Fabrication of Obstacle Detectors for the Blind
Bionic Instruments, Inc.
221 Rock Hill Road, Bala Cynwyd, Pa. 19004
Thomas A. Benham, J. Malvern Benjamin, Jr., and D. Ridgeley Bolgiano

During the first half of 1972, work was done on the design of a new "C-5" laser cane incorporating a series of modifications discussed in the report in BPR 10-17 Spring 1972 (pp. 248, 252).

In particular, much attention was devoted to the improvement of the operation of the lower channel or down-step detector; the laser and optics were both modified to produce a sharper beam which would range more precisely. In order to improve the channel's effectiveness without increasing the power, it was necessary to redesign the amplifier circuit to increase the signal-to-noise ratio for the system. The result of all of these changes is to produce a down-step detector, which now operates on all materials from white cement to clean, black, wet asphalt, at a distance of approximately 2½ ft. from the cane tip to detect a down-step of 5 in. or more when the cane is held at an angle of 45 deg.
New, small, nickel-cadmium batteries are being used, which allow
the upper-staff diameter to be reduced from 1 1/4 to 1 in. o.d. at a
sacrifice in operating time between charges. The cane will now operate
approximately 2 hours between charges instead of 4 hours. This length
of time should be ample for 2 days' use under most conditions. The
batteries have been life-tested and found to be as reliable as the ones
they are replacing.

The design of the C-5 will be completed during the last half of 1972,
and a first prototype of the new cane will be built.

Research on Audible Outputs of Reading Machines for the Blind
Haskins Laboratories, Inc.
270 Crown Street, New Haven, Conn. 06510
Franklin S. Cooper, Ph. D, Jane H. Gaitenby, Ignatius G. Mattingly,
Ph. D, Patrick W. Nye, Ph. D, and George N. Sholes, Ph. D.

The goal of research on reading machines for the blind at Haskins
Laboratories is to produce by machine methods an output of clear,
audible English from an input of ordinary printed text. The core
problem—generating acceptable speech from phonetic spellings—seems
very near a successful solution through synthesis-by-rule methods. How-
ever, there is still much to be done by way of evaluating and improving
the synthetic speech; in addition, the research is now concerned with
some of the other problems involved in setting up a complete Reading
Service Center for the blind. During the first 6 months of 1972, attention
focused on automating the process of generating synthetic speech
from written text as a prerequisite for further evaluation studies. Part-
cular attention has been given to arrangements and planning for
evaluation studies and to modifications in the speech synthesis proce-
dure that will improve speech naturalness.

Plans for Evaluation Trials

The results obtained in initial evaluation trials with blind students
were reported in the BPR 10–17 Spring 1972 issue of the Bulletin of
Prosthetics Research (pp. 253–254). Briefly, students have listened to
long passages of synthetic speech generated from textbook and litera-
ture assignments. The students' comments on this material revealed that
they had no difficulty in understanding the speech and that they were
more or less enthusiastic about its utility as a study tool. However, these
preliminary tests were severely limited in scope by the laborious hand
methods needed to produce the spoken text; hence, general comments
of the kind cited were about all that could be expected.

Further evaluations are needed and will be of two general kinds:
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Both formal and informal tests with sighted students and with blinded students and veterans will be conducted (but imposing on the time of blinded students no more than is absolutely necessary). These tests will be used to answer specific questions about comprehensibility as a function of rate of speaking, complexity of the written text, and changes in synthesis procedures aimed at improving naturalness. Further evaluations, less formal and closer to real-life situations, will follow, limited only by our capability for generating synthetic speech in quantity and the resources we will require to monitor the users and to collect and analyze the observations. The laboratory-scale methods on which we are now working will provide recordings for a few students; production-scale methods, to be implemented at the Reading Service Center planned for the University of Connecticut campus, will extend these evaluation trials to more students and more text. A substantial effort during the past 6 months has gone into assembling a research team at the University of Connecticut and planning with them for the evaluation studies outlined above. Work is underway at Haskins Laboratories on initial materials for testing the intelligibility and comprehensibility of synthetic speech at its present level of development. These tests will be produced and used during the fall semester while the work to be described below on production methods is being completed.

Automating the Speech Synthesis Process

The production of synthetic speech from a printed text involves a number of distinct steps. In summary, the information on the printed (or typewritten) page must be converted into an alphanumeric magnetic tape by an optical character recognizer (OCR). The tape is then read into a computer, where it is converted from orthographic spelling to phonetic spelling. Stress and intonation are then adjusted by the application of context rules to make the speech sound natural, the revised phonetic text is converted to control parameters according to a synthesis-by-rule program, and finally these control parameters operate a hardware synthesizer that generates a spoken version of the original printed text. (The component procedures were described in some detail in BPR 10–17 Spring 1972, pp. 254–257).

Principal efforts during the past 6 months have been directed to automating the process so that substantial quantities of synthetic speech can be generated for evaluation studies. Two things were needed: OCR equipment to produce alphanumeric input tapes for the computer, and computer programs to convert the “text” tapes to the “phonetic” tapes needed for synthesis-by-rule. Good progress has been made toward both objectives.

Chineses for the Blind

by, Ignatius G. Mattingly, Ph. D.

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OCR Equipment. A thorough canvass was made of existing optical character recognizers that could be used in text-to-speech processing. We found that it would be possible to lease equipment that reads a number of type fonts, including those with the variable spacing commonly used in printed books, but these machines are presently more expensive than the needs of the evaluation program could justify. Fortunately there is a wider selection of single-font machines available that convert type-script into alphanumeric tapes. One of these machines—the Cognitronics System/70—has, at a competitive price, many attractive features (including software recognition which allows reprogramming for additional fonts). Funds for the purchase of a System/70 OCR unit were granted by The Seeing Eye, Inc.; the equipment is on order with delivery scheduled for mid-November. The only significant limitation of this machine for the present research is that for the entry of text into the computer, the contents of a book will need to be typed (with an OCR typeball for best results). Clearly, this would be a serious limitation on the routine production of synthetic-speech recordings, but it should be adequate for the evaluation studies that are planned for the next year or two.

Programming the Conversions from Alphabetic to Phonetic Text. Several computer programs are required to carry out this conversion. All have now been coded and are being “debugged.” The first step is to edit the input text in order to make it fit a standard format on magnetic tape that consists of short records of the English words and punctuation marks. A block of about 2,000 text words is then read into core memory and reformatted to match the pronouncing dictionary, a part of which is stored in core and the remainder on disk files. The individual words of the text are then “looked up” in the dictionary by first searching for entries in a short core-stored lexicon of high-frequency words. If the word is not found there, then an index is consulted to find the page of memory on which the word will appear and this page number is added to the word entry. When all words have been found or indexed, the next step is to pull pages from the main dictionary and copy into core the phonetic entries that correspond to words of the text. At the conclusion of these steps, the word entries (originally in orthographic form) will have been overwritten by the phonetic form of the word plus a “grammer tag” that will later be used in making allophonic and stress adjustments according to context rules. Punctuation marks will have been replaced by intonation symbols. Words not found in the pronouncing dictionary will remain in their original orthographic form, with a flag to indicate their status.

Stress Adjustments for Naturalness. The lexical stress that each English word normally bears is contained in each phonetic entry in the
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main dictionary, and so is transcribed during the preceding search. However, some classes of words change their level of stress when they occur in sentence context. A very substantial part of the work of the past 6 months has been to formulate rules for these context-sensitive changes which could be programed, and to carry out the coding. This has now been done and these programs are also being “debugged.”

The application of the stress adjustment rules takes place in the process of outputting each transcribed block of phonetic text. In the first step of this process, the words of the sentence are examined pairwise to see if their “grammar tags” require application of the context rules and a consequent reassignment of the grade of lexical stress of one of the words. Subsequently, the text is again reformatted to make it compatible with the normal input to the speech-synthesis-by-rule program, i.e., to match the format that has until now been generated by the phonetic typewriter.

Supervisory Editing. The speech-synthesis-by-rule programs that have been in use for a year or more have been revised to accept the output tapes from the preceding operations. If a flawless input were available to the synthesis program, the remainder of the operation would be entirely automatic and a speech recording would be generated as rapidly as the material is processed by the computer, i.e., faster than real time. As a practical matter, one must expect that there will be errors, words not found in the dictionary, and inappropriate pronunciations or stress assignments. Hence, the plans are to monitor the synthesis operation and to intervene manually, whenever necessary, to assist the program or to correct errors. A number of modifications have been made to the synthesis and editing programs to facilitate these correctional procedures.

Combining the Operations. The present status of the speech production process is that all of the individual sub-processes are nearing completion, but that they must yet be meshed into a single working system. Much of this can be done, insofar as the computer programs are concerned, before the optical character recognizer is received and connected to the Laboratories’ computer system. It is this task of putting the system together and making shakedown tests that will occupy most of the coming 6 months.

Improvements in the Synthetic Speech

A substantial amount of effort has continued on improving naturalness of the synthetic speech. However, perhaps the most important recent accomplishment has been the development of three programs to facilitate synthesis improvements. One of the latter consists of a set of routines which allow a phoneme table, i.e., the stored description of a

was made of existing optical text-to-speech processing. We then read into core memory; dictionary, a part of which is files. The individual words dictionary by first searching for high-frequency words. If the consulted to find the page of this page number is added been found or indexed, the dictionary and copy into memory. But at the continuously in orthographic form, the orthographic form of the word plus a taking allophonic and stress punctuation marks will have is not found in the pronunciou an orthographic form, with a

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phoneme, to be pulled out of the program and then displayed, changed, and reinserted. This provides a straightforward means to change the way the sound will be made every time it is called. There are other situations in which one would prefer to manipulate the particular word that has been synthesized as a guide in deciding how to change the rules; this procedure has been implemented by combining existing synthesis programs with the Executive Program and putting both on the Monitor System. A third, and very important, tool has been added that allows the synthesis parameters to be drawn on an oscilloscope, displayed in the form of a sound spectrogram so that one can see the effect of changes (due either to changes in the rules or to those made with the Executive Program) as well as hear them. All these tools are proving most helpful in working on improvements of speech quality and naturalness.

Papers and Publications

The reading-machine research sponsored by the Veterans Administration was described in three papers that were read at the 1972 Conference on Speech Communication and Processing, Newton, Mass., April 24–26. The contents of the papers are indicated by their titles:


The papers appear in the Conference Record produced by the Air Force Cambridge Research Laboratories. Essentially the same papers are being submitted for publication in a special issue of the IEEE Transactions on Audio and Electroacoustics.

The Development and Evaluation of a Personal Reading Machine for the Blind
Mauch Laboratories, Inc., 3035 Dryden Road
Dayton, Ohio 45439
Hans A. Mauch and Glendon C. Smith

Other VA Research Programs

Reading and Mobility Aids for the Blind, Centrally Directed Clinical Application Program
Central Rehabilitation Section for Visually Impaired and Blinded Veterans
VA Hospital, Hines, Ill. 60141
John D. Malamazian, Leicester W. Farmer, and James J. Whitehead

During the report period, the Hines investigators continued efforts primarily on the evaluation of two mobility aids, the C-4 Laser Typhlocane and the Binaural Sensory Aid.

The Second onsite visitation of the participating veterans in June 1972 concluded the final portion of the “Preliminary Evaluation of the C-4 Laser Typhlocane” program. The 1-year program was conducted by an advisory panel created by the National Academy of Sciences—National Research Council under the chairmanship of Dr. Patrick W. Nye. Two investigators from VAH, Hines, and two from VAH, Palo Alto, are members of the advisory panel.

The C-4 Laser Typhlocane evaluation program consisted of a joint 5-week training and evaluation course at VAH, Hines, and VAH, Palo Alto, with a 9-month followup program of device utilization in the veteran’s home community. Eight blinded veterans, four at each Rehabilitation Center, entered the program in August 1971.

For the four blinded veterans trained at VAH, Hines, the followup phase concluded with an onsite visitation during June 1972. Among the recorded data were videotapes of the veteran’s mobility performance with and without the mobility device. The videotapes, along with those of the four veterans from VAH, Palo Alto, will be rated by eight staff members of the Orientation and Mobility Departments of both Centers. The results of the videotape rating, along with the complete results of the evaluation, will be compiled and reviewed by the advisory panel.

A report and future recommendations will be made to the manufacturer, Bionic Instruments, Inc., and to the Research and Development Division of the Prosthetic and Sensory Aids Service, Veterans Administration.

The Binaural Sensory Aid training and evaluation program is approximately half completed. To date six blinded subjects have been trained with the mobility aid, with several scheduled for training during July and August 1972. Each subject on successfully completing training will begin a year-long followup program.

Clinical Trials of Reading Machines for the Blind
Central Rehabilitation Section for Visually Impaired and Blinded Veterans
VA Hospital, Hines, Ill. 60141
John D. Malamazian and Harvey L. Lauer
This project relates to the clinical evaluation of reading aids for the blind. It involves the test use of hardware and teaching techniques and the teaching of skills in using the reading aids.

During this report period, binaural audible codes were further tested, and a binaural prototype instrument to replace the Visotoner was built by Mauch Laboratories of Dayton, Ohio, under VA contract. Named the Stereotoner, the prototype was used by Mr. Lauer and three other users. Reports were made and modifications were discussed.

The new “stereo” code and other design features promise to make the Stereotoner a very useful, convenient, and good appliance for determining the value of the audible code.

A test was developed in cooperation with Richard Bennett of VAH, Palo Alto, California. It is to be used for comparing audible codes and for determining the ability of individuals to learn the tonal code. The test was revised twice and should be ready for use prior to the end of 1972.

Mr. Lauer taught a new student to use the Visotoner and introduced the Stereotoner to Visotoner users and colleagues. Initial plans were made for teaching the use of the Optacon developed at Stanford Research Institute.

In April 1972, Mr. Lauer went to Dayton to confer with developers and to be familiarized with the Stereotoner. He then demonstrated the instrument at the President’s Committee on Employment of the Handicapped on May 5, 1972. He also attended the convention of the Association for the Education of the Visually Handicapped in Miami in June to exhibit and demonstrate the Stereotoner. Mr. Lauer also related to the field through conferences and demonstrations to guests here at the Center.

**Development of Correspondence Courses for Personal Reading Aids for the Blind**

The Hadley School for the Blind
700 Elm St., Winnetka, Ill. 60093
Donald W. Hathaway and Margaret Butow

During the first half of 1972 there were two completions, five cancellations, and five new enrollments in the Visotoner screening course. Fifteen introductory tapes were sent out, and on 10 of those no response had been received by the end of June 1972.

The monaural and stereophonic tape-recorded Visotoner code tests developed by Harvey Lauer and Richard Bennett were administered to six people on the staff at The Hadley School. They ranged in ages from 30 to 60 years old; three were sighted and three were blinded.
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Generally they seemed to hear letter shapes better in the stereophonic code.

In June there was an opportunity to see the prototype of the Stereotoner and to practice reading with it. It represents quite an advancement in print-reading devices because of its convenience, compactness, and the stereophonic tone-pattern code which makes the print easier to read.

A one-page brochure describing the Stereotoner and the continued use of the Visotoner screening course was written. This was distributed at several conventions where the Stereotoner was demonstrated.

Mobility and Reading Aids for the Blind, Centrally Directed Clinical Application Program

Western Blind Rehabilitation Center
VA Hospital
3801 Miranda Avenue, Palo Alto, California 94304
Loyal E. Apple, Richard Bennett, William Ekstrom, and Donald C. Cooper

During the period covered by this report, Mr. Bennett, in collaboration with Mr. Harvey Lauer and Miss Margaret Butow, continued to test various binaural codes. The code preferred by these investigators approximates that used by Mauch Laboratories in the first Stereotoner prototype.

A research tape-recorded test was prepared, incorporating a repeated measures design, to test the relative ability of naive subjects to differentiate among similar symbols when heard in both monaural and binaural mode. Testing was conducted both at The Hadley School for the Blind and at the Western Blind Rehabilitation Center. The results of these tests have not been evaluated at this time. However, it is hoped that the results of this testing will assist in continuing work on a tape-recorded test aimed at measuring the aptitude of a naive subject to "hear" a tonal code.

With Mr. William Ekstrom providing instruction, Mr. Bennett completed training in the use of the Ultrasonic Binaural Sensor. This training was conducted over a period from November 1971 to January 1972.

With the permission of Dr. Eugene F. Murphy, Mr. Bennett participated as a naive subject in experimental work being conducted by Dr. John Hill at Stanford Research Institute. The experimental sessions consisted of presentation of computer-modeled Optacon-like displays. Sessions lasted from 1 to 2 hours, and Mr. Bennett attended these sessions at S. R. I. generally three times a week from March 13, 1972, to May 10, 1972.
Mr. Bennett began to receive regular Optacon training at Telesensory Systems, Inc., Palo Alto, on June 5, 1972. Training sessions lasted 2 hours and were provided usually five times a week. By the end of June 1972, 16 training periods were completed, with the remainder slated for July 1972 at Western Blind Rehabilitation Center.

Mr. Bennett continued to provide Visotoner instruction to one blind staff member of W.B.R.C. On May 5, 1972, Mr. Bennett demonstrated the Visotoner at a meeting of the California Association of Orientation and Mobility Specialists at Albany, California. On May 18, 1972, he demonstrated the Visotoner and discussed the new Stereotoner at a reading machines meeting presented by Mobility Associates of Palo Alto. The meeting was held at the Santa Clara County Blind Center in San Jose, California.

During the first half of 1972, the evaluation of the Bionic C-4 Laser Cane continued. Each of the four trained laser cane users was visited at his home once, and three of the subjects were visited twice. The fourth subject will be revisited in July 1972. The first visit included some data gathering and also working out any travel problems with the laser cane or with the home environment. Between the first and second home visit, a telephone interview was administered to all four subjects.

The second home visit occurred in June and three subjects were video-taped while traveling. Each subject was videotaped four times—twice while using a laser cane and twice while using a long cane. One trip with each cane was in a familiar area and one trip in an unfamiliar but comparable area. While each subject was being videotaped, additional information was being recorded on a tape recorder by an observer. The on-site visit concluded with a questionnaire. The evaluation will be completed when the data are analyzed and the videotapes have been reviewed by a group of mobility instructors who will rate the travel of each subject.

Also during this period, four blinded veterans were trained with the Ultrasonic Binaural Sensors. This electronic travel aid is mounted in a pair of eyeglass frames and emits ultrasonic sound. The sound, on encountering an object, is reflected by the object back to the aid where it is picked up by two receivers and converted into an audible sound. The pitch of the sound indicates the distance the user is from the object (maximum detection distance is about 20 ft.), the purity of the tone indicates the relative smoothness of the object, and finally the two receivers on the aid provide a stereo effect that indicates the left-right position of the object. These four subjects are part of a group of approximately 200 blind people who are being trained with the aid.
tac on training at Telesensory?

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the United States. An evaluation of the aid with these 200 people will influence the future activities with the aid.

Development of Test Procedures for Evaluation of Binaural Hearing Aids

Northwestern University, School of Speech
Speech Annex Bldg., Room 41, Evanston, Ill. 60201
Raymond Carhart, Ph. D., and Wayne O. Olsen, Ph. D.

Work in this project is continuing to study masking-level differences under earphone and in sound-field-listening conditions. A group of sensorineural-hearing-loss subjects has been tested and work is now under way to test a group of normal hearers for comparison purposes. With the normal hearing group, however, the plans are to include measurements of the sound-pressure levels in the ear canals in the various test conditions. Miniature matched ceramic microphones have been obtained, and it now remains to build d.c. electrical-biasing networks for these microphones and to calibrate them for use in this project. The planned sound-level measurements obtained at the ear canals of these subjects should provide additional information about head diffraction and head-shadow effects, and also more definitive information for comparing masking-level differences obtained under earphone and under sound-field-listening conditions.

In addition, tape recordings of University of Oklahoma Speech Test #6 have been obtained. This test utilizes a closed response set format. Plans are being made to utilize the test to generate confusion matrices of consonant and vowel errors when words are presented under various filtering and peak clipping conditions.

Influence of Input and Gain Values Upon Electroacoustic Properties of Hearing Aids

BioCommunications Laboratory, University of Maryland,
College Park, Md. 20742
G. Donald Causey, Ph. D., Earleen Elkins, Ph.D., Rosalind Green, Ph. D., and Eleanor Wintercorn, Ph. D.

Information on hearing aids with compression amplification has been published in the annual report of the BioCommunications Laboratory, University of Maryland. The electroacoustic performance of 27 hearing aids with compression was reported in detail and copies sent to all hearing-aid manufacturers. Responses from the manufacturers and their engineers have indicated that this was a worthy endeavor. More sophisticated studies of compression amplification are presently under way.
Three sets of speech-discrimination materials have been recorded, and data are being collected on normal- and impaired-hearing populations to determine equivalency of lists and interrelationships. Subsequent investigations will determine the extent to which these materials are sensitive to small differences in electroacoustic performance of hearing aids.

Routine measurement of hearing aids received from Hines Supply Depot, to assess the quality control of manufacturers, continues. In addition, new hearing-aid models submitted to date for the regular testing program are being evaluated.