

NOTES ON VA CONTRACTORS

PROSTHETICS

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

Research continues for a practical means of attaching an external prosthesis directly or indirectly to the skeletal system.

Twenty-nine surgical procedures have been done on 22 dogs and 1 monkey over a period of 8 years, with followups ranging over a 4-year period. Combination appliances have been implanted; studies have been made of the implantation of various materials, including Teflon, silicone rubber, and Vitallium screening, and investigation has been undertaken on the use of Teflon as a material for plugging the cut end of a bone.

Two interesting phenomena have been noted:

a. Perforated or mesh material placed in the subcuticular level in a dog remains intact, in some instances for months and years, with minimal tissue reaction.

b. Usually associated with limb amputation in a dog, osteophyte formation, which precludes weight bearing, may be prevented by the use of an end-bone plug of resilient material, forming an end-bearing stump similar to a Syme's.

Gilmatic, Inc., Northridge, California
Gilbert M. Motis

This project on mechanisms for use in upper-extremity prostheses is relatively new, though Mr. Motis has a long history of contributions through Northrop Aircraft and UCLA. His elbow lock, two-load hook, and improved Bowden cable fittings have been widely used for many years. The present project is currently emphasizing wrist rotation for short below-elbow, above-elbow, and shoulder disarticulation cases, who typically must rely upon passive rotational adjustment of the terminal device. As a corollary, Gilmatic will attempt to develop axial or central-control systems for terminal devices to avoid the problems encountered in tightening or loosening of present external Bowden cables during rotation of the terminal device with consequent spiralling of the cable about the forearm. A further goal is the development of mechanically or electrically powered elbow locks which can be triggered by slight body motions.

Gilmatic has presently built two wrist rotation devices, one cable-operated and one electrically powered. The cable-operated unit provides an alternator action, intended to allow the amputee to rotate the wrist to any desired position and then selectively return to any other position or, if necessary, to rotate further in the original direction. Automatic locks against rotation under external torques in either direction are provided.

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

During the past several months, Mauch Laboratories conducted tests to decrease the minimum resistances of the Mauch Swing-control System, Model B. The latest designs of the Model B will incorporate a lower viscosity fluid, resulting in lower minimum resistances with only a minimal effect on the upper end of the resistance range.

The project continued to provide technical, diagnostic, and reconditioning services on swing-control units.

A clinical application study is being planned by the Veterans Administration on the Henschke-Mauch "Hydraulik" Swing-and-stance Control System, Model A.

Redesign of a prototype of a hydraulic ankle-control unit was completed, and the modified prototype is being tested by one amputee.

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

Primarily through the activities of the Committee on Prosthetics Research and Development (CPRD) and the Committee on Prosthetic-Orthotic Education (CPOE), the National Academy of Sciences-National Research Council continued to provide advisory services and to help correlate VA's prosthetics research and educational programs with those of other organizations. Elsewhere in this *Bulletin* are printed the Newsletter of the Chairman, CPRD, and a report on progress and future plans by CPOE.

New York University, New York
Renato Contini

A final evaluation report was submitted by this project on the Henschke-Mauch "Hydraulik" Swing-and-stance Control System, Model A. An abstract of this report is presented for summary purposes:

The Henschke-Mauch "Hydraulik" Swing-and-stance Control System, Model A, has been evaluated in a comprehensive series of bench and biomechanical tests. Its applicability to a selected portion of the general amputee population has also been assessed through the collection and study of subjective data gathered from 12 above-knee amputees over a 2-year period.

Results of this program have shown that the unit is a highly advanced prosthetic development which offers a great many positive features to its wearers. Among these advantages are such particular stance-phase-control features as: minimization of knee buckling by giving the amputee (1) a means of recovering safely in potential stumbling situations, (2) the ability to descend stairs and ramps in a step-over-step manner, and (3) protection against extreme forces.

Also examined and judged favorably were the maintenance record of the knee as well as its swing-phase operating characteristics. (Negative features such as weight and residual knee resistance are also included.)

Recommendations for the improvement of the device are suggested as well as its prompt acceptance for clinical field testing.

Biomechanical evaluation has continued on the University of California pneumatic swing-control unit. The New York University project has also undertaken pressure-measurement studies. Attempts are being made to secure a pressure transducer which will accurately reflect the pressure distribution existing around the circumference of an above-knee socket under both static and dynamic wear conditions.

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

This project has continued its efforts to develop devices and techniques useful in meeting the particular needs of individuals with difficult prosthetics problems and the special needs of geriatric amputees.

A polycentric knee, especially useful for geriatrics, is presently under evaluation. Disc friction units for lower-extremity prostheses, providing programmed mechanical friction are similarly undergoing evaluation. Numerous designs of sockets are being studied to provide flexibility for muscular activity and controlled transition of stiffness near the brim. A new system for casting below-knee stumps under weight-bearing conditions is being explored.

Two designs of coordinated-motion arms, providing rotation of the wrist simultaneously with elbow flexion, are being studied to facilitate eating and toilet care for severe bilateral amputees. Presumably, these mechanisms could be used with conventional artificial arms or with the Northwestern University electrically driven elbow joint controlled by position of the AE stump.

Project Progress, Inc., Virginia, Minnesota
Maurice J. Fletcher

Two models of the stair-negotiating wheelchair were received by the Bioengineering Research Service of the VA Prosthetics Center. Evaluations performed in the VA Prosthetics Center indicated several major deficiencies. A restudy of the feasibility of using body power for stair ascents and

descents now seems necessary; nevertheless, VAPC plans call for redesign of the Project Progress wheelchair to make it more efficient mechanically and possibly limiting its application to curb climbing.

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

This project has continued its needs analyses for the development of externally powered prostheses design specifications. The objectives of this study are (1) To re-evaluate currently used design specifications of existing conventional prosthesis subsystems as, for example, terminal devices and elbow lift and lock mechanisms; (2) To compare these design specifications with available criteria for externally-powered prosthesis subsystems, and the specific design goals in terms of functional regain; and (3) To integrate the findings of the needs analysis into design criteria quantification of the complete externally powered prosthetic system.

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

Active research efforts continued in lower-extremity prosthetics and orthotics.

A report is being written on a PTB socket with flexible RTV liners which provide additional support on the distal portion of the stump. A fixture has been designed to permit quantitative evaluation of the amount of end bearing associated with the flexible liner total-contact socket.

In connection with the immediate postoperative fittings being performed at the San Francisco General Hospital, the design and development group have concentrated on the special prosthetic devices and techniques needed in this novel approach.

Work on an adjustable brace has been completed. An alignment-transfer device for use with the adjustable brace has been revised for simplified use. A report will be published on this brace.

Research has continued on the biomechanics of the foot and ankle, knee joint, and hip joint. A study was completed on intradiscal pressures in normal persons and in persons with degenerated discs. It was found that pressures were greater in the sitting than in the standing or reclining position. These results would seem applicable in the design and prescription of braces and corsets in the treatment of low-back pain.

Veterans Administration Hospital, Seattle, Washington
Ernest M. Burgess, M.D.

This project has been investigating the feasibility of fitting lower-extremity prostheses immediately after amputation. This technique was originally demonstrated by Dr. Marian Weiss of Warsaw, Poland, who emphasized the psychological as well as the physiological advantages of early postoperative prosthetic fitting.

Dr. Ernest M. Burgess is serving as principal investigator of the project with the assistance of Dr. Robert L. Romano. Mr. Joseph Traub is the research prosthetist. Results obtained to date indicate that the immediate postoperative prosthetic fitting approach may profoundly alter and improve amputee management. Drs. Burgess and Romano and Mr. Traub will visit Poland in the near future to confer and work with Dr. Weiss.

The Committee on Prosthetics Research and Development has appointed an *ad hoc* committee to review the technique and to establish meticulous controls and data collection procedures.

SENSORY AIDS

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

Current work on this project centers around miniaturizing the obstacle detector, Model G-5, already developed and in trial use. The aim is to reduce the size by a factor of 10. This miniature device is under construction and will be packaged in an elliptical tube (Fig. 1). The unit will involve only a single channel and will be a nonranging device. Using the experience from this construction, the designers will build a miniaturized version with ranging capabilities. These small units are being designed with the probable ultimate configuration in mind, e.g., a cane, which will "look" ahead for obstacles, and upward to protect the head-and-shoulder region, will also be able to detect down-curbs and up-curbs.

Figure 2 is a block diagram of the new single-channel nonranging unit now nearing completion. The xenon flash lamp used in the older Model G-5 has been replaced with a gallium arsenide infrared source; the transmit-and-receive lenses have been reduced in size from a 3-in. to a 1-in. diameter, and microminiature circuits have been employed. It is expected that true lasers using gallium arsenide will become available at suitable prices within a year or so. These will be directly applicable in the new miniature units, improving performance and reducing battery requirements.

From the relatively informal user tests of the G-5 unit being conducted by Professor Benham, a definite consensus has emerged that the unit be miniaturized as much as possible, at least so it can be stowed in a pocket when not

in use, even if this size reduction means some loss in information-handling capabilities. The users also display considerable interest in using the device as an exploring probe to inform about the environment, rather than merely as an object detector to find a clear path ahead. An informal report by one such user, generally quite favorable, but too long for inclusion here, is available.

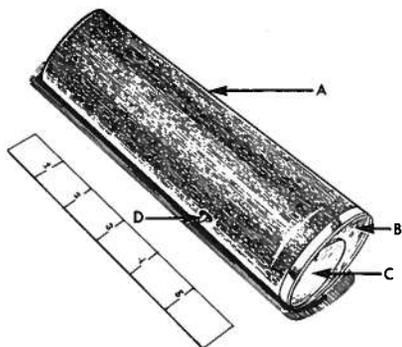


FIGURE 1. Miniature hand-held non-ranging obstacle detector.

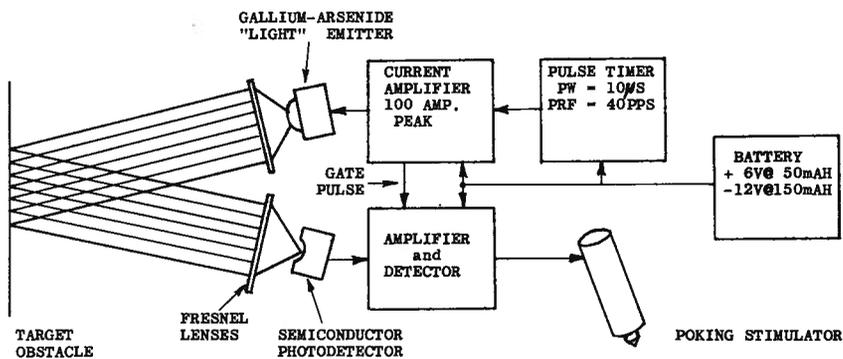


FIGURE 2. Block diagram of the miniature non-ranging obstacle detector.

Research on Human Perception of Objects by Use of Pulsed Sound
Lockheed-California Co., Burbank, California
John J. Dreher, Ph. D.

Personnel in the Contractor's Bionics and Human Factors Unit, Acoustics Research Group, are studying human perception of objects by the use of pulsed or high-frequency sound, with special attention to mobility of the blind.

Company-supported research on sonic echo location by humans has been in progress at Lockheed for some time. An experimental audiometer capable of measuring human hearing thresholds up to 25 kilocycles has been developed. Lockheed's existing anechoic chamber will be used on this VA research project.

Subjects will be asked to judge by listening for the echoes, for the presence or absence of a target. This continues the basic study of human perception of targets by auditory means already started at the Contractor's laboratory. The effects of click frequency components, background noise, and the echoic environment will be investigated. In addition to the theoretical work with flat plates and cylinders as targets, tests will also be conducted to determine the efficacy of pulsed click trains in the detection of such obstacles as down-curbs, up-curbs, outside and inside 90°-wall corners, and plane walls at various angles.

The initial work undertaken to date has been a replication, using state-of-the-art instrumentation, of the studies carried out by Dallenbach and his associates in the 1940's. This has included evaluations of the efficiency of selected acoustic signals for the production of echoes used in auditory detection of targets. Continuous and gated random noise and discrete frequencies are being evaluated in this context. In addition target thresholds achieved using a broadband pulse as an outgoing signal have been repeated with results similar to those previously reported.

Detection of targets via a remote listening system is being investigated. Both stationary and moving sound sources are used with the echo returns for the ensemble of signal types being delivered to the subject through earphones. While the short duration pulses are apparently most effective for this purpose, the random noise (another broadband-type sound) is also predictably effective for echo location.

Analyses of the physical parameters of the outgoing sounds and echoes generated in all tests are being implemented. Microphone pickups are located at the sound source, at the target position, and at the subject position. The signal at each of these stations is photographed and also recorded on magnetic tape for subsequent spectral analysis. Computer facilities are utilized for this $\frac{1}{3}$ -octave band analysis with direct readings for levels in each of the bands.

Auditory response of subjects used in these tests is measured by conventional audiometry and by the system designed to establish thresholds for frequencies extending from 8 kc.p.s. to 25 kc.p.s. The clinical implications for thresholds in this frequency range are also being studied.

Spelled-Speech for Automatic Readers Usable by the Blind
Metfessel Laboratories, Inc., Los Angeles, California
Milton Metfessel, Ph. D.

Conceived by Professor Metfessel in April 1964, the "compatible spelled-speech" approach to alphabet construction focuses on the problem of how to secure for a spelled-speech alphabet a set of letter sounds that all belong to the same universe of sounds.

With the alphabets previously developed by this project, it was possible to synthesize spelled-speech that closely resembles rapid natural spelling; however, the quality of the material formed with these alphabets suffers if played on reproducers with frequency response characteristics different from the recording system. This phenomenon appears related to slight differences between letters (e.g., in level of background noise) that show up under some playback conditions. Obtaining a set of letter sounds that belong to the same universe appears crucial if an alphabet is to produce consistently good spelled-speech under the varying playback conditions that may be expected in other than experimental use.

The "compatible spelled-speech" procedure uses recordings in which letter sounds are pronounced in a setting of conventional pronunciation, to facilitate their being spoken in a natural and homogeneous manner. It also includes a method for testing the compatibility of letter sounds with both usual word pronunciation and with each other. Preliminary results with this approach have been highly encouraging. Development of an alphabet with it is in progress.

In the research on effective programming of spelled-speech training with Educo teaching-machine prototypes, several major developments have occurred. During the fall of 1963, 39 trainees participated in five experimental sessions. Results from these: (1) Demonstrated the practicality of using earphones in spelled-speech training (their utilization did not interfere with coalescence nor did it affect the learning rate detrimentally); (2) Demonstrated the suitability of the training tapes for sessions self-administered by each participant, as would be the case in home-training sessions for the blind; and (3) Gave information on differential pacing on the part of fast and slow learners when permitted to stop and start the machine as they wished. During the summer of 1964, a pilot study of five sessions with eight subjects was initiated to investigate the effects of presenting a somewhat slower intra-word rate at the start of training. Systematic investigation of this procedure is soon to be conducted.

During 1963-1964, the following pieces of equipment were designed and constructed: (1) *Audiocator*, an instrument to automate the location of bigram series; (2) *Autorecorder*, an instrument coordinated with the preceding one and used to record bigrams automatically once they are located.

Other recent activities have included: (1) A study to compare learning rates with the teaching machine as contrasted with the instruments used in previous experimental training sessions; (2) A study to determine the rate at which material synthesized with the spelled-speech alphabets can be comprehended at the outset by young adults; (3) Research to determine the effectiveness of the use of rhyme in spelled-speech training material; (4) Presentation of a paper, "The Relation of Similarity of Vowel Sounds to Perception and Learning of Spelled-Speech Words," at the Western Psychological Association convention in Portland, Oregon; and (5) Reading of a paper, "Controlled Association in Learning the Auditory Code of Spelled Speech," at the meetings of the American Psychological Association, Los Angeles, September 1964.

Research on Audible Outputs of Reading Machines for the Blind
Haskins Laboratories, Inc., New York, N.Y.
Franklin S. Cooper, Ph. D.

Work is continuing on the development of a hybrid-system formant-type of speech synthesizer to provide a relatively high-grade audible output for an automatic reading system for the blind. Accepting input signals from character recognition devices or other "machine information" media such as perforated tape, the unit will produce a readily understandable, though admittedly not perfectly "natural," spoken output.

The 7,200 word-recordings already made by a specially instructed speaker at Haskins Laboratories will be fed through an existing digitizer-analyzer, which will convert the speech information to digital form for storage in a magnetic disc file. This digital data on each word in the system will be used to control a formant-type synthesizer now being designed. This synthesizer will yield back understandable speech, improved in quality over the compiled speech realizable from the original 7,200 recordings, because it will be made to incorporate pitch, duration, juncture, and other information responsive to the sentence or phrase being processed. Work on a thorough understanding of such suprasegmental speech information has occupied Haskins' researchers for some time now, and an impressive body of knowledge has already been obtained.

Output Characteristics and Construction of an Interim Word-reading Machine
Haskins Laboratories, Inc., New York, N.Y.
Franklin S. Cooper, Ph. D.

Original plans for this device, which is to produce compiled speech as an output from punched-tape input, involved a control unit using fairly complex relay circuitry. Early in 1964 Haskins Laboratories installed a Computer

Control Co., Inc., DDP-24 electronic computer. With this tool available, it has been decided to use the computer to control the word-reading machine rather than the less flexible relay unit. The necessary program and electronics needed at the interface between the computer and word-reading machine are currently in development.

Carefully controlled recordings of some 7,200 words have been made and exist on magnetic tapes affixed to IBM-style cards. These recorded utterances will be used to "load" the tape, which will form part of the random access word store of the completed unit. To improve the chances that such recorded words, recombined in almost any order, will not sound utterly unnatural in the compiled sentence, extensive linguistic analyses have been conducted. Diagrams have been made illustrating the sort of probabilistic thinking related to systematizing knowledge about how sentences are actually constructed.

The Development and Evaluation of Optophone Devices for the Blind Battelle Memorial Institute, Columbus, Ohio

John L. Coffey

Construction of all 10 units of VA-Battelle optophones was completed during Fiscal Year 1964. In September 1964 five optophones remained in the Columbus, Ohio, area, and five were under direct control of our Research and Development Division in New York. Three of the Columbus units were in the hands of former students at Battelle who continued to use the devices; one unit was at Battelle for reference and demonstration purposes, and another was at the Mauch Laboratories. One of the New York units was in use at R&D Division, PSAS, for an "in-house" evaluation of both the device and the Battelle training program; one optophone was at Hines VA Hospital for similar purposes, one was at Princeton University where applications to tactile readout were under study, and two were in storage.

A test was conducted June 26, 1964, at Battelle to measure reading speeds of former students with the device after a considerable absence from formal training. Three persons were tested for a 20-minute interval, reading material taken from the June 1964 issue of *Readers Digest*. At the end of their formal training, one year prior to the retest for two subjects and five years prior for one subject, performance averaged 16.6 words per minute, not including time to change from line to line. Under similar conditions on the retest, an average of 13.8 w.p.m. was achieved, a loss of 17 percent in reading speed during the period when no formal instruction was given but when the devices were used on a voluntary basis by the subjects in their homes.

At the Research and Development Division, PSAS, New York, a blind VA employee is voluntarily enrolled in a training program with the opto-

phone. While plans called for three 1-hour sessions per week, occasional illness, emergency detail to interfering duties, vacations, and holidays have permitted actual attendance of only 1.34 hours per week. The subject remains interested and has made some progress. The sessions commenced in January 1964 and by July the subject could average 3 words per minute on course reading materials, often reading some lines at a higher rate. In spite of reduced intensiveness of training and lack of peer competition that would result from a classroom situation, the volunteer VA student manages to keep abreast of the median Battelle performers.

The unit at Hines VA Hospital in Illinois has been used in training one of the blind braille instructors at that activity. Both under instruction, and self-taught, commencing in April 1964 the student had completed about 120 lessons by September 1964. He is able to devote more time to the optophone than the volunteer in New York and has made considerably more progress. Estimates of reading speed are in the order of 12 words per minute. The subject has been able to read some of a typewritten letter received from his sister-in-law, and thinks well of the device.

The unit at Princeton University is not being used in strictly orthodox fashion. The probe is suspended over a controlled typewriter carriage which carries the typed material. The outputs are used to control nine vibratory stimulators located at various points on the body. The tones are used, but for monitoring only, this being an experiment in tactile communication, the information path being from print on a page to the brain of the user, via the skin, rather than by the eyes or ears.

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

Mauch Laboratories, Inc., Dayton, Ohio

Hans A. Mauch

The reading machine being developed at Mauch Laboratories will have an auditory output using the "spelled-speech" sounds of Metfessel Laboratories. Recognition of the popular type fonts at moderate reading speed (80-90 w.p.m.) and accuracy will be accomplished by letter feature analysis. Components of this reading-machine system, and some units, which are developments based on system components, are usable independently for reading at a lower speed.

The Visotactor A, now being developed, will be a hand-held optical scanner containing eight tactile stimulators arranged along a line to operate against four fingers of a user's hand. It may be thought of as a "tactile optophone." It will enable the user of the Mauch system to adjust the

magnification in the scanner to accommodate print sizes from 7 to 36 points, to locate lines of print, and to sense numerals and characters not within the recognition capabilities of the system. In addition to the eight photocells in linear array, the Visotactor A will also have a two-line arrangement of cells used to give sequential signals for the "multiple snapshot" character recognition circuitry. This logic circuitry, to be housed in the Word-Synthesizer unit, will analyze the signal data from the photocells to determine presence or absence of identifying letter features. After letter identification, the Word Synthesizer, which has already been built in a first model, will reproduce the appropriate spelled-speech output from its store of 31 pre-recorded sounds.

The Colineator is an optional mechanical tracking aid designed at Mauch Laboratories for use with Mauch or other reading machines for the blind. It should permit easier tracking for relatively extended periods of reading. Two have been built.

The Visotactor B, already constructed in first prototype form, has the same probe, tactile stimulators, and eight-channel electronics as the Visotactor A, but does not contain any of the cells or wiring associated with the automatic letter recognition section. The B unit can be operated from a small rechargeable battery and may be carried in a coat pocket for use where small size, portability, and low cost are more important than the superior performance to be expected from the complete system. Trials with the first Visotactor B prototype have indicated that the capitals A, V, M, N, Y, W, Z, X, T, L, and I are more readily identified than C, G, O, and Q, which are sometimes confused with one another. Lower case letters with descenders are recognized with little training, but considerable practice is needed to distinguish lower case a, s, and e.

An improved Visotactor B has been constructed with stroking, rather than poking, stimulators, a new optical barrel, brighter illumination, and an encapsulated photocell array. Its evaluation will include training a blind person in its use. Two additional Visotactors are being constructed for VA evaluation.

A prototype of the Visotoner is under construction. Using the same frame, optics, and photocell arrangements as the Visotactor, the Visotoner will have a nine-channel system giving an output sound very much like that of the Battelle Optophone. The unit will have the advantage of pocket portability and battery operation.

A seven-page illustrated summary report, *The Development of a Reading Machine for the Blind*, by Glendon C. Smith and Hans A. Mauch, dated June 30, 1964, contains additional information relative to this work for the period July 1, 1963, through June 30, 1964.

Electroacoustic Characteristics of Hearing Aids

Houston Speech and Hearing Center, Houston, Texas

James Jerger, Ph. D.

Work continues on this project to develop more satisfactory methods for measuring the performance of hearing aids psychoacoustically, and to apply these methods to the evaluation of the critical electroacoustic parameters of hearing aids. The results of this research will provide an empirical basis on which the Veterans Administration may more objectively apply electroacoustic data in its hearing-aid procurement methods.

Development of Test Procedures for Evaluation of Binaural Hearing Aids

Northwestern University, Evanston, Illinois

Raymond Carhart, Ph. D.

Eligible veterans are currently issued hearing aids, where indicated, on the basis of audiological evaluation. It is essential that these evaluation techniques offer precision and reliability in hearing-aid selection. A principal effort on this project is to develop techniques which will lead to more precision and reliability in clinical procedure. Improved methods for detecting superiority in performance of binaural versus monaural hearing-aid systems are also being sought. Past work on this project suggests that aids, monaural or binaural, do not give the wearer as much assistance in everyday listening situations as one might believe on the basis of data obtained in the clinical setting. Reasons for this phenomenon, and corrective measures leading to improved audiological rehabilitation, are also being searched for by the project staff.

The Effects of Distortion on Hearing-Aid Performance

Auditory Research Laboratory, VA Hospital, Washington, D.C.

Henry E. Spuehler, Ph. D., and Roger Kasten, Ph. D.

The investigators on this project are seeking explanations as to why certain hearing aids displaying above-average performance characteristics for their gain group are issued in the prescriptive clinical setting in significantly lower numbers than would be predicted on the basis of their electroacoustic quality. Research work is being conducted to provide additional selection criteria to be used when judging hearing aids for use in VA audiological rehabilitation services.