ANNUAL SUMMARY REPORT[a]
ACTIVITIES FOR YEAR ENDED JUNE 30, 1966

COMMITTEE ON PROSTHETICS RESEARCH AND DEVELOPMENT
DIVISION OF ENGINEERING
NATIONAL ACADEMY OF SCIENCES — NATIONAL RESEARCH COUNCIL

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PURPOSE

The Committee on Prosthetics Research and Development undertakes activities serving research in the fields of prosthetics, orthotics, and sensory aids when such activities are accepted by the National Academy of Sciences as a part of its functions.

The Veterans Administration, the Department of Defense, and several agencies within the Department of Health, Education, and Welfare have responsibilities to amputees and others with physical and sensory impairments. In addition, a number of private foundations are similarly concerned.

Because the volume of business in the fields of artificial limbs, orthopaedic appliances, and sensory aids for the blind and the hard of hearing is not sufficiently great to support the types of research necessary to maintain progress commensurate with other technical fields, it has become necessary for these Government agencies and private foundations to support research and development either within their own organizations or by contracting with universities and industrial laboratories, or by both means.

The objectives of the Committee on Prosthetics Research and Development are: to correlate and coordinate prosthetics and sensory aids research sponsored by the Veterans Administration, the Vocational Rehabilitation administration, the Children's Bureau, the Army, the Navy, and others; to develop information by means of special reports, periodic reports, and personal liaison, which will enable the National Academy of Sciences — National Research Council to advise the sponsors concerning the scope of the program and the progress made; to ensure that successful new devices and techniques are made available promptly to the organizations concerned with the education of medical and paramedical personnel in the fields of prosthetics and orthotics; and to provide wide dissemination of the results of research by the publication of the program journal *Artificial Limbs* and other technical reports.

ORGANIZATION

The Committee on Prosthetics Research and Development is a part of the Division of Engineering. The Committee membership is drawn from the engineering and medical professions and from other disciplines interested in furthering the development and utilization of prosthetic and orthotic devices and sensory aids. The appointments to the Committee, which are normally for a 3-year period, are made by the Chairman of the Division of Engineering, subject to the approval of the President of the National Academy of Sciences.

The Committee on Prosthetics Research and Development utilizes five permanent subcommittees: the Subcommittee on Fundamental Studies, the

Subcommittee on Design and Development, the Subcommittee on Evaluation, the Subcommittee on Child Prosthetics Problems, and the Subcommittee on Sensory Aids.

Formed during the past fiscal year in recognition of the desirability of paying more discrete attention to fundamental studies, the Subcommittee on Fundamental Studies is responsible for organizing small working panels of persons directly interested in basic studies for the exchange of ideas and the stimulation of research.

By arranging frequent meetings of small groups of persons directly concerned with the design and development of prosthetic and orthotic devices at the working level, the Subcommittee on Design and Development stimulates an active interchange of information and ideas between the various design and development groups, provides leadership in attacking critical problems, evaluates new ideas and suggestions from the standpoint of engineering feasibility, and encourages competent designers.

Evaluation, always a difficult task, is a major continuing responsibility of the Committee on Prosthetics Research and Development. To enable the Committee to fulfill this responsibility more efficiently, the Subcommittee on Evaluation was created to study evaluation problems in detail in order to advise the Committee on Prosthetics Research and Development concerning the status of specific devices and techniques and to coordinate the activities of laboratories engaged in evaluation.

The Subcommittee on Child Prosthetics Problems, which has existed for nine years, stimulates studies and disseminates the results of research in prosthetics for child amputee patients. Under the auspices of this subcommittee, the Child Amputee Research Program is carried on through some 22 participating child amputee clinics. The subcommittee publishes, through New York University, a monthly *Inter-Clinic Information Bulletin,* the material for which is assembled and edited by the Assistant Executive Director of the Committee on Prosthetics Research and Development.

The Subcommittee on Sensory Aids exists to provide advisory service to interested agencies — government and private — concerning the development of sensory aids for the blind and the hard of hearing.

The Committee on Prosthetics Research and Development is served by a staff of full-time personnel employed by the Academy — Research Council, consisting of an executive director, an assistant executive director, a staff editor, an administrative assistant, and a secretary (Fig. 1).

OPERATIONAL CONCEPT

General

The responsibilities of the Committee on Prosthetics Research and Development are carried out in a variety of ways, depending upon requirements and circumstances. Generally, Committee business is conducted by the

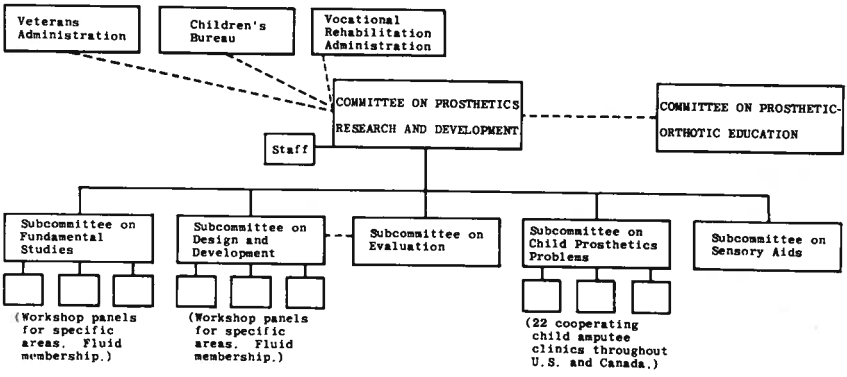

FIGURE 1.—Organization of Committee on Prosthetics Research and Development.

Committee as a whole and its subcommittees, which report fully to the Committee. The work of certain of the subcommittees is closely interrelated; for example, Design and Development, and Evaluation; Design and Development, and Child Prosthetics Problems. Liaison is maintained by a degree of interdigitating membership.

Problems requiring special or technical knowledge are referred to selected *ad hoc* committees for study and report. Appointments to such *ad hoc* committees are not restricted to the membership of the Committee on Prosthetics Research and Development; persons are chosen for their special knowledge of the problem at hand. For such *ad hoc* committee assignments, the Committee on Prosthetics Research and Development has available a large number of persons affiliated with the prosthetics research program who are qualified for appointment and willing to serve.

The recommendations of the subcommittees and the *ad hoc* committees are reviewed by the Committee on Prosthetics Research and Development, which meets twice a year, or as necessary, to conduct its business.

Governmental Relationships

The Committee on Prosthetics Research and Development is responsible for advisory services through the Academy — Research Council to the Veterans Administration, the Children's Bureau, and the Vocational Rehabilitation Administration, the last two being agencies of the Department of Health, Education, and Welfare. Liaison representatives have been designated by these Government agencies and take part in Committee deliberations. The Army Medical Biomechanical Research Laboratory, the Navy Prosthetics Research Laboratory, and the Veterans Administration Prosthetics Center are among the participating laboratories cooperat-

ing with the Committee on Prosthetics Research and Development. From time to time these laboratories are represented on the Committee.

Interdivisional Relationships

Liaison with the Committee on Prosthetic-Orthotic Education, Division of Medical Sciences, National Academy of Sciences — National Research Council, is achieved by naming the chairman of that Committee as a liaison member of the Committee on Prosthetics Research and Development, and through persons who are members of both committees. Copies of all Committee on Prosthetics Research and Development publications are transmitted to the Committee on Prosthetic-Orthotic Education. *Artificial Limbs* is a joint undertaking of the two committees.

ACTIVITY REPORTS

General

During the period July 1, 1965 through June 30, 1966, the Committee on Prosthetics Research and Development continued to advise and assist in the coordination of Government-sponsored and privately sponsored research in the fields of prosthetics, orthotics, and sensory aids. At the request of the sponsoring agencies concerned, the Committee during the past year made specific recommendations through Academy-Research Council channels on some 22 proposals for research and development (nine for the Veterans Administration, two for the Children's Bureau, and 11 for the Vocational Rehabilitation Administration). At the request of the sponsoring agencies concerned, the Committee made three site visits and submitted extensive reports (two for the Veterans Administration and one for the Children's Bureau). In addition, at the request of the sponsoring agency concerned, the Committee prepared a comprehensive evaluative report on the role of the Veterans Administration in prosthetics and orthotics research and education during the period from the end of World War II to the present. At the request of the American Orthotics and Prosthetics Association, the Committee participated extensively in the program of the Association's annual assembly, making presentations on immediate postsurgical prosthetics fittings and on developments in externally powered prostheses and orthoses. At the request of the American Academy of Orthopaedic Surgeons, the Committee assisted the Academy in the preparation of guidelines for minimum standards for prosthetics and orthotics services to be provided under recent Medicare legislation. The American Academy of Orthopaedic Surgeons will submit the guidelines to the Secretary of the Department of Health, Education, and Welfare for his consideration in the administration of the legislation. At the request of the Michigan Crippled Children Commission, the Assistant Executive Director, and the Staff Editor of the Committee on Prosthetics Research and Develop-

ment assisted in the preparation of an extensive report on an electrically powered, programed, child's feeding arm. During March 1966, the Executive Director of the Committee made a presentation — lecture, projection slides, and motion pictures — on *Recent Developments in Prosthetics and Orthotics Research* before a combined meeting of the Maryland, Virginia, and District of Columbia chapters of the American Physical Therapy Association at Georgetown University.

One meeting of the Committee on Prosthetics Research and Development was held during the past fiscal year, and a comprehensive report has been prepared and distributed to those concerned. In addition, there have been numerous meetings of subcommittees, working panels, and various other groups sponsored by the Committee. Reports of these meetings have been distributed to those concerned and have been appended, or will be appended, to the minutes of the appropriate meetings of the parent Committee.

Overall, the activities of the Committee on Prosthetics Research and Development were marked by opportunities not fully anticipated and by unforeseen requests for service, with the result that limitation of funds necessitated the curtailment of activities during the latter part of the fiscal year. Had more funds been available, additional working meetings could have been held advantageously and an additional issue of the Committees' journal, *Artificial Limbs,* could have been published, since the material was available.

Subcommittee on Fundamental Studies

The Subcommittee on Fundamental Studies, formed during the latter part of the past fiscal year, initiated plans for its first meeting, to be held during the early fall of 1966 for the purpose of developing a general pattern of operating procedures.

Subcommittee on Design and Development

The impact of the activities of the Subcommittee on Design and Development has become increasingly apparent. The workshop panel on lower-extremity prosthetics fitting has met twice during the past fiscal year and concerned itself with fittings of an air-cushion socket designed to provide self-regulating constant pressure between socket and stump, fitting and hardware problems in relation to the immediate postsurgical fitting of prostheses, various below-knee casting techniques, the possibility of eliminating plaster of Paris in socket formation, and a number of new industrial adhesive materials that may be useful to prosthetics technologists. The workshop panel on lower-extremity orthotics has also met twice and concerned itself with the identification of problems requiring research, the assignment of priorities, the evaluation of existing orthotic devices, and the

initiation of new developmental research. The workshop panel on upper-extremity prosthetics components met concurrently with the Subcommittee on Child Prosthetics Problems; there was a stimulating interchange of ideas between developers and clinical personnel, and arrangements were made for clinical trials of new developments. The workshop panel on upper-extremity prosthetics fitting, harnessing, and power transmission met for the twofold purpose of (1) defining current practice in the fabrication, fitting, and harnessing of upper-extremity prostheses in order to establish a new baseline for further research in the field; and (2) assisting the staff of the Prosthetics-Orthotics Program at the University of California, Los Angeles, in an advisory capacity as to needed revisions in the *Manual of Upper-Extremity Prosthetics.*

Thus, through the workshop panel meetings, the Subcommittee on Design and Development fostered communication and offered guidance to persons engaged in prosthetics and orthotics design.

Subcommittee on Evaluation

Under the auspices of the Subcommittee on Evaluation, a workshop conference on linkage feeders (upper-extremity orthotic devices to assist severely paralyzed patients) was held during the past fiscal year. The primary purpose of the conference was the interchange of information among the various designers of linkage feeders and analytical commentary by engineering consultants not affiliated with any particular design group. Additional—hoped-for—goals are changes by the designers on the basis of the discussion at the conference and insights into the needs for further study. A development of the conference was the realization of a need for more widespread dissemination of information concerning the application of these orthotic devices. (Three articles on linkage feeders will appear in the Spring 1966 issue of *Artificial Limbs.*)

The Subcommittee on Evaluation also met informally to consider ways in which evaluation procedures might be improved and recommended the establishment of a more extensive clinical evaluation program.

Subcommittee on Child Prosthetics Problems

In addition to its concurrent meeting with the workshop panel on upper-extremity prosthetics components of the Subcommittee on Design and Development, the Subcommittee on Child Prosthetics Problems held two other meetings during the past fiscal year.

The first of these was in conjunction with the annual meeting of the chiefs of the cooperating child amputee clinics. Clinic chiefs and guests attending the meeting numbered some 60 persons. There were demonstrations of a number of devices to provide mobility for bilateral lower-extremity amelic children, such as a self-propelled electric cart developed at the Child Amputee Prosthetics Project of the University of California,

Los Angeles, and a lateral-sway walker developed at the Ontario Crippled Children's Centre, and the results of a number of studies on upper-extremity prosthetic devices for children were reported. A report was made of a significant study conducted by New York University, under the auspices of the Subcommittee, of children who had sustained amputations by reason of malignant bone tumor; the report showed clearly that such children should be fitted with prostheses. (The study was initiated as a result of administrative decisions in certain states prohibiting the use of public funds for the fitting of a prosthesis to a child within one year of amputation when the amputation resulted from malignancy.) A system of *Nomenclature for Congenital Skeletal Limb Deficiencies* developed under the auspices of the Subcommittee was also reported. Establishment of this nomenclature should materially improve communication concerning certain types of anomalies, their frequency of occurrence, and their treatment (Fig. 2).

An important feature of this meeting of the Subcommittee was a Symposium on Normal and Abnormal Embryological Development, at which presentations were made on *The Normal Development of the Human Embryo, Inductive Interplay During Limb development, Abnormal Limb Development, The Contribution of Histochemistry to Our Understanding of Limb Morphogenesis and Some of its Congenital Deviations,* and *Environmental Factors in Human Teratology,* by leading authorities. The publication of these papers is under consideration.

At the second meeting, the Subcommittee reviewed numerous prosthetic components under development for children and took steps to expedite their transition from the developmental laboratories to clinical application.

Subcommittee on Sensory Aids

Toward the fulfullment of its responsibility for an overall review of research sponsored by the Veterans Administration, the Subcommittee on Sensory Aids made site visits during the past fiscal year to the laboratories of Veterans Administration contractors in Dayton, Ohio; Bala Cynwyd, Pa.; New York, N. Y.; and Newton, Mass., reporting fully on the results of the visits. The items under development at the laboratories are communication and mobility aids for the blind.

Immediate Postsurgical Prosthetics Fittings

Throughout the year the Committee on Prosthetics Research and Development has concerned itself with a technique for the immediate postsurgical fitting of lower-extremity prostheses. The technique came to the attention of Americans through a lecture delivered by Dr. Marian Weiss at the Sixth International Prosthetics Course in Copenhagen in 1963. Dr. Weiss, who is Director of the Federal Rehabilitation Center at Konstancin, Poland, reported the successful use of the technique, by which patients are

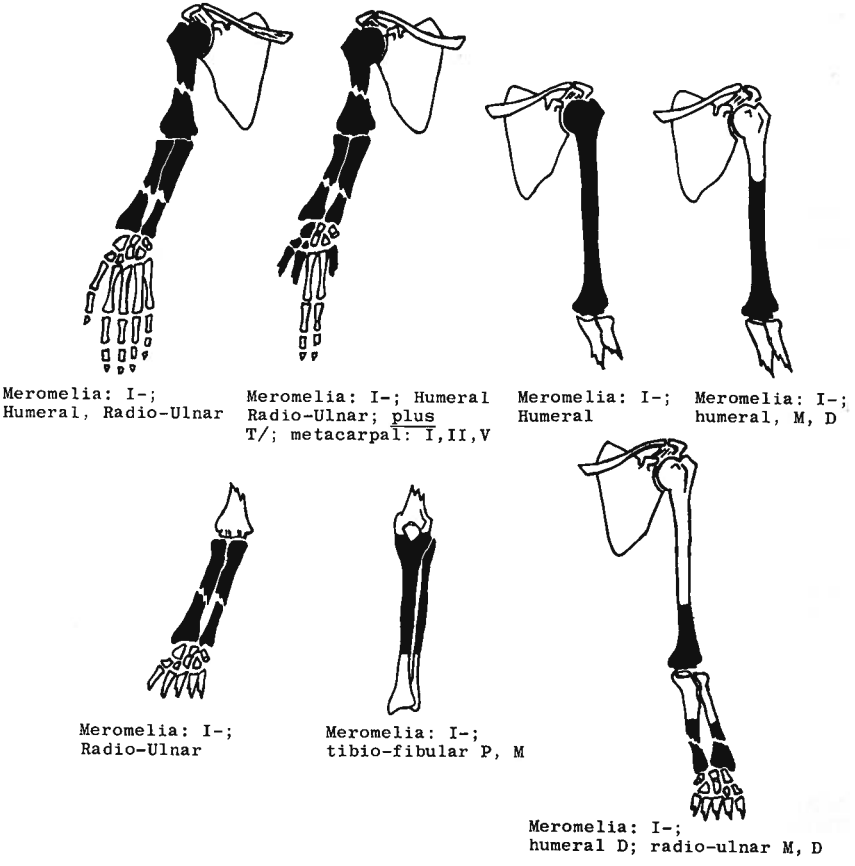

FIGURE 2. — Some example sketches illustrating the recently developed Nomenclature for Congenital Skeletal Limb Deficiencies. The shaded areas represent absent elements or parts thereof. Only two basic descriptive terms are used: *amelia,* or *complete* absence of a free limb, and *meromelia,* or *partial* absence of a free limb. Thus the use of such descriptive terms as hemimelia, peromelia, extromelia, phocomelia, dysmelia, etc., has been eliminated. General use of the standardized nomenclature will facilitate communication concerning the anomalies, improve record-keeping, and, it is hoped, improve the methods of treatment. (For description of symbols appearing in this illustration, see the Spring 1966 issue of *Artificial Limbs,* pp. 25 and 26.)

fitted with prostheses immediately after surgery and commence ambulation the following day. Chiefly because of the efforts of the Committee on Prosthetics Research and Development, interest in America has focused on the technique, and as of the end of the past fiscal year more than 200 cases have been treated in this manner throughout the United States with extremely encouraging results. Goals of the technique are control of post-

surgical edema, marked reduction in pain, and a material reduction in "off-the-job" time. It appears that in the case of patients with peripheral vascular disease many more knee joints can be saved than was formerly the case. To effect a basis for the interchange of information between various groups employing the immediate postsurgical fitting technique in the United States, the Committee on Prosthetics Research and Development has sponsored a series of meetings and created an *ad hoc* committee to coordinate current and future research work in this area (Fig. 3 and 4).

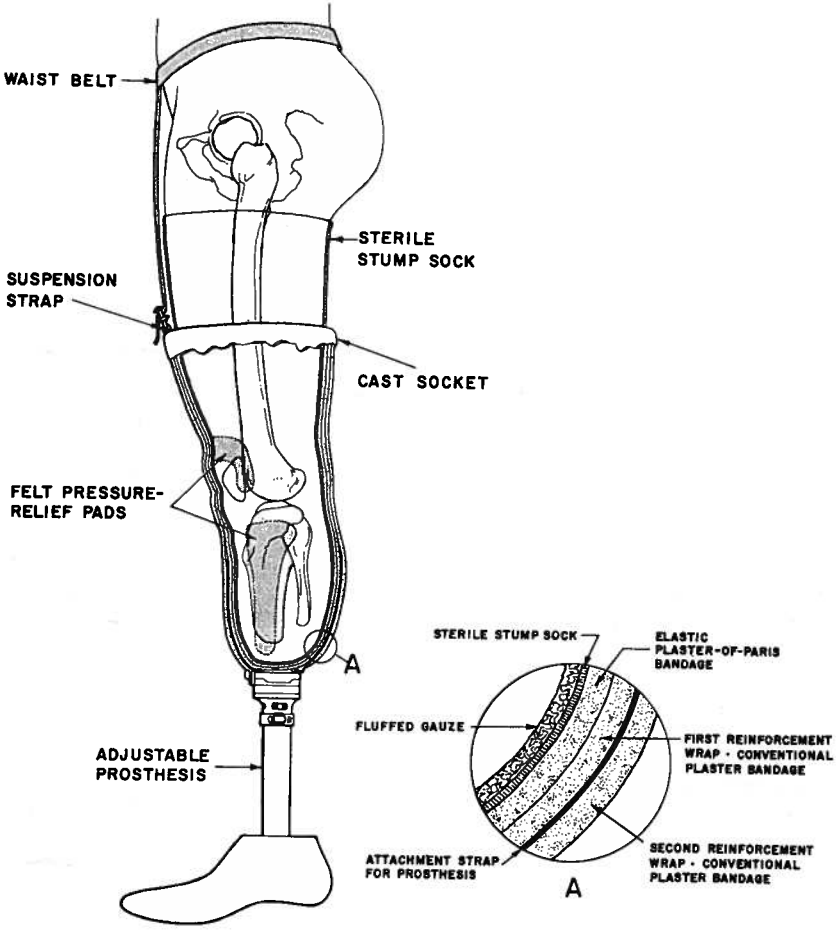

FIGURE 3. — Schematic cross section showing most of the elements of the application of a prosthesis to a below-knee amputee immediately after surgery. View "A" is an enlarged schematic section of the cast socket, prosthetic unit attachment straps, stump sock, and fluffed gauze at the distal portion of the stump.

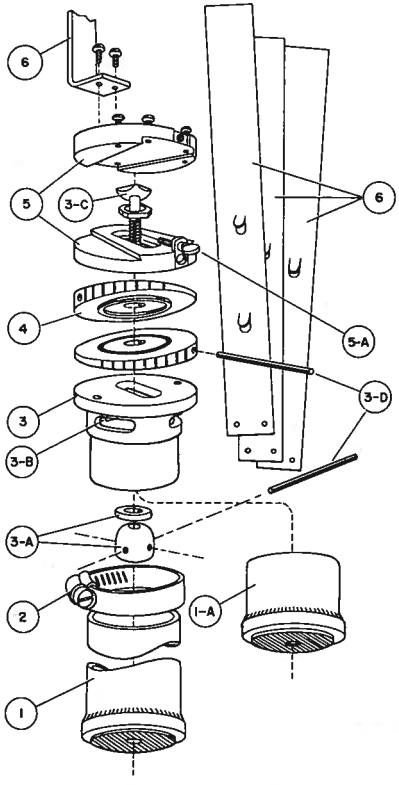

FIGURE 4. — Exploded view of the United States Manufacturing Co.'s adjustable unit for use in immediate post-surgical fitting. The unit consists of six elements: 1. pylon tube, 2. metal hose clamp, 3. base plug, 4. wedge disks to provide for adjustment of socket tilt, 5. quick disconnect, 6. socket-attachment straps.

Dissemination of Information

The Control of External Power in Upper-Extremity Rehabilitation (Publication 1352) was published by the National Academy of Sciences — National Research Council during the past fiscal year. The report of a conference sponsored by the Committee on Prosthetics Research and Development at Airlie House, Warrenton, Va., April 8–10, 1965, the 369-page publication is illustrated and contains a list of conference participants and an extensive bibliography. The participants represented virtually every group that is currently engaged in research in the field of external power and in related fields. The report is a comprehensive, up-to-date summary of research and development in the field of externally powered prostheses and orthopaedic appliances, and it is hoped that its recommendations will provide long-range goals and guiding principles for future research and development in the field. Titles of the major groupings of papers in the publication are: "Panel on Sources of Control Signals," "Panel on transducers," "Panel on Actuators," "Panel on Signal Processing," "Panel on Sensory Feedback," and "Panel on Selection and Training of Patients."

These groupings are followed by summaries: "From the Viewpoint of the Basic Scientist," "From the Viewpoint of the Clinician," and "From the Viewpoint of the Engineer." The papers represent the work of some 43 authors.

Throughout the year there continued to be a steady demand for the reports of other major conferences sponsored by the Committee on Prosthetics Research and Development in previous years, for example, *The Geriatric Amputee* (1961), *The Application of External Power in Prosthetics and Orthotics* (1961), and *Orthotics Research and Development* (1962).

In addition to the demand for the reports of the various workshop panels which met during the yast year, there were numerous requests for the reports of earlier workshop panels, the report on criteria for external power being of particular interest to developers of externally powered prosthetic and orthotic devices.

The regular circulation of *Artificial Limbs* is now more than 4,600. Numerous requests are received for additional copies. In addition to addressees in the United States and Canada, *Artificial Limbs* is sent regularly to more than 65 countries and territories throughout the world. To refine the mailing list and to obtain Zip Code numbers in compliance with Post Office Department regulations, addressees have been requested during the past year to state whether or not continued mailings of *Artificial Limbs* were desired and to supply Zip Code numbers. As of the end of the fiscal year, more than 2,000 responses have been received in the office of the Committee on Prosthetics Research and Development. The replies — from physicians and surgeons, librarians serving hospitals and medical schools, departments of orthopaedic surgery and physical medicine in hospitals and medical schools, prosthetists, orthotists, physical and occupational therapists, rehabilitation centers, limbshops, boards of health, development laboratories, and various other individuals and organizations — have been overwhelmingly affirmative, and most writers took the opportunity to make laudatory comments on the journal. Two issues of *Artificial Limbs* — Spring 1965 and Autumn 1965 — were published during Fiscal Year 1965-1966, and the Spring 1966 issue was in the hands of the printer at the end of the year.

There was an increasing demand, both in the United States and abroad, for the *Inter-Clinic Information Bulletin,* which now has a circulation of more than 1,700. Twelve issues were distributed during Fiscal Year 1965-1966. Issues contained contributions from the cooperating child amputee clinics and other material of special interest to physicians, surgeons, prosthetists, therapists, nurses, and others directly engaged in the care and management of child amputees.

During the year, the office of the Committee on Prosthetics Research and Development responded to more than 900 requests for technical information.

International Activities

The Committee on Prosthetics Research and Development has consistently made every effort to cooperate with international groups concerned with prosthetics and orthotics research and development.

During the past year, the Executive Director of the Committee of Prosthetics Research and Development participated in two meetings of the North American Subcommittee on Prosthetics and Orthotics of the International Society for Rehabilitation of the Disabled. Projects of the North American Subcommittee include the preparation of an international catalogue of prosthetic and orthotic components, the development of a standardized set of projection slides (now being selected through the joint efforts of the Veterans Administration and the Commitee of Prosthetic-Orthotic Education) and participation in various international courses in prosthetics and orthotics. During the past year, the Executive Director of the Committee on Prosthetics Research and Development prepared a brochure on research activities throughout the world for publication by the International Committee on Prosthetics and Orthotics of the International Society for Rehabilitation of the Disabled.

During the past year, members of the staff of the Committee on Prosthetics Research and Development assisted in arranging programs for visitors from overseas to the United States, including representatives from Laos, Great Britain, Spain, Denmark, and Poland.

During October 1965, an engineer member of the Committee on Prosthetics Research and Development visited the Central Institute for Prosthetics Research and Development in Moscow, USSR, where he was treated very hospitably and shown in detail various items under development in the laboratories, including electrically powered, upper-extremity prosthetic devices that could be operated by electromyographic signals.

FUTURE PLANNING

General

The Committee on Prosthetics Research and Development proposes to continue to coordinate and correlate governmentally and privately sponsored research projects in the fields of prosthetics, orthotics, and sensory aids, particularly attempting to bring about a more organized program in orthotics and sensory aids; to continue its efforts toward stimulating and maintaining a balanced research and development program in those areas; to ensure that the prosthetics and orthotics education schools, the University Council on Orthotic-Prosthetic Education, and the American Orthotics

and Prosthetics Association are promptly informed of developments within the program; and to ensure widespread dissemination of information by publication of *Artificial Limbs,* the *Inter-Clinic Information Bulletin,* and appropriate reports.

The Committee on Prosthetics Research and Development plans to meet a minimum of twice yearly for the conduct of its business and to receive the reports of its standing subcommittees (Fundamental Studies, Design and Development, Evaluation, Child Prosthetics Problems, and Sensory Aids).

Subcommittee on Fundamental Studies

The recently established Subcommittee on Fundamental Studies will develop an inventory of fundamental research applicable to problems confronting the Committee on Prosthetics Research and Development, acquaint itself with pleas for basic information that have been voiced at various panel meetings of the Subcommittee on Design and Development, determine which areas of research should receive earliest attention, and arrange for panel meetings of workers in those areas to provide for an interchange of information and ideas.

Subcommittee on Design and Development

To guide and stimulate the design and development of prosthetic and orthotic devices, the Subcommittee on Design and Development will sponsor frequent meetings of small groups of persons actively engaged in prosthetics design and development at the working level. Membership in these groups will be kept small and appropriate to the particular tasks to be considered. Meetings on work in the following areas will be held: upper-extremity prosthetics components; upper-extremity prosthetics fitting, harnessing, and power transmission; lower-extremity prosthetics components; lower-extremity prosthetics fitting; lower-extremity orthotics; and external power in prosthetics and orthotics.

Subcommittee on Evaluation

The Subcommitee on Evaluation will be actively engaged in accepting and seeking out prosthetic and orthotic devices and techniques for evaluation, advising the evaluation laboratories, coordinating evaluations, and focusing attention on specific areas with a view toward use of the findings of evaluation to aid the designer in improving his device. Its particular immediate concern will be the development of coordinated clinical evaluation programs for prosthetic and orthotic devices.

Subcommittee on Child Prosthetics Problems

By its activities over a period of years, the Subcommittee on Child Prosthetics Problems has established a well-defined pattern of work which

will continue in the years ahead. As in the past, it will coordinate the activities of the cooperating child amputee clinics, employing them as a means for obtaining information concerning the amputee population and as a medium for evaluating new methods of treatment and bringing new devices and techniques into use. The monthly *Inter-Clinic Information Bulletin* will continue to serve as an important means of communication to practitioners. The Subcommittee will encourage the general use of the recently developed system for the classification of congenital skeletal limb deficiencies, thereby improving communication concerning these anomalies. The establishment of an internationally accepted system will also be encouraged. It is hoped that eventually notations based upon the classification will become a part of the national vital statistics (birth certificates, for example), making it possible to determine how many children are born with defects and whether or not such births are on the increase.

Subcommittee on Sensory Aids

In time, the Subcommittee on Sensory Aids intends to concern itself with all forms of sensory deprivation. At present, however, its activities are concerned primarily with the blind and the deaf-blind. In the immediate future, the Subcommittee will continue its overall review of research in sensory aids sponsored by the Veterans Administration.

Immediate Postsurgical Prosthetics Fittings

During July 1966, representatives of the Committee on Prosthetics Research and Development will participate in a meeting sponsored by the University Council on Orthotic-Prosthetic Education for the purpose of considering the readiness of the immediate postsurgical prosthetics fitting technique for formal academic presentation in the universities affiliated with the Prosthetics-Orthotics Education Program, probably in conjunction with the medical schools of the universities.

It is anticipated that, throughout the year ahead, the Committee on Prosthetics Research and Development will continue to coordinate further studies of the technique, to gather data on its applications, and to foster the development of improved prosthetic components for use in connection with the technique.

International Activities

The Committee on Prosthetics Research and Development will continue to participate in meetings and projects of the North American Subcommittee on Prosthetics and Orthotics of the International Society for Rehabilitation of the Disabled and to supply material — including articles for publication — to the Society's information center in Copenhagen, Denmark. Representatives of the Committee on Prosthetics Research and Development will participate in the program of the Tenth World Congress of

the International Society for Rehabilitation of the Disabled to be held in Wiesbaden, Germany, during September 1966, and a member of the Committee will serve as panel chairman at an International Symposium on External Control of Human Extremities to be held in Dubrovnik, Yugloslavia, during August and September 1966.

In general, the Committee on Prosthetics Research and Development will continue its efforts to keep abreast of developments in prosthetics and orthotics research abroad and cooperate with research groups in other countries.

PUBLICATIONS

Annual Summary Report of Activities for Year Ending June 30, 1965. (Report to the Veterans Administration, the Vocational Rehabilitation Administration, and the National Institutes of Health from the Committee on Prosthetics Research and Development.)

Report of First Workshop Panel on Lower-Extremity Orthotics, June 22, 1965.

Report of Fourth Workshop Panel on Lower-Extremity Prosthetics Fitting, July 7–9, 1965.

Report of Meeting of Ad Hoc Committee on Immediate Postsurgical Fitting, July 14, 1965.

Report of Workshop on Linkage Feeders, July 26–27, 1965.

Report of Second Workshop Panel on Lower-Extremity Orthotics, September 1965.

Report on Classification Nomenclature for Congenital Skeletal Limb Deficiencies, prepared by Child Prosthetic Studies, New York University, under the auspices of the Subcommittee on Child Prosthetics Problems of the Committee on Prosthetics Research and Development, September 1965.

Report of Meeting of Editorial Board, Committee on Prosthetics Research and Development and Committee on Prosthetic-Orthotic Education, October 1, 1965.

Report of Meeting of Subcommittee on Child Prosthetics Problems, October 19–21, 1965.

Report of Fourth Workshop Panel on Upper-Extremity Components, October 19–21, 1965.

Report of Meeting of Ad Hoc Committee on Immediate Postsurgical Fitting, October 27, 1965.

Report on Prosthetic Fitting of Children Amputated for Malignancy, prepared by Child Prosthetic Studies, New York University, under the auspices of the subcommittee on Child Prosthetics Problems of the Committee on Prosthetics Research and Development, October 1965.

Minutes of the Fifteenth Meeting of the Committee on Prosthetics Research and Development, November 11–12, 1965.

Report of Meeting of the Subcommittee on Evaluation, December 20, 1965.

Report of Third Workshop Panel on Lower-Extremity Orthotics, January 4–6, 1966.

Report of Subcommittee on Child Prosthetics Problems and Annual Meeting of Child Amputee Clinic Chiefs, January 25–28, 1966.

Report of Third Workshop Panel on Upper-Extremity Fitting, Harnessing, and Power Transmission, February 1–3, 1966.

Report of Fifth Workshop Panel on Lower-Extremity Prosthetics Fitting, February 6–9, 1966.

Report of Meeting of Subcommittee on Child Prosthetics Problems, May 12, 1966.

The Control of External Power in Upper-Extremity Rehabilitation, National Academy of Sciences Publication No. 1352, March 28, 1966. (Report of a conference held at Airlie House, Warrenton, Va., April 8–10, 1965.)

Inter-Clinic Information Bulletin (Monthly publication of the Subcommittee on Child Prosthetics Problems, 12 issues.)

Artificial Limbs, Vol. 9, No. 1, Spring 1965.

Artificial Limbs, Vol. 9, No. 2, Autumn 1965.

Artificial Limbs, Vol. 10, No. 1, Spring 1966, in press at end of Fiscal Year 1965–1966.

Appendix A

PARTICIPATING AND COOPERATING PROJECTS

PROSTHETICS AND ORTHOTICS

(Listed below are major projects in the United States coordinated by the Committee on Prosthetics Research and Development.)

Organization and principal investigator	Major area (or areas) of investigation	Sponsoring agency
American Institute for Prosthetic Research (AIPR)— Henry H. Kessler Edward A. Kiessling	Development of Pneumatic Prostheses	VRA
Army Medical Biomechanical Research Laboratory (AMBRL)— Peter M. Margetis Fred Leonard	Development of Prosthetic and Orthotic Materials and Devices	U.S. Army
Attending Staff Association of the Rancho Los Amigos Hospital, Inc. (RANCHO)— Vernon L. Nickel	Investigation of Externally Powered Orthotic Devices	VRA
Robert B. Pearson	Interval Measurements Applied to Skeletal Motor Units	VRA
Worden Waring	Investigation of Myoelectric Control of Functional Braces	VRA
Russell Forney	Development and Evaluation of Procedures for Selection of Students for an Orthotic-Prosthetic Training Program	VRA
California, University of, San Francisco and Berkeley, Biomechanics Laboratory (UC–BL)— Verne T. Inman	Prosthetic and Orthotic Design and Studies of Human Locomotion.	VA
	Fundamental and Applied Prosthetics Research	VRA
	Energy Expenditure in Certain Types of Disability	VRA
	Clinical Evaluation of Experimental Orthotic Devices and Procedures	VRA

Organization and principal investigator	Major area (or areas) of investigation	Sponsoring agency
California, University of, San Francisco and Berkeley, Biomechanics Laboratory (UC–BL)—*Continued*	Children's Lower-Extremity Orthotics Problems	CB
	Medical Problems of the Amputee	NIH
	Physiological Factors in the Occurrence and Modification of Human Spastic States.	VRA
California, University of, Los Angeles, Biotechnology Laboratory (UCLA–BL)— John Lyman	Fundamental and Applied Research Related to the Design and Development of Upper-Extremity Externally Powered Prostheses	VA
	Fundamental Studies of Arm Prostheses Sensory-Motor Control	VRA
California, University of, Los Angeles, School of Medicine (UCLA–PEP)— Charles O. Bechtol Miles H. Anderson	Revision of the University of California at Los Angeles Manual of Upper-Extremity Prosthetics	VRA
California, University of, Los Angeles, Child Amputee Prosthetics Project (UCLA–CAPP)— Charles O. Bechtol Milo B. Brooks	An Interdisciplinary Research, Teaching, and Service Program in the Management of the Child Amputee	CB
Case Institute of Technology, Engineering Design Center (CIT)— James B. Reswick	Biomedical Research on Cybernetic Systems for the Disabled	VRA
Duke University Medical Center (DU)— J. Leonard Goldner	Use of Temporary Plaster or Plastic Pylons Preparatory to Fitting of a Permanent Above-Knee or Below-Knee Prosthesis	VRA
Gasow Veterinary Hospital (ESSL)— John O. Esslinger	Semiburied Implants for the Attachment of External Prostheses	VA
Gilmatic (GIL)— Gilbert M. Motis	Development of Upper-Extremity Prosthetic Components	VA
International Society for Rehabilitation of the Disabled (ISRD)— Donald V. Wilson	International Prosthetics Information Service	VRA
Iowa, State University of, Iowa City, Iowa (UI)— Adrian Flatt	Surgical Rehabilitation of Arthritic Finger Joints by the Use of Metallic Prosthetic Joints	VRA

Organization and principal investigator	Major area (or areas) of investigation	Sponsoring agency
Mauch Laboratories, Inc. (MAUCH)— Hans A. Mauch	Research and Development in Lower-Extremity Prosthetic Devices	VA
Michigan, University of (UM)— James W. Rae, Jr.	Advanced Development of Upper-Extremity Orthoses	VRA
Michigan Crippled Children Commission (MCCC)— George T. Aitken	Clinical Testing of Prosthetic Devices and Techniques for Child Amputees; and the Development of Improved Clinical Management Procedures	CB
Navy Prosthetics Research Laboratory (U.S. Naval Hospital, Oakland, California) (NPRL)— Frank L. Golbranson	Immediate Postsurgical Fitting of Prostheses; and Lower-Extremity Prosthetic and Orthotic Development	U.S. Navy
New York University, School of Engineering and Science, Research Division, Prosthetic Devices Study (NYU–PDS)— Renato Contini	Determination of the Pressure Distribution between Lower-Extremity Sockets and Stumps	VA
	Accelerographic Analysis of Pathological Gait	VRA
New York University, Post-Graduate Medical School, Prosthetic and Orthotic Studies (NYU–POS)— Sidney Fishman		
Adult Prosthetic Studies	Evaluation of Adult Prosthetic Devices and Techniques	VRA
Orthotic Studies	Evaluation of Orthopedic Brace Designs	VRA
Child Prosthetic Studies	Evaluation of Prosthetic Devices and Techniques for Child Amputees	CB
New York University Medical School and Post-Graduate Medical School (NYU–MS)— Allen S. Russek	Investigation of Immediate Prosthetic Fitting and Early Ambulation Following Amputation in the Lower Extremity	VRA
Northwestern University Prosthetic Research Center (NUPRC)— Clinton L. Compere Edward C. Grahn	Design and Development of Devices and Techniques for the Improvement of Prosthetic Practices, Especially for Geriatric and Problem Cases	VA

Organization and principal investigator	Major area (or areas) of investigation	Sponsoring agency
Prosthetics Research Study (PRS)— Ernest M. Burgess Joseph E. Traub	Immediate Postsurgical Prosthesis Fitting and Ambulation	VA
Temple University (TU)— Bernard Sandler	Electromyographic Control of Prostheses	VRA
Texas Institute for Rehabilitation and Research (Baylor University College of Medicine) (TIRR)— William A. Spencer Thorkild J. Engen	The Development of Powered Upper-Extremity Orthotic Systems	VRA
Veterans Administration Prosthetics Center (VAPC)— Anthony Staros	Development and Testing of Prosthetic and Orthotic Devices and Techniques	VA
Virginia, University of (UV)— J. Hamilton Allan	A Medical-Industry Team Approach to Accelerate the Application and Production of Prosthetic and Orthotic Developments	VRA
Wisconsin State Board of Vocational and Adult Education, Rehabilitation Division (WISC)— Alfred E. Kritter	Study of Immediate Prosthetic Fitting of Amputees; Upper and Lower Extremities	VRA

(Listed below are projects in the Dominion of Canada which cooperate closely with the overall program)

Prosthetic Research and Training Program, Ontario Crippled Children's Centre — Colin A. McLaurin	Development of a Wide Variety of Upper-Extremity and Lower-Extremity, Body-Powered and Externally Powered, Prosthetic Devices and Components for Children
Rehabilitation Institute of Montreal — Maurice Mongeau	Development of Externally Powered Upper-Extremity Prosthetic Devices, with Special Reference to Children
Prosthetics and Orthotics Research and Development Unit, Manitoba Rehabilitation Hospital — James Foort	Development of a Variety of Prosthetic Devices for Children, with Special Reference to Lower-Extremity Requirements
The University of New Brunswick Bio-Engineering Institute — R. N. Scott	Orthotics Systems Research with Special Emphasis on the Employment of Electromyographic Signals as Controls

SENSORY AIDS

Organization	Major area (or areas) of investigation	Sponsoring Agency
American Center for Research in Blindness and Rehabilitation	Clinical Determination of Performance Attainable by Blind Individuals with the Battelle Optophone	VA
	Evaluation of the Ultrasonic Aid for the Blind	VA
Bionic Instruments, Inc.	Manufacture of 15-20 Obstacle Detectors for the Blind	VA
Center for Sensory Aids, Evaluation and Development, Massachusetts Institute of Technology	Evaluation of a Wide Variety of Devices from the Very Simple to the Very Complex	VRA
Haskins Laboratories, Inc.	Fundamental Studies of Speech and Speechlike Sounds as Outputs for Various Types of Reading Machines for the Blind	VA
Mauch Laboratories, Inc.	Further Development of the Mauch Personal-type Reading Machine for the Blind.	VA

Appendix B

MAJOR STUDIES BEING CONDUCTED IN PROSTHETICS AND ORTHOTICS IN THE UNITED STATES

Fundamental Studies

PROSTHETICS

Lower Extremity

Considerations in a Lower-Extremity Training Program (CAPP)

Determination of the Pressure Distribution between Lower-Extremity Sockets and Stumps (PDS–NYU)

The development and application of instrumentation to map accurately the distribution of internal bearing pressures for several types of above-knee and below-knee prosthetic sockets currently in use. Determination as to whether or not the newer types of sockets, i.e., the total-contact for above-knee and the patellar-tendon-bearing for below-knee amputees actually have the effect of distributing the pressure gradients more uniformly across the socket and whether this results in increased comfort for the wearer.

After a thorough literature review, four of the more promising transducers were tested and the best features of each were selected for the study. The present design consists of a strain gage bridge mounted on two parallel cantilever beams. Only two of the four gages are active with the remaining pair being used for temperature compensation purposes. The entire device is mounted on the outside of the socket so that only the face of its plunger extends into the interior.

Using a highly accurate but expensive commercial gage as a standard, several prototype versions of the NYU transducer were tested both in a laboratory apparatus and on a total-contact above-knee socket made for a staff amputee. Dynamic tests have already been conducted at two sites. It is planned to increase this to six using both the standard gage and improved models of the NYU transducer. Finally, the number of pressure pickups will be increased to sixteen and the study expanded to cover a number of socket types and categories of amputees.

Knee Joint Placement (VAPC)

A point has been identified about which the instantaneous center of knee rotation displaces minimally in the functional knee flexion range (100 deg.) A technique has been developed to locate this point by reference to easily identified external landmarks. The present theory is being validated in an independent study on cadavers, and the reliability of the technique is being evaluated in another independent study employing a large sample of normal subjects.

Effects on Gait Parameters and Energy Costs of Reducing the Vertical Oscillations of the Body CG (VAPC)

The theory relating amplitude of vertical CG oscillation in level walking to energy conservation is being tested. A device which simulates the effect of normal knee flexion by reducing the magnitude of the vertical CG oscillation in the stance phase has been designed for installation in an above-knee prosthesis. Comparative

analyses will be undertaken of amputee performance in level walking with a conventional above-knee prosthesis and with the knee flexion simulator.

Above-Knee Alignment Study (VAPC)

Variations in alignment relationships involving foot placement, knee center location in the A-P plane, and socket attitude are being correlated with gait characteristics and energy expenditure.

Energy Cost of Various Modes of Locomotion(VAPC)

Reference data are being collected on the relative energy costs of walking for unilateral and bilateral users of below-knee, above-knee, and hip-disarticulation prostheses, leg and leg-thigh braces, wheelchairs, crutches, and canes.

Changes in the Linear Velocity of the Total Body CG as a Criterion of Gait Efficiency (VAPC)

A hypothesis has been developed linking gait efficiency in terms of minimum energy expenditure and the absence of gait deviations with minimum acceleration of the total body CG. Energy cost data are being correlated with measures of change in instantaneous velocity of the body CG obtained on normal subjects walking on a treadmill.

Work Capacity of Geriatric Amputees (VAPC)

A long-range program has been designed to develop reference data on the resistance of nominally geriatric subjects to the stresses of ambulation and other activities of daily living. These data will provide the basis for establishing achievement levels in physical rehabilitation programs. All the required equipment is available, and it remains for an appropriate sample to be selected.

Studies of Human Locomotion and Other Investigations Related to Design of Prosthetic Devices (UC–BL)

Research in human locomotion is aimed at achievement of a comprehensive picture of the biomechanical role of all segments of the body. Present investigations include those of biomechanics of the foot and ankle and of the knee and hip joints.

Upper Extremity

Fundamental and Applied Research Related to the Design and Development of Upper-Extremity Externally Powered Prostheses (UCLA)

Laboratory evaluation of standards for externally powered prostheses proposed by the Subcommittee on Design and Development of the Committee on Prosethtics Research and Development.

Continuation of a long-term investigation to provide functionally independent body-control sites by means of minor surgery and perceptual-motor training. A quantitative evaluation of the functional characteristics of an experimental muscle hernia in the pectoralis muscle will be conducted.

Study of control-site harnessing in relation to externally powered prostheses, including consideration of the relationship of control sites to types of transducers.

Fundamental Studies of Arm Prostheses Sensory-Motor Control (UCLA)

Research activities are designed to accomplish the following objectives: To maximize functional regain by analyzing engineering replacement requirements at each level of amputation; to facilitate personal and vocational rehabilitation through the development of efficient training methods to achieve full utilization of advanced prosthetic systems; to minimize the amputee's physical and mental energy requirements by assessing the value of specific externally powered functions and electronic "memories" in advanced prostheses; to provide the design engineer with basic physiological and psychological data for the development of efficient mechanical,

electrical and pneumatic transducers in the various combinations necessary for amputee achievement of multiple proportional and coordinated arm control movements; to provide preliminary data on relevant parameters of engineering economic analysis for advanced prosthetic systems and to develop an "index of economic acceptability."

Energy Cost of Standardized Upper-Extremity Tasks (VAPC)

Energy costs have been determined for standard manual tasks performed with conventional and externally powered prostheses.

Investigation of Myoelectric Control of Upper-Extremity Prosthetic Device (TU)

The purpose of this study is to develop a functional upper-extremity prosthetic device utilizing external power actuated by a pattern of myoelectric signals. A pattern of myoelectric activity is deemed to be a requirement in the electromechanical design of proportional control so that the quality of motion resulting is natural in appearance and not of the robot-like quality typical of on-off signals. Signal detection has been accomplished by an equipment complex designed and built by the Philco Corporation. By this means, the activity of multiple muscle sources is recorded simultaneously. Automatic preprocessing, extraction of the energy value of the myoelectric signals, and coding into decimal form render the data acceptable for computer analysis. Studies to date have been directed toward the analysis of practical control motions and the discrete myoelectric patterns involved. Computer analyses have demonstrated usable signal patterns from the shoulder and upper-arm complex during elbow flexion and forearm rotation. These control motions have been incorporated in a two-axis experimental prosthetic device. Present lines of investigative pursuit are being directed toward developing a four-axis device to include elbow flexion and extension, humeral and forearm rotations, and terminal prehension.

General Medical Problems

Crisis Periods in the life of the Child Amputee (CAPP)

Long-Term Follow-up of Outcomes of Early Prosthetics Fitting (CAPP)

Semiburied Implants for the Attachment of External Prostheses (GVH)

To study attachment of external prostheses in dogs, either by bone plugging or semiburied attachment. Involves investigation of (a) acceptability of different materials, (b) effect of plugging amputated bone with Teflon, or in combination with other materials using multiple designs, (c) attainment of direct end-bearing by semiburied implants alone or attached to the end of bone plugs, (d) development of external prostheses for animals with which items (b) and (c) have been successfully resolved.

Immediate Postsurgical Fitting of Prostheses (Seattle, NYU, NPRL, Duke, NU, Wisconsin)

Claims made for immediate postsurgical fitting of prosthes include: control of postsurgical edema, marked reduction in pain, improved wound healing, and a material reduction in "off-the-job" time. These claims are being investigated by the various groups participating in the research. Additional special problems being studied are:

1. Outcomes related to level of amputation.
2. The influence of myoplasty (tension myodesis) on the amputation stump.
3. The development of adjustable sockets for post-operative amputation stumps.
4. Changes in stump volume and contours related to postsurgical time and ambulation.

ORTHOTICS

Lower Extremity

Accelerographic Analysis of Pathological Gait (PDS–NYU)

This is a recently activated program. Its primary purpose is to apply the techniques of accelerometric and harmonic analysis to the study of pathological gait. The study will attempt to establish accelerographic patterns and frequency spectra for "normal" walking against which other patterns may be compared. These will include those for certain specific neuromuscular disorders such as Parkinson's disease, hemiplegia, multiple sclerosis and cerebral palsy.

Accelerographic patterns will be studied in conjunction with photographed "stick" diagrams. It will be attempted to relate these by comparing the accelerographic record with values computed from the stick diagrams such as, for instance, the high peak acceleration at heel contact.

In previous work, N. Bernstein has shown that accelerograms exhibit a number of standard waves. He has suggested that some of the more pronounced harmonics as well as the frequency spectrum which results from a Fourier analysis may aid in interpreting certain body phenomena, such as the correlation of gait data with the phasic action of certain body segments.

If it is determined that by mathematical or statistical treatment of accelerographic data, distinct patterns emerge, then the use of the technique for evaluating therapeutic treatments will be considered.

Foot Balance (VAPC)

Weight distribution and centers of pressure on the plantar surfaces of feet are being studied in relation to several types of arch supports and shoe corrections. Data have been collected on the effects of Whitman plates, Thomas heels, and heel wedges.

Evaluation of the Physiological Stresses and the Biomechanics of Hemiplegic Gait (VAPC)

This study, a joint effort with the Division of Rehabilitation Medicine, Montefiore Hospital, New York, N.Y., is designed to characterize hemiplegic gait in terms of cardiovascular stress and gait mechanics including temporal, kinematic and kinetic factors.

Brace Ankle Joint Placement (VAPC)

The effects of varying brace ankle joint alignment in the transverse and sagittal planes are being determined in terms of bending moment on the brace sidebars, calf band pressure, and relative motion between the leg and brace in several planes. Instrumentation required for this study has been developed. Three test braces have been fabricated, one with ankle joints aligned conventionally, another with the ankle joints in the same horizontal plane as the subject's ankle, and a third with the joints aligned coaxially with the subject's ankle joint in both horizontal and vertical planes.

Studies of Children's Lower-Extremity Orthotics Problems (UC–BL)

The work is divided into four main areas: (1) fundamental studies primarily concerned with the effects of growth and function upon the development of the joint system of the lower extremity; (2) clinical studies concerned with evaluation of disability and clinical testing and evaluation of experimental devices and procedures; (3) design and development studies concerned with design of new devices and refinement of existing devices in accordance with information obtained in the first two areas of study; (4) applied studies involving the development of fabrica-

tion techniques and fitting procedures for devices and shoe modifications. Current studies include pes planus, axial rotation deformities of the leg, and congenital talipes equinovarus.

Upper Extremity

Bio-Medical Research on Cybernetic Systems for the Disabled (CIT)

Engineering Analysis of Motor Activities as a Cybernetic System:

a. Research on information storage, retrieval, and data processing.
b. "Man-machine" interactions—motor expressive or feed-forward and receptive or sensory feedback.
c. Synthesis of control systems including the development of advanced control theories.
d. Development of the concepts and basic theory of multilevel decision-making systems.

Investigation of Myoelectric Control of Functional Braces (RANCHO)

The purpose of the investigation is to explore the problems appearing when myoelectric control is applied to braces of patients having a reduction or an absence of some normal abilities. The principal aim is to develop a technique of convenient control applicable to patients with a variety of disabilities. To achieve this, the program will investigate the characteristics of muscle signals from patients with various disabilities, study the patterns of muscle activities in different tasks and movements (both in normal subjects and in patients), and design and construct the necessary electronic and mechanical equipment to use such signals for each of a number of different patients.

General Medical Problems

Role of Various Physiological Factors in the Occurrence and Modification of Human Spastic States (UC–BL)

The study of electromyographic, respiratory, and metabolic changes occurring in human subjects with spastic disorders and in normal control subjects under static conditions and during passive and active motion of the upper and lower extremities was initiated in order to identify the peripheral physiological factors in muscles, joints, tendons, and skin that may contribute to the development of spasticity. Current investigations include: (1) the effects of isotonic and isometric exercise on reflex excitability of muscles of the lower extremity; (2) the effects on reflex excitability of ischemia, hyperemia, and congestion produced by the use of ligatures, cold, heat, and perhaps other agencies; (3) the inhibition of reflex excitability in agonists by stretch of antagonists; (4) the effects of posture on reflex excitability.

PROSTHETICS AND ORTHOTICS

The Mechanical Properties of Human Tendon (UM)

The mechanical behavior of tendon subjected to low levels of stress is being studied. Specimens of human tissue have been obtained from limbs removed at surgery and have consisted primarily of the extensor digitorum tendons of the foot. This material has been studied both in fresh condition and after preservation by freezing. So far efforts have been directed toward obtaining stress-strain hysteresis curves for tendon subjected to sawtooth loading functions representing various rates of load application.

Hysteresis studies on human tendon are to be continued in order to obtain data which will be useful in the quantitative prediction of tendon behavior under other

types of loading as well. Extension of LaBan's work on the creep and recovery processes in tendon subjected to step-loading, and the relating of this information to that obtained from hysteresis studies is also planned.

Interval Measurements Applied to Skeletal Motor Units (UM)

Observation and measurement of the rate of behavior of motor neurons both on a beat-to-beat and by long-term statistical analysis is planned. The action potentials of single motor units in skeletal muscle will be studied.

Investigation of Myoelectric Control of Functional Braces (UM)

The purpose of this project is to explore the problems appearing when myoelectric control is applied to braces of patients having a reduction or an absence of some normal abilities. The principal aim is to develop a technique of convenient control applicable to patients with a variety of disabilities. To achieve this, the program will investigate the characteristics of muscle signals from patients with various disabilities, study the patterns of muscle activities in different tasks and movements (both in normal subjects and in patients), and design and construct the necessary electronic and mechanical equipment to use such signals for each of a number of different patients.

Activation of Paralyzed Muscles Using Telemetric Devices (CIT)

(a) Research and development of an overall concept of telemetry method for controlling muscles.

(b) Development of components for telemetric control systems (micro-miniature and solid state electronic devices).

(c) Evaluation of components and systems in animals and man.

Kinesiophysiological Studies and Myoelectric Control of Paralyzed Muscles (CIT)

(a) Research into surface stimulation of paralyzed and normal muscles in man.

(b) Research into peripheral nerve stimulation of muscles in animals.

Neurophysiological Studies of Muscles (CIT)

Involves continued research on the lower motor neuron system including experiments on animals. The efferent and afferent interconnecting paths of the lower motor neuron control system will be viewed as a multiloop control system as defined by the engineer. It is proposed that neurosurgeons and neurophysiologists working closely with control engineers can reduce the neuromuscular control system to an engineering model which will permit the design of telemetric transducers.

Interval Measurements Applied to Skeletal Motor Units (RANCHO)

Observation and measurement of the rate of behavior of motor neurons both on a beat-to-beat and by long-term statistical analysis is planned. The action potentials of single motor units in skeletal muscle will be studied.

Development and Evaluation of Procedures for Selection of Students for an Orthotics-Prosthetics Training Program (RANCHO)

This research involves a study of the relationships between scores on tests of mechanical aptitudes, intellectual capacities, and personality characteristics and performances in a prosthetics-orthotics training program to determine selector criteria for students.

Energy Expenditure in Certain Types of Disability (UC–BL)

Investigation of energy expenditure during locomotion of normal subjects and of subjects with certain types of disabilities is part of the comprehensive analysis of body mechanics during locomotion. Ambulation of subjects is studied on a motor-powered treadmill or on a measured track. Measurements are based on oxygen

uptake. Oxygen consumption, carbon-dioxide production, and heart rate are determined, and related physiological information is gathered. Electromyographic studies of certain muscles of the trunk and certain muscles of the extremities are also made in an effort to determine the mechanism for changes in energy expenditure during immobilization of body segments.

PROSTHETICS

Lower Extremity

Porous Laminates (AMBRL)

Recently a process was worked out for the preparation of porous laminates without the use of solvents. The method is undergoing tests for the preparation of various types of prostheses.

Prosthesis for Immediate Postoperative Use (AMBRL)

A prototype of a transducer for measuring the load on an immediate postoperative prosthesis was designed, constructed, and tested. It was indicated that the design was a feasible one.

Semiconducted-type strain gages have been obtained and used in lieu of the 120 OHM gages which were used on the prototype model transducer. A recorder which does not require signal amplifications is being considered for use with the transducer.

A Polyethylene Suspension Cuff for PTB Prosthesis (CAPP)

Hydraulic Ankle Control Unit for AK and BK Amputees (ML)

Lateral Motion Foot Control for AK and BK Amputees to be Integrated with Hydraulic Ankle Control Unit (ML)

Transverse Rotation Foot Control for AK and BK Amputees to be Developed and Possibly Integrated with Hydraulic Ankle Control Unit (ML)

Stump-Actuated Hydraulic Swing and Stance Control Unit for AK Amputees (ML)

Polycentric Knee (NU)

A unit combining complete stability at knee extension with easy flexion at toe off. Also incorporated in this device is a mechanical friction swing-phase control unit.

Thigh Pylon for Hip-Disarticulation Prosthesis (NU)

A pylon which allows medial-lateral, anterior-posterior, and rotational adjustment. The first prototype has been constructed using Wilson-Riblett wedges.

Suspension Casting Technique (NU)

This casting technique consists of allowing the amputee to bear half of his weight on the stump suspended in a cast sock during casting. If properly used, consistent replicas of the stump under weight-bearing conditions are possible regardless of who takes the cast. The positive mold requires less modification than previously. This casting technique is very successful with BK amputees and is being extended to other levels of amputation. A sling-suspension casting technique has been developed for hip disarticulations and hemipelvectomies.

Socket Materials (NU)

Sockets incorporating rigid and flexible areas have been made. One model has been worn approximately two years. Epoxy and Versamid materials, in combination, have been used. Polyester resins and silastic laminates have also been used. Durability of materials is under evaluation.

Sockets (NU)

Sockets for above-knee amputees are being constructed utilizing pneumatic pressures to accommodate volumetric differences between the socket and the stump. (PVC materials are being used to construct air bags.) Different areas of the socket to be inflatable are being evaluated such as the anterior and posterior portions. The lateral wall is also being considered not only for volumetric stability but as a means of controlling the adduction angle in the socket.

Molded Foam Foot (NPRL)

A two-component flexible polyurethane foam is under investigation. Materials for mold and keel construction are also being studied.

Simplified Artificial Leg (NPRL)

Basically a pylon device with foamed exterior, this item is being designed for rapid and inexpensive application to large numbers of amputee casualties. It would also be applicable in the immediate postsurgical fitting of prostheses. Prototypes of combination above-knee and below-knee alignment jigs have been completed and are under test. The above-knee component includes a swing-phase control basically similar to the Variable Friction Knee Mechanism.

AK Pylon Designed for Use with Various Swing- and Swing-and-Stance Control Mechanisms (VAPC)

An above-knee pylon-type prosthesis is being designed which accepts six different fluid and mechanical knee-control mechanisms. This device serves as a temporary prosthesis without cosmetic cover where early postoperative ambulation is indicated; as a clinical instrument to permit the physician to observe patient performance with several knee-control mechanisms before final prescription; and fitted with a cosmetic cover, as a permanent prosthesis which permits easy interchange of knee components. Limited clinical trials are now in progress to evaluate the utility of the device.

Torque Absorber (VAPC)

Several devices to absorb the forces tending to rotate the leg in the transverse plane have been designed for installation in a prosthesis. Biomechanical studies are in progress to determine the phasic pattern of function, excursion in the internal-external rotation range, resistance forces and the influence on gait. Clinical application studies have been started with the installation of three of one type of unit into both BK and AK prostheses to obtain feedback on performance, strength and durability. We have found one design to have structural deficiencies.

Through-Knee Hydraulic Unit (VAPC)

A device has been designed which permits fluid-controlled knee units to be installed in through-knee prostheses. It consists essentially of an externally placed socket-attachment strap which is free to pivot around the knee center. The required spatial relationships are maintained by means of a yoke connected to the attachment strap at two points and to the piston rod of the hydraulic unit. Several patients are being fitted to aid in further development.

Stump-Controlled Hydraulic Knee-Locking Device (VAPC)

A laboratory model has been constructed of a device which permits volitional control of locking and unlocking of a prosthetic knee. Phasic pressure differentials between the stump and socket actuate hydraulic pressure transducers which control the knee-lock mechanism. Current experiments are aimed at identifying the most efficient control sites.

Improved Alignment Device for Pylons (VAPC)

Recent pylon designs have used alignment adjustment apparatus intended as a permanent part of the pylon assembly, even for permanent prosthesis use. So far there have been several deficiencies (slippage, difficulty of adjustment) noted. We have designed a simple apparatus in order to overcome these difficulties. A prototype is now being built.

Pneumatic Casting (VAPC)

A pneumatic pressure system has been developed to distribute external forces of controlled magnitude on stumps during casting. Our experiences in fitting over 30 patients by this technique have been highly encouraging, and the procedure is being tested in several other laboratories. The required equipment, including a pneumatic pressure sleeve, a specially contoured forming sleeve, and the accessory hardware, has been distributed to these centers.

Direct Forming of Sockets (VAPC)

Experiments continue to identify a material suitable for forming a socket directly over the stump under appropriate external forces to produce a biomechanically sound socket design without requiring conventional modification.

Studies to Improve Techniques for Fabricating, Fitting, Aligning, and Suspending Lower-Extremity Prostheses (UC–BL)

Five major studies are currently being conducted: (1) continuation of the immediate postoperative casting program for below-knee amputees; (2) preparation of a report on the newly developed air-cushion patellar-tendon-bearing below-knee prosthesis and evaluation of the use of fluids other than air to provide the cushion effect; (3) work on a pneumatic cushion socket for use with above-knee prostheses; (4) a comparative evaluation of German and American bench alignment techniques; (5) construction of device based on the Canadian-type hip-disarticulation prosthesis that will feature adjustability wherever possible in order to evaluate such characteristics as alignment, bumper function and location, swing control, and stability. Four additional studies, undertaken as time permits, are: (1) development of instrumentation to evaluate weight-bearing distribution on the socket in order to determine the degree of end-bearing; (2) improvement of suspension systems for the patellar-tendon-bearing and nonsuction-socket above-knee prostheses; (3) study of the feasibility of designing cooling systems for sockets; (4) continued study of new materials and techniques for prosthesis fabrication and function.

Upper Extremity

Elbow with Electrically Powered Unlock (AMBRL)

Development has been completed. Prostheses incorporating the item are being fitted to one forequarter and one shoulder-disarticulation amputee. Six models are being made commercially for evaluation.

Electrically Powered Prosthesis (AMBRL)

An electrically powered forequarter prosthesis utilizing nickel cadmium batteries, miniature d.c. motors, flexible drive shaft worm gears, and screw drives is under development.

The two model d.c. motors, each having a continuous torque of 2.5 in. oz. and a rated speed of 5400 r.p.m., will be connected to gearboxes having a reduction ratio of approximately 15:1. The gearboxes will be attached to a flexible drive shaft leading to a 50:1 ratio worm-gear arrangement in the prosthetic elbow and a drive-screw mechanism in the terminal device. Lifting capacity will be about 5 lb. at the terminal device, and prehension force in a No. 3 size hand is estimated at 5 lb.

Gloves and Glove Materials (AMBRL)

A change made in the RREP glove formulation has reduced viscosity and considerably improved processability. Information has been disseminated to interested glove manufacturers.

Artificial Hands (AMBRL)

(a) Size No. 3, Voluntary-Opening with Following Lock. Two hands (one right, one left) are being assembled and will be evaluated.

(b) Size No. 5, Voluntary-Opening with Following Lock. Two hands (one right, one left) are being assembled and will be evaluated.

(c) Size No. 4, Resilient. This hand has been modified to change the position of the cable exit, strengthen the exterior foam, make the thumb spring more reliable, and reduce "puffiness." Three hands have been submitted for evaluation, and three others are being made for test purposes.

Hooks (AMBRL)

(a) Flexion Mechanism (FLAC). This device which is a modified Dorrance hook with a mechanism to provide 0 deg. and 35 deg. of flexion, built into the base of the fingers, is under development.

(b) Adjustable Spring Prehension. Four prehensile force adjustments (½ lb. to 4 lb.) are provided by a specially coiled spring. Adjustments are effected by a coin.

(c) Graded Prehension. Design studies are being undertaken to develop a graded prehension hook that will be housed in a hook case of design similar to the present APRL hook. The adjustment of prehension forces will be accomplished by means of a corrugated roller that will extend through the hook case and permit easy adjustment on any surface.

Plastic Cable Transmission System (AMBRL)

The plastic cable transmission was packaged and sent out to three organizations for field tests.

Active (cable-controlled) Hook Operation for the Infant Unilateral Below-elbow Amputee (CAPP)

An Infant Quick-Change Wrist Unit (CAPP)

Devices for Transcarpal Amputations or Single Digit Anomalous Upper Extremities (CAPP)

Center Pull Hooks (Mark I and Mark II) (CAPP)

A Nylon "Passive" Hook (Mark III) (CAPP)

A Nylon Friction Wrist (CAPP)

An Infant "Unit" Arm (CAPP)

A Control Attachment Source for Infant Quadrilaterals (CAPP)

Mechanical Wrist Rotator (GILMATIC)

This device provided wrist rotation for a mid-forearm or shorter below-elbow amputee. It utilizes single cable pull operation to actuate in alternate directions. Two lock rods are used to provide a lock system.

Bench model devices have been tested for operation and lock loads as well as reliability of operation. Limited field testing of these models is in process.

Electric Elbow Lock (GILMATIC)

A breadboard model of this unit has been completed for testing of operating condition.

A standard Hosmer elbow modified to accommodate the electrical mechanism for this unit is used. A yoke is used to transfer the load to each side pivot of the elbow. This yoke passes around the solenoid to permit mounting and elbow motion.

The method of solenoid use results in operation of either cycle, locking or unlocking, with a maximum of twenty milliseconds of current consumption which prolongs battery life. Two units of finalized design are being assembled for field tests. Single-spring construction for both alternator and pick-up has improved the operation of the latest design.

Wrist Flexion Unit (GILMATIC)

This unit incorporates the use of an integral bearing and lock mechanism. To reduce the length and bulk of wrist flexion units as commonly constructed, the pivot point is machined into the moving parts so as to eliminate a thrust shaft or stub shafts connected to the rotating parts.

Locking is accomplished with a detent-type push-button bar to securely lock the elements together.

Axial Motor (Electrical) (GILMATIC)

A ring-type motor which permits the installation of two interacting lead screws and a drive nut are combined to accomplish speed reduction. The inner lead screw is stationary and connects to the operated device and can either push or pull the load. A screw which mates the inner screw on the inside and passes through a stationary "Teflon" nut on its outside thread is driven by the motor. Bench tests to establish curves are in process.

Position Sensor (GILMATIC)

A method of feedback sensing for either angular or load changes has been designed for bench test use. Basically differences in angulation or load are transmitted through a music wire and vinyl tube to selected portions of the body, where a traveling ball contacts the body to cause a sensing action.

Electrical Drive Wrist Unit (GILMATIC)

This unit adapts a very inexpensive motor with a spur gear drive to rotate a wrist unit. It can be used for feeding or low-load operation such as terminal device pre-positioning.

Spring Load Terminal Device (GILMATIC)

To eliminate rubber bands on the hook-type terminal device, a new approach is being tested. The axis of the hook is made to resemble a spiral engagement of the fixed to moving parts. The spring load is induced by a series of "Belleville" washers stacked on the mechanism to create the desired work load.

Film Bearings (GILMATIC)

An investigation to establish further information on the use of film bearings (bushings). "Teflon" film is under study. These bearings were incorporated in Mechanical Wrist Rotator field-test units.

Elbow-Rotation Lock (NU)

A manually controlled lock is mounted below the elbow turntable. The device is spring-loaded to forcefully engage a locking pin into the turntable to prevent inadvertent rotation. Development has been completed.

Electric Toilet Care Arm (NU)

A prototype model has been constructed and is designed for achieving independence in toilet care and for carrying out related dressing motions. Applicable for bilateral SD or bilateral very short AE. A patient is now being fitted with this device.

Electric Power Assist Unit (NU)

This is a unit to be used with a conventional body-powered prosthesis. It is designed to supply approximately 50 percent of the work required for operation; the amputee supplies the remainder. Two units have been fittted to patients for trials.

Adult Center Control Hook (NU)

This device has the pivot offset and the fingers set 25 deg. in radial deviation to allow for center cable pull. Following favorable amputee reactions to a prototype model, six units are being produced for test purposes.

Ball-and-Socket Shoulder Joint (NU)

This shoulder joint is comprised of a 1-in. diameter ball and socket capable of sweeping out a cone with a 90 deg. included angle. It has a lock which applies friction in four steps from free swinging (approximately 5 in.-lb.) up to 20 in.-lb. of torque. The first prototype is being constructed.

Power Transmission Systems for Upper-Extremity Prostheses (WWRC)

The purpose of the research is the application of external power to upper-extremity rehabilitation. The immediate goal is to provide power assistance to conventional harnessing and to improve the transmission efficiency of body power. Demonstration models for below-elbow amputees will be fabricated and subjected to functional-engineering tests. Results from this testing will be used in design studies for prostheses for higher level amputees.

Development of an Improved Pneumatically Powered Upper-Extremity Prosthesis (AIPR)

The purpose of this project is to develop externally powered artificial arm components and systems for both child and adult upper-extremity amputees. Basic systems and control units using compressed CO_2 as an energy source have been designed, fabricated, and fitted to patients. The components and control valves have been designed so that any combination of the major functions of the upper extremity may be achieved by external power. It is planned that by fitting various combinations of units the relative importance of each function can be ascertained. Experience gained with these units to date warrants further refinement of the basic systems and the production of a sufficient number of units for the development of a prescription rationale. Work will proceed along these lines with especial emphasis on the requirements of the grade-school child.

ORTHOTICS

Lower Extremity

Arch Support (AMBRL)

A technique for preparing arch supports has been developed and is under evaluation.

Plastics as Metal Substitutes (AMBRL)

An epoxy resin glass stockinet formulation has been identified as satisfactory for short-leg brace use. Brace sidebars of this formulation are being prepared by a special laminating procedure for test purposes.

Brace Contouring (AMBRL)

A method for preparing contoured all plastic braces has been developed. The method consists of making a tracing of the limb to be braced on a 1-in. thick piece of wood and cutting the wood along the tracing marks allowing sufficient relief

areas. A fabric resin lay-up is then prepared around the perimeter of the tracing cutout.

For the resin fabric lay-up, a series of prepregs using shrinkable Tedlar film for application of pressure as well as filament winding is being investigated.

New Concept in Production of Orthopaedic and Amputee Tracings (NPRL)

The concept essentially involves a tilt-table device for manipulation of patient body position and the use of light sensitive paper to obtain limb silhouettes. Comparative studies with other tracing methods are in process.

Hydraulic Brace Former (NPRL)

This device is expected to substantially reduce time, hence cost, of forming brace components to pattern.

New Dip-Coating Process for Orthopaedic Braces (NPRL)

A simple dip-coating process is under development whereby orthopaedic braces may be rapidly, inexpensively and durably "finished" with a thin, resilient plastic coating in appropriate skin tones.

Bracing for the Rheumatoid Knee (UM)

The prime objective has been to design a brace which provides rotatory torque to correct valgus, and sheer forces to prevent anterpostrior translational movement, while still permitting free flexion-extension of the knee. Results have been encouraging but to meet the need for precision in the adjustment and to avoid the many days of hospitalization required for proper fitting, an adjustable brace is being designed for use during the painstaking fitting procedure.

Plastisol Coating (UM)

Plastisol coating of metal splints and braces provides a more durable, economical, and easily cleaned product than previously used leather padding. With the aid of a specially designed oven, details of the coating and curing process have been worked out and tested, with a view toward standardization of methods.

Friction-Controlled Ankle Joint for Drop-Foot Brace (VAPC)

A drop-foot brace has been designed to employ friction ankle joints to control motion instead of conventional spring-loaded joints. Constructed essentially of two thin steel disks and designed for installation in a thin plastic laminated shell molded about the ankle, the weight of the patient and the applied plantar-flexion moment are sufficient during and after heel contact to overcome frictional resistance at the ankle. Similarly, the dorsiflexion moment during stance overcomes the resistance at the joint and restores a "toe pick-up" position. When the patient's foot is lifted from the floor after roll-over and dorsiflexion, the frictional resistance holds the foot in the last attitude established.

Single Bar Brace (VAPC)

This device has been fitted to 17 patients to date, including bilateral and unilateral leg and leg-thigh brace wearers. Further development is centered on increasing the rigidity of the coupling between the single external lateral bar and the "internal" support provided by tibia and/or femur by means of specially designed bands. The currently used thigh band spirals downward from the gluteal fold to an anteromedial point approximately 4 in. above the knee.

An Adjustable Device for Alignment of Shoe Extensions (VAPC)

There is a need for an adjustable device that would facilitate fitting and alignment of shoe elevations for lower-extremity shoe extensions. Such a device is especially needed for congenital patients having lower-extremity shortening in

excess of 2 in. Its function would be similar to that of the VA Prosthetics Center coupling in that it would offer the adjustments necessary to provide optimum alignment of the shoe extension relative to the foot. In our opinion such an instrument would not only be helpful to the shoe modifier and the brace maker but would also be beneficial to a clinic team as a diagnostic tool. We have made rough drawings of such a device and will fabricate one model in the near future.

Upper Extremity

Powered Upper-Extremity Orthotic Systems (BUCM)

A comparative evaluation of finger prehension and related hand and arm motions is being made between normal individuals and patients with flaccid and spastic bilateral shoulder, arm, and hand paralysis. The results of the study will be used for the further development of controllable, externally powered orthotic systems to restore purposeful arm and hand functions of paralyzed patients.

Plastic Arthritic Hand and Wrist Splints (UM)

Three types have evolved: (1) one for use when the disease process is active, to minimize the development of deformity at the MCP and wrist joints; (2) one to reduce deformities that have become established, such as ulnar deviation and volar subluxation at the MCP joint, and ulnar deviation, flexion, and volar subluxation at the wrist joint; and (3) one to reduce ulnar deviation at the MCP joint only.

The plastic selected for the splints is 0.125-in. rigid polyvinylchloride by Bakelite.

Adjustable Axillary Burn Splint (UM)

To prevent deformity in the axilla, an adjustable splint which can be fitted to different patients and which can position the arm in any number of desired ways has been designed.

External Power and Control in Orthotic Devices (UM)

General design criteria have been developed and an electropneumatic system using electromyographic signals at the control site has been designed. Elements of this system have been assembled or are in process of construction.

Subloxometer (UM)

Because of the interest in the pathogenesis and treatment of deformity in the rheumatoid hand, a device is being developed for measuring quantitatively the extent of subluxation of the metacarpophalangeal joint. Preliminary tests have been promising, and it seems likely that the principles of this device can eventually be applied to the measurement of deformity in other rheumatoid joints also.

Isometric Hand-Pressure Device (UM)

A device for continual measurement of hand-grip forces has been developed that adds the following provisions to formerly used instruments: instantaneous force measurements which can be recorded by a direct-writing oscillograph, isometric mode of measurement, and variable size to accommodate hands of different sizes and gripping positions.

Investigation of Externally Powered Orthotic Devices (RANCHO)

The development and evaluation of externally powered orthotic devices that will provide severely paralyzed persons with voluntary-arm motion through the entire functional range are planned.

Apparatus design is based primarily on the utilization of miniature electrical motors to drive a splint structure which is analogous to the anatomical arm in range

and segmental proportions. Pneumatic arm assists, as currently used, will be extended to bilateral application.

Final device evaluation will be based on clinical methods of appraisal and expressed in terms that are definitive of practical usage.

Items Being Evaluated

PROSTHETICS

Lower Extremity

Pylon Prostheses (VAPC)

Several models of pylons featuring various adjustable alignment assemblies were evaluated. The study included a mechanical analysis of design, materials, and function, as well as clinical experiences. Deficiencies noted were brought to the manufacturers' attention while acceptable units have been recommended for limited clinical trials.

Swing-Control Units (VAPC)

The above includes the Kingsley Hydra Nu-Matic, the U. S. Manufacturing Co. Hydra-Knee, and the UCB pneumatic knee. Laboratory tests and limited use by patients of the first two devices resulted in indications for redesign which the developers are studying. The UCB pneumatic swing-control device is now undergoing bench testing to evaluate operational characteristics. Several patients, selected as test wearers, will be fitted with the unit and data will be collected on prosthetic experiences, performance, comfort, and maintenance.

Swing- and Stance-Phase Control Units (VAPC)

Now being evaluated are the Henschke-Mauch Model A, the Regnell Model A, and the Blatchford Stabilized Knee. Mauch units are scheduled for VA-wide clinical trials, and the Regnell unit has been evaluated on the basis of experiences in fitting three pilot wearers. Deficiencies identified in the Regnell unit have been brought to the attention of the developer for redesign of the foot and the improvement of tolerances. Upon receipt the revised models will be evaluated.

UCB—Air Cushion Socket (VAPC)

Clinical fittings are now in progress to facilitate analysis of the functional aspects of the socket design, casting methods, and fabrication techniques. Special consideration will be given to the physiological effects on the stump, comfort, and dimensional stability of the socket after long periods of wear.

Patellar-Tendon-Bearing Air-Cushion Sockets (NYU–POS)

The overall indication on the basis of preliminary evaluation indicates that the air-cushion socket with the air chamber sealed at atmospheric pressure contributes to the comfort of below-knee amputees.

Distal Contact Regulators (NYU–POS)

Some four below-knee and two above-knee prostheses equipped with distal contact regulators are being fitted as subjects become available. Work is continuing to perfect the reliability of the pneumatic chamber.

Winnipeg Pylon Prosthesis System for Below-Knee Child Amputees (NYU–POS)

Lack of availability of child-size prefabricated receptacles and cosmetic covers has interrupted the evaluation program.

Navy Prosthetics Research Laboratory Variable Friction Knee (NYU–POS)

Subjects have been recruited for this study, and fittings will commence shortly.

Upper Extremity

Externally Powered Systems (VAPC)

A program has been established to evaluate several externally powered systems for upper-extremity prostheses. To date, one subject has been fitted with one complete system of AIPR components. Presently also being evaluated are the electrically controlled AMBRL and Gilmatic elbow locks.

CAPP Hook (VAPC)

Six prototype models of this device were fabricated and sent to various laboratories for evaluation. Our evaluation centered on studies of the design and materials for the palmar section and functional utility. The device is being modified from a push-pull actuation to conventional voluntary-opening for test purposes.

Center Pull Hooks (NU) (VAPC)

Six prototype models were fabricated and will be distributed to various laboratories for evaluation. The device features a center control whose cable passes through the axis of the mounting stud. The pivot is offset 1⅝ in. from the stud centerline giving the hook fingers a radial deviation of approximately 25 deg. Operational forces and functional characteristics will be evaluated.

Gilmatic Wrist Rotator (VAPC)

One model of this body-powered "pronator-supinator" has been tested in the laboratory and on one amputee. Results, already communicated to the developer, suggest problems in controlling and powering the unit in an otherwise conventional above-elbow prosthetic system.

Army Medical Biomedical Research Laboratory Resilient Hands (NYU–POS)

The overall indication from the preliminary evaluation is that the resiliency incorporated into the hands was well received by the large majority of the amputees testing the AMBRL resilient hands. However, the contour of the hands was unacceptable for masculine cosmesis.

Münster-type Below-elbow Prosthesis Fabrication Technique Field Study (NYU–POS)

Fifty-four children have been fitted with the experimental arm in 16 clinics. There has been a high degree of acceptance by children, parents, and clinics. Positive attributes cited are improved function, cosmesis, and comfort. Problems are related to the limited range of elbow motion, clothing wear and harness discomfort caused by the low-riding cable, and growth of the patient.

Dorrance Juvenile Size No. 2 Hand Field Study (NYU–POS)

Thirty-one of the 33 children fitted with the Dorrance No. 2 hand have completed a 6-month test-wear period. All the children elected to continue to wear the hand at the termination of the study. Children and parents have reacted positively to the cosmesis and function of the hand.

ACAC-NUPRC Electric Feeder Arm (NYU–POS)

Experience to date indicates that children fitted with the ACAC-NUPRC electric feeder arm are able to obtain a consistently neat feeding pattern without undue effort. Maintenance of the arm and use of the arm for activities other than feeding have presented problems.

Army Medical Biomechanical Research Laboratory Electric Elbow (NYU–POS)

Two units have been received from the developer for evaluation and will be fitted to two shoulder-disarticulation amputees.

Army Medical Biomechanical Research Laboratory Shoulder Unit (NYU–POS)
Two units have been received and will be fitted to subjects for test wear.

Army Medical Biomechanical Research Laboratory No. 3 Hand (NYU–POS)
Three children have test-worn the hand and found that the hand cosmesis and function were excellent.

Dorrance No. 3 Hand (NYU–POS)
Hand cosmesis and function have been rated as satisfactory by all participants in the study. No mechanical problems have developed to date.

New Brunswick Myoelectric Control Unit (NYU–POS)
The study will be carried out in two phases: (1) testing of the control unit and trainer on a minimum of 15 children; (2) application of the myoelectric control unit to electrical prosthetic components.

ORTHOTICS

Lower Extremity

Arch Supports (VAPC)
In an effort to determine the utility of currently prescribed arch supports, a sample of patients is being fitted with several types of foot appliances including metal Whitman braces, leather Shafer plates, Silverman Fiberglas Heel Stabilizers and various plantar molds. The effectiveness of these devices is being evaluated in terms of patient reactions to comfort and performance, objective measures of posture and gait, and orthotist's experience in applying them.

U of C Biomechanics Laboratory Shoe Insert Technique (NYU–POS)
A total of ten children and six adults have been fitted with the shoe inserts.

Prefabricated Ischial Weight-Bearing Brace Top (NYU–POS)
Test fittings have commenced.

Upper Extremity

Texas Institute for Rehabilitation and Research Plastic Hand Orthosis (NYU–POS)
A final summary of experiences with the TIRR plastic hand orthoses is being prepared.

Special Studies

Rheumatoid Hand Exhibit (UM)
The exhibit illustrates the salient points of a theory concerning the causative factors in deformity of the rheumatoid metacarpophalangeal joint. It consists of a three-dimensional model of the joint, with cords representing flexor tendons and joint ligaments. The model is mechanized so that measured tension can be applied to the flexor tendons in programed cycles. At the same time, force gages register the tension developed in the joint ligaments restraining these forces. One cycle shows the joint in its normal configuration, and another shows the restraining structures elongated, with the joint assuming the position of typical rheumatoid deformity.

Proportional Wheelchair Control (UM)
Commercially available wheelchair controls are "on-off" devices causing abrupt changes in velocity which are unsuited to the transporting of paralyzed individuals; moreover, they require significant torques from arms, shoulders, and hands, or coordinated X-Y motions of one hand, which cannot be provided by the severely disabled patient. The device undergoing investigation takes advantage of the mechanical control sites afforded by the Michigan Feeder, along with germanium transistor switching circuits and with Servo potentiometers that require very low torques.

Prosthesis Costs for the Unilateral Below-elbow Child Amputee (CAPP)

Survey of Inactive Patients re Prosthesis Acceptance—Rejection and Vocational Experiences (CAPP)

Group Training for Amputees and Group Discussion Sessions for Parents (CAPP)

An Electric Cart for Multilateral Amputees (CAPP)

Functional Standards for Prosthetic Knee Mechanisms (VAPC)

Over 30 different models and makes of knee mechanisms are now available to U. S. clinicians. We have recognized the need to aid the physician and the purchaser by developing functional standards to classify and to some extent rate these devices. Standards are now under development based primarily on functional and maintenance requirements.

Effect of Venous Compression by Elastic Hosiery on Measurable Blood Flow Characteristics (VAPC)

To provide a basis for the development of functional specifications for elastic hosiery, the effects of compression forces applied to the lower extremity by elastic stockings are being studied. Blood pressure, pulse rate, and cardiac output are being measured on normal subjects with and without elastic hosiery.

Wheelchair Standards (VAPC)

Based on laboratory and clinical experiences in evaluating 20 novel and conventional wheelchairs, we are developing functional standards to guide design and VA procurement and prescription policies. The proposed functional standards are based on dimensional factors, stability, durability, patient performance and safety.

Wheelchairs and Accessories (VAPC)

In a continuing program both newly developed and commercially available wheelchairs are being evaluated. Currently under study are the Gendron lightweight wheelchair and an American wheelchair featuring padded upholstery and Lexan polycarbonate caster wheels. Also being evaluated is a Stand-O-Matic wheelchair which incorporates a hydraulic lift in the seat, the E & J Mono-Drive — an electric wheelchair, and a Lincoln wheelchair that also functions as a mechanical patient lift and as a commode seat. These wheelchairs have been evaluated mechanically and biomechanically, and are presently undergoing clinical testing.

Crutches (VAPC)

A pair of electrically powered hydraulic crutches designed to lift and deposit patients from and into chairs, and to serve as crutches for ambulation, is being evaluated. Our clinical findings suggested that a larger field test be undertaken to identify the specific types of patients who can benefit the most from this device. This field test will be initiated.

New Materials (Commercially Available Products Currently Under Study) (VAPC)

Lamiflex—as a material to absorb loads in a lower-extremity rotator.

Polypropylene fibers—for polyester and epoxy laminations to provide increased strength and transparency.

Neoprene polymer—for "dynamic" arch supports.

Silicones—for shoe inserts.

Pre-Impregnated Fiberglas—for selective reinforcement of laminates.

Appendix C

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