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RESEARCH IN LIMB PROSTHETICS AND ORTHOTICS

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RESEARCH IN LIMB PROSTHETICS AND ORTHOTICS

A Report of an International Conference Sponsored by the

COMMITTEE ON PROSTHETICS RESEARCH AND DEVELOPMENT
of the
DIVISION OF ENGINEERING—NATIONAL RESEARCH COUNCIL
and the
INTERNATIONAL COMMITTEE ON PROSTHETICS AND ORTHOTICS
of the
INTERNATIONAL SOCIETY FOR REHABILITATION OF THE DISABLED

Held at Cacapon State Park
Berkeley Springs, West Virginia
April 28-May 2, 1969

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NATIONAL ACADEMY OF SCIENCES
WASHINGTON, D.C.
1969

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The International Conference on Limb Prosthetics and Orthotics was conducted as part of the work under Contract No. SRS-69-12 between the Social and Rehabilitation Service of the Department of Health, Education, and Welfare, and the National Academy of Sciences.

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P R E F A C E

The Social and Rehabilitation Service is pleased to have been able to play a part in the first International Conference on Research in Limb Prosthetics and Orthotics. Our continued deep involvement in prosthetics and orthotics research, demonstrations, and training on both the national and the international scene is a result of our commitment to develop improved services to people through the rehabilitation process. It has been our experience that the field of prosthetics and orthotics has developed a model program of research, demonstration, and service to people. We are proud of the part we have been able to play in the development of this program for the United States and are now quite pleased to participate in the expansion of the program to include international activities.

Since 1961, the Social and Rehabilitation Service (formerly the Vocational Rehabilitation Administration) has conducted the international rehabilitation research program through the use of United States-owned foreign currency, derived from the sale of U.S. surplus agricultural commodities, that has been determined to be in excess of the normal requirements of the United States in given countries. In this way, it has been possible to supplement and complement the programs we support under our regular domestic research and demonstration programs. Most importantly, it has given us the opportunity to assist in the solution of human problems and thus to build a bridge of understanding between countries. The field of prosthetics and orthotics has assumed a major role in this international program.

This report reflects the beginning of true cooperative efforts between countries and international agencies in the field of prosthetics and orthotics. The spirit of cooperation

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and the coordination of programs is exemplified by the development of the program in the United States, in which the Veterans Administration, the Army, the Navy, the National Institutes of Health, and the Social and Rehabilitation Service have cooperated and have coordinated their activities in this field to develop, through the Committee on Prosthetics Research and Development, a meaningful complementary program. In this way, the United States has been able to make the best possible use of the limited resources available.

The papers of Dr. Stewart, Mr. Kosunen, and Dr. Hindley-Smith delineate the need for continued and expanded cooperation and for more formal coordination of international prosthetics and orthotics research, demonstration, and training programs. The needs of people throughout the world dictate that we all make every effort to ease their burdens and suffering as quickly and imaginatively as possible. We can do this together if we plan and conduct our activities to complement one another, and if we compete only in the spirit of getting the job done rather than of seeking recognition and fame.

We are very pleased to learn that in the four months since the conference was held, and as a direct result of the conference recommendations, some of the participants have reported the initiation of programs to complement activities in other parts of the world.

JAMES F. GARRETT, Ph.D.

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F O R E W O R D

This report presents in brief the conclusions and recommendations arrived at during a week of intense work, with both formal and informal discussions.

The questionnaire, circulated to researchers in many countries before the meeting, provided extremely useful information regarding the present status of prosthetics research; the replies formed the basis for the work of the conference.

Research activities of most of the centers in the world have been recorded. Research content and methods vary with local needs and available facilities. In some countries a serious discrepancy exists between research capacity, funds available, and the tremendous need for prosthetic services. Recent efforts in these countries have, therefore, focused on studies of simplified, inexpensive designs, and the application and testing of materials available locally.

From advanced centers great long-term programs are recorded; these involve all relevant professions and employ elaborate technical equipment, with the general goal of replacement of pure empiricism with valid objective data.

The conference unveiled fields in which conjectural statements must be replaced with objective evidence, based upon findings produced by future studies. This applies to several medical procedures and to prosthetic-orthotic items as well. Election of amputation levels, the surgical procedures, and socket design are some of the subjects which must be explored and evaluated further.

The conference made it apparent that increased international cooperation will benefit all, especially the participating research centers. It is therefore desirable to circulate

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detailed information on research projects and research results to avoid undue duplication and to effect a correlation of allied projects. Information on existing needs, the achievements, and the failures--all related to specific research items or conditions--will result in frequent reviews and readjustment of research and production activities.

Principles and problems of evaluation were discussed, and the conference recommended the establishment of standards that will assist in the conduct of an effective evaluation project on the international level.

In the past, the International Committee on Prosthetics and Orthotics, within its presently limited capacity, has supported the integration and coordination of prosthetics, research, evaluation, and service. A research information service has facilitated communication among active research centers by exchange of provisional and final reports. This conference reinforces the need for expansion of the activities of ICPO.

The conference has most efficiently supported the efforts of improved communication--much beyond what appears from the present report.

The proceedings indicate the need for continued and intensified communication within the over-all program and the need for future conferences on specific research projects.

The Social and Rehabilitation Service of the U. S. Department of Health, Education, and Welfare, and the Committee on Prosthetics Research and Development have indeed offered a gracious contribution to the international program on rehabilitation by making this unique meeting possible.

The report presents a challenge to the delegates and to all engaged in prosthetics and orthotics service and research.

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It is my sincere hope that study groups may be formed across the frontiers to tackle and to answer the questions posed.

The ICPO shall be found among the dedicated allies in this program.

KNUD JANSEN, M.D., Chairman
International Committee on
Prosthetics and Orthotics

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C O N T E N T S

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INTERNATIONAL CONFERENCE ON RESEARCH IN LIMB PROSTHETICS AND ORTHOTICS

INTRODUCTION

Between World War I and World War II very little research in limb prosthetics and orthotics was carried out. World War II inspired a number of countries to establish research programs in prosthetics and orthotics and these programs continue twenty-five years later. The thalidomide tragedy increased the interest in artificial limbs, especially in those countries most affected. The United Nations from its beginning has regarded rehabilitation as an important part of its program.

Under Public Law 480, the United States has been able to support research in artificial limbs and braces in foreign countries with money received from the sale of excess agricultural commodities.

In an effort to disseminate prosthetics and orthotics information as widely as possible, the International Committee on Prosthetics and Orthotics of the International Society for Rehabilitation of the Disabled has, since 1957, conducted courses in prosthetics and orthotics for clinic teams from throughout the world. These courses have been staged about once a year, usually in Copenhagen. Because many of the faculty for these courses have been drawn from research projects, it has been possible to effect an exchange of a good deal of information, although necessarily on a limited, informal basis. Several international conferences have been held on externally powered prostheses; but this subject comprises only a small part of the problem, of course.

Because research workers throughout have felt for some time the need for a structured conference in limb prosthetics and orthotics, the Social and Rehabilitation Service of the U. S. Department of Health, Education, and Welfare, through its International Division and the National Academy of Sciences, made available funds for conducting such a conference.

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The International Conference on Research in Limb Prosthetics and Orthotics was organized and conducted by the Committee on Prosthetics Research and Development, NAS, and the International Committee on Prosthetics and Orthotics, ISRD. It was held April 28--May 2, 1969, at Cacapon State Park, Berkeley Springs, West Virginia, and was attended by 60 individuals from 19 countries (Appendix A). The purpose of this conference was to bring together research personnel from various parts of the world to exchange information, to set forth the present status of research throughout the world, to define unmet needs, and to develop recommendations for future work. In many ways it resembled the conference conducted by CPRD in December 1966, following up the recommendations of that conference, but of course was much broader in scope as a result of foreign participation.

To provide the participants with as much useful information as possible before the conference, participants were asked to submit to the secretariat information concerning research activities in each country. This material was catalogued, reproduced, and made available to the conferees when they registered.

After the opening session the conference addressed itself to the problems by subject matter as follows (Appendix B):

Monday	- Lower-Extremity Prosthetics
Tuesday	- Upper-Extremity Prosthetics
Wednesday	- Lower-Extremity Orthotics
Thursday	- Upper-Extremity Orthotics Spinal Orthotics Orthotics - General
Friday	- Evaluation Concluding Session

The formal sessions were restricted to general subject matter and concern for the over-all program. Time was made available in the afternoons and evenings for presentation of individual work.

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In this report we have tried to include the tangible results of the conference in the form of recommendations by subject matter, reinforced with reference material which we hope will be useful to research groups throughout the world.

A. BENNETT WILSON, JR.
Executive Director, CPRD

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OPENING SESSION

The conference was opened by Dr. Elftman who welcomed the participants to Berkeley Springs. Dr. Jansen paid tribute to the Social and Rehabilitation Service and the Committee on Prosthetics Research and Development for making the conference possible, and thanked all conferees for attending.

Dr. McCavitt welcomed the group on behalf of Dr. Garrett, who had been unavoidably detained in Washington. He said that this conference provided him the opportunity to meet personally many of the people he had known by correspondence and reputation. He noted that representatives were present from eight of the nine countries active in the program supported by Public Law 480.

Mr. Traub stated that SRS was pleased to have been able to support the conference and to assist in its organization. He felt that the success of the United States program was the result of maximum cooperation between government agencies and contractors, and hoped that this conference would lead to the same sort of successful program on an international scale.

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THE UNITED STATES VETERANS ADMINISTRATION PROGRAM

Eugene F. Murphy
for Robert E. Stewart

For more than 20 years, the Prosthetic and Sensory Aids Service of the Veterans Administration has conducted and supported a comprehensive and integrated program in prosthetics. There are at least two major reasons for its acknowledged effectiveness. First, it is closely coordinated, with the research and clinical programs intimately related. Second, the program is broad in nature, so that activities begin with basic research and go through all the intermediate steps leading to the clinical application of the device or technique for thousands of patients. In turn, clinical uses point out problems and priorities for new research.

Intramural research is conducted by VA personnel, primarily at the VA Prosthetics Center in New York. The Veterans Administration also supports contractual research at a number of universities and laboratories.

For many years, we have been fortunate in having the advice of committees of the National Academy of Sciences--National Research Council. They have been particularly effective in correlating the prosthetics research activities of the Veterans Administration with those of other agencies. Moreover, they have been helpful in disseminating information about research results. Under its legislative mandate, the Veterans Administration makes the results of its research programs available so that all disabled people may benefit.

One of the most successful by-products of our research and education program has been the establishment of a network of clinic teams in various VA hospitals and clinics throughout the country. We realized many years ago that no single profession could provide the total prosthetics management required by our

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amputee patients. The clinic teams consist typically of an orthopaedic consultant, a doctor of physical medicine, one (or more) prosthetist-orthotist, a therapist, and a technically oriented administrator whom we call a prosthetics representative. In addition to such formally established clinic teams, many informal teams have been set up in VA hospitals. It has been gratifying through the years to see that this teamwork approach has been adopted by many other agencies and centers. Our chain of clinic teams has also served as a mechanism for various evaluation programs conducted by the Veterans Administration and, in some cases, by the Committee on Prosthetics Research and Development.

As an administrator, I was quite impressed by the results of a study done by our Mr. William H. Talley, which was published as an editorial in the BPR 10-10 Fall 1968 issue of the *Bulletin of Prosthetics Research*. Copies of this editorial have been made available to you by Mr. Wilson. During the period 1948-1968, the Veterans Administration spent $20,107,000 for research and development in all phases of prosthetic and sensory aids. Some $16,000,000 were spent on research on artificial limbs, affecting some 25,000 eligible amputee veterans (and directly or indirectly helping almost one million other civilian amputees). Over the same 20-year period, the actual costs for artificial limbs and repairs for these eligible veterans were $28,500,000 less than would have been expected, based upon 1948 costs. This remarkable record of the savings far exceeding the research costs undoubtedly is attributable to the developments achieved under the prosthetics research program. The improved artificial limbs developed under the prosthetics research program during the past 20 years are, on the average, lasting about twice as long as those which were available in 1948. Because of the body of knowledge that has developed from our research program, prescriptions for prostheses are being more thoughtfully written, and initial prostheses are being fitted and aligned more satisfactorily than was the case 20 years ago. Premature replacement has therefore been reduced

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substantially. The prosthetics research program has more than paid for itself over the past 20 years. It has certainly satisfied administrators, who must of necessity be cost-conscious.

The Veterans Administration is charged by law not only to conduct a program of research in prosthetics for disabled veterans, but to disseminate the results of such research in the interests of all disabled people. We have, therefore, conducted a wide variety of educational programs designed to help all members of the rehabilitation community. We have produced films intramurally or through research contractors, which we make available on a loan basis. The *Bulletin of Prosthetics Research* is published semiannually, and we help to support the publication *Artificial Limbs*. The Veterans Administration supported the establishment of the first two university prosthetics education schools, namely, the University of California at Los Angeles and New York University. These and other university programs have subsequently been supported by the Social and Rehabilitation Service and its predecessor agencies of the Department of Health, Education, and Welfare. Intramural training programs, workshops, and symposia have been conducted, to which we have invited members of the medical and allied health professions. Both contractors and our own staff have made many contributions to the literature in the form of reports, manuals, articles, and book chapters.

Of particular interest to this group is the fact that a number of Veterans Administration specialists have served as consultants to other governments in their local prosthetics programs. Also, the VA Prosthetics Center has provided training, without charge, for many doctors and technicians from other countries. We maintain a large prosthetics reference exhibit and collection in our New York office, which I would certainly invite you to visit.

In summary, for the past 20 years we have had an on-going educational program as part of our total research and development

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function. These efforts assure that research developments do not languish in a laboratory, but rather are carried through to the point where they can be prescribed for individual patients.

I should like to extend my best wishes for a successful conference.

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ROLE OF THE UNITED NATIONS IN LIMB PROSTHETICS AND ORTHOTICS

Esko Kosunen

It is a great pleasure for me to bring to this conference the best greetings and wishes for success from the United Nations and, particularly, from its Rehabilitation Unit for the Disabled.

Actually, the role of the United Nations in prosthetics research is almost nonexistent. Its program in the field of rehabilitation of the handicapped in general is a service-oriented program. Its principal aim is to provide information service and technical assistance to developing countries to help them develop their own rehabilitation service. The development of prosthetics services is a part of the United Nations rehabilitation program, but only a part.

United Nations activities in the field of rehabilitation of the disabled have their origin in a resolution adopted by the United Nations Social Commission in 1949 which laid down the broad guidelines for the program. In another resolution adopted by the Economic and Social Council of the United Nations at the recommendation of the Social Commission about one year later, the Secretary General of the United Nations was particularly requested:

--to plan jointly with the specialized agencies (of the United Nations) and in consultation with the interested nongovernmental organizations a well-coordinated international program for rehabilitation of physically handicapped persons,

--to provide technical assistance in this field,

--to expand the present facilities for dissemination of information on rehabilitation,

--to assist in providing for the exchange of knowledge and materials for the manufacture of all types of prosthetic devices.

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The authorization to use funds reserved for technical assistance in the United Nations' regular budget has been particularly important for the United Nations rehabilitation program. The assistance has been given mainly in the form of experts sent to developing countries or in the form of fellowships awarded to the nationals of those countries for studies abroad. The expert missions in the field of prosthetics have had varying aims depending on the particular needs of the countries concerned and on the level of services they have had. As examples of different types of expert missions in this field, I should like to mention the following:

1. Dr. Henry H. Kessler was sent in 1950 to Yugoslavia to advise its government on the development of rehabilitation services in general. Among other things, he recommended that "a limb fitting doctor" and workshop technicians be sent abroad to improve their knowledge and, particularly, to learn modern methods of limb making and the use of new materials. Accordingly, several fellowships were granted and the level of prosthetic services has been raised through this action.

2. Some years later, Mr. Kurt Jansson, then Chief of the United Nations Rehabilitation Unit, was sent to Burma for a similar mission. But the situation there was quite different from that in Yugoslavia. No prosthetics service existed; artificial limbs were imported from India. Another solution was needed, and he recommended that a foreign specialist be sent to the country to open a prosthetics workshop to start service, and to train local personnel to operate it.

3. The first United Nations' technical assistance mission exclusively in prosthetics was that undertaken by Mr. Tosberg to Japan in 1955. There he conducted a course on modern methods and techniques for existing prosthetics personnel.

To disseminate information on rehabilitation, the United Nations Rehabilitation Unit has initiated a series of monographs, "Basic Services and Equipment for Rehabilitation Centres," of which

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six parts have been published so far. The first of them dealt with the equipment needed in a prosthetics workshop. The sixth issue is devoted to orthopaedic appliances for leprosy patients.

Closest to prosthetics research among the United Nations activities in rehabilitation has come the Seminar on Standards for the Training of Prosthetists, which was held in Denmark in 1968 and which was organized jointly by the United Nations and the Government of Denmark in cooperation with the International Committee on Prosthetics and Orthotics of the International Society for Rehabilitation of the Disabled. Although the main subject was the training of personnel, the Seminar also discussed items related to prosthetics research, and included references to research in several of its final conclusions. I should like to mention the following as examples of the Seminar's interest in prosthetics research.

The Seminar recommended that a manual on guidelines for design of prosthetics-orthotics laboratories be prepared and published by ICPO. It established a model for the layout for such a laboratory and worked out the lists of equipment, tools, and raw materials needed. It established the responsibilities for both the prosthetist-orthotist and the prosthetic-orthotic technician and curricula for their training courses. The Seminar supported a plan to establish an international training center in Denmark and suggested that it carry out international exchange of information on research, and provide assistance to research projects. It further suggested that regional prosthetics training centers be established and that they initiate and conduct research activities with special reference to the particular needs of the region concerned. It was also recommended that any prosthetics-orthotics training center should be responsible for developing research and teaching publications and ensuring efficient information exchange. The Seminar also discussed such questions as simplified procedures in prosthetics, application of prosthetic principles to local conditions,

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standardization of devices and international terminology, and adopted conclusions on these items. Finally, the Seminar adopted a conclusion on Research and Development in Prosthetics-Orthotics in which it stated "that research at both fundamental and applied levels is essential for the improvement of prosthetic-orthotic services," and suggested that "research and development be carried out in cooperation with surgeons, prosthetists, orthotists, engineers, etc., and that particularly locomotion and other functions be studied." It further suggested that "research be undertaken on properties of materials as well as on appropriate designs and procedures," that "more research be done in orthotics as knowledge in orthotics is less advanced and as the need for orthoses is paramount, studies on prosthetic problems, particularly on control mechanisms, be continued, and medical and surgical research in relation to prosthetics-orthotics be furthered." The Seminar finally suggested that "ICPO in cooperation with the proposed International Training Center undertake appropriate measures in order to promote and correlate research in prosthetics-orthotics."

I am very pleased to see that, although such an international training center does not exist yet, many of these proposals of the Seminar are actually being implemented by the present conference.

The future plans of the United Nations in rehabilitation include a training course for instructors in prosthetics to be organized jointly with the Government of Denmark and in cooperation with ICPO later this summer. We are also planning--together with some of the specialized agencies of the United Nations, the International Labor Organization, UNESCO, and the World Health Organization, and in cooperation with the Government of Denmark--a five-year program of seminars and training courses in various aspects of rehabilitation, including prosthetics.

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ROLE OF THE PAN-AMERICAN HEALTH ORGANIZATION IN LIMB PROSTHETICS AND ORTHOTICS

Dr. R. Hindley-Smith

As you probably know, the PAHO exists to provide advisory services to governments in health activities, mainly to governments in Latin America.

During the past ten to fifteen years, many countries in this region have embarked on programs of full rehabilitation, that is, programs to provide services of physical, psychosocial, and vocational rehabilitation, and even more countries have set up units or departments of physical rehabilitation.

Naturally, in all general programs for the physically disabled, assistance must be made available for the amputee and, consequently, for the provision of prostheses.

Amputation is said to be, and correctly so, one of the physical disabilities most potentially rewarding to rehabilitate. The lower-limb amputee particularly--if he can be provided with a suitable walking mechanism--can usually enter the competitive labor market quite easily.

However, the provision of a prosthesis suitable to the Latin-American patient is much more complicated than it would seem at first sight, owing to the enormous variations in the ways of life of the amputee in this region.

Theoretically, one standard, inexpensive type of prosthesis could be constructed and distributed on a continental basis, but almost always this "standard" is either too simple or too sophisticated for any specific patient. A girl from a well-to-do family living in Mexico City or Buenos Aires, for example, will understandably demand a prosthesis which is most nearly indistinguishable from a normal limb. In other situations, a "gaucho" from the Pampas wants the limb which is most practical when he is on the

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back of a horse since that is where he spends most of his time; and a Peruvian fisherman needs something which will get him to his boat. Once he is in the boat, he is usually better off without a prosthesis.

Many other factors are involved which have nothing to do with the desirability of the prostheses themselves: the need for most countries to use their own national woods and other basic materials to avoid the complexities and expenses of importations; the availability or otherwise of good amputee surgery; and finally--and like it or not, this is the factor that has the greatest influence in prosthetics work in the region--the funds available, all influence the type of prosthesis provided.

Thus, we are not able to say "what is the ideal prosthesis for this particular patient?" but must ask ourselves "what is the least expensive way that we can enable this man to look after himself and, if necessary, his family?" When it comes to the question of advising governments, we have to say "knowing that it is not economically feasible to cover all possible prosthetic needs, of what types are the amputees whose rehabilitation would be most economically helpful to the community, and what are the minimum efficient prosthetic needs for these people?"

I am purposely putting the problem to you in this way because I am not at all certain that research workers in highly developed countries actively appreciate that most of the amputee world at present is not able to be concerned with the best possible type of prosthesis but only with the minimum necessary to keep him independent, and that for every wearer of a myoelectric hand there are three or four thousand waiting for a functional leg.

This is not to underestimate the need for continued research into prostheses which more nearly simulate the human limb. On the contrary, this work is essential in the hope that one day perfection will be achieved and that a substitute limb will be produced indistinguishable from the real thing. Almost certainly such a device will be expensive, but we have to hope that by then we would rather use

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public money to subsidize this type of activity than the militant ways which we apparently prefer to spend it now.

However, what we have to try and solve is today's problem of keeping the amputee mobile and independent, and at a minimum cost. Experience has taught us to try and be as flexible as possible about this.

There are three basic ways of tackling production of prostheses:

1. The first is the independent craftsman who is capable of making a prosthesis virtually single-handedly from local materials. This type of activity is rarely seen now in the developed countries but is still absolutely essential in communities where demand is small and communication with other areas is poor. A craftsman of this type, working in a hospital in a town of, say, 250,000 inhabitants a thousand miles away from the Capital, can be of great assistance to the amputees of that area.

2. The second possibility is for a country starting a prosthetics program to import semifinished parts so that the prostheses have only to be assembled and fitted.

This is the simplest way of ensuring good prostheses as the only highly skilled professionals which the country will need are fitters. Unfortunately, at present, very few Latin-American countries are prepared to give priority to this type of import since prices for this type of manufactured goods tend to be high.

3. The third approach is for the country to manufacture its own "semifinished" parts and distribute them throughout the country. This method is suitable for countries with sufficient industrial development and a large home market.

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PAHO has been associated with all these types of manufacture at different times and in different countries in this region and will probably have to continue this diversity of approach in accordance with the needs and possibilities of the countries wishing to help their amputees.

The first full PAHO prosthetics program was set up in Santiago, Chile, in 1962. Here the problem was to try to provide adequate prostheses for nationwide distribution through the Chilean National Health Services. It was considered important that importation for this program should be kept to a minimum. The plan devised was:

1. To import the basic machinery required for manufacture of those components which were easiest to make and in greatest demand (feet, shanks, knee joints, etc.);
2. To import a small stock of components too expensive or too elaborate for local manufacture (functional hands, elbow joints, cosmetic gloves, etc.);
3. To train students to manufacture the components mentioned in paragraph 1, using local materials to set up a stock (It should be noted that it took some time to find out which were the most suitable national woods, steels, plastics, etc., for this purpose.); and
4. To train students as fitters and assemblers.

The above plan enabled patient services to be provided in the Capital where most of the amputees were concentrated or to which they could come. However, to eliminate the need for difficult and expensive journeys from the provinces, it was also planned to provide in several major provincial cities at least one technician attached to the local hospital who could act as a fitter, repairer, and adjuster, as required.

Such a program takes several years to put into practice.

A minimum of three years is needed to prepare the technicians. It is often longer as the training of fitters is usually not

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feasible until students have been trained as manufacturers and stock is available. However, if properly financed and followed through, a program of this type would establish a base which should be able to supply all prostheses and orthoses normally needed and to achieve reasonable nationwide coverage.

Naturally, in countries where distances are vast and communications sometimes difficult, it is not feasible to try to provide 100 per cent coverage of the rural amputee population because maintaining contact with patients in remote areas becomes disproportionately expensive.

During the period, PAHO also continued to give consultant prosthetic services to other countries in the region: in Bolivia where the prosthetists were trained as individual craftsmen as best fits the country's needs, in Peru, and in Uruguay; but the next major PAHO activity in this field was the cooperation in the establishment of a Training School in Buenos Aires in 1966. Here prosthetists are taught systematically to be as independent and flexible as possible so that they can be capable of producing prostheses under any circumstances in which they may find themselves, either as fitters and assemblers in some large urban workshop, or as someone capable of making a prosthesis single-handedly as he may have to in some less developed area. This method is used as the school serves not only Buenos Aires but the provincial districts of Argentina and also students from other Latin-American countries.

The next proposed PAHO prosthetics activity will be to cooperate with the Brazilian Social Security Agency--an agency which covers some 20 million people--in the establishment of a prosthetics service for their amputees. To accomplish this, it is proposed to set up a factory and training center in Rio de Janeiro for the teaching of trainees and for the production of prostheses and orthoses. This will start in 1970.

Earlier work in Brazil provided for the training of prosthetists who were specifically taught to make prostheses for the

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patients of the University Teaching Hospital, adapting the already existing workshop.

PAHO has not been directly concerned with the prosthetics program of Mexico. It is an example of a unit working almost entirely with imported parts and functioning swiftly and efficiently. But Mexico is exceptional in having the funds and the governmental possibility of approving these imports.

PAHO tries to work as closely as possible with other international agencies in this field so that the resources available are used to best advantage. Such agencies are the UN Rehabilitation Unit which was responsible for the original work in Brazil and subsequently in the Dominican Republic and Guatemala, and the World Rehabilitation Fund which has been very active in many countries of the region.

I should also like to add to an audience such as this that we are at all times most happy to receive any suggestions as to how best to achieve this aim of keeping the amputee independent. One of our chief activities is to act as a clearinghouse for good ideas. Suggestions are most enthusiastically welcomed.

One thing, of course, we have to be careful of, and that is to avoid recommending to Governments and other authorities, the establishment of expensive machinery that may be rapidly superseded. To avoid this, it is most important for us to be aware of any potential changes in methods or materials as early as possible.

To conclude, then, I have presented some material on the activities of PAHO in prosthetics in this region, less from the point of view of trying to present a single, definitive solution to an important problem than to try and show how diverse such a program must be. Our constant preoccupation is to keep the amputee independent at a minimum cost. I am aware that ideally we should not be so cost-conscious that "health has no price," but in fact that is not the way that Government Health Authorities operate and, while they are concerned with costs, so must we be.

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LOWER-EXTREMITY PROSTHETICS

George Murdoch -- Moderator

Because it was impossible to cover the subject adequately in the time allotted, three study groups were formed as follows:

Surgery and Related Studies	--	Cameron B. Hall,	Chairman
Socket Design and Fabrication	--	James Foort Gunnar Holmgren	Co-Chairmen
Components	--	C. W. Radcliffe Bosko Zotovic	Co-Chairmen

This report is composed of the reports submitted by the study groups and is supplemented by the views of the moderator with respect to subjects not considered by the study groups but which in his opinion should be mentioned.

A. SURGERY AND RELATED STUDIES

The participants in the Study Group on Surgery and Related Studies discussed various aspects of tissue reaction in amputation surgery. The preoperative, early postoperative, and late postsurgical response of these organ systems as related to general stump health and prosthetic fitting was considered in detail. The results of research to date suggest the following:

1. The circulatory status of the skin rather than of the deeper tissues seems to determine the ultimate level of amputation. Advances in socket design and fitting techniques permit great latitude in the placement of scars provided the latter are painless and not firmly adherent to underlying skeletal structures. The relative absence of dermal trauma in the modern socket allows the utilization of greater stump length. Skin grafts, once thought incapable of withstanding socket trauma, now can tolerate stabilizing and supporting forces with the consequent preservation of length in the badly traumatized stump.

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2. The advent of rigid postsurgical dressings appears to control extracellular fluid accumulation and may enhance tissue healing. The total-contact socket developed for use at all amputation levels has markedly reduced the incidence of stump edema.

3. In the candidate for amputation, the circulatory status of the muscles per se does not determine the level of ablation. The condition of muscles in the healed stump is under investigation. Their fate appears to depend on levels of amputation and on the maintenance of near normal function. The ultimate result of myodesis or myoplasty is as yet undecided.

4. Present prosthetic techniques appear to allow transection of the fibula at nearly the same length as the tibia, producing a stump of greater symmetry and surface area.

5. The modification of condyles and malleoli in the properly selected cases may improve prosthetic cosmesis at the expense of some degree of socket suspension.

6. Attempts to enhance end-bearing qualities of lower-extremity stumps by autogenous or exogenous materials are still in an experimental stage.

7. The functional performance of the below-knee amputee is superior to that which follows amputation at any more proximal level. The preservation of the knee joint, therefore, is of utmost importance. Modern prosthetic technique allows the satisfactory fitting of nearly all levels of below-knee stumps, regardless of their length.

Future research by qualified disciplines is respectfully suggested in the following areas:

1. Stump tissue metabolism and blood flow early and late in the healing process.

2. Surgical and prosthetic aspects of the partial-foot amputee.

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3. The ultimate fate of the musculature distal to the last surviving joint.

4. The development of effective criteria, including instrumentation of a practical nature, to establish optimum amputation levels in vascular amputees.

5. Methods of enhancing weight-bearing capabilities of the stump.

6. The investigation of proprioceptive qualities of the stump.

7. Retrospective studies related to all aspects of amputation surgery and prosthetics.

8. The prevention of painful neuroma.

9. The effect of early weight-bearing and/or ambulation on stump healing.

Discussion was divided on the value of studies on the quality of the stump, e.g., its physical properties, strength, and proprioceptive capacity; on the long term, such study might pay off in determining the more desirable surgical techniques and the most appropriate socket desiderata.

B. SOCKET DESIGN AND FABRICATION

The group decided to approach the problem by developing statements encompassing the requirements of socket design, fabrication, and fitting for each level of amputation.

Syme's Level

Requirements and Desirable Characteristics

1. Relative movement between stump and socket should be reduced to a minimum.

2. Maximum use should be made of end bearing; no patellar-tendon bar is required.

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3. The socket over the condylar flares should be flexible to make entry into the socket easier while retaining suspension potential.

4. The structural form should be cosmetically acceptable.

5. The socket should be structured so as to give support in required areas, and yielding or open elsewhere.

6. The socket should be extended proximally on the medial and lateral sides to improve rotational stability. Careful fitting of the medial tibial flare is required. The anterior trim line can be low.

7. The upper end should encircle the shank completely, but can be cut lower behind than in front.

8. Wedges inserted over the condyles should be considered when suspension is a problem.

9. The end should be padded only if necessary.

10. The foot should be multicomponent in nature to permit adjustability of function, alignment, and height.

11. Casting techniques that have been found to be satisfactory are:

a. Free cast (wrapped)

b. Northwestern University suspension casting

c. Weight-bearing on cast with impression material contained in it or outside to imprint the weight-bearing surface.

Below-Knee Level

1. Socket design should utilize all weight-bearing areas possible including the distal end. The PTB is typically made too deep.

2. Reliefs in the socket should be as small as possible.

3. Sockets should not be uniformly rigid.

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4. The popliteal area should not have an inward bulge.

5. The posterior wall should be flat and the edge well flared.

6. Suspension: Every effort should be made to eliminate the posterior section of the suspension cuff. Possible alternatives:

a. Reduce leg weight.

b. Use the medial condylar flare of the femur.

c. Use the patella, i.e., suprapatellar socket extension, or suspension loop over the patella.

d. Pre-stretch the tissues into the socket when possible.

e. Consider adhesives.

f. Use suction suspension.

Needed is evaluation of the various possibilities so that criteria for their use can be established.

7. Casting techniques: It was strongly held that the casting technique is less important than how the model is interpreted for modification purposes.

In any event, the following points should be taken into account:

a. Proximal impression should be accurately shaped.

b. Medial flare area is important for weight-bearing.

c. Any equipment or technique which increases reproducibility of casts or sockets is desirable.

Above-Knee Level

1. The AK socket should be designed to take into account the following weight-bearing areas:

a. The ischial tuberosity

b. The hamstring tendons

c. The gluteus maximus

d. The lateral surface of the femur

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e. The muscle bellies and hydrostatic elements

f. The distal end

g. The inguinal crease area

h. The tendons originating at the ischiopubic ramii.

2. There was wide support for the concept of having socket forms made of a thermoplastic material in a range of sizes "on the shelf" to permit rapid fitting of primary amputees. This concept may not be applicable in certain countries because of climatic problems or to certain patients--e.g., heavy sweating--but it has clear advantages in quick construction and capacity for change in shape and, to a small degree, change of volume to accommodate to early maturation process of the strings.

Knee-Disarticulation Level

There appears to be residual concern regarding relative merits of the various transcondylar procedures and disarticulation at the knee. This would seem to be resolved by accurate prescription during patient management, i.e., no one would question retention of the undisturbed lower femoral epiphysis on the young or alternatively consider higher amputation.

More work, however, is required on the socket requirements and associated technical procedures to ensure maximum end-bearing and to make full use of the femoral condyles for suspension. This is largely an exercise in spatial geometry with respect to any fenestration or a study of available compressive and flexible materials.

All Levels

Materials

1. Resins in order of preference for strength for socket fabrication are (a) epoxies, (b) acrylics, (c) polyesters.

2. Such fibers as boron and carbon filaments should be considered for future use. High strength--low weight should be the aim.

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3. Plastic fabrication should be very carefully done to get the best out of the materials. There should be greater use of monofilaments.

4. Techniques which reduce the waiting time for patients and the work time for prosthetists are highly desirable.

C. COMPONENTS

The session was begun with a presentation and discussion of slides showing projects currently under way at the following laboratories:

1. New York University
2. Northwestern University
3. The U.S. Navy Prosthetics Research Laboratory
4. The University of California, Berkeley
5. The Veterans Administration Prosthetics Center
6. The Orthopaedic Hospital, Copenhagen, Denmark
7. Officine Ortopediche, I.N.A.I.L., Bologna, Italy
8. C. A. Blatchford and Sons, Ltd., England
9. Hosmer--DuPaCo, Campbell, California

Knee Units

There followed a discussion of various swing-control devices for the above-knee amputee, either commercially available or now nearing completion of their development. Four different pneumatic swing-control units were described:

1. The University of California (UC-BL) Pneumatic Swing Control: This unit is currently under test through the Veterans Administration.

2. The Blatchford Pneumatic Swing Control: This unit is under test in England and will soon be available commercially as part of a comprehensive system of modular components.

3. The DuPaCo Pneumatic Swing Control: A unit with many features in common with the DuPaCo hydraulic unit is under development.

4. The (Yugoslav) Pneumatic Swing Control: Production prototypes are undergoing amputee tests.

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The discussions of swing-control devices and other knee-joint design problems indicated the following:

Manufacturers of prosthetic components are capable of excellent design and development work based on principles developed within research programs, and continued efforts should be directed toward tranferring the "development" phase of new component production to the manufacturer as early as possible.

The next major breakthrough in prosthetic knee-joint design might be an attempt to duplicate the action of the normal knee during the stance phase. It was agreed that the control problems are difficult and that such a device might have application limited to the younger active amputee. Myoelectric signals from stump musculature for control appear to be out of phase with timing requirements, but studies should be continued until the question is resolved.

Foot-Ankle Units

The influence of alignment on foot function was discussed with particular reference to the SACH foot (*S*olid-*A*nkle, *C*ushion-*H*eel). Prof. Radcliffe recommended that a special SACH(AK) foot, designed specifically for the AK amputee, would allow the application of principles of alignment, well known in Germany for years, which are difficult with the present SACH foot. The present SACH foot is considered excellent for below-knee prostheses and should be continued in production as a SACH(BK) foot.

The Mauch hydraulic ankle is an attempt to improve foot-ankle function with particular emphasis on improving knee stability on sloping ground. This work should be encouraged.

The UC-BL shank rotation unit was demonstrated and its potential benefits explained. The benefits of shank rotation devices have been proved through research and evaluation, but their use has been limited by the availability of durable units. The design and production of rotation units with a torsional spring constant in the 2 to 6 in.-lb. per deg. range should be encouraged.

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Modular Construction

Mr. Schmidl presented a series of slides on the use of modular construction with hip-disarticulation prostheses. The open socket with lateral side cut away was of considerable interest from both a functional and a cosmetic standpoint.

Components adapted for so-called modular construction were shown by several of the participants. There was a general discussion of the advisability of standardization, particularly in the sizing of the connectors between functional elements. The standard USA pylon tubing is 1½ in. in diameter, the Blatchford Co. in England uses 1¼ in., while the Otto Bock Co. in Germany uses a 30-mm diameter. It should be possible to agree upon a world standard, perhaps adopting the 1¼ in. as a compromise, with a sleeve adapter for the slightly smaller 30-mm (1.15 in.) metric size. Such standardization depends upon the availability of 1¼-in. tubing in the USA. The present 1½-in. size was, in part, dictated by the availability of this size through normal suppliers.

Another problem in modular prostheses is the clamp-connector system used for assembly of the functional components. Most of the semipermanent modular systems under development make use of a female receptacle for the tubing with or without an internal expanding clamp. Connectors of this type result in smooth external contours and facilitate the application of cosmetic coverings. On the other hand, immediate postoperative prostheses often use external clamping of the tubing over a rigid cylindrical plug. The design of an internal expanding clamp satisfactory for both temporary and semipermanent assembly should be encouraged.

* * * * * * *

Gait analysis and other techniques should clearly continue to establish, so far as is possible, the nature and quality of events that occur in normal locomotion under different circumstances in varying environments. This can be justified solely on the need to

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increase the knowledge on which so much of the work in this field is ultimately based.

Similar studies of pathological gait should be encouraged.

In one particular way these fundamental studies have clinical relevance. It seems a reasonable objective to develop a clinical tool or evaluation system employing developed measuring devices linked to data-acquisition and process systems to provide an output in graph or other form which will be readily understood by the clinician in a clinic situation.

Several areas of further study emerge if this objective is accepted, especially with respect to instrumented pylons, radio telemetry of signal, and data acquisition, handling, storage, and presentation.

It is strongly recommended that investigators in this field ensure that they have high quality prosthetic help available. This underlines the needs with regard to prosthetic education programs. Without these programs, valid research will be inhibited.

It is finally suggested that literature exchange and retrieval are of paramount importance and especially so to the small laboratories where university libraries, etc., are not readily available. Any effort to improve this situation should be encouraged.

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UPPER-EXTREMITY PROSTHETICS

Gordon Robin -- Moderator

PATIENT ACCEPTANCE

The session opened with a discussion on the problem of patient acceptance of the upper-limb prosthesis. It was pointed out that there were few activities in daily living which demanded bilateral function and that, therefore, cosmesis and comfort were no less important factors in acceptance than functional demand. Social, psychological, and cultural factors often played a part. It was suggested that there was a necessity for a definition of "needs" in relation to these factors. Recent experience in Denmark, the United Kingdom, and the United States had brought forward the feeling that early fitting after amputation had increased acceptance amongst adult amputees. Experience in Germany suggested that fitting of dysmelic children must be delayed until the child had developed a sensory intake pattern using residual limbs, and had developed a stable posture.

LIMB MOVEMENTS

Although information on normal limb movements has been available for many years, a need was still felt, especially by those involved in design, for a definition of the movements required from the upper-limb prosthesis. It was accepted that movement of the proximal prosthesis is only required for positioning of the terminal device. Recent work on the kinetics of joint movement using accelerometers had suggested that normally proprioceptive control of the proximal joints was developed to a greater degree than those of the distal joints, and it was felt that this should be taken into account in prosthetic design.

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SOCKETS

Experience with the use of thermoplastics for socket fitting was reported from several centers. In most places the material used was "Polysar," a synthetic balata. The advantages and disadvantages of the material were discussed. It was suggested that accurate fitting of the socket was of less importance in the upper limb, and a suggestion was made that prefabricated, standard-sized sockets, requiring only minor final fitting, could be introduced.

TERMINAL DEVICES

Although in the U.K. and the U.S.A. the tendency still exists to prefer the hook to the "cosmetic-functional" hand, in other parts of Western Europe use of the cosmetically acceptable prosthetic hand was increasing. It was felt generally that at some level a decision for either improved function or better cosmesis has to be made. It was pointed out that for designers to attempt to reduplicate the human hand would entail detailed specification and a lengthy engineering program. No agreement was reached as to whether at this stage present hardware should be accepted while lengthy research programs were instituted toward producing an improved terminal device, or whether empirical progress should be continued as in the past. Suggestions for compromise, such as a cosmetic cover over an endoskeletal prosthesis, were made.

EXTERNAL POWER

There was a division of opinion as to the need for external power in the below-elbow prosthesis. Many agreed that for the above-elbow amputee a powered elbow was an advantage, although it was still felt by some that the simplicity of the mechanically powered prosthesis was an advantage. It was accepted that systems for locking joints were essential, although free-swing movement was also considered by some to be of value in certain circumstances. A suggestion was made for improving mechanical control of the prosthesis by a system that could relax or tighten the harness according to need.

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No firm opinion as to the value of electrically powered elbows over pneumatic elbows was obtained. The combination of different power systems in one prosthesis was also suggested as being advantageous.

CONTROL

A survey of presently used control sites and types was made. The problems of complexity, time lag, input/output interface, and stability were raised. The advantages of muscle-bulge control which allowed some proportional actuation of the terminal device over other electric or bioelectric systems were described, although it was suggested that these advantages were counteracted by the loss of control of other functions of the prosthesis. Voice-control systems were described as were myoelectric systems.

CONCLUSIONS

1. Further studies of needs both at the psychosocial and functional levels are required.
2. Early postsurgical fitting should be encouraged since it may lead to better patient function and acceptance.
3. Experience should be obtained with the use of prefabricated, stock-sized, thermoplastic sockets requiring only final fitting.
4. Research into improvements in terminal devices should be continued.
5. Experience with presently available powered elbow units should be obtained to determine which, if any, are of value.
6. Problems of power systems and control should be further investigated.

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LOWER-EXTREMITY ORTHOTICS

Robert Klein -- Moderator

FUNDAMENTAL STUDIES

There is a large number of appliances for foot drop and its associated disabilities, although allowing the foot to move in supination and pronation, which is desirable, causes early breakdown of materials.

It was considered desirable that the splint axis should correspond as nearly as possible to the anatomical axis.

Although the painless flail knee could not really be looked at in isolation, its control is not difficult. However, the rotary function of the limb during ambulation cannot be ignored, and the Fontainbleu joint, which allows the junction, might be further studied.

Where orthoses are required for weight and/or pain relief, several serious problems occur. Because surgeons do not think of the problem in mechanical terms, there is considerable difficulty in their supplying adequate prescriptions, and while the surgeon, engineer, and orthotist might see the majority of patients as a group, this is time-consuming and expensive.

No solutions could be offered for bracing the slipped femoral epiphysis. An acceptable "knee cage" is needed for the elderly patient with a deformed and painful arthritic knee.

It was considered that the 3-plane charts and a functional classification of hardware, developed recently by the American Academy of Orthopaedic Surgeons, would go a long way in helping to solve the problem of prescription.

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NEW BRACES AND DEVICES

The Army Medical Biomechanical Research Laboratory (AMBRL) fiberglass reinforced plastic rods and strips used in the manufacture of foot-drop appliances were demonstrated by James Hill.

A Canadian design for a Legg-Perthes brace which allowed the patient to ambulate and sit down was described by Colin McLaurin.

FRACTURE BRACING

Dr. Sarmiento reported on his work in which below-knee fractures can be treated by applying an unpadded full-leg cast for two weeks, followed by a PTB cast on which the patient ambulates. After a further two weeks, the PTB cast can usually be replaced by a PTB brace.

The possibility exists that femoral fractures might be treated in a similar manner.

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UPPER-EXTREMITY ORTHOTICS

Colin A. McLaurin - Moderator

It should be recognized that throughout the world polio is still a major contributor to upper-extremity dysfunction, and research into orthotic systems applicable to these cases should be given a high priority.

Patient acceptance is a very important consideration in hand orthoses. Neat custom design using lightweight materials with varying degrees of flexibility and elasticity, such as polypropylene, is indicated. Low-temperature thermoplastics have advantages for use by occupational therapists.

Fundamental studies in time and motion could yield significant information leading to the design of simplified arm orthoses by eliminating certain mechanical joint motions.

The application of external power in orthotic devices should be directed toward individual patient needs as determined in both institutional and home situations. The orthotic system should take advantage of any sensory system existent in the human limb.

It was generally agreed that mobilizing an existing arm is preferred to a manipulator, largely because it encourages any possible increase in residual limb function.

Technical aids should be considered as an important adjunct or alternative to any orthotic service, and awareness of the extensive array of existing devices is essential.

Some of the apparent advantages in lower-extremity fracture bracing may be realized in upper-extremity fractures.

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SPINAL ORTHOTICS

The need for spinal orthoses or corsets to achieve stability in cases of fracture and pain is not met adequately in either function or patient acceptability. Improvements in function can be anticipated only after further intensive studies in related mechanics.

Research into and design of orthoses for arresting scoliosis should include an investigation into the use of dynamic structures using pneumatic principles, flexible materials, and joint systems.

Supportive orthoses for patients with extensive muscle weakness as found in muscular dystrophy and polio may well include means for intermittent adjustment to relieve prolonged tissue pressure and minimize interference with (or assist) breathing.

The effect of corrective footwear on spinal alignment and the effect of spinal orthoses on lower-limb function should be investigated.

ORTHOTICS--GENERAL

Electrical stimulation of paralyzed muscles offers exciting new possibilities in orthotics, but extensive clinical application should be predicated on more factual information on the physiological effects.

Awareness of new developments in control technology, such as adaptive computors, is important for future application of sophisticated and complex systems.

Training in well-defined fitting procedures, commensurate with prosthetics practice should be encouraged.

Since considerable useful information may be forthcoming from such studies, the continued comprehensive study and evaluation of orthotic designs (spinal, upper and lower) in current widespread use should be encouraged.

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EVALUATION

Knud Jansen
Herbert Elftman - Moderators

At the request of the moderators Dr. Fishman outlined some of his thoughts concerning the conduct of evaluation programs in prosthetics and orthotics. He pointed out that there are four main factors to be taken into consideration: amputee acceptance, function or performance, fitting and fabrication problems, and durability and maintenance. Unfortunately, subjectivity enters into the evaluation of all of the factors, and it is the task of the evaluation group to reduce subjectivity as much as possible.

He then set forth certain rules he considers important to effective evaluation:

1. Evaluation in the latter stages of development of a device or technique should be carried out by a group independent of the developing group.

2. As many variables as possible should be controlled.

3. A well-motivated, interdisciplinary group is required for evaluation.

4. The basic factors affecting amputee acceptance are function, comfort, and cosmesis.

Dr. Fishman concluded by stating that in most instances sophisticated equipment is not necessary in evaluation and that he felt a good deal of evaluation could be carried out effectively in those countries just beginning research programs.

Dr. Jansen followed up by saying that he felt that an international cooperative evaluation program would be most helpful to all the research groups if it can be effected. He noted that the way in which immediate postsurgical fitting procedures were evaluated and

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introduced is an example of what can be done. He hoped that the International Committee, with the help of CPRD and others, will be able to initiate a more formal program in the near future. He pointed out that such a program would certainly strengthen the education programs.

Considerable discussion was centered around the development of standards and specifications, and it was agreed that every effort should be made to develop standards and specifications on an international basis. Dr. McKenzie brought to the attention of the group a pamphlet entitled "The Use of SI Units"* that describes in detail the Système International d'Unités (SI) for the use of metric units.

The session was concluded by re-emphasizing the desirability of initiating more evaluation programs on an international scale.

* *The Use of SI Units*, PD 5686, January 1969, British Standards Institution, 2 Park Street, London W.1, England.

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CONCLUDING SESSION

Knud Jansen
Herbert Elftman - Moderators

The moderators called upon Dr. Cameron Hall to present the recommendations drafted by the Editorial Committee. The following section represents the report of the Editorial Committee as modified by the Conferees during the concluding session.

Report of the Editorial Committee

Mr. Chairman:

Responding to the request that the Editorial Committee formulate specific recommendations regarding future projects for investigation and research by qualified disciplines, the following points are respectfully suggested:

I. LOWER-EXTREMITY PROSTHETICS

A. Surgery and Related Studies

1. That stump tissue metabolism and blood flow early and late in the healing process be studied.

2. That surgical and prosthetic aspects be studied for patients with partial loss of the foot.

3. That the ultimate fate of the musculature distal to the last surviving joint be determined.

4. That effective criteria, including practical instrumentation, be developed in order to establish optimum amputation levels in patients with vascular problems.

5. That methods of enhancing weight-bearing properties of the stump be studied.

6. That proprioceptive qualities of the stump be investigated.

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7. That retrospective studies relating to all aspects of amputation surgery and prosthetics, particularly as related to German case loads already partially documented, be initiated.

8. That a study of painful neuroma be carried out.

9. That the effect of early weight-bearing and ambulation on stump healing be determined.

B. Socket Design and Fabrication

1. That the design and use of prefabricated sockets be undertaken. The sockets could be used permanently or as preforms that could be adjusted to the patient's requirements.

2. That sockets be designed which are selectively rigid, flexible, and elastic to better suit the physical characteristics of stumps.

3. That the design of equipment and techniques for objective determination of stump topography, tissue characteristics, and the location of the underlying bone-tendon structure be undertaken to determine the feasibility of mechanized fitting and fabrication procedures.

4. That sockets that respond dynamically to pressures and movements between the stump and socket be designed.

5. That adjustable sockets be designed and evaluated.

6. That socket surface characteristics be studied in reference to adherence of the socket to the stump (corrugations, fenestrations, etc.).

7. That modular sockets be designed.

8. That frame-like sockets be designed.

9. That studies concerning the response of tissues to pressure and movement be initiated.

10. That the phenomenon of sweating be studied in reference to amputations and prostheses.

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11. That sockets using inflated sections be studied. Inflated sockets offer a chance for easy adjustability.

12. That efforts to develop reproducible casting techniques be continued.

C. Lower-Extremity Components

1. That development of modular systems for all levels be continued, and that attempts be made to standardize modular components throughout the world based on the metric system.

2. That the usefulness of the modular system in developing countries with large case loads be evaluated. The problem of cosmesis should be solved with locally available materials.

3. That continued efforts should be directed toward transferring the development phase of new component production to the manufacturer as early as possible.

4. That prosthetic knee joints to duplicate the normal knee during the stance phase be developed.

5. That the problems of foot design be re-examined.

6. That improved knee joints be developed for long above-knee and through-the-knee amputees.

D. Education and Source Material

1. That prosthetics education programs be continued on every level in order to maintain the flow of high-quality professional personnel for treatment and research.

2. That literature exchange and retrieval are of paramount importance, especially in the small laboratories without ready access to university libraries. Any effort to improve this condition should be encouraged.

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II. UPPER-EXTREMITY PROSTHETICS

A. That further studies of needs both at the psychosocial and functional levels be carried out.

B. That early postsurgical fitting be encouraged since it may lead to better patient acceptance.

C. That experience be obtained with the use of prefabricated stock-sized thermoplastic sockets requiring only final fitting adjustments.

D. That research into improvements in terminal devices be continued.

E. That evaluation of presently available powered components be encouraged.

F. That problems of power systems and control be further investigated.

G. Because it is felt that adequate efforts are being directed to the development of sophisticated technical systems to provide significant functional regain for the upper-extremity amputee, all new efforts should be reviewed carefully for their potential value before money is invested in them. Furthermore, evaluation of presently available systems should be carried out as soon as possible.

H. That the usefulness of exoskeletal structures be explored fully.

III. LOWER-EXTREMITY ORTHOTICS

That future orthotics research and development should be directed toward systematic control of motions and forces related to disabilities involving the lower extremity; controls should be those minimally required to yield performance or capability needed for essential functions in normal living. Specifically required are activities in the following areas:

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A. Measurement of the kinematics and kinetics of normal motion.

B. Studies of the patterns of dysfunction classified by disease or disability entity.

C. Research on tissue tolerance to pressure.

D. Examination of the possibilities of voluntary control of passive elements in functional systems.

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Certain development projects which might produce earlier results include:

A. Development of a suitable nomenclature for describing (1) dysfunction, and (2) the hardware employed for providing control and function.

B. An improved device for control of instability of the knee.

C. Improved systems to eliminate the need for locked knees during ambulation.

D. Controlled applications of plastics and plastic composites in brace components.

E. Applications of modular principles to brace construction.

F. Braces designed with thought for cosmesis.

G. Improvement of seat configurations for the handicapped.

H. Intensive evaluation of crutches, canes, and other walking aids.

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Educational programs should be expanded to make application of what is known more systematic.

The system of nomenclature and definition of disability for the lower extremity now being evaluated by the American Academy of Orthopaedic Surgeons should be considered as a basis for an international system.

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IV. UPPER-EXTREMITY ORTHOTICS

A. It should be recognized that throughout the world polio is still a major contributor to upper-extremity dysfunction, and research into orthotic systems applicable to these cases should be given a high priority.

B. Patient acceptance is a very important consideration in hand orthoses. Neat custom design using lightweight materials with varying degrees of flexibility and elasticity, such as polypropylene, is indicated. Low-temperature thermoplastics have advantages for use by O.T.'s.

C. Fundamental studies in time and motion could yield significant information leading to the design of simplified arm orthoses by eliminating certain mechanical joint motions.

D. The application of external power in orthotic devices should be directed toward individual patient needs as determined in both institutional and home situations. The orthotic system should take advantage of any sensory system existent in the human limb.

E. It was generally agreed that mobilizing an existing arm is preferred to a manipulator, largely because it encourages any possible increase in residual limb function.

F. Technical aids should be considered as an important adjunct or alternative to any orthotic service, and awareness of the extensive array of existing devices is essential.

G. Some of the apparent advantages in lower-extremity fracture bracing may be realized in upper-extremity fractures.

V. SPINAL ORTHOTICS

A. The need for spinal orthoses or corsets to achieve stability in cases of fracture and pain is not met adequately in either function or patient acceptability. Improvements in function can be anticipated only after further intensive studies in related mechanics.

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B. Research into and design of orthoses for arresting scoliosis should include an investigation into the use of dynamic structures using pneumatic principles, flexible materials, and joint systems.

C. Supportive orthoses for patients with extensive muscle weakness as found in muscular dystrophy and polio may well include means for intermittent adjustment to relieve prolonged tissue pressure and minimize interference with (or assist) breathing.

D. The effect of corrective footwear on spinal alignment and the effect of spinal orthoses on lower-limb function should be investigated.

VI. ORTHOTICS--GENERAL

A. Electrical stimulation of paralyzed muscles offers exciting new possibilities in orthotics, but extensive clinical application should be predicated on more factual information on the physiological effects.

B. Awareness of new developments in control technology, such as adaptive computors, is important for future application of sophisticated and complex systems.

C. Training in well-defined fitting procedures, commensurate with prosthetics practice should be encouraged.

D. Since considerable useful information may be forthcoming from such studies, the continued comprehensive study and evaluation of orthotic designs (spinal, upper and lower) in current widespread use should be encouraged.

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Valuable data might be retrieved from an analysis of conference participant answers to the queries posed on the General Information

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Sheets (Appendices C and D), particularly in the areas of:

1. Research now in progress.
2. Future plans.
3. Research needed but not being carried out.

Respectfully submitted,

The Editorial Committee

Cameron B. Hall, *Chairman*
James Foort
Colin A. McLaurin
Anthony Staros

September 1969

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APPENDIX A

LIST OF PARTICIPANTS

INTERNATIONAL CONFERENCE ON RESEARCH IN LIMB PROSTHETICS AND ORTHOTICS

conducted by
COMMITTEE ON PROSTHETICS RESEARCH AND DEVELOPMENT
NATIONAL ACADEMY OF SCIENCES, U.S.A.
and
INTERNATIONAL COMMITTEE ON PROSTHETICS AND ORTHOTICS
INTERNATIONAL SOCIETY FOR REHABILITATION OF THE DISABLED

Cacapon State Park, Berkeley Springs, West Virginia April 28--May 2, 1969

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INTERNATIONAL CONFERENCE ON RESEARCH IN LIMB PROSTHETICS AND ORTHOTICS

CACAPON STATE PARK
Berkeley Springs, West Virginia **April 28-May 2, 1969**

Co-Chairmen: Knud Jansen and Herbert Elftman

MONDAY, APRIL 28, 1969

WELCOME
Herbert Elftman, Knud Jansen

ORIENTATION
James F. Garrett

THE U.S. VETERANS ADMINISTRATION RESEARCH PROGRAM
Robert E. Stewart

ROLE OF THE UNITED NATIONS IN PROSTHETICS AND ORTHOTICS
Esko Kosunen

ROLE OF THE PAN AMERICAN HEALTH ORGANIZATION IN PROSTHETICS AND ORTHOTICS
Robin Hindley-Smith

I. Lower-Extremity Prosthetics
Moderator: George Murdoch

A. Fundamental Studies
B. Surgical Studies
C. Component Development
D. Technique Development
E. Evaluation

TUESDAY, APRIL 29, 1969

II. Upper-Extremity Prosthetics
Moderator: Gordon Robin

A. Fundamental Studies
B. Body-Powered Prostheses
C. Externally Powered Prostheses
   1. Terminal Devices
   2. Elbows
   3. Other Components
   4. Complete Systems
   5. Power Packages
D. Control System Studies
E. Cosmesis, Sensation

WEDNESDAY, APRIL 30, 1969

III. Lower-Extremity Orthotics
Moderator: Robert W. Klein

A. Fundamental Studies
B. New Braces and Devices
C. Fracture Bracing

THURSDAY, MAY 1, 1969

IV. Upper-Extremity Orthotics
Moderator: Colin A. McLaurin

A. Fundamental Studies
B. Externally Powered Braces
C. Control Systems
D. Devices and Technical Aids
E. Fracture Bracing

V. Spinal Orthotics

VI. Orthotics—General

A. Fundamental Studies
B. Electrical Stimulation
C. Materials

FRIDAY, MAY 2, 1969

VII. Evaluation
Moderators: Knud Jansen, Herbert Elftman

VIII. Concluding Session
Moderators: Knud Jansen, Herbert Elftman

Committee on Prosthetics Research and Development
National Academy of Sciences, USA
and
International Committee on Prosthetics and Orthotics
International Society for Rehabilitation of the Disabled

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INTERNATIONAL CONFERENCE ON RESEARCH
IN LIMB PROSTHETICS AND ORTHOTICS

Cacapon State Park, Berkeley Springs, West Virginia, U.S.A.

April 28--May 2, 1969

AUSTRALIA

Robert W. Klein

General Status

One small unit within the Repatriation Department comprising Medical Director, 1 engineer, 2 prosthetic/orthotic technicians, 1 draftsman, 1 therapist. Mainly concerned with clinical evaluation and development, for patient application, of the results of research elsewhere. Disseminates information and directs education of prosthetic-orthotic personnel.

Future Plans

Continue with development aimed at wide patient application. Continue study of devices for lower-extremity amelics, above-knee casting jig, and splint jig. Major expansion of prosthetic education programme is planned.

Research in Your Opinion Needed but Not Being Carried Out

1. Biomechanics of spinal (including pelvic) bracing. Work with muscular dystrophic patients might give insight into the biomechanics involved.

2. Investigation of "adaptation" to sensory stimuli (e.g., vibrations). Might not adaptation allow subconscious recognition and therefore useful response after a reasonable length of time?

3. Bracing of the arthritic (painful and unstable) hip joint and knee joint.

4. Stump swelling and shrinkage (physiology).

5. Desirable (physiologically) pressure variations in adhesive prostheses.

6. Suspension of lower-extremity prostheses.

7. Proprioception in lower-extremity prostheses, which being less essential may provide basic information which might be "refined" in relation to the upper extremity.

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CANADA, DOMINION OF

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 and Orthotic Devices for Children
Rehabilitation Institute of Montreal-- Maurice Mongeau	Development of Externally Powered Upper-Extremity Prosthetic Devices, with Special Reference to Children
Prosthetics/Orthotics Research and Development Unit, Manitoba Rehabilitation Hospital-- James Foort	Development of a Variety of Prosthetic Devices with Special Reference to Lower-Extremity Requirements
The University of New Brunswick Bio-Engineering Institute-- R. N. Scott	Orthotics and Prosthetics Systems Research with Special Emphasis on the Employment of Electromyographic Signals as Controls

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DENMARK

K. Jansen and E. Lyquist

General Status

Prosthetics and Orthotics research in Denmark is performed mainly in the Orthopaedic Hospital, Copenhagen, although some clinical investigations take place in other orthopaedic centers. An organized unit for prosthetic/orthotic research under the direction of Mr. Lyquist was established three years ago. Close cooperation with the University Institute of Technology has provided new useful devices for clinical and technical research. The research program includes various items, mainly for lower limb problems. Coordination with the Swedish Research Programme has been initiated.

Future Plans

An expansion of the Danish and Scandinavian research programs is planned. This development is promoted by the establishment of a national medico-technical committee. A Scandinavian prosthetic/orthotic society is expected to ensure intensified, coordinated research. A perfected tread mill has been designed and constructed by an engineering group. This machine should facilitate observations of normal and prosthetic gait and offer guidance to improved prosthetic/orthotic designs.

Research in Your Opinion Needed but Not Being Carried Out

The particular possibilities for long-time follow-up studies of patients fitted and trained with appliances have not been exploited sufficiently. There is, however, evidence that several young researchers are ready to join in this program.

ENGLAND

General Status

The Biomechanical Research and Development Unit, Roehampton, is a permanent research and development organization financed by the Department of Health and Social Security with ultimate staff of about 60, directed solely to work on prosthetics. Budget includes projects placed extramurally. Some research is carried out independently, mainly in universities and by Medical Research Council units, and mainly on aspects of externally powered devices in addition to manufacturers' own programs. Research in orthotics is less well organized and less well endowed, and such effort as exists tends to be at a relatively unsophisticated level.

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Future Plans

1. Development of measurement techniques in BRADU with the primary objects of: a. Confirming or, if necessary, challenging a number of the findings of the University of California Fundamental Studies of Locomotion with particular reference to modern British fitting practice. b. Studying lower limb dynamics with special reference to the performance of the knee joint with the object of designing optimal or an optimal range of knee mechanisms and control (not excluding externally powered devices) and with voluntary modulated control a desired objective. It is anticipated that it may be necessary to extend this study, for example, to ankle joint performance and interactions. c. The establishment of a data processing facility for colleagues working in the same area in smaller laboratories.

2. BRADU will continue to encourage work on externally powered devices in the many laboratories already engaged in this work, to finance selected projects, and to endeavor to help to coordinate effort.

3. Ad hoc encouragement and financial aid to limb making contractor's developments.

4. BRADU hopes to extend work to at least some of the items in the following section in due course.

Research in Your Opinion Needed but Not Being Carried Out

1. There is a need in Britain to set up a major center or centers for fundamental and applied research in orthotics with some form of central administration or at least coordination.

2. There is a need for a sophisticated fundamental study of the man/machine interface with particular reference to control philosophy for upper-extremity devices associated with detailed anatomical and physiological study of all potential control sites in all possible modes (input and output) at various typical levels of disability.

3. Development of a power pack of at least an order better in terms of power/weight ratio and such that the associated actuators attract at least no penalty in terms of response and power/weight ratio.

4. "Building brick" modules for externally powered devices, pneumatic, electric, and hydraulics.

5. A detailed study of the optimal environment of the immediate postoperative stump at the various levels from the point of view of wound healing.

6. Reliable methods of determining the level of viability of stumps when amputation is required in peripneral vascular disease.

7. To develop progressively a definitive environmental specification for prosthetic and orthotic devices.

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GERMANY, WEST — Goetz-Gerd Kuhn

General Status

Research work in the overall field of prosthetics and orthotics is conducted in about ten centers. The research is financed by the Federal Ministry of Health and Ministry of Labour and in part by the regional governments and private donors. There is a severe shortage of funds, research workers are poorly paid, and, therefore, there exists a personnel problem.

Future Plans

Concentration of research funds, better coordination of the research projects, and improved interchange of research results.

Research in Your Opinion Needed but Not Being Carried Out

There is a very small beginning of basic research in West Germany and a big need for the background for the research programs in the future. More research on the patients is needed and less in complicated techniques.

GERMANY, WEST — Ernst Marquardt

General Status

Prostheses (external power and with cable control) for amelia and phocomelia of the upper extremities of thalidomide children. Bioelectric prostheses for forearm and above-elbow amputees.

Prostheses and walking apparatuses for lower-extremity deformities. Immediate fitting of upper- and lower-extremity amputations. Electric driven wheelchair for quadrilateral phocomelia. Technical aids for the independence of severe and multi-handicapped persons. Corrective splints and adaption of the cane for club-hands.

Future Plans

Change from the pneumatic to the bio-electric system for the prostheses of severe malformation and amputation of the upper extremities. Proportional control from myoelectric signals (Dr. Roesler), studies of dynamics of upper extremities (Dr. Roesler).

Research in Your Opinion Needed but Not Being Carried Out

Neuro-muscular studies (Arbeitskreis für Biophysikalische Prothetik). More differentiated studies in upper-extremities dynamics.

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INDIA

M. Natarajan

General Status

Objectives of the research program are:

1. To locate and develop locally available raw materials and components for the fabrication of prostheses and orthoses and to eliminate the import of these from abroad.

2. To standardize these components.

3. To mass-produce the standardized components from local material. These objectives are being achieved except for upper-extremity prostheses for which work is in progress.

Future Plans

1. To organize research work in the field of prosthetics and orthotics on an interdisciplinary basis with the cooperation of engineering faculties.

2. To develop new knowledge and techniques equipped with knowledge thus gained.

3. To develop knowledge and techniques to meet the problems of prosthetic and orthotic fitting, peculiar to the country's social and economic environment.

Research in Your Opinion Needed but Not Being Carried Out

Modernization has not altered many cultural and social customs and traditions peculiar to this country. As an example, it is impossible to make all Indians wear shoes. Hence, certain functional modifications have to be made for prostheses, orthoses, and other aids for physically handicapped persons for use in situations warranted by cultural and social customs and traditions. Some of these functions are: 1. Use of prostheses without shoes in temples, houses, and fields. 2. Squatting or sitting on the floor at home and use of Indian-type water closet, etc. 3. Performance of religious ceremonies, rites, and other functions. 4. Modifications required due to dress and food habits, etc., of the people.

ISRAEL

Gordon C. Robin

General Status

Research is being carried on in two major centers in Israel; the Orthopaedic Research Laboratory of Hadassah University Hospital, and the Technion Israel Institute of Technology in Haifa. Multidisciplinary teams have been developed and research at both of these institutions is progressing.

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Future Plans

In both of the centers plans are now being drawn up for continuation of the work after completion of the present research projects, and these should be ready in the near future. In both these instances, the basis of future programming, continuation and further development of the research projects are at present being carried out; i.e., in Jerusalem, the use of plastic materials in orthotics and mechanical investigation of orthotic appliances and, in Haifa, further development of the powered prostheses developed there.

Research in Your Opinion Needed but Not Being Carried Out

1. Fatigue testing of orthotic and prosthetic appliances under conditions similar to those in normal use, in order to evaluate areas of potential weakness in construction and determine techniques for improvement.

2. Further investigation of interaction between orthotic appliances and patients' musculature in order to determine whether standard design braces in any way limit function which might be of value to patients.

ITALY — Hannes Schmidl

General Status

Since 1964, the National Institute for Insurance against Industrial Accidents (INAIL) has achieved, as its primary research project, the myoelectrically controlled prosthesis. INAIL is a member of the research group of the European Coal and Steel Community, under the auspices of which the researches are carried out.

Future Plans

Further miniaturization and refinement of devices and controls already developed.

Research in Your Opinion Needed but Not Being Carried Out

1. The utilization of muscular potential for control of the deambulatory stage in above-knee amputees.

2. The application, where possible, of muscular stimulators in cases of paralysis.

3. The utilization of myoelectrical controls in the field of orthotics.

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MOROCCO — Jean Bourand

General Status

No work is being carried out at the present time.

Future Plans

To develop a research program in prosthetics and orthotics.

Research in Your Opinion Needed but Not Being Carried Out

1. Prevention of leg shortening in polio cases by early and proper bracing.

2. Correction of inequality of legs in youth after polio.

3. Approach to the amputee problems:
   a. The one fitted with poor prosthesis.
   b. The upper-extremity prosthesis with low educational level.

4. Resettlement.

PAKISTAN — S. R. Kermani

General Status

Rehabilitation of patients with orthopaedic handicaps. The emphasis has been on the use of local material. There are mainly four Demonstration Projects; one in Karachi, three in Lahore.

Future Plans

Comparison of the effectiveness of porous and nonporous PTB prostheses in Pakistan (Jinnah Postgraduate Medical Centre, Karachi).

Research in Your Opinion Needed but Not Being Carried Out

First step "Service Testing," then "Shakedown Testing."

POLAND — Janina Tomaszewska

General Status

General data. Research projects dealing with the problems of prosthetics and orthotics in Poland are presently conducted in two special Centers of university type:

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1. Rehabilitation Centre in Konstancin near Warsaw known in world mainly because of its works on immediate postsurgical fittings. Prof.dr. M. Weiss is the director of this center.

2. Orthopaedic Clinic and Medical Rehabilitation Clinic of Medical Academy in Poznan, forming together one center named State Clinic Hospital Nr 4. This is to be transformed in the near future into the Institute of Orthopedia and Rehabilitation. Prof.dr. A. Senger is the Director of the Orthopaedic Clinic, doc.dr. J. Tomaszewska is the Director of Medical Rehabilitation Clinic, and W. Miedzyblocki is the chief engineer of the Orthopaedic Workshop.

The unofficial division of research projects assumes that the Rehabilitation Centre in Konstancin works on the problems concerned with lower extremities; the Clinic in Poznan--on the problems concerned with upper extremities.

There is also a number of other special centers in Poland dealing with the problems of prosthetics and orthotics. Theoretically, the Board of Orthopaedic Industry is a coordinating unit, having the Research Laboratory as its branch. The coordination of research on prosthetics-orthotics subjects comprises only applied prosthetic-orthotic problems.

It includes accordingly the study of designs, materials, and production engineering problems. The titles of the subjects are approved by the Scientific Council of the above mentioned Board of Orthopaedic Industry.

The Research Laboratory acts without close cooperation with any specialized orthopaedic rehabilitation center. In future, the research work will be conducted by the two Centres mentioned at the beginning, with their Orthopaedic Workshops and suitable research outfit.

The Orthopaedic Workshop in Poznan will deal with problems of fitting artificial limbs in cases of upper-extremity amputations, specially in difficult ones, including the use of external power sources. They will introduce this source of power in functional upper-extremity braces as well. The plans of research on lower-extremity prostheses include the construction of hydraulic prosthesis, the problems of measurements of pressures distribution inside the stumpsocket. Thorough investigations concerning the problems of walking are also expected. Also planned is the investigation work on the activities of particular muscle groups during their work, as well as evaluation of the results obtained on patients with dysfunctions or amputations of the upper extremity, supplied with prosthetic or orthotic appliance.

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The research in limb prosthetics and orthotics up to now has been conducted by both the above-mentioned Clinics. The fundamental research work which is being done deals chiefly with the application of modern techniques.

Doc.dr. Janina Tomaszewska is engaged in research work of the subject and she has already printed a number of works such as: "Pathokinetics of Muscles after the Thigh Amputation," "Analysis of Skiing Course for Amputees," "Postamputational Rehabilitation."

Technical problems connected with prosthetics and orthotics, being a part of Orthopaedic and Rehabilitation Clinics' work, are solved by Orthopaedic Workshop.

The chief engineer of the Workshop, at the same time the manager, is responsible for solving these problems. The research work in existing conditions is based mostly on cases which arise during the medical treatment of clinical cases.

The actual tasks awaiting to be solved are:

1. To elaborate the parts for functional upper-extremity prosthesis for use in Polish conditions.

2. To apply porous resins in fitting upper- and lower-extremity prostheses.

3. Medico-technical cooperation while working on the problems of immediate postsurgical fittings.

The methods worked out by leading foreign centers, learned during the international courses, from literature, or from reports of research centers, are applied in research work of this Workshop.

This part of the research which concerns the design is reduced to adapting foreign designs to local conditions.

Within the framework of activities of the Institute of Orthopaedia and Rehabilitation, which is to be founded in the near future in Poznan, the following chief subject is expected to be dealt with: Restitution of Activity in Dysfunctions of the Upper Extremity.

Future Plans

Research dealing with restitution of activities in amputations and dysfunctions of the upper extremities. It comprises medical and technical research work together with evaluation.

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Research in Your Opinion Needed but Not Being Carried Out

In our country there is a need for research in application of external power to upper-extremity prosthetics and orthotics as well as in energy consumption by patients fitted with various prosthetic or orthotic appliances.

SCOTLAND — George Murdoch

General Status

1. Systematic biomechanical analysis of lower-extremity joints is nearing completion, at Strathclyde University and the Dundee Limb Fitting Centre.

2. A general philosophy of upper-extremity function has been evolved and is gradually being applied in prosthetics and soon will be in orthotics.

3. Research on basic medical parameters has been initiated.

4. Beginnings of research into fundamentals of prosthetic and orthotic devices now evident, e.g., modular prosthetic system (Strathclyde), upper-extremity prosthetics (Edinburgh).

Future Plans

With regard to nature and extent of future plans, research is dependent on 1) Institution of formal education programs for prosthetists and orthotists and for others working in these fields, notably doctors; 2) Institution of a national research organization to identify projects, mobilize funds, and ensure information exchange and collaboration.

Research in Your Opinion Needed but Not Being Carried Out

1. Further investigations with regard to causal disease, e.g., peripheral vascular disease, cerebral palsy, etc.

2. Studies of stumps as stumps, e.g., with regard to physical nature, anatomy, physiological attributes.

3. Further studies re stump/socket relationships, e.g., dynamic pressure studies.

4. Extension of scope of locomotor investigations in situations other than straight level walking. Involves design of pylon monitoring and development radio telemetry.

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5. Evolving systems of evaluation of clinical management including sociological aspects.

6. Problem of data acquisition, storage, and processing which is largely a financial one that inhibits initiation and progress in these fields.

SWEDEN

Bo Klasson and Gunnar Holmgren

General Status

Research and Development previously recognized as the SVEN-Programme are now coordinated by the new (founded 1/7/68) Swedish Institute for the Handicapped. Long-term product development is mainly handled by the Research Institute for the Swedish National Defence. Some research, primarily on a clinical basis, occurs outside of the coordinated program.

Future Plans

Finishing the current projects to, when this is the aim, commercially available products. Organizing Applied Prosthetic/Orthotic Research Unit.

Research in Your Opinion Needed but Not Being Carried Out

For different countries, relevant needs analysis.

TUNISIA

Aicha Chakroun

General Status

At present, there exists only a center of orthopedic devices, which is an application center.

Future Plans

In Tunisia's forthcoming Fourth Plan there is provision for the construction of a center for orthopedic devices which, alongside of its application service, will have a research center.

Research in Your Opinion Needed but Not Being Carried Out

1. Research in new processes, especially using local materials.

2. Development of devices more adapted to severe amputations.

3. Research in perfecting orthotics.

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UNITED ARAB REPUBLIC

M. A. S. El Banna and S. El Hommosani

General Status

Research had been confined to the manufacture of artificial limbs and braces from local materials and training of prosthetic and orthotic technicians into the modern prosthetic and orthotic devices.

Future Plans

Improving the prosthetic and orthotic devices to match the modern trend. Equipping the prosthetic and orthotic workshops with modern machines and plastic units. Training abroad for the prosthetic and orthotic technicians.

Research in Your Opinion Needed but Not Being Carried Out

Producing standard simple prefabricated parts for reducing the time of delivery of the prosthetic and orthotic devices. Establishing a small simple unit for child prosthetics as this service is not available.

Research in spinal orthotics for scoliosis as the local devices are not up to the required standard.

UNITED STATES OF AMERICA

A. Bennett Wilson, Jr.

General Status

Nearly all research in limb prosthetics and orthotics in the U.S.A. is supported by the federal government. The Veterans Administration and the Social Rehabilitation Service, Department of Health, Education, and Welfare, award contracts and grants for research. The VA, the Army, and the Navy operate their own research laboratories. The Committee on Prosthetics Research and Development of the National Academy of Sciences correlates and coordinates the various projects in the United States and Canada, and advises the various government agencies concerned. A list of projects currently under way follows:

Organization and Principal Investigator	Major Area (or Areas) of Investigation	Sponsoring Agency
Albert Einstein College of Medicine, New York City-- Richard M. Herman	Neuromotor Control Systems	SRS
Army Medical Biomechanical Research Laboratory, Washington, D. C.-- Orlyn Oestereich Fred Leonard	Development of Prosthetic and Orthotic Materials and Devices	U.S. Army

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Organization and Principal Investigator	Major Area (or Areas) of Investigation	Sponsoring Agency
Attending Staff Association of the Rancho Los Amigos Hospital, Downey, Calif.-- Vert Mooney	Application of Orthotic Devices in the Treatment of Lower-Extremity Fractures and Degenerative Arthritis	SRS
Worden Waring	Investigation of Myoelectric Control of Functional Braces	SRS
Baylor University, Houston-- Lewis A. Leavitt	Evaluation of Fit and Analysis of Gait of Lower-Extremity Amputees	SRS
California, University of, San Francisco and Berkeley, Biomechanics Laboratory-- Verne T. Inman	Dual-Axis Ankle Control System	SRS
	Electrical Stimulation of Afferent Fibers as a Means of Reducing Spasticity	SRS
H. J. Ralston	Dynamics of the Human Body During Locomotion	SRS
Charles W. Radcliffe Howard D. Eberhart James M. Morris	Design of Prosthetic and Orthotic Devices, including Spinal Braces, and Biomechanical Studies of the Lower Extremities	VA
California, University of, Los Angeles, Biotechnology Laboratory-- John Lyman	Fundamental and Applied Research Related to the Design and Development of Upper-Extremity Externally Powered Prostheses	VA, SRS
California, University of, Los Angeles, School of Medicine-- Charles O. Bechtol	Functional Long-Leg Brace	SRS
	Endoskeletal Upper-Extremity Prosthesis	SRS
California, University of, Los Angeles, Child Amputee Prosthetics Project-- Charles O. Bechtol Yoshio Setoguchi	An Interdisciplinary Research, Teaching, and Service Program in the Management of the Child Amputee	CB
Case Western Reserve University, Cleveland-- James B. Reswick	Biomedical Research on Cybernetic Systems for the Disabled	SRS
Victor H. Frankel	Pathomechanics of Disorders of the Locomotor System	SRS

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Organization and Principal Investigator	Major Area (or Areas) of Investigation	Sponsoring Agency
Charles Long, II	Basic and Clinical Study of Normal and Abnormal Human Motion	SRS
Olgierd Lindan	Application of Medical Engineering to Patient Care and Rehabilitation	SRS
Duke University Medical Center, Durham, N. C.-- J. Leonard Goldner Edward A. Kiessling	Development and Evaluation of Pneumatic Prostheses	CB, SRS
Emory University, Atlanta, Georgia-- Martin B. Ewing	Radiographic Study of Hip Dysplasia in Cerebral Palsy	CB
Esslinger, John O., Birmingham, Mich.	Skeletal Attachments of Prostheses	VA
Georgetown University, Washington, D. C.-- George W. Hyatt	Biophysical Evaluation of Healing Bone	SRS
Gilmatic, Northridge, Calif.-- Gilbert M. Motis	Development of Upper-Extremity Prosthetic Components	VA
Harvard University, Boston-- Richard Warren	Survey of Lower-Extremity Amputations for Ischemia	VA
Illinois, University of, Medical School, Chicago-- Jorge Galante	A Study of Spinal Orthotics in Idiopathic Scoliosis	SRS
Iowa State University, Ames, Iowa-- Allan G. Potter	Development of a Myoelectrically Controlled Brace for the Hand	SRS
Iowa, University of, Iowa City, Iowa-- Adrian Ede Flatt	A Clinical Research Study of Congenital Hand Anomalies	CB
Maryland, University of, Baltimore-- Fred Gornick	Electrochemical Muscle Studies	SRS
Massachusetts Institute of Technology, Boston-- Robert W. Mann	Development of a Myographically Controlled Artificial Arm	SRS and Liberty Mutual Ins.Co.

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Organization and Principal Investigator	Major Area (or Areas) of Investigation	Sponsoring Agency
Mauch Laboratories, Inc., Dayton, Ohio-- Hans A. Mauch	Research and Development in Lower-Extremity Prosthetic Devices	VA
Miami, University of, Coral Gables, Florida-- Augusto Sarmiento	The Development of Functional Methods of Treatment of Tibial, Femoral, and Forearm Fractures	SRS
Michigan, University of, Ann Arbor, Mich.-- James W. Rae, Jr.	Biomedical Engineering in Physical Rehabilitation	SRS
Michigan, University of, School of Public Health, Ann Arbor, Mich.-- Ned Sharples	Disability Outcomes and Antecedents	CB
Michigan Crippled Children Commission-- George T. Aitken Charles H. Frantz	Clinical Testing of Prosthetic Devices and Techniques for Child Amputees, and the Development of Improved Clinical Management Procedures	CB
Moss Rehabilitation Center, Philadelphia-- Leonard D. Policoff	Biomedical Engineering Research and Development	SRS
Navy Prosthetics Research Laboratory (U.S. Naval Hospital, Oakland, Calif.)-- D. W. Rohren	Immediate Postsurgical Fitting of Prostheses; and Lower-Extremity Prosthetic and Orthotic Development	U.S. Navy
New York University Medical Center-- Richard Lehneis	Bioengineering Design and Development of Lower-Extremity Orthotic Devices	SRS
Ralph Lusskin	Control of Adventitious Bone Formation with Plastic Implants	SRS
New York University, School of Engineering and Science, Research Division, Prosthetic Devices Study-- Renato Contini	Determination of the Pressure Distribution between Lower-Extremity Sockets and Stumps	VA
	Body Segment Parameters	SRS

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Organization and Principal Investigator	Major Area (or Areas) of Investigation	Sponsoring Agency
New York University, Post-Graduate Medical School, Prosthetic and Orthotic Studies-- Sidney Fishman Walter A. L. Thompson	Development of Devices and Techniques to Facilitate Diagnosis of Problems and Improve Fitting of Lower-Extremity Prostheses and Orthoses	SRS
Sidney Fishman	Evaluation of Prosthetic Devices and Techniques for Child Amputees	CB
Northwestern University Prosthetic Research Center, Chicago-- Robert G. Thompson	Design and Development of Devices and Techniques for the Improvement of Prosthetic Practices, Especially for Geriatric and Problem Cases	VA
Northwestern University Prosthetics-Orthotics Program, Chicago-- Charles M. Fryer	Evaluation of Orthotic Devices	SRS
Pennsylvania State University, Univ. Park, Pa.-- Chauncey A. Morehouse	Evaluation of Knee Stability and Its Relationship to Knee Injuries	SRS
Prosthetics Research Study, Seattle-- Ernest M. Burgess Joseph H. Zettl	Immediate Postsurgical Prosthesis Fitting and Ambulation	VA
Rochester, University of, Rochester, New York-- Robert C. Dickerson	Effectiveness of Treatment for Orthopedic Conditions of Childhood	CB
Texas Institute for Rehabilitation and Research, Houston-- Thorkild J. Engen	Research Developments of Lower-Extremity Orthotic Systems as They Relate to Patients with Various Functional Deficits	SRS
Carlos Vallbona	Evaluation of a Reduced Gravity Simulator for Early Ambulation of the Disabled	SRS
Veterans Administration Hospital, San Francisco-- Wesley S. Moore Albert D. Hall	Study of Below-Knee Amputation for Vascular Insufficiency	VA

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Organization and Principal Investigator	Major Area (or Areas) of Investigation	Sponsoring Agency
Veterans Administration Prosthetics Center, New York City-- Anthony Staros	Research, Development, and Testing of Prosthetic and Orthotic Devices and Techniques	VA
Virginia, University of, Charlottesville, Va.-- David W. Lewis	Evaluation of Pressure Distribution between Stump and Socket in Lower-Extremity Prosthetics	SRS
Yale University School of Medicine, New Haven, Conn.-- Wayne O. Southwick	Factors Influencing Rehabilitation of Elderly Patients Having Hip Surgery	SRS

Future Plans

Continuation at about the same or slightly higher level of effort.

Research in Your Opinion Needed but Not Being Carried Out

Methods of training amputees to use prostheses.

Spinal orthotics.

The effect of pressure on human tissues.

Determination of optimum methods of amputation surgery.

YUGOSLAVIA — Bosco Zotovic

General Status

Currently underway are studies involving application of electronics and pneumatics in the field of prosthetics and orthotics, investigation of new materials and development of new techniques of work, immediate postoperative fitting of lower-extremity amputees, development of evaluation methods for upper-extremity prosthetic devices, Belgrade automatic hand, and electrostimulation of the urinary bladder for patients with spinal cord injury.

Future Plans

Further work in the application of electronics and pneumatics in the field of prosthetics and orthotics, further work in evaluation of both upper- and lower-extremity prosthetic and orthotic devices. Development of evaluation methods, through the energy consumption studies, for different disability groups and different appliances or components they use (evaluation of the degree of their rehabilitation); energy consumption studies of spinal cord dysfunction cases in respect to the probability of their maximal rehabilitation potential.

Research in Your Opinion Needed but Not Being Carried Out: Stated above.

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MONDAY, April 28, 1969

Moderator: George Murdoch

I. LOWER-EXTREMITY PROSTHETICS

A. Fundamental Studies
B. Surgical Studies
C. Component Development
D. Technique Development
E. Evaluation

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TITLE OF RESEARCH PROJECT:

Human Locomotion

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. D. W. Grieve

NAME OF INSTITUTION:

Biomechanics Laboratory, Royal Free Hospital, London (Prof. Ruth Bowden), England

OBJECTIVE OF THE PROJECT:

Fundamental studies of certain gait parameters.

METHOD USED:

Photometric techniques are being used together with a polarised light goniometer designed by Dr. Grieve.

STATUS OF THE PROJECT:

Work is at an early stage.

FUTURE PLANS:

It is hoped that work will extend to study pathological gait in due course.

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TITLE OF RESEARCH PROJECT:

Lower-Limb Dynamics

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. A. H. Bottomley

NAME OF INSTITUTION:

B.R.A.D.U. (Roehampton), London, England

OBJECTIVE OF THE PROJECT:

To study dynamic factors of knee performance with a view to providing criteria for the design of optimal knee mechanism.

METHOD USED:

The forces, torques, accelerations obtained about the knee during walking by experienced B/K amputees will be studied first.

STATUS OF THE PROJECT:

An instrumented prosthesis has been designed. Optimal transducers are awaited.

FUTURE PLANS:

This work is the start of a long-term programme of fundamental study of gait parameters. Opportunity will be taken to confirm aspects of the Californian studies hopefully using large samples and computer techniques. Studies likely to be extended to foot/ankle interactions and the possibility of voluntarily controlled power assisted leg control will be borne in mind.

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TITLE OF RESEARCH PROJECT:

Force Plate

NAME OF RESPONSIBLE INVESTIGATOR:

Mr. J. L. J. Barnes

NAME OF INSTITUTION:

Biomechanical Research and Development Unit, Department of Health and Social Security, Roehampton, London, S.W.15, England

OBJECTIVE OF THE PROJECT:

To design and fabricate force plates for gait analysis having improved performance particularly in respect of frequency response.

METHOD USED:

The plates will be made of a honeycomb sandwich between two sheets of carbon filament resin material. We are receiving help from Messrs. Rolls Royce on the material.

STATUS OF THE PROJECT:

Samples of the sandwich appear promising on test and detailed design is proceeding.

FUTURE PLANS:

It is expected that monitoring in three planes only will be required. Analysis will be computerised.

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TITLE OF RESEARCH PROJECT:

Investigation of the force actions developed in locomotion of the normal human.

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. J. P. Paul

NAME OF INSTITUTION:

BioEngineering Unit, University of Strathclyde, Montrose Street, Glasgow, C.1, Scotland

OBJECTIVE OF THE PROJECT:

Determination of muscle, ligament and joint forces and energy changes in locomotion, with a view to specifying optimum conditions for prosthetic and orthotic devices.

METHOD USED:

Ground to foot force measurement by force plate and position registration by cinephotography. Muscular activity recorded by EMG from surface electrodes.

STATUS OF THE PROJECT:

Initial results have been published. Investigations are continuing.

FUTURE PLANS:

Extension to activities more arduous than walking.

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LOWER-EXTREMITY PROSTHETICS

FUNDAMENTAL STUDIES

TITLE OF RESEARCH PROJECT:

Investigation of the role of kinetic specification in studies of the lower-extremity amputee.

NAME OF RESPONSIBLE INVESTIGATOR:

George Murdoch

NAME OF INSTITUTION:

Dundee Limb Fitting Centre, Dundee, Scotland

OBJECTIVE OF THE PROJECT:

To identify the parameters which may be readily used for an evaluation of socket fit and to use these parameters to study the effects of different surgical procedures and socket designs.

METHOD USED:

Simultaneous cinephotographic, force plate, electromyographic records of both legs during level walking.

STATUS OF THE PROJECT:

Equipping of laboratory approaching completion, initial proving tests being undertaken.

FUTURE PLANS:

Selected amputees are being fitted with a number of different types of sockets which will be readily interchangeable by making use of a commercially produced modular prosthetic system, thus eliminating variable or limb construction to make studies of effect of different sockets possible.

A programme of analysis of amputees in whom a stump revision is planned with a second analysis subsequent to surgery will allow comparison of surgical techniques.

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TITLE OF RESEARCH PROJECT:

Stability studies on lower-limb amputees.

NAME OF RESPONSIBLE INVESTIGATOR:

J. Hughes, B.Sc., C.Eng., M.I.Mech.E.

NAME OF INSTITUTION:

BioEngineering Unit, University of Strathclyde, Montrose Street, Glasgow, C.1, Scotland

OBJECTIVE OF THE PROJECT:

To develop objective means of comparing characteristics of prosthetic devices designed to provide stability in the stance phase. To evaluate functional ability of amputees and assess requirements in terms of stability.

METHOD USED:

Test rig to assess stability characteristics in static situation. Strain gauged pylon studies to evaluate dynamic situation. Dynamometer to assess moment exerting capability of amputee.

STATUS OF THE PROJECT:

Project started December 1967. First series of tests carried out.

FUTURE PLANS:

Improvement of data processing facility to enlarge test population.

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TITLE OF RESEARCH PROJECT:

Voluntary control of lower-extremity mechanisms.

NAME OF RESPONSIBLE INVESTIGATOR:

T. C. Duggan, B.Sc. A.Inst.P

NAME OF INSTITUTION:

Regional Department of Clinical Physics and BioEngineering,
Western Regional Hospital Board, Glasgow, Scotland

OBJECTIVE OF THE PROJECT:

To establish modalities for the control of LE mechanisms.

METHOD USED:

Simple walkway used to establish kinematic aspects of locomotion of the amputee; relationship between electrical activity of muscles of normal leg or amputation stump and kinematic events of locomotion used to identify possible control signals for active mechanisms.

STATUS OF THE PROJECT:

Walkway operative, experimental studies commence 3/69.

FUTURE PLANS:

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TITLE OF RESEARCH PROJECT:

Biomechanical analysis of the forces acting at the normal ankle joint during level walking.

NAME OF RESPONSIBLE INVESTIGATOR:

David N. Condie

NAME OF INSTITUTION:

Dundee Limb Fitting Centre, Dundee, Scotland

OBJECTIVE OF THE PROJECT:

To evaluate the forces acting in the muscles and ligaments controlling the ankle joint and the variations in joint forces during the walking cycle.

METHOD USED:

Simultaneous cinephotographic, force plate and electromyographic records of the test subject are reduced to allow calculation of forces necessary for dynamic stability. Muscle functions are derived from tests performed on dissected specimens confirmed by EMG records.

STATUS OF THE PROJECT:

A digital computer programme is being prepared to perform the analysis. Tests will proceed when this is completed.

FUTURE PLANS:

1. To extend the tests to other normal activities, e.g., ramp, stair climbing, side-slope walking.

2. To develop the analysis to consider functional disabilities and implanted joints.

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TITLE OF RESEARCH PROJECT:

Stump-Socket Pressure in Above-Knee Prostheses

NAME OF RESPONSIBLE INVESTIGATOR:

L. A. Leavitt, M.D.

NAME OF INSTITUTION:

Baylor University, Houston, Texas, U.S.A.

OBJECTIVE OF THE PROJECT:

To determine pressure distribution in above-knee sockets.

METHOD USED:

Pressure transducer measurements in socket along with measurement of kinematic variables such as cadence and knee angles.

STATUS OF PROJECT:

FUTURE PLANS:

To expand study with pressure measurements at more locations and with more kinematic variables.

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TITLE OF RESEARCH PROJECT:

Data Processing Procedures

NAMES OF RESPONSIBLE INVESTIGATORS:

Prof. C. W. Radcliffe
Prof. H. D. Eberhart
J. M. Morris, M.D.

NAME OF INSTITUTION:

University of California Medical Center, San Francisco, California, U.S.A.

OBJECTIVE OF THE PROJECT:

Automatize the collection of data, provide a convenient mode of storage and facilitate treatment of the data to yield information pertinent to design by use of analog and digital computer facilities.

METHOD USED:

Collect information in form of analogous electrical signals and store on recorder tape where analog signals will be digitalized for digital computer processing. Data will then be displayed by various means.

STATUS OF THE PROJECT:

Equipment is ready for use. Software programs are being developed.

FUTURE PLANS:

Continue development of software programs.

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TITLE OF RESEARCH PROJECT:

Kinematics of the Lower Extremity

NAMES OF RESPONSIBLE INVESTIGATORS:

Prof. C. W. Radcliffe
Prof. H. D. Eberhart
J. M. Morris, M.D.

NAME OF INSTITUTION:

University of California Medical Center, San Francisco, California, U.S.A.

OBJECTIVE OF THE PROJECT:

METHOD USED:

Measurement of kinematic variables on an instrumented exoskeletal linkage attached to the body at selected, appropriate bony prominences.

STATUS OF THE PROJECT:

Components of exoskeleton are in development. It is to be completed this year.

FUTURE PLANS:

To collect and analyze motion data for (a) all three angular components of hip motion, (b) flexion and axial rotation of ankle with flexion and rotational movements at the knee. Measurement of pelvis as referenced to a fixed coordinate is also planned.

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TITLE OF RESEARCH PROJECT:

Ambulation Geometry

NAMES OF RESPONSIBLE INVESTIGATORS:

Prof. C. W. Radcliffe
Prof. H. D. Eberhart
J. M. Morris, M.D.

NAME OF INSTITUTION:

University of California Medical Center, San Francisco, California, U.S.A.

OBJECTIVE OF THE PROJECT:

To simplify the study of the effects on ambulation of different design shoes, different walking surfaces, etc.

METHOD USED:

Establish characteristic step length as a function of cadence and leg geometry to substantiate hypothesis that comparison of data between individuals is valid when step geometry is identical.

STATUS OF THE PROJECT:

Study has been initiated and is continuing.

FUTURE PLANS:

To incorporate this concept of data control in related studies.

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TITLE OF RESEARCH PROJECT:

Dynamics of the Human Body during Locomotion

NAME OF RESPONSIBLE INVESTIGATOR:

H. J. Ralston, Ph.D.

NAME OF INSTITUTION:

University of California Medical Center, San Francisco, California, U.S.A.

OBJECTIVE OF THE PROJECT:

To establish interpretations of observed changes in mechanical energy levels and concomitant metabolic energy expenditures.

METHOD USED:

Record displacements of head, trunk, arms and legs and record EMG activity simultaneously. Correlate energy output, metabolic energy cost, and EMG activity.

STATUS OF THE PROJECT:

Experimental set-up has been completed and work on subjects is being conducted.

FUTURE PLANS:

Study will be extended to include selected conditions of gross metabolic energy cost changes including walking with a lower-extremity prosthesis.

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TITLE OF RESEARCH PROJECT:

Electrical Inhibition of Pain

NAME OF RESPONSIBLE INVESTIGATOR:

James B. Reswick, D.Sc.

NAME OF INSTITUTION:

Case Western Reserve University, Cleveland, Ohio, U.S.A.

OBJECTIVE OF THE PROJECT:

To study electroanalgesia as a nondestructive, non-narcotic means of suppressing chronic "intractable pain in man."

METHOD USED:

Animal experimentation to determine the parameters of nondestructive electrical stimulation of nerve tissue, followed by human experimentation.

STATUS OF THE PROJECT:

Dorsal column stimulating electrodes have been implanted in two patients suffering intractable pain.

FUTURE PLANS:

Further studies are needed to quantify the effectiveness of this procedure.

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TITLE OF RESEARCH PROJECT:

Stump-Socket Pressure in Below-Knee Lower-Extremity Prostheses

NAME OF RESPONSIBLE INVESTIGATOR:

James W. Rae, M.D., M.S.

NAME OF INSTITUTION:

University of Michigan, Ann Arbor, Michigan, U.S.A.

OBJECTIVE OF THE PROJECT:

To measure socket interface pressure distribution for PTB below-knee prostheses.

METHOD USED:

Use of pressure transducers with pressure information fed into a computer program to yield visual display of data.

STATUS OF THE PROJECT:

Experimental set-up has been completed and subject information is being collected.

FUTURE PLANS:

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TITLE OF RESEARCH PROJECT:

Stump-Socket Pressure in Above-Knee Lower-Extremity Prostheses

NAMES OF RESPONSIBLE INVESTIGATORS:

Frank Appoldt
Leon Bennett
Renato Contini

NAME OF INSTITUTION:

New York University, New York City, U.S.A.

OBJECTIVE OF THE PROJECT:

To determine the distribution of socket interface pressure for above-knee amputations.

METHOD USED:

Use of pressure transducers incorporated into socket to yield a pressure distribution pattern.

STATUS OF THE PROJECT:

Published in "Journal of Biomechanics", December, 1968.

FUTURE PLANS:

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TITLE OF RESEARCH PROJECT:

Transparent Sockets

NAME OF RESPONSIBLE INVESTIGATOR:

Ronald Lipskin

NAME OF INSTITUTION:

New York University, New York, U.S.A.

OBJECTIVE OF THE PROJECT:

To develop techniques for fabrication of sockets which would serve as tools for the study of motions and pressures between stump and socket.

METHOD USED:

Two methods were used: 1. Transparent plastic was vacuum-formed to make the socket. 2. A casting resin was used to make the socket.

STATUS OF THE PROJECT:

The procedures for both techniques and some applications have been outlined in a report, "The Development of the NYU Transparent Socket Fabrication Technique," by Ronald Lipskin and Thomas Grille.

FUTURE PLANS:

To investigate stump-socket pressures by using polarized light and photoelasticity techniques.

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TITLE OF RESEARCH PROJECT:

Study of Gait in Human Locomotion

NAME OF RESPONSIBLE INVESTIGATOR:

Victor Frankel, M.D.

NAME OF INSTITUTION:

Veterans Administration Hospital Biomechanics Laboratory,
Cleveland, Ohio, U.S.A.

OBJECTIVE OF THE PROJECT:

METHOD USED:

Movement of light source targets on subject are recorded every 1/60 second by TV camera. Computer program will provide displacement, velocity and acceleration data. Force plate will provide biomechanics data.

STATUS OF THE PROJECT:

In progress.

FUTURE PLANS:

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TITLE OF RESEARCH PROJECT:

Pressure Measurement--Stump-Socket Interface

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. Edward Peizer

NAME OF INSTITUTION:

Veterans Administration--A joint project between the Seattle VA and New York VA., U.S.A.

OBJECTIVE OF THE PROJECT:

1. To investigate pressure and pressure change between stump and the immediate postoperative socket with time.

2. To investigate the effect on pressure of alignment changes. Pressure data will be correlated with myoelectric data.

METHOD USED:

STATUS OF THE PROJECT:

FUTURE PLANS:

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TITLE OF RESEARCH PROJECT:

Surgical amputation technique.

NAME OF RESPONSIBLE INVESTIGATOR:

A. Bjørn Christensen

NAME OF INSTITUTION:

Orthopaedic Hospital, Copenhagen, Denmark

OBJECTIVE OF THE PROJECT:

Evaluation of conventional myoplasty and myo-procedures in relationship to physiology, prosthesiology, and general clinical course.

METHOD USED:

Comparative studies including clinical evaluation, electromyography, circulation, ergometry, etc.

STATUS OF THE PROJECT:

FUTURE PLANS:

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TITLE OF RESEARCH PROJECT:

Level of amputation in vascular disorders.

NAME OF RESPONSIBLE INVESTIGATOR:

Knud Jansen, M.D.

NAME OF INSTITUTION:

Orthopaedic Hospital, Copenhagen, Denmark

OBJECTIVE OF THE PROJECT:

To study the correlation of existing laboratory tests and actual level of viability. Comparison of surgical technique and stump conditions, surgeon method.

METHOD USED:

Part of experimental clinical procedures.

STATUS OF THE PROJECT:

Clinical material collected for study.

FUTURE PLANS:

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TITLE OF RESEARCH PROJECT:

Immediate Postoperative Fitting

NAMES OF RESPONSIBLE INVESTIGATORS:

Mr. M. Vitali, F.R.C.S.
Dr. R. Redhead
Mr. K. P. Robinson, F.R.C.S.
Mr. B. G. Andrews, F.R.C.S.

NAME OF INSTITUTION:

Biomechanical Research and Development Unit, Roehampton
Queen Mary's Hospital, Roehampton, London, England

OBJECTIVE OF THE PROJECT:

Evaluation and application of techniques.

METHOD USED:

Clinical application based on the Seattle methods.

STATUS OF THE PROJECT:

Clinical research project still at somewhat tentative stage.

FUTURE PLANS:

Study of environmental conditions affecting wound healing.

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TITLE OF RESEARCH PROJECT:

Immediate fitting of upper- and lower-extremity amputations.

NAMES OF RESPONSIBLE INVESTIGATORS:

Prof. Cotta
Dr. Marquardt
Dr. Rossak
Dr. Koch

NAME OF INSTITUTION:

Orthopadische Klinik und Poliklinik der Universitat Heidelberg und Chirurgische Klinik der Universitat Heidelberg in Zusammenarbeit mit der Abteilung fur Dysmelien und technische Orthopadie, Heidelberg, Germany

OBJECTIVE OF THE PROJECT:

Immediate fitting for all kinds of amputations of the lower and upper extremities.

METHOD USED:

On the lower extremities the technic of WEISS, on the upper extremities the myoplastic operation of DEDERICH, after operation plaster of Paris cast, fitting of the prosthesis between the third and fourth week after amputation.

STATUS OF THE PROJECT:

Working well.

FUTURE PLANS:

Continuation.

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TITLE OF RESEARCH PROJECT:

The immediate fitting of prostheses by the use of skeletal prostheses and adjustable, prefabricated plastic pieces.

NAMES OF RESPONSIBLE INVESTIGATORS:

Hannes Schmidl
Prof.Franco Zarotti

NAME OF INSTITUTION:

I.N.A.I.L.--Officina Ortopedica, Vigorso di Budrio (Bologna)
Centro Traumatologico Ortopedico of Bologna, Italy

OBJECTIVE OF THE PROJECT:

METHOD USED:

In surgery, the method of Dr.Dederich of Bonn; as regards the technical aspect, in accordance with the results of the researches of this orthopedic workshop.

STATUS OF THE PROJECT:

Practical application directly on an amputee has already been carried out. The research is, however, in the experimental stage.

FUTURE PLANS:

Detailed research into synthetic materials that better respond to aesthetic requirements.

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TITLE OF RESEARCH PROJECT:

Investigation of tissue viability in peripheral vascular disease.

NAME OF RESPONSIBLE INVESTIGATOR:

W. F. Walker (Cardio-Vascular Surgeon)

NAME OF INSTITUTION:

Dundee Royal Infirmary, Dundee, Scotland

OBJECTIVE OF THE PROJECT:

To assess limits of tissue viability and thus identify lowest levels of amputation consistent with stump survival and hence capacity to withstand surgical assault, resist locomotor forces and prosthetic pressures.

METHOD USED:

Study of subjects based on: 1. Angiography. 2. $P.O._2$ measurement. 3. Pathological examination of amputated specimen. Structure of study implies initially amputation at level determined on clinical grounds.

STATUS OF THE PROJECT:

Submission for funds.

FUTURE PLANS:

Correlation with other methods of evaluation, e.g., thermography, chromosomal degeneration, etc., and tissue response (in terms of oxygen tension) to physical and (bio)chemical stimuli.

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TITLE OF RESEARCH PROJECT:

Immediate Postoperative Fitting of Lower-Extremity Amputations

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. Bosco Zotovic

NAME OF INSTITUTION:

Center for Prosthetics, Belgrade, Yugoslavia

OBJECTIVE OF THE PROJECT:

Development of this technique of work, investigation of the feasibility of it in respect to different age groups, formulating indications and contraindications; investigation of histamine influence on stump responses.

METHOD USED:

As mentioned above. Also, analysis of influences of different approaches (standard technique versus osteomyoplasty) to the application of this technique.

STATUS OF THE PROJECT:

Under way.

FUTURE PLANS:

Continuation of work.

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TITLE OF RESEARCH PROJECT:

Rapid release ankle attachment.

NAME OF RESPONSIBLE INVESTIGATOR:

Not allotted.

NAME OF INSTITUTION:

Repatriation Department's Central Development Unit, Melbourne, Australia

OBJECTIVE OF THE PROJECT:

Enable females to change artificial feet adapted to different heel heights.

METHOD USED:

Similar to Hosmer Quick Release Wrist Unit.

STATUS OF THE PROJECT:

Not commenced.

FUTURE PLANS:

According to work loads.

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TITLE OF RESEARCH PROJECT:

Modification of the Canadian Swivel Walker

NAME OF RESPONSIBLE INVESTIGATOR:

In view of small unit, most persons directly involved. Concept by Mr. R. Duncan (prosthetist).

NAME OF INSTITUTION:

Repatriation Department's Central Development Unit, Melbourne, Australia

OBJECTIVE OF THE PROJECT:

Reduction of energy consumption.

METHOD USED:

4-bar linkage.

STATUS OF THE PROJECT:

Some reduction of energy requirement achieved.

FUTURE PLANS:

Reduction and refinement of mechanism to improve cosmesis.

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TITLE OF RESEARCH PROJECT:

Knee-Disarticulation Prosthesis

NAMES OF RESPONSIBLE INVESTIGATORS:

Knud Jansen, M.D.
Erik Lyquist, P/O

NAME OF INSTITUTION:

Orthopaedic Hospital, Copenhagen, Denmark

OBJECTIVE OF THE PROJECT:

To develop an improved prosthesis with special regard to cosmesis, function, and stability. To study socket design and fitting methods.

METHOD USED:

Testing of different designs on amputees.

STATUS OF THE PROJECT:

One prototype including a polycentric knee is completed and is being tested by an amputee.

FUTURE PLANS:

a. Redesign or improvements of present prototype as indicated by the preliminary test.

b. Testing of various socket designs.

c. Study scope and technique for through-knee amputations.

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TITLE OF RESEARCH PROJECT:

Pneumatic Swing Phase Control

NAME OF RESPONSIBLE INVESTIGATOR:

Mr. B. G. Blatchford

NAME OF INSTITUTION:

Chas. A. Blatchford & Sons, Ltd., Basingstoke, Hants, England

OBJECTIVE OF THE PROJECT:

To productionise a pneumatic swing control unit.

METHOD USED:

Design based on information supplied by Prof. Radcliffe of U.C. Berkeley.

STATUS OF THE PROJECT:

Field trials being initiated.

FUTURE PLANS:

General release and marketing.

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TITLE OF RESEARCH PROJECT:

Modular Assembly A/K Leg

NAME OF RESPONSIBLE INVESTIGATOR:

Mr. B. G. Blatchford

NAME OF INSTITUTION:

Chas. A.Blatchford & Sons, Ltd., Basingstoke, Hants, England

OBJECTIVE OF THE PROJECT:

Modular construction of A/K components to speed manufacture and assembly. Built-in alignment components.

METHOD USED:

Engineering development.

STATUS OF THE PROJECT:

Field trials of Mark I in process.

FUTURE PLANS:

Progressive upgrading, following putting Mark I into general service by the manufacturer.

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TITLE OF RESEARCH PROJECT:

Stabilised Knee

NAME OF RESPONSIBLE INVESTIGATOR:

Mr. D. R. W. May

NAME OF INSTITUTION:

J. E. Hanger & Co. Ltd., Roehampton, London, England

OBJECTIVE OF THE PROJECT:

To produce self-locking mechanical device to stabilise the knee of A/K legs under load in flexion.

METHOD USED:

The design incorporates a Spragg clutch which locks against flexion but not against extension, making recovery possible. (It differs in this respect from the Blatchford Stabilised Knee.) A small degree of compliance of the main knee pivots causes the clutch to be engaged, spring return frees the clutch when weight begins to be transferred to the contra-lateral foot.

STATUS OF THE PROJECT:

Clinical trial and laboratory testing being carried out.

FUTURE PLANS:

General release and marketing.

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TITLE OF RESEARCH PROJECT:

Interrupted Friction Swing Phase Control

NAME OF RESPONSIBLE INVESTIGATOR:

Mr. D. R. W. May

NAME OF INSTITUTION:

J. E. Hanger & Co. Ltd., Roehampton, London, England

OBJECTIVE OF THE PROJECT:

To productionise an interrupted friction swing phase control.

METHOD USED:

Design derived originally from the U. S. Navy Variable Cadence device and has been developed as a multidisc device somewhat similar to that developed at Northwestern University in Chicago by, I believe, McLaurin.

STATUS OF THE PROJECT:

Field trials in process.

FUTURE PLANS:

General release and marketing. This unit is compatible with the stabilised knee under development by the same firm and can with advantage be prescribed simultaneously.

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TITLE OF RESEARCH PROJECT:

Modular Assembly Prosthetic System

NAMES OF RESPONSIBLE INVESTIGATORS:

Dr. R. G. Redhead
Mr. C. Snowdon

NAME OF INSTITUTION:

Biomechanical Research and Development Unit, Department of Health and Social Security, Roehampton, London, S.W.15, England

OBJECTIVE OF THE PROJECT:

To design complete range of modular components to enable lower-limb prostheses to be assembled rapidly to meet the needs of patients with all levels of amputation and all degrees of disability. Systems for optimising alignment to be incorporated, and a technique for stump casting and rapid socket fabrication is a requirement. The ideal will be to provide the ability to complete the fabrication from measurement to check-out in peripheral clinics within one working day.

METHOD USED:

Basically a drawing office/engineering workshop task. Structural engineering and choice of materials will be important.

STATUS OF THE PROJECT:

Test models of various approaches have been made. Target for first clinical trials of the components for below-knee prostheses, summer 1969. Above-knee casting technique under development.

FUTURE PLANS:

Target for completion of drawings and specifications late 1972.

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LOWER-EXTREMITY PROSTHETICS

COMPONENT DEVELOPMENT

TITLE OF RESEARCH PROJECT:

Lower-extremity prosthetics:

a) Skeleton A/K and Hip Disarticulation Prostheses
b) KBM-Prostheses (Muenster-Type Below-Knee Prostheses)
c) Component parts for lower-extremity prostheses (artificial foot, knee, hip and swing phase control systems)

NAME OF RESPONSIBLE INVESTIGATOR:

Prof. Goetz-Gerd Kuhn, M.D.

NAME OF INSTITUTION:

University of Muenster, Orthopaedic Hospital, Department of Orthopaedic Techniques and Rehabilitation, Muenster/Westfalen, Germany

OBJECTIVE OF THE PROJECT:

Improvement of function, cosmesis, comfort, and efficiency of artificial legs.

METHOD USED:

Creation, construction, realisation, application, evaluation--all in the same center.

STATUS OF THE PROJECT:

This project has high priority.

FUTURE PLANS:

Continuation of projects and dissemination of the results of same.

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TITLE OF RESEARCH PROJECT:

Modular Assembly System for Lower-limb Prostheses.

NAME OF RESPONSIBLE INVESTIGATOR:

J. Hughes, B.Sc., C.Eng., M.I.Mech.E.

NAME OF INSTITUTION:

BioEngineering Unit, University of Strathclyde, Montrose Street, Glasgow, C.1, Scotland

OBJECTIVE OF THE PROJECT:

To design and develop a modular assembly system for lower-limb prostheses--suitable for all major levels of amputation above Syme's.

METHOD USED:

STATUS OF THE PROJECT:

Project started December 1967. Preliminary studies completed. Alignment device at "product design" stage.

FUTURE PLANS:

To incorporate devices specified as a result of the complementary project on stability.

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TITLE OF RESEARCH PROJECT:

Application of Service Walker (McLaurin)

NAMES OF RESPONSIBLE INVESTIGATORS:

D. W. Lamb
D. C. Simpson

NAME OF INSTITUTION:

Princess Margaret Rose Orthopaedic Hospital, Edinburgh, Scotland

OBJECTIVE OF THE PROJECT:

Ambulation of phocomelic children.

METHOD USED:

Modification of McLaurin Walker.

STATUS OF THE PROJECT:

Clinical research.

FUTURE PLANS:

Possible application to high bilateral A/K amputations and spina bifida.

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TITLE OF RESEARCH PROJECT:

Lower-Extremity Prosthetics

NAME OF RESPONSIBLE INVESTIGATOR:

Gunnar Holmgren

NAME OF INSTITUTION:

Een Och Holmgrens Ortopediska AB, Uppsala, Sweden

OBJECTIVE OF THE PROJECT:

Development of modular components (knee and ankle joint) legs for phocomelic children. Investigation of the possibilities of voluntary control of the mechanical characteristics of a passive prosthesis. Investigation of the influence of socket configuration and volume (in collaboration with the Academical Hospital of Uppsala).

METHOD USED:

STATUS OF THE PROJECT:

Legs for phocomelics finished. Rest under initial investigation.

FUTURE PLANS:

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LOWER-EXTREMITY PROSTHETICS

COMPONENT DEVELOPMENT

TITLE OF RESEARCH PROJECT:

Distal-Contact Regulator

NAME OF RESPONSIBLE INVESTIGATOR:

Thomas Grille

NAME OF INSTITUTION:

New York University, New York, U.S.A.

OBJECTIVE OF THE PROJECT:

To develop a device which could be used to regulate the amount of back pressure exerted on the bottom of a B/K or A/K stump in the socket.

METHOD USED:

STATUS OF THE PROJECT:

FUTURE PLANS:

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TITLE OF RESEARCH PROJECT:

Simplified Skeletal Prosthesis for Lower-Extremity Amputations

NAMES OF RESPONSIBLE INVESTIGATORS:

Luba Gavrilovic, Dipl. Ing.
Dr. Marija Miletic

NAME OF INSTITUTION:

Center for Prosthetics, Belgrade, Yugoslavia

OBJECTIVE OF THE PROJECT:

Development of simple, prefabricated prosthetic parts, easily aligned and readily used for fast production of A/K and B/K prostheses.

METHOD USED:

Design, review of present literature, testing and evaluation.

STATUS OF THE PROJECT:

Local project under way.

FUTURE PLANS:

Continuation of work.

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LOWER-EXTREMITY PROSTHETICS
TECHNIQUE DEVELOPMENT

TITLE OF RESEARCH PROJECT:

A/K. Plaster Casting Jig

NAME OF RESPONSIBLE INVESTIGATOR:

All unit involved. Concept by Dr. Klein.

NAME OF INSTITUTION:

Repatriation Department's Central Development Unit,
Melbourne, Australia

OBJECTIVE OF THE PROJECT:

A/K. jig producing cast requiring virtually no modification.

METHOD USED:

Modification of V.A.P.C. jig by variation in the size and position of all plates and the use of nonrigid materials in some areas.

STATUS OF THE PROJECT:

Still in design stage.

FUTURE PLANS:

Progression as time permits.

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TITLE OF RESEARCH PROJECT:

Cord Suspension A/K Sockets.

NAME OF RESPONSIBLE INVESTIGATOR:

All members. Mr. R. Duncan.

NAME OF INSTITUTION:

Repatriation Department's Central Development Unit, Melbourne, Australia

OBJECTIVE OF THE PROJECT:

To upgrade the old cord suspension for definitive prostheses as used by Burgess for immediate A/K prostheses.

METHOD USED:

Polythene tubing housing incorporated in plastic socket. Nylon parachute cord suspension. Possibility of suspension from body belt about pelvic hoop.

STATUS OF THE PROJECT:

Not commenced.

FUTURE PLANS:

According to work load.

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LOWER-EXTREMITY PROSTHETICS

TECHNIQUE DEVELOPMENT

TITLE OF RESEARCH PROJECT:

1. Prefabricated Socket Design
2. Flexible Socket Design

NAME OF RESPONSIBLE INVESTIGATOR:

J. Foort

NAME OF INSTITUTION:

Prosthetics/Orthotics Research and Development Unit, Sanatorium Board of Manitoba (Winnipeg, Manitoba, Canada)

OBJECTIVE OF THE PROJECT:

1. To develop sockets which can be used for early fitting of new amputees--BK and AK.

2. To design flexible sockets for BK and AK amputees and methods for connecting the sockets to the rest of the prosthesis.

METHOD USED:

1. Molds were made on the basis of measurements for BK and AK sockets using quadrilateral forms for the AK's and PTB forms for the BK's. The AK sockets were made adjustable by overlapping on the lateral side. The BK's are one piece. Various sizes were made to provide range of coverage.

2. Nylon Stockinet and Nylon Tricot reinforcement of polyester resins provide flexible inner sockets. More rigid supporting receptacles are used to back up the flexible sockets and connect them to the rest of the prosthesis.

STATUS OF THE PROJECT:

1. Over 150 amputees have been fitted with the temporary sockets.

2. 25 BK amputees have been fitted with flexible sockets.

FUTURE PLANS:

1. To design one-piece prefabricated AK sockets for use in early fitting of prostheses.

2. To refine design of the prefabricated BK sockets so that their use can be prolonged for better preparation of the stump for definitive fitting.

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TITLE OF RESEARCH PROJECT:

Polythene Temporary Sockets for AK Amputees

NAME OF RESPONSIBLE INVESTIGATOR:

Camille Corriveau

NAME OF INSTITUTION:

Rehabilitation Institute of Montreal, Montreal, Canada

OBJECTIVE OF THE PROJECT:

To develop polythene (polyethylene) sockets for use in early ambulation of AK amputees.

METHOD USED:

AK sockets were fabricated out of sheet stock polyethylene for use on adjustable legs as temporary sockets in the rehabilitation of AK amputees.

STATUS OF THE PROJECT:

The polyethylene sockets are used routinely in the training prostheses of AK amputees.

FUTURE PLANS:

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LOWER-EXTREMITY PROSTHETICS
TECHNIQUE DEVELOPMENT

TITLE OF RESEARCH PROJECT:

Variations of the PTB Prosthesis.

NAME OF RESPONSIBLE INVESTIGATOR:

Mr. Erik Lyquist

NAME OF INSTITUTION:

Orthopaedic Hospital, Copenhagen, Denmark

OBJECTIVE OF THE PROJECT:

To determine value and prescription criteria.

METHOD USED:

Clinical studies on a number of amputees as indicated (normally not less than 20 and not more than 50).

STATUS OF THE PROJECT:

Clinical study of the PTB air-cushion socket completed.

FUTURE PLANS:

Testing of other variations as developed.

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LOWER-EXTREMITY PROSTHETICS
TECHNIQUE DEVELOPMENT

TITLE OF RESEARCH PROJECT:

Above-knee Socket for Geriatric Amputees.

NAME OF RESPONSIBLE INVESTIGATOR:

Erik Lyquist

NAME OF INSTITUTION:

Orthopaedic Hospital, Copenhagen, Denmark

OBJECTIVE OF THE PROJECT:

To develop an A/K socket which the amputee can pull on separate from the prosthesis while lying in bed. The prosthesis itself developed with a receptacle for easy insertion and fixation of the socket.

METHOD USED:

STATUS OF THE PROJECT:

At the stage of initial planning.

FUTURE PLANS:

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LOWER-EXTREMITY PROSTHETICS

TECHNIQUE DEVELOPMENT

TITLE OF RESEARCH PROJECT:

Total Surface Bearing Socket

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. R. G. Redhead

NAME OF INSTITUTION:

Biomechanical Research and Development Unit, Department of Health and Social Security, Roehampton, London, S.W.15, England

OBJECTIVE OF THE PROJECT:

Technique of A/K socket fitting to enable weight load to be carried on the total stump area through the quasi-hydrostatic characteristics of the soft tissues. A self-suspending (adherent) and belt-suspended version are required.

METHOD USED:

Casting is achieved by applying calculated pressure to the stump by an elastic sock and fixing it with plaster. No modification of the model is required. It has been found unnecessary to have an adverse pressure gradient and pressures under peak load do not exceed about 6 p.s.i. at any area.

STATUS OF THE PROJECT:

Self-suspending type now being taught to clinic prosthetists. Suspended type being developed by detailed clinical experiment.

FUTURE PLANS:

Possibility of extending similar techniques to other sites of amputation.

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TITLE OF RESEARCH PROJECT:

Prostheses and Walking Apparatuses for Lower-Extremity Deformities.

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. Marquardt

NAME OF INSTITUTION:

Orthopadische Klinik und Poliklinik der Universitat, Abteilung fur Dysmelien und technische Orthopadie, Heidelberg, Germany

OBJECTIVE OF THE PROJECT:

The cast and alignment for walking apparatuses of lower-extremity phocomelia. New kind of tuber seat. Rotation walker (Dr. Marquardt) similar to the swivel walker of McLaurin with three axial hip joint units (rotation unit in parallelogram construction).

METHOD USED:

Experimental.

STATUS OF THE PROJECT:

The development of the rotation walker is finished. Other problems are still in development, for example, knee joints, etc.

FUTURE PLANS:

Continuation of the project.

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LOWER-EXTREMITY PROSTHETICS
TECHNIQUE DEVELOPMENT

TITLE OF RESEARCH PROJECT:

Air Cushion Socket

NAME OF RESPONSIBLE INVESTIGATOR:

Prof. C. W. Radcliffe

NAME OF INSTITUTION:

Biomechanics Laboratory, University of California, Berkeley and San Francisco, California, U.S.A.

OBJECTIVE OF THE PROJECT:

To develop a socket which would provide pneumatic back-pressure on tissues of the distal two-thirds of the stump for edema control and contribute to support of body weight.

METHOD USED:

The socket designed has plastic laminate for high force transmission, and an RTV Silastic sling for the pneumatic section. This is achieved by laminating the socket in two steps with the same fabric lay-up involved. An outer chamber of plastic laminate ensures that forces from entrapped air are transmitted to the stump through the RTV sling.

STATUS OF THE PROJECT:

Many amputees have been fitted and are successfully wearing air-cushion sockets on a routine basis. A technical report describing the procedures involved has been completed.

FUTURE PLANS:

To increase application of the air-cushion socket at the clinical level through the dissemination of information.

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LOWER-EXTREMITY PROSTHETICS
TECHNIQUE DEVELOPMENT

TITLE OF RESEARCH PROJECT:

Suprapatellar Suspension of BK Prostheses

NAME OF RESPONSIBLE INVESTIGATOR:

Mr. Robert Nitschke

NAME OF INSTITUTION:

Empire Artificial Limb Company, Rochester, New York, U.S.A.

OBJECTIVE OF THE PROJECT:

To improve suspension methods for BK prostheses.

METHOD USED:

Amputees have been fitted with suprapatellar socket extensions which serve as suspension hooks over the kneecap.

STATUS OF THE PROJECT:

Most of the amputees passing through treatment are being fitted with suprapatellar suspension when they are candidates for PTB prostheses. Instructions have been given and procedural outlines published so that education work can proceed.

FUTURE PLANS:

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TITLE OF RESEARCH PROJECT:

Supracondylar-Wedge-Type Suspension

NAME OF RESPONSIBLE INVESTIGATOR:

Carlton Fillauer

NAME OF INSTITUTION:

Fillauer Surgical Supplies Inc., Chattanooga, Tennessee, U.S.A.

OBJECTIVE OF THE PROJECT:

To improve suspension methods for BK prostheses.

METHOD USED:

Amputees have been fitted with medial femoral condyle wedges set between socket and stump to hold the prosthesis on. Wedges are prefabricated in three sizes of PVCA (polyvinyl chloride acetate).

STATUS OF THE PROJECT:

Most of the amputees passing through treatment are being fitted this way. Improvements are needed in wedge design.

FUTURE PLANS:

To improve wedge design and refine technique.

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TITLE OF RESEARCH PROJECT:

Fluid-Lined Sockets

NAME OF RESPONSIBLE INVESTIGATOR:

Mr. Fred Hampton

NAME OF INSTITUTION:

Prosthetics/Orthotics Center, Northwestern University, Chicago, Illinois, U.S.A.

OBJECTIVE OF THE PROJECT:

To design sockets which are adjustable and respond dynamically to the pressures developed between them and the stump.

METHOD USED:

AK sockets were made which had inflatable panels embedded in them. Pressure within the panels could be set by hand pump.

STATUS OF THE PROJECT:

FUTURE PLANS:

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LOWER-EXTREMITY PROSTHETICS

TECHNIQUE DEVELOPMENT

TITLE OF RESEARCH PROJECT:

Supracondylar Suspension of BK Prostheses

NAME OF RESPONSIBLE INVESTIGATOR:

Mr. J. Zettl

NAME OF INSTITUTION:

Veterans Administration Hospital, Seattle, Washington, U.S.A.

OBJECTIVE OF THE PROJECT:

To develop a method for suspending BK prostheses.

METHOD USED:

Fabricated wedges are made and fitted between the medial femoral condylar flare and the medial side of the BK socket to form a suspension hook over the medial femoral condylar flare.

STATUS OF THE PROJECT:

FUTURE PLANS:

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TITLE OF RESEARCH PROJECT:

Direct Forming of Sockets

NAME OF RESPONSIBLE INVESTIGATOR:

Mr. Hank Gardner

NAME OF INSTITUTION:

Veterans Administration Prosthetics Center, New York City, U.S.A.

OBJECTIVE OF THE PROJECT:

To develop a technique for the direct forming of sockets on the stumps of amputees.

METHOD USED:

Polysar, a balata rubber which softens at approximately 180°F, is pulled onto the stump. While the polysar is still moldable, a pressure sleeve is drawn over the polysar-covered stump and compressed to force the polysar against the stump. The formed socket is attached to the prosthesis and minor modifications are made as the amputee tries out the socket.

STATUS OF THE PROJECT:

The technique has been sufficiently advanced to permit its use for fabrication of prostheses for BK amputees during the early part of their rehabilitation.

FUTURE PLANS:

To refine the technique, to disseminate informtion, and to extend use of the technique to other applications which seem compatible.

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TITLE OF RESEARCH PROJECT:

Follow-up Study of Lower-limb Amputees.

NAME OF RESPONSIBLE INVESTIGATOR:

F. O. Petersen

NAME OF INSTITUTION:

University Hospital, Copenhagen, Denmark

OBJECTIVE OF THE PROJECT:

To study the late fate of lower-limb amputees, medically and socially.

METHOD USED:

Investigations based on records and interviews.

STATUS OF THE PROJECT:

Material collected, analysis going on.

FUTURE PLANS:

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TITLE OF RESEARCH PROJECT:

Evaluation of Porous (AMBRL) Laminate Patellar-Tendon-Bearing BK Prosthesis

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. S. Fishman

NAME OF INSTITUTION:

New York University, New York, U.S.A.

OBJECTIVE OF THE PROJECT:

To evaluate the value of porous laminates for socket construction as a means of reducing effects of perspiration on comfort and skin health.

METHOD USED:

Amputees were fitted with prostheses which had porous laminate sockets.

STATUS OF THE PROJECT:

The study has been completed and a report, "The AMBRL Porous Laminate Patellar-Tendon-Bearing Prosthesis," has been published as a technical report by Mr. Clyde M. E. Dolan.

FUTURE PLANS:

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TUESDAY, April 29, 1969

Moderator: *Gordon Robin*

II. UPPER-EXTREMITY PROSTHETICS

- *A. Fundamental Studies*
- *B. Body-Powered Prostheses*
- *C. Externally Powered Prostheses*
  1. *Terminal Devices*
  2. *Elbows*
  3. *Other Components*
  4. *Complete Systems*
  5. *Power Packages*
- *D. Control System Studies*
- *E. Cosmesis, Sensation*

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UPPER-EXTREMITY PROSTHETICS

FUNDAMENTAL STUDIES

TITLE OF RESEARCH PROJECT:

Introducing Modern Techniques into Everyday Practice in Fitting the Patients of Orthopaedic and Rehabilitation Clinics

NAME OF RESPONSIBLE INVESTIGATOR:

Wieslaw Miedzyblocki, M.Sc.

NAME OF INSTITUTION:

Orthopaedic Workshop of Medical Academy,
Poznan, Poland.

OBJECTIVE OF THE PROJECT:

To help both Clinics in solving technical problems connected with rehabilitation of the patients.

METHOD USED:

Mostly methods adapted from leading specialistic Centres in advanced countries.

STATUS OF THE PROJECT:

As it is no definite project it is difficult to speak about the status.

FUTURE PLANS:

Introducing external power into prosthetic and orthotic practice.

Evaluation of different muscles which are used in upper-extremity prosthetics.

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TITLE OF RESEARCH PROJECT:

Restitution of Activity in Cases of Disfunction of Upper Extremities

NAME OF RESPONSIBLE INVESTIGATOR:

Janina Tomaszewska, M.D., Ass't. Prof.

NAME OF INSTITUTION:

Rehabilitation Department of Academy of Medicine, Poznan, Poland.

OBJECTIVE OF THE PROJECT

The investigation work on the activities of particular muscle groups during their work, as well as evaluation of the results obtained on patients with disfunctions or amputations of the upper extremity, supplied with prosthesis or orthotic appliances.

METHOD USED:

We want to adapt the methods worked out in other countries.

STATUS OF THE PROJECT:

It has not yet started.

FUTURE PLANS:

They are given under the title of Research Project.

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UPPER-EXTREMITY PROSTHETICS

FUNDAMENTAL STUDIES

TITLE OF RESEARCH PROJECT:

Needs Analysis, Upper-Extremity Prosthetics

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. Stig Jonsäter

NAME OF INSTITUTION:

Eugeniahammet, Stockholm, Sweden

OBJECTIVE OF THE PROJECT:

To examine the domestic market with regard to upper-extremity prostheses and to inquire into the need for these from the standpoint of the social economy, and the needs for the individual wearers of a prosthesis from the psychological aspect.

METHOD USED:

STATUS OF THE PROJECT:

A preliminary investigation has been performed with grants made available by Norrbackainstitutet and Handikapp-Institutet. Social-psychology part of investigation is being finished.

FUTURE PLANS:

Individual investigation of amputees will start as soon as running investigation is finished.

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TITLE OF RESEARCH PROJECT:

Veterans Administration Prosthetics Center
Direct Forming of Upper-Extremity Sockets

NAME OF RESPONSIBLE INVESTIGATOR:

Mr. Clyde M. E. Dolan

NAME OF INSTITUTION:

New York University, Prosthetic Devices Study
New York City, U.S.A.

OBJECTIVE OF THE PROJECT:

Development of a technique to form the socket directly on the stump.

METHOD USED:

Heating a synthetic rubber tube by immersion in hot water until pliable and drawing over the stump to form the socket.

STATUS OF THE PROJECT:

Undergoing preliminary evaluation at New York University.

FUTURE PLANS:

Continued limited clinical trials.

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TITLE OF RESEARCH PROJECT:

Upper-Extremity Kinematic Studies

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. William A. Spencer
Mr. Thorkild J. Engen

NAME OF INSTITUTION:

Texas Institute for Rehabilitation and Research
Houston, Texas, U.S.A.

OBJECTIVE OF THE PROJECT:

To establish an objective description of normal upper-extremity movements as they relate to acceleration, velocity, deceleration, and changing angulations.

METHOD USED:

In collaboration with the Veterans Administration Prosthetics Center, normal subjects were photographed with movie camera while performing various activities. Computer analysis was intended but was found to be economically unfeasible.

STATUS OF PROJECT:

Photographic information is now being analyzed manually.

FUTURE PLANS:

Completion of analysis and reporting of results.

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TITLE OF RESEARCH PROJECT:

1. Prefabricated Arm Sockets
2. Polysar Sockets

NAME OF RESPONSIBLE INVESTIGATOR:

Mr. Colin A. McLaurin

NAME OF INSTITUTION:

Prosthetic Research and Training Unit, Ontario Crippled Children's Centre, Toronto, Canada

OBJECTIVE OF THE PROJECT:

1. To arrive at prefabricated socket shapes for above-elbow amputees so that sockets can be available for use on training prostheses.

2. To develop techniques for socket fabrication using polysar, and determining its limits and practical prospects as a socket material.

METHOD USED:

1. Forms for fabrication of prefabricated upper-arm sockets were made, and sockets of plastic laminate made over these were tried on amputees.

2. Polysar sockets have been made for a variety of rehabilitation problems, including amputation sockets, special devices such as splints and contoured seats.

STATUS OF THE PROJECT:

1. Molds are available for the fabrication of prefabricated upper-arm sockets and these are suitable for general application at the clinical level for at least new amputees, and possibly for mature ones.

2. Polysar sockets and custom-made body forms are suitable for general clinical use in a variety of situations. Perspiration has a deleterious effect on the material. High loads deform it.

FUTURE PLANS:

To broaden experience with it through clinical application.

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TITLE OF RESEARCH PROJECT:

Upper-Extremity Modular System

NAME OF RESPONSIBLE INVESTIGATOR:

Mr. D. W. Collins

NAME OF INSTITUTION:

Hugh Steeper and Co., Ltd., Roehampton, England.

OBJECTIVE OF THE PROJECT:

To develop a modular system to enable rapid assembly of arms for all levels of amputation, and to permit easy interchange of any alternative mechanism.

METHOD USED:

Engineering development.

STATUS OF THE PROJECT:

Prototypes have been made.

FUTURE PLANS:

Development to production stage.

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TITLE OF RESEARCH PROJECT:

Prehension Device

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. A. H. Bottomley

NAME OF INSTITUTION:

Biomechanical Research and Development Unit,
Roehampton, England.

OBJECTIVE OF THE PROJECT:

A new terminal device incorporating some of the features of a hook and some of a hand in an attempt to improve function and cosmesis.

METHOD USED:

An articulated "thumb" controlled by a 4-bar linkage is incorporated. Finger tip, 3-point and hook grasp are possible.

STATUS OF THE PROJECT:

Prototypes have been made as pneumatically powered devices for amelic children.

FUTURE PLANS:

Conversion to cable control to enable trial by experienced amputees.

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TITLE OF RESEARCH PROJECT:

1. Upper-Extremity Prosthetics
   a. Skeleton Technique
   b. Openend Prostheses
   c. Development of Component Parts and Control Systems
2. Externally Powered Prostheses

NAME OF RESPONSIBLE INVESTIGATOR:

Kuhn, Goetz-Gerd, Prof., M.D.

NAME OF INSTITUTION:

University of Muenster, Orthopaedic Hospital,
Department of Orthopaedic Techniques and Rehabilitation,
Muenster/Westfalen, Germany.

OBJECTIVE OF THE PROJECT:

Amelioration of function and cosmetics, comfort and efficiency of artificial arms.

METHOD USED:

Creation, construction, realization, application, evaluation, all in the same center.

STATUS OF THE PROJECT:

This project has high priority.

FUTURE PLANS:

Continuation of projects and dissemination of the results of same.

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TITLE OF RESEARCH PROJECT:

Unitized Passive Infant Arm

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. Yoshio Setoguchi
Mr. Carl Sumida

NAME OF INSTITUTION:

University of California at Los Angeles
Child Amputee Prosthetics Project
Los Angeles, California, U.S.A.

OBJECTIVE OF THE PROJECT:

To provide a cosmetically improved unitized or modular infant arm which can be manually positioned.

METHOD USED:

The arm is composed of the new design CAPP terminal device, an endoskeletal structure with modular components and a soft cosmetic covering, and a simple locking device for the elbow and/or shoulder.

STATUS OF THE PROJECT:

Trial fitting of below-elbow and above-elbow arms.

FUTURE PLANS:

Production of prototypes for field evaluation.

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TITLE OF RESEARCH PROJECT:

Terminal Device Design

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. Yoshio Setoguchi
Mr. Carl Sumida

NAME OF INSTITUTION:

University of California at Los Angeles
Child Amputee Prosthetics Project
Los Angeles, California, U.S.A.

OBJECTIVE OF THE PROJECT:

To provide a terminal device with improved function and cosmesis for child amputees.

METHOD USED:

The final design has a wide, contoured palmar section with a spring-loaded movable thumb which can be activated by center pull.

STATUS OF THE PROJECT:

Production of prototypes for evaluation.

FUTURE PLANS:

Field test and evaluation.

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TITLE OF RESEARCH PROJECT:

Gilmatic Extendo-Flex Wrist Unit with Either External or Axial Control

NAME OF RESPONSIBLE INVESTIGATOR:

Mr. Gilbert Motis

NAME OF INSTITUTION:

Gilmatic, Northridge, California, U.S.A.

OBJECTIVE OF THE PROJECT:

Provide wrist flexion for upper-extremity prosthesis.

METHOD USED:

Cable extends tube distally in an offset angle producing wrist flexion.

STATUS OF THE PROJECT:

Models are available for limited clinical trials.

FUTURE PLANS:

Two units will be fitted, one by Mr. A. Muilenburg, one by Mr. C. Nelson.

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TITLE OF RESEARCH PROJECT:

Rimjet Turntable (Designed by Mr. J. Ivko)

NAME OF RESPONSIBLE INVESTIGATOR:

Mr. Thomas Pirrello

NAME OF INSTITUTION:

Veterans Administration Prosthetics Center
New York, New York, U.S.A.

OBJECTIVE OF THE PROJECT:

Application and utility of humeral rotation device.

METHOD USED:

Incorporate into a prosthesis of a small number of appropriate patients and test for effectiveness.

STATUS OF THE PROJECT:

Selection of patients difficult due to excessive weight and special harnessing requirements.

FUTURE PLANS:

Continued subject selection.

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TITLE OF RESEARCH PROJECT:

OCCC Electric Hook

NAME OF RESPONSIBLE INVESTIGATOR:

Mr. Colin A. McLaurin

NAME OF INSTITUTION:

Ontario Crippled Children's Centre
Toronto, Ontario, Canada

OBJECTIVE OF THE PROJECT:

Development of externally powered terminal device.

METHOD USED:

Battery power,control by active body motion, child-size, two-finger prehension.

STATUS OF THE PROJECT:

Development work and clinical application in process.

FUTURE PLANS:

Continued development evaluation.

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TITLE OF RESEARCH PROJECT:

Northern Electric Hydraulic Hand

NAME OF RESPONSIBLE INVESTIGATOR:

Mr. H. Lukas

NAME OF INSTITUTION:

Northern Electric Company, Ottawa, Canada.

OBJECTIVE OF THE PROJECT:

Development of externally powered terminal device.

METHOD USED:

Child-size battery-operated hydraulic pump and solenoid valve controlled by active body motion.

STATUS OF THE PROJECT:

Development of additional control system in progress.

FUTURE PLANS:

Continued development evaluation.

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TITLE OF RESEARCH PROJECT:

RIM Myo-Electric Control Hand

NAME OF RESPONSIBLE INVESTIGATOR:

Mr. C. Corriveau

NAME OF INSTITUTION:

Rehabilitation Institute of Montreal
Montreal, Canada.

OBJECTIVE OF THE PROJECT:

Development of externally powered terminal device.

METHOD USED:

Battery powered,control by means of EMG electrodes.

STATUS OF THE PROJECT:

Units commercially available. Device presently under evaluation.

FUTURE PLANS:

Continued evaluation study.

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TITLE OF RESEARCH PROJECT:

Design of Externally Powered Hand Prosthesis

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. D. C. Simpson

NAME OF INSTITUTION:

Orthopaedic Bio-Engineering Unit, Princess Margaret Rose Orthopaedic Hospital, Fairmilehead, Edinburgh, Scotland.

OBJECTIVE OF THE PROJECT:

Production of powered child's hand with much improved performance.

METHOD USED:

STATUS OF THE PROJECT:

In progress.

FUTURE PLANS:

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TITLE OF RESEARCH PROJECT:

Electromechanical Prosthetic Hand
(The SVEN Hand)

NAME OF RESPONSIBLE INVESTIGATOR:

Mats Wager

NAME OF INSTITUTION:

Research Institute of the Swedish National Defense
Stockholm, Sweden.

OBJECTIVE OF THE PROJECT:

The purpose is to develop an electrically controlled artificial arm for a below-elbow amputee. The intention is to furnish it with four separately controlled electromechanical mechanisms for finger flexion, thumb rotation, dorso-palmar flexion, and pro-supination. All controls proportional. Adaptive grip.

METHOD USED:

High quality electric motors and gear mechanisms are used. The force is transmitted to the fingers and thumb by a polyester-silk cord, treated for minimum elongation. The overall efficiency of the system is optimized.

STATUS OF THE PROJECT:

The hand, the gear mechanisms, and the electric control-circuits have been built and tested. Sockets, soft tissues, and cosmetic gloves (see separate project) are being developed. All current work is directed towards functional tests of the total device under laboratory conditions.

FUTURE PLANS:

Functional tests during 1969, immediately followed by thus indicated modifications. Clinical tests, hopefully starting after further a year. Final modifications will then be carried on.

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TITLE OF RESEARCH PROJECT:

AMBRL Piezo-Electric Hand

NAMES OF RESPONSIBLE INVESTIGATORS:

Mr. Albert Colman
Mr. Lloyd Salisbury

NAME OF INSTITUTION:

U.S. Army Medical Biomechanical Research Laboratory, Walter Reed Army Medical Center, Forest Glen Section, Washington, D.C., U.S.A.

OBJECTIVE OF THE PROJECT:

Development of externally powered terminal device.

METHOD USED:

Hand mechanisms and servomotor are contained in a skeleton-type hand frame with resilient foam exterior. It incorporates a slippage-detection system (piezo-electrical crystal). Battery power, control by active body motion.

STATUS OF THE PROJECT:

Undergoing test at AMBRL to determine compliance with standards and specifications.

FUTURE PLANS:

Continued development evaluation.

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TITLE OF RESEARCH PROJECT:

Viennatone Myo-Electric Control Hand

NAME OF RESPONSIBLE INVESTIGATOR:

Mr. M. Pollak

NAME OF INSTITUTION:

Fidelity Electronics Corporation, Chicago, Illinois, U.S.A.

OBJECTIVE OF THE PROJECT:

Development of externally powered terminal device.

METHOD USED:

Battery power, control by means of EMG electrodes.

STATUS OF THE PROJECT:

Units commercially available. Device presently under evaluation.

FUTURE PLANS:

Continued evaluation study.

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TITLE OF RESEARCH PROJECT:

Belgrade Electric Hand

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. R. Tomovic

NAME OF INSTITUTION:

University of Belgrade, Belgrade, Yugoslavia

OBJECTIVE OF THE PROJECT:

Development of externally powered terminal device.

METHOD USED:

Battery operated, control by means of active body motion.

STATUS OF THE PROJECT:

Model not in working condition.

FUTURE PLANS:

Undetermined.

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TITLE OF RESEARCH PROJECT:

Evaluation of the Belgrade Electronic Hand

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. Milica Kajganic

NAME OF INSTITUTION:

Center for Prosthetics, Belgrade, Yugoslavia

OBJECTIVE OF THE PROJECT:

Evaluation of the hand.

METHOD USED:

Battery of tests developed for evaluation of different amputation levels.

STATUS OF THE PROJECT:

SRS Project (under way).

FUTURE PLANS:

Further development of evaluation means, including different hands and types of upper-extremity prostheses in total.

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TITLE OF RESEARCH PROJECT:

Application of Electronics in the Field of Prosthetics and Orthotics

NAME OF RESPONSIBLE INVESTIGATOR:

Strhinja Kispatic, Dipl. Ing.

NAME OF INSTITUTION:

Center for Prosthetics, Belgrade, Yugoslavia.

OBJECTIVE OF THE PROJECT:

Designs of simplified hands and orthotic devices for upper extremity, testing and evaluation; comparison with the present approaches and designs.

METHOD USED:

Design - developments, fitting of the patients, evaluation.

STATUS OF THE PROJECT:

Local project (under way)

FUTURE PLANS:

Continuation of work.

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TITLE OF RESEARCH PROJECT:

OCCC Electric Elbow

NAME OF RESPONSIBLE INVESTIGATOR:

Mr. Colin A. McLaurin

NAME OF INSTITUTION:

Ontario Crippled Children's Centre
Toronto, Ontario, Canada

OBJECTIVE OF THE PROJECT:

Development of externally powered elbow.

METHOD USED:

Analysis of the mechanical and functional characteristics, patient performance and compatibility with current techniques. Battery power, switch control by active body motion.

STATUS OF THE PROJECT:

Units (child's size) are available in limited quantity.

FUTURE PLANS:

Special application field study.

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TITLE OF RESEARCH PROJECT:

Electrically Operated Pneumatic Elbow

NAME OF RESPONSIBLE INVESTIGATOR:

Eskil Ulén

NAME OF INSTITUTION:

Research Institute of the Swedish National Defense
Stockholm, Sweden.

OBJECTIVE OF THE PROJECT:

The purpose is to develop an elbow with, among other things, voluntarily operated dynamic stiffness. The device will be powered pneumatically (CO_2 40-50 bar) but to permit adaptation to electrical input signals (e.g. EMG) an electrically operated pneumatic valve is being designed.

METHOD USED:

STATUS OF THE PROJECT:

An experimental system is developed and tested. The system is equipped with specially developed valves and has a locking device. Preliminary functional tests are being performed.

FUTURE PLANS:

The experience from the experimental system will be used in designing a more definite system that will be subject to clinical tests.

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TITLE OF RESEARCH PROJECT:

AIPR Pneumatic Powered Elbow

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. Edward A. Kiessling

NAME OF INSTITUTION:

American Institute for Prosthetic Research
Greenlawn, New York, U.S.A.

OBJECTIVE OF THE PROJECT:

Development of externally powered elbow.

METHOD USED:

Analysis of mechanical and functional characteristics, patient performance and compatibility with current techniques. CO_2 power, switch control by active body motion.

STATUS OF THE PROJECT:

Unit in limited production.

FUTURE PLANS:

Special application field study in progress.

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TITLE OF RESEARCH PROJECT:

AMBRL Electric Elbow

NAMES OF RESPONSIBLE INVESTIGATORS:

Mr. Albert Colman
Mr. Lloyd Salisbury

NAME OF INSTITUTION:

U.S. Army Medical Biomechanical Research Laboratory, Walter Reed Army Medical Center, Forest Glen Section, Washington, D.C., U.S.A.

OBJECTIVE OF THE PROJECT:

Development of externally powered elbow.

METHOD USED:

Analysis of the mechanical and functional characteristics, patient performance and compatibility with current prosthetic techniques. Battery power, switch control by active body motion.

STATUS OF THE PROJECT:

Prototype and engineering drawings in process for fabrication of limited number of units (25).

FUTURE PLANS:

Continued development evaluation.

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TITLE OF RESEARCH PROJECT:

Gilmatic Electric Elbow

NAME OF RESPONSIBLE INVESTIGATOR:

Mr. Gilbert Motis

NAME OF INSTITUTION:

Gilmatic, Northridge, California, U.S.A.

OBJECTIVE OF THE PROJECT:

Development of externally powered elbow.

METHOD USED:

Analysis of the mechanical and functional characteristics, patient performance and compatibility with current techniques. Battery power, switch control by active body motion.

STATUS OF THE PROJECT:

Prototypes and engineering drawings in process for fabrication of limited number of units (25).

FUTURE PLANS:

Continued development evaluation.

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TITLE OF RESEARCH PROJECT:

Boston Arm

NAME OF RESPONSIBLE INVESTIGATOR:

Mr. C. Ohlenbush

NAME OF INSTITUTION:

Liberty Mutual Company, Boston, Massachusetts, U.S.A.

OBJECTIVE OF THE PROJECT:

Development of externally powered elbow.

METHOD USED:

Analysis of the mechanical and functional characteristics, patient performance and compatibility with current techniques. Battery power, control by EMG electrodes.

STATUS OF THE PROJECT:

Units are commercially available.

FUTURE PLANS:

Continued development evaluation.

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TITLE OF RESEARCH PROJECT:

Rancho Electric Elbow

NAMES OF RESPONSIBLE INVESTIGATORS:

Mr. J. Allen
Mr. A. Karchak

NAME OF INSTITUTION:

Rancho Los Amigos Hospital, Inc.
Downey, California, U.S.A.

OBJECTIVE OF THE PROJECT:

Development of externally powered elbow.

METHOD USED:

Analysis of mechanical and functional characteristics, patient performance and compatibility with current techniques. Battery power, switch control by active body motion.

STATUS OF THE PROJECT:

Unit is commercially available in three sizes.

FUTURE PLANS:

Special application field study.

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TITLE OF RESEARCH PROJECT:

VAPC Electric Elbow

NAME OF RESPONSIBLE INVESTIGATOR:

Mr. C. Mason

NAME OF INSTITUTION:

Veterans Administration Prosthetics Center
New York, New York, U.S.A.

OBJECTIVE OF THE PROJECT:

Development of externally powered elbow.

METHOD USED:

Analysis of the mechanical and functional characteristics, patient performance and compatibility with current techniques. Battery power, switch control by active body motion.

STATUS OF THE PROJECT:

Redesigned model in process to reduce the noise and improve the efficiency.

FUTURE PLANS:

Continued development.

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TITLE OF RESEARCH PROJECT:

Powered Devices

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. A. B. Kinnier Wilson

NAME OF INSTITUTION:

Medical Research Council's Powered Limbs Research Unit
Hendon, England.

OBJECTIVE OF THE PROJECT:

Wide program in the application of power to prosthetic and orthotic devices.

METHOD USED:

STATUS OF THE PROJECT:

FUTURE PLANS:

Proformas have been sent to Dr. Kinnier Wilson asking him to complete them in respect to the current projects.

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TITLE OF RESEARCH PROJECT:

Powered Prostheses and Orthoses

NAME OF RESPONSIBLE INVESTIGATOR:

Mr. Nigel Ring

NAME OF INSTITUTION:

Lady Hoare Experimental Workshop
Chailey Heritage Hospital and Craft Schools
Sussex, England.

OBJECTIVE OF THE PROJECT:

Sundry developments in the application of pneumatically powered systems to dysmelic children and other disabled.

METHOD USED:

Ad hoc developments. Engineering services support a clinical program in a residential hospital/school for handicapped children. Mr. Ring is probing particularly control problems, (including a gas-powered orthosis featuring a position servo) in support of a more fundamental study on these problems.

STATUS OF THE PROJECT:

Hardware is fitted to resident patients as developed on a partly experimental/partly clinical basis.

FUTURE PLANS:

Design of hardware to exploit the findings of the above studies.

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TITLE OF RESEARCH PROJECT:

AIPR Wrist-Flexion and Rotation Unit

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. Edward Kiessling

NAME OF INSTITUTION:

American Institute for Prosthetic Research
Greenlawn, New York, U.S.A.

OBJECTIVE OF THE PROJECT:

To provide wrist flexion and passive pronation and supination.

METHOD USED:

CO_2 powered thrust rod connected to polycentric pivot.

STATUS OF THE PROJECT:

Nine models ranging from child to adult sizes are in production.

FUTURE PLANS:

Field study evaluation.

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TITLE OF RESEARCH PROJECT:

Gilmatic Electric Elbow Lock

NAME OF RESPONSIBLE INVESTIGATOR:

Mr. Gilbert Motis

NAME OF INSTITUTION:

Gilmatic, Northridge, California, U.S.A.

OBJECTIVE OF THE PROJECT:

Electrical Control of Elbow Lock

METHOD USED:

Electrically operated Solenoid switch mounted in the socket and activated by bulging residual stump muscles.

STATUS OF THE PROJECT:

Twelve models, six for adults and six for children are being fabricated.

FUTURE PLANS:

Prototypes will be fitted to subjects for limited clinical trials.

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TITLE OF RESEARCH PROJECT:

Gilmatic Combined-Motion Adjustable Screw Activator for Shoulder-Disarticulation Prosthesis

NAME OF RESPONSIBLE INVESTIGATOR:

Mr. Gilbert Motis

NAME OF INSTITUTION:

Gilmatic, Northridge, California, U.S.A.

OBJECTIVE OF THE PROJECT:

Combine and coordinate motions at the shoulder joint of a shoulder-disarticulation prosthesis.

METHOD USED:

Development of an electrically powered "phase-shifting" control to permit selection of several modes in prepositioning the shoulder joint.

STATUS OF THE PROJECT:

Design changes were in progress.

FUTURE PLANS:

Continued development.

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TITLE OF RESEARCH PROJECT:

N.U. Power Assist

NAME OF RESPONSIBLE INVESTIGATOR:

Mr. E. Grahn

NAME OF INSTITUTION:

Northwestern University Prosthetics Research Center
Chicago, Illinois, U.S.A.

OBJECTIVE OF PROJECT:

An assist to body power by utilizing electrical power for terminal device and elbow flexion.

METHOD USED:

Actuated by conventional body motions, an electric motor takes up slack in the control cable.

STATUS OF THE PROJECT:

Three units presently being worn by amputees with a fourth unit in process for use with wrist rotator and electric hand controlled by a seven-mode controller.

FUTURE PLANS:

Continued development.

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TITLE OF RESEARCH PROJECT:

N. U. Powered Wrist Rotator

NAME OF RESPONSIBLE INVESTIGATOR:

Mr. E. Grahn

NAME OF INSTITUTION:

Northwestern University Prosthetics Research Center
Chicago, Illinois, U.S.A.

OBJECTIVE OF THE PROJECT:

To provide externally powered wrist rotation.

METHOD USED:

Wrist rotation utilizing harmonic drive for power transmission.

STATUS OF THE PROJECT:

Two units presently being worn, a third under construction. Features an improved design.

FUTURE PLANS:

Continued development.

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TITLE OF RESEARCH PROJECT:

VAPC Humeral Rotator

NAME OF RESPONSIBLE INVESTIGATOR:

Mr. C. Mason

NAME OF INSTITUTION:

Veterans Administration Prosthetics Center
New York, New York, U.S.A.

OBJECTIVE OF THE PROJECT:

Externally powered humeral rotator

METHOD USED:

Rotation is controlled by means of two double-throw shear switches located into the wall of the socket, in contact with the stump. Axial rotation of the stump controls directional power input.

STATUS OF THE PROJECT:

A new control switch is being fabricated.

FUTURE PLANS:

Continued development.

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TITLE OF RESEARCH PROJECT:

Application of Pneumatics in the Field of Upper- and Lower-Extremity Prosthetics

NAME OF RESPONSIBLE INVESTIGATOR:

Co-Investigator: Luba Gavrilovic, Dipl. Ing.
Co-Investigator: Dr. Bosco Zotovic

NAME OF INSTITUTION:

Center for Prosthetics, Belgrade, Yugoslavia.

OBJECTIVE OF THE PROJECT:

Development and design of new prosthetic devices pneumatically operated for the most difficult upper-extremity amputations, particularly for bilateral shoulder-disarticulation cases. Coordinated motion, with eight and six deg. of freedom with respect to the dominant side; selection of motion by the amputee with respect to his needs and vocational potential, design of a pneumatic knee unit in three different versions.

METHOD USED:

New designs, training and evaluation - laboratory and field.

STATUS OF THE PROJECT:

Pending SRS project (locally under way).

FUTURE PLANS:

Continuation of above-mentioned work, combination of two power sources - electronic and pneumatic, with the final goal of developing electropneumatic upper-extremity prostheses.

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TITLE OF RESEARCH PROJECT:

Development of Externally Powered Upper-Extremity Prosthetic Devices

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. Maurice Mongeau

NAME OF INSTITUTION:

Rehabilitation Institute of Montreal
Montreal, Quebec, Canada.

OBJECTIVE OF THE PROJECT:

Powered artificial arms for children.

METHOD USED:

Fabrication and fitting of electrically powered, EMG controlled arms and new electrohydraulically powered, bodily controlled arms.

STATUS OF THE PROJECT:

Continuing.

FUTURE PLANS:

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TITLE OF RESEARCH PROJECT:

Powered Upper Limb

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. A. H. Bottomley

NAME OF INSTITUTION:

Biomechanical Research and Development Unit
Roehampton, London, England.

OBJECTIVE OF THE PROJECT:

To design a pneumatic powered arm for 8-10-year-old amelic children, incorporating radius vector movements and constant attitude of wrist platform in relation to the table surface.

METHOD USED:

The design follows ideas developed by Dr. David Simpson. Shoulder is self-locking and uses gravity-assisted movement.

STATUS OF THE PROJECT:

Prototype about two-thirds developed. Wrist and terminal device in drawing office.

FUTURE PLANS:

Clinical application for functional assessment. Study of control made.

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TITLE OF RESEARCH PROJECT:

Interfaces in Powered Prosthetics

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. A. B. Kinnier Wilson

NAME OF INSTITUTION:

Medical Research Council, Powered Limbs Research Unit,
West Hendon Hospital, London, N.W. 9, England.

OBJECTIVE OF THE PROJECT:

To clarify the rationale of use of specific engineering techniques for the specific types of disability encountered.

METHOD USED:

Analysis of the existing interfaces between parts of the system. What is transferred across the interface and what should be for optimum usage, in the light of the characteristics of particular interfaces as they exist in specific disabilities.

STATUS OF THE PROJECT:

Collection of information of current engineering techniques. Analysis of the status of interfaces in specific disabilities.

FUTURE PLANS:

Analysis and correlation of the above.

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TITLE OF RESEARCH PROJECT:

Children's Research Prosthesis Project

NAMES OF RESPONSIBLE INVESTIGATORS:

R. McWilliam (Principal Investigator, Physiologist)
S. R. Montgomery (Mechanical Engineer)
J. C. Chapman (Mechanical Engineer)
D. D. Sanderson (Designer Draughtsman)
W. Godfrey (Technical Research Assistant)

NAME OF INSTITUTION:

Medical Research Council, Powered Limbs Research Unit,
West Hendon Hospital, London, N.W.9, England
in cooperation with
Children's Prosthetics Unit, Queen Mary's Hospital,
Roehampton, London, England.

OBJECTIVE OF THE PROJECT:

Investigation of (a) value to young dysmelic children of a powered arm prosthesis specifically intended to enable them to carry out ADL in a normal environment, (b) problems of providing movements and forces needed for task performance, within limitations of available control outputs and acceptable weight and space, (c) systematic method of designing and evaluating such a device.

METHOD USED:

Entire process of detailed specification, design, construction, fitting, and evaluation of complete prostheses for three selected children, with accompanying experimental work and recording of biological and engineering data.

STATUS OF THE PROJECT:

Most of design and construction work completed; control tests being run on individual actuators, before assembly of first prototype.

FUTURE PLANS:

(a) Completion and fitting of prosthesis to the patients.

(b) Evaluation of prosthesis on the patients (extending to comparison with other systems, in laboratory and/or field).

(c) Examination of any specific problems arising out of (b) and development of prosthesis to an acceptable level.

(d) Development and possible incorporation of electro-pneumatic control system.

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TITLE OF RESEARCH PROJECT:

1. Upper-Extremity Prosthetics
   a. Skeleton Technique
   b. Openend Prostheses
   c. Development of Component Parts and Control Systems
2. Externally Powered Prostheses

NAME OF RESPONSIBLE INVESTIGATOR:

Kuhn, Goetz-Gerd, Prof., M.D.

NAME OF INSTITUTION:

University of Muenster, Orthopaedic Hospital
Department of Orthopaedic Techniques and Rehabilitation
Muenster/Westfalen, Germany

OBJECTIVE OF THE PROJECT:

Amelioration of function and cosmetics, comfort and efficiency of artificial arms.

METHOD USED:

Creation, construction, realization, application, evaluation, all in the same center.

STATUS OF THE PROJECT:

This project has high priority.

FUTURE PLANS:

Continuation of projects and dissemination of the results of same.

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TITLE OF RESEARCH PROJECT:

Further Development of the Pneumatic Prosthesis for Amelia and Phocomelia of the Upper Extremities (for example, a new type of pneumatic prosthesis for phocomelia incomplete)

NAMES OF RESPONSIBLE INVESTIGATORS:

Dr. Ernst Marquardt
Dr. Roesler

NAME OF INSTITUTION:

Orthop. Klinik u. Poliklinik d. Univ.
Abtellung f. Dysmelien u. techn. Orthopädie
Heidelberg, Germany

OBJECTIVE OF THE PROJECT:

Pneumatic prostheses for amelia and phocomelia incomplete.

METHOD USED:

Experimental.

STATUS OF THE PROJECT:

The development of a new type of prosthesis for phocomelia incomplete is finished.

FUTURE PLANS:

Change from the pneumatic to the electric system.

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TITLE OF RESEARCH PROJECT:

A New Limb for Thalidomide Children

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. D. Busso

NAME OF INSTITUTION:

TECHNION, Israel Institution of Technology
Haifa, Israel.

OBJECTIVE OF THE PROJECT:

Development of an upper-limb powered prosthesis with 6 deg. of freedom using a rotatory actuator.

METHOD USED:

A new type of artificial muscle ("pouch actuator") has been developed. A working model has been successfully developed using CO_2 power, controlled by micro switches.

STATUS OF THE PROJECT:

A successful prosthesis has been developed and clinical trials are now being started.

FUTURE PLANS:

Future plans to introduce electronic control of the CO_2 powered prosthesis possibly by using electromyographic potentials as the control mechanism.

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TITLE OF RESEARCH PROJECT:

Design and Development of a Complete Externally Powered Arm with Position Servo Control of Spherical Polar Coordinates of the Hand

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. D. C. Simpson

NAME OF INSTITUTION:

Orthopaedic Bio-Engineering Unit
Princess Margaret Rose Orthopaedic Hospital
Fairmilehead, Edinburgh, Scotland.

OBJECTIVE OF THE PROJECT:

Fitting prostheses to patients.

METHOD USED:

STATUS OF THE PROJECT:

Three years already spent. Five design models built, prototype for fitting now under construction. Position servo system with feedback of position, four complete.

FUTURE PLANS:

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TITLE OR RESEARCH PROJECT:

Development and Application of Externally Powered Arms for Thalidomide Children

NAME OF RESPONSIBLE INVESTIGATOR:

Mr. Bo Klasson

NAME OF INSTITUTION:

Norbackainstitutet, Stockholm, Sweden.

OBJECTIVE OF THE PROJECT:

Increase prosthetic function for amelic and phocomelic cases. Development of prosthetic systems and, if necessary, components for these systems. Development of more reliable methods for need analysis, assessment and specification.

METHOD USED:

Pneumatic arm systems, consisting of commercially available and, to some extent, own original actuators in combination with own original valves for the control are tested on amelic and phocomelic children and adult shoulder disarticulees.

STATUS OF THE PROJECT:

Valve program in principle finished. New assessment program recently started.

FUTURE PLANS:

Further development of systems from the specifications that can be derived from the assessment of current systems.

Marketing of developed components for pneumatic control.

Development of automatic lock for pneumatic elbow, shoulder and wrist.

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TITLE OF RESEARCH PROJECT:

Hydraulic Hardware for Upper-Extremity Prostheses

NAME OF RESPONSIBLE INVESTIGATOR:

Mr. A. K. Godden

NAME OF INSTITUTION:

University of Oxford, Department of Engineering Science
Oxford, England, (Prof. D. W. Holder, F.R.S.)

OBJECTIVE OF THE PROJECT:

(a) Design of electro/hydraulic power pack.

(b) Design of a range of actuators and valves.

METHODS USED:

There are no commercially available components for pumps and accumulators small enough for prosthetic application. A vane pump is being designed with an elastic accumulator to give five watts peak output and two and one-half watts continuing. This is thought to be maximum consistent with portability.

STATUS OF THE PROJECT:

First prototype undergoing testing.

FUTURE PLANS:

Feasibility study of a full hydraulic prosthetic system.

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TITLE OF RESEARCH PROJECT:

CO_2 Power Pack

NAME OF RESPONSIBLE INVESTIGATOR:

Mr. C. Snowdon

NAME OF INSTITUTION:

Biomechanical Research and Development Unit
Department of Health and Social Security
Roehampton, London, England.

OBJECTIVE OF THE PROJECT:

Design of CO_2 storage pack of maximum portable capacity.

METHOD USED:

(a) Modification of a standard welded high tensile steel bottle marketed by Bristol Aerojet.

(b) Incorporation of regulator designed by Royal Aircraft Establishment, providing optimal flow rates, heat transfer, etc. for operation in all attitudes, with complete inbuilt safety.

STATUS OF THE PROJECT:

Test run of 40 packs being manufactured - 160 gm. content anticipated.

FUTURE PLANS:

Development of fool-proof home-filling facility.

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TITLE OF RESEARCH PROJECT:

Fluid Energy Sources

NAMES OF RESPONSIBLE INVESTIGATORS:

Mr. C. Snowdon
Mr. R. W. Levell

NAME OF INSTITUTION:

Biomechanical Research and Development Unit
Department of Health and Social Security
Roehampton, London, England.

OBJECTIVE OF THE PROJECT:

To determine the optimum fluid for use as an energy source for powered arms.

METHOD USED:

Study mainly concerned with fluorinated hydrocarbons versus CO_2. Brief consideration was given to a prime mover/heat engine power pack which proved discouraging.

STATUS OF THE PROJECT:

Work completed. CO_2 remains the available "best buy." A full report has been prepared.

FUTURE PLANS: -

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TITLE OF RESEARCH PROJECT:

Investigation into Energy Storage and Utilization Systems for Externally Powered Prostheses.

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. D. C. Simpson

NAME OF INSTITUTION:

Orthopaedic Bio-Engineering Unit
Princess Margaret Rose Orthopaedic Hospital
Fairmilehead, Edinburgh, Scotland.

OBJECTIVE OF THE PROJECT:

Development of a practical system to replace present CO_2 based system.

METHOD USED:

STATUS OF THE PROJECT:

Commencing 1st June 1969.

FUTURE PLANS:

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TITLE OF RESEARCH PROJECT:

EMG Control

NAME OF RESPONSIBLE INVESTIGATOR:

Prof. R. N. Scott

NAME OF INSTITUTION:

University of New Brunswick, Bioengineering Institute, Fredericton, New Brunswick, Canada

OBJECTIVE OF THE PROJECT:

Electromyographic signal control of externally powered upper-extremity prostheses.

METHOD USED:

Research on muscle function analysis, measurement of amputee stump for fitting, EMG control, EMG signal processing, and implantable myo-telemetry control system.

STATUS OF THE PROJECT:

Performing above research.

FUTURE PLANS:

Continued research and development.

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TITLE OF RESEARCH PROJECT:

EMG and Muscle Bulge Control Sites in Dysmelic Children

NAMES OF RESPONSIBLE INVESTIGATORS:

Mr. P. T. Jarvis
Miss E. Rogers

NAME OF INSTITUTION:

University of Oxford, Department of Engineering Science
Oxford, England (Prof. D. W. Holder, F.R.S.)

OBJECTIVE OF THE PROJECT:

To establish potential control sites in children with amelia and phocomelia of the upper extremities.

METHOD USED:

Systematic mapping of various possible muscles in children. EMG output was studied using a special 3-pole electrode. Muscle bulge did not prove practicable.

STATUS OF THE PROJECT:

Work nearing completion.

FUTURE PLANS:

Full report will be written.

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TITLE OF RESEARCH PROJECT:

Emgor - a Totally, Permanently Implantable Sensor for EMG.

NAME OF RESPONSIBLE INVESTIGATOR:

R. E. Reilly

NAME OF INSTITUTION:

Medical Research Council, Powered Limbs Research Unit, West Hendon Hospital, London, N.W.9, England

OBJECTIVE OF THE PROJECT:

To develop a small, readily implantable EMG sensor to the stage that it can be safely implanted in human subjects and work reliably. Then, to find its potential value, if any, in various motor disabilities.

METHOD USED:

Engineering development, overlapping with trials in animals.

STATUS OF THE PROJECT:

Design now crystallised for a production unit, which has had one animal trial, resulting in successful operation over a period of 8 months (to date). Preparations being made for contract manufacture.

FUTURE PLANS:

Studies to be concentrated on functional aspects, particularly on choice of sites, obtaining multiple signals from single as well as distinct muscles, and the use of single motor unit pulses.

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TITLE OF RESEARCH PROJECT:

Bio-Electric Prostheses for Below- and Above-Elbow Amputations.

NAMES OF RESPONSIBLE INVESTIGATORS:

Dr. Marquardt
Dr. Roesler

NAME OF INSTITUTION:

Orthopadische Klinik und Poliklinik der Universitat, Abteilung für Dysmelien und Technische Orthopädie, Heidelberg, Germany

OBJECTIVE OF THE PROJECT:

Fitting middle length to short above-elbow stump with bioelectric prosthesis possible, however still with two canals, one (musculus biceps) for hand closing, the (musculus triceps) for hand opening. Dr. Roesler is working on a proportional control for myoelectric signals.

METHOD USED:

Experimental.

STATUS OF THE PROJECT:

We try to work with a 4-canal operation (Dr. Roesler).

FUTURE PLANS:

Continuation.

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TITLE OF RESEARCH PROJECT:

The Application of Myo-Electric Control in Prostheses for Arm Amputation.

NAMES OF RESPONSIBLE INVESTIGATORS:

Hannes Schmidl
Prof. Franco Zarotti

NAME OF INSTITUTION:

I.N.A.I.L. (Istituto Nazionale per l'Assicurazione contro gli Infortuni sul Lavoro), Bologna, Italy
(National Institution for Insurance against Accidents at Work)

OBJECTIVE OF THE PROJECT:

To improve the performance of the prostheses for the upper limbs to the end of a better integration of the amputees in a normal working life.

METHOD USED:

The utilization of the muscle potential as a means of control.

STATUS OF THE PROJECT:

Research already in its concluding phase, the application of the prostheses having been effected on about 40 cases of arm amputation.

FUTURE PLANS:

The utilization of coordinated controls for the simultaneous movements of prono-supination of the wrist and of flexo-extension of the elbow.

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TITLE OF RESEARCH PROJECT:

The Miniaturization of Electronic Components (Including Battery)-for myo-electric control in order to achieve the possibility of enclosing all the elements within the prosthesis.

NAMES OF RESPONSIBLE INVESTIGATORS:

Hannes Schmidl
Prof. Franco Zarotti

NAME OF INSTITUTION:

I.N.A.I.L. (Instituto Nazionale per l'Assicurazione contro gli Infortuni sul Lavoro), Bologna, Italy

OBJECTIVE OF THE PROJECT:

To improve the performance of the prostheses for the upper limbs to the end of a better integration of the amputees in a normal working life.

METHOD USED:

The use of miniaturized printed circuits and of components of sectional battery.

STATUS OF THE PROJECT:

It is in the concluding phase because over one hundred amputees have been fitted with prostheses that have the amplifier and the battery incorporated in the prosthesis itself.

FUTURE PLANS:

Further miniaturization in anticipation of the achievement of a multichannel device.

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TITLE OF RESEARCH PROJECT:

The Utilization of Various Signals Coming from a Muscular Fascia.

NAMES OF RESPONSIBLE INVESTIGATORS:

Hannes Schmidl
Prof. Franco Zarotti

NAME OF INSTITUTION:

I.N.A.I.L. (Instituto Nazionale per l'Assicurazione contro gli Infortuni sul Lavoro), Bologna, Italy

OBJECTIVE OF THE PROJECT:

METHOD USED:

Method developed by us.

STATUS OF THE PROJECT:

The utilization of these controls principally in cases of arm amputation in which a very short stump has been preserved and in cases of shoulder disarticulation.

FUTURE PLANS:

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TITLE OF RESEARCH PROJECT:

Prosthetic Control by Means of EMG Signals.

NAMES OF RESPONSIBLE INVESTIGATORS:

Ingemar Petersén, Docent
Robert Magnusson, Prof.

NAME OF INSTITUTION:

Department of Clinical Neurophysiology, Sahlgrenska Hospital, Division of Applied Electronics, Chalmers Institute of Technology, Göteborg, Sweden

OBJECTIVE OF THE PROJECT:

METHOD USED:

A research program on the use of myoelectric signals for prosthesis control is carried out along the following two principal lines:

1. Development of improved pick-up techniques; continued development of implantable microcircuits for transmitting myoelectric signals to a receiver located outside the body; development of multichannel units for transmitting the signals of several control sites by means of a single transmitter.

2. Signal characterization by means of spectral shape and constancy, statistical properties, noise level, and the relation between signal and muscle force. The results of this investigation will form the basis for recommendations on optimal signal processing (such as linear filtering).

In addition to those mentioned above, the program comprises a considerable number of projects, e.g., studies on the effect of training on EMG, comparison between EMG and other potential control signals (involving development of special mechanical/electrical transducers), psychotechnical studies of EMG control, feedback studies, etc.

STATUS OF THE PROJECT:

FUTURE PLANS:

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TITLE OF RESEARCH PROJECT:

EMG Control

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. James B. Reswick

NAME OF INSTITUTION:

Engineering Design Center, Case Western Reserve University, Cleveland, Ohio, U.S.A.

OBJECTIVE OF THE PROJECT:

Effective EMG control of prosthetic/orthotic systems.

METHOD USED:

Study of information control, EMG sites, evaluation of performance, adaptive learning, and percutaneous electrodes to provide effective EMG control.

STATUS OF THE PROJECT:

In progress.

FUTURE PLANS:

Continuation of studies.

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TITLE OF RESEARCH PROJECT:

Moss Multiple-Axis Myoelectric Control

NAME OF RESPONSIBLE INVESTIGATOR:

Mr. R. Wirta

NAME OF INSTITUTION:

Moss Rehabilitation Hospital, Philadelphia, Pennsylvania, U.S.A.

OBJECTIVE OF THE PROJECT:

Development of a myoelectric control system for multiple-axis prosthesis.

METHOD USED:

Pattern recognition techniques are used to discriminate activities of the body to provide simultaneous control of externally powered prosthetic components.

STATUS OF THE PROJECT:

Engineering model operational and tests under way to determine functional characteristics in use by amputee subject.

FUTURE PLANS:

A systematic resolution of the present problems and application to severely handicapped amputee.

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TITLE OF RESEARCH PROJECT:

Northwestern University Multiple Functional Controller

NAME OF RESPONSIBLE INVESTIGATOR:

Mr. E. Grahn

NAME OF INSTITUTION:

Northwestern University Prosthetics Research Center, Chicago, Illinois, U.S.A.

OBJECTIVE OF THE PROJECT:

Increased functions of conventional myoelectric control sites.

METHOD USED:

Three-mode controller placed at each control site multiplying possible functions of powered prosthesis.

STATUS OF THE PROJECT:

Feasibility of theory in process.

FUTURE PLANS:

Continued development.

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TITLE OF RESEARCH PROJECT:

Northwestern University Three-Mode Myoelectric Controller

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. D. Childress

NAME OF INSTITUTION:

Northwestern University Prosthetics Research Center, Chicago, Illinois, U.S.A.

OBJECTIVE OF THE PROJECT:

Development of a three-mode myoelectric controller.

METHOD USED:

Textured stainless steel electrodes capable of separating muscle contraction proportional to the strength of contraction for various functions.

STATUS OF THE PROJECT:

Prototype device is in process.

FUTURE PLANS:

Continued development.

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TITLE OF RESEARCH PROJECT:

Muscle Bulge - Control of Prehension.

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. A. H. Bottomley

NAME OF INSTITUTION:

Biomechanical Research and Development Unit, Department of Health and Social Security, Roehampton, London, S.W. 15, England.

OBJECTIVE OF THE PROJECT:

To design a pneumatically powered prehension device to be controlled by muscle bulge in BE stumps for direct comparison with E.M.G.-controlled electric hand and with cable control.

METHOD USED:

Pressure demand valves are to be used.

STATUS OF THE PROJECT:

Pressure demand valves have been designed. Hand and hook actuators to be designed.

FUTURE PLANS:

Depends on outcome of comparative trials.

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TITLE OF RESEARCH PROJECT:

The Effect of a Complex Lag on Operators' Performance.

NAME OF RESPONSIBLE INVESTIGATOR:

Miss J. M. Rudd

NAME OF INSTITUTION:

Department of Mechanical Engineering, University College London, England (Prof. T. H. Lambert)

OBJECTIVE OF THE PROJECT:

To study the effect of complex time lags on a closed-loop-position control system on operator performance and its relevance to design of a prosthetic system.

METHOD USED:

Target acquisition task with prosthetic elbow-flexion unit, measuring acquisition time (slewing + settling time) with the introduction of imposed second order complex time lag.

STATUS OF THE PROJECT:

A number of experiments have been done.

FUTURE PLANS:

Extend the experiments to tracking tasks requiring continuous movements.

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TITLE OF RESEARCH PROJECT:

Investigation of Joint Proprioception

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. G. H. Begbie
Dr. D. C. Simpson

NAME OF INSTITUTION:

Orthopaedic Bio-Engineering Unit, Princess Margaret Rose Orthopaedic Hospital, Fairmilehead, Edinburgh 10, Scotland

OBJECTIVE OF THE PROJECT:

Information relating to the control of the normal hand and arm.

METHOD USED:

Extensive comparative studies of knowledge of position with and without visual feedback.

STATUS OF THE PROJECT:

In progress.

FUTURE PLANS:

Application to prosthesis control.

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TITLE OF RESEARCH PROJECT:

Biotechnological Control System Study

NAME OF RESPONSIBLE INVESTIGATOR:

Mr. Eskil Ulèn, Sr. Research Engineer

NAME OF INSTITUTION:

Research Institute of the Swedish National Defense,
Sweden

OBJECTIVE OF THE PROJECT:

Analysis of the integrated system, consisting of the patient and the technical (prosthetic) system, by means of hybrid computer. The prime objective is to study what properties the prostheses should possess in order to get optimal performance of the integrated system.

METHOD USED:

STATUS OF THE PROJECT:

A model of an elbow system is simulated and presented on a screen. Means are provided to control it by EMG signals, and systematic experiments with the system have started.

FUTURE PLANS:

The analysis of the elbow will continue. The study will then be augmented to include the hand, which means that more than one movement at the time will be controlled. Also, some experiments with feed-in signals will be performed.

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TITLE OF RESEARCH PROJECT:

AIPR Phase-Shift Control

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. Edward Kiessling

NAME OF INSTITUTION:

American Institute for Prosthetic Research
Greenlawn, N. Y., U.S.A.

OBJECTIVE OF THE PROJECT:

Control system permitting the patient to shift from one to another operational mode.

METHOD USED:

A phase channel distributor permits voluntary selection of mode by body control motions.

STATUS OF THE PROJECT:

Two prototypes are presently in process.

FUTURE PLANS:

Field study evaluation

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TITLE OF RESEARCH PROJECT:

AMBRL Sequencing and Positioning Switches

NAMES OF RESPONSIBLE INVESTIGATORS:

Mr. L. Salisbury
Mr. Albert Colman

NAME OF INSTITUTION:

U.S. Army Medical Biomechanical Research Laboratory, Walter Reed Army Medical Center, Forest Glen Section, Washington, D.C., U.S.A.

OBJECTIVE OF THE PROJECT:

Development of a device to train patients in the use of external power and selection of optimum control method for a given patient.

METHOD USED:

A master control assembly and power pack with multiple plug in jacks for various types of control switches.

STATUS OF THE PROJECT:

Device currently being used at AMBRL in the development of various upper-extremity externally powered systems.

FUTURE PLANS:

Continued development

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TITLE OF RESEARCH PROJECT:

AMBRL Myo-Sonic Control System

NAMES OF RESPONSIBLE INVESTIGATORS:

Mr. L. Salisbury
Mr. Albert Colman

NAME OF INSTITUTION:

U.S. Army Medical Biomechanical Research Laboratory, Walter Reed Army Medical Center, Forest Glen Section, Washington, D.C., U.S.A.

OBJECTIVE OF THE PROJECT:

Develop a system which utilizes voice command to control the duration and direction of prosthetic or orthotic functions.

METHOD USED:

Voice command and a three-level muscle bulge switch which alternates the various commands permit a wide selection of functions.

STATUS OF THE PROJECT:

System is presently being studied for feasibility in practical applications.

FUTURE PLANS:

Continued development

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TITLE OF RESEARCH PROJECT:

UCLA Controls Study

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. John Lyman

NAME OF INSTITUTION:

University of California at Los Angeles Biotechnology Laboratory, Los Angeles, California, U.S.A.

OBJECTIVE OF THE PROJECT:

To study the feasibility of several actuation systems and related control circuity problems.

METHOD USED:

Open-loop pneumatic control system utilizing fluidic devices.

STATUS OF THE PROJECT:

A study in progress to compare various signal sources as to their suitability for generating appropriate control information.

FUTURE PLANS:

Construction of experimental apparatus and preliminary data recording on subjects.

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TITLE OF RESEARCH PROJECT:

Gilmatic Multiple Contact Switch

NAME OF RESPONSIBLE INVESTIGATOR:

Mr. Gilbert Motis

NAME OF INSTITUTION:

Gilmatic, Northridge, California, U.S.A.

OBJECTIVE OF THE PROJECT:

Switch to provide up to six contacts for electrical control of various prosthetic components.

METHOD USED:

Contact switch is actuated by residual muscle bulging.

STATUS OF THE PROJECT:

One model of the switch is presently being used in conjunction with the Gilmatic Electric Elbow

FUTURE PLANS:

Continued development

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UPPER-EXTREMITY PROSTHETICS

COSMESIS, SENSATION

TITLE OF RESEARCH PROJECT:

1. Upper-extremity Prosthetics
   a. Skeleton Technique
   b. Open-end Prostheses
   c. Development of component parts and control systems
2. Externally powered prostheses

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. Goetz-Gerd Kuhn

NAME OF INSTITUTION:

University of Muenster, Orthopaedic Hospital, Department of Orthopaedic Techniques and Rehabilitation, Muenster/ Westfalen, Germany

OBJECTIVE OF THE PROJECT:

Amelioration of function and cosmetics, comfort and efficiency of artificial arms

METHOD USED:

Creation, construction, realization, application, evaluation, all in the same Center.

STATUS OF THE PROJECT:

This project has high priority

FUTURE PLANS:

Continuation of projects and dissemination of the results of same.

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TITLE OF RESEARCH PROJECT:

Provision of Touch in Hand Prosthesis

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. D. C. Simpson

NAME OF INSTITUTION:

Medical Research Council Research Unit on Physical Aids for the Disabled, London, England

OBJECTIVE OF THE PROJECT:

Improve hand performance

METHOD USED:

STATUS OF THE PROJECT:

In progress

FUTURE PLANS:

Installation in hands from 1970.

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UPPER-EXTREMITY PROSTHETICS

COSMESIS, SENSATION

TITLE OF RESEARCH PROJECT:

Prosthetic Gloves

NAME OF RESPONSIBLE INVESTIGATOR:

Mr. Bo Klasson
Mr. Helmut Winderlich

NAME OF INSTITUTION:

Norrbackainstitutet - Handikappinstitutet
Stockholm, Sweden

OBJECTIVE OF THE PROJECT:

To develop prosthetic gloves, satisfying the specification given by the SVEN hand (low mechanical resistance to all joints) with over-all characteristics, true for current gloves on the market (cosmesis, lifetime, etc.).

METHOD USED:

One latex - and one PVC version under development

STATUS OF THE PROJECT:

Methods for fabrication under control
Further mechanical specification required
Spin-off has been taken from PVC version for child's hand

FUTURE PLANS:

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TITLE OF RESEARCH PROJECT:

Endoskeletal Upper-Extremity Prosthesis

NAME OF RESPONSIBLE INVESTIGATOR:

Mr. Maurice LeBlanc

NAME OF INSTITUTION:

Prosthetics-Orthotics Program, University of California at Los Angeles, California, U.S.A.

OBJECTIVE OF THE PROJECT:

To provide improved appearance and feel by cosmetic soft covering of internal structure and controls.

METHOD USED:

Skeletal structure of nylon tubing with Teflon-bearing surfaces and braided dacron cabling permits efficient internal control mechanism which is covered with a soft plastic foam and skin.

STATUS OF THE PROJECT:

Prototypes have been fitted.

FUTURE PLANS:

Continued development by Mr. R. Brown of Dorrance Co.

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Wednesday, April 30, 1969

Moderator: Robert W. Klein

III. LOWER-EXTREMITY ORTHOTICS

- *A. Fundamental Studies*
- *B. New Braces and Devices*
- *C. Fracture Bracing*

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LOWER-EXTREMITY ORTHOTICS

FUNDAMENTAL STUDIES

TITLE OF RESEARCH PROJECT:

Investigation into the Biomechanics of the Function of Orthotic Devices for the Lower Limb.

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. J. P. Paul

NAME OF INSTITUTION:

BioEngineering Unit, University of Strathclyde, Montrose Street, Glasgow, C.1, Scotland

OBJECTIVE OF THE PROJECT:

Rational design of orthotic devices.

METHOD USED:

The remaining function of the disabled is being measured and the mechanical transmission to the skeletal structure of force actions applied to the skin is being investigated.

STATUS OF THE PROJECT:

Initial stages.

FUTURE PLANS:

Production of orthotic devices.

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TITLE OF RESEARCH PROJECT:

Lower-Extremity Orthotics

NAME OF RESPONSIBLE INVESTIGATOR:

Helge Een

NAME OF INSTITUTION:

Een och Holmgrens Ortopediska AB, Uppsala, Sweden

OBJECTIVE OF THE PROJECT:

Increase possibilities for walking with paralyzed legs.

METHOD USED:

Investigation of the possibilities for voluntary control of the different joints and the relation between these in a leg orthosis.

STATUS OF THE PROJECT:

Initial.

FUTURE PLANS:

To consider the possibilities to control the mechanical characteristics of the orthosis by means of EMG signals.

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TITLE OF RESEARCH PROJECT:

Bracing Geno-recurvatum Due to Flaccid Paralysis in the Lower Limbs.

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. M. A. S. El Banna

NAME OF INSTITUTION:

Day Hospital and Occupational Rehabilitation Institute, Cairo, United Arab Republic

OBJECTIVE OF THE PROJECT:

To study muscle imbalance which leads to geno-recurvatum and find out the proper relation between lesion specificity and brace design in this condition.

METHOD USED:

History, examination, muscle testing of 100 cases of geno-recurvatum secondary to flaccid paralysis in lower limbs (mostly due to polio), gait study by cinematography and trial of different braces to find out the most suitable brace which is effective in controlling this deformity.

STATUS OF THE PROJECT:

Work has been started. Register has been done to the cases which will be investigated, muscle testing sheets are under preparation. Some pro-design for different braces is done.

FUTURE PLANS:

To complete the research and establish certain standards for bracing this condition and publish the work.

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TITLE OF RESEARCH PROJECT:

To Study the Mechanics of Walking in Ambulant Cases of Paralysis of Lower Limbs Due to Poliomelitis

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. M. A. S. El Banna

NAME OF INSTITUTION:

Day Hospital and Occupational Rehabilitation Institute,
Cairo, United Arab Republic

OBJECTIVE OF THE PROJECT:

To find out the minimal muscles required and their grades for satisfactory ambulation in cases of flaccid paralysis of the lower limbs.

METHOD USED:

Case history, muscle testing, clinical gait analysis and cinematographique study, calculation of the maximum distance which can be walked by different patients taking into consideration energy consumption.

STATUS OF THE PROJECT:

Work is just being started and the project is still in the preliminary phase.

FUTURE PLANS:

To complete and publish the work and to prepare a Gait Laboratory for research projects in the Day Hospital and Occupational Rehabilitation Institute.

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TITLE OF RESEARCH PROJECT:

Stress Analyses of Brace Structures

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. Fred Leonard

NAME OF INSTITUTION:

U. S. Army Medical Biomechanical Research Laboratory,
Walter Reed Army Medical Center, Washington, D. C., U.S.A.

OBJECTIVE OF THE PROJECT:

Determination of stresses in nonweight bearing braces and the relationship of stresses and moments in the bars and the calf band.

METHOD USED:

Loading of brace structures in testing machine, recording strain gauge outputs.

STATUS OF THE PROJECT:

Project completed.

FUTURE PLANS:

No known future plans.

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TITLE OF RESEARCH PROJECT:

Fundamental Studies of Lower-Extremity Joint Motions

NAMES OF RESPONSIBLE INVESTIGATORS:

Prof. Howard D. Eberhardt
Prof. Charles W. Radcliffe

NAME OF INSTITUTION:

University of California-Biomechanics Laboratory, San Francisco, California, U.S.A.

OBJECTIVE OF THE PROJECT:

To determine the kinematics of lower-extremity joint motion to suggest criteria for brace design.

METHOD USED:

Mechanical analog of the lower-extremity joint system has been constructed. Data employing this analog will be analyzed.

STATUS OF THE PROJECT:

Studies using the mechanical analog just started.

FUTURE PLANS:

Continued studies using the mechanical analog with data analysis by computer.

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TITLE OF RESEARCH PROJECT:

Application of Pneumatic Structures

NAME OF RESPONSIBLE INVESTIGATOR:

Mr. Charles M. Scott

NAME OF INSTITUTION:

Prosthetics-Orthotics Program, University of California-Los Angeles, Los Angeles, California, U.S.A.

OBJECTIVE OF THE PROJECT:

Application of pneumatic structures in the design and development of braces for the lower extremity (as well as the spine and upper extremity).

METHOD USED:

Analytical studies of pneumatic structures and investigations of other research and development work by such companies as Goodyear Tire and Rubber Company. Construction of models.

STATUS OF THE PROJECT:

Completed feasibility study report November 1, 1967.

FUTURE PLANS:

Begin the development and construction of inflatable system models which can be adjustable and which can take the required loads. Special attention to the use of an inflatable system for a brace knee joint.

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TITLE OF RESEARCH PROJECT:

Mechanism of Synovial Joint Lubrication

NAME OF RESPONSIBLE INVESTIGATOR:

Victor Frankel, M.D.

NAME OF INSTITUTION:

Veterans Administration Hospital Biomechanics Laboratory, Cleveland, Ohio, U.S.A.

OBJECTIVE OF THE PROJECT:

METHOD USED:

Using sheep's knee to measure intra-articular pressures of the joint under natural and imposed conditions and analysis of comparable mechanical models.

STATUS OF THE PROJECT:

In progress.

FUTURE PLANS:

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TITLE OF RESEARCH PROJECT:

Study of Femoral Neck Fractures

NAME OF RESPONSIBLE INVESTIGATOR:

Victor Frankel, M.D.

NAME OF INSTITUTION:

Veterans Administration Hospital Biomechanics Laboratory,
Cleveland, Ohio, U.S.A.

OBJECTIVE OF THE PROJECT:

Provide understanding of the high incidence of femoral neck fractures in the elderly.

METHOD USED:

A telemetry system is used to transmit forces borne by a hip nail used to treat a femoral neck fracture. Load sensing and transmitting circuitry is contained within the nail.

STATUS OF THE PROJECT:

In progress.

FUTURE PLANS:

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TITLE OF RESEARCH PROJECT:

Development and Application of Contemporary Rehabilitation Concepts for Paraplegia Patients

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. Slobodan Grobelnik

NAME OF INSTITUTION:

Institution of the Socialist Republic of Slovenia for Rehabilitation of Disabled Persons, Ljubljana, Linhartova 51, Yugoslavia

OBJECTIVE OF THE PROJECT:

To investigate the efficiency of team approach in the rehabilitation of paraplegia patients and to select better and more suitable methods for their treatment.

METHOD USED:

Incorporation of newly-developed methods into the program of the Institution for Rehabilitation of the Disabled, thus improvement of present conditions.

STATUS OF THE PROJECT:

End of the first year.

FUTURE PLANS:

To improve collaboration among institutions dealing with rehabilitation, and thus to improve modeling and functionality of orthopaedic appliances in paraplegia.

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TITLE OF RESEARCH PROJECT:

Splint Jig

NAME OF RESPONSIBLE INVESTIGATOR:

All unit members. Mechanical supervision--Mr. Spielrein (Engineer).

NAME OF INSTITUTION:

Repatriation Department's Central Development Unit, Melbourne, Australia

OBJECTIVE OF THE PROJECT:

Adaptation of tibial torsion measuring device (Mr. R. Lehneis) which is incorporated in the "standard" splint transfer jig. Will take UCLA long-leg brace components and most standard flat section bars.

METHOD USED:

Adjustable posts.

STATUS OF THE PROJECT:

One prototype completed and under evaluation in splint production area of a Limb Appliance Centre.

FUTURE PLANS:

Supply of jig to each Centre (7 in number).

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TITLE OF RESEARCH PROJECT:

Lower-Extremity Orthotics Development

NAME OF RESPONSIBLE INVESTIGATOR:

Mr. James Foort

NAME OF INSTITUTION:

Prosthetics and Orthotics R&D Unit, Manitoba Rehabilitation Hospital, Winnipeg, Manitoba, Canada

OBJECTIVE OF THE PROJECT:

Development of new devices and techniques.

METHOD USED:

a. Development of new designs for Legg-Perthes brace and application of new materials to this kind of appliance.

b. Application of plastics to arthritic bracing.

STATUS OF THE PROJECT:

Early development of the orthotics development program.

FUTURE PLANS:

Continued development. Planning the application of electronics and computer technology to the problems of bracing.

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LOWER-EXTREMITY ORTHOTICS

NEW BRACES AND DEVICES

TITLE OF RESEARCH PROJECT:

Development of Improved Lower-Extremity Brace System Design

NAME OF RESPONSIBLE INVESTIGATOR:

Mr. Colin A. McLaurin

NAME OF INSTITUTION:

Ontario Crippled Children's Centre, Toronto, Ontario, Canada

OBJECTIVE OF THE PROJECT:

Development of lower-extremity brace systems most appropriately suited to disabilities of children.

METHOD USED:

Engineering design and construction of unique devices particularly suited for spina bifida, Legg-Perthes and cerebral palsy cases.

STATUS OF THE PROJECT:

Walking aids such as parallel walkers, "H" frame crutches, and standing brace have been developed. A reciprocating gait brace using a gear system has also been designed and employed. A Legg-Perthes brace which permits flexion and extension of knees and ankle joints has been developed.

FUTURE PLANS:

Continued development of new designs for disabilities of children. Evaluation of designs already developed as well as dissemination of information on such designs to other children's clinics. Evaluation of the special bracing problems of cerebral palsy.

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TITLE OF RESEARCH PROJECT:

Modular Dynamic Clubfoot Splint (To be used in bed.)

NAME OF RESPONSIBLE INVESTIGATOR:

Mr. Erik Lyquist

NAME OF INSTITUTION:

Orthopaedic Hospital, Copenhagen, Denmark

OBJECTIVE OF THE PROJECT:

1. To design a clubfoot splint which incorporates the features of a retaining as well as a corrective splint.
2. To test the design in clinical application.
3. To further develop the splint as a true modular system.

METHOD USED:

Utilization of mechanical subtalar as well as ankle joints and a joint for abduction of the forefoot. Movements around the axis of the joints controlled by elastic straps.

STATUS OF THE PROJECT:

A clubfoot splint which incorporates the features of a retaining as well as a corrective splint has been designed and tested in clinical application.

FUTURE PLANS:

To further develop the clubfoot splint as a true modular system.

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TITLE OF RESEARCH PROJECT:

Walking Device for Spina Bifida

NAME OF RESPONSIBLE INVESTIGATOR:

Mr. G. K. Rose

NAME OF INSTITUTION:

Royal Salop Infirmary, Shewsbury, England

OBJECTIVE OF THE PROJECT:

To design a system enabling children with spina bifida to ambulate without their hands being occupied by canes or crutches.

METHOD USED:

The application of the principle of the McLaurin swivel walker to long-leg braces suitably modified.

STATUS OF THE PROJECT:

Working devices have been applied successfully. Further engineering is being undertaken.

FUTURE PLANS:

Gradual extension to study other advances in orthotics.

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TITLE OF RESEARCH PROJECT:

Telemetry Control for Orthotic Power Systems

NAMES OF RESPONSIBLE INVESTIGATORS:

Dr. Vernon L. Nickel
Mr. Andrew Karchak

NAME OF INSTITUTION:

Rancho Los Amigos Hospital, Downey, California, U.S.A.

OBJECTIVE OF THE PROJECT:

Development of a telemetry control system for a powered orthosis.

METHOD USED:

Study of telemetry device to be inserted into mouth and controlled by the tongue.

STATUS OF THE PROJECT:

In progress.

FUTURE PLANS:

Continuation of study.

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TITLE OF RESEARCH PROJECT:

Trunk orthotics:

a) Hepp's reklination corset
b) Sitting aids and supports

NAME OF RESPONSIBLE INVESTIGATOR:

Prof. Goetz-Gerd Kuhn, M.D.

NAME OF INSTITUTION:

University of Muenster, Orthopaedic Hospital, Department of Orthopaedic Techniques and Rehabilitation, Muenster, Germany

OBJECTIVE OF THE PROJECT:

Amelioration of function and cosmetics, comfort and efficiency of aids and supports.

METHOD USED:

Creation, construction, realisation, application, evaluation--all in the same center.

STATUS OF THE PROJECT:

This project has high priority.

FUTURE PLANS:

Continuation of projects and dissemination of the results of same.

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TITLE OF RESEARCH PROJECT:

Spinal Orthotics

NAMES OF RESPONSIBLE INVESTIGATORS:

Prof. C. W. Radcliffe
Prof. H. D. Eberhart
J. M. Morris, M.D.

NAME OF INSTITUTION:

University of California Medical Center, San Francisco, California, U.S.A.

OBJECTIVE OF THE PROJECT:

To determine effects of conventional lumbosacral corsets and braces on the spine.

METHOD USED:

Design and develop a lumbosacral support with inflatable components to determine the effects of various pressures and locations of the support on the spine.

STATUS OF THE PROJECT:

The inflatable lumbosacral support has been developed.

FUTURE PLANS:

Clinical study of about 25 patients over a period of 1-2 years.

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TITLE OF RESEARCH PROJECT:

Study of Mechanics of the Milwaukee Brace

NAME OF RESPONSIBLE INVESTIGATOR:

Jorge O. Galante, M.D.

NAME OF INSTITUTION:

University of Illinois Medical Center, Chicago, Illinois, U.S.A.

OBJECTIVE OF THE PROJECT:

To determine loads applied by the Milwaukee Brace and its effects upon the pathological deformity of scoliosis.

METHOD USED:

Experimental and analytical studies are being conducted--the experimental study with an instrumented brace and the analytical study with mathematical models.

STATUS OF THE PROJECT:

Experimental brace has been constructed and tested on a few subjects.

FUTURE PLANS:

Future plans depend on financial support.

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TITLE OF RESEARCH PROJECT:

Study of Mechanical Characteristics of a Module of the Spinal Column

NAMES OF RESPONSIBLE INVESTIGATORS:

Prof. R. C. Juvinall
Mr. Charles Aquino

NAME OF INSTITUTION:

University of Michigan, Ann Arbor, Michigan, U.S.A.

OBJECTIVE OF THE PROJECT:

To determine the stress distribution induced in vertabrae by shock loads imposed by lap seat belts.

METHOD USED:

The determination by measurement of the pertinent physical constants of a module of a vertebral disc and the two adjacent vertebrae from the lumbar-sacral region under axial and transverse loading.

STATUS OF THE PROJECT:

To be completed in the near future.

FUTURE PLANS:

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TITLE OF RESEARCH PROJECT:

Biomechanics of Low Back Pain

NAME OF RESPONSIBLE INVESTIGATOR:

Donald B. Chaffin

NAME OF INSTITUTION:

University of Michigan, Ann Arbor, Michigan, U.S.A.

OBJECTIVE OF THE PROJECT:

To seek out mechanical factors contributing to low back pain.

METHOD USED:

Included are experimental work on cadaver spines and analytical work.

STATUS OF THE PROJECT:

A report of this work is expected to appear in the "Journal of Biomechanics" in the near future.

FUTURE PLANS:

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ORTHOTICS - GENERAL

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TITLE OF RESEARCH PROJECT:

Development of Functional Nomenclature for Orthotic Devices

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. Robert Thompson, Chairman, Committee on Prosthetics and Orthotics

NAMES OF INSTITUTIONS:

American Academy of Orthopaedic Surgeons, Chicago, Illinois, U.S.A., in cooperation with American Prosthetic and Orthotic Association, and Veterans Administration

OBJECTIVE OF THE PROJECT:

1. Define deficiencies of the musculoskeletal system by use of a combination of a graphical presentation and bioengineering terminology.

2. Define orthotics hardware using a matching format and equivalent terms.

METHOD USED:

Conference discussions and clinical trials of developed systems.

STATUS OF THE PROJECT:

1. Experimental charts being evaluated by several clinics.

2. Chart of hardware functions being disseminated for further discussion.

FUTURE PLANS:

1. Refine charts of dysfunction specification and hardware nomenclature.

2. Employ both in educational media.

3. Prepare hardware catalog.

4. Begin rewrite of Orthopaedic Appliances Atlas Volume I.

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ORTHOTICS - GENERAL

FUNDAMENTAL STUDIES

TITLE OF RESEARCH PROJECT:

Biomedical Engineering and Physical Rehabilitation

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. James W. Rae

NAME OF INSTITUTION:

University of Michigan, Ann Arbor, Michigan, U.S.A.

OBJECTIVE OF THE PROJECT:

To obtain more fundamental information about biomechanics and bio-electronics and to use this information in the design and development of improved devices for the disabled.

METHOD USED:

Studies of joint mechanics and the mechanical properties of connective tissues; measurements of deformity; measurements of pressures, forces, and stress distributions in fitted appliances; clinical application of externally powered devices; measurements of muscle fatigue with direct stimulation; and design and development of certain kinds of braces.

STATUS OF THE PROJECT:

FUTURE PLANS:

As stated in "Method Used."

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TITLE OF RESEARCH PROJECT:

Orthotics Design as Part of Rehabilitation Biomedical Engineering

NAMES OF RESPONSIBLE INVESTIGATORS:

Leonard D. Policoff, M.D.
Ray Finley, Ph.D.

NAME OF INSTITUTION:

Moss Rehabilitation Hospital, Philadelphia, Pennsylvania, U.S.A.

OBJECTIVE OF THE PROJECT:

Using objective measures to study mobility patterns of hemiplegics in order to establish biomechanical requirements and to direct orthotics developments, both techniques and devices.

METHOD USED:

Accumulation of fundamental data on mobility and locomotion, bio-engineering evaluation of existing designs, and the formulation of new designs.

STATUS OF THE PROJECT:

Apparently started.

FUTURE PLANS:

Collection of data using typical bio-engineering laboratory equipment as well as specially designed apparatus. Computer handling of the data is anticipated.

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TITLE OF RESEARCH PROJECT:

Electrical Stimulation of Muscles

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. James B. Reswick

NAME OF INSTITUTION:

Engineering Design Center, Case Western Reserve University, Cleveland, Ohio, U.S.A.

OBJECTIVE OF THE PROJECT:

Determine feasibility of electrical stimulation for effective control of muscles for orthotic systems.

METHOD USED:

Study of percutaneous implant, skeletal muscle, and tonic stimulation.

STATUS OF THE PROJECT:

In progress.

FUTURE PLANS:

Continuation of studies.

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TITLE OF RESEARCH PROJECT:

EMG Control of Functional Braces

NAME OF RESPONSIBLE INVESTIGATOR:

Worden Waring, Ph.D.

NAME OF INSTITUTION:

Rancho Los Amigos Hospital, Downey, California, U.S.A.

OBJECTIVE OF THE PROJECT:

To study advantages and limitations of using EMG activity for the control of externally powered rehabilitative devices.

METHOD USED:

Study of crosstalk of muscle activity, performance of surface electrodes, control sites, etc.

STATUS OF THE PROJECT:

Study in process.

FUTURE PLANS:

Continue study of above and the design of electronic circuitry for EMG control systems.

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TITLE OF RESEARCH PROJECT:

Functional Electrostimulation of Upper and Lower Extremities

NAMES OF RESPONSIBLE INVESTIGATORS:

Strhinja Kispatic, Dipl. Ing.
Dr. Bosco Zotovic

NAME OF INSTITUTION:

Center for Prosthetics, Belgrade, Yugoslavia

OBJECTIVE OF THE PROJECT:

Functional electrostimulation of patients with central motor neuron lesion, construction of the FES short-leg braces, evaluation of this method of work and development of indications and contraindications for its application.

METHOD USED:

As mentioned above.

STATUS OF THE PROJECT:

Local project under way.

FUTURE PLANS:

Further work in the field of the FES.

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ELECTRICAL STIMULATION AND EMG CONTROL

TITLE OF RESEARCH PROJECT:

Development of Orthotic Systems Using Functional Electrical Stimulation and Myo-Electric Control
SRS-YUGO 23-68

NAME OF RESPONSIBLE INVESTIGATOR:

Prof. Lojze Vodovnik, Sc.D.

NAME OF INSTITUTION:

Faculty for Electrical Engineering, University of Ljubljana, Yugoslavia

OBJECTIVE OF THE PROJECT:

To develop clinically useful orthotic devices for patients with paralyzed extremities. To conduct applied research which would be required in order to develop orthotic systems.

METHOD USED:

Investigations on the use of electrical currents to provide functional movements and prevent involuntary muscle contraction. Regarding control signals, preference is given to myo-electric voltages generated by normally innervated muscles.

STATUS OF THE PROJECT:

We are at the end of the first year of a three-year grant period. Some results: development of an electronic peroneal brace with walking rate dependent tetanisation; development of a high-efficiency implantable stimulator; a new biomechanical and control-theoretical approach to locomotion and proposals for new electronic walking aids; investigation of hysteresis effects in electrical stimulation.

FUTURE PLANS:

Continue work on projects mentioned above in accordance with the goals stated in the proposal. Implants of functional stimulators in humans. Development of a single channel clinical myo-stimulator. Investigations on optimum stimulation currents. Modelling of pathological neuromuscular systems which would hopefully lead to improved therapeutical stimulation. Development of a concept of combined or sequential therapeutical and functional (orthotic) stimulation.

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TITLE OF RESEARCH PROJECT:

Orthotics (general)

NAME OF RESPONSIBLE INVESTIGATOR:

Mr. Tuck

NAME OF INSTITUTION:

Royal National Orthopaedic Hospital, Stanmore, England

OBJECTIVE OF THE PROJECT:

Improvements in orthoses.

METHOD USED:

Ad hoc developments in hardware and fitting technique largely involving the application of newer materials such as Plastizote.

STATUS OF THE PROJECT:

Continuing programme.

FUTURE PLANS:

Possible development of more sophisticated research under the wing of the Biomechanics and Surgical Materials Research Institute (Dr. John Scales) which has hitherto worked mainly on implants.

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TITLE OF RESEARCH PROJECT:

Mechanical Investigation and the Application of Plastic Materials in Orthotics

NAME OF RESPONSIBLE INVESTIGATOR:

Gordon C. Robin, F.R.C.S.

NAME OF INSTITUTION:

Hadassah University Hospital, Jerusalem, Israel

OBJECTIVE OF THE PROJECT:

To determine the possibilities of the systematized use of plastic materials in orthotics and to continue the investigation of orthotic appliances, from a mechanical point of view, in order to determine the mechanical behaviour of appliances under conditions of gait.

METHOD USED:

Standard design braces are being fabricated from plastic materials with minor structural alterations as required and necessitated by change in material. Plastic braces of new design are being investigated in clinical trials. Dynamic stress valuations of varying lower-limb braces are being carried out using strain gauge techniques.

STATUS OF THE PROJECT:

The present project is due to end during the present year.

FUTURE PLANS:

Continuance of research on the same general lines with the addition of simultaneous EMG analysis to determine the reciprocal effect of lower-limb braces on muscle action in the partly paralysed lower limb.

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TITLE OF RESEARCH PROJECT:

Application of New Materials in Orthotics

NAME OF RESPONSIBLE INVESTIGATOR:

William J. McIlmurray

NAME OF INSTITUTION:

Veterans Administration Prosthetics Center, New York, New York, U.S.A.

OBJECTIVE OF THE PROJECT:

The application of direct forming materials in the construction of components for the lower-extremity brace.

METHOD USED:

Thermoplastic materials (such as Polysar) are being applied for sockets and cuffs.

STATUS OF THE PROJECT:

Experimental application of the components now being performed.

FUTURE PLANS:

Development of procedural information covering the application of thermoplastic materials for certain lower-extremity brace parts.

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TITLE OF RESEARCH PROJECT:

Development and Application of New Materials and New Techniques of Work in the Field of Prosthetics and Orthotics

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. Bosco Zotovic

NAME OF INSTITUTION:

Center for Prosthetics, Belgrade, Yugoslavia

OBJECTIVE OF THE PROJECT:

Investigation of new materials, development of new techniques of work, education and distribution of information obtained.

METHOD USED:

As mentioned above.

STATUS OF THE PROJECT:

Terminating this year.

FUTURE PLANS:

Continuation of the same work.

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DEMONSTRATION AND EDUCATION PROJECTS

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TITLE OF RESEARCH PROJECT:

Educational Principles and Methods

NAMES OF RESPONSIBLE INVESTIGATORS:

Knud Jansen, M.D.
W. Kragstrup

NAME OF INSTITUTION:

Orthopaedic Hospital, Copenhagen, Denmark

OBJECTIVE OF THE PROJECT:

To find suitable methods for achieving maximum of benefit from minimum of limb.

METHOD USED:

STATUS OF THE PROJECT:

The fifteenth prosthetic course now being prepared for.

FUTURE PLANS:

Selective curricula and teaching based upon actual findings.

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TITLE OF RESEARCH PROJECT:

Research and Demonstration Project with Follow-up Studies on the Production and Utilization of Prosthetic and Orthotic Devices under Rural Conditions in India

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. G. P. Modayil

NAME OF INSTITUTION:

St. John's Medical College and St. Martha's Hospital, Bangalore, India

OBJECTIVE OF THE PROJECT:

1. To standardize the production of orthotic and prosthetic appliances with special reference to their application to rural conditions.

2. To improve the efficiency of appliances made from local materials.

3. To evaluate the effects of prostheses with regard to ulceration, edema, stump neuromas, dermatitis, and osteomyelitis.

4. To evaluate the effects of providing prostheses and other appliances in the economic capabilities of the patients.

5. To coordinate with the neurophysiology department in the study of muscular degeneration and the causes of phantom limb phenomena.

METHODS USED:

Detailed procedures and forms will be developed for intake of patients, periodic evaluation of their progress, and follow-up of the success or failure of their rehabilitation. Plans will be made for documentation, evaluation, and analysis of project results.

Studies will be made of the sources of supply and effective uses of local materials. Practical workshop techniques will be developed to increase the production of prostheses and braces to decrease the cost of the same.

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STATUS OF THE PROJECT:

This project was started at St. Martha's Hospital in a small workshop with basic equipment, manufacturing only orthotic appliances. The Department of Health, Education, and Welfare, Social and Rehabilitation Service, approved of the research project submitted to them and have sanctioned a grant of Rs.397,880 to be used over a period of 3 years. The building to house this project is being constructed by the hospital and will be ready by the end of April. All the staff and other personnel will be employed by the beginning of May. Nearly all the equipment has already been purchased and orders for some of the raw materials have also been sent.

FUTURE PLANS:

At the end of three years, it is hoped that the project will continue on the momentum generated and will continue to serve both in the social aspect as well as a training programme for personnel as well as further research in the various aspects of rehabilitation.

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TITLE OF RESEARCH PROJECT:

Research and Demonstration Project, VRA-IND/21-65. With aid from Social and Rehabilitation Service, Department of Health, Education, and Welfare, Washington, D.C., U.S.A.

NAME OF RESPONSIBLE INVESTIGATOR:

Prof. Natarajan, B.A.,M.B.,M.Ch.(Orth),F.R.C.S.(Eng) Project Director, VRA-IND/21-65, Director, Artificial Limb Centre; Orthopaedic Surgeon, Government General Hospital; and Professor of Orthopaedics, Madras Medical College, Madras.

NAMES OF INSTITUTIONS:

Artificial Limb Centre, Department of Orthopaedic Surgery, Government General Hospital, and Madras Medical College, Madras, India

OBJECTIVE OF THE PROJECT:

To demonstrate the social and economic usefulness in the rehabilitation of orthopaedically handicapped persons.

1. Prostheses and orthoses from domestic materials.

2. Design, fabrication and fitting to suit climate, social and economic environments of the country.

3. Establish Sub-Centres.

4. Teaching and training.

5. Vocational and prevocational training centres, sheltered and nonsheltered workshop.

METHOD USED:

1. Utilise patients attending the Centre as clinical material.

2. Use local materials for fabrication of components.

3. Set up referral Sub-Centres.

4. Set up Vocational Training Centre.

STATUS OF THE PROJECT:

Research of an applied and clinical nature. Prefabrication of standardised components to suit Indians from local raw materials. This has been achieved except for upper-extremity prostheses. Two Sub-Centres set up 300 miles from the main Centre. Short-term training course conducted for Technicians.

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FUTURE PLANS:

1. To organise research work in the field of prosthetics and orthotics on an interdisciplinary basis with the cooperation of engineering faculties.

2. To develop new knowledge and techniques equipped with knowledge thus gained.

3. To develop knowledge and techniques to meet the problems of prosthetic and orthotic fitting, peculiar to the country's social and economic environment.

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DEMONSTRATION AND EDUCATION PROJECTS

TITLE OF RESEARCH PROJECT:

To Investigate Methods for the Rehabilitation of Persons with Orthopaedic Disabilities Resulting from Neurological, Muscular, Bone, and Joint Conditions.

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. Robert W. Dunlap

NAME OF INSTITUTION:

United Christian Hospital, Lahore, West Pakistan

OBJECTIVE OF THE PROJECT:

Demonstration project.

METHOD USED:

Use of local material.

STATUS OF THE PROJECT:

V.R.A.-Pak-3-64.

FUTURE PLANS:

Nil.

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TITLE OF RESEARCH PROJECT:

To Establish a Comprehensive Rehabilitation Programme for the Orthopaedically Handicapped, Including Studies for Their Medical, Psychological, Social, and Vocational Needs

NAME OF RESPONSIBLE INVESTIGATOR:

Prof. Abdur Rahim

NAME OF INSTITUTION:

Orthopaedic Department, Civil Hospital, Karachi, West Pakistan

OBJECTIVE OF THE PROJECT:

Demonstration project.

METHOD USED:

Use of local material.

STATUS OF THE PROJECT:

V.R.A.-Pak-7-65.

FUTURE PLANS:

Nil.

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TITLE OF RESEARCH PROJECT:

To Establish a Multidisciplinary Rehabilitation Research and Training Centre for the Orthopaedically Disabled in West Pakistan

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. Manzoor Khan

NAME OF INSTITUTION:

King Edward Medical College, Lahore, West Pakistan

OBJECTIVE OF THE PROJECT:

Demonstration project.

METHOD USED:

Use of local material.

STATUS OF THE PROJECT:

V.R.A.-Pak-5-64.

FUTURE PLANS:

Nil.

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TITLE OF RESEARCH PROJECT:

Fabrication, Fitting and Training for Use of Artificial Limbs and Braces

NAME OF RESPONSIBLE INVESTIGATOR:

Dr. Manzoor Ahmad Khan

NAME OF INSTITUTION:

King Edward Medical College and Mayo Hospital, Lahore, West Pakistan

OBJECTIVE OF THE PROJECT:

Establishment of a centre.

METHOD USED:

Standard practice.

STATUS OF THE PROJECT:

Satisfactory.

FUTURE PLANS:

To improve upon it.

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TITLE OF RESEARCH PROJECT:

Investigation into Mehods for Developing Total Rehabilitation Practices, Particularly in the Field of Medicine and Establishment of an Experimental Prosthetics and Orthotics Center at the Medical School, University of Cairo

NAMES OF RESPONSIBLE INVESTIGATORS:

Dr. Salah-El-Din El Hommosanni
Dr. H. Abd El Fattah
Mr. Ali Abd El Ghaffar

(In cooperation with the Social Rehabilitation Department, Ministry of Social Affairs.)

NAME OF INSTITUTION:

Day Hospital Foundation for the Rehabilitation of the Handicapped in Cairo, "The Day Hospital and Occupational Rehabilitation Institute"

OBJECTIVE OF THE PROJECT:

To develop a center wherein the investigation of new prosthetic and orthotic devices can be carried on. To investigate and develop the use of new and domestic materials for fabricating these devices.

METHOD USED:

Development of a center for prosthetics and orthotics as a first step in the development of standardized prosthetic and orthotic devices in the U.A.R.

STATUS OF THE PROJECT:

The end of the research stage was in November 1968, and we are preparing for the issue of the final report.

FUTURE PLANS:

To establish new center in the Governorates on the same principles as what has been done in that project.

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