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EVALUATION AND DEVELOPMENT OF SENSORY AIDS AND DEVICES. FINAL REPORT. (TITLE SUPPLIED).

MASSACHUSETTS INST. OF TECH., CAMBRIDGE

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DESCRIPTORS- *VISUALLY HANDICAPPED, *EXCEPTIONAL CHILD RESEARCH, EQUIPMENT EVALUATION, BRAILLE, VISUALLY HANDICAPPED MOBILITY, SENSORY AIDS, BLIND, COMPUTERS, ELECTROMECHANICAL AIDS, ELECTROMECHANICAL TECHNOLOGY, ELECTRONIC EQUIPMENT, MACHINE TRANSLATION, MATERIAL DEVELOPMENT, PRODUCTION TECHNIQUES, RESEARCH AND DEVELOPMENT CENTERS, RESEARCH PROJECTS, TRAVEL TRAINING, DOTSYS,

THIS REPORT PRESENTS INFORMATION ON THE DEVELOPMENT AND EVALUATION OF SENSORY AIDS AT THE SENSORY AIDS EVALUATION AND DEVELOPMENT CENTER AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY (MIT) BETWEEN OCTOBER 1965 AND NOVEMBER 1966. INCLUDED ARE (1) THE DESIGN, CONSTRUCTION, AND TESTING OF A RELIABLE MONOTYPE TAPE READER WHICH WILL BE USED IN PRODUCTION FEASIBILITY DEMONSTRATION TO CONVERT MONOTYPE TAPE TO GRADE TWO BRAILLE, (2) THE COMPLETION OF THE TELETYPESETTER PHASE OF DOTSYS AND TWO PRODUCTION FEASIBILITY DEMONSTRATIONS (THE CONVERSION OF UNITED PRESS INTERNATIONAL NEWS TO GRADE TWO BRAILLE AND THE GENERATION OF GRADE TWO BRAILLE FROM TEXTBOOK INFORMATION STORED ON TELETYPESETTER TAPE), (3) THE FABRICATION AND FIELDTESTING BY LONG CANE USERS OF HEAVY DUTY COLLAPSIBLE CANES, (4) THE RELIABILITY TESTING AND REDESIGN OF THE MIT HIGH-SPEED BRAILLE EMBOSSER, (5) A BEGINNING EVALUATION OF 1 E FIRST OF THREE ULTRASONIC PATH SOUNDERS, (6) THE COMPLETION OF THE EXPERIMENTAL DESIGN FOR A STUDY CONCERNING LENGTH AND DISTANCE CONCEPTS IN CONGENITALLY BLIND CHILDREN, AND (7) THE ESTABLISHMENT OF BETTER COMMUNICATIONS BETWEEN TECHNOLOGY AND BOTH SPECIAL EDUCATION AND REHABILITATION CENTERS. THE EVALUATION OF OTHER AIDS IS ALSO OUTLINED. PROPOSED WORK FOR THE PERIOD OF DECEMBER 1966 TO NOVEMBER 1967 INCLUDE^ THE STUDY OF FUTURE USERS OF DOTSYS, EVALUATION OF ULTRASONIC PATH SOUNDERS, EXPERIMENTS WITH SPEEDED SPEECH, REDESIGN OF COLLAPSIBLE CANES, THE USE OF COMPUTERS IN VARIOUS PROJECTS, CONFERENCES, SEMINARS, AND FURTHER WORK INVOLVING BRAILLE AND SENSORY AIDS. THE ADMINISTRATION STRUCTURE AND SCOPE OF ACTIVITIES OF THE CENTER ARE DESCRIBED. PHOTOGRAPHS OF SENSORY DEVICES ARE INCLUDED. THE APPENDIXES CONTAIN RELEASE, INTRODUCTION, AND GENERAL INFORMATION FORMS AND PRE-TEST AND POST-TEST QUESTIONNAIRES. (CG)

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FINAL REPORT

to

VOCATIONAL REHABILITATION ADMINISTRATION
DEPARTMENT OF HEALTH, EDUCATION AND WELFARE

Washington, D.C.

of work done under Contract SAV-1045-66
for the period

1 October 1965 through 30 November 1966

from

THE SENSORY AIDS EVALUATION AND DEVELOPMENT CENTER
Massachusetts Institute of Technology

292 Main Street
Cambridge, Massachusetts 02142

3 April 1967

EC 001 387

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

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I. INTRODUCTION

The Sensory Aids Evaluation and Development Center was established on September 1, 1964, under Contract SAV-1036-65 from the Vocational Rehabilitation Administration, Department of Health, Education and Welfare. Members of the Staff include:

Mr. John K. Dupress, Managing Director

Miss Catherine A. Walsh, Secretary

Mr. Murray Burnstine, Engineer

Miss Sylvia Tufenkjian, Psychologist

Mr. Richard M. Dougans, Technical Research Assistant

In addition to the regular staff members, the following persons performed work on specific projects (on a part-time basis) during the second contract year:

Mr. and Mrs. Joseph Schack - Consultants, Computer Programming

Mr. Lindsay Russell - Consultant, Engineering

Mr. Ernest Cataldo - Electronics Technician

Mr. David Crafts - Electronics Technician

Mr. John Ebert - Electronics Technician

The Steering Committee and the National Advisory Committee provide necessary leadership and advice.

The scope of activities, as outlined in the initial contract, is as follows:

"The Center's activities consist of the following: (1) Evaluation of existing sensory aids and devices; (2) Location of new and promising aids for evaluation; (3) To encourage others to develop new aids which then can be submitted for production engineering at the Center; (4) In conjunction with the above, but to a lesser degree, development of new sensory aids for

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the blind; (5) Development of training principles and techniques for blind users of the sensory aids; (6) Behavioral research with blind users under field conditions; and (7) Development of objective standards to evaluate such devices.

Basic research and development will not constitute a major activity of the Center."

II. PROPOSED WORK

A. Computer Processing

1. DOTSYS

On August 18, 1966 the feasibility of DOTSYS was successfully demonstrated: teletypesetter tape, in the form of news, was converted to Grade 2 Braille. The demonstration took place during a week-long Summer Session (held at M.I.T.) on Special Education and Technology.

On November 18, 1966 the feasibility of converting textbook information on teletypesetter tape to error-free Grade 2 Braille was successfully demonstrated. Card output from the M.I.T. 7094 (at the M.I.T. Computation Center) was forwarded to the American Printing House for the Blind (Louisville, Kentucky) where 200 copies of interpointed Grade 2 Braille were produced. The Braille copy and print equivalent were disseminated by the Sensory Aids Center to participants in the November 18, 1966 Braille Research and Development Conference which was held at M.I.T.

In the last month of the 1965-1966 contract year, work began on complete documentation of the teletypesetter phase of DOTSYS. The documentation has been omitted in this Report because it appears in the Proceedings of the November 18, 1966 Brail. Research and Development Conference.

2. Evaluation of Output from Teletypesetter Tape-to-Spoken Word Converter

No evaluation was possible because large samples of material were not available from Haskins Laboratories. The project at Haskins was terminated in the early part of our second contract year.

3. Computer Sampling for Time Compressed Speech

The Center obtained samples of computer time compressed speech from Harvard University, the United States Air Force and Bell Laboratories. The samples were presented to 14 professionally employed blind adults, and to the group of special education teachers who attended the Special Summer Session on Technology and Special Education. Further development is being undertaken by a number of research facilities.

The best roles the Center can play are as an information source on time compressed speech, and in an advisory capacity to the Center for Rate Controlled Recordings at the University of Louisville.

4. On-Line Computer Translation of Braille

Professor Edward L. Glaser and associates at Project MAC (Multiple Access Computer at M.I.T.) have developed equipment interfaces for successful on-line Braille translation. In addition, as part of DOTSYS, on-line translation of Braille can be achieved by a person who can type, but knows no Braille.

5. Evaluation of Output from Small Computer (PDP-8) Translation of Braille

Professor Glaser's group evaluated Braille output from the PDP-8 and came to the conclusion that the resulting 1.8 Braille is acceptable.

B. Monotype Reader

The monotype reader is a photoelectric device whose purpose is to read the 31-channel paper tape used in the monotype typesetting system. The object of its development is to achieve a means of converting the data contained in existing printers tapes into an electrical form suitable for recording on magnetic tape. In the magnetic tape form, it would then be available for Braille conversion programs.

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The reader consists of three units: scanner, amplifier, and power supply. The scanner contains the mechanical tape transport drive, a row of 31 tiny photodiodes, and a fluorescent light source. Each diode is mechanically aligned to view the light source through a particular channel on the tape; fluctuating diode currents convey presence or absence of the individual information-carrying perforations of the tape.

The amplifier (all solid state), in addition to amplifying these currents, clamps the signal to one of two levels; the output of each of the 31 identical amplifier channels is zero volts when a perforation is present, and minus three volts when absent.

The power supply provides the voltage to start and run the fluorescent lamp, as well as the voltage supply for the amplifier.

An auxiliary, or 32^d, amplifier channel provides regular timing impulses, each of which occurs at the instant a row of holes is approximately centered over the diode bank. These impulses are derived from a 32^d photodiode illuminated through a perforated wheel attached to the tape transport sprocket.

Figure 1 shows typical output and timing signals. The immediate objective of the development is to produce signals in just this form and to show that the reading of the tape can be sensibly error-free over long periods of time.

As of November 30, 1966 the amplifier was being completed, and the power supply and scanner were finished. A program of checkout and debugging will be the next and last step.

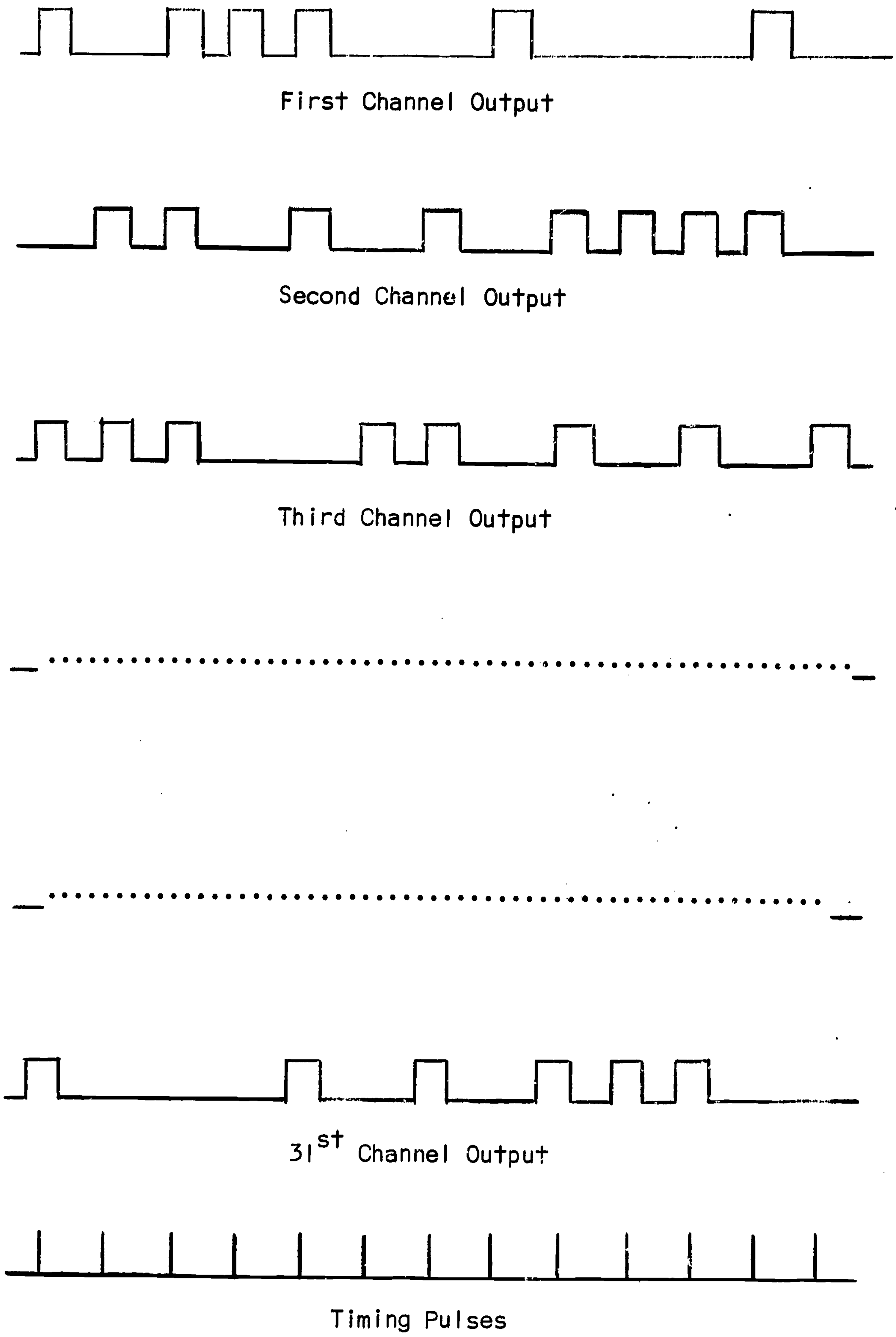

FIG. 1. MONOTYPE READER OUTPUT SIGNALS

C. Braille Embosser

A high-speed Braille embossing system has been under development in the Mechanical Engineering Department at M.I.T. since 1960. A detailed historical account was included in last year's Final Report to the Vocational Rehabilitation Administration (Contract SAV-1036-65). At present, the disposition of Braille embosser units for field testing is as follows:

Unit No. 1 was released in January, 1965 to Mr. Ray E. Morrison (Staff Engineer, Illinois Bell, Chicago, and Chairman of the Technical Aids Committee, National Braille Association). Mr. Morrison found it necessary to develop control circuits (comprised of available telephone hardware) for the embosser, because of difficulties he encountered in maintaining the brailler circuit board. This embosser is used in a system devised by Mr. Morrison as a terminal using both wire and radioteletype (RTTY) modes of transmission.

Unit No. 2 remained at the Sensory Aids Center and was kept on various durability test schedules. It was also used to evaluate the readability and acceptance of a range of embossed plastic materials. In July, 1966 it was released, without circuit board, to Professor Troxel of the sensory aids group in the Research Laboratory of Electronics at M.I.T. Professor Troxel and his staff are developing control circuits based on models not previously available commercially. This brailler is scheduled to serve as a "picture embosser".

Unit No. 3 was released to the sensory aids group in the Mechanical Engineering Department at M.I.T. in February, 1965. A graduate student, as his Master's thesis project, modified it to serve as a terminal of the PDP-8 computer at Project MAC. At MAC, the brailler electronics were maintained by another student as part of his Bachelor's thesis program.

Units 4 and 5 were released to the sensory aids group in the Mechanical Engineering Department in November, 1966, where they are being installed in consoles, similar to the one at Project MAC, for evaluation as terminals to be used in public and private schools. Cost of the unique parts requred for these consoles is being borne by the Mechanical Engineering Department.

Unit No. 6 is 70% assembled; the remaining electrical harness work is being done at the Center by a part-time student electrical engineer. This unit will remain at the Center for demonstrations, development, and life testing.

Based on field experience during 1966, the following design changes were incorporated in all completed Braille embossers:

1. An adjustable stop to limit the upward travel of the escapement rack was added to eliminate head guide pin scoring.

2. The "busy" switch, originally driven by a cycle shaft cam, was relocated to the cycle clutch anti-reverse latch, thus eliminating all sliding contact and subsequent switch roller failure.

3. The "start of line" and "end of line" microswitch levers were replaced by lower rate leaf springs because the old design tended to inhibit embossing head movement.

4. The steel head guide pins have been replaced by bronze head guide bars to eliminate nicking due to the high unit loads experienced by the head support slots.

5. A flywheel was added to the cycle clutch drive pulley to store energy and smooth out the "paper advance" event.

A manufacturer, wishing to expand his product line, expressed an interest in manufacturing the M.I.T. Braille embosser. Subsequently, he received a complete set of drawings and specifications. His unofficial cost estimate is $2,250 per embosser in quantities of 50.

D. Collapsible Canes

In the course of our first year, certain design parameters were established as desirable features for collapsing cane prototypes:

1. The weight of the cane cannot exceed one pound.

2. The folded cane must fit into a coat pocket (5 x 10 x 5/8" deep).

3. Aside from collision damage, the assembly must survive 5000 collapse-extend cycles, based on one year of use by an active blind traveller.

4. The assembled unit must provide a handle and glide-tip ferrule with similar "feel" and sound generation capabilities as those experienced by current long cane users.

5. When the extended cane length cannot be changed by the user, the design must include provisions for supplying the cane assembly in one-inch increments of length over the range 36 - 70 inches.

6. Opening and closing input forces cannot exceed the capabilities of women, children, and the multiply handicapped.

7. Opening, closing, locking, and storing procedures must be compatible with "one-hand" operation.

8. The over-all design must be simple. Fabrication of component parts should not require specialized techniques, select fitting, or assembly.

The major engineering design task is, therefore, to design a mechanism which will extend at least seven times its stored length while retaining the properties of a continuous, one-piece member.

A cane joint comprised of nested cones offers the following design advantages over telescoping or folding joints:

1. The cane sections are self-centering and self-aligning without additional radial constraints.

2. The joints are self-cleaning.

3. The cane joint can withstand axial loads without additional locks or stops, limited only by the tensile (hoop) strength of the material.

4. If the central shaft area of a segment is bent or flattened by collision damage, the joints will still assemble and the traveller can proceed with a bent, but still rigid, cane.

5. The cone joint will automatically compensate for surface wear by advancing to a more stable engagement.

6. There is a continuous metallic path along the cane axis so that all of the vibro-tactile information capabilities of a one-piece unit are available to the user.

Interaction of the following design parameters for hollow cones, formed on constant diameter tubing, was considered. The cone angle must exceed the "self-holding", or locking, angle for the materials, surface finishes, and elastic deformations expected. As the cone angle increases, the axial load required for lateral stability increases. Large cone angle-forming techniques might exceed the plastic flow capabilities of the material. For a given wall tubing section, as the cone angles decrease the ratio of assembled length to disassembled length will also decrease.

The locking angle for lathe-turned aluminum cones, with surface finish estimated at 100 micro-inches RMS, was established using a series of test plugs made in 4° increments of total cone angle over the range of 2-18°. Reliable release was obtained with cone angles greater than 6°. The design angle selected was 10°, to allow for additional surface roughness and environmental surface film deposits. With .50" dia. x .035" wall aluminum tubing, the 10° cone angle resulted in a 0.450" engagement length with a 0.350" dia.

minimum opening through the male cone. The aluminum tubing alloy selected was 6061-T6 (selection was based primarily on availability and work hardening properties). In order to fold the cane into the flat-pack package, the segment lengths were established at 8.50".

A detailed account of the Center's activities in collapsible cane design and testing can be found in previously published reports (Final Report to the VRA of work completed under Contract SAV-1036-65; Progress Report No. 1 for the period 1 October 1965 through 31 January 1966; Progress Report No. 2 for the period 1 February 1966 through 31 May 1966).

I. Evaluation of the Collapsible Cane

This evaluation of the prototype collapsible cane (cc) is presented in four sections: (a) selection of blind cane users, (b) the questionnaire, (c) the analysis of comparisons between the cc and previously used canes, and (d) general conclusions concerning the cc in its present state.

(a) Selection of Subjects

The goal was to obtain a group of adult subjects who would not be a random sample of the cane-using population but a selected group of cane users having high mobility capability, cane experience, and cognizance of cues generated by the cane. Mobility capability was assessed in terms of independent travel in familiar and unfamiliar areas, and the amount of time spent daily in cane travel.

Only those subjects who met the above criteria and demonstrated motivation for participation in the evaluation were considered for this initial study. A release form, signed by participating subjects, was drawn up by the Legal Department at M.I.T. (see Appendix A).

Nine adults (eight male and one female) served as subjects; most were from the greater Boston area. General subject information is presented in

Figs. 2A and 2B.

FIG. 2A. GENERAL SUBJECT INFORMATION

Subject	Age	Sex	No. of Years Blind	Degree of Vision	Mobility Training	No. Years Cane Experience
1	38	M	6	LP	Yes	3
2	44	M	44	TB	Yes	10
3	38	M	29	TB	Yes	25
4	34	M	9	LP	Yes	9
5	20	M	6	TB	yes, Informal	2
6	46	M	4	TB	Yes	4
7	24	M	24	LP	Yes	9
8	40	M	31	TB	yes, Informal	27
9	40	F	33	TB	Yes	8

TB = Totally blind

LP = Light perception

FIG. 2B. GENERAL SUBJECT INFORMATION

Subj.	Wt. of User's Cane (ounces)	Wt. of User's cc (ounces)	Time Cane Actively Used Per Day (hours)	Education Highest Grade Completed	Travel in Very Familiar Areas	Travel in Completely Unfamiliar Areas	Travel in Semi-Familiar Areas
1	8	10	1/2-2	Ph.D.	b & c	a	b
2	8-1/2	9.5	1/2-2	HS	b & c	b	b
3	8	14	3+	A.B.	b & c	b	b
4	6-1/2	15	1/2-2	A.B.	b & c	b	b
5	8	9.5	2+	HS	b & c	b	b
6	9-1/2	10	1/2-2	10gr. HS	b & c	a & b	a & b
7	8	10.6	1-1/2	A.B.	b & c	b	b
8	8	9	3/4	Ph.D.	b & c	a & b	b
9	5.8	9.5	2+	S.M.	b & c	b	b

a = mostly with a sighted person, occasionally use a cane

b = mostly with a cane

c = with no cane or other aid

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(b) Questionnaire

An intensive questionnaire* was developed to collect data pertaining to the evaluation of the Sensory Aids Evaluation and Development Center's prototype cc. This questionnaire is both structured (with multiple choice-type questions - questions suggesting possible replies) and unstructured (containing short exposition-type questions). The questionnaire covers six major areas:

1. Personal background information (see Appendix B)
2. Mobility habits
3. General attitudes toward the use of the cane
4. Physical features of canes regularly used by Ss
5. Physical features of the prototype cc
6. Comparisons between canes customarily used and the prototype cc

The major assumption underlying the development of the prototype cc is that such a modification of the conventional one-piece cane with crook, by the addition of collapsing capability, would meet a major need of the cane using population.

The evaluation procedure was as follows. Following the selection of blind cane users, the length of the cane and the type of cane tip that each S customarily used was recorded. These two features were duplicated in the prototype cc tested by Ss. This duplication was a major consideration in the preliminary evaluation. A valid and reliable comparison between canes could not otherwise be made.

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* This questionnaire was developed with the assistance of Dr. Robert Hawkes, Associate Professor, School of Public Communication, Boston University.

Before participating in the experiment, some Ss used collapsible-type canes almost exclusively, while others used a one-piece design. The comparisons made, therefore, are between canes regularly used by the S prior to testing (either non-collapsible and/or collapsible) a.d the trial collapsible cane.

Subjects were interviewed prior to and after field testing of the prototype cane. Prior to field testing, Ss were instructed in the mechanics of the collapse-extend operation until their performance indicated a familiarity with both the structure and operation of the cane. The first, or pre-field test, questionnaire was then verbally administered covering factors such as attitudes toward the use of the cane and physical features of Ss' regular canes. Then, the Ss were requested to use the trial cc exclusively for eight weeks. After the trial period, canes were returned to the Center, and the second, or post-test, questionnaire was administered.

The pre-test questionnaire is shown in Appendix C. Some of the questionnaire items are discussed below:

Those canes previously used by Ss may be divided into two categories - folding and telescoping canes and rigid one-piece canes. The average life span of the first type ranged from two months to two years; that of the latter type ranged from three years to an indefinite period, with minor repair.

Seven subjects owned more than one cane (ranging in number from two to four). However, these Ss used one or two of their canes exclusively, the others only rarely and as spares. One S owned 50 canes and used each of them intermittently.

Six Ss owned both one-piece and collapsing-type canes: three used the one-piece cane almost exclusively; two Ss used the collapsible-type cane solely; and the remaining S used both types.

All canes owned by Ss were made either of stainless steel or aluminum.

Following the issuing of canes, no contact was made with Ss prior to the end of the test period, unless malfunctioning of the cane was reported. Four subjects reported malfunctioning after using the cane from 5 to 41 days. These failures were loosening of a hinge fastener, an abrasive failure of the central cable at the tension lever, and two cable failures at the tension lever clamp ferrule due to the use of the wrong size crimping tool.

(c) Analysis of Comparisons between the cc and Previously used Canes

The post-test questionnaire is shown in Appendix D. The most pertinent questionnaire items are discussed below, followed by a summary of the comments. The question is stated first and a discussion of the results follows.

Q. 30 When you are using the cc, does it feel loose at the joints or loosely connected?

A. The cane was assessed as very firm by all Ss, except for one whose response fell into the 'somewhat firm' category.

Q. 31 Do you feel secure using the cc?

A. All Ss responded yes to this question. The fact that Ss felt the cane to be rugged and rigid gave them a feeling of security and safety.

Q. 33 Do you feel the cc is too fragile or wobbly for your regular use?

A. All Ss reported no to this question.

Qs. 37-38 Have you tapped, or hit (a) others (b) yourself when collapsing or extending the cc?

A. No Ss reported tapping or hitting either himself or others when

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collapsing or extending the cane.

Q. 67 In comparison to your regular cane, does the cc feel (a) safer, (b) same, or (c) less safe?

A. All Ss, save one, replied that the cc felt the same or safer than their regular canes. One S replied the prototype felt less safe because he was not able to control and maneuver it as well as his regular cane.

Q. 34 When you keep the cane collapsed, (a) do you (b) don't you have enough time to put it together when you need to use it?

A. Five Ss gave an unconditional 'I do' to this question. One of these Ss claimed the time element was important only in collapsing the cane rather than in extending it. Two Ss said the time element determined their use of the collapsing feature. If they felt they would not have enough time to reassemble the cane, they would not collapse it. Another S maintained that the spatial element, rather than the time element, was the determining factor in his decision to collapse or not collapse the cane.

Q. 43 What features of the cc do you like?

A. Those factors mentioned most frequently were rigidity, collapsibility, and ability to withstand abuse. The dual characteristics of rigidity and collapsibility incorporated in a single cc appear to be important factors.

Q. 32 When extended, does the cc have good balance?

A. Most Ss responded negatively to this question. The perceived effect was imbalance towards the lower portion of the cane. Comments included the following:

1. "It (the cc) moves my wrist rather than me moving it; it exerts pressure on my wrist; it is not steady."
2. "The cc does not have good balance; add heaviness to the handle."
3. "It is too heavy at the bottom and overall; my hand tires if I use it for a long period of time."
4. "It has a pendulum effect, giving it its own pace; swinging the extra weight is tough on the wrist at a fast pace."
5. "The balance could be better; it is not only the heaviness of the cane but where the weight is that is important; as is, the cane needs more weight at the handle, but less weight at the end would be better."

It appears that the major variables affecting the use and acceptance of a cc, and therefore a prime factor in its construction, are the perceived balance of the cane, the perceived overall weight of the cane, and the relation of these factors to each other.

To the cane user, good balance subjectively refers to the "good", or "right", feeling of the cane while sampling the space where he will place his feet. The psychophysics of cane balance has not been investigated and defined.

What happens during a cycle of a single arc as the user samples the space where he will place his feet? In the course of describing an arc, the S exerts variable forces at the handle. As he begins his swing, he (1) exerts an upward, or vertical, force to lift the tip from the ground; (2) since he has a limited amount of time to move the tip to where his leading foot will be placed, he has to accelerate this mass in mostly a sideways, or horizontal, movement; (3) as he is nearing the end of the intended arc, he must exert a counterforce to decelerate the mass so that he does not over-swing; and (4) as he approaches the end of the swing and decelerates, he lets the tip drop so that he may sample the terrain.

It appears that if there is too much weight below the point where he grasps the cane, the user will perceive the cane to be very heavy. What he is reacting to is the force he must exert to accelerate and decelerate rapidly a small amount of extra mass. It seems that it is not the total weight of the cane that is significant, but rather the distribution of the weight above and below the point where the user grasps the handle that is important.

Redistribution of the mass so that the user is grasping the cane at the balance point is a poor solution. The reason is that subsequent to completion of the swing, the S must now push the tip down because gravity is no longer helping him and therefore, without exerting additional force, he gains little terrain information.

It appears that a better mass distribution may be achieved in the situation where the S has just enough mass to aid gravity as he deliberately positions the tip through his searching arc.

A lightweight cane inherently tends to have less mass below the point where it is grasped, thus reducing those problems encountered in poor balance. This follows, since the torque is equal to the distance from the pivot point (holding point) to the center of gravity times the overall weight below the pivot point.

The average weight of canes previously used by Ss (both one-piece and collapsing) was 7.7 ounces. The average weight of the prototype cc was 9.8 ounces for the non-hinge type and 12.0 ounces for the hinge type.

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The perceived poor balance in the prototype cc appears, then, to be due to the turning moment applied at the wrist by the distributed weight of the constant section segments, the steel cable, and the 0.2 ounce tension mechanism at the far end of the moment arm.

Q. 44 What features of the cc don't you like?

A. Those factors mentioned most often were imbalance, over-all weight, clatter produced during the collapse-extend cycles, the spatial requirements necessary for collapse and extension, and the lack of a holding feature permitting a "flat pack" array. In addition to the perceived imbalance and over-all weight of the cane previously discussed, most Ss reported a dislike of the noise produced during the collapse and extend cycles. They consider this feature to be an additional "attention getter" and thus is regarded unfavorably.

Q. 60 When you are sitting down and have to find a place to put your cane, do you feel more comfortable with the cc (e. g., in thinking you are taking up less room)?

A. All Ss responded "yes, all of the time" to this question, indicating that this factor relating to the collapse feature of the cane was an important one.

Q. 63 Have you noticed any difference in your ability to make fine discriminations with the cc as compared to your regular cane?

A. Most Ss replied there was no difference in their ability to make fine discriminations with the cc. One S maintained there was improved discrimination with the high rigidity of the cc. Another S noted that the cc vibrated more than his regular cane and that his differentiation was slightly better with his regular cane.

Q. 64 It is thought that cane users identify objects both by the contact of the cane with the object and by the sound the cane makes when hitting an object. When the cane comes in contact with an object, does it give you as much information about the object as your regular cane?

A. Most Ss mentioned the cc gave them about as much information as their regular canes. One S noted that the cc gave him a little more information and that he could discriminate textures more easily with the cc as compared to his regular cane.

Q. 65 When using sounds to identify objects, most people use both direct sounds and sound echoes. (a) As compared to your regular cane, does the cc make the same or different kind of direct sounds when tapping familiar surfaces underfoot?

A. Most Ss replied that the cc made a different kind of direct sound. Responses varied as to the kinds of sound produced by the cc, but no overall decrement in discriminatory ability due to this sound modification was noted.

(b) In comparison to your regular cane, does the cc produce the same or different echoes when tapping familiar surfaces underfoot?

A. Half of the Ss reported that the cc produced the same sounding echo as their regular cane and the other Ss reported the cc produced different echoes. However, these Ss could not define the difference and could only state that such a difference was apparent to them. However, no decrement in the use of such echo information was reported by these Ss.

Q. 69 In comparison of the cc to your regular cane have you noticed any differences in your ability to estimate distances to objects?

A. All but one S noticed no differences in their ability to estimate distances to objects. One S could not define the difference and could only state that more guess work was involved in the estimation.

(d) General Conclusions

One of the important conclusions derived from this evaluation was the fact that there appears to be no appreciable difference in discriminatory ability, identification of objects, and estimation of distance to objects with the prototype cc. In addition, the most desirable characteristics of rigidity and durability, in combination with collapsibility, are built into or maintained simultaneously in a single cane.

On the whole, the major negative feature educed from this investigation was the relevance of balance to the acceptance and consequent use of the cane. Heretofore, balance was always assumed to be a factor, but exactly how it was incorporated in the structure of a cane was not known and its affect on performance was unclear.

The problem of balance may be approached in either of two ways: (1) the use of a lighter weight metal retaining the desirable characteristics of aluminum would result in a reduction of total weight. The problem of imbalance is reduced since a light-weight cane, regardless of weight distribution, inherently tends to have less mass below the point where it is grasped. (2) To achieve better balance, weight may be added above the point where the cane is grasped. Arrangements are being made with the peripatology group at Boston College to trial-test the cc using this second method of approach.

Of the 10 canes tested, four were of the hinge-type and six were of the simple-type (no hinge). (See engineering section for description.) The evaluation of the hinge-type cane appeared to be generally unfavorable. An

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average increase in weight of three ounces due to the addition of the hinges and their described effect on cane balance was reported to be excessive. Also, subjects reported that rattling of the hinges distracted them and interfered with the perception of sound cues from the terrain.

Subsequently, 12 prototype collapsible canes were assembled for subject evaluation. All canes featured identical bent handles, cable tensioning mechanism, and 8-1/2" long swaged cone aluminum tubing sections. Six of these canes, in addition, were assembled with sliding hinge joints to force the stored cane segment array into a flat pack. The weight of each 8-1/2" long segment was 1.3 ounces. The weight of each sliding hinge assembly was 0.60 ounce. A folded, hinged, 55" long cane assembly with glide tip ferrule is shown in Fig. 3 (total weight, 10.6 ounces).

The cane opening sequence is as follows. The user grasps the bent handle and allows the segments to fall until the central steel cable has unfolded. At cane axis angles near vertical, all nested cone ends will assemble. Cane segments falling into alignment are shown in Fig. 4. The user then slides the captive locking lever into the detent in the cane handle (Fig. 5). The final cable tension is applied as the free end of the locking lever is moved towards the cane handle and engages a locking pawl (Fig. 6). To unlatch the cane, a tab projecting from the locking pawl is rotated towards the locking lever.

Representative measured input forces required to operate the cane were as follows: locking lever to detent, one pound force; cable tension input, 10 pounds force for 50 pound cable tension load; and unlatch tab, 2 ev input force. A threaded tensioning arrangement in the lowest cane segment is used at assembly to adjust the initial cable tension. The canes are

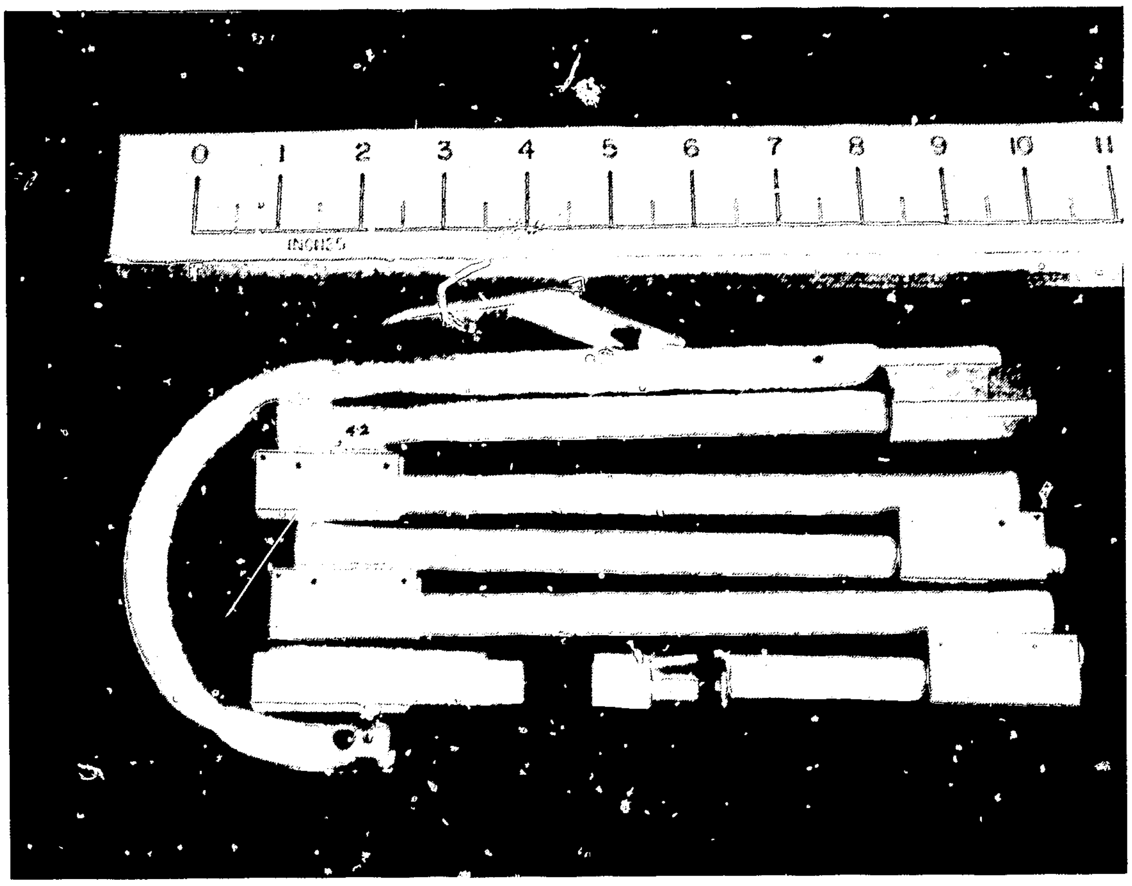

FIG. 3. Center's 55" long swaged tube, central steel cable, collapsible cane with hinges shown folded for storage.

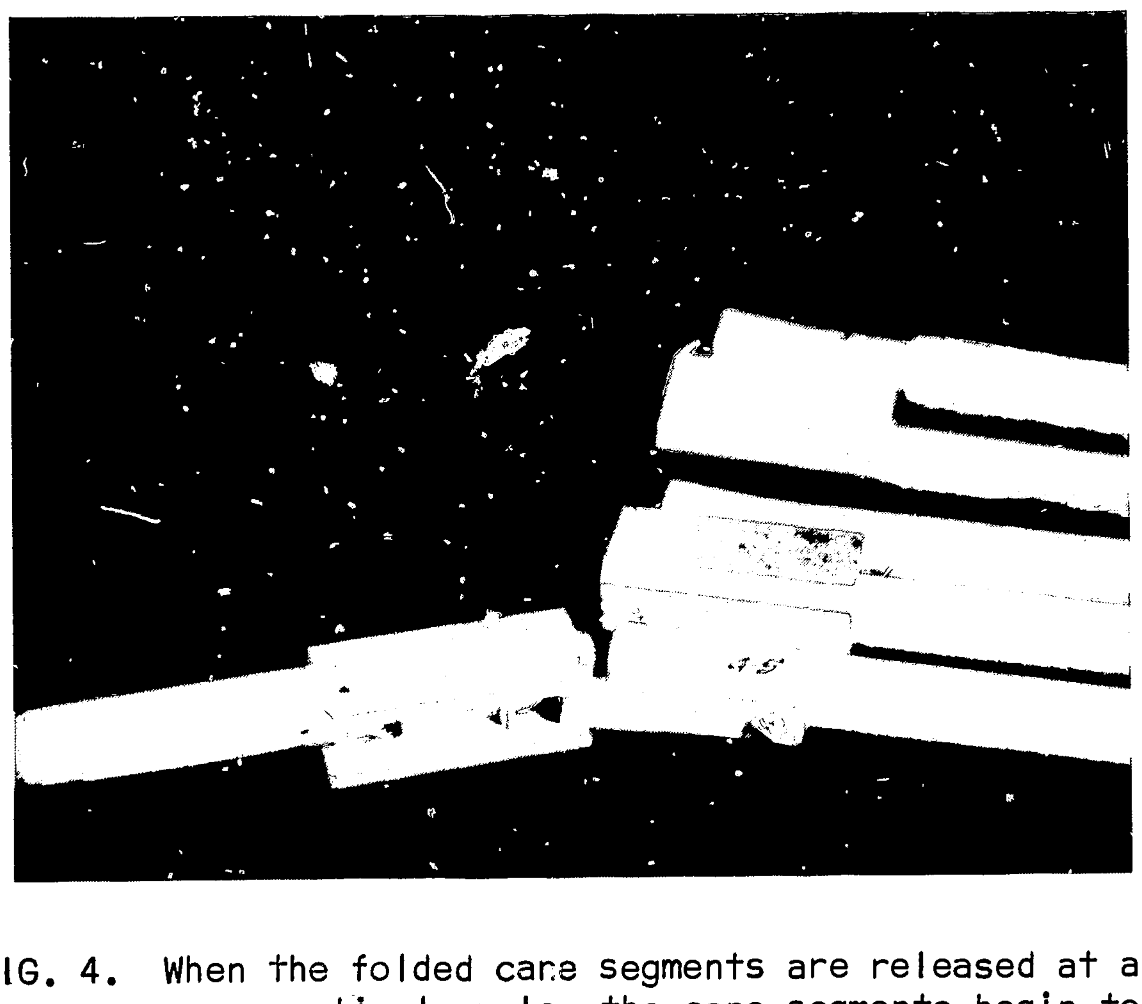

FIG. 4. When the folded cane segments are released at a near vertical angle, the cane segments begin to engage.

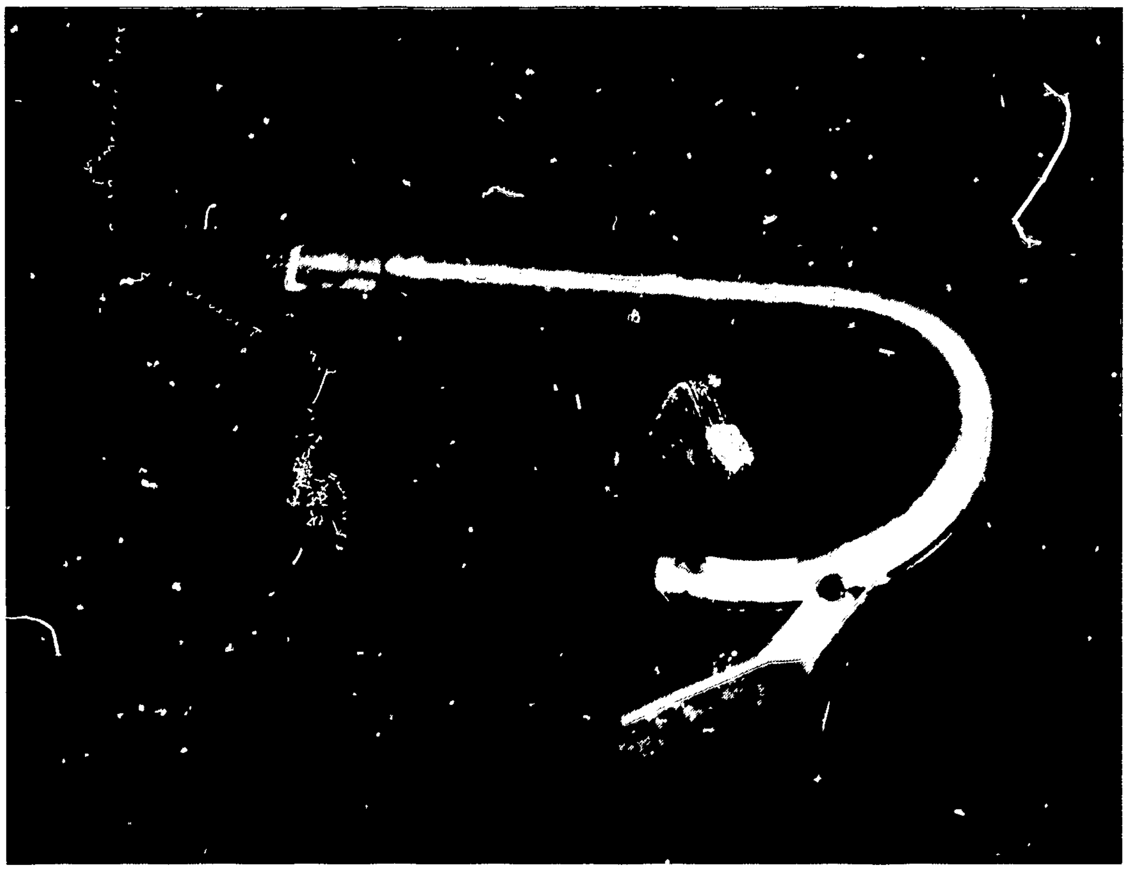

FIG. 5. The sliding captive locking lever shown in the "detent" position.

FIG. 6. The locking lever shown in the final, locked, cane assembled position.

stored overnight in the extended position to stretch the cable and then re-tensioned before being released to subjects.

Based on subsequent field tests, the remaining problem was occasional kinki·· and weakening of the central cable. Various designs of commercially available braided steel cables are being tested.

E. Path Sounders

In November 1966, the first of three monaural ultrasonic probes (developed by Mr. L. Russell of Cambridge, Massachusetts) was delivered to the Center and evaluation was begun. The other two units are scheduled to be delivered to the Center at the beginning of the new contract year (December 1, 1966).

The monaural ultrasonic probe is a small battery-operated sonar device intended for use by blind travellers, particularly cane users. It is worn suspended on the user's chest by means of a neckstrap. It scans the area directly ahead of the user, providing surveillance of the space through which his head and shoulders will pass, thus protecting the user from colliding with objects above the waist which the cane would not encounter. In addition, sighted pedestrians are detected before they are encountered by the cane, thus avoiding the social penalty.

The probe emits short pulses of sound at 40KC at a rate of 15 pulses per second. Echoes are received from objects ahead of the user, and the range is established by a time delay measuring circuit. When there are no echo-producing objects ahead within six feet, the device makes no audible sound.

The instrument has been designed so that range zone limits and characteristic range zone sounds can be readily modified by internal adjustments. In addition, the instrument design facilitates pick-off of electrical signals to operate tactile displays.

F. RNIB Tape Position Indicator (Catalogue No. 9395)

This tape position mechanism displays the accummulated number of revolutions of a tape recorder reel. The tactile readout is identical to a Braille clock, i. e., double dots at 3, 6, 9, and 12 o'clock positions. The "hour" hand is shorter and is further identified by a Braille dot. A reset button is provided which allows the clock hands to be positioned manually without driving through the clock gearing. The rotational input hub of the clock mechanism contains three pins which engage the central slots on the tape take-up spool. The weight of the clock mechanism is the only force available to maintain drive pin-to-tape spool engagement. Because of this design feature, the indicator cannot be mounted on tape reels which rotate in a vertical plane. The clock case is prevented from rotating by a telescopic arm-drive hub assembly which engages the supply spool central slots. The device is shown in Fig. 7 mounted on a Wollensak tape recorder.

The total weight of the tape position indicator is 7.4 ounces. The telescopic arm range of adjustment for tape hub center distances was 5.1" through 9.2". The torque required to drive the clock hub was measured at 0.37 ounce-inch. The torque required to drive the idler hub was 0.24 ounce-inch. The frictional torque of each of the Wollensak recorder spindles on the free position was 0.30 ounce-inch.

The clock gear ratio was determined by comparison of the input and output turns. Twelve revolutions of the input hub will drive the minute hand to the "five minute" position and 144 input revolutions/"hour" display. Therefore, the total capacity of the clock for unique display was 1728 revolutions.

The gear train backlash observed at the input hum was one turn, i. e.,

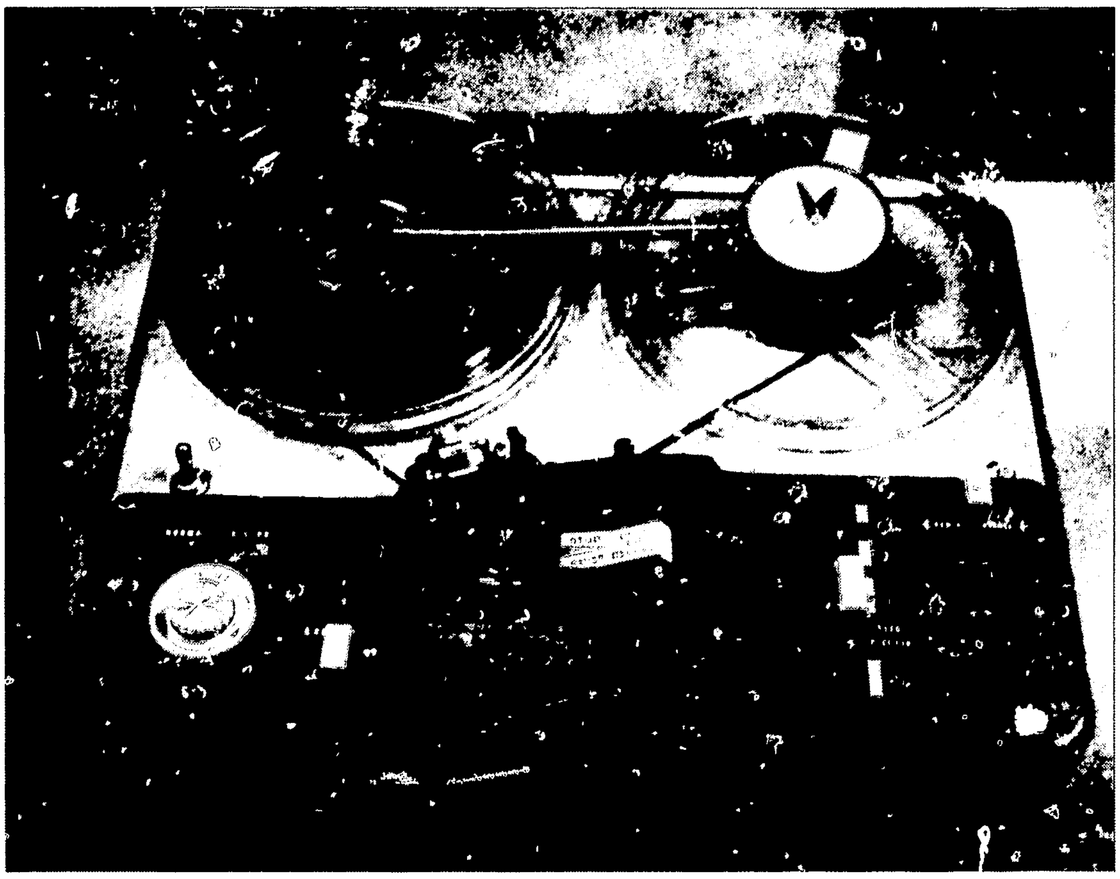

FIG. 7. RNIB (Royal National Institute for the Blind) tape position indicator installed on Wollensak tape recorder.

when spool motion was reversed, it required an additional turn of the input shaft to return the clock hands to the initial reading.

Assuming perfect read-out of the display by the user, the observed gear train backlash will result in the following tape location errors at the outside of a seven inch tape spool:

3 seconds of text at 7-1/2 ips tape speed

6 seconds of text at 3-3/4 ips tape speed

12 seconds of text at 1-7/8 ips tape speed

24 seconds of text at 15/16 ips tape speed

Subject Evaluation

Seven blind males served as Ss in an informal evaluation of the RNIB tape position indicator. Each S was instructed in the mechanics and use of the device. Simultaneously he tactually examined the indicator and explored the fitting of the clock mechanism and anchor plug to the drive and take-up spools. All Ss were already familiar with the reading of a Braille clock.

After some initial difficulty in the placement of the indicator, Ss learned both the positioning of the indicator and the localization of a specific place on the tape. The Test Selection was an article from CONSUMER REPORTS. As Ss listened to the passage, the experimenter randomly stopped the tape recorder. The S read the Braille clock and the tape was advanced or retracted by use of the advance, or rewind, function. The S was then asked to locate that specific position on the tape.

Localization of a specific position requires the use of both hands, the fingers of one hand following the reading of the Braille clock and the other hand regulating the forward, or rewind, lever. Most Ss reached an accuracy of within two to five tape reel turns from the desired location on the tape. Most of the time in locating a position was spent in hunting and subsequent re-reading of the Braille clock. All Ss, except one with only one useful hand, reacted favorably and considered the indicator to be useful.

This informal evaluation seems to support the following recommendations: (1) a more precise distinction between the minute and hour hands to facilitate their differentiation; (2) an increase in the length of the telescopic arm coupling the indicator to the anchor plug in order that the device may be used on recorders where the distance between spindles exceeds the maximum length of the arm (9.2 inches).

In practice, this procedure must be preceded by an initial reading of the tape. The user then makes a reference list in terms of Braille clock readings. Therefore, he subsequently can return to these locations directly without having to listen to portions of the tape.

It should be noted that in order to obtain unique correlations between clock readings and tape locations, the following conditions must be satisfied: the thickness of the tape, the diameter of the tape reel hub, and the tension on the take-up reel must be the same.

G. Optical Probes

Two "light probes", or devices that convert ambient light intensity into an audio display, were evaluated.

The laboratory set-up was as follows: A fluorescent light tube was masked so that only a 1" x 1" area, equidistant from each end, was exposed. The exposed area was covered with a flat ground glass plate, and then surveyed with the probe of a precision photometer. A constant light value reading was observed across the exposed source area. A clamping fixture was constructed which located either of the test probes or the photometer probe an equal distance from the ground glass, so that the inverse square attenuation was constant for all runs. A set of semi-opaque filters were interposed between the source and probes to incrementally decrease the apparent brightness. When all filters were interposed between source and probe, the relative light value observed was three units. With no filters, the observed light value was 1535 units. The audio output frequency of each probe at the test points was determined by an immediate A-B comparison with the output of a variable frequency oscillator using human judges.

1. Wexler Device

This probe (with accessories) was obtained from Mr. A. Wexler of Melbourne, Australia. The brass photodiode holder and screw-on orifice collimator weigh two ounces; the electronics pack (battery and earphone) weighs an additional three ounces. The unit is powered by one "U-7" (1-1/2 volt) penlite cell. The only external control is a slide-type on-off switch (no volume control) located on the electronics case. A pin-type audio output jack and screw terminals for the probe leads are located at the switch-end of the electronics pack. For the unit tested, probe components bore the following identification numbers:

Photodiode holder	# 17
0.055" diameter orifice collimator	# 17
0.100" diameter orifice collimator	# 17
electronics package	# 11

The approximate rate of change of output frequency was 1.1 cps/unit of light value. With the large orifice, the output display threshold occurred at a relative light value of 72 units. With the small orifice, the output display began at a relative light value of 176 units. The repetition rate of the audio output display ranged from 4 cps to 1800 cps.

The probe was evaluated individually by seven blind adult subjects. All subjects seemed highly motivated to try out the probe. The initial response of each subject upon being presented with the probe was to "scan" familiar objects, i. e., fingernails, shirt, tie, eyebrows, polka dots on a dress, etc. Subjects were asked to scan the test card (Fig. 8) which accompanied the probe. Several design features of the probe proved annoying to the subjects, and tended to interfere with their concentrating on the test, i. e., the earphone would not stay in the ear, and both the probe cord and the earphone cord tangled. All subjects had difficulty maintaining orientation of the probe without casting a shadow on the target, thereby reducing the signal-to-noise ratio below the threshold for discrimination. With the small collimator installed, each subject was able to find portions of both the black and the white letter "L" on the test card. Only one subject could consistently follow the shape of the entire letter "L". Two subjects were able to consistently note the green-to-red transition line on the test card. One subject thought the display was too loud; none thought it was too soft.

Subjects were asked what use they would have for the device. Since all were professional people, they tended to envision the device as a vocational aid rather than an education aid. For example, A music teacher wanted to follow lines of the music staff on a blackboard; a programmer wanted to count the column of letters on a punch card (he was not successful at this, but was able to locate the blue striped area of the punch card); a typist would like to determine where the typing ends on a page; an attorney wanted to know when he was "talking to himself - people wave goodbye and leave"; a housewife wanted an infra-red detector so that she wouldn't pick up hot objects; and

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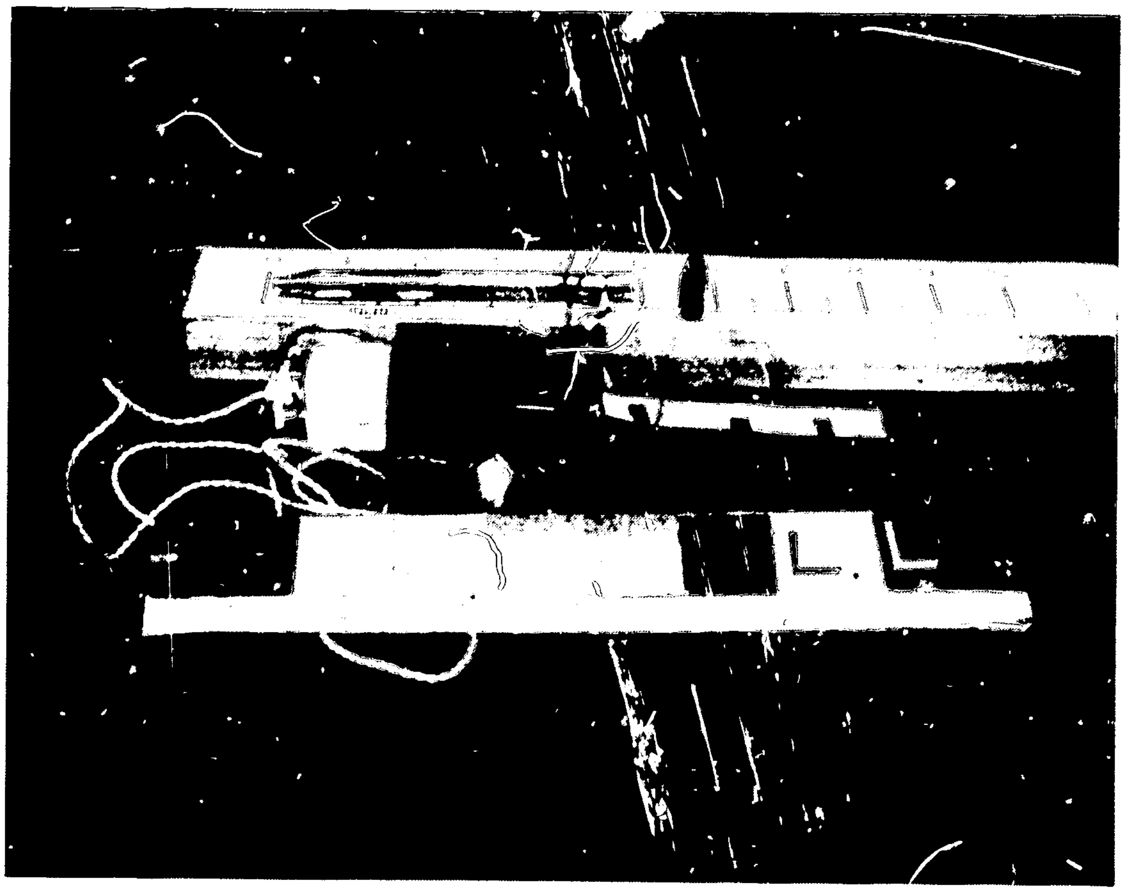

FIG. 8. The Wexler light probe and accessory kit.

several subjects would use the probe to determine if the hall lights, controlled by a remote switch, were "on" or "off".

The Wexler probe has been designed to provide optimum utility in the classroom. The separate electronics package can provide an audio display for numerous probes to sense various laboratory phenomena. The individual earphone feature is a necessity in the classroom, as is the heavy "child-proof" brass probe case. The probe design, however, is not optimal for the mobile occasional user who requires a single package, light weight unit.

The mass market price of the device was estimated at $30.00.

2. The RNIB Light Probe (Fig. 9)

This device was obtained from the Royal National Institute for the Blind (London, England). The probe and output transducer are contained in an aluminum cigar-size case. The entire assembly, including battery, weighs 1.5 ounces. The only external control is a bi-stable "on-off" switch rod. The approximate rate of change of output frequency was 8.7 cps/unit of light value. The output display threshold occurred at a relative light value of three units. The repetition rate of the audio display ranged from 22 cps to 13,200 cps.

The mass market price of the device was estimated at $25.00.

Ten blind adults served as subjects in the evaluation of this probe. They used the device for periods of 10 minutes up to one-half hour. Their reactions were as follows: (a) All Ss were pleased with the lightness and compactness of the unit; (b) All Ss found it a useful detector of light position, intensity, and whether a light was in an "on" or "off" position; and (c) Although lines on a sheet of paper could be detected, most Ss encountered some difficulty in orienting properly to light sources and avoid-

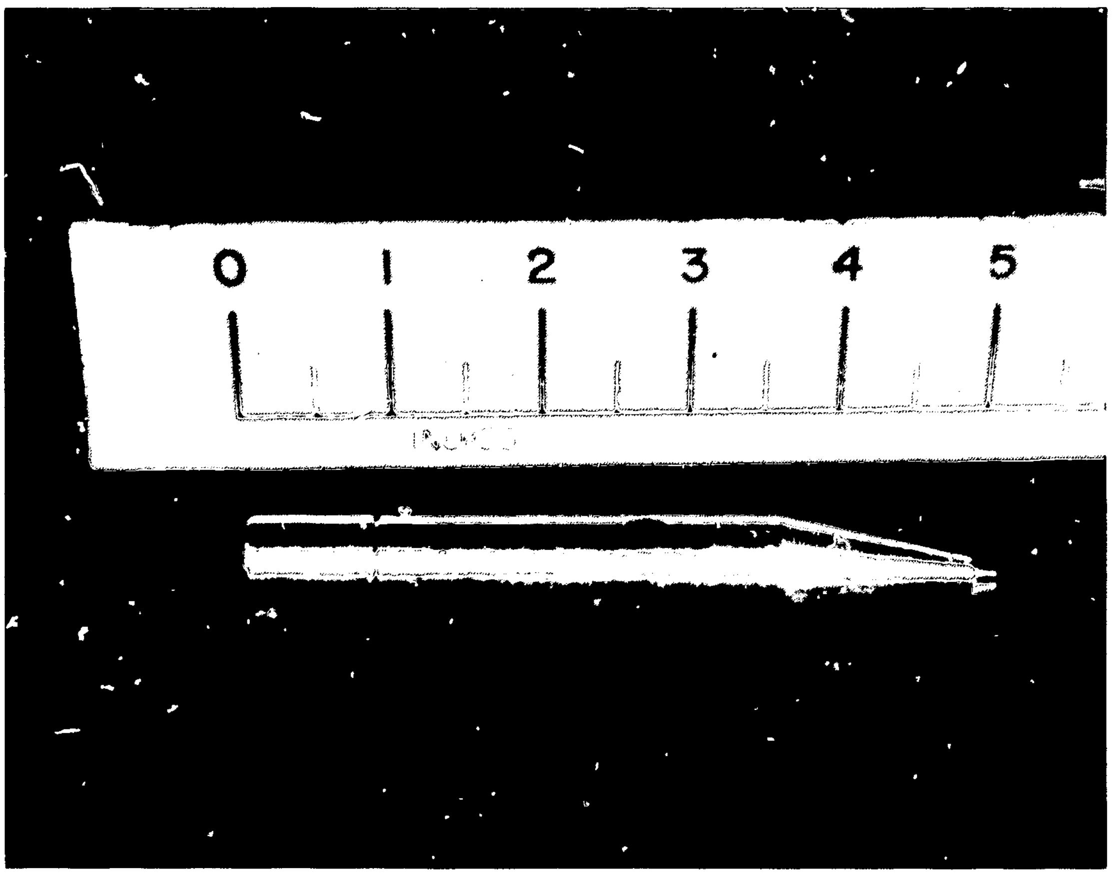

FIG. 9. The RNIB Light Probe.

ing shadows produced by their hands, body, or nearby objects. Several Ss suggested that a light source be built into the probe, or attached thereto.

The RNIB design tends to be more useful as a general aid for other than classroom use. In general, neither device was able to detect a black dot smaller than 1/4" in diameter on a white background when lighted by reflected light. A self-contained light source directed ahead of the sensitive end of the probe, and a transparent spacer to maintain probe-to-object distance, are recommended as essential design additions to improve the resolution of either device.

H. Long Wave Radio Direction Finder

During the St. Dunstan's International Conference on Sensory Aids for the Blind (June, 1966 - London, England), Mr. James C. Swail (National Research Council of Canada) and Mr. Lindsay Russell (Cambridge, Massachusetts) suggested that a battery operated, long wave radio receiver might serve as a straight-line indicator for the blind. Therefore, the Center undertook a preliminary evaluation of the idea.

A small Phillips, battery operated, transistor, long wave receiver was analysed for its directional properties and freedom from interference by nearby metal structures. This unit did not have adequate directional acuity to add any useful data to unaided human performance for straight-line travel across open areas. The unit only indicated directional changes of approximately 45°. In previous evaluations of straight-line indicators and human performance, 1 to 2° was determined to be the instrument acuity required.

I. Displays

1. Picture Brailler and Multiple-Line Bead Grid Display

The Center did not evaluate these items because (a) the sensory aids group in the Research Laboratory of Electronics (at M.I.T.) did not complete a prototype of the multiple-line bead grid display during the period covered by this Final Report, and (b) although a prototype of the picture brailler was completed by this same group, Center staff felt that the group had devised a better alternative.

2. Kedam Bi-stable Pin Braille Belt

The original prototype was returned to the sensory aids group in the Mechanical Engineering Department (at M.I.T.) for further development by a graduate student.

3. Blanco Braille Belt

This prototype was returned to Professor E. E. Blanco of Tufts University for further development.

4. Bellows Continuous Belt Braille Display

No further development on this instrument was justified because the design does not allow sufficiently high presentation rates for most experienced Braille readers.

5. Piezoelectric Bimorph Single- and Multiple-Line Braille Display

Stanford Research Institute colleagues have provided more than sufficient evidence that a closely packed array of piezoelectric bimorphs can present single or multiple lines of Braille coding at rates acceptable to fast readers. The Center, therefore, did not undertake the construction of such an array. Such a project would be justified only as part of a system in which Braille coding is stored on punched cards or magnetic tape for read-out and conversion to signals acceptable to the piezoelectric bimorph array.

J. Evaluation of Braille Generated by Converted Computer Line Printers

1. Comparison of Braille Produced by University of Cincinnati, I.B.M., and Honeywell Line Printers

As of 30 November 1966, the only Braille produced on a converted computer line printer, which was of standard dot height, was that available from the Honeywell Model 222. Samples of Braille output from other computer line printers contained dots five to eight mills high. Compared to the standard 18 to 20 mill height, these samples are marginally acceptable to most Braille readers, and are too easily damaged during use, or when stored.

2. Single Character Embosser

A high-speed, single character (one cell at a time), Braille embosser was designed by two students at the Research Laboratory of Electronics. The Center did not evaluate this pre-prototype model because further development is required to establish reliability for testing with blind subjects.

K. Vocational Aids

1. Vocational Aids Conference

The Center had planned to hold a conference on vocational aids during the past contract year but did not because, in the planning stage, no consensus could be reached concerning agenda, objective, and effective means of communication between technological researchers and rehailitation specialists.

Prior to such a conference, better communications must be established. The Center took a preliminary step by preparing special information sheets on the "centering fixture" and "doweling jig", which were forwarded to the Vocational Rehabilitation Administration on October 4, 1966, for dissemination to rehabilitation facilities. The sheets included the following information:

(a) A picture of the devices

(b) Detailed specifications

(c) A list of tasks for which the devices might be useful

(d) Estimated costs to manufacture small quantities

(e) Results of evaluations with blind subjects

2. Carpenter's Levels (N.R.C. and A.F.B.)

The Center obtained two carpenter's levels (one from the National Research Council of Canada and one from the American Foundation for the Blind) which were evaluated by the following procedure. A test fixture was assembled so that the operating characteristics and accuracy of the levels could be assessed in the laboratory. This fixture is comprised of an aluminum channel section beam (four feet long) supported by a bearing through its center so that it is free to rotate in the vertical plane. A threaded rod adjustment allows the beam to be rotated in small incremental angles with the horizon. A flash-light (projection pointer) which projects the image of its lamp filament was taped to one end of the aluminum beam to form an optical lever arm (20 feet long) between the beam pivot and a wall. A scale was constructed using triganometric functions with scale divisions at 0.1° increments. The beam was adjusted to a horizontal position (zero degrees) using a precision spirit level. The optical scale was aligned on the wall to coincide with the bubble level zero orientation. The beam portion of the fixture is shown in Fig. 10.

(a) National Research Council of Canada Level

This level was obtained from Mr. James C. Swail of N.R.C. It is an electronic instrument whose output is a constant frequency audio tone. In the "level" condition, the amplitude of this tone is at a minimum. The

FIG. 10. The pivoted beam test set-up used in calibrating the carpenter's levels.

device is shown in Fig. 11. The level weighs 22.5 ounces and occupies a retangular volume 7.8" x 3" x 1.5". The electronics are battery operated and feature loud speaker output. The only external control is a combined "on-off" and "volume" control knob. The level sensing transducer was sealed in potting compound and was not disassembled. Mr. Swail describes the sensing transducer as a commercially available unit which utilizes a fluid-filled tube to produce changes in electrical resistance as the angle between the axis of the tube and the horizon changes. During the laboratory test, the audio output of the device was monitored through a set of lead wires connected in parallel with the speaker terminals and driving the "Y" axis of an oscilloscope. The resultant performance curves (audio output voltage vs. angular deviation from horizontal) are shown in Figs. 12 and 13.

The level sensing element is mounted parallel to the working surface of the device within $\pm$ 0.05 degrees. Audio output readings were noted at identical true angle inclinations for both positive and negative changes in angle. The observed hysteresis was less than 0.05°. No reliable change in audio output level was recorded for angles greater than +1.25° or -1.6°. The average rate of change of audio output voltage with respect to changes in angle throughout the range of the instrument was calculated at 8 units/degree. At small angles ($\pm$ 0.2°) the average rate of change of audio output voltage was 10.3 units/ degree. The response time of the device was estimated at 300 milliseconds, i. e., angular perterbations of shorter duration do not produce audio output changes. As the instrument passes through zero, the output pulses change polarity and wave form, so that an audio tone of different timbre is produced allowing an experienced user to determine the sense of the angular error.

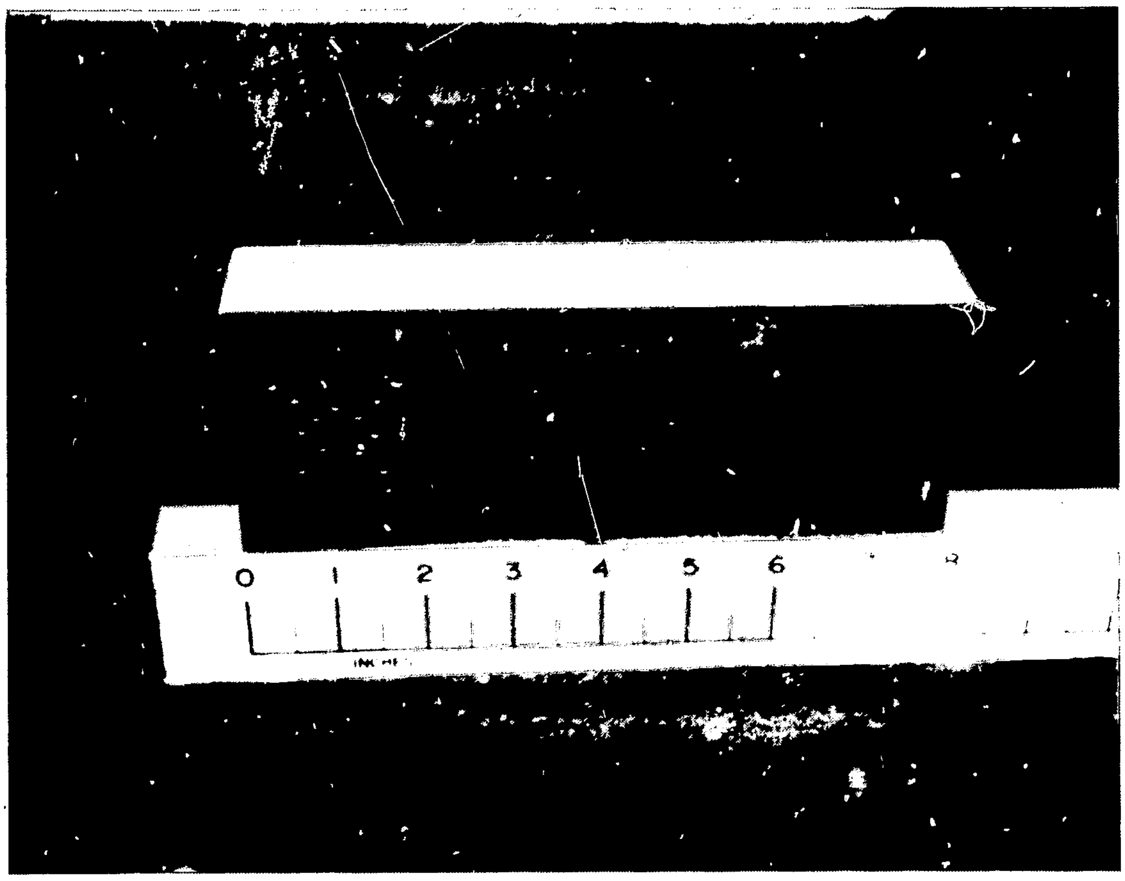

FIG. 11. National Research Council of Canada Level.

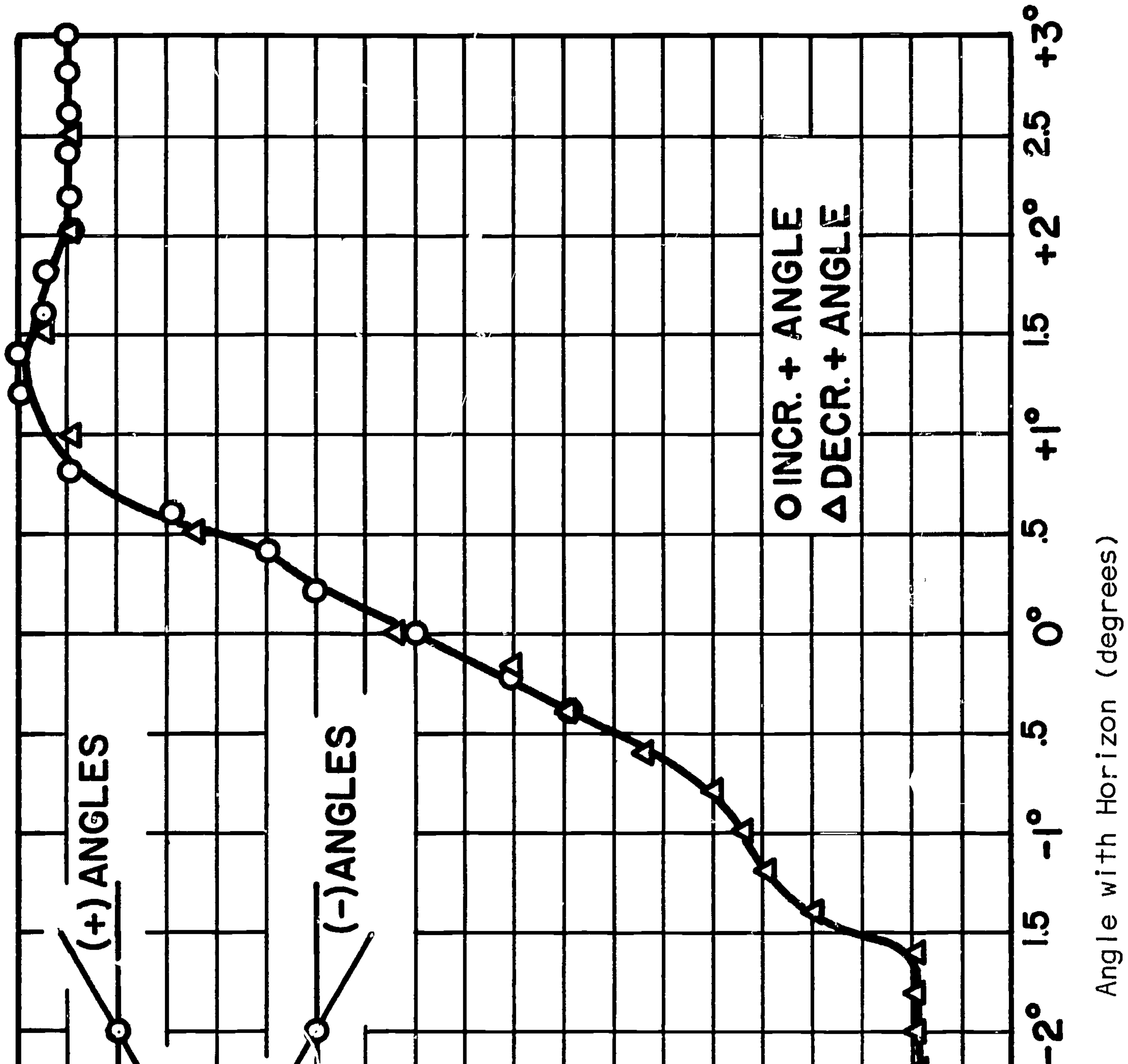

FIG. 12. Total display performance curve, NRC level.

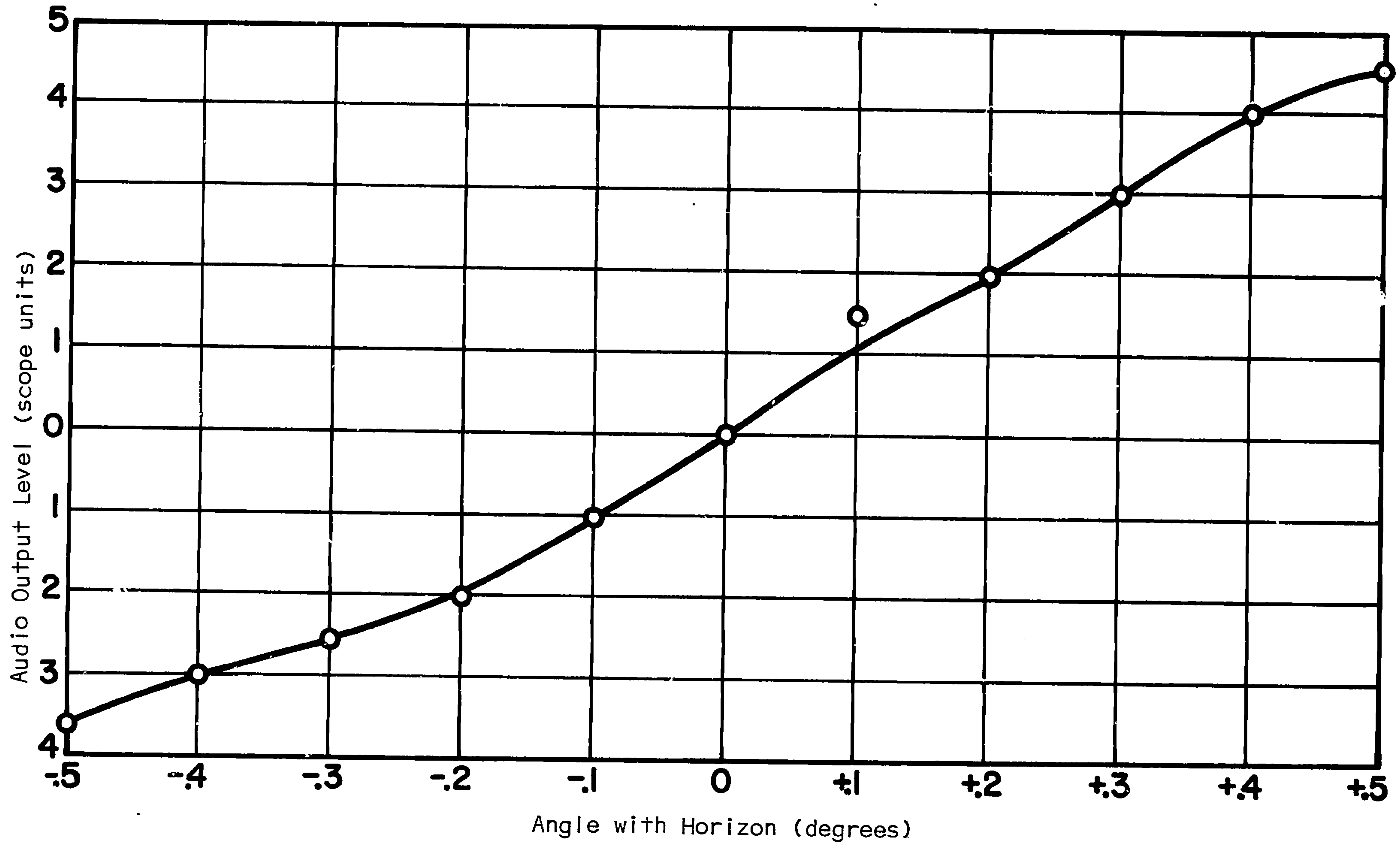

FIG. 13. Performance curve of NRC level at small angles.

(b) A.F.B. Carpenter's Level

This level was obtained from the Sales Division of the American Foundation for the Blind. It is listed in the catalog of aids and appliances as item TS-134. The device is shown in Fig. 14.

The level sensing element is a 7/8" diameter steel ball which is free to roll in a 90° steel Vee trough. Fixed stops are provided at the ends of the trough so that the total allowable movement of the ball is 5.2". A retaining rod mounted above the ball allows the fixture to be transported without loosing the ball. The trough is normally supported by a blunt "knife edge" at one end and a pin of fixed length at the other. A bolt is provided adjacent to the fixed pin so that the level may be adjusted to sense a "level" condition after a predetermined angular error has been introduced by turning the bolt. The bolt thread is 16 pitch and the bolt is displaced 7.17" from the knife edge. Based on trigonometric calculations, this geometry will tilt the level 0.5° for each turn of the bolt. The total range of adjustment is five turns (2.5°). The fixture weighs 13.5 ounces, is fabricated of steel weldments, nickel plated, and appears to be durable enough to be transported in a tool box without additional protection.

A laboratory test was conducted using the previously described hinged beam. The steel ball level is not a tactual analogy of the fluid-filled spirit level, i. e., the ball will not center itself along the axis of the trough when "level". The level condition is indicated when the ball is stationary and anywhere along the trough except at the extremities. Under steady state conditions, it is possible for the beam to be inclined 0.25° without motion of the ball. If the level is tapped while in the inclined position, the ball will roll to indicate the out-of-level condition reliably to within $\pm$ 0.1° of true angle. The observed phenomenon is due, in part, to

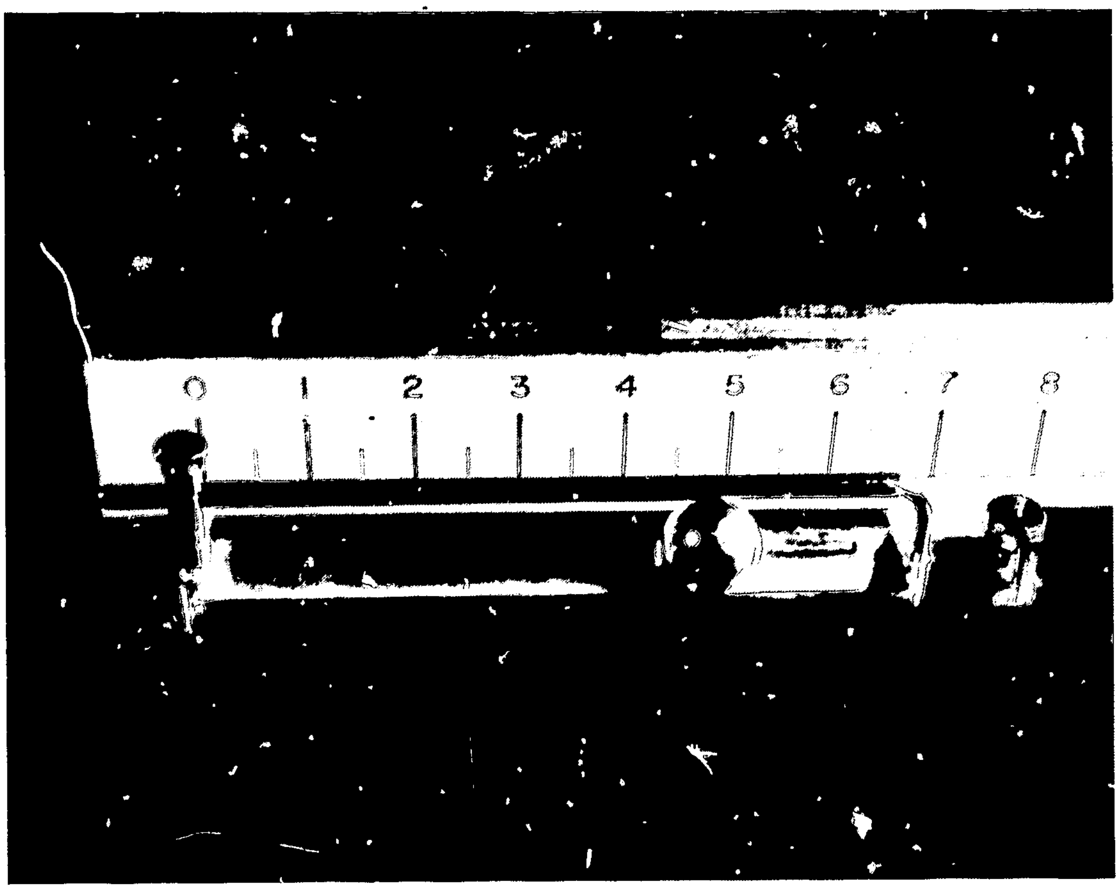

FIG. 14. A.F.B. Carpenter's Level.

different coefficients of friction for the static and rolling conditions. The precision of the device might be improved by imparting a finer surface finish to the trough edges, where pitting and flaking of the plated surface was observed.

(c) Subject Testing

The described pivoted beam fixture was modified by the addition of cork clutch plates at the central bearing to approximate the "feel" of a shelf tracked at one end. The problem presented to each subject was to raise and lower the free end of the beam until and axis of the "bookshelf" was level. The shelf pivoted at chest height. The time from when the subject first grasped the shelf until he indicated that it was level was recorded. The corresponding final true inclination via the optical lever arm system was recorded. Each subject was allowed three trials using each level. Subjects were interviewed to determine if they needed a "level", which of these levels they preferred, how much would they pay, and what specific tasks would they use if for.

Seven subjects were tested; all participated in the full test, although two indicated they had never needed a level (an insurance salesman and a social worker, not presently home owners). In using the ball level, subjects adjusted the shelf with the left hand and sensed the state of the steel ball between the thumb and forefinger of the right hand. The largest final errors observed were 0.4° (ball level) and 0.15° (electronic level). The median time required to arrive at a level decision was 24 seconds (ball level) and 16 seconds (electronic level).

None of the subjects would pay more than $10.00 for a level. At that cost, they would prefer enlisting the aid of a sighted person.

All subjects felt that the primary advantage of the electronic level was that it did not "use up a hand". Two subjects objected to the "manufactured sound" of the electronic level.

Subjects indicated they would use a level to facilitate the following tasks:

1. Level a phonograph turntable
2. Level a kitchen range
3. Put up bookshelves, especially the adjustable type where it is easy to get the shelf in the wrong notch
4. Training blind subjects to carry a cafeteria tray (electronic level).

A sighted craftsman leveling a bookshelf is able to mark the "level" location of the shelf on a mating structure, remove the level, and then nail or screw the shelf with reference to the mark. For a blind craftsman, however, a non-visual display of level does not facilitate the entire task unless the instrument design includes a clamping arrangement to rigidly attach it to the shelf so that the final fastening of the shelf can be completed without removing or damaging the instrument. The level errors experienced during subject testing were assessed as acceptable to most "around the home" tasks for either level.

The ball level is available at $8.50, and the mass market cost of the electronic level is estimated at $40.00.

L. Educational Aids

With increased emphasis on time compressed speech for educational and vocational purposes, simple and inexpensive methods are needed which can be made available to, and owned by, individual blind persons. One solution is to modify a tape recorder by changing the capstan diameter.

A Wollensak tape recorder was selected from the numerous style recorders available at the Sensory Aids Center, because it represents a home-type, inexpensive ($80.00) unit.

In the Wollensak design, the idler wheel-to-capstan force is through a detent and spring arrangement. Our tests have indicated that the detent linkage will function satisfactorily as the capstan diameter is increased up to and including a 90% increase in diameter. The recorder selector mechanism allows tape speed selection in 100% increments (15/16, 1-7/8, 3-3/4, and 7-1/2 ips).

A set of brass capstan bushings were made which slip over the capstan (0.250" diameter) and whose outside diameters were larger than the capstan diameter by 20, 30, 40, and 60%, respectively. These bushings are shown in Fig. 15 placed next to the capstan. Only two bushings were required since each is stepped in diameter (20-30% and 40-60%). The largest diameter of each bushing need only be long enough to ensure contact along the full tape width when installed. The smaller diameter, however, must be long enough to extend above the top of the pressure roller so that the roller cannot contact the larger diameter. In order to allow for thermal expansion of the bushings and still maintain a secure bushing-to-capstan fit, saw cuts were made at either end of the bushing (Fig. 15). The saw cuts allow the bushing ends to be deformed out of round - slightly in the free position - yet be forced back when the bushing is slipped over the capstan so that the bushing cannot rotate relative to the capstan.

The bushings can be installed or removed without rewinding the tape. An annoying delay was experienced when changing capstan bushings, because the Wollensak design utilizes a combined "AC on-off volume control" knob, so that when the capstan is switched "on" after a bushing change, the user

FIG. 15. "Slip on" bushings used in speeded speech evaluation.

had to wait for the audio circuit components to warm up and re-adjust the volume control. Subsequently, a switch was added to interrupt the AC motor leads. The total down time required for the bushing change, with the motor switch addition, was reduced to five seconds.

The cost of the bushings for limited production runs was estimated at $1.00 each.

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III. ADMINISTRATIVE STRUCTURE

The Managing Director and Staff of the Center are responsible to the Mechanical Engineering Department at M.I.T. In addition, all Center projects are submitted to its Steering Committee for approval.

Members of the Steering Committee participate in the day-to-day activities of the Center as consultants in their areas of individual specialization (Sensory Psychology, Mechanical Engineering, Electrical Engineering, Rehabilitation, Special Education, etc.) Also, this committee is divided into behavioral science and engineering task forces to assist staff members in designing and carrying out major projects.

The Advisory Committee to the Center maintains more effective contact for Center staff with research and rehabilitation facilities throughout the country. Their other main function is to join with the Steering Committee and Center staff to develop optimum planning.

A joint meeting of the Committees and Center Staff was held at M.I.T. on Friday, March 11, 1966. During this meeting, five sub-committees (listed below) were formed for long-range planning.

1. Administrative Structure (Prof. R. W. Mann, Chairman)
2. Mobility Scale (Prof. I. F. Lukoff, Chairman)
3. Perception (Prof. E. Foulke, Chairman)
4. Mobility Simulation (Prof. S. J. Mason, Chairman)
5. Reading (Dr. B. White, Chairman)

The Steering and Advisory Committees held individual meetings on the following dates: Steering Committee, Monday, October 17, 1966; Advisory Committee, Monday, December 20, 1965.

Members of the Steering and Advisory Committees are listed below:

National Advisory Committee

Dr. R. A. Bottenberg, Air Force Personnel Lab., Lackland A.F.B., Texas
Dr. E. E. David, Jr., Bell Telephone Labs.
Prof. E. Foulke, Dept of Psychology, University of Louisville
Prof. R. H. Gibson, Dept of Psychology, University of Pittsburgh
Dr. H. Goldstein, Children's Bureau, H. E. W.
Dr. M. D. Graham, American Foundation for the Blind
Prof. J. G. Linvill, Electrical Engineering Dept., Stanford University
Prof. I. F. Lukoff, School of Social Work, Columbia University
Dr. C. Y. Nolan, American Printing House for the Blind
Dr. R. A. Scott, Sociology Department, Princeton University
Dr. M. R. Rosenzweig, Psychology Dept., Univ. of California, Berkeley
Dr. W. P. Tanner, Jr., Sensory Intelligence Lab., Univ. of Michigan
Dr. B. W. White, Lincoln Laboratories, M. I. T.

Steering Committee

Mr. C. Davis, Perkins School for the Blind
Prof. R. Held, Psychology Department, M. I. T.
Prof. S. J. Mason, Electrical Engineering Dept., M. I. T.
Prof. A. W. Mills, Psychology Department, Tufts University
Prof. R. B. Morant, Psychology Department, Brandeis University
Mr. J. F. Mungovan, Massachusetts Commission for the Blind
Dr. L. H. Riley, American Center for Research in Blindness and Rehabilitation
Dr. O. Selfridge, Lincoln Laboratories, M. I. T.
Prof. T. B. Sheridan, Mechanical Engineering Dept., M. I. T.
Dr. M. L. Simmel, Psychology Department, Brandeis University
Prof. R. W. Mann (Chairman), Mechanical Engineering Dept., M. I. T.
Mr. J. K. Dupress (ex officio member)

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IV. ACTIVITIES

A. Conferences

On November 18, 1966 the Center sponsored its Annual Braille Research and Development Conference at M. I. T. Financial support of this Conference was provided by the American Foundation for the Blind. This fund was administered by the Research Laboratory of Electronics at M. I. T.

The agenda was as follows:

Goldish, Louis H.: A Study of Braille Production, Distribution and Use

Sterling, Dr. Theodor D.: Automated Braille and the Profession of Programming for the Blind

Boyer, John J.: BRAILLETRAN: A Comprehensive Braille Transcription Program (with emphasis on technical material)

Glaser, Prof. Edward L.: Small Computers and Grade 2 Braille

Grunwald, A. P.: On Reading and Reading Braille

Haynes, Robert: Computer Translation of Grade 2 Braille at the American Printing House for the Blind, May, 1964 - November, 1966

Woodcock, Prof. Richard W.: Braille Research at George Peabody College

Foulke, Prof. E. and Joel Warm: The Effects of Pattern Complexity and Redundancy on the Tactual Recognition of Metric Figures

Bishop, Donald: Computer Programming and the Blind

Windebank, Clive: Computer Production of Braille at the Royal National Institute for the Blind

Schack, Ann and Joseph: Computer Conversion of Compositors Tapes to Grade 2 Braille

Baumann, Professor Dwight M.: Braille Embosser and Display Systems

Morrison, Ray E.: Advances in Braille Embossing

B. Special Summer Session

From August 15-19, 1966, the Center, in conjunction with the Department of Special Education, Teacher's College, Columbia University, sponsored a special one-week summer session at M. I. T. entitled, "Technological Developments and the Education of the Blind and Visually Impaired". Participants were special education teachers from all over the United States. The session was such a great success, the Center and Columbia plan to extend it to a two-week course in the summer of 1967.

The schedule of lectures and demonstrations was as follows:

Monday, August 15, 1966 9:00 A.M. to 12 Noon

1. Introduction
2. Present status of reading machine research for the blind (United States and abroad)
3. (a) Printed character-to-spelled speech research at the Research Laboratory of Electronics, M. I. T.

   (b) Plans for future research on reading machines at M.I.T. and elsewhere
4. (a) Compositors tapes-to-the-spoken word research at Haskins Laboratories

   (b) Research, development, and evaluation of the Battelle reader

1:30 P.M. to 5:00 P.M.

1. Research Predictions
2. Demonstration of reading machines and reading machine outputs

Tuesday, August 16, 1966 9:00 A.M. to 12 Noon

1. Status of present research on blind human mobility and mobility aids
2. Active, energy-radiating mobility aids and ambient light mobility aids
3. Evaluation of mobility aids
4. Mobility simulation facilities

1:30 P.M. to 5:00 P.M.

Demonstration of mobility aids and evaluation procedures

Wednesday, August 17, 1966 9:00 A.M. to 12 Noon

1. Sound recording - state of the art (tape players)

2. Sound recording - state of the art (recorders - portable and AC)

3. Time compressed speech (electronic and computer)

4. Time compressed speech (speeded)

1:30 P.M. to 5:00 P.M.

1. Laboratory demonstrations of time compressed and speeded speech

2. Summary and discussion

Thursday, August 18, 1966 9:00 A.M. to 12 Noon

1. Present status of computer Braille translation and computer line printer Braille embossing

2. Compositors tapes to Braille translation

3. Braille displays

4. Computer and "on-line" Braille outputs

1:30 to 5:00 P.M.

1. Multiple Access Computer (Project MAC)

2. Demonstration on CTSS of teletypesetter-to-Grade 2 Braille

6:00 to 9:00 P.M.

Cocktails and Dinner, M. I. T. Faculty Club

Friday, August 19, 1966 9:00 A.M. to 12 Noon

1. Educational aids for teaching physical sciences and engineering

2. The development and evaluation of sensory aids: a report on sensory aids

3. Report on St. Dunstan's International Conference on Sensory

Friday, August 19, 1966 9:00 A.M. to 12 Noon (Continued)

Devices for the Blind (June 13-17, 1966, London, England)

4. Research programs in the areas of mobility, reading, and perception

1:30 P.M. to 4:30 P.M.

1. A long-range research program for the blind and deaf-blind

2. Summary and discussion

C. Publications and Presentations

The following papers emanated from the Center:

Dupress, John K.: Research, Development and Evaluation of Sensory Aids for the Blind, Proceedings, Conference on Aid to the Visually Limited, American Optometric Association, Washington, D. C., March 1966. Also, The New Outlook, American Foundation for the Blind, March 1967.

Dupress, John K.: Sensory Aids Evaluation: Procedures and Instrumentation, Proceedings, St. Dunstan's International Conference on Sensory Devices for the Blind, London, June 13-17, 1966.

Dupress, John K.: Sensory Aids and Computers: State of the Art and Predictions, Presented at the 8th General Session of Instructors for the Blind Conference, Salt Lake City, Utah, June 27-30, 1966.

Mr. Dupress spoke before the following groups:

1. The New York Commission on Urban Education (January, 1966)

2. Veterans Administration Conference, Washington, D.C. (28 January)

3. Illinois Association of Workers for the Blind (18 March 1966)

4. St. Paul's Rehabilitation Center (5 July 1966)

D. Special Conferences and Activities

1. Mr. Dupress attended special conference and meetings at the following places:

   a. New York Center for Urban Education (2 March 1966)

   b. Recordings for the Blind, Inc. (3 March 1966)

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c. Associated Blind of Massachusetts Conference (19 May 1966)

d. Veterans Administration (29 July 1966)

e. I. B. M. (New York City) special demonstration (7 Sept. 1966)

f. Library of Congress Symposium on Compressed Speech (October 18-21, 1966)

2. During 1966, Mr. Dupress made two field trips to England and visited the following research and rehabilitation facilities. It should be noted that both trips were made at personal expense, since funds for foreign travel are not available from subject contract.

a. The University of New Castle upon Tyne

b. Bradford Institute of Technology

c. Lanchester College of Technology

d. Nottingham University

e. National Physical Laboratory

f. Cambridge University, Computer Laboratories

g. University of London

h. Oxford University, Institute for Experimental Psychology

i. St. Dunstan's

j. Royan National Institute for the Blind

3. The eighth year of monthly Sensory Research Discussions (organized and conducted by Mr. Dupress) continued in the contract year 1965-66, thereby availing researchers, and rehabilitation and vocational specialists of information on progress in sensory aids research, development and evaluation for the blind and deaf-blind. The Discussions were held in the R.L.E. Conference Room at M. I. T.

4. Mr. Dupres continued as a member of the Committee on Computers and

the Blind, Association of Computer Machinery, and is a member of the following committees: Committee on Research on the Partially Sighted, American Optometrics Association; Steering Committee, Center for Rate Controlled Recordings: Planning Committee, National Academy of Sciences Subcommittee on Sensory Aids Research and Development for the Blind and Deaf-Blind.

E. Consultation

Data has been, and continues to be, exchanged with the following facilities throughout the United States:

Boston College, Peripatology Program
Washington University, St. Louis, Dept. of Computer Sciences
San Francisco State College, Dept. of Special Education
University of Louisville, Department of Psychology
M. I. T.: Psychology Department, Mechanical Engineering Department, Electrical Engineering Department, Research Laboratory of Electronics, Instrumentation Laboratory and Lincoln Laboratories
Columbia University, Teacher's College, Dept. of Special Education
U. C. L. A., Physical Education Dept., Perceptual-Motor Learning Lab.
Stanford University, Department of Electrical Engineering
Harvard University, Graduate School of Education
American Printing House for the Blind
American Foundation for the Blind, Research Division and IRIS
National Institute for Neurological Diseases and Blindness
Library of Congress, Division for the Blind and Physically Handicapped
Massachusetts Commission for the Blind
National Braille Press, Inc.
Veterans Administration, Prosthetics and Sensory Aids Division
Recordings for the Blind, Inc.
Jewish Guild for the Blind
Industrial Home for the Blind
Clovernook Home and School for the Blind
Perkins School for the Blind
Oakland School District, Pontiac Michigan

St. Paul's Rehabilitation Center and the American Center for Research in Blindness and Rehabilitation

National Braille Association

Braille Institute of America

Stanford Research Institute

Honeywell Corporation

International Business Machines Corporation

Massachusetts Association for the Adult Blind

V. SUMMARY

During the second contract year, emphasis was switched to completion of small projects, ending phase one of major projects, establishing communications with rehabilitation and special education facilities, and beginning negotiations to implement production feasibility demonstrations. A brief review of progress follows.

A reliable monotype tape reader was designed, constructed, and tested at the Center, and will be used in a production feasibility demonstration to convert monotype tape to Grade 2 Braille.

The teletypesetter phase of DOTSYS was completed and two production feasibility demonstrations given. The first involved the conversion of UPI news to Grade 2 Braille (August 18, 1966), and the second the generation of Grade 2 Braille from textbook information stored on teletypesetter tape (November 18, 1966). Both demonstrations took place at M. I. T. By mid-November, 1966, Grade 2 Braille produced by computer was error-free, and preparation of documentation was begun.

Heavy-duty collapsible canes were fabricated and field-tested by long cane users in the greater Boston area. Most Ss found the canes satisfactory, except for the balance. The field study led to the following conclusions: if the Center design is to be optimized, magnesium tubing or reinforced epoxy plastic tubing should be used.

Reliability testing and redesign of the M.I.T. high-speed Braille embosser continued in cooperation with Professor Glaser and his associates at Project MAC, and with the sensory aids group in the Mechanical Engineering Department. During the second year, three additional embossers were assembled and tested for special projects.

The first of three ultrasonic path sounders was delivered to the Center where evaluation was started. With this device, a blind cane user will be able to detect objects in the intended travel path and above where the cane is searching.

The experimental design has been completed for a study concerning length and distance concepts in congenitally blind children. Children at Perkins School for the Blind and from the Boston public schools will participate in this study which is relevant to the design of mobility aids.

Major efforts were made to establish better communications between technology and special education, and between technology and rehabilitation. A one-week special summer session was organized and conducted by Center Staff in conjunction with the Department of Special Education, Teacher's College, Columbia University. Also, a one-day Braille Research and Development Conference was organized and conducted by Center Staff, which concentrated on completed instrumentation and computer projects.

VI. PROPOSED WORK

Proposed work for the period 1 December 1966 through 30 November 1967 is listed below.

A. Applications for DOTSYS

1. Conversion of news summaries for the deaf-blind, in cooperation with Perkins School for the Blind and The Howe Press.

2. Conversion of small quantities of textbook material to demonstrate the feasibility of using DOTSYS for this purpose.

3. Interfacing the output from DOTSYS with IBM magnetic tape typewriters which can then be used to drive the converted Model C electric typewriters to emboss Braille.

B. Conversion of Monotype Information to Grade 2 Braille using DOTSYS

Our present monotype computer program to convert monotype information, to be used as an input to DOTSYS, will be completed during the third continuation year. A public feasibility demonstration will be given early in the continuation year. Samples of textbooks published from monotype tape will be made available to rehabilitation facilities to demonstrate the usefulness of this approach.

C. Evaluation of Ultrasonic Path Sounder Aids

The Center received the first of three production prototypes of the Russell ultrasonic path sounder in November, 1966. The other two are scheduled for delivery in early December, 1966. These prototypes will include some improvements on those incorporated in the unit demonstrated at St. Dunstan's International Conference on Sensory Devices for the Blind. During the third

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continuation year, the Center will evaluate the usefulness of the aids with the help of blind subjects chosen from the greater Boston area. Although controlled experiments in the laboratory will be conducted, primary emphasis will be on the acceptance of the device in real life situations. After the laboratory experiments, subjects will use the device in the field for a period of approximately two months.

D. Cooperative Project Involving the Use of Computers and an MIT Braille Embosser to Produce Experimental Raised Line Drawings

The sensory aids group at the Research Laboratory of Electronics (at MIT) will connect a high-speed Braille embosser (developed in the Mechanical Engineering Department at MIT) to a computer to produce raised line drawings from pictures and other graphic forms. The Center will cooperate with these groups to maximize the effectiveness of this computer and Braille embosser research tool. Recordings for the Blind, Inc., is particularly interested in more effective raised line drawings to be used as supplements to their sound recorded textbooks.

E. Extending DOTSYS to Include the Sp ken Word as an Output

There is growing evidence that sound recordings are playing an ever increasing role in the education and employment of the blind. If the project originating from Medcomp Research Corporation is funded by the Vocational Rehabilitation Administration, initial data will be available on speech outputs. If it is not, the Center will explore the data processing field to locate optical-to-digital inputs and speech outputs for DOTSYS.

Should sufficient amounts of useful data be available from Medcomp, the Center will concentrate on the interface with DOTSYS, evaluation, and

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further development based on extensive testing with blind subjects. Only those speech outputs will be used which can be comprehended immediately and require no learning on the part of the blind subject.

Center staff are familiar with all currently known forms of speech time compression including electronic instrumentation (the Fairbanks unit, Tempo Regulator, Varivox, harmonic compressor from Bell Labs, as well as computer time sampling and computer time sampling and blending). Center staff believe that there are many applications for speeded speech (at presentation rates up to 325-340 wpm), if appropriate time delays to one ear, high fidelity phones, and frequency sloping are added to a tape recorder. It is also believed that the machine-like presentation will be less distracting and stress-producing to the individual at high presentation rates, if time compression is included.

F. Experiments to Improve Speeded Speech by Introducing Mechanical and Electrical Time Delays, Condenser and Electrostatic Headphones, and Frequency Sloping

Blind persons have used speeded speech successfully for many years. Speeded speech is obtained by changing the capstan speed or the diameter of capstans on tape recorders, by using variable frequency power supplies, D.C. motors, etc. In spite of some objections to the "donald duck" effect (at presentation rates up to 325-340 wpm), every word can be clearly comprehended. Experiments will be conducted to increase the acceptability of speeded speech by using acoustical and electronic delay lines, electrostatic and condenser headphones, and frequency sloping that works to shift sound energy to appropriate points on the curve.

G. Collapsible Canes using Beryllium, Magnesium, or Epoxy Plastics

Preliminary results of the Center's field trials of extremely heavy-duty and rigid canes which can be used by long-cane travellers indicate that although the cane is extremely rugged subjects prefer a lighter weight unit. The only way to maintain the strength and rigidity characteristics of the Center's canes, and lighten them at the same time, is to use exotic-type material employed in the aerospace field. Although beryllium, magnesium, and epoxy plastics are extremely expensive, all possibilities will be explored.

Since more blind persons use a cane as a mobility device, rather than a guide dog which may cost as much as $2,800 apiece, the Center sees no objection to a cane costing as much as $100 to $300, as long as it is effective in maintaining mobility for the blind.

Light-weight aluminum versions of the Center's present prototype canes probably will be acceptable to the majority of the blind who are not long-cane users.

H. Comparison of Readers for Hollerith Computer Cards

In the past few years, several training facilities for blind computer programmers, as well as independent groups, have developed card readers. Among the facilities are the University of Cincinnati, the University of Southern California, M. I. T., Tufts, and the Educational Testing Service of Princeton, New Jersey. The Center proposes to borrow or construct one prototype of each design and evaluate the units with blind programmers who will be selected from a list provided by the Association for Computer Machinery.

I. Study of Length and Distance Concepts of Congenitally Blind Children

J. Two-Week Summer Session Sponsored by the Sensory Aids Center and Held

at M.I.T.

This is a cooperative project with the Department of Special Education, Teacher's College, Columbia University. Emphasis is on technology and special education.

K. Computer Generated Braille in the Classroom

This is a cooperative project involving the Sensory Aids Center, Columbia University's Department of Special Education, and the New York City Board of Education, Bureau for Education of the Visually Handicapped.

L. Two-Day Implementation Conference in the Area of Braille Research and Development

This is a cooperative project involving the Sensory Aids Center, Perkins School for the Blind, and the Library of Congress, Division for the Blind and Physically Handicapped.

M. Cane Balance Experiments

This is a cooperative project involving the Sensory Aids Center, the Peripatology Group at Boston College, and the Department of Psychology at the University of Louisville.

N. Universal Computer Languages

An ad hoc committee will be formed to study universal computer languages for Braille "translation" on large and small computers.

O. Braille Keyboards

An ad hoc committee will be formed to study the standardization of Braille keyboards.

P. A Technologist in the Field of Rehabilitation

A cooperative project with the Massachusetts Commission for the Blind to ascertain the feasibility of employing a technologist in the field of rehabilitation.

Q. Braille Translation by means of a Small Computer

A cooperative project with the Royal National Institute for the Blind in which a small computer will be used for Braille "translation".

R. Collapsible Canes and Ultrasonic Mobility Devices

A cooperative project with the Electrical Engineering Department at the University of Canterbury (New Zealand) to combine a collapsible cane and an ultrasonic mobility device.

S. Sensory Aids Group in the Mechanical Engineering Department (MIT)

A cooperative project on Braille in the classroom, and monotype to magnetic tape conversion.

T. Conferences and Seminars

1. Seminar for participants in the International Congress on Education of Blind Youth.

2. Two-day conference for mobility aids researchers and peripatologists.

3. Annual Braille Research and Development Conference.

VII. REFERENCES

1. Proceedings, Rotterdam Mobility Conference, American Foundation for the Blind, L. L. Clark (ed.), May, 1965.

2. Final Report to the Vocational Rehabilitation Administration from the Sensory Aids Evaluation and Development Center, October 31, 1965.

3. Proceedings, St. Dunstan's International Conference on Sensory Devices for the Blind, June 13-17, 1966 (to be published).

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APPENDIX A

RELEASE

I, ______________________________, wish to participate in a program conducted by the Sensory Aids Evaluation and Development Center of Massachusetts Institute of Technology. I am participating in this project entirely upon my own initiative and at my own risk and responsibility. In order that Massachusetts Institute of Technology will consider me as eligible to participate in this program, I release Massachusetts Institute of Technology, its agents and employees, on my own behalf and on behalf of my heirs and administrators, from all liability whether based on negligence or otherwise, which may arise out of my participation in this program, including my use of experimental devices such as the "collapsible cane" or other mobility aids.

The foregoing has been read to me by the witness hereof and I hereunto set my hand and seal this day of 1966, in Cambridge, Massachusetts.

______________________________(LS)

I hereby state that I have read this document in its entirety to the signer hereof prior to the affixing of his or her signature.

WITNESS:

____

(If the participant is a minor, the following must be completed)

I, individually and as parent and guardian of the above-named minor, do hereby release and discharge Massachusetts Institute of Technology, its agents and employees, from any and all liability as aforesaid on account of the participation in such experimentation of my child and ward.

IN WITNESS WHEREOF, I have hereunto set my hand and seal at this day of 1966.

WITNESS:

______________________________ ______________________________(LS)

Parent or Guardian

APPENDIX B

SENSORY AIDS EVALUATION AND DEVELOPMENT CENTER, M.I.T.
292 Main Street, Cambridge, Massachusetts 02142 864-6900 Ext. 5331

INTRODUCTION

We would like to enlist your help in testing and evaluating a new collapsible cane. This cane may be taken apart and collapsed to a total size of 5" x 11" x 5/8". It will extend at least seven times its stored length while still retaining the characteristics of a continuous one-piece cane.

These canes, the result of several year's work and development, have been reliability tested and will survive 5000 collapse-extend cycles based on one year of maximum use by an active cane user.

We ask you to use this new collapsible cane in place of your regular cane for two months. We will be asking you specific questions relating both to your regular cane and to the collapsible cane (cc) in order that comparisons between the two types of canes be made.

A questionnaire with both multiple choice and short exposition types of questions will be administered verbally both before and after your trial use and field testing of the new cane.

We need your aid in this evaluation, and we sincerely appreciate your interest and help.

ST/caw
4666

SENSORY AIDS EVALUATION AND DEVELOPMENT CENTER, M.I.T.
292 Main Street, Cambridge, Massachusetts 02142 864-6900 Ext. 5331

REPORT FORM IA

General Information

Name ________________________________

Address ________________________________

Birthday __/__/__ Height __ft __ in Sex ____ Marital Status ______

Number and age of children ________________________________

Age at onset of blindness ______ Degree of vision: totally blind _____,

light perception _____, useable vision ______

Mobility training Yes ___ No ___; where ________________________________

______; extent ________________________________

Number of years cane experience ___ School taught cane travel _______,

self-taught cane travel _____ Was there a lapse of time between

your cane training and your actual use of it? Yes__ No __

Extent ________________

Length of cane currently used ________________________________

Weight of cane currently used ________________________________

Weight of prototype cane ________________________________

Color of cane currently used ________________________________

Are you employeed? Yes __ No __

Job or profession ________________________________

Do you work primarily with blind ____ or sighted _____?

Highest school grade completed ________________________________

Appearance ________________________________

Date ________ Interviewer ________________________________

Date - end of test period ________ ST:caw4666

APPENDIX C

SENSORY AIDS EVALUATION AND DEVELOPMENT CENTER, M. I. T.
292 Main Street, Cambridge, Massachusetts 02142 (617) 864-6900 Ext. 5331

NAME: ______________________________

DATE: ____________

PRE-TEST QUESTIONNAIRE

1. Approximately how often do you actively use your regular cane each day?

   (a) 1/2 hour or less ___; (b) 1/2 to 2 hours ___; (c) more than 2 hours ___; (d) not at all ___; or (e) other (specify) ____________.

2. A. What is the average life of the cane(s) you have used in the past? ________ months

   B. What is the average life of the cane tip(s) you have used in the past? ________ months

3. A. Is your regular cane (a) wood ___; (b) aluminum ___; (c) stainless steel (golf shank) ___; (d) bamboo ___; (e) fiberglass ___; (f) other (specify) ________?

   B. Is your regular cane (a) fixed ___, or (b) collapsible ___?

4. What material do you prefer for a cane? ____________ Why?
____
____

5. What kind of shape do you prefer for a cane tip (a) peg ___; (b) button or disc ___; (c) disc, flat at bottom and tapered to the shaft ___; (d) disc, round at bottom and tapered to the shaft ___? Why? ___
____
____

6. What material do you prefer for a cane tip (a) wood ___; (b) nylon ___; (c) stainless steel ___; (d) hardened steel ___; (e) other (specify) ________? Why? ________
____

7. A. How many canes do you own? ____________

B. How many canes do you use? ______________________________

C. How often do you use each of them? ______________________

8. Do you use a reflectorized coating on your cane? Yes __ No __

9. How much do you expose your regular cane to sand and salt water? (a) frequently ___; (b) sometimes ___; (c) rarely ___; (d) never ___

10. How much do you expose your regular cane to snow and slush in the winter? (a) frequently ___; (b) sometimes ___; (c) rarely ___; (d) never ___

11. Is there anything about your regular cane that you do not like or would like to see changed? ____

____

12. Where do you put your regular cane when you are at work? __________

____

13. Where do you put your regular cane when you are at home? __________

____

14. Where do you put your regular cane when you are using public transportation (i. e., train, bus, plane, streetcar)? ______________

____

15. Where do you put your regular cane when you are in an automobile?

____

16. Where do you put your regular cane when you are in a restaurant?

____

17. Where do you put your regular cane when you are in an auditorium or theatre? ____

18. A. When you first started using a cane, did you feel embarrassed or uncomfortable with it? (a) always ___; (b) most of the time ___; (c) sometimes ___; (d) never ___. If (a), (b), or (c), expand:

____

____

B. Have your feelings changed over time? Yes ___ No ___. If 'Yes', change is to (a) ___; (b) ___; (c) ___; (d) ___ of part 18-A.

19. If the answer to 18-A is (a), (b), or (c), do you feel less embarrassed or uncomfortable having and using a collapsible cane (cc)? (a) less ___;

(b) more ___; (c) same ___. Why? ______________________________

____

20\. A. Do you have any other thoughts about the cane, outside of its use as a mobility aid? ______________________________

____

B. Would you like the cane to indicate to others that you are blind? Yes __ No __. If 'Yes', would you like the cane changed to be more of a symbol? ______________________________

If 'No', how would you like the cane changed to be less of a symbol of blindness? ______________________________

____

C. Do you think most blind people have the same ideas? __________

____

21\. A. Do you use a white cane? Yes __ No __

B. If 'Yes', do you feel conspicuous using a white cane? Yes __ No __ If 'No', would you feel conspicuous? ______________________________

C. If you do feel conspicuous using a white cane, what other finish would you prefer? ______________________________

22\. When you are travelling in an unfamiliar area, do you use your regular cane in the same way as you do in familiar areas? Yes __ No __ If 'No', what are the differences ______________________________

____

23\. When you are in a crowded and busy area, how often do you touch other people with your cane? (a) rarely ___; (b) never ___; (c) sometimes ___; (d) frequently ___.

24\. When you are in an area that is noisy, and where the sounds you use as cues are drowned out, do you probe more often with your cane than you do under more quiet conditions? (a) most of the time ___; (b) sometimes ___; (c) rarely ___; (d) never ___.

25\. Other than the cane, what travel aids do you use? ______________________________

____

26\. A. Do you like to walk? Yes __ No __.

B. Do you ever go for a walk by yourself just for enjoyment, or is all your walking alone a means of getting somewhere? Enjoyment ____ Purpose ____.

27. In very familiar areas (i. e., the route you travel each day, or the block around your house), do you travel (a) mostly with a sighted person, occasionally use a cane? ___; (b) mostly with a cane? ___; (c) with no cane or other aid? ___; (d) not at all? ___; (e) other (specify) ____________________

____

28. In completely unfamiliar areas (i. e., when you are in a new neighborhood or town, where you have never been before), do you travel (mostly with a sighted person, occasionally use a cane? ___; (b) mostly with a cane? ___; (c) with no cane or other aid? ___; (d) not at all? ___; (e) other (specify) ____________________

____

29. In those areas you have been to infrequently, and in which you do not travel as easily as you do in familiar areas (i. e., travelling to a particular restaurant or to a friends' house to which you have been in the past but which is not part of your daily travel), do you travel (a) mostly with a sighted person, occasionally use a cane? ___; (b) mostly with a cane? ___; (c) with no cane or other aid? ___; (d) not at all? ___; (e) other (specify) ____________________

____

APPENDIX D

POST-TEST QUESTIONNAIRE

1. When you are using the cc, does it feel loose at the joints or loosely connected? (a) very firm ___; (b) somewhat firm ___; (c) somewhat loose ___; (d) very loose ___.

2. Do you feel secure using the cc? Yes __ No __

3. When extended, does the cc have (a) good balance? ___; (b) feel too heavy at the bottom? ___; (c) feel too heavy at the handle? ___.

4. Do you feel the cc is too fragile or wobbly for your regular use? Yes __ No __. If 'Yes', expand ______________________________

____

5. When you keep the cane collapsed, (a) do you ___, (b) don't you ___ have enough time to put it together when you need to use it?

6. If you do not have enough time to put it together, under what circumstances does this occur? ______________________________

____

7. If you had this cc, do you think that you would use it all the time, or just on special occasions as a second cane? (a) all the time ___; (b) most of the time ___; (c) some of the time ___ (d) special occasions (rarely) ___; (e) never ___.

8. Have you tapped or hit other people when collapsing or extending the cc? Yes __ No __ If 'Yes', how? ______________________________

____

9. Have you hurt yourself when collapsing or extending the cc? Yes __ No __ If 'Yes', how? ______________________________

____

10. Can you take apart the cc by using only one hand? Yes __ No __

11. Can you put the cc together by using one hand? Yes __ No __

12. In putting the cc together, do you find it to be (a) no trouble? ___; (b) fairly easy? ___; (c) hard? ___; (d) very hard? ___. If (c) or (d), give reasons: ______________________________

____

13. In taking apart the cc, do you find it to be (a) no trouble? ___; (b) fairly easy? ___; (c) hard? ___; (d) very hard? ___ If (c) or (d), give reasons: ______________________________

14. What features of the cc do you like? ______________________________

____

15. What features of the cc don't you like? ____________________________

____

16. In addition to those features of the cc which you do not like, what would you like changed or added? ______________________________

____

17. Since you have been using the cc, have you noticed that there has been a reduction in your travelling unassisted (for example, situations where you would have used you cane if you did not have to extend it and decided it would be less trouble to rely on someone as a guide)?
Yes __ No __ If 'Yes', expand: ______________________________

____

18. Do you find that you use the cc in different situations than those in which you used your regular cane? Yes __ No __ If 'Yes', expand:

____

____

19. When collapsed, is the cane small enough for your storage purposes?
Yes ___ No ___ If 'No', what is the next smallest size that you could use conveniently? ______________________________

20. Approximately how many times per day have you collapsed and extended your cc? Count taking the cane apart and extending it as two separate times. __________ times

21. Where do you put your cc when you are in an automobile? ____________

____

22. Where do you put your cc when you are at home? ____________________

____

23. Where do you put the cc when you are using public transportation (i. e., train, plane, bus, streetcar)? ______________________________

24. Where do you put your cc when you are at a friend's home? __________

____

25. Where do you put your cc when you are in an auditorium or theatre?

____

26. Where do you put your cc when you are in a restaurant? ____________

____

27. Where do you put your cc when you are at work? ____________________

28. How much would you be willing to pay for this cc? $_____

29. Does the cc ever get too hot or too cold so that it feels unpleasant to hold? Yes __ No __ If 'Yes', expand: ____________________

____

30. Would you like to own a cc? Yes __ No __ Indifferent __

31. When you are sitting down and have to find someplace to put your cane, do you feel more comfortable with the cc (e. g., in thinking you are taking up less room)? (a) all of the time ___; (b) sometimes ___; (c) never ___.

32. A. Since you have been using the cc, have other people assumed you were sighted? Yes __ No __

B. Would it bother you if other people assumed you could see? Yes __ No __ If 'Yes', expand : ____________________

____

33. A. To how many sighted and blind persons have you shown the cc? _____

____

B. What were their reactions and opinions in regard to it? _______

____

____

34. Have you noticed any difference in your ability to make fine discriminations with the cc, as compared to your regular cane (e. g., recognizing textural changes on surfaces of familiar sidewalks and streets)? Yes __ No __ If 'Yes', expand: ____________________

____

35. It is thought that cane users identify objects both by the contact of the cane with the object and by the sound the cane makes when hitting an object.

A. When the cc comes in contact with an object, does it give you as much information about the object as your regular cane? Yes __ No __

B. If 'No', what kind of information doesn't the cc give you? ____

____

C. How could it be changed to include this? ________________

____

36. When using sounds to identify objects, most people use both direct

and sound echoes.

A. As compared to your regular cane, does the cc make (a) the same ___; (b) different ___ kinds of direct sounds when tapping familiar surfaces under foot?

B. In comparison to your regular cane, does the cc produce (a) the same ___; (b) different ___ echoes when tapping familiar surfaces underfoot?

37. Is the cc (a) the same weight ___; (b) lighter ___; (c) heavier ___; (d) I don't know ___ than your regular cane?

38. In comparison to your regular cane, does the cc feel (a) safer ___; (b) same ___; (c) less safe ___?

39. With the cc, as compared to your regular cane, do you travel to places you haven't been to before? Yes ___ No ___ If 'Yes', where? ___

___

40. In comparison of the cc to your regular cane, have you noticed any differences in your ability to estimate distances to objects? Yes ___ No ___ If 'Yes', expand: ___

___

41. With the cc, as compared to your regular cane, do you travel (a) faster ___; (b) slower ___; (c) same speed ___?

42. Do you feel the cc has the same kind of springyness and bounce as your regular cane? Yes ___ No ___ If 'No', expand: ___

___

43. Do you feel that you get any more or less information when using the cc, as compared to your regular cane? (a) more ___; (b) less ___; (c) same amount ___. If (a) or (b), expand: ___

___

___