a low-cost, leave-in, permanently adjustable alignment device.

13. *Thigh Cosmesis.* The possibility of casting an air bag for thigh cosmesis on the Canadian hip prosthesis is being investigated.

14. *Goniometric Compensator.* A simple low-cost wafer system for rotation about the vertical axis of the limb has been designed in modular concept. Stability, fabrication methods, and materials compatibility are being studied. The compensator will be about 1 in. thick and can be employed in existing designs.

15. *Powered Knee Extension.* A design is being investigated whereby orthotic knee braces could be placed asymmetrically on an above-knee artificial limb. The brace would then serve simultaneously as a joint and a spring. The spring action results from the torsion of the brace bars with flexion of the knee.

SENSORY AIDS

Howard Freiberger, A.M.
Electronics Engineer

Research and Development Division
Prosthetic and Sensory Aids Service
Veterans Administration
252 Seventh Avenue
New York, N.Y. 10001

Fabrication of Obstacle Detectors for the Blind

Bionic Instruments, Inc., Bala Cynwyd, Pa. 19004
Thomas A. Benham, J. Malvern Benjamin, Jr., and D. Ridgeley Bolgiano

During the period 7/1/70–12/31/70, a series of modifications were made to the cane, as recommended at an evaluation meeting at Hines, Ill. VA Hospital on September 3, 1970.

The meeting was attended principally by mobility trainers who were working with the cane.

The general attitude toward the cane seemed to be cautiously optimistic. All found the forward channel to be either currently useful or potentially useful if its range were moved forward 2 ft., and one group (Hines) found the lower channel to be useful in its present form. It was generally considered that a laser cane, even with only a forward channel, would be a significant improvement over a simple mechanical cane, and that the usefulness of the other two channels would vary with the individual, the geographical location and patterns of travel, and the extent to which mechanical, electronic, and inherent optical problems (primarily in the lower channel) could be corrected.

On the basis of experience to date it was decided to make the following modifications to all 10 canes to improve their functioning:

1. Replace the continuous ranging lever with a switch or pushbutton that will set the cane for detection out to 6 ft. or 12 ft. (maximum range).

2. In certain canes replace some of the weaker forward and downward lasers with 6 watt (± 20 percent) ones, if possible, in order to increase the power, on the average, and to make the response more uniform from one cane to another. (Laser safety considerations, now seeming adequately conservative, should not be affected if all lasers are merely brought up to the most powerful level now used.)

3. Increase the volume of the audio output, making it more uniform from one cane to another, and maximize the difference in frequency between the high and low pitches, also making them uniform from one cane to another.

4. Move the upward channel setting so the cane would warn of head-height objects 2 ft. in front of the cane tip.

5. Improve the stimulator to achieve more reliable operation.

6. Put a locating wall and/or depression around the stimulator to help in positioning the finger, thus possibly reducing tension on the finger flexors.

7. Remove the downward channel sensitivity control, setting the downward-channel amplifier to maximum gain.

8. Improve the on-off-volume control.

The modifications are currently being made and are scheduled for completion during March 1971.

Research on Audible Outputs of Reading Machines for the Blind
Haskins Laboratory, Inc., New Haven, Conn. 06510
Franklin S. Cooper, Ph. D., Jane Gaitenby, and Ignatius G. Mattingly, Ph. D.

The generation of spoken English from printed text to serve as the output of a reading machine for the blind is the objective of the research at Haskins Laboratories. A series of listening tests using Compiled Speech texts has been made in recent months and tests have begun of texts recorded in Synthetic Speech. The purpose of these tests was to find out what blind listeners like (and what they will tolerate) in these two forms of machine speech.

Compiled Speech and Synthetic Speech are dissimilar approaches to the reading machine output problem. Compiled Speech, an interim approach, was developed because it was an obvious and accessible exploratory strategy. Sentences in Compiled Speech are built up word by word from a pre-recorded spoken vocabulary of 7200 items. The word assembly is done by computer from an input of punched tape that corresponds to a printed text (see Fig. 1). Synthetic Speech, on the other hand, is more promising as a *long term* approach. It consists of audible sentences which have been generated electronically from (at present) a

typed phonetic input. This temporary input method simulates word retrieval by computer from a large dictionary, stored in the computer memory, of the spelled and phonetic forms of words.

Listeners and Recordings

The listeners were veterans at the Eastern Blind Rehabilitation Center, Veterans Administration Hospital, West Haven, Connecticut. All were male volunteers, acquired as subjects for the tests through the warm

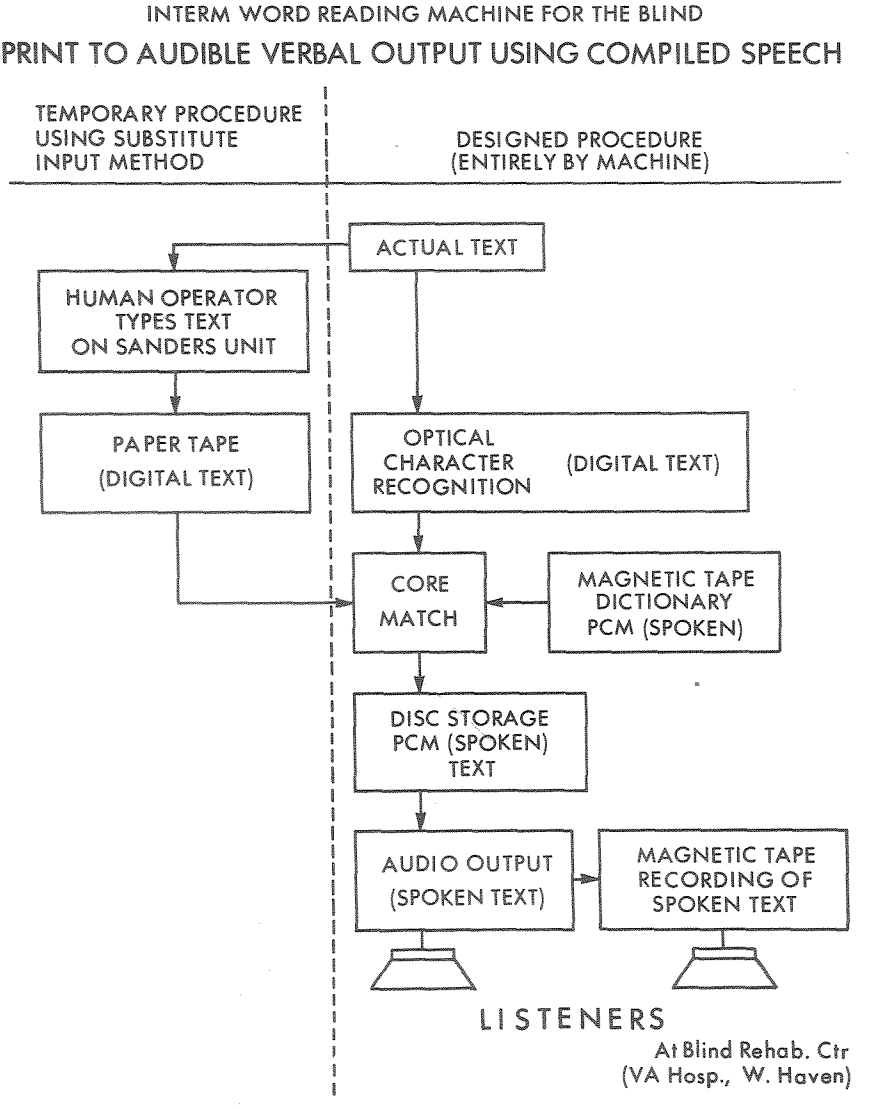

FIGURE 1

cooperation of Mr. George Gillispie, Chief of the Center, and his assistants (of whom Mr. William Kingsley deserves special thanks). There was a total of 11 subjects, most of them in their early twenties. There were eight hour-long tests (each presented to a minimum of two listeners and some to as many as four).

Thirty-six sample tapes (27 different texts or versions of texts) were presented in the course of the tests. Listening time per sample ranged from less than a minute to about 10 minutes. Four tapes of Synthetic Speech (three different texts) were used in the beginning phase of this part of the study. An attempt was made to control various characteristics of the readings:

1. Rate of the Speech.—The range tested extended from 70 to about 225 words per minute. Ten rates within this range were pre-selected for testing.

2. Type of Rate Manipulation (in Compiled Speech only).—

a. Time compressed tape. The speeded recordings were prepared by the Center for Rate Controlled Recordings, University of Louisville, Louisville, Ky. (The original rate in Compiled Speech was from 100 to about 115 wpm.) The amounts of time compression tested were 60, 65, 70, and 75 percent. (Compression is accomplished by dropping regular segments of the speech at brief, regular intervals. Fundamental frequency remains as it was in the original.) Discard segments of 10, 15, and 20 msec. were tested at each compression.

b. Capstan-speeded tape. Here the output rate is changed by using a different capstan. The fundamental frequency rises proportionately to the increase in rate.

c. No rate manipulation. (It should be noted that overall average rates of less than 100 words per minute were a function of the amount of spelling that occurred in given texts.)

3. Text (Author and Topic).—Among these were Dickens, *Oliver Twist;* Steinbeck, *Travels with Charley;* Pierce, *Waves and Messages;* a New York Times sports feature entitled *"Hit and Write."*

4. Amount of Spelling.—This variable applies only to Compiled Speech, in which all words of the text that are not contained in the pre-recorded vocabulary are spelled, letter by letter.

5. Form of Machine Speech Production.—Compiled or Synthetic.

The Test Situation

The test sessions took place at the Rehabilitation Center, in whatever room was available. The atmosphere was relaxed and somewhat informal. The investigator began each session with a brief introduction to reading machine research and stressed to the listeners that there were no right or wrong answers to the tests and that, in fact, no answers as such were needed—only candid comments on anything about the tapes that they cared to mention. It was made clear that the purpose of the

tests was toward the eventual improvement of a reading machine output. All the subjects took the task very seriously.

It was thought by the investigator that the listeners' gross reactions—their free and unprompted comments after each sample—would provide both the broadest and the simplest type of qualitative judgment. The test results given below are a summary of the listeners' spontaneous opinions, as recorded at the time of the tests.

[It must be pointed out that these were preliminary tests. Although the major aim was to have the machine speech evaluated, further purposes were to zero-in on aspects of the tapes that should be controlled in later tests, and on aspects of the speech itself that should be improved. (The interactions between the variables are of note, as the results show.)]

Results with Compiled Speech

At the original recorded rates (100 to 115+ wpm), Compiled Speech has errors of intonation and word-phrase stress and timing. Listener opinions indicate that these deficiencies are more evident in time compressed tapes when the word rate is either above or below the middle of the range that was tested, i.e., preferred rates were in the range of 150-175 wpm—about normal speaking rates. In capstan-speeded speech, rhythmic and inflectional oddities are most intrusive above 120-135 wpm. With no rate manipulation, Compiled Speech is considered too slow for comfortable listening.

Any spelling in a text, at any of the tested rates, is rejected by the listeners. (One subject said that he was unable to follow spelling even when it was done by a human reader, reading the Morning Telegraph aloud to him.)

In the time compressed tapes, there was a slight preference for the 20 msec. discard interval over the 15 msec. discard interval, at all rates. The 10 msec. interval was unsatisfactory because "warble effects" were produced in the voice quality, though this may be an artifact of the fundamental frequency of the speaker's voice.

The preferred word rates varied with the subject matter of the text, and with the author's style. Also, some topics required more spelling than others. A simple chapter from *An Introduction to Sculpture* by William Zorach, in which there was very little spelling, was of great interest to the blind listeners although played at the relatively slow rate of 110 wpm. And a humorous Saroyan story about a vain young man asking for a screen test (in which there were no spelled words) held their attention through many samples of the same text (played at various rates in time compressed, capstan speeded and Synthetic Speech). Yet two other stories by Saroyan (also without spelling) were deemed so dull, regardless of rate, that the subjects could scarcely bear to listen to them. (One story was largely a dialogue; the other, a monologue.)

The length of the speech sample is another factor in the appraisals.

Half a minute is too short an exposure for reasonable evaluation (if the topic of the text is unknown, and if the tape is begun at a random location in the text). A minimum of 1 minute seems adequate, no matter what the topic or where the tape is begun—at least if the tape rate is within a reasonable range.

The overall evaluation of Compiled Speech that emerged from these tests is that it is acceptable at *some* rates in either time compressed or capstan-speeded form, but it is not enjoyable. Spelling is its worst feature. Temporal irregularities are also distressing. Listeners doubt that Compiled Speech (with or without spelling) would be tolerated for extended periods of time.

Preliminary Tests With Synthetic Speech

Four samples of speech synthesized by rule have been tested thus far and the provisional evaluations represent the views of only six listeners.

Synthetic Speech was quite easily understood with exposures as brief at ½ minute—and at rates ranging from 136 to approximately 225 wpm. It was not necessary to time compress or to capstan speed Synthetic Speech tapes because texts at a variety of rates are easily made within the synthesis-by-rule program itself. (Rates higher or lower than those tested are also readily produced by the program.)

After hearing Synthetic Speech, the listeners' comments dealt mostly with the subject matter of the texts, indicating that the prosody (intonation, etc.) was acceptable, or at least not distracting. This was seldom true of Compiled Speech which evoked comments dealing chiefly with rate irregularities. The one aspect of Synthetic Speech that was faulted was what the listeners called its "accent"—which some of them actively enjoyed. [One man from inland Maine called it "Bostonian"; another (from Brooklyn) though it "foreign".]

One listener called Synthetic Speech "Great . . . really cool!" Such unrestrained approval probably reflects assets that are intrinsic to Synthetic Speech, but not to Compiled Speech: no words are spelled; rates are equivalent to or faster than, normal speech; there are normal transitions between words; intonation is naturalistic and flowing; pauses are reasonable and rhythm is realistic.

[It must be noted however, that two important liberties were taken in the production of these Synthetic Speech tapes. First, the assumption was made that its stored reference vocabulary contained all of the text words encountered. (In the final machine, as now planned, new or rare words will be generated by rules for syllabification and syllable synthesis.) Second, only one of the three texts depended on rules for parsing, i.e., for stress and juncture assignments; the other two tapes had stress signals supplied by a human operator.]

Conclusion

Comparison of the appraisals that have thus far been made of the

two forms of machine output indicates that Compiled Speech is effectively rejected in favor of Synthetic Speech. Natural voice quality (commented on approvingly in Compiled Speech when played at its original rate) is the one obvious lack of Synthetic Speech. Much of the work now underway is aimed at improvements in the naturalness of Synthetic Speech and at the production of additional and longer texts for a more adequate evaluation of its usefulness as a reading machine output.

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

A number of significant improvements which increased recognition accuracy and reading speed were developed and incorporated in the Cognodictors during the period from July 1 to December 31, 1970.

Viso*toner* 031 was modified to function as a recognition probe for use with Cognodictor 002 in lieu of the Viso*tactor*. Mr. Lauer and others at Hines VA Hospital, Hines, Illinois, began using this combination during October 1970. After a few hours experience, Mr. Lauer reported that he could read with the Viso*toner* and the "spelled speech" sounds being presented at the same time. Switching his attention from one to the other when necessary was time-consuming, however. He expects this effect to diminish with practice.

All three existing Cognodictors were improved when compensation capacitors were added to the photocell circuits. These capacitors increase the amplitudes of photocell signals at the highest reading speeds (80–120 words per minute) and partly compensate for the somewhat sluggish response of the CdSe photoconductors. A number of changes which were made in the recognition logic improved recognition accuracy on upper- and lower-case letters of several types of fonts.

Two new designs for the Baudot matrix in the Cognodictor were designed and breadboarded. Two prototypes of the more promising design which uses priority encoding principles were built and installed in Cognodictors 001 and 003. The original version of the Baudot matrix sometimes produced a confusing output signal when the recognition matrix lacked sufficient data to discriminate between two similar letters. With priority encoding, the letter with highest priority, in this case the letter with the larger binary number in the Baudot code, will dominate and prevent the other letter from affecting the output signal.

Cognodictor 001 and Visotactor A 015 were inspected after about 8 months' use at Hines VA Hospital. Except for the low volume of two "spelled speech" letters and a faulty reversing switch, its performance had not changed significantly over that period. The low volume was the result of high leakage currents in two silicon photocells in the 32 cell array in the Word Synthesizer film drum. A suitable replacement

array was ordered. Alternate word Synthesizer designs are also being considered. The reversing switch was improved by adding a dimple in the clutch spring on the pacer which acts as the movable contact.

At the end of 1970, Cognodictor 002 and Visotoner 031 were operating satisfactorily at Hines VA Hospital, Cognodictor 003 and Visotactor A 016 were being used by Mrs. Deal in Dayton, and Cognodictor 001 and Visotactor A 015 remained at Mauch Laboratories to test additional improvements.

In this reporting period 10 Visotoners, nine Visotactors and 17 Colineators were updated and/or repaired. Theoretical studies of the future Digitactor-Cognodictor combination also continued but the needs of higher priority work delayed the construction of a breadboard model.

A paper on the Cognodictor design and performance was prepared and presented at the 23rd Annual Conference on Engineering in Medicine and Biology. A U.S. Patent, No. 3,531,770, covering the "multiple snapshot" recognition process was issued and published.

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 and Harvey L. Lauer

1. *Testing Reading Devices:* The program at Hines for getting reading machines into service and evaluating new modifications continued. Considerable effort was devoted to the two Cognodictor prototypes which were used by three persons. The Cognodictor is an optical character reader with a spelled-speech output. The first of these used a Visotactor for scanning, and the Visotoner students who were available to try it were handicapped by their inexperience with the Visotactor's tactile output. The second machine uses a Visotoner for scanning and is liked by the three persons who have used it. It achieves a higher level of character recognition than the first machine and works well on several type styles including that of the Battelle course material. Several hours of recordings were made, duplicated, and shared with some persons in the project. Mr. Lauer is the only person who has had much experience with it, and after forty or more hours, he was able to read at 50 words per minute. His maximum speed with the Visotoner alone is about 40 words per minute.

The estimated maximum output pace for the Cognodictor is about 75 words per minute. Reading speeds actually achieved may be lessened by four things: line change time, user errors, machine errors, and the nature of the material, such as the need to read numerals.

tests of a binaural Visotoner code. These are as yet inconclusive.

At Hines and in New York, there was participation in brief simulation

2. *Developing Teaching Aids:* A 1-hour illustrated tape on techniques for reading numerals in several print styles was developed and distributed to most students. It was duplicated and shared along with copies of print samples. The text of the tape will become part of the teaching manual. Better equipment for telephone teaching is under study.

3. *Teaching Students:* Two students were added during this reporting period, one of whom is primarily interested in teaching. The other is most promising as a user and teacher. Contact, largely by phone, was maintained with most other students. During this period, a report of the entire project at Hines over the past 3½ years was begun. Data were gathered and forwarded to Mr. Howard Freiberger on eight veterans and 10 non-veterans who have achieved some capability with the Visotoner or its predecessors, the Battelle Optophone, or the British Optophone. This information was compiled into two tables which appeare elsewhere in this issue of the Bulletin in Mr. Freiberger's article on "Deployment of Reading Machines for the Blind."

4. *Conferences and Publicity:* During this period, several potential reading-machine course candidates were evaluated. There were frequent visitors to the project, and reading machines were demonstrated and discussed with many visitors to the Blind Rehabilitation Section. Mr. Lauer demonstrated reading machines at the Blinded Veterans Association's convention in July and also in October 1970 at the combined 25th anniversary of the Committee on Prosthetics Research and Development and the Prosthetic and Sensory Aids Service. These trips also included teaching visits to students and conferences with personnel.

Development of Correspondence Courses for Personal Reading Aids for the Blind

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

During the period from July 1 through December 31, 1970, an article was prepared for publication regarding the 2-year history of the Visotoner Screening Course. The article was submitted to the NEW OUTLOOK FOR THE BLIND December 1970 for possible publication. A very short version of the article with a photograph appeared in the January 1971 newsletter of the National Home Study Council. The National Home Study Council is the official accrediting agency for correspondence schools.

The article describes the development and content of the Screening Course and provides a discussion of home study courses, in general, with an analysis of the number of people who complete or do not complete these courses and the reasons why. It has a table showing the number of people served from October 1968 through June 1970. During the past 2 years, 100 people received the demonstration tape with introductory

lesson. Seven completed the course, and after further training at Hines, now have their own Visotoners. One person in England completed the course and had some training with the Battelle Optophone, but has since dropped out of the project for personal reasons. Three more people who have completed the course are still waiting to arrange further training with the Visotoner. Twenty-four people are currently active in the course. Thirteen tapes were sent back to Hadley without comment. Seventeen people cancelled the course due to apparent lack of time and motivation.

Since July 1970, 17 tapes have been sent out, 12 have been returned without comment, and four people have enrolled in the screening course. Two have completed the screening course and are arranging to get further training.

The Visotoner was demonstrated at the Mid-Atlantic Regional meeting of the American Association of Workers for the Blind in September 1970. It was also demonstrated at several local service organizations during this time.

In December 1970, a report was submitted to Dr. Eugene F. Murphy, Chief, Research and Development Division, Prosthetic and Sensory Aids Service, Veterans Administration, covering work in England, progress with the screening course, and personal uses of the Visotoner.

A proposal is being prepared for submission to the Social and Rehabilitation Service, Department of Health, Education, and Welfare, to build more Visotoners.

Development of Test Procedures for Evaluation of Binaural Hearing Aids
Northwestern University, Evanston, Ill. 60201
Raymond Carhart, Ph. D., and Wayne O. Olsen, Ph. D.

Work supported by this contract includes evaluating the extent to which persons with bilateral hearing losses can benefit from binaural hearing. At present, individuals with bilaterally symmetrical and equal hearing losses are being tested in monaural listening conditions and in homophasic and antiphasic binaural listening conditions. Briefly, the procedure is to complete first conventional pure tone and speech audiometry to assure that subjects have essentially equal hearing in each ear for pure tones and speech. Then 500, 1000, and 2000 Hz pure tone thresholds in masking noise are established via Bekesy Audiometry for monaural and binaural listening conditions. In the monaural presentation the pure tone pulses and continuous noise are presented simultaneously to the same ear. In the binaural listening conditions the tones and noise are delivered to both ears. The noise is maintained at 80 dB sound pressure level (SPL) and the tones are increased and decreased equally in the two ears while the subject traces his pure tone threshold. In one binaural condition the tone is in phase with itself at the two ears

and the noise is also in phase with itself at both ears (homophasic). In other conditions either the tone or the noise is 180 deg. out of phase with itself at the two ears (antiphasic). These conditions are also employed to establish thresholds for spondees and to determine speech discrimination scores in 0 dB and –6 dB signal-to-noise ratios. Modulated white noise at 80 dB SPL is the masker for the speech tests. All of the above signal presentations are under earphones. Sound field conditions are also employed for these same speech tests. For monaural listening one ear is covered with a Wilson muff. In the binaural conditions both loudspeakers (one for delivering the noise and one for reproducing the test words) are directly in front of the listener for one listening situation, while in other conditions one of the loudspeakers remains in front of the subject while the other loudspeaker is maintained at the same distance from the listener, but is 90 deg. to his right or to his left. In this way the extent to which persons with bilateral hearing losses will achieve binaural release from masking under earphones and the relationships between such earphone test conditions and sound field listening situations is determined. Although data collection is not complete, it appears that persons with bilaterally symmetrical and equal hearing impairments can derive binaural release from masking under the specialized listening conditions, in some instances almost equal in size to those obtained by normal hearers.

The Development of Improved Techniques for the Analysis of Hearing-Aid Performance

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.

A preliminary study is underway to compare selected electroacoustic characteristics of hearing aids with preferences for the instruments obtained from hearing-aid users. The initial portion of the investigation will employ 10 models submitted for evaluation in the FY 1972 annual analysis by the Veterans Administration. All aids will be of the body type and in the "strong" category as indicated by their gain and maximum output power values. Only one sample of each model wll be employed.

The subjects will be 10 veterans with hearing impairments of severity requiring an aid from the strong power category. All will be previous hearing-aid users. The experimental session, to be conducted in a room which is not sound-treated, will require the subject to listen to selected recorded materials and make judgments as to which aid he prefers. All testing will be done on an individual basis with each subject evaluating five hearing aids. Instructions regarding the task will be the same for each subject and will permit him to listen to all 10 possible paired-

combinations. A work-sheet will be provided on which he may record his judgments. The subject will be required to assign a rank to each aid relative to the remaining aids. The recorded materials to be used were developed to simulate everyday communicative situations and consist of single and multiple speakers producing conversational speech with various background noises.

Following the ranking portion of the test-session, the subject will listen to recorded speech discrimination lists through each hearing aid. The lists consist of 25 monosyllabic words and speech spectrum noise at a signal-to-noise ratio to be determined by a study in progress.

The data for all 10 hearing aids will be pooled so that rank order correlations between subject preference and final category ranking may be evaluated. Multiple correlations will also be performed between preference rank, speech discrimination score, index of effectiveness score, and final performance score. Depending on the outcome of these results, further investigations will be made with aids from the "mild" and "moderate" power categories as well as other electroacoustic characteristics of the instruments.