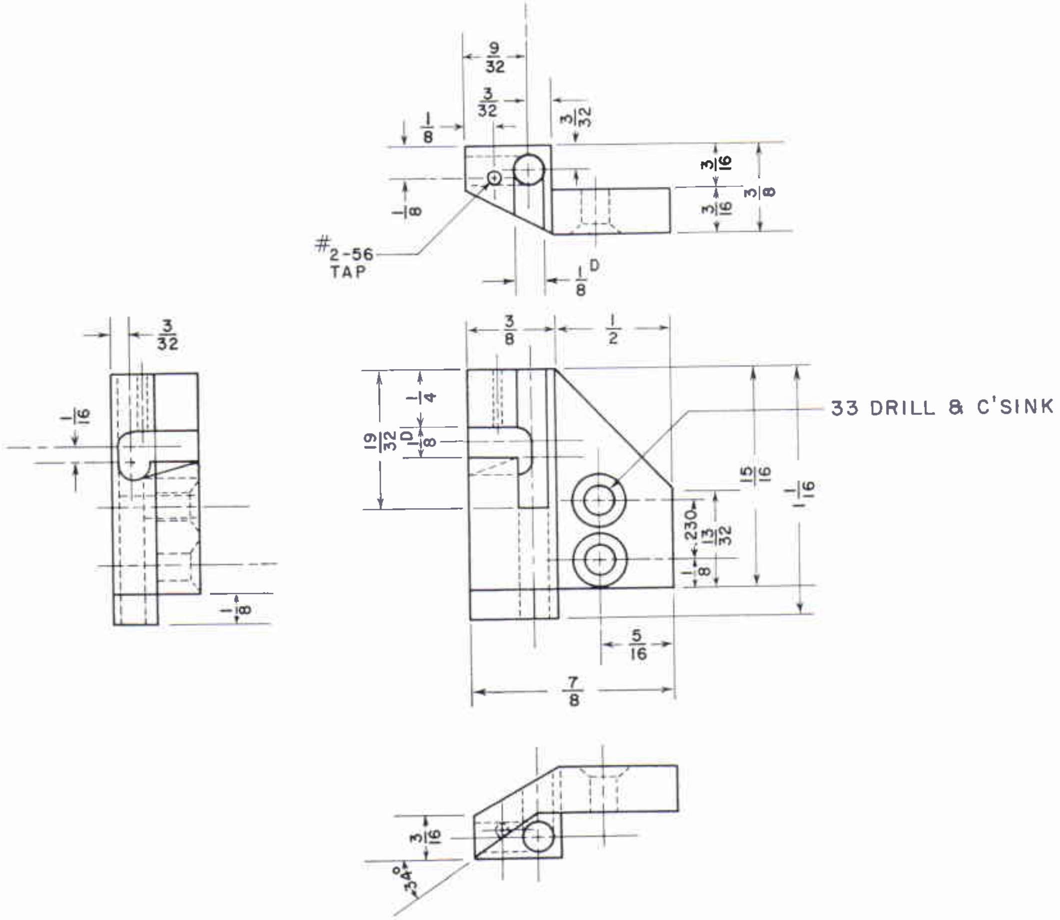



Fig. 3. Drawing of base of lock.

mounted on the posterior rim of the elbow frame. A $\frac{3}{16}$-in. locking pin was used and has proved to be very durable. The lever which latches and unlatches the lock has been replaced because of breakage. A disadvantage was the requirement for modification of the elbow frame and extensive modification of the cork and teflon gasket. Another disadvantage was the location of the lock lever at the back of the elbow rather than at the side. The device has been worn continuously for 20 months with no malfunction in the locking pin.

One unit of the second prototype (as shown in the illustrations for this article) of the lock was fitted to EA, a 38-year-old farmer and bulldozer operator who is a right above-elbow amputee. The device has functioned well for a period of more than 16 months, and the amputee reports that he uses it several times daily. He is able to lock and unlock the device without removing winter clothing.

Another unit of the second prototype of the lock was fitted to IS, a 40-year-old farmer who is a right above-elbow amputee. The device malfunctioned after six months when the elbow became free-moving without the usual amount of friction. This caused excessive strain on the locking pin, which bent under the load. The pin was replaced, friction was restored, and the device has worked for 10 additional months. The amputee reports using the lock when holding materials to be

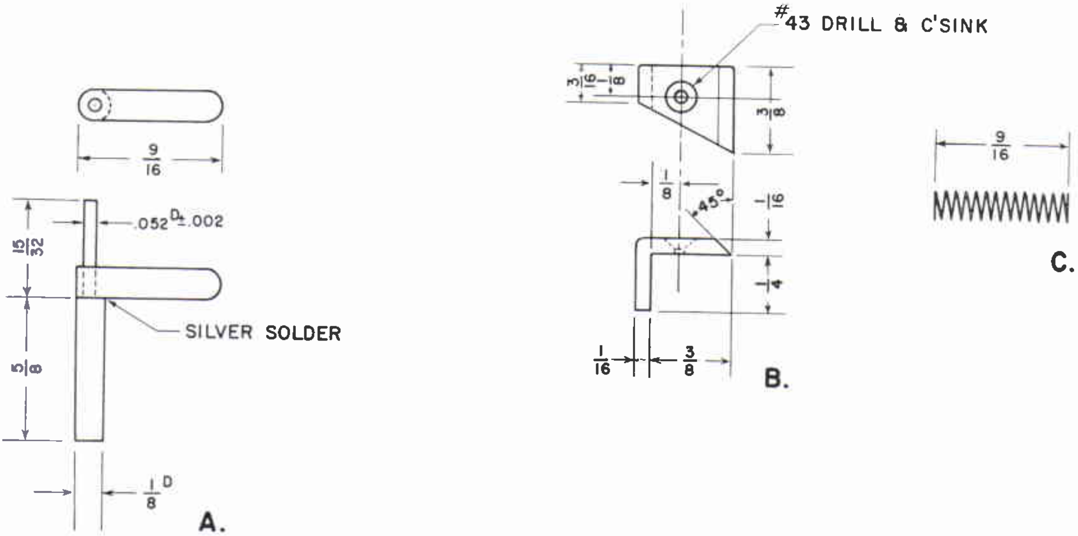



Fig. 4. Drawings of lock components. *A*, Pin; *B*, cap; *C*, spring.

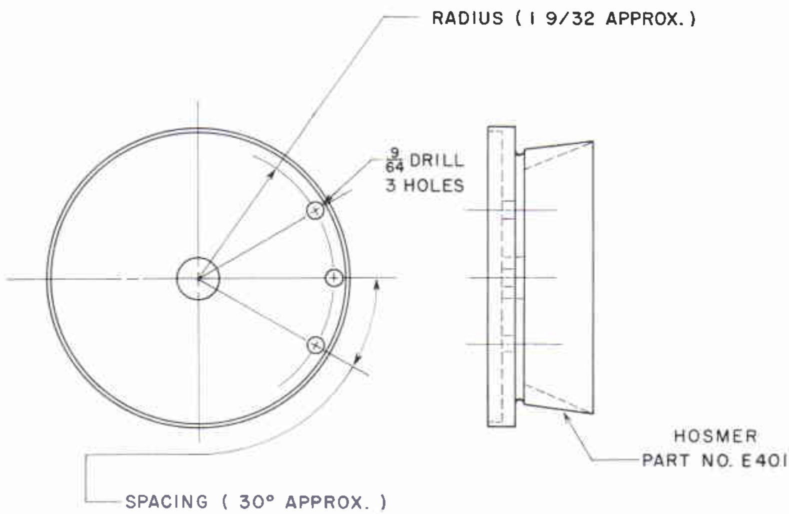



Fig. 5. Drawings of modified turntable. The radius of the indexing holes may be determined by using a ⅛-in. diameter scriber in the lock base mounted on the elbow and scribing directly on the turntable. The amputee can best select the locking positions after completion of the socket.

butt-welded, when climbing ladders, and in other situations where a static arm is required.

LITERATURE CITED

1. Aitken, George T., T. J. Bushey, Edward R. Ford, and Fred Leonard, *Upper-extremity components*, Chap. 2 in *Orthopaedic Appliances Atlas*, Vol. 2, Edwards, Ann Arbor, Mich., 1960.
2. Sammons, Fred, *Elbow rotation lock*, Northwestern University Prosthetics Research Center, July 1964.

# News and Notes

## CPRD Subcommittee and Workshop Panel Activities

### *Fourth Meeting of Subcommittee on Evaluation*

The fourth meeting of the Subcommittee on Evaluation of CPRD was held at the Ontario Crippled Children's Centre in Toronto, Ontario, on June 4 and 5, 1964. Professor Herbert R. Lissner, Chairman of the Subcommittee, presided; members present were Dr. Robert L. Bennett, Colin A. McLaurin, and Bert R. Titus. Others present were Charles Asbelle, Dr. Herbert Elftman, Dr. Sidney Fishman, Howard Gage, Hector W. Kay, Anthony Staros, and A. Bennett Wilson, Jr., Technical Director of CPRD.

Two variable-friction knee units—one developed by the Navy Prosthetics Research Laboratory and the other developed by the Northwestern University Prosthetics Research Center and modified by the Navy Prosthetics Research Laboratory—were given consideration. Both units are undergoing tests at the Veterans Administration Prosthetics Center.

Consideration was given to a procedure developed by the Navy Prosthetics Research Laboratory for accelerated construction of leg braces. The procedure consists of a tracing method, utilizing a tilting table and diazo paper; a forming method, utilizing a hydraulic unit; and a finishing method, utilizing dipping into a liquid plastic. It was the consensus of the Subcommittee that these techniques offered much promise. The Navy Prosthetics Research Laboratory was requested to conduct cost-comparison studies and to prepare a report.

Dr. Fishman and Mr. Kay gave progress reports on the following prosthetics developments currently undergoing evaluation at New York University: a procedure developed by the Army Medical Biomechanical Research Laboratory for the fabrication of porous plastic laminate sockets for PTB prostheses; an air-escape valve developed by the Navy Prosthetics Research Laboratory for the ventilation of total-contact, above-knee sockets; the "Flexicage" socket for above-knee prostheses; the Münster technique for fitting above-elbow sockets; the half-cycle elbow unit developed by the Army Medical Biomechanical Research Laboratory; and a distal-contact regulator for above-knee sockets.

Orthotics developments currently undergoing evaluation at New York University included the PTB brace developed by the Veterans Administration Prosthetics Center, basic hand orthoses developed by the Texas Institute for Rehabilitation and Research, shoe inserts developed by the University of California at San Francisco, and an ulnar-deviation splint developed by the University of Michigan.

An *ad hoc* committee, consisting of Dr. Fishman, Dr. Eugene F. Murphy, and Mr. Titus, was appointed to plan a conference on "feeders" to be held at Duke University.

The Subcommittee also concerned itself with the development of a numerical system for rating prosthetic and orthotic devices.

### *Fourth Meeting of Subcommittee on Design and Development*

The fourth meeting of the Subcommittee on Design and Development of CPRD was held in New York City on June 26, 1964. Colin A. McLaurin, Chairman of the Subcommittee, presided; members of the Subcommittee who attended were Dr. Fred Leonard, Dr. John Lyman, and Anthony Staros. Other participants were Dr. Robert W. Corell, Dr. Robert W. Mann, Dr. Edward Peizer, and A. Bennett Wilson, Jr., Technical Director of CPRD.

The primary purpose of the meeting was to develop criteria for some design projects that might be used in undergraduate engineering design courses. It was brought out during the meeting that the trend in engineering design education is to employ more realistic problems than the more or less stereotyped examples that have been used for years. The areas of prosthetics and orthotics seem to have an abundance of problems that would lend themselves to the engineering design class, because the student is already familiar with the basic functioning of the human extremities. However, since the majority of professors of design are unfamiliar with the problems in prosthetics and orthotics, the Subcommittee set itself the task of developing a number of projects, complete with reference material, in the hope that such projects would be welcomed by professors. The Subcommittee considered that it would be unreasonable to expect many useful designs to emerge from such a program, although some ingenious designs might result. What the Subcommittee considered more important is the possibility of stimulating students to enter the field of biomechanics and make contributions to prosthetics and orthotics over a period of many years.

*Fifth Meeting of Subcommittee on Design and Development*

The fifth meeting of the Subcommittee on Design and Development of CPRD was held in Chicago, Ill., on November 24, 1964. Colin A. McLaurin, Chairman of the Subcommittee, presided; members of the Subcommittee who attended were Dr. Fred Leonard, Dr. John Lyman, Charles W. Radcliffe, and Anthony Staros. Other participants were Richard Blackmer; A. Bennett Wilson, Jr., Technical Director of CPRD; and James R. Kingham, Staff Editor of CPRD.

The chief purpose of the meeting was to commence the preparation of up-to-date recommendations on design and development matters for presentation at the January 1965 meeting of the Committee on Prosthetics Research and Development.

There was extensive discussion of a number of sample projects in prosthetics design for students in engineering colleges. It was considered that the problems would be suitable either as creative design exercises for undergraduates or as projects which would require graduate students about a year to become conversant with them.

Progress reports were received from the chairmen of the Workshop Panels on Lower-Extremity Fitting; Lower-Extremity Components; Upper-Extremity Components; and Upper-Extremity Fitting, Harnessing, and Power Transmission.

Dr. Robert D. Keagy was appointed to the chairmanship of the Workshop Panel on Lower-Extremity Orthotics.

Consideration was given to the problem of the procurement of prototypes.

*First Workshop Panel on Criteria for External Power*

Under the chairmanship of Dr. John Lyman, the first Workshop Panel on Criteria for External Power met at the University of California at Los Angeles, Calif., on May 15 and 16, 1964. Present for the meeting were Thorkild J. Engen, Dr. Hilde Groth, Dr. Robert Mazet, Jr., Colin A. McLaurin, Gilbert M. Motis, Victor T. Riblett, Fred Sammons, Carl Sumida, Dr. Gershon Weltman, and James R. Kingham, Staff Editor of CPRD.

The participants in the panel sought to make a number of statements of criteria for external power in prosthetics and orthotics which would be useful to developers. It was recognized that in making such statements the panel was necessarily becoming involved in many matters of opinion. Accordingly, ratings were given to the statements. If all the members were in complete agreement as to the correctness of a statement, it was given a rating of 1. If some doubt existed as to the correctness of a statement, it was given a rating of 2. A very tentative statement was given a rating of 3. Major areas in which statements were made included electric and pneumatic power, harnessing and fitting, safety standards, control, materials, economic criteria, transducers, mechanisms, philosophical criteria, and clinical evaluation. Altogether, some 27 statements were made. In addition, the panel recommended that a concentrated effort be made to furnish inventor-fitted amputees to the UCLA Biotechnology Laboratory for control studies.

*Second Workshop Panel on Upper-Extremity Components*

Under the chairmanship of Colin A. McLaurin, the second Workshop Panel on Upper-Extremity Components met at the American Institute for Prosthetic Research in New York City on June 24 and 25, 1964. Present for the meeting were Hector W. Kay, Edward A. Kiessling, Dr. John Lyman, Gilbert M. Motis, Dr. Edward Peizer, Thomas Pirrello, Jr., Victor T. Riblett, and Carl Sumida.

After inspecting prototype models of soft-palm hooks developed by Carl Sumida, the panel members considered them an improvement over existing terminal devices. The panel recommended that models be made available to the Army Medical Biomechanical Research Laboratory for laboratory testing, to the

Veterans Administration Prosthetics Center for functional amputee testing, to the American Institute for Prosthetic Research for fitting with carbon-dioxide actuators, and to the Child Amputee Prosthetics Project at the University of California, Los Angeles, for fitting with electric actuators.

Other items considered by the panel included a quick-disconnect wrist friction unit developed by Carl Sumida, the AMBRL electric hand, the AMBRL electric elbow, the AMBRL resilient hand, AMBRL flexed hook fingers, the Motis-Belleville voluntary-opening hook, the Motis wrist mechanism, the Motis fluid-actuated fingers, AIPR carbon-dioxide pressure regulators, the Meadows' hook, the Ontario Crippled Children's Centre electric hook, and the Ontario Crippled Children's Centre lock for a transmetacarpal hand.

There was general agreement among the panel members that it is desirable for prototype models to be fabricated by industrial facilities so that the developer would be free to pursue his own line of endeavor.

In summing up the meeting, the panel chairman, Mr. McLaurin, said that the items considered represented a general change in philosophy and outlook that had taken place during the past year. With respect to hooks, there was a general acceptance of the soft-palm approach to increase hook function, particularly in those areas where hands were considered more functional. With respect to hands, it appeared that the trend is toward a soft, more highly articulated device using fluid support rather than mechanical structures. There was, Mr. McLaurin said, a general acceptance that terminal devices should be considered from the standpoint of use with conventional harnessing and use with external power. Mr. McLaurin thought it encouraging that the meeting not only reflected a general trend toward more advanced concepts in functional design but also illustrated some practical solutions.

### CPRD Participation in Project ROSE Seminars

At the invitation of the Space Nuclear Propulsion Office of the U. S. Atomic Energy Commission and the National Aeronautics and Space Administration, the Committee on Prosthetics Research and Development (CPRD) participated in a Project ROSE (Remotely Operated Special Equipment) seminar held in Germantown, Md., on May 26 and 27, 1964.

The purpose of the seminar was to encourage technical communication between the different disciplines working in the field of remotely operated special equipment. There are indications that some advanced work being done in the development of prosthetic devices will have applications in the design of remotely operated special equipment. Conversely, it is believed that some of the work in the design and development of manipulators may be of use to the research and design groups concerned with prosthetics and orthotics.

Representing CPRD at the seminar were Dr. Herbert Elftman, of the College of Physicians & Surgeons of Columbia University; Dr. John Lyman, Project Director of the Biotechnology Laboratory of the Department of Engineering of the University of California at Los Angeles; Victor T. Riblett, Chief of the Biomechanical Devices Division of the Army Medical Biomechanical Research Laboratory; Colin A. McLaurin, of the Prosthetic Research and Training Unit of the Ontario Crippled Children's Centre in Toronto; Dr. Eugene F. Murphy, Chief of the Research and Development Division of the Veterans Administration's Prosthetic and Sensory Aids Service; Professor J. Raymond Pearson, of the Department of Mechanical Engineering of the University of Michigan; Dr. James B. Reswick, Director of the Engineering Design Center of the Case Institute of Technology; and A. Bennett Wilson, Jr., Technical Director of CPRD. With the exception of Mr. Wilson, whose primary responsibility is the overall coordination of the CPRD research and development program, all of the persons representing CPRD at the seminar are directly concerned with the development of upper-extremity prosthetic and orthotic devices and their controls.

Other organizations participating in the seminar included: Argonne National Laboratory, Vitro Engineering Laboratory, AMF Atomics Division, American Car and Foundry Industries, General Electric Company, Lockheed Missile and Space Company, Los Alamos Scientific Laboratory, Battelle Memorial Institute, Wright Patterson Air Force Base, Burns and Roe, Inc., Westinghouse Electric Corporation, Programmed and Remote Systems Corporation, and the Cleveland Nuclear Propulsion Office. All of these organizations have been or are concerned with handling materials at a distance under adverse conditions.

In an analysis of hostile-environment methodologies, Dr. John W. Clark, of Battelle Memorial Institute, pointed out at the seminar that special tools for dealing with hostile or dangerous environments are almost as old as human history. Such tools as fire tongs and fire shovels to enable man to work with objects too hot to handle may be considered as early examples of hostile-environment equipment. At the other end of the scale are the space probes which require extremely complex instrumentation to explore a very different hostile environment.

The availability, just after World War II, of powerful fissionable and radioactive sources initiated the development of hostile-environment techniques employed today. More recently, interest in developing the resources of the ocean has focused attention on the sea as a hostile environment, and the exploration of space carries with it the need to perform useful work in this unfriendly environment.

Dr. Clark said that an orderly study of the equipment and techniques with which useful work can be performed in any hostile environment should result in knowledge which will be applicable to work in extremes of temperature as encountered in fire fighting or in Arctic exploration, to tunneling and excavating, to working with explosives, and to numerous other occupational activities, as well as to the somewhat more glamorous nuclear, underwater, and space environments.

Regardless of the methodology employed to perform useful work in a hostile environment (protective clothing, protective barriers, remotely controlled equipment, directly controlled equipment, or programmed systems), Dr. Clark pointed out that there are six distinct functions which must be accomplished: manipulation, locomotion, observation, communication, display and control, and power.

Other speakers at the seminar discussed various types of manipulator systems, exoskeletal structures, human factors in remote handling, proposed applications of remote handling in space, and other related subjects. During the extensive general discussions, the representatives from CPRD pointed out the value of the prosthetic terminal device (split hook) as compared with a device having parallel jaws for handling materials and objects.

A second Project ROSE seminar, which will have participants representing CPRD, is scheduled for November 4 and 5, 1964.

### Conference on Control of External Power in Prosthetics and Orthotics

Because of recent developments and worldwide interest, the Committee on Prosthetics Research and Development has decided to hold a conference on control of external power in prosthetics and orthotics at Airlie House, near Warrenton, Va., during the period April 7–10, 1965. Financial sponsorship of the conference is being assumed by the Vocational Rehabilitation Administration.

The conference—the exact name for the gathering has yet to be determined—will, through its deliberations, seek to develop an expert summary of the state of all aspects of the control problem and their possible solutions, as related to upper-extremity functional regain. Hoped-for outcomes of the conference will be long-range goals and guiding principles for research and development in externally powered prostheses and orthopaedic appliances.

Major topics to be covered by panels and discussion during the conference are: sources of control (biomechanical and bioelectric); transducers; signal processing and utilization; actuators; sensory feedback; and the selection, preparation, and training of the patient. The proceedings of the conference will be published by the National Academy of Sciences—National Research Council.

Chairman of the conference will be Dr. John Lyman, Director of the Biotechnology Laboratory at the University of California, Los

In center of group is Dr. Marian Weiss, Director of Federal Rehabilitation Center at Konstancin, Poland, and originator of immediate postoperative fitting technique. Second from left is Anthony Staros, Chief of Veterans Administration Prosthetics Center, New York City. At far right is J. Morgan Greene, President of U.S. Manufacturing Co., Glendale, Calif. Other two men are research associates of Dr. Weiss.

Angeles, Calif. It is expected that there will be some 100 participants from the United States, Canada, and overseas. Early in the conference, Dr. George T. Aitken, Chairman of the Committee on Prosthetics Research and Development, will give an orientation lecture, and the conference will be concluded by a summation by Dr. Lyman and others.

### Technical Director of CPRD Makes European Trip

At the request of the International Society for Rehabilitation of the Disabled and the World Veterans Federation, A. Bennett Wilson, Jr., Technical Director of the Committee on Prosthetics Research and Development, spent three weeks in August 1964 in Denmark to assist in developing an international information center for workers in the fields of prosthetics and orthotics.

Before proceeding to Copenhagen, Mr. Wilson spent five days in England conferring with various projects and clinics there. Of especial interest in Great Britain is the establishment of a number of research groups for the purpose of developing externally powered prostheses and braces for the severely handicapped. This work is being followed carefully by American research groups, and it is anticipated that the leaders in the British groups will participate in a conference on externally powered devices to be conducted by the Committee on Prosthetics Research and Development at Airlie House, near Warrenton, Va., in April 1965.

In addition to his primary duties in Copenhagen, Mr. Wilson assisted in the conduct of the last two weeks of a United Nations-sponsored Seminar on Prosthetics and Orthotics. Arranged for the benefit of the so-called developing nations, the seminar was attended by 32 students from 27 countries. Nations in South America, Africa, the Middle East, and the Far East sent students. Because of the extreme variations in conditions among the countries represented, emphasis was placed on mechanical and biomechanical principles which form the basis for modern practices in prosthetics and orthotics, rather than stressing the use of specific tools and materials, although the most modern tools and materials were demonstrated.

Mr. Wilson also had an opportunity to observe research and clinical facilities in Sweden and Finland, where prosthetics and orthotics practices are based largely upon techniques and components developed under the American program. Several research projects have been launched recently in Sweden, and it is hoped that they, too, can be represented at the forthcoming conference on externally powered devices.

Late in August Mr. Wilson was joined in Copenhagen by Anthony Staros, Chief of the Veterans Administration Prosthetics Center in New York City, and Henry Gardner, an orthopaedic technologist at the Veterans Administration Testing and Development Laboratory in New York City, to form a team for the purpose of assisting prosthetics-orthotics research teams formed in Poland and Yugoslavia by the Vocational Rehabilitation Administration under the terms of the Agricultural Trade and Development Act, whereby certain surplus funds in these countries can be used for research in the field of physical rehabilitation.

Four days were spent at the Federal Rehabilitation Center, Konstancin (near Warsaw). This center was of special interest to the team because its director, Dr. Marian Weiss, is the originator of the theory of fitting prostheses immediately upon the completion of surgery, while the patient is still under the influence of anaesthesia. Parallel studies had been initiated in the United States as a result of rather meager information supplied by Dr. Weiss, and the visit presented an opportunity to begin a cooperative effort in further development of this technique. As a result, a surgical-prosthetics research team from America was scheduled to work with the Polish team during November 1964. It is expected that when these techniques are perfected the hospitalization and rehabilitation time for amputees will be substantially reduced. Furthermore, it appears that amputees treated in this manner suffer less pain and have fewer medical and psychological problems.

Three weeks were spent in Yugoslavia, where a research and clinical program was established in 1960. A six-day seminar was conducted in Belgrade for clinical teams throughout the country. More than 100 physicians, therapists, and prosthetists attended the sessions designed as a refresher and updating course.

Assistance was rendered engineers and manufacturers in the selection of standards for artificial-limb and brace components and in the design of a project for the selection and development of materials based on local conditions.

The team returned to the United States via Athens, where they visited the Federal Rehabilitation Center and the Greek Royal Army Prosthetics Workshop.

In summary, it was gratifying to observe the progress that the European nations have been making in the management of amputees and others with orthopaedic disabilities. To date, this progress has been effected largely by the work of individuals and philanthropic agencies by making some interchange of information possible.

### Symposium on Plastics in Surgical Implants

Committee F-4 (Surgical Implant Materials) of the American Society for Testing and Materials sponsored a symposium on plastics in surgical implants in Indianapolis, Ind., on November 5 and 6, 1964, in which several persons associated with the Committee on Prosthetics Research and Development took an active part. They included Dr. Fred Leonard, Scientific Director of the Army Medical Biomechanical Research Laboratory, who served as general chairman of the symposium and headed the program committee. Dr. Eugene F. Murphy, Chief of the Research and Development Division of the Veterans Administration's Prosthetic and Sensory Aids Service, served as chairman for the session on *Properties and Design* and also served as a member of the program committee which developed the symposium. Another member of the program planning committee was Dr. S. C. Woodward, of the Institute of Research of the Walter Reed Army Medical Center, who presented a paper during the *Compatibility* session. The opening session of the symposium was concerned with *Medical Applications of Plastic Implants*.

Dr. Leonard is also editor of the proceedings of the symposium, which will be published by ASTM in the near future.

The primary function of Committee F-4 is to develop standards for all materials which are temporarily or permanently implanted in the human body. Chairman of the Committee is Professor Herbert R. Lissner, Coordinator of the Biomechanics Research Center at Wayne State University, who also serves as Chairman of the Subcommittee on Evaluation of the Committee on Prosthetics Research and Development.

Committee F-4 has scheduled a symposium on metals for surgical implants to be held in Detroit, Mich., during October 1965.

**CPOE Subcommittee Activities**

At its 1964 spring meeting in Los Angeles, Calif., the Subcommittee on Prosthetics in Paramedical Education of the Committee on Prosthetic-Orthotic Education recommended the establishment of an *ad hoc* committee to review prosthetic-orthotic visual aids and to compile an annotated list of these aids for use by educators in the various paramedical fields. Members of the recently appointed *ad hoc* committee are: Mrs. Florence S. Linduff, Chief of Physical Therapy, Veterans Administration; Miss Lena M. Plaisted, Professor of Rehabilitation Nursing, Boston University School of Nursing; Miss Nancy B. Ellis, Associate Director, Occupational Therapy Course, Columbia University; and Miss Jamie Lisle, Director of Physical Therapy, Medical College of Virginia. The first meeting of the committee was held in Washington, D.C., on September 28 and 29, 1964.

**Exhibit Depicting Statistical Study of Amputees**

An exhibit entitled *A Statistical Study of 12,000 Amputees* was shown at two professional meetings in Denver, Colo., during 1964 under the sponsorship of the Subcommittee on Prosthetics in Paramedical Education of the Committee on Prosthetic-Orthotic Education. In June it was displayed at the annual conference of the American Physical Therapy Association, and in October at the annual meeting of the American Occupational Therapy Association. The exhibit, which is based on information developed jointly by the Committee on Prosthetic-Orthotic Education and the American Orthotics and Prosthetics Association, shows the distribution of new amputee cases by cause, age, sex, side, site, and extremity.

**Presentation on Research Opportunities for Occupational Therapists in Prosthetics and Orthotics**

At the annual meeting of the American Occupational Therapy Association in Denver, Colo., October 26–28, 1964, an entire general session was devoted to a presentation on the subject, *Research Opportunities for Occupational Therapists in Prosthetics-Orthotics*. Colonel Ruth A. Robinson, Chief of the Occupational Therapy Section at Walter Reed Army Medical Center and Chairman of the Subcommittee on Prosthetics in Paramedical Education of the Committee on Prosthetic-Orthotic Education, acted as chairman for this session. Dr. Miles H. Anderson, Director of the Prosthetics-Orthotics Program at the University of California, Los Angeles, Calif., introduced the panel members, who included Miss Marjorie Fish, an occupational therapy consultant of the Vocational Rehabilitation Administration; Miss Jeannine Dennis, a research occupational therapist at the UCLA Child Amputee Prosthetics Project; Fred Sammons, a research therapist at the Northwestern University Prosthetics Research Center; and Hector W. Kay, Associate Director of Prosthetics and Orthotics at NYU School of Engineering and Science.

**VRA Research Grants for Prosthetics and Orthotics**

The Vocational Rehabilitation Administration recently announced that research grants totaling $419,028 were awarded during Fiscal Year 1964 to 13 new projects in prosthetics and orthotics. In addition, there were 14 ongoing projects in these fields which received continuation grants totaling $416,284.

Since the inception of its research grant program in 1955, VRA has awarded more than

$5,000,000 to 55 projects in prosthetics and orthotics.

### UCOPE Activities

The University Council on Orthotic-Prosthetic Education met at Northwestern University, Chicago, Ill., on October 2, 1964. Dr. Clinton L. Compere, of the Northwestern University Medical School, served as chairman of the meeting, and Dr. J. Warren Perry, of the Vocational Rehabilitation Administration, served as secretary. Liaison representatives were invited from the following organizations: the Veterans Administration, the American Orthotics and Prosthetics Association, the American Board for Certification in Prosthetics and Orthotics, the Committee on Prosthetic-Orthotic Education, and the Committee on Prosthetics Research and Development.

The major items on the agenda concerned plans for new teaching manuals and the revision of existing texts, reports on the proposed Associate in Arts program, and the use of clinical facilities for prosthetics and orthotics trainees.

The next meeting of UCOPE will be held at the University of California, Los Angeles, Calif., in January 1965.

### VA Prosthetic and Sensory Aids Service Initiates Semiannual Bulletin of Prosthetics Research

Edited by William M. Bernstock, Assistant Chief of the Research and Development Division of the Veterans Administration's Prosthetic and Sensory Aids Service, and Anna Syarse, an experienced technical writer, the new semiannual *Bulletin of Prosthetics Research* published by the Prosthetic and Sensory Aids Service made its initial appearance in the spring of 1964.

The first issue, which numbers 153 pages, contains an introduction by Dr. Robert E. Stewart, Director of the Prosthetic and Sensory Aids Service; an article entitled *The Swing Phase of Walking with Above-Knee Prostheses*, by Dr. Eugene F. Murphy, Chief of the Research and Development Division of the Prosthetic and Sensory Aids Service; an article entitled *Properties of Fluid Flow Applied to Above-Knee Prostheses*, by Anthony Staros, Chief of the VA Prosthetics Center, and Dr. Murphy; an article entitled *Clinical Application Studies*, by Mr. Bernstock; an article entitled *The Prosthetic Representative*, by William H. Talley, Chief of the Plans and Policies Division of the Prosthetic and Sensory Aids Service; and an article entitled *Bioengineering Methods of Wheelchair Evaluation*, by Dr. Edward Peizer, Chief of the Bioengineering Laboratory at the VA Prosthetics Center, Donald Wright, a research physiologist at the Bioengineering Laboratory, and Howard Freiberger, an electronics engineer in the Research and Development Division of the Prosthetic and Sensory Aids Service.

In addition, the issue includes a brief description of the prosthetics program in Argentina, the semiannual report of the VA Prosthetics Center for the period July–December 1963, notes on VA contractors, a calendar of events, news items, notes on recent patents, and a list of recent publications of interest.

In his introduction to the *Bulletin*, Dr. Stewart indicates that the scope of the publication includes not only artificial limbs, orthopaedic appliances, and aids to the hard-of-hearing and the blind, but also a wide variety of other aids or accessories for deficiencies of form or function of the human body (for example, cardiac pacemakers, wheel chairs, cosmetic facial restorations, and orthopaedic shoes). Dr. Stewart points out that, although the *Bulletin* is published by the Veterans Administration, its contents are not to be regarded as official policy, since statements of policy will continue to be made in the usual circulars and manuals. In keeping with the policy of the Prosthetic and Sensory Aids Service to give wide dissemination to the results of research, the *Bulletin* will be available to agencies and persons outside the Veterans Administration. In addition, key workers outside the United States may receive the *Bulletin*.

Correspondence should be addressed to the Editor, *Bulletin of Prosthetics Research*, Research and Development Division, Prosthetic and Sensory Aids Service, Veterans Administration, 252 Seventh Ave., New York, N.Y. 10001.

Participants in regional course in prosthetics for Central America held in Guatemala. Rudolf Thys (in short-sleeved white shirt) and Dr. Eugene F. Murphy (wearing dark suit), who were the principal instructors for the course, stand in the center of the group.

Practical work in prosthetics by participants in the course in Guatemala.

### Regional Course in Prosthetics for Central America Held in Guatemala

Under the sponsorship of the International Society for Rehabilitation of the Disabled, a four-week course in prosthetics for Spanish-speaking participants was held in Guatemala during the period November 9 through December 4, 1964.

Principal instructors for the course were Dr. Eugene F. Murphy, Chief of the Research and Development Division of the Veterans Administration's Prosthetic and Sensory Aids Service, and Rudolf Johan Thys, staff prosthetist at the Hospital Ortopedico Infantil in Caracas, Venezuela. Lecturers included engineers and physicians well versed in the principles and practice of prosthetics and orthotics, and prosthetists and orthotists with experience in training and lecturing. Practical shop training for technicians was based primarily on prosthetics with some limited attention to bracing.

The program for the first week consisted of orientation, mechanics, anatomy, physiology and kinesiology, components of prostheses and braces, and principles of fitting and alignment. Suspension and harnessing were considered as well as methods of fabrication of prostheses and braces, prescription principles, check-out principles, and research developments. Psychological and sociological factors were considered along with advanced methods of fabricating new components. Instruction during the remaining three weeks was limited to twelve prosthetists and orthotists who participated in the first week, and consisted of practical work in their technical field.

**Visit to Israel by AMBRL Team**

A project site study team consisting of Dr. Fred Leonard, Scientific Director of the Army Medical Biomechanical Research Laboratory, and Mr. John J. Urban, a technologist at the Laboratory, worked with personnel associated with the Vocational Rehabilitation Administration project, *The Application of Plastics to Braces*, at the Hadassah University Hospital in Jerusalem, Israel, during the period May 4–23, 1964.

The team devoted its time to studying the status of the project and its research approach and to lectures and demonstrations of the latest plastics materials and technology applicable to the field of orthotics. For the demonstrations, approximately 100 lbs. of materials were shipped to Israel.

Recommendations made by the team as a result of its study were that a research coordinating committee (physician, orthotist, mechanical engineer, and plastics technologist) be formed for the project; that the research contract be renegotiated if necessary to permit the inclusion of engineers in the project; and that the research orthotist for the project visit the United States for a period of six weeks to become familiar with the handling of plastics material in prosthetics and orthotics.

The team noted particularly the excellent cooperation given by project personnel to make the visit a success.

**Annual Assembly for 1964 of AOPA**

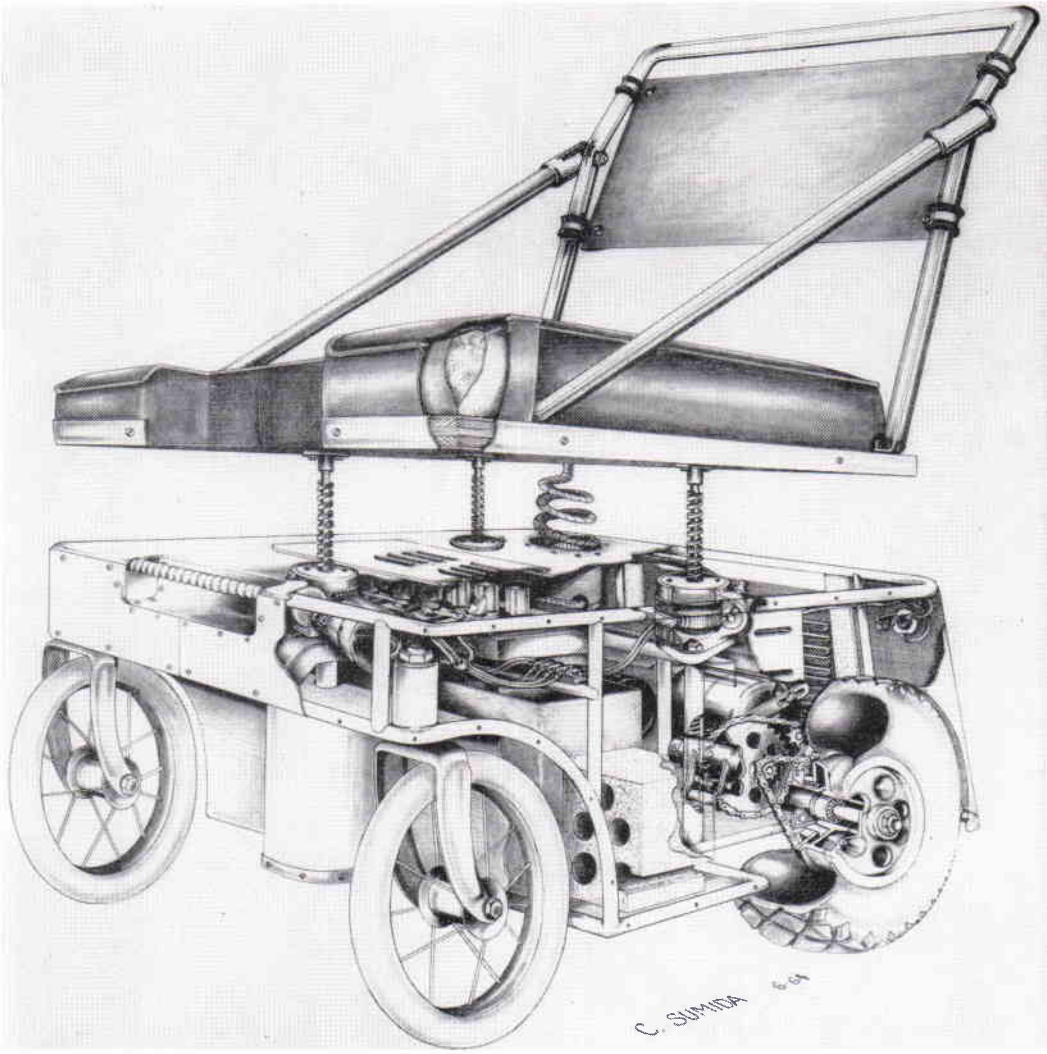
The annual assembly of the American Orthotics and Prosthetics Association was held in Hollywood Beach, Fla., during the period November 8–11, 1964. The President of the Association, Mr. Robert C. Gruman, of Minneapolis, Minn., presided. Registered attendance numbered more than 500. Exhibitors were well represented.

Professional and technical matters considered during the meetings included the Milwaukee Brace in the treatment of scoliosis, the hip-disarticulation prosthesis, juvenile orthotics and prosthetics, the management of geriatric amputees, biomechanics and foot deformity as they relate to orthopaedic appliances and orthopaedic shoes, the fitting technique for very short-below-elbow and partial-hand amputees, and international activities in prosthetics and orthotics.

The keynote address for the assembly was delivered by Dr. Edward R. Annis, Past President of the American Medical Association and of the World Medical Association. Principal speaker at the assembly banquet was Dr. Carl C. Byers, an educator and humorist-philosopher, of Cleveland, Ohio.

Herbert J. Hart, of Oakland, Calif., was installed as the new President of the Association for 1964–1965. Serving with him are President-Elect David C. McGraw, of Shreveport, La.; Vice-President Fred J. Eschen, of New York, N.Y.; and Secretary-Treasurer M. P. Cestaro, of Washington, D.C.

The American Orthotics and Prosthetics Association maintains its national headquarters at 919 Eighteenth St., N.W., Washington, D.C. 20006. Executive Director of the Association is Lester A. Smith. Members




Cutaway drawing of self-propelled cart for multilateral amputees showing means of propulsion and other mechanism. The cart is capable of a top speed of seven miles per hour.

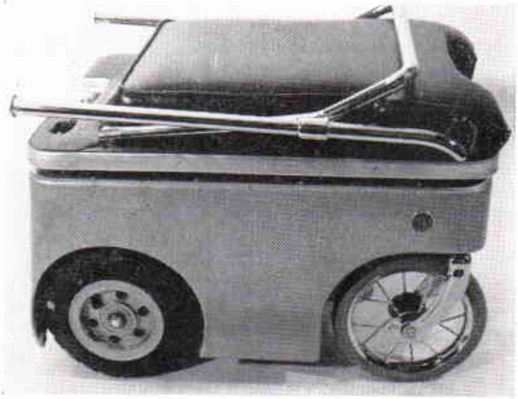
of the Association are located throughout the United States and Canada, and there are corresponding members in England, Belgium, Lebanon, Mexico, Norway, South Africa, Southern Rhodesia, and Venezuela.

### Self-Propelled Cart for Multilateral Amputees Developed at CAPP

To provide mobility to severely handicapped young patients at the Child Amputee Prosthetics Project of the University of California at Los Angeles, Carl Sumida, a research prosthetist on the Project staff, and his brother Wallace Sumida, an electronics engineer who also works for the Project, have developed the self-propelled cart depicted in the accompanying illustrations.

Criteria considered in the design and fabrication of the cart included: controls sufficiently simple for a young child to comprehend and operate; cart size and maneuverability consistent with the dimensions of standard doorways, beds, dining tables, desks, washbasins, and toilets; sufficient sturdiness to withstand rough treatment combined with sufficient lightness to be portable; moderate cost.

The body of the cart consists of a tubular steel frame covered with aluminum panels. Power is supplied by a 12-volt aircraft battery, with provision for recharging overnight. Each pneumatic-tired rear wheel is driven by a separate motor. A third motor drives the lifting mechanism for the seat. The motors and other major components are readily and fairly



The back rest has been collapsed to facilitate carrying and storage of the cart. There are also hand grips for carrying the cart, on the front and rear edges of the body.

The control shown in the illustration was designed for a nine-year-old patient who is a quadrilateral amputee but has a dexterous phocomelic foot. This same control could be inverted and used as a chin control.

inexpensively obtainable as shelf items from automotive and other supply houses.

Controls for the cart are housed in a specially molded fiberglass shell, which can be adapted for use with several different types of controls —a chin control, for example, if the child has no other means of control. To obtain forward motion, both left and right motors operate in forward rotation, and can be switched into reverse to slow down or to go backward. For a left turn, the left motor reverses while the right motor rotates forward, and a right turn is accomplished with the opposite procedure. All these movements are controlled by four microswitches centrally mounted on a joystick arrangement.

The cart is 24 in. long and 16 in. wide, and its height (with the seat at maximum elevation) is 37 in. Its total weight is 91½ lb. Although designed for children, it is sturdy enough to support a 200-lb. man. It is not intended for outdoor use, but rather for the home or a special school that is provided with ramps instead of steps.

Easily transportable, maneuverable, simple to operate, and relatively inexpensive to construct, this cart offers a degree and range of mobility difficult to provide by other means at this time, and it may prove to be of great assistance in helping the severely involved amputee to achieve a greater degree of independence than has been possible in the past.

A detailed report on the device, with sketches, drawings, and specifications, will be published by the Child Amputee Prosthetics Project. Information can be obtained by writing to the Project at 10975 Wilshire Boulevard, Los Angeles, Calif. 90024.

## *Harper's Weekly* on the Status of Limb Prosthetics in 1867

William H. Henderson a research engineer in the Biomechanics Laboratory at the University of California, San Francisco, recently ran across the following item while going through some old series of *Harper's Weekly*:

WOODEN ARMS AND LEGS

(*Harper's Weekly*, Vol. XI, No. 557, Saturday, August 21, 1867, page 547)

Perhaps there never was a time when artificial limbs were so common as now. Warfare in all civilized countries necessarily maims many thousands yearly, who avail themselves of wooden arms and legs for the sake of appearance rather than from their positive utility. The perfection of the art of manufacturing substitutes for lost members is an extraordinary triumph of art. Some are actually walking about in patent leather boots on a pair of artificial pedestals, and no one would suspect it if uninformed of the fact. Artificial arms make a coat fit a little better than none at all, and artificial hands make a very fine show covered with elegant gloves, but neither of them ever prove so decidedly useful as artificial lower extremities.

The Government of the United States seems to have been in advance of all others in providing its gallant but unfortunate soldiers with artificial limbs. It is creditable to the humanity and consideration of Congress that large sums have been appropriated for providing everyone who has lost a limb in the public service with the best substitute the ingenuity of the best mechanics could devise. It has become a distinct profession in North America to fabricate artificial limbs, and consequently carries to a high degree of artistic perfection.

## Errata

Corrections in the text of the Spring 1964 issue of *Artificial Limbs* should be made as follows:

Page 51; the formula in the middle of the right column should read:

$$I = M\left[\frac{l^2}{9}\left(1 + \frac{d}{r + r_1}\right) + \frac{(r + r_1)^2 - 2d^2}{16}\right]$$

Page 58; the formula at the bottom of the right column should read:

$$m = \frac{(S_m - S_0)D}{d(1 - \cos\varphi)}$$

Page 60; the formula at the top of the right column should read:

$$m = \frac{(S_m - S_0)D}{d(1 - \cos\varphi) + e}$$

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## NATIONAL ACADEMY OF SCIENCES—NATIONAL RESEARCH COUNCIL

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

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

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

### 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 Industrial Research 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.