HIGHLIGHTS OF VA CONTRACTUAL RESEARCH PROGRAM

PROSTHETICS

John O. Esslinger, M.D.
Birmingham, Michigan

Animal experiments are continuing on passage through the skin and attachment to the bone. Methods to give pain-free end-weight-bearing on amputated bones are being developed as an interesting by-product both on this project and, as a result of it, under private auspices.

Semi-buried Vitallium mesh has been placed subcuticularly and allowed to protrude through the skin without problems for as much as a year and a half. Raveling of the mesh has been prevented in some cases by fusing and in other cases by coating with Teflon. Experiments have recently begun with Dacron mesh inserted subcuticularly.

In accordance with ideas advanced by several others, an experiment was begun several years ago looking toward a two-stage procedure for skeletal attachment of a prosthesis. A plastic plug was screwed into the amputated and tapped end of the tibia, and the skin was closed over the plug. The initial goal was to allow firm healing of the plug into the bone and to assure absence of infection. (The second stage was intended to provide a portion snapped over the end of the plug, passing through the skin, and allowing fastening to an external prosthesis.) The animal proved able to walk so comfortably on the healed skin covering the dome-like end of the plug after the first stage that this method of securing end-weight-bearing seemed worthy of further development.

Numerous similar experiments have been made with rigid plastic plugs or with Silastic RTV (room-temperature-vulcanizing) rubber in the distal medullary canal and forming a mushroom-like projection over the amputated end. (The latter, like the elastic heel pad of the Syme stump, seemed to provide cushioning.) To assure that the animal actually used the stump, usually the opposite leg was disarticulated at the hip.

Though most experiments have been on the tibia, there is a little experience at other levels. In one case seen during a site visit in July 1965, a dog accidentally amputated by a power mower, Teflon plugs were placed in the amputated ends of the metatarsals; as a control, the similarly amputated ends of the metatarsals of the opposite paw initially were left unplugged. The animal walked most of the time on the paw with the plugged ends,

only occasionally on that with unplugged bones. The skin under the plugged ends remained intact and became somewhat calloused, while that under the unplugged ends was beginning to ulcerate. Dr. Esslinger was considering plugging the metatarsals of the second paw to attempt to heal ulceration and restore symmetry.

Dr. Charles Frantz of Grand Rapids, long an active participant in the Artificial Limb Program, became interested in the possibilities for treating the end of the bone without attempting to project through the skin. The goals would be to improve tolerance for end-weight-bearing in any amputee and to avoid need for surgical revision to avoid pain or perforation of the fascia and skin by overgrowth of bone compared with soft tissue in a growing child. With support of the Hartford Foundation, he began experiments which have now been taken over by his colleague, Dr. Alfred Swanson, at Blodgett Memorial Hospital, Grand Rapids, Michigan. A Silastic plug with mushroom end is placed in the amputated end of the bone. Recently, prefabricated molded plugs have been used. In addition to a number of experiments on dogs, a few human cases have been so treated. Initial results are encouraging.

Gilmatic, Northridge, California
Gilbert M. Motis

Mechanical wrist rotation units were sent to three laboratories for test. Harnessing must be developed to provide the additional function provided by this new mechanism.

A prototype electrical elbow lock modified from a Hosmer E–400 mechanical elbow lock proved successful in operation with low current consumption. It was demonstrated at a Workshop Panel on Upper-Extremity Components on October 19, 1965. Two additional models are under construction.

Four switches have been developed for various control modes: two for harness straps, one for nudge control by the chin, and a fourth for muscle-bulging with very low force and excursion. They are undergoing bench tests.

Preliminary bench tests of screw drives with high reduction ratios have shown rather encouraging efficiencies. A small ring-type motor to be used with these screw drives for axial control is being developed by a manufacturer.

Mauch Laboratories, Inc., Dayton, Ohio
Hans A. Mauch

The Henschke-Mauch "HYDRAULIK" Swing Control System, Model B has been in production for several months and is available for prescription. A clinical application study of the Model A, Swing and Stance Control System is being planned for the near future.

During the past few months, good progress has been made with the development of foam shanks. Improvements in pouring and mixing techniques have simplified the molding operation and greatly improved the foam structure. A test amputee is using a pedometer in a foam shank to provide a record regarding the number of steps taken.

Somewhat reduced development efforts continued on a hydraulic ankle control unit.

Studies continued on a stump actuated hydraulic swing- and stance-control unit. The problems of suitable control principles are being investigated.

National Academy of Sciences-National Research Council
Washington, D.C.

Dr. Herbert Elftman is the new chairman of the Committee on Prosthetics Research and Development replacing Dr. George T. Aitken who will remain as a permanent member.

A newsletter from Dr. Aitken appears elsewhere in this issue. Outlined in the letter are the many events of his chairmanship including the newly formed Subcommittee on Sensory Aids chaired by Robert W. Mann, Professor of Mechanical Engineering at the Massachusetts Institute of Technology. An ad hoc group from the Subcommittee visited Mauch Laboratories, Bionic Instruments, Haskins Laboratories, and the American Center for Research in Blindness and Rehabilitation in November.

A meeting of the CPRD was held on November 11–12, 1965 in Washington, D.C. Both Dr. Murphy of the PSAS and Mr. Staros of the VAPC attended. A variety of matters were discussed. Reports from several panel workshops were presented.

New York University, New York
Renato Contini

During the past several months, the NYU project continued to follow the maintenance experience of 12 wearers of the Henschke-Mauch HYDRAULIK" Model A, Swing and Stance Control System.

Pressure measurements studies have continued. The most recent version of the NYU pressure transducer responds linearly to pressure up to 200 p.s.i. This has been accomplished by increasing the thickness of the strain gage beam to 0.032 in. The design of the transducer positioning inserts has been improved. The outside surface of the inserts will be knurled to insure positive anchorage in the socket after lamination. A method has been developed for quickly and firmly locking the transducer in the insert at the proper level.

Northwestern University, Chicago, Illinois
Clinton L. Compere, M.D.

Elsewhere in this issue are two reports prepared by this project: The Use of Low Friction Housing Liners in Upper-Extremity Prostheses and Impedance Plethysmography in Relation to the Unilateral Amputee.

An amputee has been fitted with a socket as part of a "toilet care arm" being developed. An electrical control system will be utilized, consisting of a "joy-stick" arrangement mounted inside the socket and operated by the tip of the acromion. Four motions—shoulder elevation, depression, flexion, and extension—will be used to operate both motors, forward and reverse, with a spring return to the center off positions. The control will also allow both motors to be operated simultaneously in any combination of directions. A harnessing and control system is being developed. The socket is a typical shoulder disarticulation type with a section approximately 6 in. in diameter removed from the area of the acromion. A vertical metal strap to which the "joy stick" is attached is contoured and fastened over this area. The other end of the "joy stick" is fixed to a small swivel which is attached to a cap over the acromion.

The project continued its development activities in both the upper- and lower-extremity fields. Several experimental devices using electrical auxiliary power have been built. One mechanism, for example, allows electric operation of a conventional Bowden cable control to aid a severely handicapped patient.

University of California at Los Angeles
Biotechnology Laboratory
John Lyman, Ph.D.

An experimental muscle hernia (described in BPR 10–3 Spring 1965) eventually healed. The nodule of scar tissue remaining, though, continued to serve as a localized site for voluntary control by bulging the muscle against a transducer.

During a site visit by Dr. Murphy in September, the above amputee demonstrated both independent and coordinated use of several muscles, including the pectoral muscle bulge.

University of California at San Francisco and Berkeley
Charles W. Radcliffe

A conference at San Francisco in July 1965 (BPR 10–3 Spring 1965) brought together prosthetists from several laboratories, under chairmanship of Mr. Anthony Staros. It emphasized three newly developed casting methods as well as fabrication and application of the UC air cushion socket for below-knee amputees. Participants later conducted clinical trials in their own institutions to assist in further development and consideration.

The manual on installation and adjustment of the UC pneumatic swing-control unit was published. Plans have been developed for service testing of ten of the prototypes at the VA Prosthetics Center, including both bio-engineering tests and clinical use.

A site visit in September 1965, reviewed both VA-sponsored work and related projects under other agencies.

VA Hospital, Seattle, Washington
Ernest M. Burgess, M.D.

A full report of the activities of this project is published elsewhere in this issue.

SENSORY AIDS

Fabrication of Obstacle Detectors for the Blind
Bionic Instruments, Inc., Bala Cynwyd, Pennsylvania
J. Malvern Benjamin, Jr. and D. Ridgeley Bolgiano

Work has continued in development of the cane-like electronic aid for the blind illustrated in Figure 1. The unit is currently undergoing initial laboratory testing by the developers. In addition to providing somewhat the same sensory information and physical protection as an ordinary long cane, this unit has electronic-optical systems to "look for" and warn of protruding dangers (which may injure head or shoulders), obstacles out ahead, and (in development) curbs or platform edges. Special arrangements, still being refined, have been incorporated in the photosensitive-element design of the unit to render its output less sensitive to the reflectance characteristics of objects which may be in its field. It thus tends to "see"

FIGURE 1. Early prototype of cane-like electronic mobility aid for the blind.

and warn of an impending danger over a wide range of surface characteristics of the object. Of course, as with any radiant energy reflecting scheme, if the object is "dead" black or nearly so, or an obliquely placed mirror, no indication of its presence may be signalled by the electronic system. Fortunately, such objects often have diffusely reflecting frames. The user's auditory and tactile systems receiving information from the environment through the cane and otherwise may still allow the blind person to avoid the rather exceptional objects which are completely nonreflecting optically. [Because of the longer wave lengths of sonic or ultrasonic energy compared with optical, there is much more danger that an oblique wall or projecting corner will fail to reflect diffusely enough energy to give a warning echo.] Messrs. Bolgiano, Benham, and Benjamin of this Contractor's staff presented a paper, "Travel Aid for the Blind" at Session XX of the 18th Annual Conference on Engineering in Medicine and Biology, held November 10–12, 1965 at Philadelphia, Pennsylvania. Current aspects of the research project were covered.

Research on Human Perception of Objects by Use of Pulsed Sound
Lockheed-California Co., Burbank, California
John E. Parnell and L. J. Shepherd

This project was completed in June 1965, and the notes given here are taken chiefly from the final report:

> Parnell, J. E., and Shepherd, L. J., "Human Perception of Objects by Use of Reflected Sound," Summary Report VA Contract V1005P–297–A, Lockheed-California Co. Report No. LR 19011, 27 pp plus 12 figs., June 19, 1965.

The ability of human subjects to use reflected sound to detect the presence of objects in an ideal environment has been the subject of this systematic laboratory investigation. Using previously documented research to establish the qualitative role of acoustic phenomena in the sensing of obstacles by blind persons and certain animals, the investigators in this project have focused on an evaluation of the basic parameters contributing to this ability in people. A representative array of acoustic signals was evaluated ranging from the type employed by certain whales and bats for navigation and food-finding to electronically tailored signals incorporating the supposed optimum characteristics inherent in the animal's echolocation sounds. These acoustic signals were focused by a paraboloid which the subject could sweep across an anechoic environment in which a target could be placed. (Occasional blank trials were made without a target to guard against mere guessing.)

The aluminum cylinders employed as targets for most of the tests were treated as symmetrical sound scatterers to simplify the comparison and analysis of target returns. Test results included detection threshold values and optimum spectra and pulse repetition rates for the various signal types tested.

This investigation provided an opportunity to use modern instrumentation techniques to review some of the concepts brought out in the experiments conducted by Dallenbach and coworkers at Cornell University in the 1940's. As part of this evaluation, a remote binaural listening system was constructed. Measurements were made to determine echolocation efficiency with different target shapes and materials. During the course of the investigations, auditory thresholds were measured throughout the audible spectrum using special techniques developed to extend measurement capabilities to the 10–20 kc. per second range.

The most significant developments in the program include the initial determinations of optimum signal types for human echolocation and the specification of instrumentation and techniques for evaluating this function in people. The rectangular pulses found to be most effective may be easily achieved with solid-state circuitry and would provide the basis for small scale field test instrumentation.

The role of audio-frequency echolocation signals as a navigation aid for the blind has been considered. While people demonstrated an unexpected capability in this area, it is felt that this system would not be feasible as a sole source of navigational information. However, echolocation utilizing electronically generated signals shows significant promise as a technique for use in selected situations at the discretion of the individual.

Several promising research directions were noted during the course of this program. These include the following:

1. The part played by human auditory response to frequencies above 8 kc. per second in echolocation ability. This information should be useful in training blind persons to utilize environmental sounds effectively.
2. The remote listening system can provide extensive information regarding the physical characteristics of the echo returns picked up by the listener.
3. The frequency modulated bat-type pulses appeared unusually effective during initial tests. Evaluation of this signal type in noise environments and with moving targets should prove of interest.

The Lockheed results may be interpreted as an indication of the need for careful prescription. Some individuals display remarkable ability to detect very small cylinders in a quiet environment. High frequency hearing is important. A young blind person with very acute hearing in high frequencies might not need such an aid; an elderly blind person with severe high-frequency losses probably would not detect even strong echoes. In selected cases, though, a device emitting pulses might usefully supplement other travel aids by raising the intensities of echoes from obstacles above the high-frequency threshold of a particular blind user.

THE EDITORS

Spelled-Speech for Automatic Readers Usable by the Blind

Metfessel Laboratories, Inc., Los Angeles, California
Milton Metfessel, Ph.D.

Work on the development of a system of spelled-speech has continued along the general lines indicated in BPR 10–3 Spring 1965, pages 170–172. Professor Metfessel indicates he will have a completed set of rules governing the production of spelled-speech elements by the end of this contract year (June 1966). These rules and instructions should enable others generally skilled in the speech and recording arts to prepare spelled-speech alphabets locally for use in their own work.

In the VA program on reading machine development, the output format of Mauch Laboratories' recognition machine is spelled-speech. The best developments of Metfessel Laboratories may be drawn upon in the careful recording of the master utterances for the Mauch arcuate magnetic tape storage and playback "word synthesizer" or for other designs. Similarly at Haskins Laboratories, locally prepared spelled-speech utterances, spoken by the same recordist used to make the master word-tape, will be necessary if the system is to handle words not in its 7,000-word recorded "dictionary."

Professor Metfessel now feels that the elusive echo-like background sound noticed by some listeners of spelled-speech is traceable to sound reflections from walls of the recording room. Steps taken to give some acoustic treatment to the walls, and to record in a space with non-orthogonal wall-planes, have corrected the difficulties attributed to the echoes.

Research on Audible Outputs of Reading Machines for the Blind

Haskins Laboratories, Inc., New York, N.Y.
Franklin S. Cooper, Ph.D., Jane Gaitenby

With the appearance in June 1965 of a "Status Report on Speech Research," SR–1 (1965) dated February, 1965, Haskins Laboratories have embarked on a new report publication approach wherein they will report from time to time on all aspects of their speech research for several sponsors. The work reported in SR–1 has been supported in part by the National Institute of Dental Research, the Veterans Administration, and Haskins Laboratories. The report series will be devoted to studies on the nature of speech, instrumentation for its investigation, and practical applications. Latest available report in the series is the third, dated August, 1965, which discussed stop consonants, instrumentation, and Thai among other topics.

In a section of the first report on speech perception, the authors indicate they feel no surprise on discovering that speech is a uniquely distinctive set of acoustic signals. No other acoustic signals will work nearly so well. Non-speech ciphers on the phonemic structure of language have been developed and tested, not only in the familiar case of the Morse code, but also in fifty years of research and development in the attempt to build reading

machines for the blind. Non-speech ciphers, unfortunately, seem to work much less efficiently than speech.

A study of pitch, duration, and loudness of speech utterances continues.

Output Characteristics and Construction of an Interim Word-Reading Machine

Haskins Laboratories, Inc., New York, N.Y.
Franklin S. Cooper, Ph.D. and Paul Brubaker

Construction of the "hardware" of the Word-Reading Machine is continuing. To achieve greater naturalness in the output of the completed device, it is planned that some manipulation of the pitch, duration, and loudness of the speaker-recorded reference words will be effected. This will be done by a computer programed on the basis of knowledge about sentence utterance obtained from the current study of suprasegmental speech elements mentioned in the preceeding section.

The Development and Evaluation of a Personal Reading Machine for the Blind

Mauch Laboratories, Inc., Dayton, Ohio
Hans A. Mauch and Glendon C. Smith

The most advanced personal-type reading machine being developed by Mauch Laboratories is designed to provide the blind user with a "spelled-speech" utterance for each upper- and lower-case letter or ligature scanned by the hand-held optical probe. The character recognition technique tested in the laboratory recognizes a number of popular type fonts with moderate accuracy (90–95 percent) and speed (80–90 words per minute) by using a special arrangement of photoconductors to gather information on letter features. The development of the hand-held probe for this machine has resulted in a family of direct translation reading aids which are pocket sized and battery operated and may be used independently for low speed reading. These are the Visotactor A which may also be used with the recognition unit, the Visotactor B, and Multicolumn Visotactor which are "tactile optophones" with one or more columns of photocells and associated stimulators, and the Visotoner which is a nine tone self-contained optophone. One or more operating prototypes of each device (except the Multicolumn Visotactor which is still experimental) have been completed.

The Recognition Prototype, designed, constructed, and evaluated during the past year, is a laboratory version of the advanced reading machine. It is used to investigate the "multiple snapshot" character recognition technique and to aid in the improvement of the photocell array and recognition matrix designs. The Recognition Prototype, the Visotactor A probe, and the Word Synthesizer can be operated together. The Recognition Prototype differs from the production version of the reading machine mainly in that the prototype uses conventional discrete component construction and a large

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number of indicator lamps, whereas, the much smaller production version will use micro-miniature solid-state integrated circuitry and no visual indicators.

Photocell construction techniques using inexpensive equipment were developed and have permitted Mauch Laboratories to make photocell arrays ranging in complexity from the relatively simple optophone type to the combined recognition-optophone array which has 20 or more photoconductive cells of varying sizes, shapes, and orientations in a half-inch diameter circle.

The Visotoner electronic circuits were miniaturized to fit inside the probe handle by using conventional size transistors (38 total) in a "cordwood sandwich" design. The first prototype has received some preliminary evaluation at the American Center for Research in Blindness and Rehabilitation, Catholic Guild for All the Blind, Newton, Massachusetts.

A blind student was trained to use the Visotactor B and Colineator. At a point one-third the way through the Battelle 200-lesson training course, sustained tactile reading speeds of six words per minute were achieved. There are no indications of reaching a plateau yet. Since the test situations use self-tracked IBM Executive type, a speed reached in this manner is not directly comparable with speeds achieved with mechanically generated and scanned block letters with perfect tracking and uniform pacing.

Mauch Laboratories began investigating the feasibility of adding one or two columns of photocells and associated tactile stimulators to the present Visotactor to produce a Multicolumn Visotactor. Multiple column tactile reading aids will produce reading speeds higher than the single column devices. For a three-column device the photocell array would consist of three vertical columns of eight photocells each (see Figure 2). Each of the 24 photocells would activate a corresponding fingertip stimulator when that particular cell "sensed" black at a height location in the line of print corresponding to the cell's position in its column. Each of the four fingers of the right hand will be positioned so that each fingertip contacts six stimulator points arranged and spaced similarly to the six dots in a braille cell, though the significance will differ and the Visotactor will not provide the coding which is such a key feature of braille. This arrangement was chosen because it seems to be nearly optimum for discriminating tactile stimuli with the fingertips. The two proximal stimulators on each finger (e.g., 3 and 6) correspond to two adjacent cells in the first vertical column of photocells to scan over the letter. The display is so oriented that the bottom part of the letter (including descenders) will selectively activate the index fingertip stimulator and the upper part of the letter (or riser) will stimulate the little finger. As the probe is rolled over a line of print, a large dot pattern replica eight points high and three columns wide travels under the fingertips with the spacing between columns sufficient to allow three columns to cover about one-half of an average letter width. It is hoped that such a

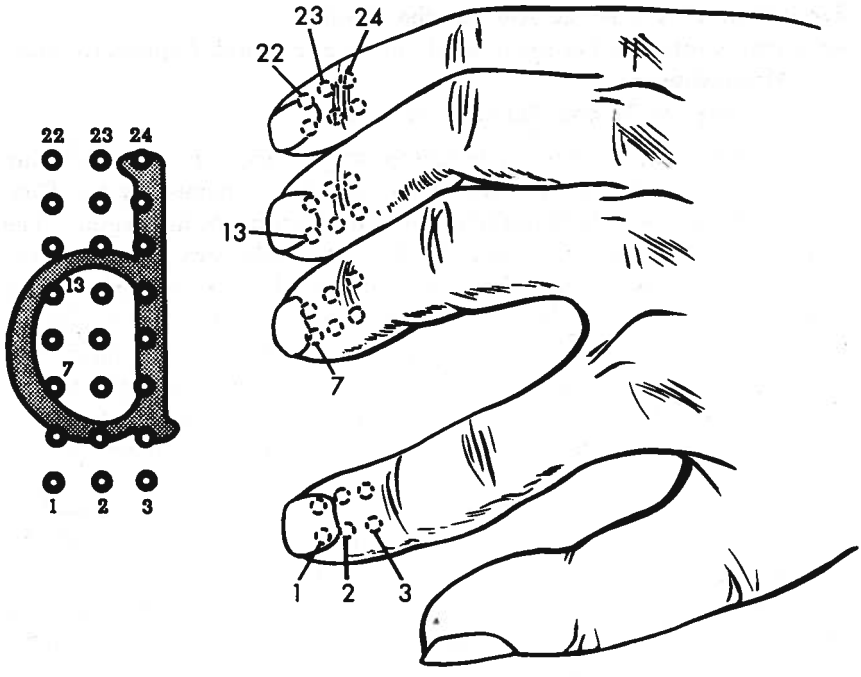

FIGURE 2. Photocells scanning the letter "d" and corresponding tactile stimulators under the fingertips in the arrangement planned for the multicolumn Visotactor.

simultaneous presentation of a three-dimensional pattern will allow faster and more accurate recognition of letters, numerals, and other characters.

Determination of Performance Attainable with the Battelle Optophone
American Center for Research in Blindness and Rehabilitation, Newton, Massachusetts
Leo H. Riley, M.D. and Ann Harrington

The two subjects learning the VA-Battelle optophone system at ACRIBAR continue in their work despite delays caused by illness of one and extended travel by the other. These two blind persons are reading material clearly printed in IBM Executive font and of a First Grade level. Their performances are similar to the average performances achieved at Battelle Memorial Institute and at the VA Research and Development Division of the Prosthetic and Sensory Aids Service by persons going through the same course of study. The two subjects averaged 5.5 words per minute and 4.0 words per minute respectively on Test No. 7 in the training series. Test No. 7, at the 70th lesson, comes nominally in the 70th hour of instruction.

Evaluation of Ultrasonic Aid for the Blind

American Center for Research in Blindness and Rehabilitation, Newton, Massachusetts
Leo H. Riley, M.D. and Gunther Weil, Ph.D.

All stages of this project preliminary to actual work with test subjects are well underway. Special staff personnel have been retained by the Contractor, and training the trainers in use of the instrument has begun. The inventor of the unit, Dr. Leslie Kay, formerly at Lanchester College of Technology, Coventry, England, and now at Canterbury University, Christchurch, New Zealand, visited ACRIBAR in August 1965 to examine the ten instruments involved in this study, and to exchange viewpoints on evaluation of the device. Dr. Kay noted slight differences in the sounds of the several units and assisted in correcting those instruments not up to his standards. Certain other equipment problems, not yet fully analysed, have come to light during preliminary use of the ultrasonic blind aids by the project personnel and other ACRIBAR staff members. Plans for screening interviews of prospective subjects were completed. The investigators hope to be far enough along in their work to make a solidly based contribution to an International Conference to be held in London in June 1966. Reports on a number of evaluation studies from several countries are expected to be presented at this conference.