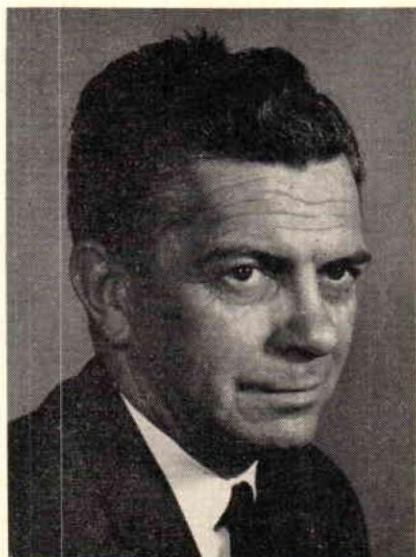


PROSTHETICS RESEARCH



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Since the inception of the nationwide prosthetic research program, New York University-Prosthetic Devices Studies has been primarily concerned with the testing and evaluation of new prosthetic devices, techniques, and treatment procedures as they have been developed.

Initially, prosthetic development and the work of this laboratory had as its focus the problems and treatment of the Veteran amputee, and was adult-oriented. However, as the research program continued, the newer concepts of amputee treatment developed for adults were increasingly applied to the management of the child amputee. This trend was accelerated greatly by the Prosthetics Education Program and the nation-wide Upper Extremity Field Studies (1954-1957).

Thus the modern treatment of the child amputee began largely as an adaptation of procedures and a miniaturization of equipment developed originally for adults. To some extent, this process still continues. However, with the emergence of an extensive and active program for the treatment of juvenile patients, it became increasingly apparent that the child amputee was not a miniature adult. Such considerations as growth and development, optimal fitting age, the role of the parents, and of the school, apply only to children and indicated a need for specialized study of their problems. To meet this need, New York University-Prosthetic Devices Studies established the Children's Prosthetic Studies Group as a separate entity to study the needs and management of the child amputee, while maintaining the Adult Prosthetic Studies Group for continued research with adult amputees. The work of these two study groups is described in the following pages.

ADULT PROSTHETIC STUDIES

Since its inception some twelve years ago, the prosthetics research program, under the sponsorship of the Veterans Administration and with the coordination of the National Research Council-National Academy of Sciences, has witnessed the development of many new prosthetic devices and techniques. University, industrial, and armed services developmental laboratories, and many private citizens have all contributed to the continuous outpouring of new items designed to improve the lot of amputees.

Each new development has sought acceptance and incorporation into the prosthetic treatment program. Of necessity the usefulness of each new item had to be appraised and its role in the treatment of amputees determined. Essentially each new prosthetic component or technique seeks to compete with existing practice. To obtain acceptance a new item should either provide a prosthetic function or service not currently available, or perform some function better than existing devices. Since the offerings were numerous and the stakes were high, such determinations could not be made arbitrarily or haphazardly—an organized evaluation program was required. Such a program should seek factual information concerning an experimental item, rather than relying solely upon opinion; it should be unbiased; and it should take into account not only the device, but also the amputees who are to wear it.

New York University-Prosthetic Devices Studies was assigned the major role in developing and conducting such an evaluation program and in the past has tested more than 100 different prosthetic items and published 27 major technical reports, plus more than 75 reports dealing with less comprehensive evaluations.

The entire prosthetic evaluation program at New York University has had the support of the Committee on Prosthetics Research and Development which not only encourages basic research, but also coordinates the smooth transition of new items from the developer's first relatively crude bench model to commercial production. From experiences over the years, these "transition procedures," as they are called, have evolved into a smoothly working pattern of operations. For prosthetic components the pattern involves: (a) Prototype Model Testing; (b) Production Model Testing; (c) Field Testing (if indicated). Prosthetic techniques ordinarily require only a single laboratory testing procedure, but supplementary field testing may also be employed.

Prototype Model Testing

This procedure involves a preliminary study of developers' models of new prosthetic components and has four prime purposes:

- 1) To provide initial assurance that new devices are mechanically and structurally sound, and do not endanger the well-being of amputees.
- 2) To establish the prosthetic applicability of the new component and to develop written directions for this application.
- 3) To assist the developer to overcome any mechanical, functional, and cosmetic problems revealed by the evaluation.
- 4) To provide initial assurance concerning the merits of the device prior to extensive fittings or production engineering.

Production Model Testing

This is the core evaluation procedure in the total testing program. The procedure is accomplished on production models and involves a larger sampling of cases than in Prototype Testing. The purposes of Production Model Testing are:

- 1) To determine that the production models embody the positive features of prototype models previously tested and that recommended changes in procedures, design or materials have been made.
- 2) To confirm on a larger and more representative sample of amputees the findings of prototype testing.
- 3) To provide valid information on all pertinent factors so that sound judgments concerning the merits of the item can be made.
- 4) To determine prescription criteria for clinic and prosthetist application of the device.

Technique Evaluation

The aims of Technique Evaluation are:

- 1) To determine the effectiveness of a technique.
- 2) To test the adequacy of the instructions provided and the applicability of the technique by personnel not associated with its development.
- 3) To establish indications and contra-indications for use.

Typically, Technique Evaluation proceeds from a small number of initial fittings to a larger sampling of the amputee population as confidence is gained and problems resolved.

Field Testing (Components or Techniques)

This procedure is typically reserved for critically important and/or expensive items. It has been developed to provide additional information concerning the value of experimental devices and techniques as applied under prosthetic clinic conditions, rather than in the controlled laboratory setting. A secondary purpose is to provide information concerning geographical, occupational, or other factors which might affect the value of the device or technique, and thus delineate additional prescription criteria. Field Testing would thus be confined to selected evaluation items and appropriate geographical areas.

Scope of the Evaluation Program

In line with the procedures described above, the testing experience at New York University-Prosthetic Devices Studies has encompassed more than 100 different items in the prototype model stage, some 30 to 40 production model items, and about 10 that have undergone Field Testing. This latter group has included such items as the APRL Hand, the APRL Hook, the Navy Variable Cadence Knee, the Navy "Soft Socket" Below-Knee Leg, and the Henschke-Mauch "Hydraulik" Swing Control Unit (Figures 1-4)

Prominent among the items tested through the production model stage are such components as the "Hydra-Cadence" Knee and the SACH Foot (Figures 5 and 6). In addition, certain significant Field Studies, unrelated to "transition procedures," have been completed. Noteworthy among these are a survey of cineplasty amputees and the massive Upper Extremity Field Studies conducted in conjunction with the Upper Extremity educational program.

New fabrication, fitting, and alignment techniques have also been studied extensively in the development and evaluation programs. The evaluation of these potentially important advances in prosthetic practice require consideration not only of the usefulness of the technique in the hands of its developer, but even more critically of the "transmittability" of the technique to others. Over the years such items as the plastic Syme prosthesis, the University of California at Berkeley Quadrilateral Above-Knee Socket and patellar tendon bearing below-knee fitting and alignment techniques, and the Blevens Prosthesis (Figures 7-8) have been studied in the New York University-Prosthetic Devices Studies laboratory.

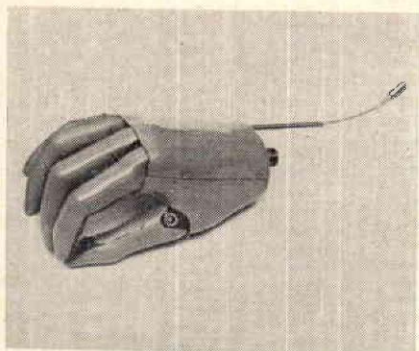


FIGURE NO. 1A—APRL HAND.

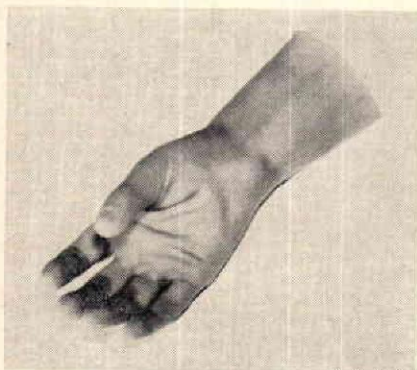


FIGURE NO. 1B—APRL GLOVE (MILTON).

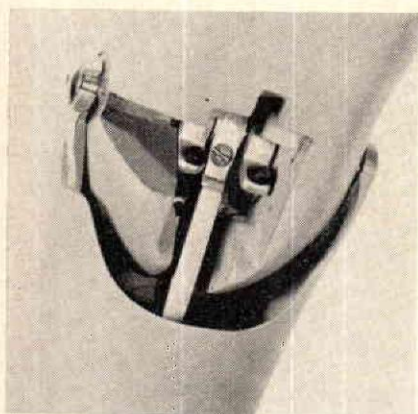


FIGURE NO. 3—NAVY VARIABLE
CADENCE KNEE.

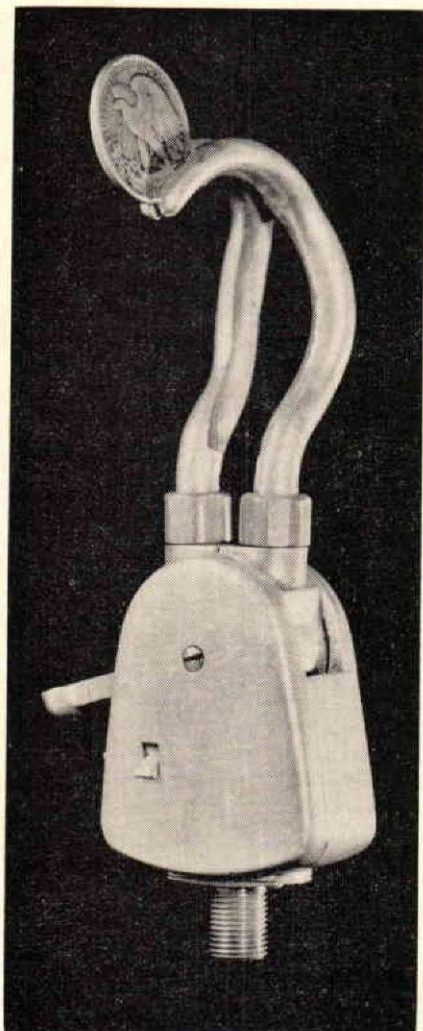


FIGURE NO. 2—APRL HOOK.

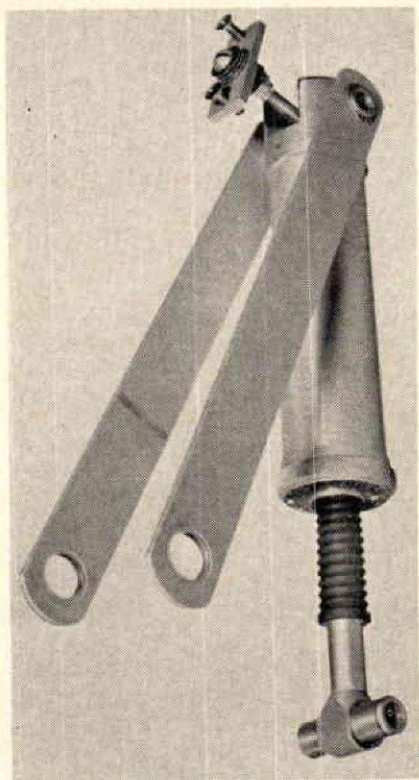


FIGURE NO. 4A—HENSCHKE-MAUCH "HYDRAULIK" SWING CONTROL UNIT.

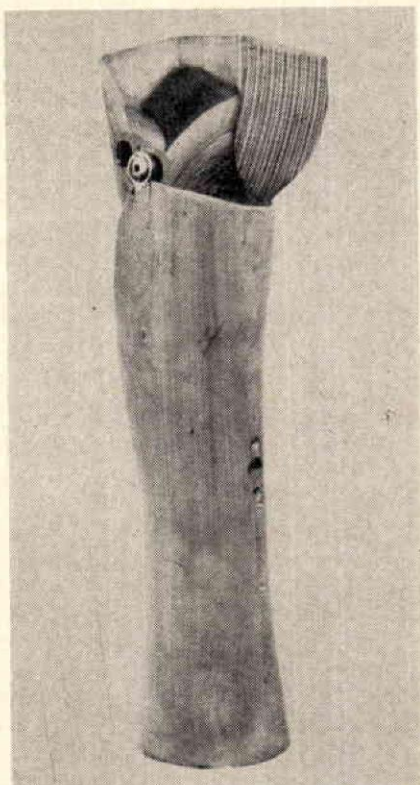


FIGURE NO. 4B—SET UP FOR HENSCHKE-MAUCH "HYDRAULIK" SWING CONTROL UNIT.

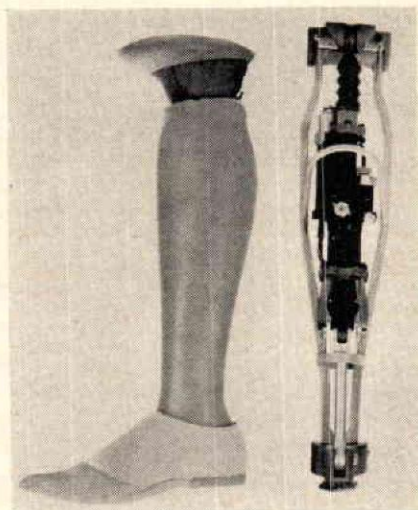


FIGURE NO. 5—"HYDRACADENCE" UNIT WITH AND WITHOUT COSMETIC COVER.

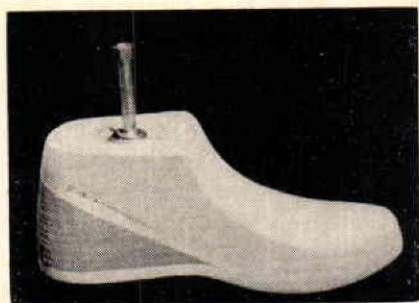


FIGURE NO. 6—SACH FOOT.

As yet the steady stream of new or improved prosthetic techniques and devices shows no sign of tapering off. Currently under evaluation are such promising items as the Henschke-Mauch "Hydraulik" Swing and Stance Control Unit, the Army Prosthetics Research Laboratory's Porous Laminate Fabrication Technique for Upper Extremity Prostheses (Figure 9) and the Hosmer E-400-2 Spring Forearm Lift Assist Elbow (Figure 10).

As a testing agency, the New York University-Prosthetic Devices Studies has a responsibility not only to determine the usefulness of a specific item, but also, where possible, to determine for whom it is useful; i.e., to provide information that will guide the prescription and purchase of the particular device. Moreover, evaluation results are seldom wholly favorable or completely negative. Hence, the test program should provide information which will help a developer or manufacturer improve his product, usually by the elimination of undesirable features. Another consideration which can be quite critical in certain instances is the development of accurate, detailed instructions for the installation, fabrication, alignment, or adjustment of the new item. The development or refinement of such instructions is an inherent part of the evaluation process.

Evaluation Techniques

To achieve the results required of the testing program, New York University-Prosthetic Devices Studies has evolved a four-pronged approach to the appraisal of new items. This approach has been dictated both by the nature of the problem and by the desirability of conducting the evaluation primarily in a laboratory setting under rather rigid controls. In essence prosthetic evaluation, whether of a device or technique, involves two elements: a mechanical gadget (prosthetic component or complete prosthesis) and an amputee. A comprehensive evaluation program must include the study of both factors, plus their interaction. Thus the four areas of inquiry which have been found to yield the most fruitful information under laboratory conditions are the prosthetic, psychological, engineering and biomechanical, and medical. The findings from each of these areas are coordinated and interrelated to present the most meaningful total picture.

Fundamentally the worth of a new prosthetic device or technique can best be determined by comparing it with the item or items it might replace. The value of a hydraulic knee mechanism, for example, would most appropriately be gauged by comparing it with other knee mechanisms available for above-knee amputees by such criteria as function, appearance and energy expenditure. The implicit frame of reference within which comparisons are made is whether an amputee can function more "normally" with one device or prosthesis than another—that is, more like a non-amputee. Hence, the typical evaluation procedure involves at least two determinations of amputee "status"—once without the experimental item and the other with it. These determinations are made in each of four areas of study—prosthetic, medical, biomechanical and engineering, and psychological.

However, before discussing this operational pattern in somewhat more detail, a word should be said concerning the amputees who act as subjects for the research. All amputees participating in the various evaluation projects conducted over the years have been volunteers, serving entirely without remuneration. They come from all walks of life and include both men and women, veterans and non-veterans. Some have been referred by various agencies and hospitals in New York City, Long Island, and New Jersey. Many have learned of the research program from other amputees. A number have participated in more than one project. Since most of the evaluation projects involve considerable amputee cooperation—in time, in conforming

to an experimental plan, in submitting to a testing program—subjects for each project are screened and selected. Thus, the participants are not representative of a total amputee population but rather of the more progressive and cooperative element of that population. Except in studies where fresh amputees may participate, all experimental subjects are required to have a functional prosthesis in good condition. The reasons for this requirement



FIGURE NO. 7—PLASTIC SYME PROSTHESIS.

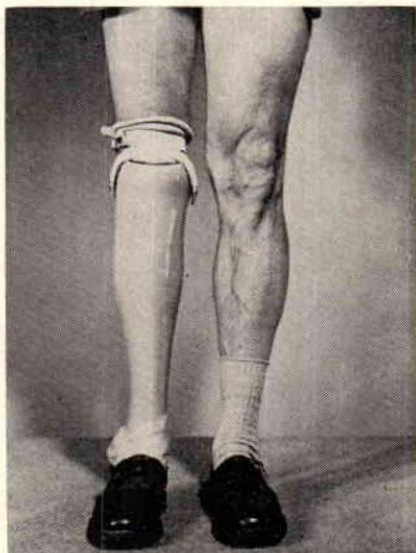


FIGURE NO. 8 — UCB PATELLA TENDON BEARING BELOW-KNEE PROSTHESIS.

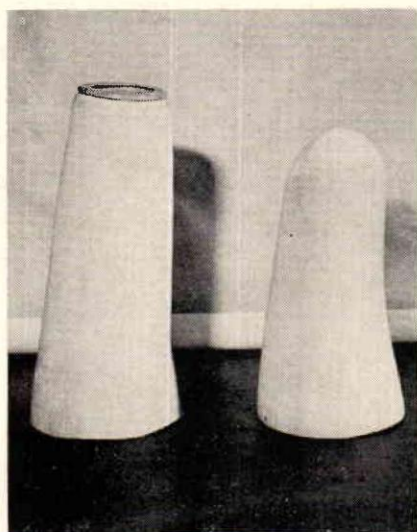


FIGURE NO. 9—APRL POROUS LAMINATED SOCKET FOR THE UPPER EXTREMITY PROSTHESIS.

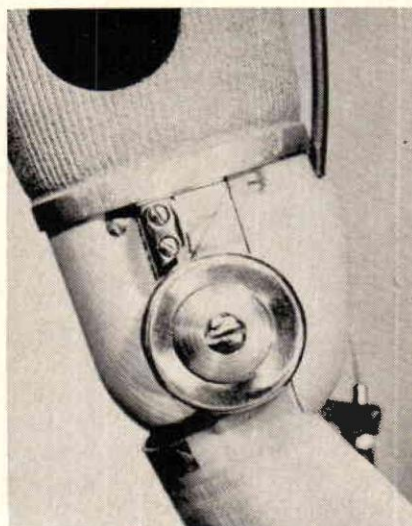


FIGURE NO. 10—HOSMER E-400-2 SPRING FOREARM LIFT ASSIST ELBOW.

are simple. When the item being evaluated is a single component, e.g., a new type of knee, the most meaningful information can be obtained when the experimental unit is substituted for the old, with all other components held constant. If several components were to be changed simultaneously, the effect of the experimental item would be considerably diffused. Or if a new fabrication technique were being tested, the evaluation data would be markedly affected if the subjects' old prostheses were in such poor condition that practically anything would be an improvement.

AMPUTEE TEST BATTERIES

Each discipline involved in the testing program has gradually evolved and refined evaluation instruments designed to provide the most meaningful information in the specific field. Further improvements in testing techniques are under continuing study. The major items currently used in each test battery are listed below. It should be emphasized that *all* test items are not applied to each subject in each study, but that from the instruments available, those appropriate to the specific item being evaluated are used.

Prosthetic

No tests are applied by the prosthetic group other than to fit the experimental item to amputee subjects in accordance with the developer's instructions with all other variables held constant. Problems of prosthetic application and maintenance are identified. The prosthetists also play a major role in the evaluation and clarification of installation or fabrication instructions provided by a developer or manufacturer.

Psychological

All candidates for participation in any given study are interviewed and given a psychological test battery. The results obtained serve as a partial basis for the selection of suitable candidates for the specific project. The screening results also provide initial baseline psychological data for subsequent evaluations.

In the clinical interview given as part of the psychological evaluation such factors as ease of interrogation and lack of ambiguity are noted. Indications of pre-amputation personality, adjustment to amputation and prosthesis, and present vocational and social adjustment are also sought, as is information concerning pain and phantom limb experiences.

The psychological test battery is designed to assess personality characteristics which have been found to be significant in prosthetic adjustment. Included are such factors as impulsivity, anxiety, depression, withdrawal, pessimism, level of aspiration, stress tolerance, and somatic preoccupation. Two tests to determine surface and deep tissue pain tolerances are also given.

A separate validation study of the psychological and psychophysiological instruments used is now in progress, under the sponsorship of the Office of Vocational Rehabilitation, and should result in an improved test battery for both the screening and evaluation of amputee subjects participating in the laboratory projects of the Prosthetic Devices Studies. This study is discussed elsewhere in this issue by Dr. S. A. Weiss.

Biomechanics and Mechanical Design Analysis

Included in these evaluation procedures are study of (A) the man-prosthesis combination in relation to the environment (biomechanics); (B) relationships between socket and stump (pressure measurements); and (C) design and structural features of mechanical devices.

A. Biomechanics

1. Temporal Factors

A walking time recording technique (Figure 11) is employed to gather raw data on the time components of walking at various cadences.

These data are then analyzed to determine the symmetry of gait by study of such factors as the ratio of swing phase time to stance phase time, variation of double support time, variability of step times, etc.

2. *Kinematic Factors*

Photographic records (Figure 12) obtained with the use of an Interrupted Light camera (Figure 13) are used to study the geometry of walking, including such aspects as

linear measurement of hip, knee and ankle displacements, heel and toe rise and stride length; angular variations of the thigh, knee and ankle motions; and the linear and angular velocities and accelerations of these body components and the instantaneous horizontal velocity of the trunk.



FIGURE NO. 11—WALKING TIME RECORDING TECHNIQUE.

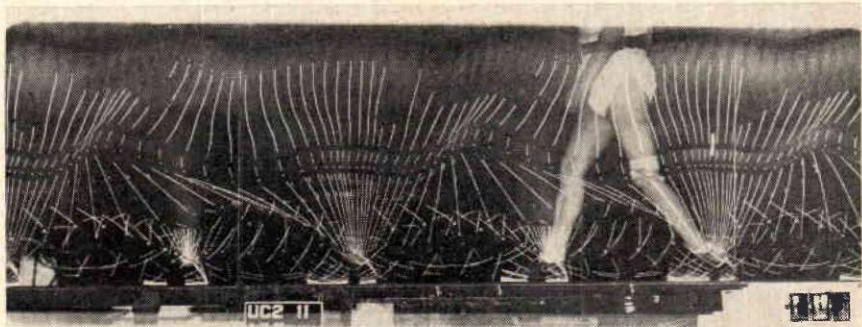


FIGURE NO. 12—"STICK" PICTURE OBTAINED WITH INTERRUPTED LIGHT CAMERA.

3. Kinetic Factors

Measurements of the forces between the foot and the ground are obtained by means of force plates (Figure 14) in order to study the forces and moments acting on the lower extremity during the stance phase of ambulation. Specific measures include

- vertical load,
- fore and aft and lateral and medial shear forces, and
- torsional forces.

From these and the previously mentioned kinematic measures, moments about the hip, knee and ankle are determined.

4. Stability

The ability of an individual to maintain balance under static and dynamic conditions is studied by means of tests utilizing force plates, the inclined plane, and the rolling platform (Figures 15, 16).

B. Pressure Measurements

The development of strain gauge instrumentation (Figure 17) for the measurement of pressures between the stump and the socket has proceeded to a point where preliminary practical application is envisaged before the close of the current year. Initially such application would involve mapping the pressure patterns in selected cases and a study of the effect of various prosthetic variables on these patterns.

C. Design and Structural Features

The design, materials, and mechanical function of each experimental item are also examined in relation to the developer's claims and drawings, and where indicated, accelerated testing (cycling) is arranged. Malfunctions and material failures are analyzed and, where indicated, recommendations for design or material changes are made.

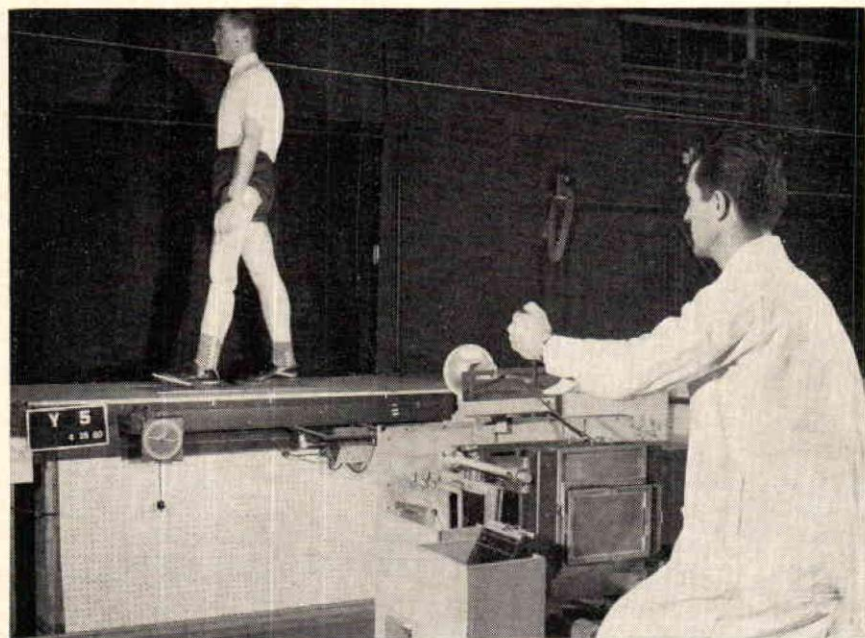


FIGURE NO. 13—INTERRUPTED LIGHT CAMERA TECHNIQUE

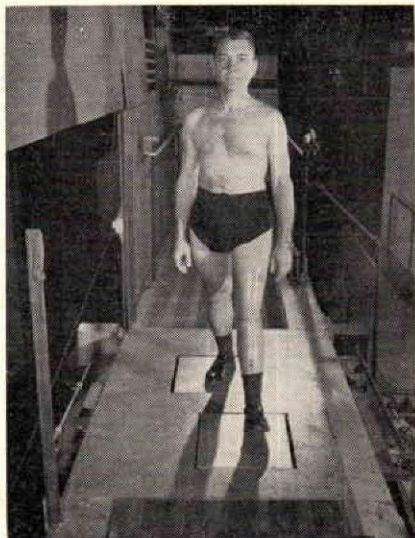


FIGURE NO. 14—FORCE PLATES.



FIGURE NO. 16—ROLLING PLATFORM.

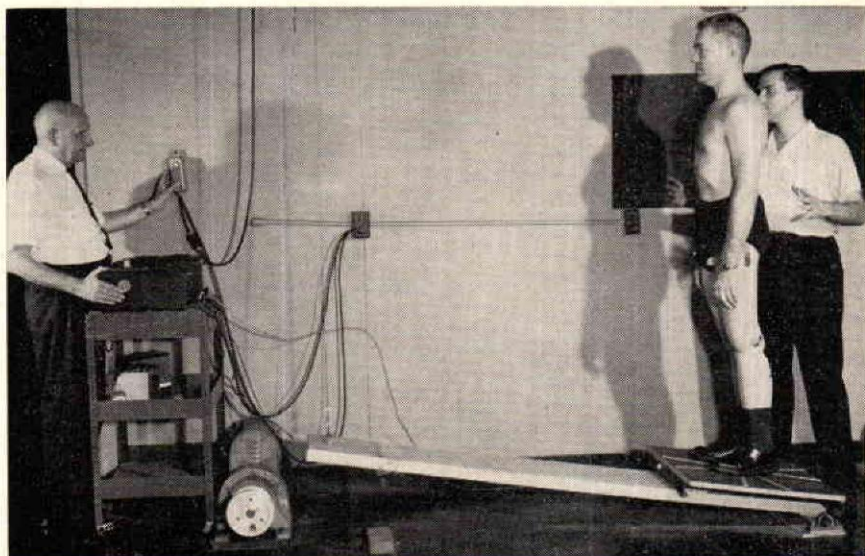


FIGURE NO. 15—INCLINED PLATFORM.

Medical

In addition to the gathering of medical information, this aspect of evaluation also independently cross-checks certain types of data collected by other members of the evaluation team. The areas of interest here include:

1. Data to determine the medical status of amputees for selection purposes.



FIGURE NO. 17—STRAIN GAGE.

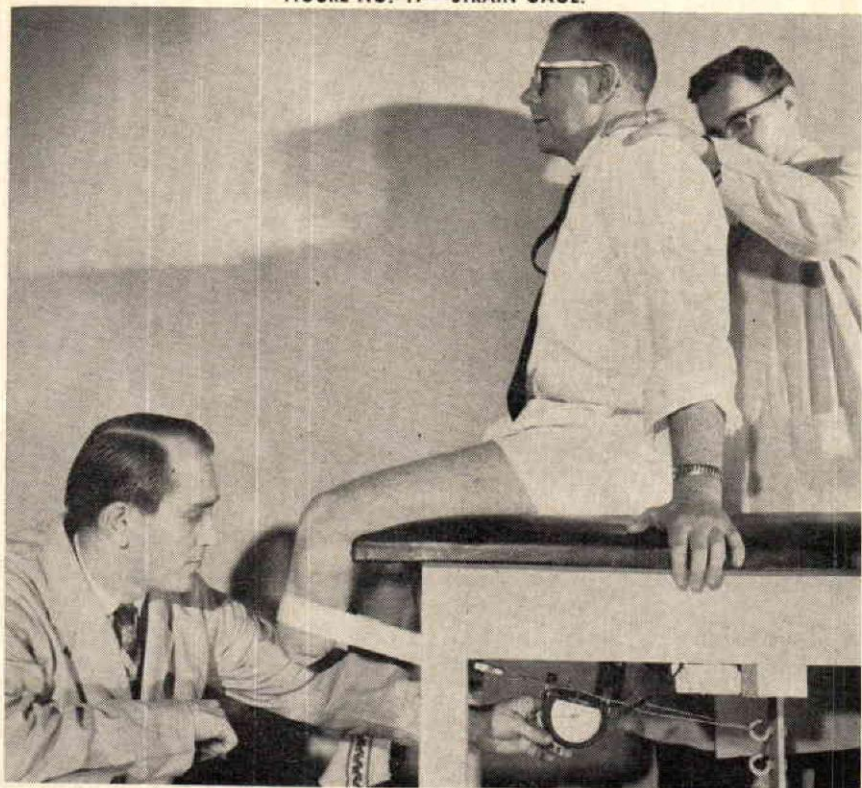


FIGURE NO. 18—STRENGTH TEST.

2. The clinical determination of dermatological and circulatory changes in stumps, with color photography used to obtain comparative data.
3. Anthropometric measures to determine significant changes in circumferential and other dimensional aspects of stumps, and the determination of changes in strength (Figure 18).
4. X-ray examination of stumps to determine significant osseous changes arising from use of experimental limbs, and to determine the medical status of stumps if problems are anticipated.
5. Subjective gait and performance evaluations to determine significant changes attributable to the use of experimental legs. These subjective data may then be compared with findings of the biomechanical analysis.
6. Amputee reactions to experimental limbs—these data may be related to both prosthetic and psychological findings.
7. Metabolic measurement to determine the energy expenditure involved in the use of experimental limbs in comparison with that required for conventional prostheses will be introduced into the evaluation program shortly. (Figure 19)

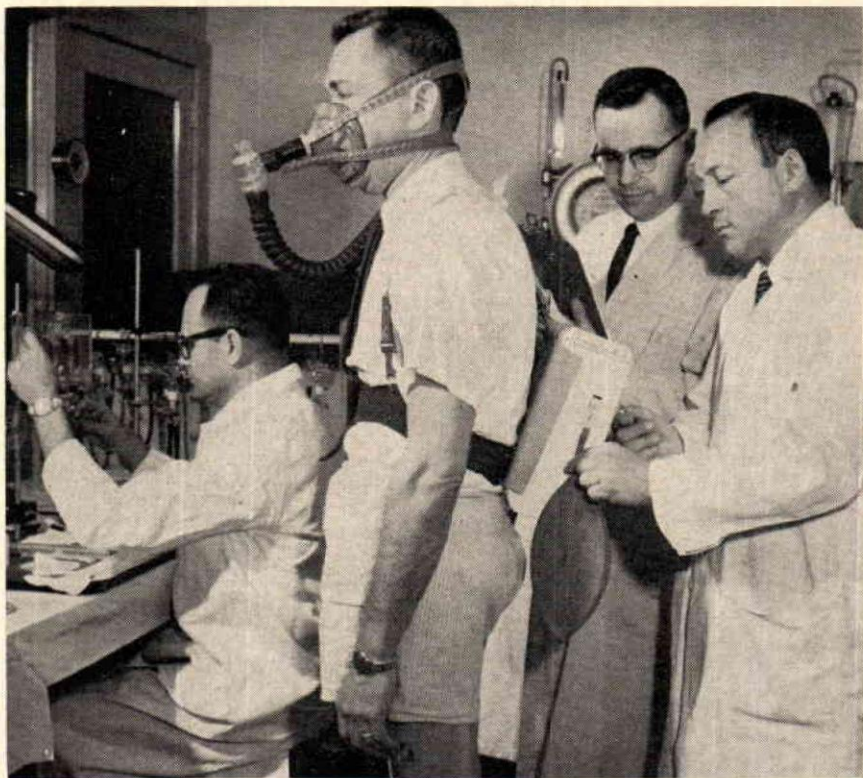


FIGURE NO. 19—METABOLIC MEASUREMENT

CHILDREN'S PROSTHETIC STUDIES

"He who helps a child helps humanity with an immediateness which no other help given to a human creature in any other state of life can possibly give again." —Phillips Brooks

A discrete segment of the research activities at New York University is centered on the special needs of the child amputee. This project (designated as the Children's Prosthetic Studies) is sponsored by the New York State Department of Health and the Children's Bureau of the Department of Health, Education and Welfare. It functions in direct cooperation with the Committee on Child Prosthetic Problems, a sub-committee of the Committee on Prosthetic Research and Development, National Research Council, National Academy of Sciences.

These children's studies began early in 1958, with two major goals: 1) to develop a body of reliable information about the current clinical treatment of child amputees, and 2) to provide a program through which new developments in prosthetics for children could be efficiently tested and the results reported to the treatment centers without delay.

For these purposes, studies were designed to collect information about the techniques and methods of child amputee management used in clinics throughout the country and to distribute the findings to individuals and agencies interested in the problems of child amputees. A second and equally important aim was to introduce new prosthetic techniques and components for trial and evaluation in the member clinics after preliminary study and tests under laboratory conditions in our laboratories in New York City.

Organization

There are twelve Child Amputee Centers distributed throughout the nation participating in the Children's Prosthetic Studies at the present time (as depicted in Figure 20).

The medical directors of each of these modern child amputee treatment centers were invited to join the program on the basis of criteria established by the Committee on Children's Prosthetic Problems.

- 1) The clinic team must include a physician as clinic chief, a social worker, an occupational and/or physical therapist, and a prosthetist. These personnel should have successfully completed the upper-extremity and lower-extremity prosthetic courses.
- 2) Adequate consultation services in the essential medical specialties should be available to the clinic team.
- 3) Psycho-social services should be available to the clinic.
- 4) Acceptable prescription-writing and checkout procedures must be followed and an adequate record system and case follow-up plan used.
- 5) Photographic facilities (both stills and movies) should be available.
- 6) A satisfactory post-fitting training program must be followed: preferably in-patient, although good out-patient training programs are acceptable.
- 7) The clinic should meet not less than once every two weeks.
- 8) The clinic should have a potential admission rate of not less than 25 new cases annually, including both amputees and patients with congenital anomalies which may be treated with prostheses.

Types of Studies

In the two years since their inception, the Children's Prosthetic Studies have engaged in two types of research studies: A) Evaluation of prosthetic components and techniques, and B) a Normative Survey.

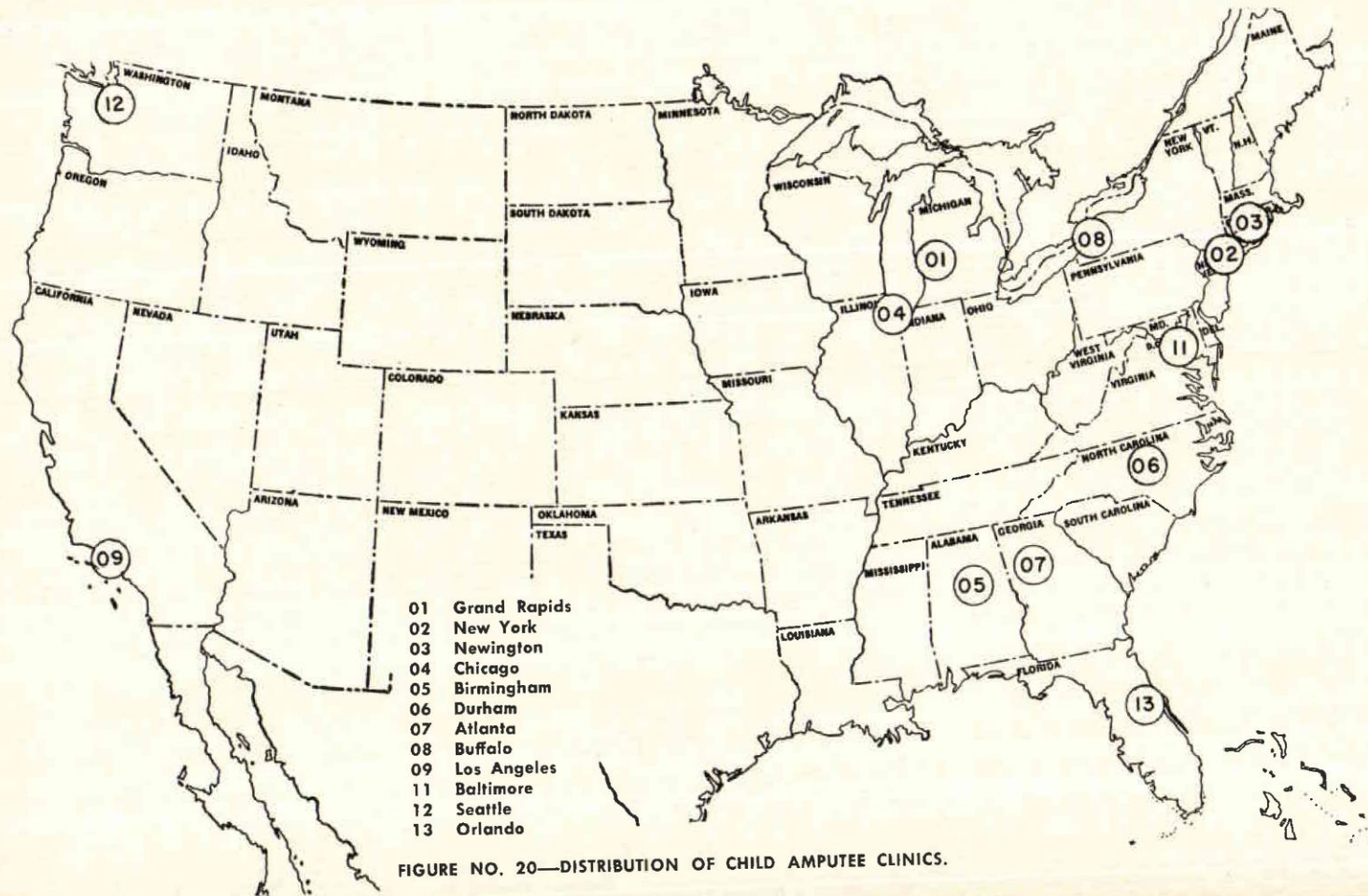


FIGURE NO. 20—DISTRIBUTION OF CHILD AMPUTEE CLINICS.

A. Evaluation Studies

The evaluation of prosthetic components has followed a similar pattern to that previously described for the adult studies, with initial testing of items in the laboratory and nearby clinics followed by more extensive testing in the field. The typical test procedure for such items includes a design and material analysis and a limited clinical test with a small number of children. These tests are usually completed in two to three months and results are quickly transmitted to the developer. Such items as the Sierra 209 Elbow, APRL Child Prehension Device, Hosmer Wrist Flexion Union and APRL-Sierra Child Hand have been tested in this manner.

Our reports to the developer usually contain recommendations for revision and improvement, and in some cases retests are conducted on improved models until a particular device is approved for general distribution to the public. In the case of the Child Size Hand, for example, laboratory tests were conducted over a period of one year, during which the original prototype model was significantly revised a number of times by the manufacturer. The current (production) model is now being field-tested in the member clinics.

The continuing cooperation of the twelve participating child amputee centers has made possible the extensive and routine use of "Field Study" procedures. In a typical field study a research design is prepared, together with the necessary data gathering instruments and forms. The information required in the study is then collected by clinic personnel and sent to New York University, where it is organized and reported.

This field study technique, normally used as an extension of laboratory studies on prosthetic devices, has also been used as a means for gathering information concerning techniques or components which have not undergone laboratory testing. Included in this latter group has been an investigation of the suitability of the quadrilateral socket for above-knee amputees below 13 years of age; the suitability of the SACH Foot for children, and the suitability and utility of the pre-flexed socket for very short below-elbow amputees as compared to split socket prostheses.

- 1) *The Quadrilateral Socket Study* plan called for the fitting of above-knee amputees with the experimental quadrilateral socket utilizing existing clinic procedures. The information collected included data on fit, comfort and function, stump examination for medical problems, quality and extent of the child's ambulatory activities, and maintenance requirements of the prosthesis. This study was concluded in January 1960 when it was established that the Quadrilateral Socket was in general use at all of the participating clinics and that none of the prosthetists reported any difficulty in fitting it to children. Although the socket was fitted to all types of above-knee amputees above eighteen months of age, some supplementary suspension was used for children below age 5. Above this age many children were fitted with suction as the only suspension.
- 2) *The SACH Foot Study* was also brought to a close in January 1960 as it was found that this component was being fitted to children on a routine basis. Fifty-six of the seventy-five lower extremity amputees reported by the member clinics were wearing SACH feet, and the utility and maintenance requirements of this item were generally satisfactory.
- 3) *The Preflexed Arm Study* is still in process, with additional cases being added as new preflexed arms are prescribed for previous wearers of split socket prostheses.
- 4) *APRL-Sierra Child Size Hand Model 1A*—A field study of the child-sized prosthetic hand is now being activated. Its purposes are to: introduce

the hand to the field; corroborate the findings of previous laboratory studies, and to evaluate acceptability and utility of the production model of the hand.

A number of children will be fitted with the hand in each of the participating clinics with a total of approximately 40 fittings anticipated. The evaluation will be based on:

- a) The opinions of children, parents, and others relating to the experimental hand and to previously worn terminal devices.
- b) Observations of classroom behavior during treatment period.
- c) Ratings of the amputees' performance of standard tasks using both experimental and old terminal devices.
- d) Maintenance.

The hand to be tested is a voluntary-opening type and is covered with a cosmetic glove (Figure 23). The age range of children for whom the hand would be applicable has been tentatively set at 4 to 10 years. However, this range of application will be tested in the field study and a narrower range may eventually be established.

Initial tests with the APRL-Sierra 1A Hand have been quite promising and the item may well be a useful addition to the armamentarium of prosthetic components for the child amputee.

B) *The Normative Survey*

The Normative Survey was set up primarily to develop a continuing census of the child amputee population. Secondly, it was planned to provide a pool for the selection of children for studies of specific prosthetic components and special treatment techniques.

A complete set of survey forms is administered to each child appearing at the cooperating clinics for evaluation, treatment, or service. The information collected is similar to that normally recorded by many of the clinics. It includes:

- 1) Identification, vital statistics, amputation history, school recreational activities, and prosthetic wear pattern.
- 2) Physical descriptions with special attention to the stump.
- 3) Ranges of motion and muscle strength.
- 4) Description of prosthesis and prescription information.
- 5) Upper-extremity checkout.
- 6) Lower-extremity checkout.
- 7) Lower-extremity performance rating (gait deviations in level walking at normal speed; performance in ascending and descending ramps and stairs.)

The large numbers of subjects required for census-type investigations led us to consider pre-coding the data collection forms so that the clinical data could be transferred directly to IBM cards without costly, time-consuming clerical work. Although this system of pre-coding was not familiar to many of the clinic personnel, and appeared somewhat complicated at first, the forms were found to be relatively simple to use and the system was quickly and easily mastered by therapists and others. Each form (as illustrated in Figure 21) provides a series of questions relating to a particular type of data. One simply checks the correct answers and writes in any information which is not included in the answers provided on the form. The forms are designed for easy administration, requiring only the circling of a number, the entry of a figure, or in a few instances, writing in a short phrase.

Col. 1 X
 Col. 80 1
 Col. 1 CLINIC NAME
 Col. 2 CLINIC ADDRESS
 Col. 3 Patient's Name
 Col. 4 Address
 Col. 5 City, State

FIGURE 21
 SAMPLE DATA COLLECTION FORM

Farm: Yes No
 Phone

(A) IDENTIFICATION

INSTRUCTIONS: Insert appropriate numbers where codes are not listed, as: to record 35 inches.
 Col. a 3
 Col. b 5
 Col. c 0
 If codes are listed, circle appropriate numbers.

DATE

Col. 6 Month (Use Col. 6)
 Col. 7 Year (Use Cols. 7 & 8)
 Col. 8

SEX

Col. 9 1 Male
 2 Female

DATE OF BIRTH

Col. 10 Month (Use Col. 10)
 Col. 11 Year (Use Cols. 11 & 12)
 Col. 12

HEIGHT

Col. 13 Tens of Inches
 Col. 14 Units of Inches
 Col. 15 Half Inches

WEIGHT

Col. 16 Hundreds of Pounds
 Col. 17 Tens of Pounds
 Col. 18 Units of Pounds

DATE OF AMPUTATION

Col. 19 Month (Use Col. 19)
 Col. 20 Year (Use Cols. 20 & 21)
 Col. 21

PREVIOUS PROSTHETIC WEAR

Col. 22 1 Yes
 2 No

ETIOLOGY (Multiple Coding Permitted)

Co. 23 1 Congenital Amputation
 2 Congenital Anomaly
 3 Accident
 4 Disease
 5 Fracture

ACCIDENT RESULTING IN AMPUTATION

Col. 24 0 Does Not Apply
 1 Automobile or Bus
 2 Train
 3 Trolley Car
 4 Tractor—Power Takeoff
 5 Combine or Hay Baler
 6 Corn Picker
 7 Fall
 8 Shot Gun
 9 Explosion
 Col. 25 0 Does Not Apply
 1 Freezing
 2 Burning
 3 Snake Bite
 4 Other

DISEASE CAUSING AMPUTATION

Does Not Apply Col. 26 0
 Gangrene 1
 Thrombosis 2
 Tumor 3
 Brachial Plexus Deficit 4
 Poliomyelitis 5
 Spina Bifida 6
 Erb's Palsy 7
 Volkmann's Contracture 8
 Osteomyelitis 9
 Tuberculosis of Bone X
 Other (Specify) Y

DATE OF LAST REVISION

Month (Use Col. 27) Col. 27
 Year (Use Cols. 28 & 29) Col. 28
 Col. 29

CAUSE OF LAST REVISION

(Write in) Col. 30 0
 1

PREVIOUS REVISIONS (Write in)

Date	Reason	Col. 31
.....	0
.....	1
.....	2
.....	3

TYPE & SIDE OF AMPUTATION(S)

Unilateral Upper Left Col. 32 1
 Unilateral Upper Right 2
 Unilateral Lower Left 3
 Unilateral Lower Right 4
 Bilateral Upper Extremity 5
 Bilateral Lower Extremity 6
 Double Left 7
 Double Right 8
 Double Upper Left & Lower Right 9
 Double Upper Right & Lower Left 0
 Triple (Circle one): BULL BURL
 LUBL RUBL X
 Quadruple Y

ANOMALIES IN ADDITION TO THE LIMB TREATED (MC Permitted)

Does Not Apply Col. 33 0
 Foreshortened 1
 Rudimentary Hand or Foot 2
 Split-Ray Hand 3
 Rudimentary Digits 4
 Syndactylia 5
 Pulmonary 6
 Cardiac 7
 Gastro-Intestinal 8
 Urino-Genital 9
 Unknown X
 Other (Specify) Col. 34

**LOCATE AND FURTHER SPECIFY
ANY OF THE ABOVE CONDITIONS**

.....

HOURS PER DAY USUALLY WORN

- Col. 35 Tens
 Col. 36 Units

ON WHAT OCCASIONS WORN

- Col. 37 0 All day for all activities
 1 At school
 2 After school in play
 3 In the home
 4 When visiting
 5 When company comes
 6 Other (Specify)

GRADE IN SCHOOL

- Col. 38 0 None (Pre-School)
 1 Play School
 2 Kindergarten
 3 1st Year Grade School
 4 2nd Year Grade School
 5 3rd Year Grade School
 6 4th Year Grade School
 7 5th Year Grade School
 8 6th Year Grade School
 9 7th Grade or Higher

- Col. 39 0 6th Grade or Lower
 1 7th Grade
 2 8th Grade
 3 9th Grade
 4 10th Grade
 5 11th Grade
 6 12th Grade

TYPE OF SCHOOL

- Col. 40 0 None (Pre-School)
 1 Public School
 2 Parochial School
 3 Private (Non-denominational)
 4 Other (Specify)

SCHOOL PROGRAM (MC Permitted)

- Col. 41 0 Does not apply (Pre-School)
 1 Unmodified Program
 2 Special Gym Class
 3 Special Class Activities
 4 Other (Specify)

ADDITIONAL SCHOOL ACTIVITIES

Multiple Coding Permitted

- Col. 42 0 Does not apply
 1 Teams
 2 Clubs
 3 Service
 4 Other (Specify)

X Requires Special Transportation

CHECKLIST OF RECREATIONAL ACTIVITIES ENGAGED IN PERIODICALLY

- | | | | |
|-------------------------------------|---|--|--------------------------------------|
| <input type="checkbox"/> Archery | <input type="checkbox"/> Fishing | <input type="checkbox"/> Jungle Gym | <input type="checkbox"/> Soccer |
| <input type="checkbox"/> Badminton | <input type="checkbox"/> Football | <input type="checkbox"/> Jumping Rope | <input type="checkbox"/> Swimming |
| <input type="checkbox"/> Baseball | <input type="checkbox"/> Ice Skating | <input type="checkbox"/> Marbles | <input type="checkbox"/> Swing |
| <input type="checkbox"/> Basketball | <input type="checkbox"/> Hopscotch | <input type="checkbox"/> Ping Pong | <input type="checkbox"/> Tennis |
| <input type="checkbox"/> Bicycling | <input type="checkbox"/> Hockey | <input type="checkbox"/> Roller Skates | <input type="checkbox"/> Volley Ball |
| <input type="checkbox"/> Bowling | <input type="checkbox"/> Horseback Riding | <input type="checkbox"/> See-Saw | <input type="checkbox"/> Other |
| <input type="checkbox"/> Dancing | <input type="checkbox"/> Hunting | <input type="checkbox"/> Slides | <input type="checkbox"/> |

LENGTH OF WEAR

- Months Col. 43
 Years Col. 44

For Cols. 45-49: Interview
 Parents & Children Separately.
 For Non-Wearers: leave Blank.

PROSTHETIC USE (ASK OF PARENTS)

- It is necessary to urge the
 child to wear the arm (leg)?
 Yes Col. 45 1
 No 2

If yes, when?

- Do you believe the arm (leg)
 should be worn at all times?
 Yes Col. 46 1
 No 2

If not, when is it undesirable?

When is it absolutely necessary?

When else is it desirable?

- Would it make a real difference
 if he had no prosthesis at this
 time in his life?
 Yes Col. 47 1
 No 2

If yes, in what way?

- Is his behavior different when he
 does not wear the arm (leg)?
 Yes Col. 48 1
 No 2

If yes, in what way?

PROSTHETIC USE (ASK OF CHILD)

- Could you get along just as well
 without your arm (leg)?
 Yes Col. 49 1
 No 2

When is it most necessary to wear
 the arm (leg)?

When is it undesirable to wear
 the arm (leg)?

At this time (March 31, 1960) Normative Survey data has been collected on some 288 child amputees. However, when this rather large sampling is broken down by age group, sex, type of amputation, etiology, etc., the number of children in each "cell" is quite small (See Figure 22). Hence the collection of Normative data is continuing, with a goal of 1,000 cases set as the number considered minimally adequate to provide meaningful information. A preliminary analysis of the first 216 cases in the sample made on January 26, 1960 revealed a number of interesting points which warrant further study:

- 1) Thirty-eight percent of the sample was below six years of age; consequently, ample opportunity exists for longitudinal studies of growth, development and adjustment.
- 2) Phantom sensation was reported by a relatively small percentage of the traumatic amputees, particularly among those below age six. None of the congenital amputees reported phantom.
- 3) Major problems experienced with arm prostheses were low control system efficiency, low pinch force, and limited range of hook opening.
- 4) High levels of proficiency were attained by lower extremity amputees even when multiple amputations were present.
- 5) Most of the children of school age attended regular classes and although a few of them attended special schools, the need for this was not evident.
- 6) The practice of fitting children at a very early age seemed to be well-established. Possible exceptions are children with above-elbow and shoulder-disarticulation amputations.
- 7) According to the available data, bilateral upper extremity amputees were typically fitted first with one prosthesis, with the second prosthesis added at a later date.
- 8) The data indicate that bilateral arm amputees generally wore and used their prostheses more extensively than subjects with unilateral arm amputations.
- 9) The basis and timing of surgical intervention to convert anomalous lower-extremity limbs into amputation stumps for prosthetic fitting did not appear to follow any definitive pattern.

In essence, it may be said that although the specialized study of child amputee management is relatively new, much interesting and useful information has already been gathered. A number of general trends in current practice may be identified with varying degrees of accuracy. For example:

1) The early prosthetic fitting of the child amputee appears to be a well-established if not universal procedure. At a recent clinic the writer observed a below-elbow amputee fitted with a prosthesis at the age of 4 months. At another center the clinic chief reported rather apologetically that he had not had an opportunity to fit a prosthesis to anyone younger than 15 months. These instances illustrate the typical attitude on early fitting, and represents a marked change in thinking from earlier practice.

2) Early fitting combined with childhood adaptability, growth, and maturity typically results in the development of a high level of skill and

FIGURE 22
SAMPLE—288 CHILDREN
 March 31, 1960

AGE RANGE: 0 to 15 Years		SEX	
Years	Number of Cases	Male	156
0-1	16	Female	132
2-3	35		288
4-5	59		
6-7	55		
8-9	43		
10-11	32	AMPUTATION TYPE	
12-13	33	<i>Unilateral Upper Extremity</i>	
14-15	15	Below-Elbow	126
	<hr/>	Above-Elbow	32
	288	Shoulder-Disarticulation	11
			<hr/>
			169
ETIOLOGY			
<i>Congenital</i>			
Unilateral Upper	135	<i>Unilateral Lower Extremity</i>	
Unilateral Lower	37	Below-Knee	41
Multiple Amputations	41	Above-Knee	25
	<hr/>	Hip-Disarticulation	3
	213		<hr/>
			69
<i>Traumatic</i>			
Unilateral Upper	34	<i>Multiple Amputations</i>	
Unilateral Lower	32	All Types	50
Multiple Amputations	9		<hr/>
	<hr/>		288
	75		

facility in the use of the prosthesis. In fact, the overall utilization of the prosthesis by children may be generally greater than that of adults. Moreover, the prosthesis apparently become more "a part of the child"—of his thinking and pattern of living—than is the case with adults.

3) Within recent years prosthetic techniques and components for the fitting of children have improved markedly. These advances appear to have had a number of significant effects on the attitudes of surgeons concerning prosthetic applications—both with and without surgical intervention. As prostheses have become better they have been more widely used.

4) Doubtless reflecting the improved prosthetic service available through specialized child amputee clinics, a relatively large number of children with multiple amputations or congenital anomalies are now being treated, apparently with considerable success.

"All the little ones of our time are collectively the children of us adults of the time, and entitled to our general care."

—Thomas Hardy

THE IMPACT OF PROSTHETIC RESEARCH

The progress of a new prosthetic item through the research program may be described by a simple flow chart:

New Development (component/technique) → Evaluation → Utilization

However, in practice the process is not as simple as the chart would suggest. Certain new developments are preceded by extensive basic research and in most instances initial evaluation reveals the need for further development which then requires re-evaluation. Moreover, an occasional item, for one reason or another, has to be discarded along the way, and never reaches the stage of "utilization." It is this final step in the process—utilization—that is of greatest interest, for here in a very real sense is the "pay-off" of the entire research investment.

Looking back over the years and considering the various prosthetic devices and techniques that have successfully passed through the development and evaluation program, it is apparent that "utilization" has been achieved through various means. The key factor involved, of course, is the assurance and confidence in the value of the item which is generated when it successfully completes a comprehensive evaluation program. On the basis of this assurance:

- 1) Doctors and/or clinic teams may prescribe prosthetic components and complete prostheses with confidence in the quality of the products to be used.
- 2) Individuals and organizations who purchase or provide prosthetic services may do so with equal assurance.
- 3) Similarly, prosthetists may fit, and amputees may wear, products prescribed and purchased knowing that they are using the best available materials and techniques.

Without the prosthetic education program, the benefits of developmental research and evaluation would still have occurred. However, since the prosthetic schools were established to disseminate new information as soon as it became available, these benefits have been achieved more rapidly and widely than would otherwise have been the case. In fact, it is not too much to say that as a result of the combined prosthetic research and education programs, a very significant if not revolutionary improvement in prosthetic practice for both adults and children has occurred in the United States over the past decade. Equally significant progress may be anticipated in the next ten years, with orthotics as well as prosthetics, participating in the advance.

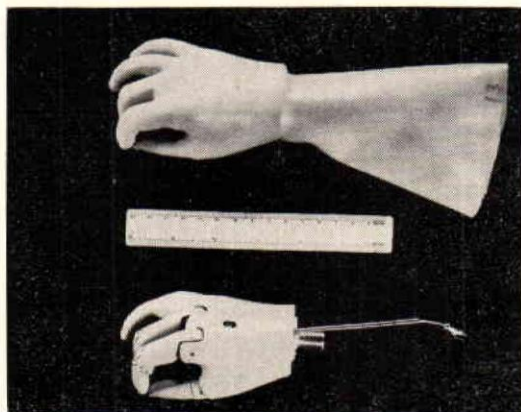


FIGURE NO. 23—APRL-SIERRA Child Hand