R E P O R T   R E S U M E S

ED 013 512 EC 000 405

PROCEEDINGS OF THE ROTTERDAM MOBILITY RESEARCH CONFERENCE (ROTTERDAM, THE NETHERLANDS, AUGUST 3-7, 1964).

BY- CLARK, LESLIE L. AND OTHERS
AMERICAN FOUNDATION FOR THE BLIND, NEW YORK, N.Y.

PUB DATE MAY 65

EDRS PRICE MF-$1.25 HC-$11.24 281P.

DESCRIPTORS- *RESEARCH NEEDS, *VISUALLY HANDICAPPED MOBILITY, *MOBILITY AIDS, *VISUALLY HANDICAPPED, EVALUATION NEEDS, TRAVEL TRAINING, SENSORY AIDS, VISUALLY HANDICAPPED ORIENTATION, ATHLETIC ACTIVITIES, HAVERFORD BIONIC INSTRUMENTS, OBSTACLE DETECTOR

THESE PROCEEDINGS WERE PREPARED FROM THE MOBILITY RESEARCH CONFERENCE HELD IN ROTTERDAM, THE NETHERLANDS, AUGUST 3-7, 1964. PROGRESS REPORTS ARE GIVEN ON THE FOLLOWING--(1) ULTRASONIC MOBILITY AID, (2) ULTRASONIC GUIDANCE SYSTEM, (3) ELEKTROFTALM MOBILITY AID, (4) PASSIVE ENVIRONMENT SENSORS, (5) AMBIENT-LIGHT OBJECT DETECTOR, (6) TRAVEL PATH SOUNDER, (7) PHONOSCOPE. PHOTOGRAPHS AND DIAGRAMS DESCRIBING EACH SYSTEM ACCOMPANY THE REPORTS. SPECIAL PROBLEMS AND TECHNIQUES CONNECTED WITH MOBILITY TRAINING, SUCH AS RETRAINING THE NEUROMUSCULAR SYSTEM TO FUNCTION WITH SENSES OTHER THAN VISION, TEACHING THE ART OF FENCING, THE USE OF SKIING AS A SPORT, AND THE IMPORTANCE OF GOOD HEARING ARE DISCUSSED. RESEARCH NEEDS ARE IDENTIFIED IN THESE AREAS--(1) THE HUMAN SKILLS NECESSARY FOR EFFECTIVE MOBILITY TRAINING, (2) THE DEVELOPMENT OF A READINESS TEST TO DETERMINE THOSE PERSONS WHO ARE READY FOR MOBILITY TRAINING, (3) MARKET RESEARCH REGARDING THE VARIOUS MOBILITY DEVICES. A SYSTEMATIC EVALUATION OF THE REAL UTILITY OF MOBILITY AIDS TO THE BLIND IS DISCUSSED AS A NECESSARY PREREQUISITE TO FUTURE DEVELOPMENT AND REFINEMENT OF ALL DEVICES. THE APPENDIX INCLUDES SPECIFICATIONS FOR THE LONG CANE, TECHNIQUES FOR TEACHING CANE TRAVEL, AND A FORM FOR EVALUATING MOBILITY TRAINING AND PERFORMANCE. REFERENCES ARE LISTED. (RS)

1-19-67-12

PROCEEDINGS OF THE ROTTERDAM MOBILITY RESEARCH CONFERENCE

MAY 1965

The RESEARCH BULLETIN
is a publication of
The American Foundation for the Blind
15 West 16th Street
New York 11, New York

Leslie L. Clark, Editor
International Research
Information Service

This publication was supported, in part, by a research and demonstration grant, number RD-1407-S, from the Vocational Rehabilitation Administration, Department of Health, Education, and Welfare, Washington, D.C. 20201.

PROCEEDINGS OF THE
ROTTERDAM MOBILITY
RESEARCH CONFERENCE

ERRATA SHEET

1. Dr. Roelf G. Boiten was not named in the Proceedings as the General Chairman of the Rotterdam meeting. His excellent conduct of the sessions did much to insure their success.

2. The year in which the meetings were held, mentioned in the Prefatory Note on page ii, should be 1964 not 1965.

3. Two papers were submitted by Professor Robert W. Mann for the Proceedings. The second, entitled "Evaluation and Simulation of Mobility Aids for the Blind," did not appear in the Proceedings. It will appear in Research Bulletin No. 11, to be published early this Fall.

4. In the paper by M. B. Clowes, on page 169 the reader is referred to reference 2 for a discussion by Dr. Mann of the use of simulation. The reference as cited, however, is in error and should read

   Mann, Robert W., "Evaluation and Simulation of Mobility Aids for the Blind," Research Bulletin No. 11 (October 1965), pp. 93-98.

5. In the Table of Contents, p. iv, Dr. Deatherage's paper should be listed as beginning on page 201 not 210.

PREFATORY NOTE

The American Foundation for the Blind is pleased to publish these Proceedings prepared from the Rotterdam Mobility Research Conference. The Conference was held in Rotterdam, The Netherlands, during the week of 3 through 7 August 1965. Sponsors of the meetings included the Foundation, the National Science Foundation, the Dutch Government, the Stichting Technische Voorlicting t. b. v. Lichamelijk Gehandicapten, the Aveugles de Guerres of France, St. Dunstan's, the Royal National Institute for the Blind, and the Mayor and Council of the city of Rotterdam.

In the 1962 International Congress on Technology and Blindness, held in New York, it was recommended in Plenary session that further meetings be oriented around specific topics and include only smaller working groups who would give intensive concentration to the several subareas of research outlined at the Congress. This meeting in Rotterdam was the first of a series of meetings which aim to carry out the recommendations of the participants at the Congress.

These Proceedings illustrate the Foundation's intent to disseminate information to the research community or to any person or group, regardless of area of concentration, who may profit from the subject matter or find it relevant to their own work. The material does not reflect the views of the Foundation, but rather the views of contributors who have lent their talents to this subject for the benefit of all the disciplines concerned.

The papers were edited and prepared for publication by the International Research Information Service (IRIS), an information dissemination program of the American Foundation for the Blind, which is supported by a number of private and government agencies.

M. R. Barnett
Executive Director
American Foundation
for the Blind

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INTRODUCTION

Roelf G. Boiten
University of Technology
Delft, The Netherlands

The main purpose of this congress was to deal with the problems of the blind, and especially orientation problems generally covered by the term "mobility."

Blindness can be defined as the inability to receive visual information from the environment. It is now accepted practice to include not only persons lacking vision, but also those for whom, even with the best optical corrections, the remaining visual power stays below a certain minimum level. Furthermore "the blind" can be subdivided into four distinct groups: those who were born blind, those who became blind in youth, during professional life, or in old age.

It is very difficult to grasp all the consequences of blindness. Only in the last few decades has some real understanding grown from the development of disciplines such as cybernetics, information theory, neurology, learning and adaptation theory, ergonomics, and perception theory.

Vision is not essential for the preservation of life. There exist a number of animals with no visual end organs, or with only primitive eyes. These animals live under conditions where all necessary information can be obtained by means of other senses: smell, sound, sense of touch, and so on. Unfortunately this is not the case for human beings living in a human society. Here many blind persons have serious difficulties in adapting themselves. The normal visual faculty permits sharp focus from distances of about 25 cm to infinity. In daylight our living world is infinitely extended in three dimensions and, as our sensory systems can also interpret the motion of moving objects, we should add time to the three length dimensions. Actually, then, we get information about our environment in four dimensions, ranging from nearly zero to infinity. With decreasing illumination levels our living world seems to shrink and in total darkness it actually is not larger than that which can be touched with our limbs. This is the world in which the blind live.

The point I wish to emphasize is that the difference between sighted and blind people is not so much the lack of visual power but rather the fact that blind persons have to live in a much smaller world, a world which does not materially extend much beyond their bodily dimensions. Yet they have to live in a society which operates on the possibility of perception over a nearly infinite range of dimensions. The impact of this situation not only has consequences for ordinary activities of daily life but also, and probably even more so, for normal mental health and welfare.

In France, a few years ago, a group of sighted persons went underground and lived for three weeks in a deep cave provided with sufficient food and water, but without any means to make light. The most surprising result, for the medical supervisors of the experiment, was that the majority of the group did not suffer unduly, and in fact showed no unfavorable after-effects. To a blind person this outcome of the experiments would be predictable. Still, these test subjects were not in the situation of the blind. They had no need to perform some specific task to earn their living, and they were not obliged to move around and find their way about.

Everybody has had the experience where even familiar surroundings become strange and seem dangerous in darkness, as in a forest (or even a private home) at night. The need to move around in darkness has a depressing effect on most humans, and they share this sensation with practically all prey animals. It is the result of the inborn instinct of fear: in darkness a possible enemy or dangerous situation might be noted too late.

Under these circumstances great emphasis is placed on other senses such as hearing and the sense of touch, but as these senses provide far less information than vision, especially for detail, the brain has to base its perceptual decisions on fewer data. This means a greater and more stressful mental effort. It is assumed now that the brain acts as a kind of data-reduction system, based on excess of information at the inputs, so as to enable it to cross-check its conclusions. Sometimes the expression used is that the brain acts on a "majority-vote" principle.

If all humans were blind, or had to live in total darkness, quite certainly they would originate a society and way of living based upon these circumstances. In some tropical regions in South America there exists an endemic disease causing blindness at an age of 15 to 20 years. Not so long ago, in certain villages, nearly all adults were blind; only the children were sighted. They were agriculturists and had selected such plants and ways of cultivation that the tending to the fields and crops could be done without vision. For certain jobs, however, they had to rely upon additional information provided by their sighted children.

In our society life is based on visual information and we ask and require that the blind conform to our way of living as much as possible. Modern life requires great mobility and the majority of cues are visual viz., drawings, pictures, printed matter, and so on. Therefore it is clear that the basic problems of the blind are mobility and access to printed matter. This conference dealt with the former, and oldest, problem, that of mobility. Referring to the previous discussion, we can say this means how the living world or environment of the blind can be enlarged. Using the sense of touch, the natural thing to do is to lengthen the arm and thus enable the exploration of an extended region; a practical solution is, for example, the walking cane. Some animals, for example bats and porpoises, make sounds and use echos as a means of object location. There is some indication that man is capable of using this technique too, but it will require an extensive research and training program. Smell and taste do not seem to offer such possibilities, although it should be noted that some aborigines in America and Australia are able to use their sense of smell to follow an animal or human spoor. Another solution is to make use of additional information obtained from external sources. This can be derived from animals, for example the guide dog, or a technical gadget (a number of which are in development).

Experience with various devices has shown that it is very improbable a solution will be found which is applicable to all blind persons. In the first place there exists a large difference between people congenitally blind and people adventitiously blind. The latter are used to evaluating visual impressions and will remember what these impressions were like. Psychologically they suffer more than the congenitally blind from the lack of vision, and it may take a lot of time and much patient coaching, sometimes even psychiatric treatment, to enable them to accept the unconditional and permanent loss of their vision. Such people often are very reluctant to accept mobility aids and are most critical of their applicability and practical use, for they always compare the restricted possibilities of the aids with the actuality of visual sensation. On the other hand, they know the world about which their sighted instructor speaks, have a mental picture of the obstructions in their way, can think in three dimensions, and have an understanding of perspective.

Those born blind are not hampered by previous experience and sometimes accept a mobility aid more willingly. Instruction in its possibilities and in its use, however, is more difficult and requires a certain level of intelligence. The walking habits of man make his third (vertical) dimension much larger than that of other animals. In the case of most obstructions normally detected by sight, it is important not to have hindrances at ground level; those at eye level have less importance. To a blind person this seems very illogical, for hindrances at ground level he quickly learns to detect by the sense of touch, (either with the feet or with a cane) while at eye level he lacks detection devices. Animals moving at low illumination levels have whiskers for this purpose. I heard a few years ago that in Japan some researchers intended to investigate the possible use of artificial whiskers with a length of about 50 cm. From a perceptual point of view this may make sense, but when I mentioned it to some blind people they abhorred the idea of bearing whiskers. Nobody likes to display his handicap too freely, and this is an indication why many handicapped persons intuitively dislike obtrusive aids. With the design and development of technical aids this point should be born in mind always, and experiments up to now have confirmed that it takes a lot of persuasion, education, and training to enable the blind to make whole-hearted use of a mobility aid.

A growing number of the totally blind population become blind in old age. For these persons it is mandatory that the use and training procedures for a mobility aid be as simple and straightforward as possible. It is a well-known fact in geriatrics that older people are, or at least feel, lonesome. Some consider this a natural phenomenon, intended to prepare man for his impending death. Perhaps this is the reason why older people quite often have a preferance for guide dogs who, besides aiding the blind person in finding his way, also offer companionship. Another category comprises those whose blindness is accompanied by other diseases or handicaps, viz., deafness, low intelligence, sensorial or nervous system defects, lack of equilibrium, etc.

The foregoing remarks will have made clear that a general solution, suitable for all blind people, is very unlikely to appear.

It seems to me that the attitude of society with regard to the blind has been changing in the last two decades. Not so long ago blindness was considered as a handicap which made an individual unsuitable to participate in normal social activities and, by appealing to a feeling of pity, money could be raised to enable him to live and, if possible, work in seclusion. This attitude has borne very unfortunate effects for the blind. Quite a number of them have become used to the idea that they cannot join in the activities of normal life and have to vegetate on what they receive from society. More recently it has become understood, and shown through example, that the blind are not without resources - but the development of their natural abilities should take place along other lines than those developed for the education of the sighted. The happy few who are so gifted that they can be coeducated together with the sighted do not contradict this remark, for they are the exceptions who confirm the rule. Especially in Russia much experience has been gathered about how to educate and train blind children and adults. The snag here is in knowing how to change the spirit of the blind to a more aggressive attitude, so that they no longer take for granted that they are second-rate citizens, but assume a fighting mood with eager willingness to prove that they may, in other ways and with other means, contribute to society on an equal level with their sighted fellows. Developments in technology, and the high level of material welfare which we enjoy today, have brought about a number of ingenious technical gadgets to increase the mobility of the blind. The complexity of modern science makes it unavoidable that these developments are carried out by specialists, who have no intimate knowledge of the needs, wishes, and potentialities of blind people. As a consequence, it has happened that some very expensive research has led to devices which were not accepted by the blind, though from a technical point of view they seemed immaculate. How far this is due to a natural reluctance of the blind test subjects, to unsuitable training methods, or to a basic inability of men to use them, is unfortunately not generally known.

The foregoing apologia was intended to stimulate discussion of the topics of this conference. It should aid in a follow-up of the more general topics of the 1962 New York conference. The first section gives a treatment of the various aids which have become available, together with their working principles and possibilities. Next, special problems of mobility training are discussed, including such techniques as skiing for blind persons. As technical aids can only be successful after producing them in numbers, a section is devoted to social and demographic aspects and market research for the special population of the blind and severely visually impaired. The last two sections deal, respectively, with research and developmental problems of mobility aids, and the evaluation in both field and laboratory of mobility prototypes, including the development of performance parameters.

I am convinced that much work is to be done and that our results only scratch the surface of the problems which must be solved. Not only must work on technical devices go on, to make them more compact, more versatile and cheaper, but the work on the powers of the remaining sensory channels, on teaching, training and learning techniques, on psychological inhibitions, on social acceptance and the behavior of the blind, and so on, must be pursued.

It is a good omen that nearly everyone present at the New York conference was here, and moreover that the ranks have swelled. It was a pleasure to welcome all to this conference, and I hope that we had both a profitable and a pleasant time.

Mention should be made of the practical and financial efforts of the American Foundation for the Blind and the U.S. National Science Foundation to get this congress under way, and of the various Dutch industries, Rotterdam business men, and the Roual Dutch government, whose financial support enabled us to undertake its organization. The overall sponsorship for the conference lay with the the Information Center for the Physically Handicapped (VLG), an organization in the Netherlands whose task is to provide technical aid and advice to all handicapped persons.

SECTION I

State of the Art Reports on the Utilization of the Electromagnetic Spectrum for Mobility Implementation

Chairman: *James C. Bliss*
Stanford Research Institute
Menlo Park, California

ULTRASONIC MOBILITY AIDS FOR THE BLIND

Leslie Kay
Lanchester College of Technology
Coventry, England

PART I: PROGRESS REPORT ON THE ULTRASONIC TORCH

Introduction

Since the frequency modulation ultrasonic mobility aid was first described in its experimental form in 1962 (2, 4), preliminary trials have been carried out using an experimental model and these have been reported at some length (5, 6, 7). The results of the trials were inconclusive in the sense that no definite statement can be made regarding the success or otherwise of the unit as an aid for the blind. Only ten units were available, and these were to a very large extent unreliable electronic devices. They required regular attention in order to keep them operating and their characteristics varied one from another over a period of time as the batteries discharged. This was not surprising since no special attention was paid to these engineering features owing both to limited finances and time available. The object initially was to produce ten units operating on the same principle as the first breadboard model and using the same circuit. These were to be used to determine the ability of blind people to recognize the characteristic sounds and assess the acceptance of such a device as a mobility aid, bearing in mind the adverse literature on the subject at the time.

Naturally, it was hoped to see some improved mobility resulting from prolonged use of the device, and there were certain preconceived ideas on how such a unit should be used. The trial program changed in concept from the beginning and developed as it proceeded largely due to the great interest shown by J.A. Leonard and A. Carpenter (7), and every effort was made to determine the behavior of a group of blind boys using the aid. The results in some respects were very encouraging, in other respects enlightening, and to some extent disappointing. It became clear that no one really knew how to train blind people in the use of an aid, and testing was an exceedingly difficult task. Some of the difficulties encountered are discussed in reference 7, together with measured results. Alternative thoughts have been expressed in reference 5.

It was well established, however, that the aid was capable of presenting information about the surrounding environment which a blind person could learn to interpret and the sounds were far from objectionable. In addition, the presentation of the sounds did not affect a person's natural hearing of external sounds to any noticeable extent. Some benefit seemed to be derived from the aid in the sense that the boys at least wished to keep the device after a period of nearly eight weeks. Some older people who had little motivation to be mobile rejected the unit as being too much trouble and did not in fact make much effort to use the device.

The feeling among those concerned with the development of the aid following the trials was that sufficient promise had been demonstrated to warrant the development of a torch, based on the experimental unit, which was well engineered, reliable, and reasonably cheap (considering the complexity of the electronics). It would be made available in small numbers to blind organizations which, together with St. Dunstan's (the original sponsoring organization), would provide a means for evaluating the unit using a wide section of the blind public. St. Dunstan's is setting up a major trial program using up to 50 aids, since it was found that 10 was an inadequate number from which to get a realistic assessment. Several blind organizations have now joined in the program and two of these are going to use at least ten each in an evaluation program.

The Torch

A working party, consisting of representatives of St. Duntan's, The National Research Development Corporation, the manufacturers (Ultra Electronics Ltd.), and the writer, formulate the final specification of the aid which is now in the form of a hand held torch weighing about 9 ounces. Attached to it by a lead is the battery and the hearing aid ear piece. All the electronics are contained in the torch; they are designed to produce consistent results over a wide range of battery voltage and allow for the discharging of the battery. The decision regarding the range of the torch was a difficult one to make. Several factors were involved. In a congested area too much information would be received if up to 20 feet were effectively "illuminated" by the transmit-receive system. A short range of a few feet would probably be best when a high degree of resolution is possible. On the other hand, if the unit were to be used as a navigation aid and distant objects had to be recognized, a long range of 20 to 30 feet would be required. While a range of 30 feet is possible, it was felt that this would be too unreliable and 20 feet was accepted as more realistic. The final choice was between 7 feet and 20 feet, selected by a push button. The remaining control is a combined on/off switch and volume control.

A mean transmission frequency of 60 kc/sec is used, producing a mean beam width of 15 degrees. The rate of change of frequency of transmission is arranged to produce an audible echo note of 3 kc/sec when the echoing object is at 20 feet or 7 feet (according to the range selected). For a single reflecting surface, such as a smooth cylindrical post or a smooth wall, the echo is an almost pure note. The pitch of the note is proportional to the distance and it is interrupted periodically during the interval when the transmission frequency rapidly reverts to the beginning of the frequency sweep. Although an interruption in the echo occurs naturally in the system, transient clicks are also heard if they are not gated out. This has been arranged with the result that the aid is almost silent when pointing into free space (like the sky). Any note or sound heard therefore indicates an object.

It has been found that a wire mesh can be placed over the rather delicate transmitting and receiving elements for protection without affecting performance, and the overall performance of the engineered aid is considerably superior to the experimental unit. Because the echo note from a single surface is so clear, complex surfaces are easily recognized.

The effect of specular reflection has been reduced by special shaping of the transmission and gating in the receiver with the result that some information is lost. This can easily be replaced and specular reflection made more noticeable, but the indications from the trials suggested that some reduction in specular effects would be a welcome step. Considerable subjective testing will be required to resolve questions of this nature.

Tests

Many blind organizations in several countries are purchasing the new aid with the object of carrying out evaluation trials. The unit has, on the whole, been enthusiastically received by blind people in the belief that they can learn to use the aid. The characteristic sounds appear to be fairly easy to interpret. The real questions have yet to be answered. Will the blind public find that mobility is in fact improved once they have learned to interpret the sounds? Will the aid be used to supplement the cane or dog, or will some use it in place of these?

Whatever the final outcome, it is essential that the reasons for the results be known, and it is therefore very important that all organizations taking part in the evaluation record results. Some tests are to be carried out under controlled conditions with psychologists conducting them. Others will be on the basis of "try it and see." Both methods will be valuable since quite different answers may result. The aid is almost certain to fail, however, if a narrow approach is to be made. Experience so far has shown that attempts to measure performance in a particular task can be very misleading. Mobility is a very complex undertaking and many cues other than those from an aid should be considered.

A blind person in a strange environment undergoing a series of tests about which there are no cues other than those from the aid may be just as lost with the aid as without it. The same person placed in a familiar environment may on the other hand move with greater confidence and less stress with the aid. Many other combinations of circumstance may determine the results and it is therefore important that blind people be tested under varied conditions and over a long period of time. Limited tests over a period of one or two weeks will be quite valueless.

Tests should commence in December or January as the aids become available. A questionnaire is being compiled and each group will be expected to return this to a central body together with any comments and suggestions. Between 100 and 200 units are to be evaluated and from the results some positive information about aided blind mobility should become available. This is the first exercise of this magnitude ever to be launched and we look forward to the outcome with considerable interest.

PART II: BINAURAL ULTRASONIC MOBILITY AID

Introduction

The possibility of using binaural perception via an ultrasonic carrier wave for the location of objects has been discussed briefly by the writer in previous papers (1, 3, 4) and the echolocation acuity of bats has been used as an example of the practical application by nature of this principle. Whatever may be the neural mechanism whereby bats locate objects in space through two spaced apertures, there is no doubt that they are using ultrasonic waves as the carrier of spacial information.

Many species of bat use a frequency sweep during the emission of the pulses of sound and, inevitably, time difference of arrival of the reflected waves at the two receiving apertures forms part of the directional information. Amplitude differences may also be used and it is possible that the time delays introduced by the complex surface of the pinna may provide additional information. Nevertheless, the physical spacing of the apertures must ultimately determine the directional acuity, other factors being of secondary importance.

The transmission of a frequency sweep is intriguing since this encodes the signal in a form which when received and decoded is very suitable for auditory processing; in essence, the time domain (involving the transmission path between transmitter, echoing object, and receiver, which is a variable quantity) is converted to the frequency domain (requiring spectral analysis). This principle has been used in a monaural ultrasonic mobility aid for the blind and it has been established that the form of display is very suitable for human auditory reception.

The extension of the monaural system to a binaural system would, therefore, seem to be a natural step because the conversion of range information from the time domain to the frequency domain also converts directional information to the frequency domain.

It is quite clear, however, that the neural processing will be very much more complex than for the monaural form of presentation where direction is determined kinesthetically, but the bat has amply demonstrated that this processing is possible. It may be that a human being can carry out the required processing provided the information is presented correctly and this implies some preauditory processing. The bat does not have this privilege and may, therefore, use a quite different process but the similarity is quite evident.

With this in mind a study of the system has been started and the following is a brief report on the progress so far with the object of encouraging discussion on the subject.

Binaural Ultrasonic Echolocation

A schematic diagram of a binaural frequency modulation echolocation system is shown in Figure 1. The transmitter frequency is

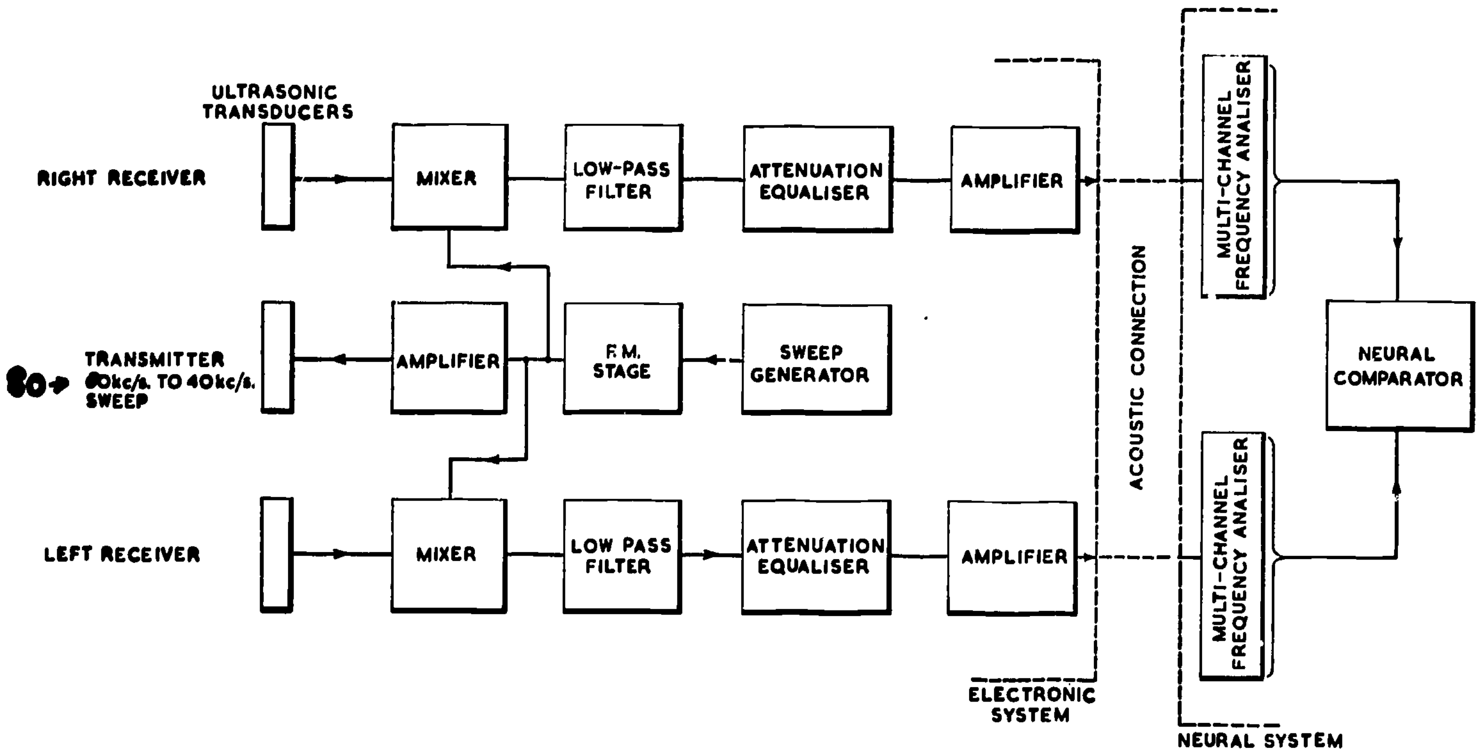

Figure 1. Binaural Frequency Modulation Blind Aid.

made to vary in a sawtooth manner over a wide frequency band of up to one octave for maximum effect, and two spaced transducers feed two separate receiver channels which produce an audible output when an echo is received. The range is determined by the pitch in exactly the same way as with the monaural system, the purpose of the binaural system being to indicate direction also without the necessity to scan a narrow beam. The receiving and transmitting transducers must, therefore, cover a wide arc and 60 degrees has been chosen arbitrarily for preliminary tests.

Echo signals from a direction other than the normal to the line joining the receivers will arrive at one receiving transducer before the other, thus introducing a time difference which is a function of the angle. Since this time difference is converted into a frequency difference the echo notes at the output of the two receivers will be slightly different. At an angle of 30 degrees, for example, the time difference corresponds to a distance of about 3 inches for a spacing of 6 inches between the receivers. If a maximum range of 10 feet is represented by a note of 3000 cps at the audio output, the frequency difference will be

$$\frac{1500 \times 3}{120} = 37.5 \text{ cps.}$$

It should be remembered that the range is measured by the two-way transmission path, whereas direction is determined only by the echo path.

Time difference of arrival as a directly measurable quantity is still retained in the system. The transmission sweep is repetitive, and following each sweep there is an interruption in the audible echo note, due to the frequency "fly back." The interruption is proportional to the range and the echo notes in the two receivers therefore exhibit a time difference as well as a frequency difference when arriving from any direction other than the normal. Directional information is thus presented in a familiar form, i.e., time difference, and in an unfamiliar form, i.e., frequency difference.

Preliminary Tests

Only a few exploratory tests have been carried out up to the time of writing but the results were a little unexpected.

It was thought that a slight tonal difference would be observed when signals were received from other than "ahead." Previously two oscillators feeding two earphones had been used to determine the frequency difference which could be detected, and a 5 cycle difference at 1500 cps was quite easily observed.

When the binaural system was used, however, no such difference was observed, although it was certainly present and could be measured. The observed sensation was that commonly known as lateralization. This suggested that the time difference between the two echo notes was of prime importance and masked the frequency difference.

It was easy to replace the FM system by a pulsed binaural system having an echo note which was the same as in the FM tests, e.g., 1500 cps for a range of 5 feet. The time difference between the two channels was unchanged but no frequency difference was present. The observed result was not the same; directional acuity was reduced.

This has raised a number of fundamental questions and an extensive series of subjective tests under a number of different conditions will have to be carried out before more can be said about the results. Personal impressions can be too misleading in this field.

The FM system was found to have other important features which have a very strong bearing on the use as a blind mobility aid. Under static conditions confusion arises when two objects are of the same range but are in different directions. Movement of either the transducer system or the objects enables an observer to resolve this confusion. This was not found so easy with the pulsed system. It is very clear that a highly complex psychological situation is presented by this form of binaural system.

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ULTRASONIC AID FOR THE BLIND

Arthur Nelkin
Westinghouse Research Laboratories
Pittsburgh, Pennsylvania

The system described herein uses ultrasonic energy for object detection as a mobility aid for the blind. It differs from other ultrasonic systems in two ways: first in that it automatically scans the volume ahead of the operator by use of multiple transducers, each looking at a specific conical volume; and second in that echo returns are presented to the operator tactually. The first experimental model uses 9 acoustic transducers in a square 3 by 3 array (see Figure 1). It is expected that later models

DWG. 744A547

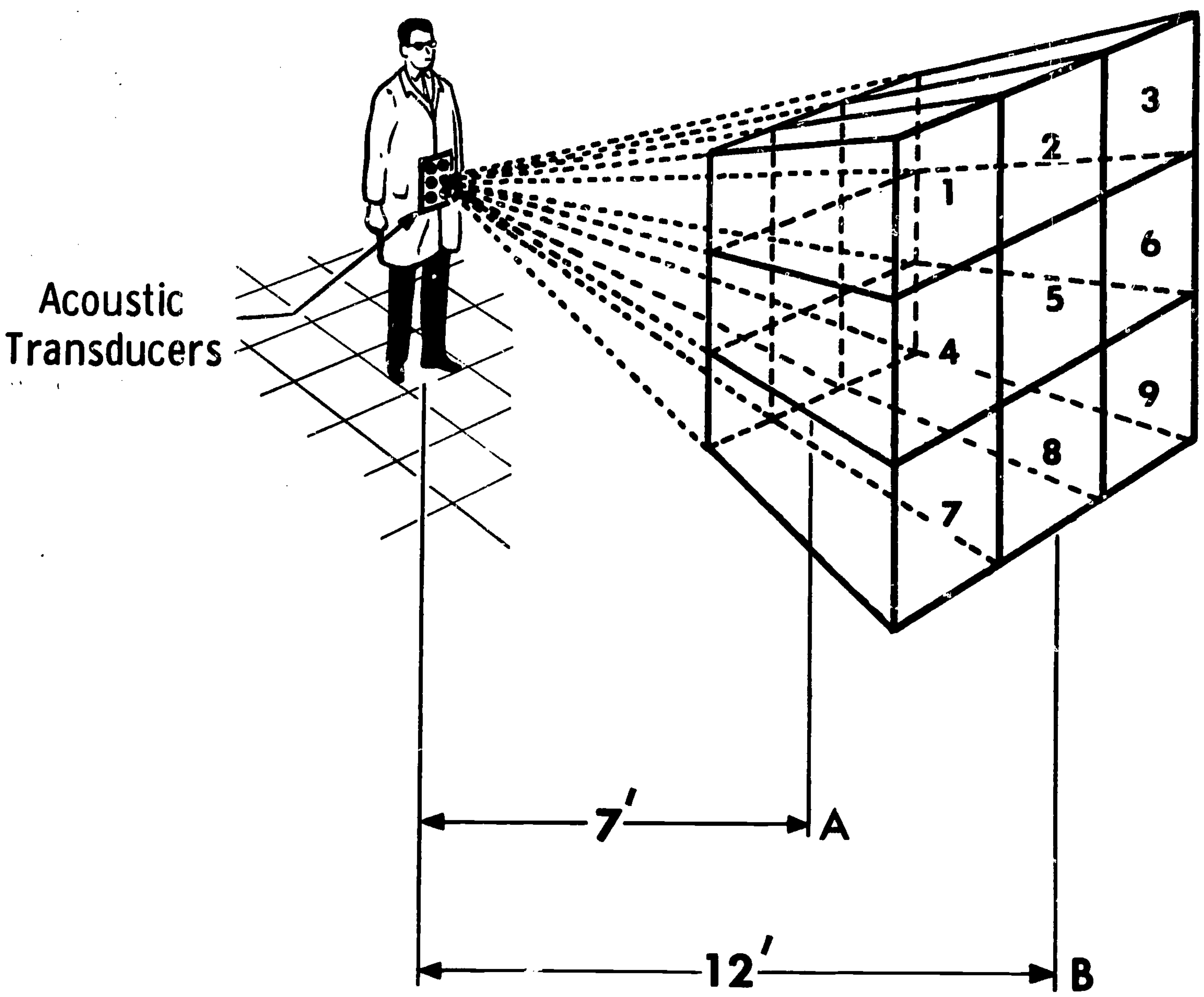

Figure 1. Ultrasonic Guidance System.

will use a larger array of acoustic transducers. The number will be limited by the amount of tactile information the operator can interpret intelligently. The tactile transducer, either electrical or pressure type, will be mounted on the operator's body in arrays positioned identically to the transducer array so that the spatial positioning of the acoustic and the tactile transducers will be the same. Thus, if a particular transducer receives an echo from an obstacle in the volume projected by its beam it will feed this signal to the corresponding tactile transducer, and the operator will know both which of the volumes is returning a signal and that an obstacle exists in that volume of space.

The unit described below is that of the first experimental model. It is an ultrasonic system operating in the 80 kilocycle frequency region and it automatically scans 9 conical volumes out ahead of the operator. The 9 transducers each have a beam of 9 degrees and they are used both for transmitting and receiving. The transmitter pulse is a 2 millisecond pulse and the system is gated so that it looks at a volume 5 feet in depth. Hence, the spatial volume ahead of the operator is scanned by 9 truncated conical beams 5 feet in depth. For example, if a signal is received from sectors 1-2-3, shown in Figure 1, the operator will know that there is a branch or awning which he will have to avoid by swerving or bending down. If a signal is received in sectors 1-4-7, the operator will know that an obstacle exists to the right of his walking axis and hence he will have to veer to his left, etc.

An array of 9 electrostatic transducers was constructed and mounted on a metal plate (see Figures 1 and 2). The center element is perpendicular to the direction of travel. The two side elements are tilted at 11 degrees from the axis. Since the transducers have 9-degree conical beams the right and left side elements cover an angle from 6.5 degrees to 15.5 degrees to the right and left of the axis of the center transducer. The same is true of the transducers above and below the center transducers, i.e., they cover an angle from 6.5 degrees to 15.5 degrees above and below the axis of the center transducer. The corner transducers are tilted so that they are 14 degrees from the axis of the center transducers.

The system may be operated at any of three distinct ranges which may be switched in by the operator. The short range is from 2.5 feet to 7.5 feet, the medium range is from 4.5 feet to 9.5 feet, and the long range is from 7 feet to 12 feet. At about 7 feet from the operator the transducer beams cover roughly an outline of 4 feet high by 4 feet wide.

A single transmitter and receiver are used. These are switched or commutated in sequence from one transducer to another. A transducer relay switches to position No. 1 connecting the

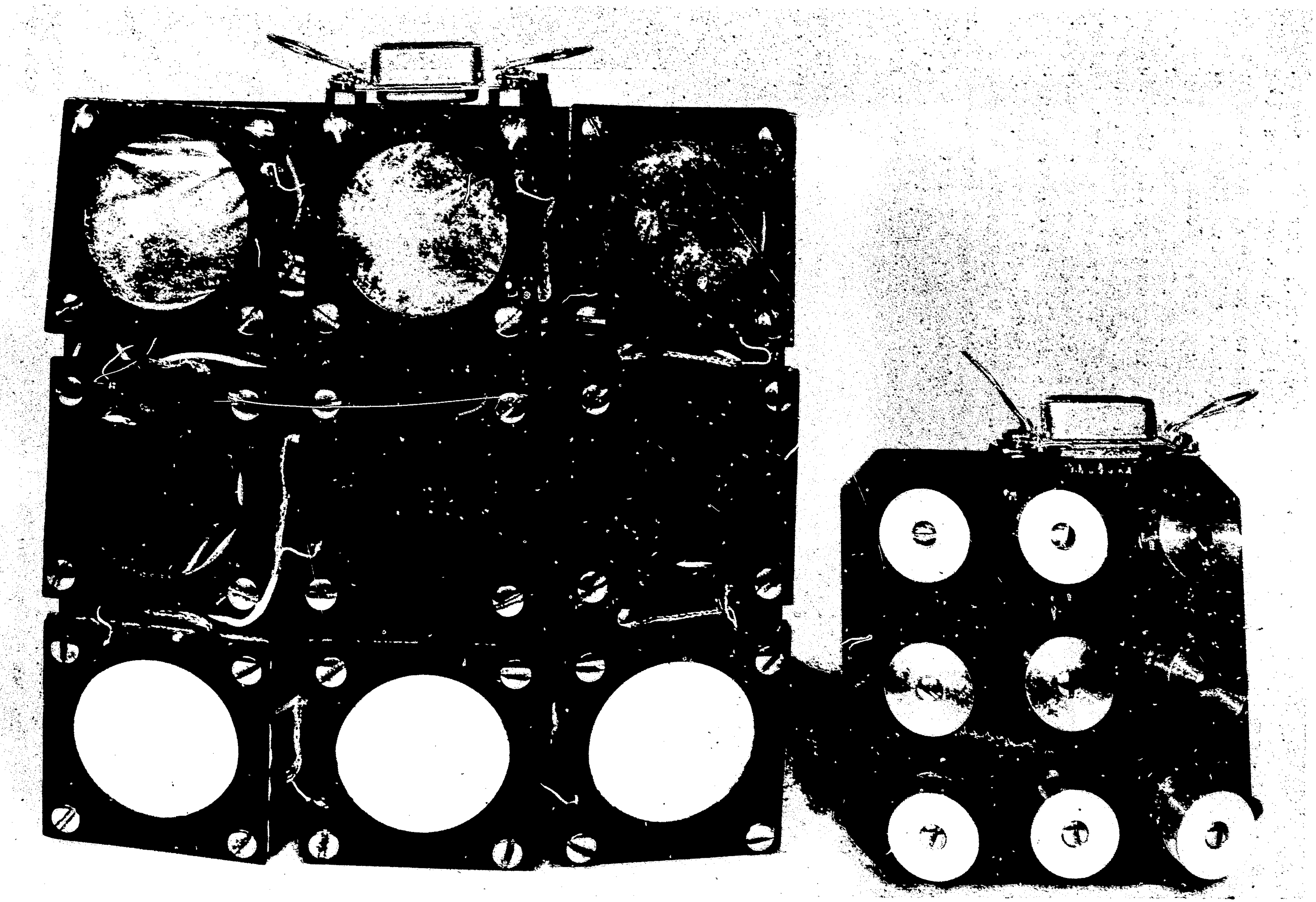

Figure 2. Left: Electrostatic Array; Right: Piezoceramic Array.

transmitter to the No. 1 transducer. The timing for the short range is as follows. For the first 4.6 milliseconds after the transmitted pulse, the receiver gate remains closed, gating out the first 2.5 feet. The receiver then remains open for 9.1 milliseconds permitting the receiver to see any echo from 2.5 to 7.5 feet. Fourteen milliseconds after the initial pulse the relay switches to transducer No. 2. This continues until the relay has connected the transmitter and receiver to all 9 transducers; then it starts back at the No. 1 position. A complete scan takes 126 milliseconds. Hence the system looks at each sector approximately 8 times a second. For the long range the receiver gate remains closed for the first 17.2 milliseconds and then opens for 9.1 milliseconds. This permits the receiver to receive echos from 7 feet to 12 feet. Twenty-seven milliseconds after the transmitted pulse the relay switches to the second transducer. A complete scan requires 243 milliseconds, so that the operator will get roughly four "looks" per second. The intermediate range provides about six "looks" per second.

The block diagram shown in Figure 3 indicates the basic system operation. The repetition rate generator provides the triggering signals for the switching circuitry. A pulse from the repetition rate generator triggers the dividers and the relay drivers which select the transducer relay to be activated; in addition it flips the transmit-receive switch to the "transmit" position and at the same time triggers the transmitter circuit through the delay circuit. The transmitter then sends a 80-kilocycle pulse to the selected transducer. The transmit-receive switch remains in the "transmit" position, keeping the receiver closed off and permitting the system to gate out the first few feet (2.5, 4.5, or 7 feet), depending on which range gate has been selected. A second trigger pulse then switches the transmit-receive to the "receive" position; the receiver remains open for 9.1 milliseconds, permitting an echo to pass through to the receiver and to the corresponding readout or tactile transducer through the readout relay. The next trigger pulse operates the divider, which switch in the next transducer.

The remainder of the circuitry operates as outlined above, and the sequence continues through the nine positions, resetting to position No. 1 on the tenth series of signals. Figure 4 shows a photograph of the experimental ultrasonic aid equipment: the battery pack; the electronic chassis; the transducer; and the array of lights used in place of tactile transducers. Figure 5 shows a photograph of an uncovered electronics chassis.

Two sets of transducers were constructed. The first is an array of nonresonant electrostatic elements; and the second is an array of piezoceramic elements resonant around 80 kilocycles. The two arrays are shown in Figure 2. The electrostatic units were made using printed circuit boards, printed circuit techniques, and an 0.5 mil Mylar aluminum coated film. The transducer has a

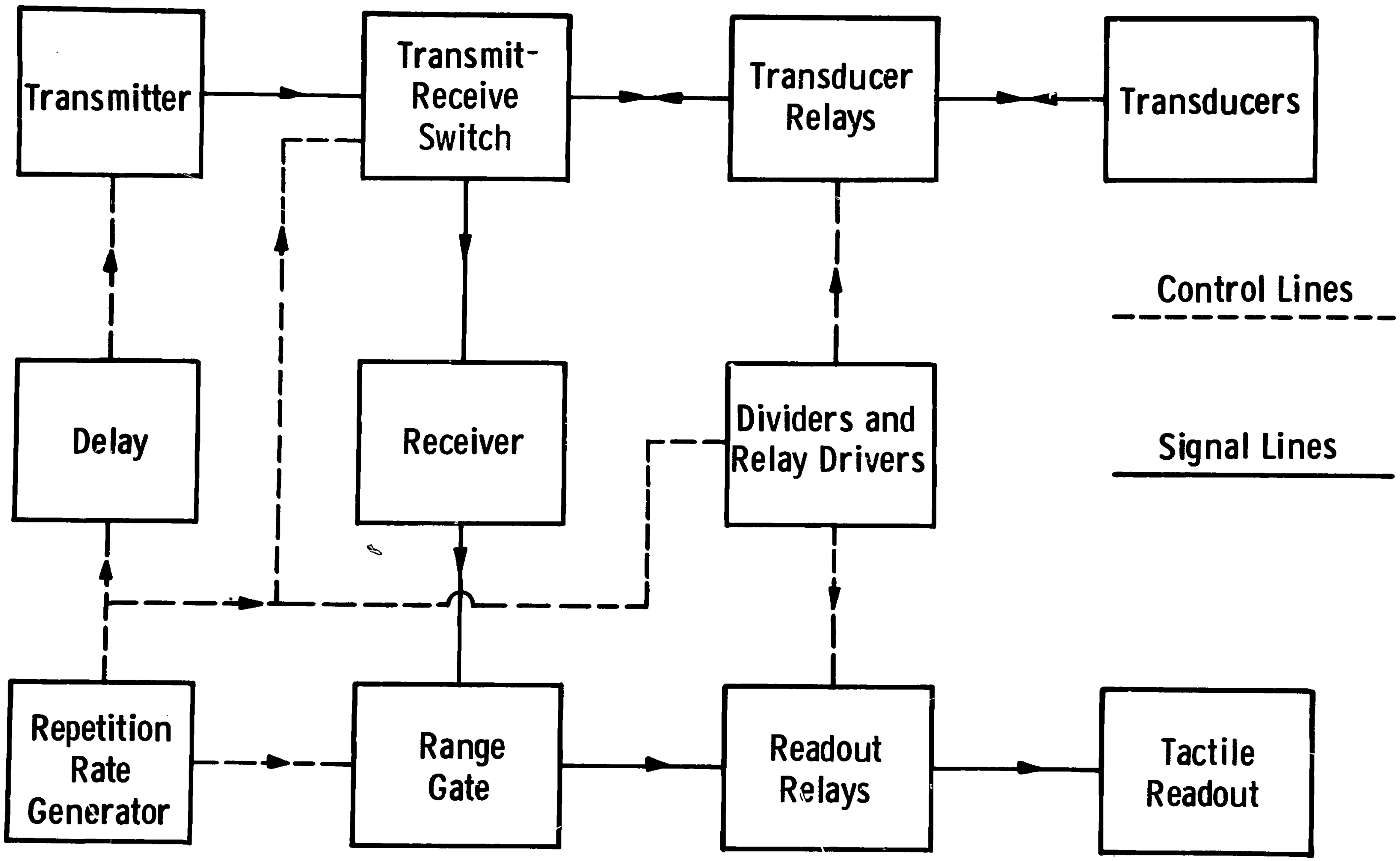

Figure 3. Block Diagram Indicating System Operation.

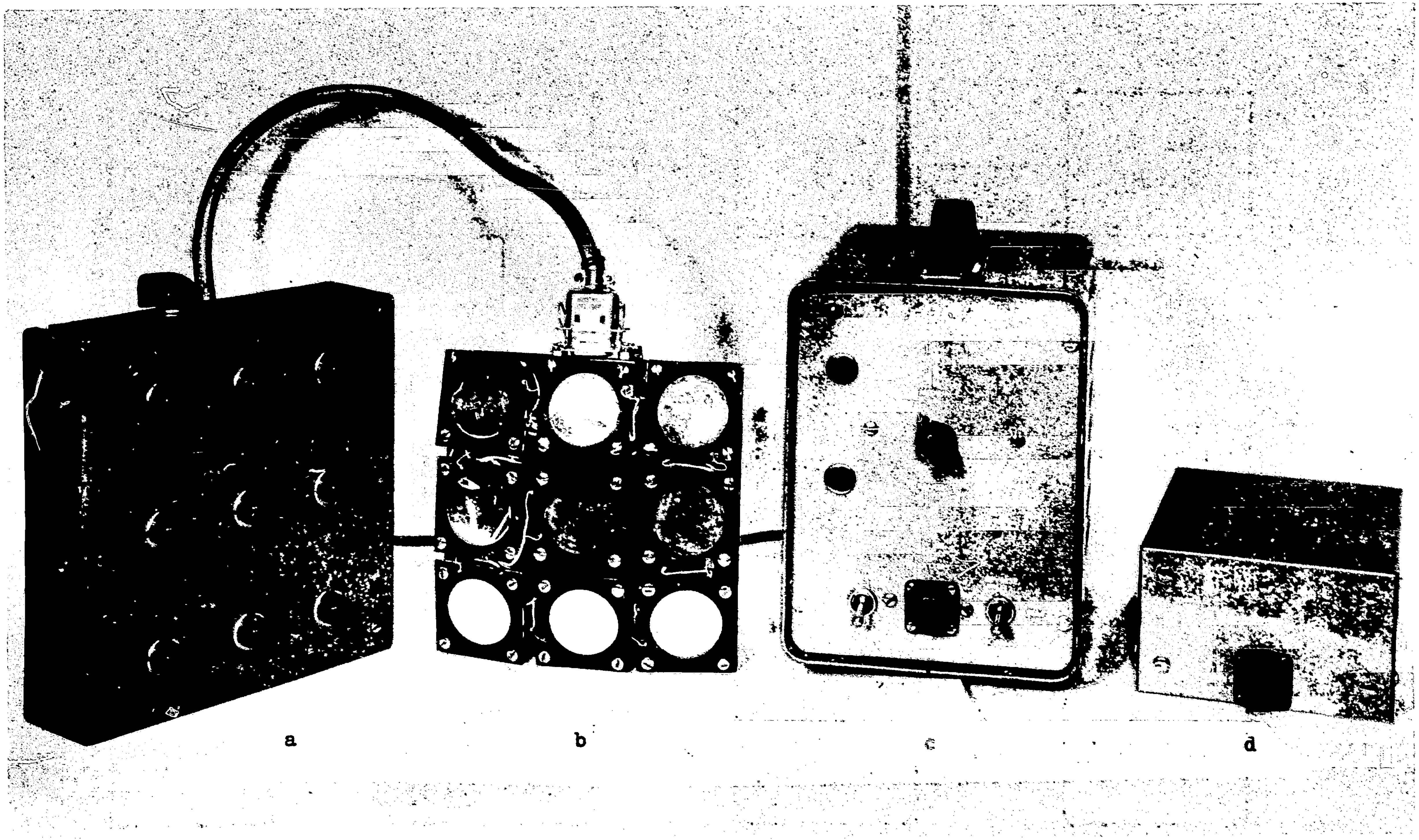

Figure 4. The Experimental Ultrasonic Aid Equipment: a) Light Array; b) Transducer Array; c) Electronics; and d) Battery Pack.

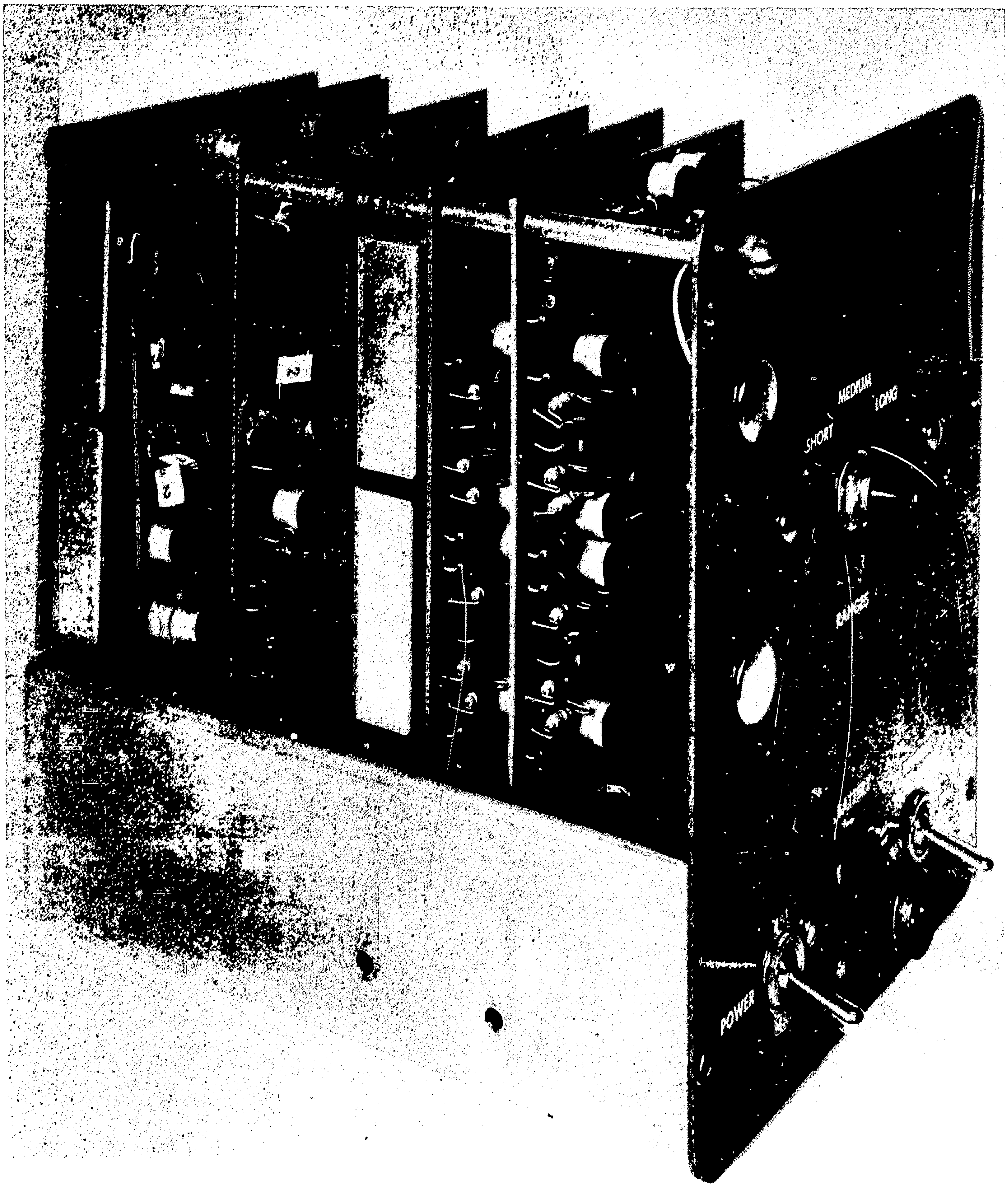

Figure 5. Uncovered Electronics Chassis.

Figure 6. Piezoceramic Around Neck of Operator.

9-degree conical beam and an efficiency of roughly 2 percent. The second set of transducers uses piezoceramic disc drivers with an aluminum head and a steel tail mass. These are somewhat smaller in diameter and produce a conical beam of 11 degrees. These units are set at an angle of 14 degrees from the axis. Due to mechanical cross-coupling problems, however, they have not yet been successfully coupled to the remainder of the circuitry. Figure 6 shows the piezoceramic worn around the neck of an operator.

Limited trials, using lights instead of tactile indicators, suggested a couple of changes. One was a selective range gate system, which now has been incorporated. A second change which might add to the systems capability would be to point the transducers at more divergent angles. It might be well for test purposes to make the angles adjustable. This of course leads to the possibility of using many more elements in the array and looking at a wider horizon. It is quite conceivable that one could go to a 5 by 4 array without overtaxing the operator's ability to handle the incoming information. This would cut down the number of "looks" per second. However, at the shorter range (2.5 to 7.5 feet), the operator would still have approximately four "looks" per second at each of the spatial volumes ahead of him. If even better resolution were desired a larger number of elements would be necessary. Because of the space problem it might be necessary to consider transducer arrays using focusing or reflecting devices such as fresnel lenses, parabolic reflectors, or spherical reflectors.

A tactile system has not yet been designed and a good bit of testing and reduction in the size and weight of equipment remains to be accomplished.

I wish to acknowledge and thank Mr. J.H. Thompson for his suggestions and assistance, Mr. C.B. Durgin for the electronic design, and Mr. F.G. Geil for his work on the transducers, as well as Messrs. W.E. Thorn, R.H. Whittaker, and R.A. Waight.

PROGRESS REPORT ON THE ELEKTROFTALM MOBILITY AID

Witold Starkiewicz
Pomeranian Medical Academy
Szezecin, Poland

and

Tadeusz Kulisrewski
Wrocław Technical University
Wrocław, Poland

INTRODUCTION

The elektroftalm is an apparatus to help the blind user to move about the lighted space which surrounds him. In contrast to other apparatus of the kind, with which the user can determine the approximate distance from an obstacle in a strictly determined direction, the Elektroftalm makes it possible to provide the blind user with a number of stimuli, each connected with the various directions of surrounding objects. A person of normal vision has perfect orientation in this surrounding space, thanks to the fact that the retina of his eye is supplied simultaneously with a large number of stimuli from several directions. A less effective orientation is that of persons with so-called "telescopic vision," in whom the field of vision is limited considerably to perhaps a few spherical degrees. The larger the number of stimuli in one's field of vision, the better one can determine the surrounding space and the objects contained in it. On the other hand, the wider the field of vision, the easier orientation in space becomes. Among the unimpaired the field of vision is about 120 spherical degrees, and the number of simultaneous stimuli over one million. It is therefore clear that no device, no matter how perfect, will replace the lost sense of sight. Yet it may help him in his orientation in space. This is, in fact, the purpose of the Elektroftalm. The field of vision of the Elektroftalm is not large, for it falls in the range of 20 to 30 spherical degrees. The number of simultaneous stimuli is 120, so that the resolution is very low. Nevertheless, we feel the Elektroftalm may be a great help to the blind user in his attempt to orient in illuminated space. We have purposefully chosen to speak of illuminated space here because we want to bring the blind individual as close as possible to the situation of a person with normal vision.

The general principles upon which the Elektroftalm is based are by now well-known. A detailed description of the device was given in our paper presented in 1962 at the International Congress on Technology and Blindness in New York (1). While we shall discuss below the experiments and results obtained with the system so far, it would seem appropriate to review briefly just what is involved in "seeing" with the Elektroftalm.

In general, the visual stimuli to which the eye reacts are transformed into a tactile stimulus field on the skin of the forehead of the blind user. In other words, the device transforms light radiation into mechanical energy. This is accomplished by means of the photoelectronic elements in the device. A general view of the Elektroftalm is given in Figure 1. On the left is the

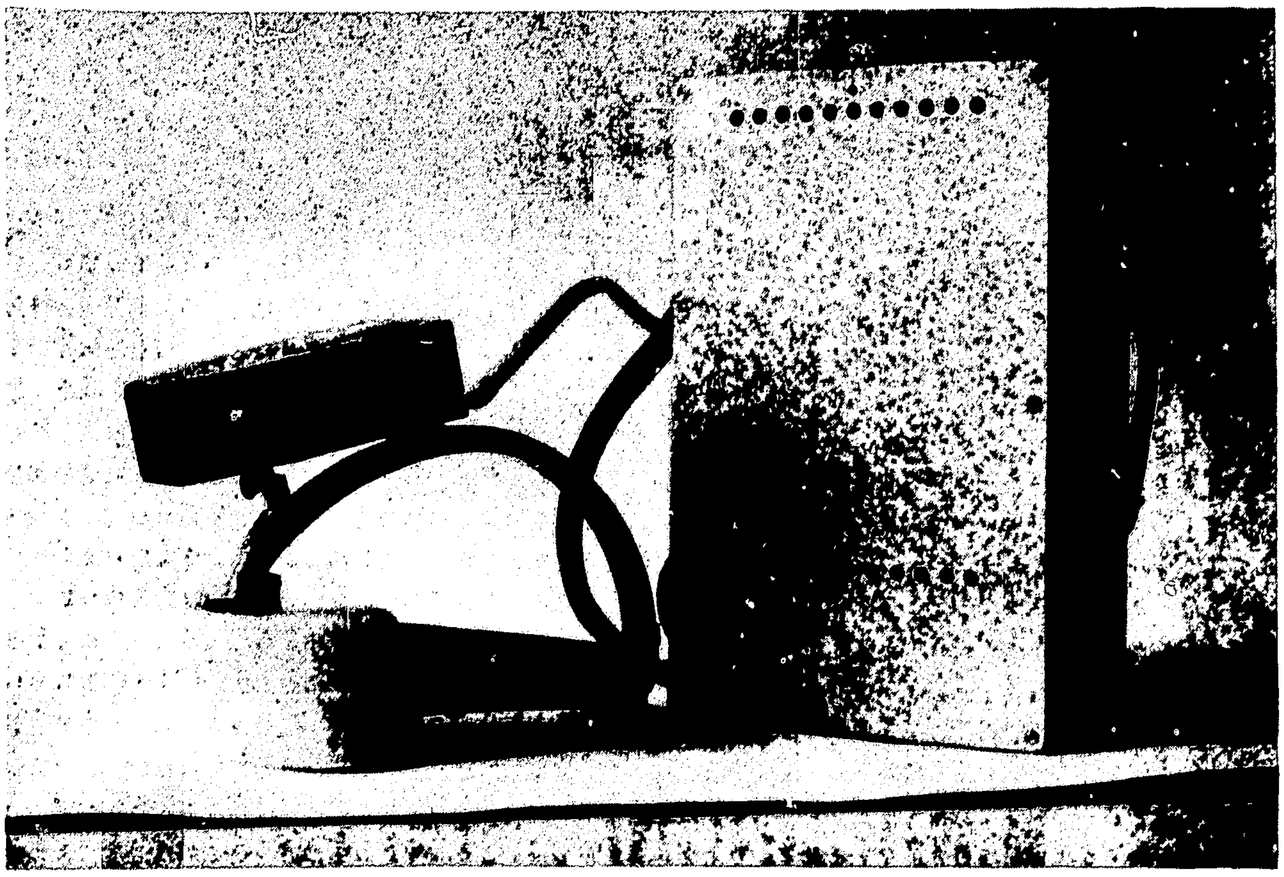

Figure 1. The Elektroftalm with Photocamera Mounted on the Headpiece.

headpiece worn by the user. It consists of a plate on which an ensemble of 120 electromagnetic transducer elements is mounted; on the upper band of the headpiece a photocamera containing 120 silicon photocells is mounted. On the right is a box containing 120 transistorized amplifiers in printed circuit boards, along with the switching elements. Figure 2 shows the Elektroftalm in use by a blind person.

In the new version of the Elektroftalm, now under construction, the camera lens throws an image on a mosaic screen comprised of 120 silicon photocells; it is here the point analysis of the image is effected. The photocell layout in the mosaic is

Figure 2. The Elektroftalm with Head-Mounted Photocamera in Use.

shown in Figure 3. It will be noted that the mosaic consists of 10 rows of 11 to 13 photocell elements arranged in staggered rows along the curve of the image field. The lens image is thus resolved into 120 points. Each point of the image activates the

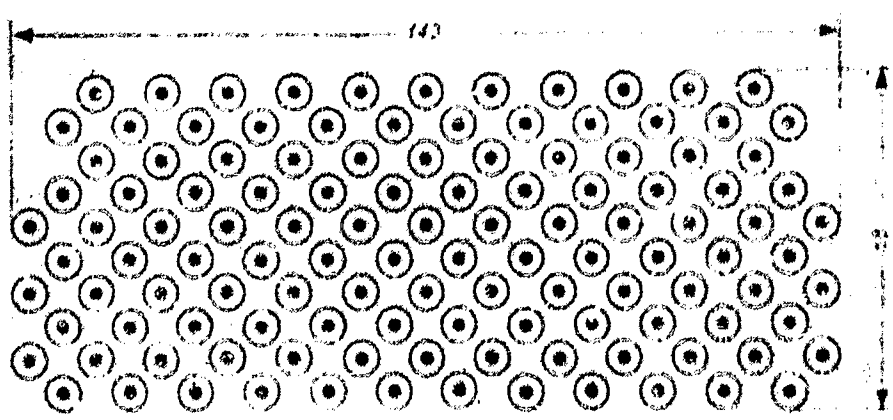

Figure 3. Mosaic Consisting of 120 Silicon Photoelements.

corresponding photocell, which transduces the light into an electrical impulse. This impulse is amplified by the transistorized amplifier and transmitted to the tactile element of that photocell-amplifier channel on the headband. The electromagnetic transducer in the headband reacts to the impulse and stimulates the skin of the forehead of the user. The array of electromagnetic transducers corresponds in layout and arrangement to the photocells of the camera mosaic; hence the tactile sensation, felt as a definite point, corresponds point for point to the image on the mosaic. Figure 4 shows the inside of the headband and the arrangement of the tactile element outputs.

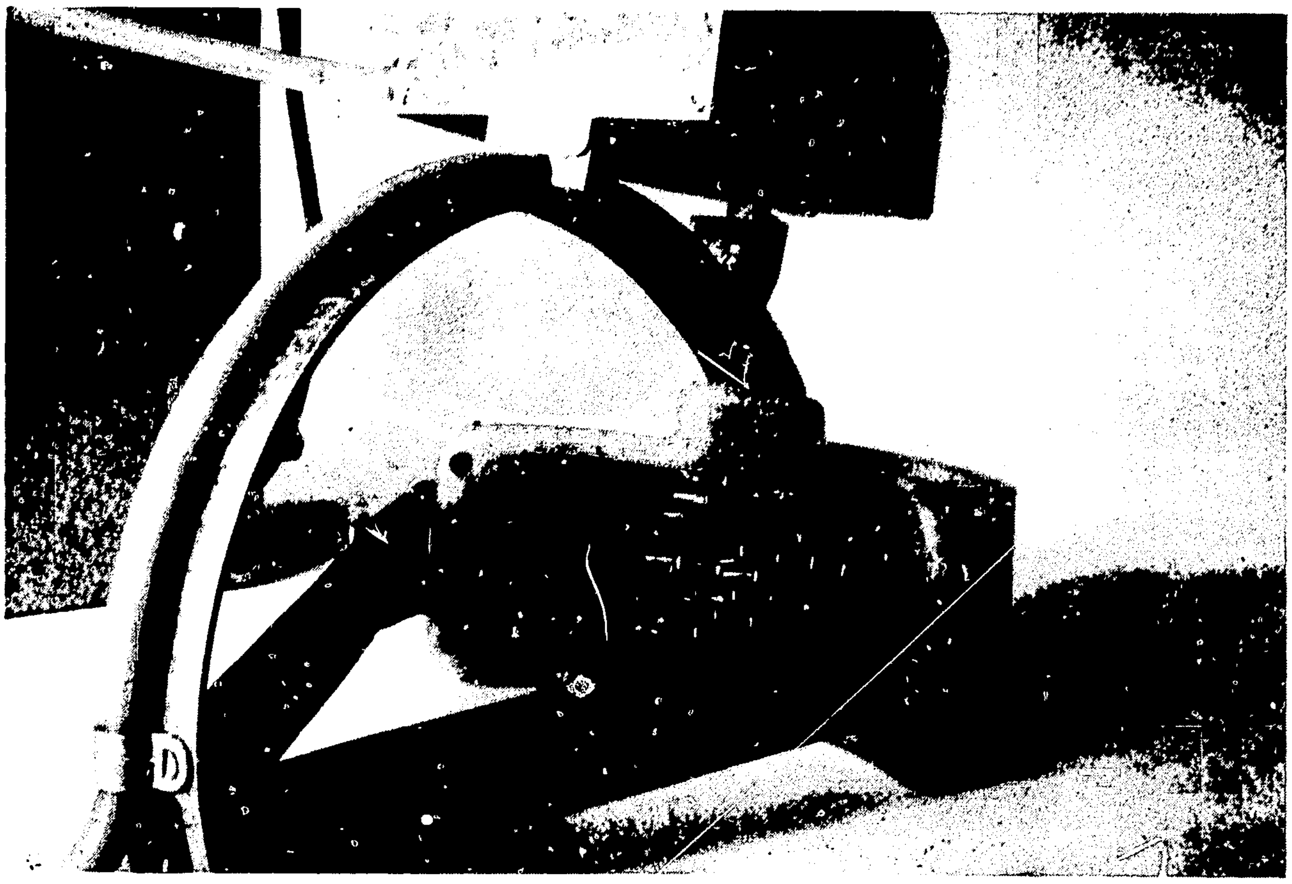

Figure 4. The Inside of the Elektroftalm Headband Showing the Arrangement of the Tactile Element Outputs.

A representation of one of the 120 channels is given in Figure 5.

Although Figures 1 and 2 indicate that the original design of the device implies wearing the camera portion on the headpiece, the camera can also be located at chest level. Here it is placed on the box containing the 120 amplifiers, the pulse generator feeder, and the storage cells (see Figure 6). Figure 7 shows a blind user with the modified apparatus.

Because of the need to maintain space/skin congruence, the mosaic of the camera and the tactile array must be kept aligned

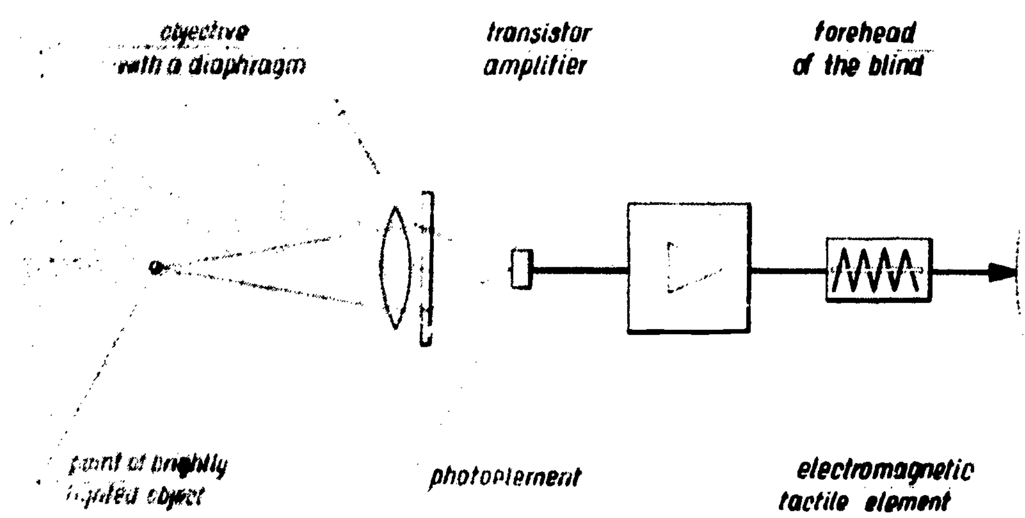

Figure 5. Diagram of a Photoelectronic Channel.

Figure 6. The Elektroftalm with Photocamera Mounted on the Box.

Figure 7. The Elektroftalm with Chest-Mounted Photocamera in Use.

or parallel with each other. If this is done then the stimulation provided by the tactile element always corresponds to the activation of the corresponding photocell and thus to the direction of the light ray from the field which is scanned. This condition is most easily fulfilled if the camera is mounted on the headband. For practical reasons this ideal is not attainable; the only alternative is to place the camera on the user's head. In either case the space/skin location response can be achieved both with the head motionless and with turning the head. If the camera is placed at the chest position the movements of neck muscles are not utilized for training the locating response; rather, the user must turn his whole body at once. In the latter case, then, the space/skin location response is an individual matter, or, if training is involved, is a matter of prolonged training.

One highly important related matter is that of the recognition of objects which are detected. It is obvious that with a 30-degree field of vision, broken up into 120 points, recognition of shapes is primitive at best, and appreciation of a distinct plastic image is out of the question. After prolonged practice the user will be able to distinguish, at best, the highlights of a lighted object against a dark background. It is hoped, however, that with even more prolonged practice the user will be able to distinguish more precisely between a line and a rectangle, a triangle and a circle, and so on.

CONSTRUCTION OF THE ELEKTROFTALM

A technical analysis of the first model of the 80-channel Elektroftalm, and the results of experiments carried out with blind subjects, have led us to draw up the following conditions which must obtain in future models of the device:

1) The point-to-point analysis of the image must be made on the basis of as large a number of elements as possible. The result is an increase in the number of tactile transducers and thus a larger area of skin which is stimulated.

2) Photocells must be sensitive only to visible light.

3) The device must function independently of ambient temperature.

4) The sensitivity of the device should be at least 20 luxs at the low end, and suitably decreased at the high end (e.g., with a diaphragm).

5) Brightness should be detected in several range steps.

6) It is desirable to control the vibratory rate of the tactile transducer, from 1 to 100 cps or so.

7) The headband carrying the tactile transducers should be flexible enough to adapt to any head shape.

8) The components should be as compact as possible to reduce weight and size, and annoy the user as little as possible during the lengthy training periods necessary.

9) The construction should be as simple as possible.

10) Costs should be as low as possible.

11) Every effort should be made to incorporate the most advanced electronic and theoretical techniques.

Our newer 120-channel Elektroftalm does not satisfy all of these conditions, unfortunately. It has the following shortcomings:

1) The resolution is too low. Although the photocell mosaic can be subdivided further, size limits of the tactile transducer array restrict us currently to a 120-channel unit.

2) The brightness gradient is poorly resolved.

3) The photodiodes are not sensitive enough either to low illumination levels or to gaseous discharge glow.

4) Construction of a 120-channel device remains complex, with that number of amplifiers, tactile elements, and a multiple of 120 soldered joints. Some elements are not miniaturized. The device is relatively heavy, and its price is very high.

5) The technological execution is not yet perfect.

In spite of these drawbacks the Elektroftalm has proved to be useful, especially with practice. After one week of practice two to three hours a day, users were able to distinguish white objects against dark backgrounds, and could indicate tolerably well the direction of the objects (grasping the object and confirming this fact seemed to give the users considerable satisfaction). Determining the shape of the object was considerably more difficult.

FUTURE DEVELOPMENT

Efforts are being made to refine the design and construction of the device by reducing the number of parts, simplifying the design, and lowering its price. Two further proposals have been made. The first applies some current television techniques to the device; the second is a modification of the output of the device.

The first proposal would substitute a Vidicon-type oscilloscope tube for the mosaic of silicon photocells. The image would be formed in the tube by a lens, and the image resolved by vertical and horizontal generator traces. The number of lines is of course arbitrary, but since the number of tactile elements is limited to 120 (arranged as above), the number of horizontal lines used in the Vidicon tube would be 10. The advantage is that only one transistorized amplifier is necessary, keyed for each channel in turn, with 120 output channels. This modification would permit a considerable reduction in bulk and price of the device.

Unfortunately the optimum electronic switches were not available to us and the problem of constructing a suitable switch is formidable. The idea has not been dropped, however, only shelved until a switch becomes available.

The second proposal was to replace the electromechanical transducer at the forehead by an electrical transducer. There are great advantages to such an approach, since the former are difficult to construct and relatively expensive, whereas an electrical transducer which applied signals directly to the forehead would require only small metal electrodes in the form of point contacts laid out on a flexible insulated mounting which followed the contours of the head. The question remains as to the best form of electrical impulses which we should use to impart pressure information without being either disagreeable or painful. A number of experiments were carried out to determine the answer to this question.

A special training apparatus was built which included a universal generator which gave arbitrarily shaped pulses of direct current of either polarity, with or without polarization, of whatever kind and voltage desired. In place of a flexible plate, a rigid forehead plate was constructed. Instead of a camera we used another plate with contacts on which a suitable "image" could be formed out of one or more contacts (see Figure 8). We called it the "Training Electrostimulator." Trials were carried out to determine the most suitable type and intensity of current, and also

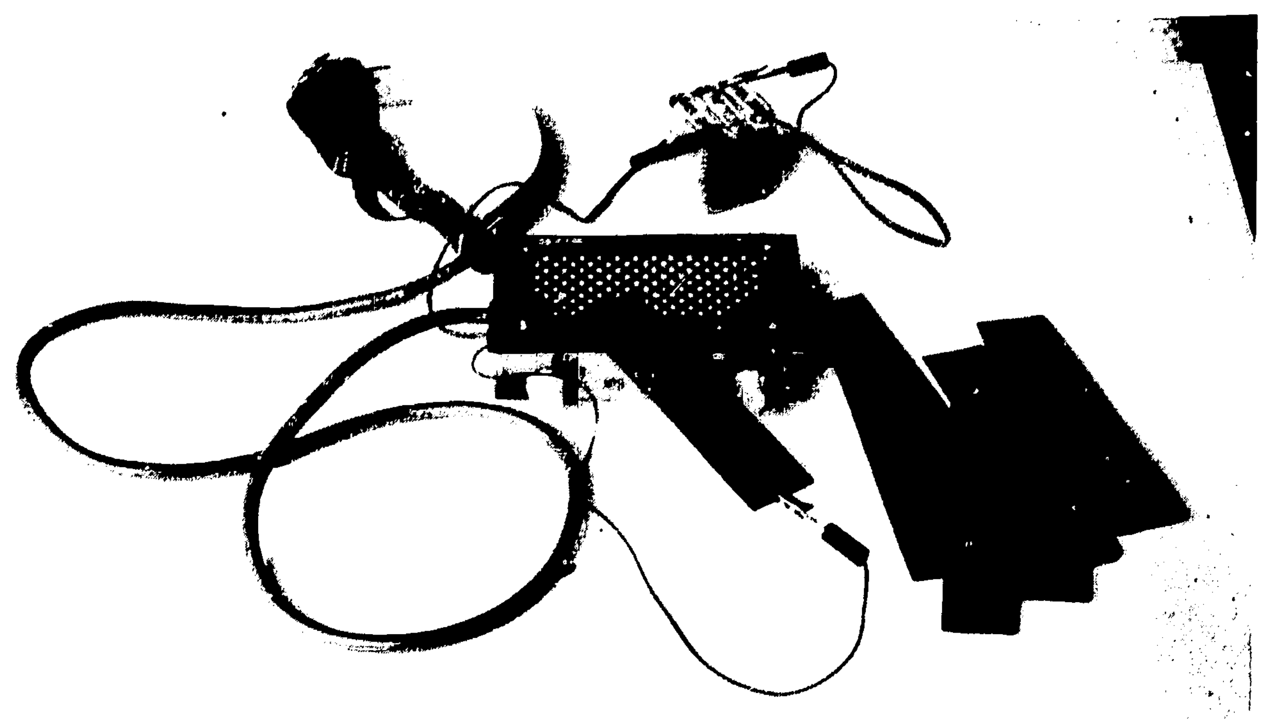

Figure 8. Training Electrostimulator. Top Left: Forehead Plate with 120 Contacts (Electrodes); Top Right: The Feeding Battery; Bottom Right: Plates with Various Figures which, when Placed in the Box, Yield Corresponding Electrical Stimuli on the User's Forehead.

to develop in the blind subject an appropriate space/skin correlation. (The ground electrode was placed on the forearm.) Experiments were conducted in the eye clinic of the Pomeranian Medical Academy in Szezcin, using one subject for one hour a day for two months.

The most pleasant stimuli for the subject were unipolar direct current impulses and low rate of repetition. These gave delimited and well-localized sensations on the forehead. Polarization effects have not been described. The best dc voltages appear to be between 8 and 10 volts. At 12 volts the pulses were too powerful, while at less than 5 volts the subject reported no sensation. Alternating current impulses resulted in a report of a diffuse burning sensation. Induction current pulses were most unpleasant, giving a reported sensation of a spreading burning. When multicontact stimulation resulted in subject confusion, a training program was initiated which started with the most easily recognizable impulses.

The first exercises used single stimuli, generated by touching single contacts on the plate. The forehead was not specially prepared. The electrical stimulation was felt distinctly. The correlation of spatial points with skin stimulation was developed by placing a 70 by 100 centimeter (about 28 by 40 inch) wooden board approximately 75 centimeters (30 inches) in front of the subject. Holes were drilled in the board in which 1.5 centimeter (1/2 inch) pegs could be inserted. The hole array matched the contact array on the forehead of the subject and simulated the angle of view of the Elektroftalm.

The subject was required to determine the direction of the stimulation by groping with his hand until he found the peg inserted into the appropriate hole. At first the hand movements were erratic: deviations from the correct peg were about 20 centimeters (8 inches). Deviations become smaller during the first week of training, ultimately reaching an error of 5 centimeters (2 inches), at which point (since the pegs were 6.5 centimeters or a little more than 6 inches apart) the subject could grasp the correct peg without touching neighboring pegs.

Six directions were established with this subject, for which he showed small errors, i.e., pointing directly to the correct peg, while remaining directions were located with an error of plus or minus five centimeters. With further training we hoped to make direction strictly determined by the subject.

When he is trained to identify directions of stimulation with one stimulus acting at a time, the plan is to train him then to identify two, three, and more stimuli arriving simultaneously and to discriminate smaller and smaller distances between any two at a time. The smallest distance reliably discriminated by the subject so far has been 12 millimeters, when stimuli were presented simultaneously to certain areas of the forehead. Other areas required greater distances between stimuli for the same level of discriminability. With enough training, we think it possible that the subject could distinguish and recognize simple figures such as horizontal, vertical, and oblique lines. With prolonged training we think it possible that his discriminatory sense could be developed so that he could discern the shapes of figures. It might even be possible to require discrimination among varying intensities of stimuli as well.

Note: Experiments were conducted for some time along the lines indicated in the above discussion. The results, however, did not seem to merit the effort expended, for they were ultimately absolutely negative. As of November 1964, therefore, we have decided to drop the idea of stimulation using electrical signals to the forehead of the user of the Elektroftalm. Only the tactile elements are left, but we shall refine them constantly.

A new camera has been built and tested using cadmium sulphide cells to replace the photocells used in the original model. These photocells are very sensitive in the visible radiation band and not in the infrared radiation band. Further, their resistance varies over a very large range under the influence of light. In the dark the resistance is approximately 10 megohms and this decreases rapidly with even weak stimulation with light. Thus with an illumination level of only 50 luxs its resistance is 2 kilohms; at a level of 1000 luxs it is only 200 ohms. These properties make the cells very useful for the Elektroftalm. They are, above all, cheap, sensitive to low illumination levels, operate independently of temperature changes, and respond to the visible spectrum. (They react, for example, to television screen images and indicator lamps, to which neither germanium photodiodes nor silicon photocells are sensitive.) Their only disadvantage in the present application is a slightly larger size - 8 millimeter - which entails a two-fold increase in the size of the Elektroftalm camera; as compensation for this increase in size, we can realize a somewhat wider field of view - 55 degrees - with the same resolution.

The increased sensitivity of the new camera permits operation of the Elektroftalm even in cloudy weather, and requires only a single stage amplifier. Thus the price of the device can be reduced and its design simplified.

Electronic parts manufacturing plants in Poland are now developing cadmium photoresistors of even smaller size which will permit a smaller camera. If designs become available which generate power in excess of the present limit of 0.1 to 0.2 watts, there is reason to believe that we can eliminate the transistorized amplifiers altogether, and refine the design still further while again reducing its size and cost.

FUTURE WORK

Future work on the Elektroftalm will include not only the modifications mentioned above but also exploration using subjects in controlled experiments with the device. This work will be conducted continuously in the development of the system.

We should also mention the perspectives opened to us by the papers of Kay, Nelkin, and Dupress (in this volume), which dealt with ultrasonic apparatus. If the Elektroftalm could be linked up in some way with an ultrasonic device which would give the distance to an obstacle, the blind user would get a very much improved device to provide him with an irreplaceable aid to him in his life of permanent darkness.

In sum we should mention that the conceptual design of the Elektroftalm is due to Professor Doctor Witold Starkiewicz of the Pomeranian Medical Academy, Szezecin (where all experimental work with the blind is carried out), while the construction, technological modification, and developmental work in connection with the device is under the direction of Professor Doctor Tadeusz Kuliszewski, Head of the Chair for Telecommunication Devices, Wrocław Technical University. The work described is a cooperative effort; hence our dual authorship.

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PASSIVE ENVIRONMENT SENSORS AND THEIR TRANSDUCERS

Walton B. Bishop
Air Force Cambridge Research Laboratories
Office of Aerospace Research,
L.G. Hanscom Field
Bedford, Massachusetts

INTRODUCTION

My interest in passive environment sensors stems from my accidental discovery in the laboratory that light passing through two pinholes would produce some very interesting outputs from a photomultiplier. I recorded these results in my laboratory notebook in 1947, but let them lie dormant for some fifteen years because the electronic circuitry involved was too cumbersome to permit any practical use to be made of the phenomena. Last year, I published a study of what might be expected from passive environment sensors, assuming that a practical one could be built (2, 3). Theoretically, a simple passive optical sensor is capable of collecting enough information from the environment to permit safe mobility. The sensor requires nothing like the complexity of the eye in order to collect this information. This simple sensor should not, however, be confused with an "artificial eye." Throughout the earlier studies, and this paper as well, the problem of sensing the environment is simplified by adopting the convention that the environment is "sensed" when sufficient information has been collected concerning it to permit an individual to move about safely.

In my studies, I have selected, for detailed consideration, the following eleven problems which a blind person might encounter:

1. Obstacle avoidance

2. Pitfall avoidance

3. Recognition of objectives

4. Bearings from three known points

5. Navigation to a position having specified bearings from three known points

6. Step-up

7. Step-down

8. Low bridge

9. Exit from low bridge

10. Recognition of approaching vehicle

11. Recognition of departing vehicle

Although the passive sensor can indeed collect adequate information for the solution of these problems, assuming that use is made of associated geometrical data, the means of coupling this information into the brain still is not readily available. In fact, the prime reason for publishing a study of the potentialities of a passive sensor was to stimulate research on better transducers, or to locate a suitable one if it should already exist.

SUMMARY OF RESULTS THUS FAR

Prior to publication of my studies concerning passive sensors, I had observed only very simple laboratory results. The 931-A photomultiplier, in 1947, had produced an audio-noise output which was modulated by the environment scanned. In 1963, a Sargent Model MR Recorder was used to amplify the output from a 1N2175 photo-duo-diode which was located behind two 0.040-inch apertures. Figure 1 shows a sample of the output obtained. Unfortunately, none of the portable units made thus far provide as much amplification as the recorder provided. The publication of potential capabilities of the passive sensor (2, 3) resulted in many expressions of interest in using and/or testing it. Not until May of this year (1964), however, was a portable working model available for demonstration. A tactile transducer, developed for other purposes, proved suitable for use with a passive optical environment sensor, and the electronic circuitry developed for tactile communications required only a little modification to make it provide the needed amplification and frequency response.

On 11 May 1964, Mr. Robert L. Lucas of Santa Rita Technology, Inc., demonstrated the simple mailing-tube model shown in Figure 2.* This frequency modulated sensor (output frequency varied directly with light intensity) provided a very impressive demonstration of the feasibility of using the passive sensor effectively.

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* This model was largely a by-product of "Applied Communications Research for Air Force Vehicles," performed by Santa Rita Technology, Inc., Menlo Park, California, under Contract AF33(657)-11591, sponsored by the Communications Branch, Air Force Avionics Laboratory, Research and Technology Division, Air Force Systems Command, United States Air Force. (Mr. John Teegarden is the Air Force Project Engineer.)

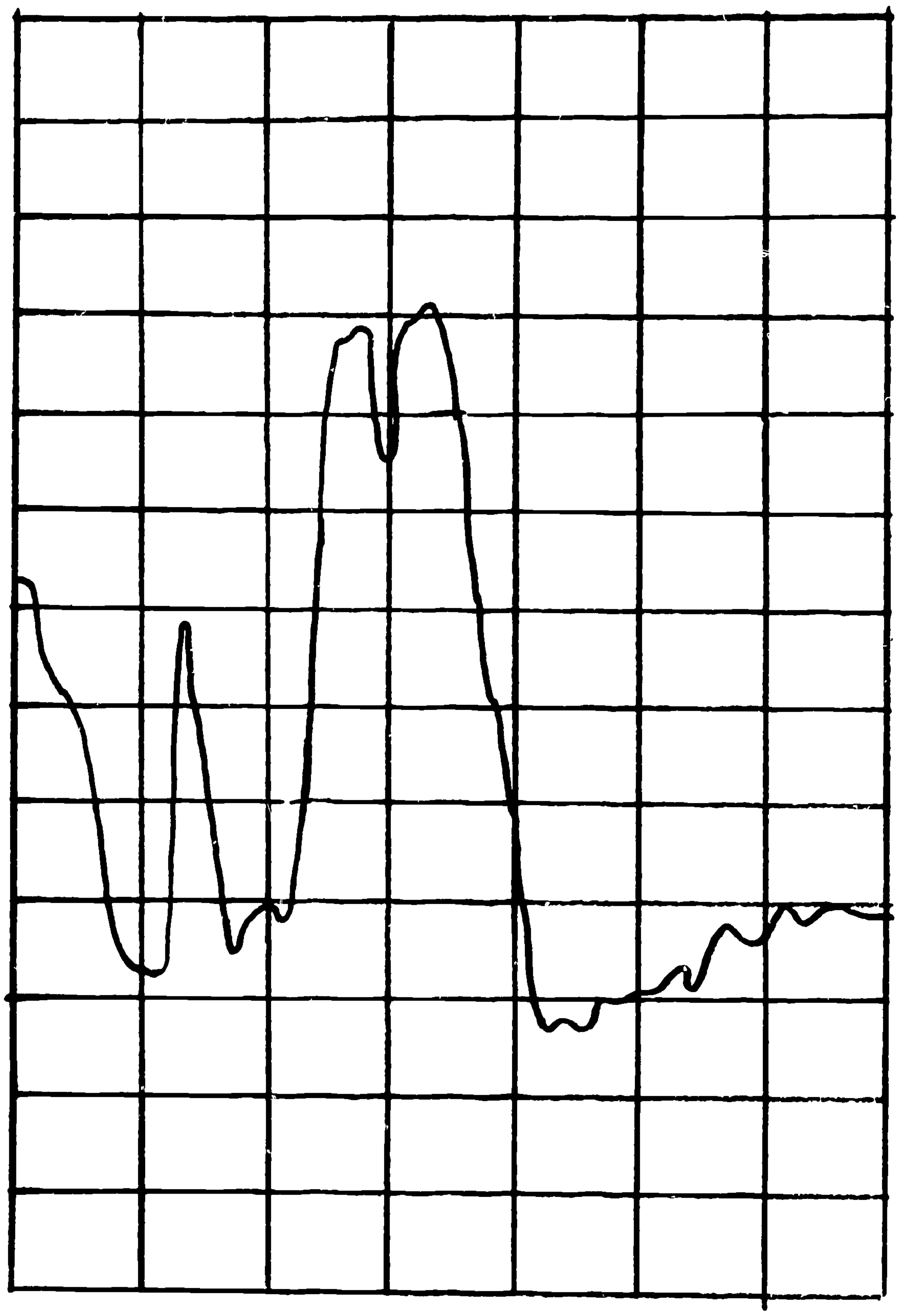

Figure 1. Sargent MR Recorder Output as Sensor Scanned across Chest of Man Twelve Feet Away and Wearing a White Shirt and a Dark Necktie.

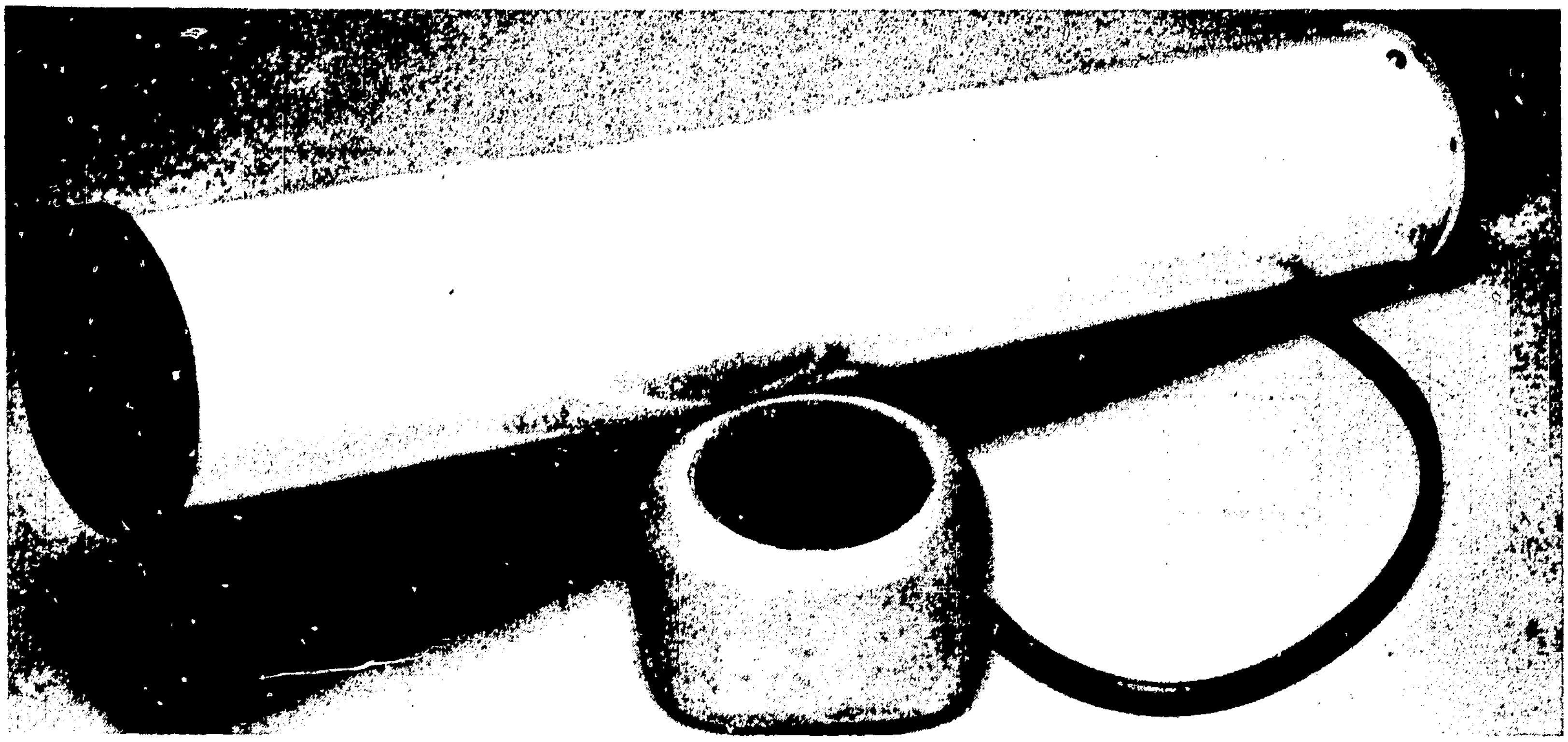

Figure 2. Mailing-Tube Model of Passive Environment Sensor Made by Santa Rita Technology, Inc.

Mr. Lucas has since constructed several more conveniently packaged sensors which he calls "BLES" for "Bishop-Lucas-Environment-Sensor." He has been kind enough to lend me two of his units for demonstration (see Figure 3).

Figure 3. "BLES," the "Bishop-Lucas-Environment-Sensor."

I have also for demonstration a model constructed by Air Force Cambridge Research Laboratories (AFCRL) under the guidance of Mr. Joseph P. Mannola (Figure 4).

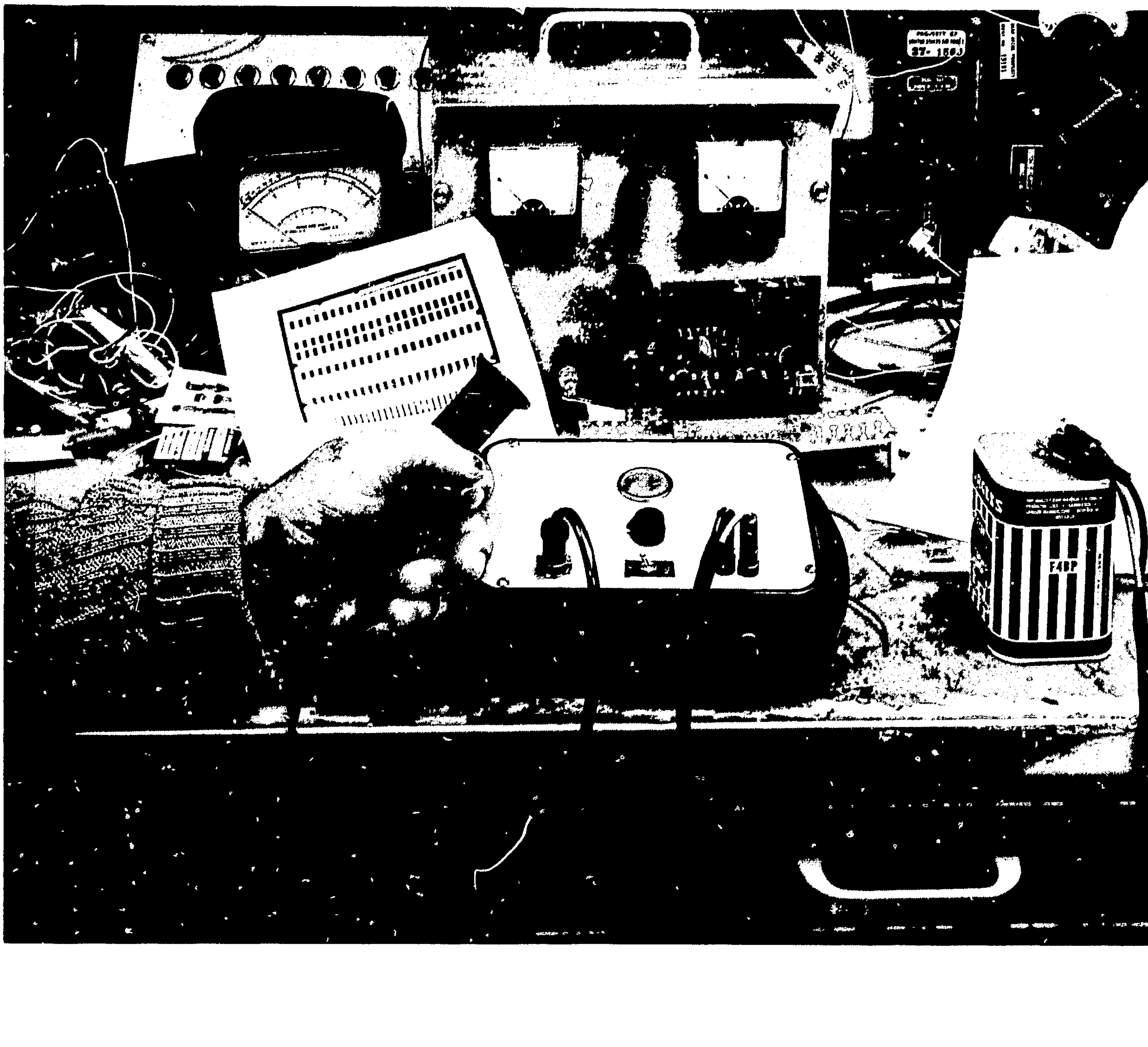

Figure 4. Demonstration Model of Passive Environment Sensor Made by AFCRL.

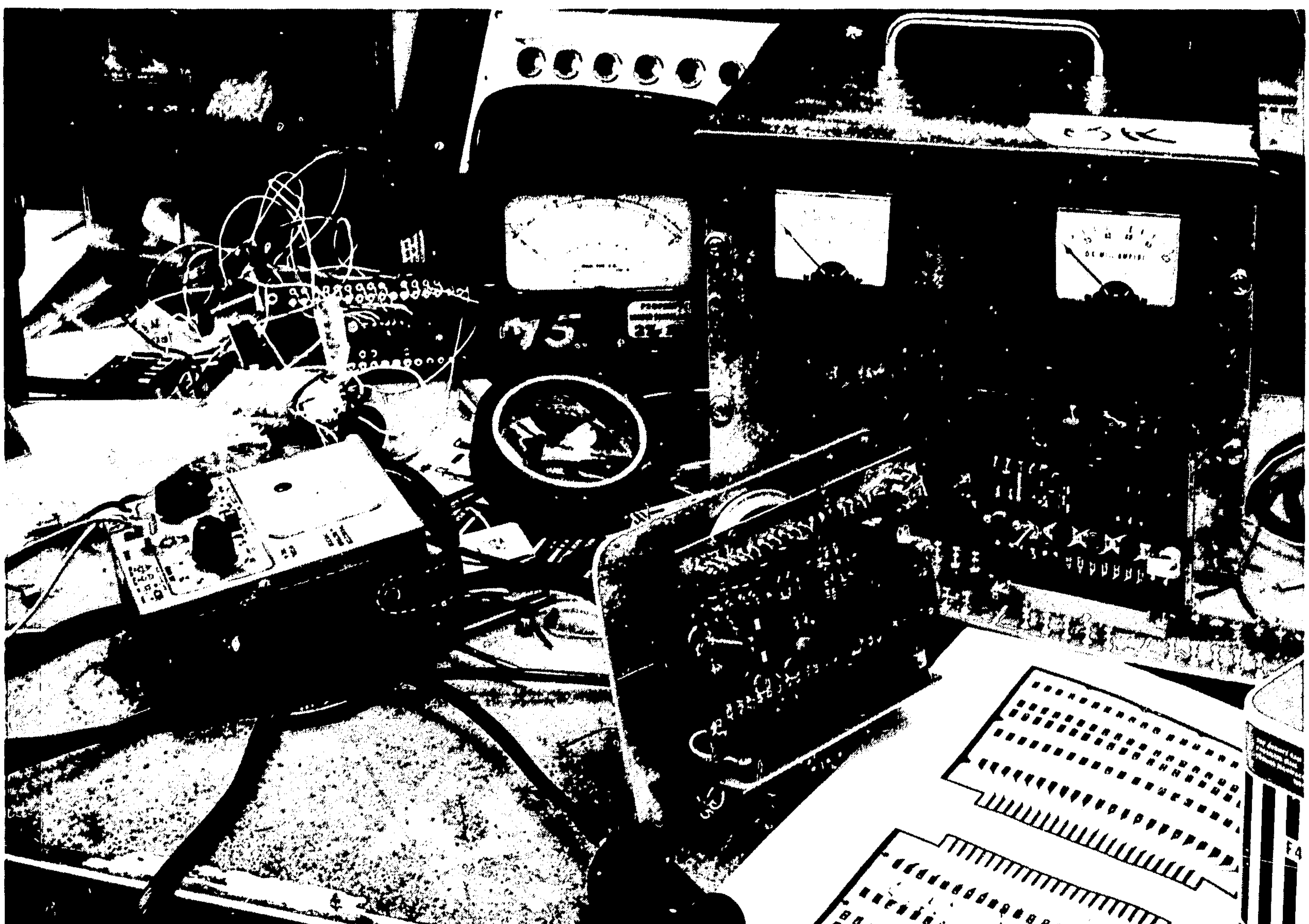

Figure 5. RHOMBREC BOARD Construction Used in AFCRL Demonstration Model.

The multivibrator in this model, as in the BLES unit, is so adjusted that an increase in the intensity of light coming from an object being scanned causes an increase in the audio output frequency, and vice versa. The loudspeaker is used only for demonstration purposes. The crude optics, consisting only of the hole in a wooden spool, are adequate to distinguish the differences between, for example, floor and wall, wall and ceiling, one wall and another, or a table and its background. Figure 5 shows some internal details of the demonstration model and a work sheet used in preparing for construction. The printed circuit board, called a "RHOMBREC BOARD" (10) originally had nearly all conceivable connections on it. The unnecessary ones were quickly removed in the laboratory to prepare it for use. This mode of construction is convenient and rapid and it makes all components readily accessible for maintenance and/or modification.

REVIEW OF THEORY OF OPERATION

The ability to perceive one's environment is so natural to sighted people that it is difficult to consider it as anything but a God-given capability which requires no training. Gibson has provided strong evidence that a large part of our environment perception capability results from a learning process (6). Hebb provides a more detailed study of the learning processes involved in perception (7). His observations concerning the contribution of eye movements to perception indicate that a serious study of the movements of an artificial sensor is needed. Wiesel and Hubel have found that depriving kittens of light and form sensations causes arrested development in their visual cortex (15). It would seem, from the results of both experimentalists (15) and theoreticians (6, 7), that environment perception invariably involves learning. First, it is necessary that one or more sensors provide the brain with responses which vary in accordance with the environment being scanned; second, it is essential for the brain to develop the capability to respond properly to these responses. The response of course, may result in either action or simple "recognition." If this interpretation of environment perception is correct, then there are three major questions to answer: (1) How can we build a usable sensor that will collect adequate information from the environment? (2) What sort of transducer will couple this information into the brain? (3) How can the brain be aided in the learning process which must take place before real environment perception can result?

It is difficult to separate the parts played by our several senses in developing a true awareness of our environment. Quite often we become all too aware of our environment and thus find it difficult to concentrate on desirable sensory inputs because of the large number of unwanted ones. In the absence of one of our senses our attention to, and apparently our ability to use, the other senses increases. The sense of hearing as an input for an artificial sensor to compensate for the loss of sight has most often been selected because of its convenience and large information capacity. It has been pretty well established, however, that hearing even without an artificial aid provides a great deal of environment sensing information (14). If we wish to provide maximum aid to the blind we should, if possible, find a way to get environment sensing information to the brain without disturbing the sense of hearing. The sense of touch offers many advantages, even though the frequency response of any particular sense element is limited. Practically the entire surface of the body, and even the tongue, may be considered as possible input points for tactile transducers. Use of the kinesthetic sense along with tactile stimulation offers some very interesting additional possibilities. Bliss has shown a number of advantages in using kinesthetic/tactile communications through the fingers (4). Other parts of the body, particularly the head, may produce even more startling results.

The passive environment sensor is, first of all, patterned after nature's method of collecting information concerning the environment. The eyes and the ears are both passive in that neither requires the subject to transmit energy although, of course, there are instances where such transmission is helpful: the use of a flashlight at night, for example, or the transmission of ultrasonic pulses by bats. An audio passive sensor could very well enhance the sensing normally accomplished by the ears, but it is the light sensitive passive sensor that seems most promising for general use.

Since we have no way as yet to connect large numbers of sensors to the optic nerve and, indeed, the blindness which we wish to overcome may be due to a damaged optic nerve, there is little point in building a sensor as complex as the eye. We can, however, build a simple sensor which operates on the same optical principles as the eye. It was this concept that led to the proposal, which I made last year, for a passive sensor and the simple models based on that proposal (3).

From the communication engineer's point of view environment sensing is a problem which fits well into the classical block diagram that has been described by Shannon (13). Figure 6 shows such a system. The signals which come from an environment sensor are equivalent to a typical message which has been encoded. Since each message will contain less than a complete description of the environment scanned the decoder will receive something very much like an encoded message that has been garbled by the addition of noise. The functions performed by a decoder, message sink, and storage facility are all the kind of operations one should expect the brain to perform; and if a suitable "programming" can be added (we usually refer to this as learning), then the call for appropriate actions should follow. The information flow for environment sensing by means of ambient light

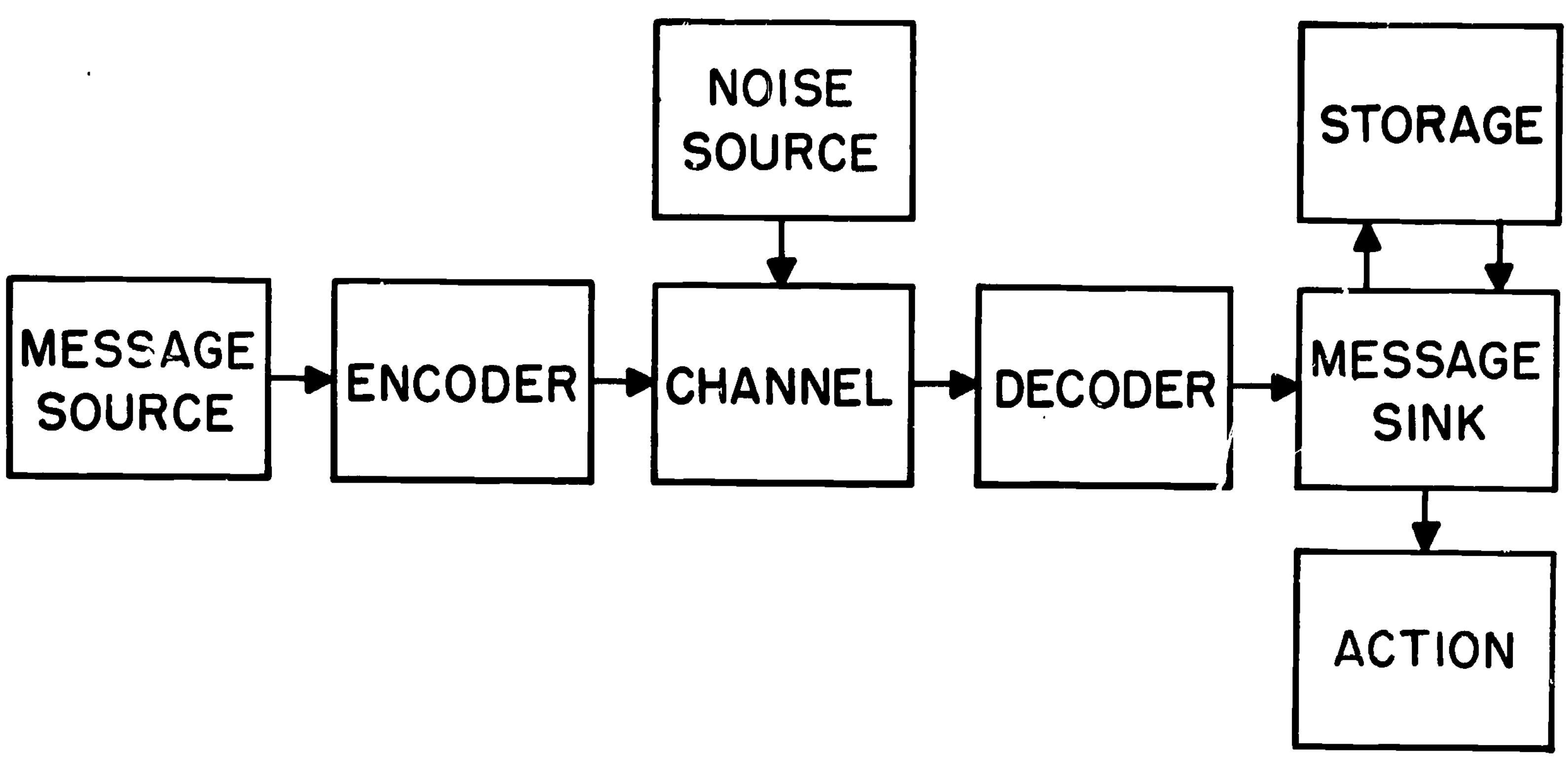

Figure 6. Typical Communication System.

thus involves only the six blocks shown in Figure 7. The ambient light reflected from the environment permits the passive sensor to operate a transducer which feeds appropriate signals to the human brain. The action which follows depends upon how well the brain has learned to respond to the signals received. If the passive sensor is pointed or scanned by the muscles that control the hand or the head, then the brain will receive patterns of information which are automatically correlated with positions in space. The learning involved in perceiving the environment by this method is not simple, but since a "stupid" electronic computer could be designed to accomplish what is needed, perhaps the human brain can do as well or even better.

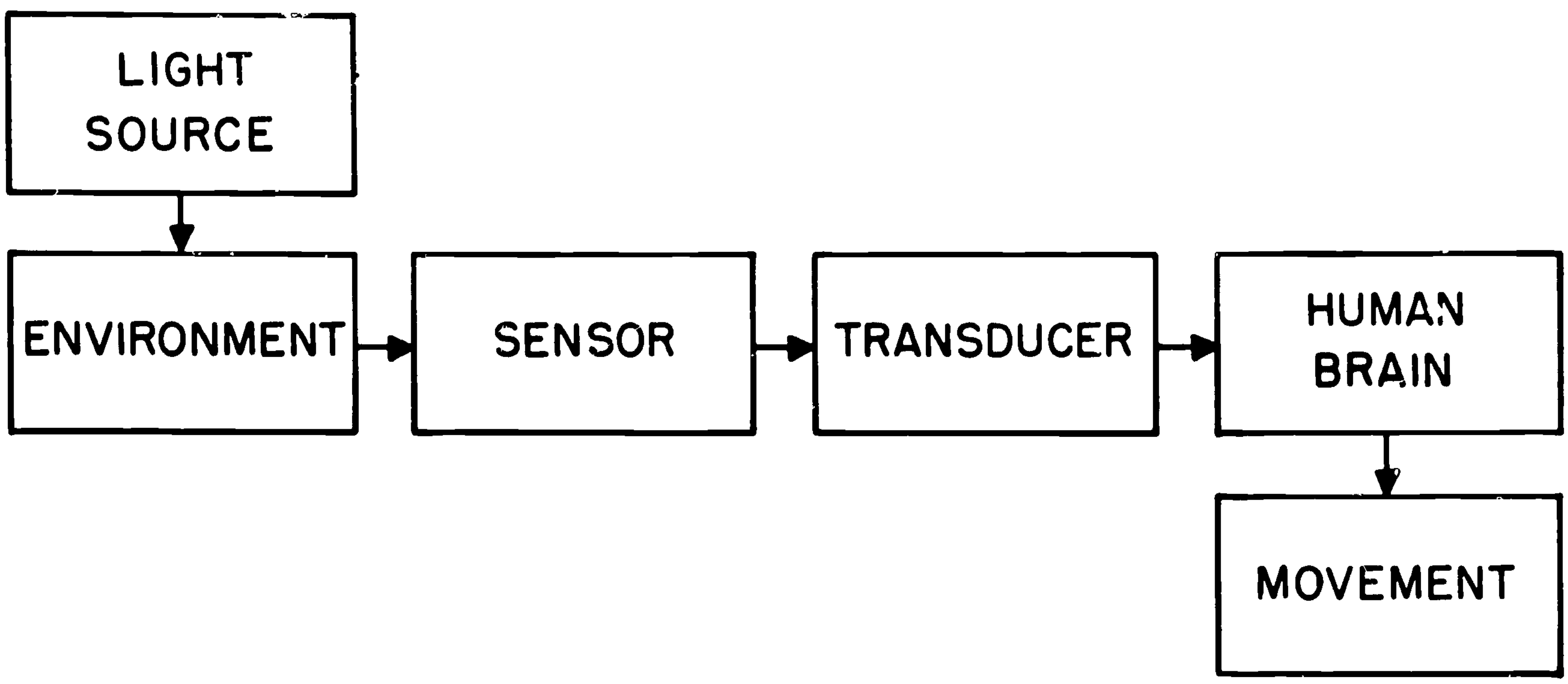

Figure 7. Information Flow for Environment Sensing.

DIRECTIONAL PASSIVE SENSORS

The basic elements required for a highly directional passive optical sensor are shown in Figure 8. The apertures *O* and *F*, usually referred to as "pinholes," actually may be considerably larger than a hole made by a pin. However, sharp discrimination of the type shown in Figure 1 will be lost if the holes are too large. The BLES unit (Figure 3) and the AFCRL demonstration model both have rather large apertures. Further testing with blind subjects is needed in order to determine the optimum size for these apertures. The photocell *C* in Figure 8 may be any of a large number of varieties. The Texas Instrument's 1N2175, which

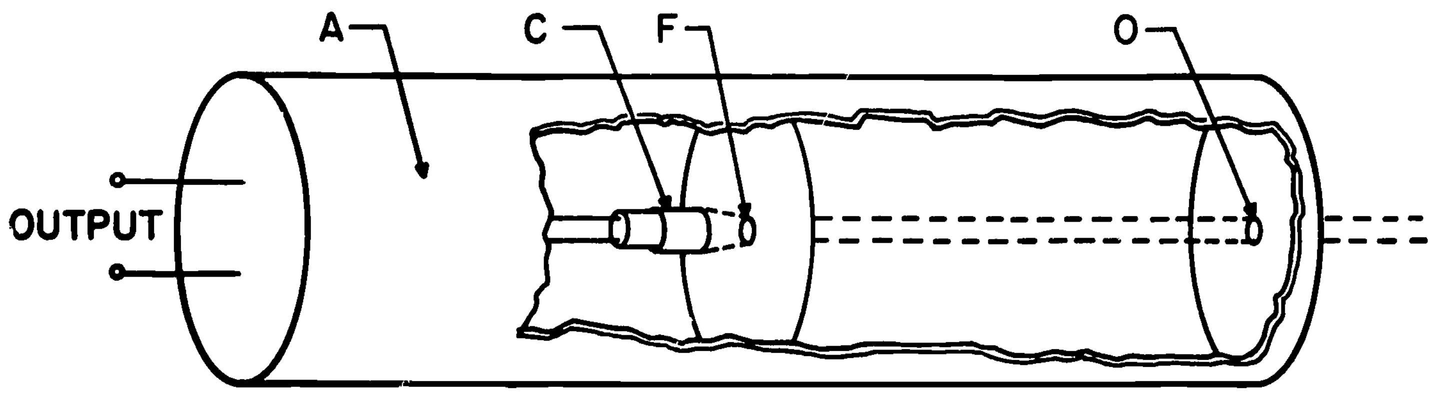

Figure 8. Narrow-Beam Optical Sensor.

has a two-microsecond rise time, offers obvious advantages if sharp discrimination is desired. On the other hand, the Clairex 605-I, which has a much slower rise time (0.007 to 2.8 seconds), requires much simpler electronic circuitry and provides outputs suitable for conducting a number of tests. My studies indicate that the ability to locate the corners of a room and the outside corners of a building is extremely important (2, 3). This should be taken into consideration as tests proceed.

The letter *A* in Figure 8 indicates where the amplifier and associated circuitry belong. The photocell output can easily be made to control the frequency of the output by the use of a multivibrator, as is done in the BLES unit, or it can control the amplitude of the output. Frequency modulated output seems desirable for the conventional "voice coil" type of tactile stimulator or for the earphone. The bimorph or other type of transducer may very well react better and provide a more usable output from an amplitude modulated signal.

Assuming that the output of a photocell behind two pinholes is adequate, and the output can be coupled to the human brain, we find that a serious learning problem remains. There may be a tendency to liken this simple passive sensor to "looking through a straw." I submit that this is not at all the case. The user of this sensor is not asked to react to raw intensity information which comes through the straw. Instead, electronic circuitry reacts to it and provides the user with patterns of information which correspond directly with his environment. These patterns of information in the simple demonstration models are frequency modulated signals in the tactile range. They can easily be made to fall in any range desired, and they can be amplitude modulated just as easily.

A hand-held environment sensor tends to extend the range at which a subject can "feel" his environment. At best, it can only serve to alert the user to the presence of obstacles or pitfalls and help him to recognize frequently encountered objects. In preliminary tests with the "mailing tube" model of the sensor made by Mr. Lucas, and with one of the earlier BLES units, Mr. John Dupress reported that "...all terrain changes showed up..." but "...it was necessary to explore these with my cane to determine whether they were artifacts which did not need step-ups or step-downs." Following Mr. Dupres' suggestion, we will prepare future models for mounting on a cane as shown in Figure 9.

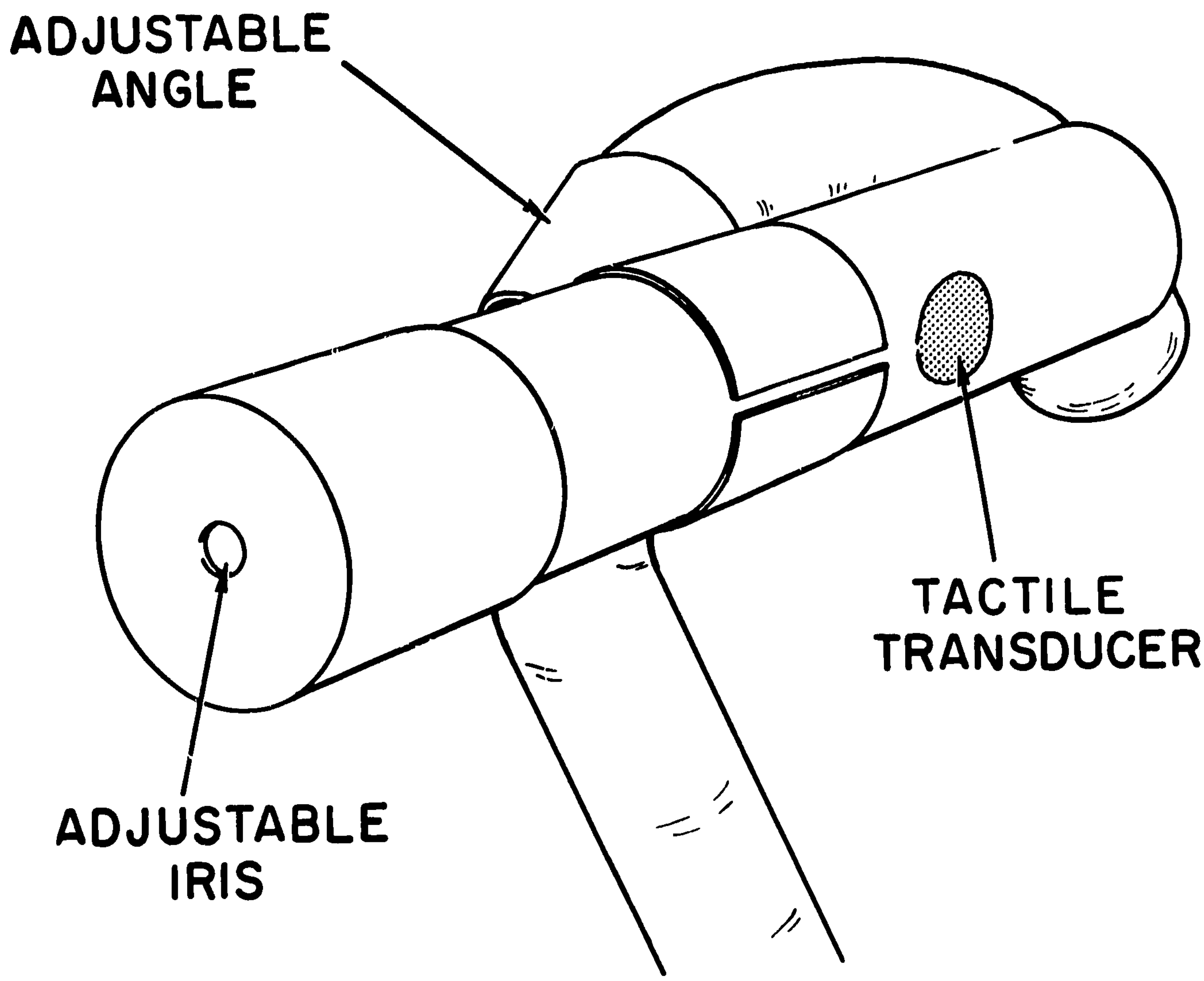

Figure 9. Cane-Mounted Passive Environment Sensor.

Mr. Dupress also requested that an automatic aperture adjustment be provided to compensate for changes in light intensity. I believe that eventually an automatic gain control will provide a better solution to the variable light intensity problems, since it will permit any desired angle of discrimination to be used.

A sensor and an appropriate transducer mounted on the blind man's head has more exciting possibilities.

First: A sensor in a fixed position on the head and looking forward would be correlated automatically with binaural hearing much in the same manner as the eyes of an owl, which are fixed in their sockets and thus always look the way the head is turned. Figure 10 illustrates a convenient way of mounting the passive sensor on the head. Of course, the output from these sensors could easily be coupled to the ears through conventional earphones, and electrical shock or other types of transducers, as well as bimorphs, could be used.

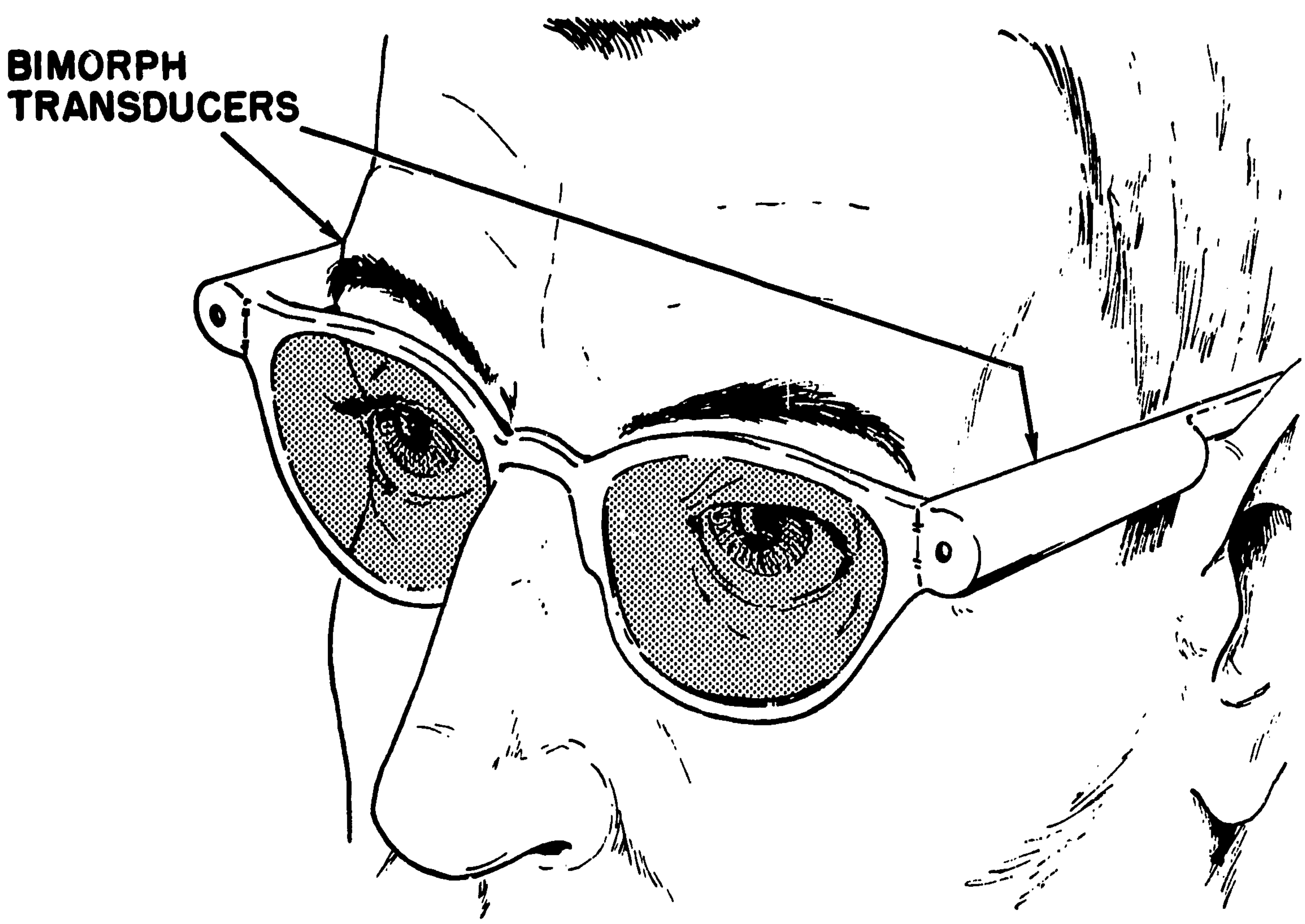

Figure 10. Convenient and Inconspicuous Head Mounting for Passive Environment Sensors.

Second: A head-mounted sensor which could be moved to right or left and up or down by means of facial muscles would offer increased capabilities. It would be extremely interesting to observe how much an individual could learn to do with such a sensor. I have not arrived at a practical means of solving the mechanical problems associated with such a sensor, but feel certain that a capable mechanical engineer could provide a solution.

Third: A passive sensor could be mounted in something resembling a pipe. (This mounting was suggested by Dr. Paul H. Sherman of the University of California at Los Angeles in June 1963.) It would even be possible to leave enough room in the pipe to permit the user to smoke it. However, being a pipe smoker myself, I know that carrying an unlit pipe in the mouth is not an uncommon occurrence; so I see no reason for encouraging the combination of smoking and sensing. The pipe shape does reduce the conspicuousness of the sensor, though, and may be worthwhile for this reason alone. Figure 11 illustrates roughly how the pipe mounted sensor might look. It should perhaps be pointed out that the snake makes use of his tongue in sensing his environment, so this configuration for the sensor is patterned after one of nature's designs as much as the others.

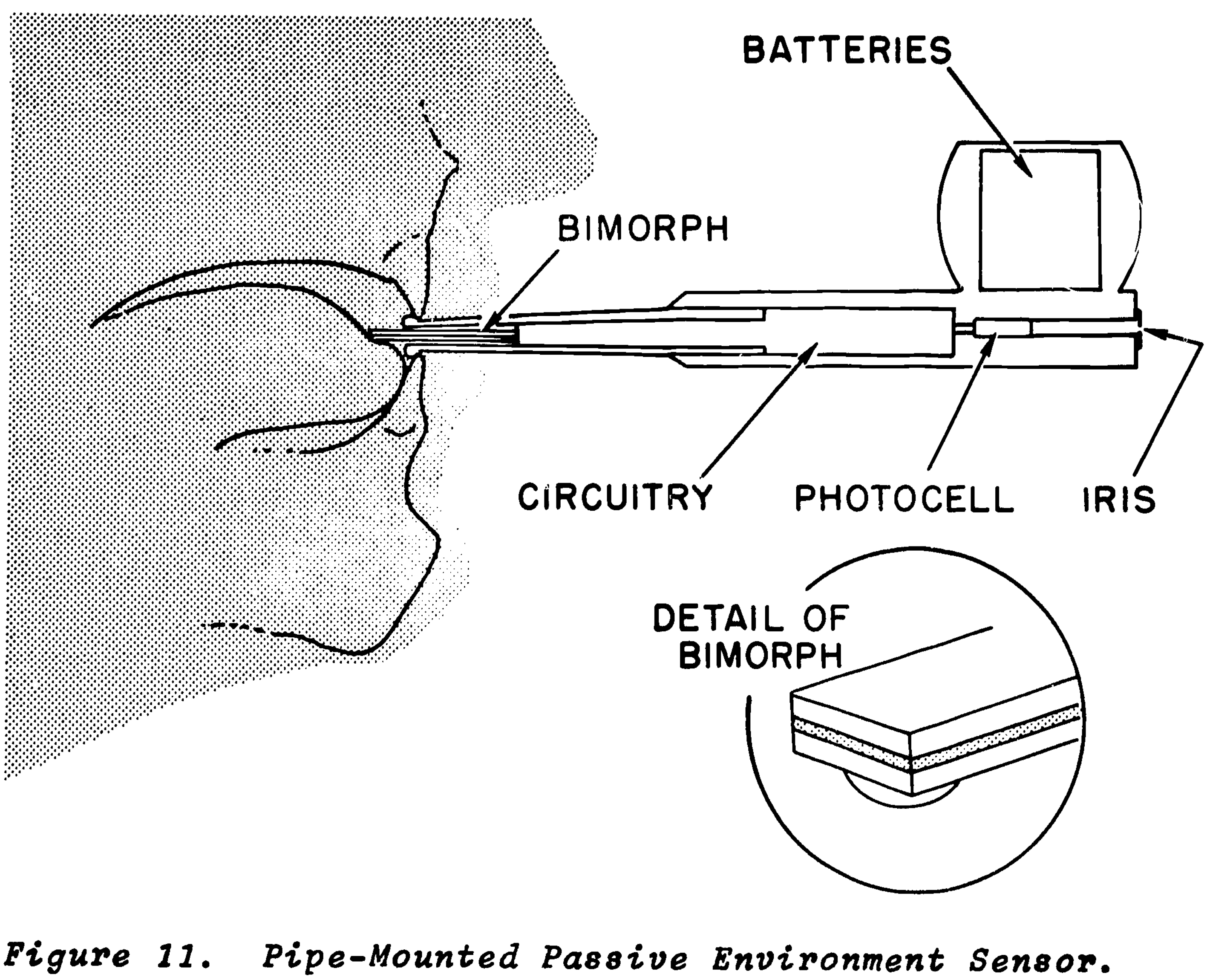

Figure 11. Pipe-Mounted Passive Environment Sensor.

Fourth: There is a special feature of a head-mounted, wide angle passive sensor that should not be overlooked. Side viewing, wide angle sensors duplicate, in a crude way, the distance measuring or motion measuring capability of the chicken's eye. Side viewing, wide angle sensors could also be concealed in a pair of eyeglasses, and they should be able to provide a peripheral sensing capability that would provide warning of rapidly moving vehicles or objects that might be missed by the directional sensor. The possible uses of wide angle sensors were discussed in more detail in Reference 2.

Besides consideration of where on the body a passive sensor should be located and where its input transducers should be, there remains another very important capability of passive sensors that is in need of further study and testing. Most photocells are color sensitive enough to indicate a change in output as the sensor scans from one color to another. The use of diferect color filters in front of a number of sensing elements in a single sensing unit could provide some very useful environmental information. A large amount of research and development has been done by television companies in determining the minimum stimulation required to make out eyes "see" various colors. I know of very little that has been done in coding tactile transducers so that we can "feel" colors.

I am not referring to the natural sense that some of us are supposed to have concerning how colored surfaces feel to the fingers (12). Even something as simple as the sensor shown in Figure 12 would provide useful information concerning traffic lights. It seems quite likely that, with sufficient practice

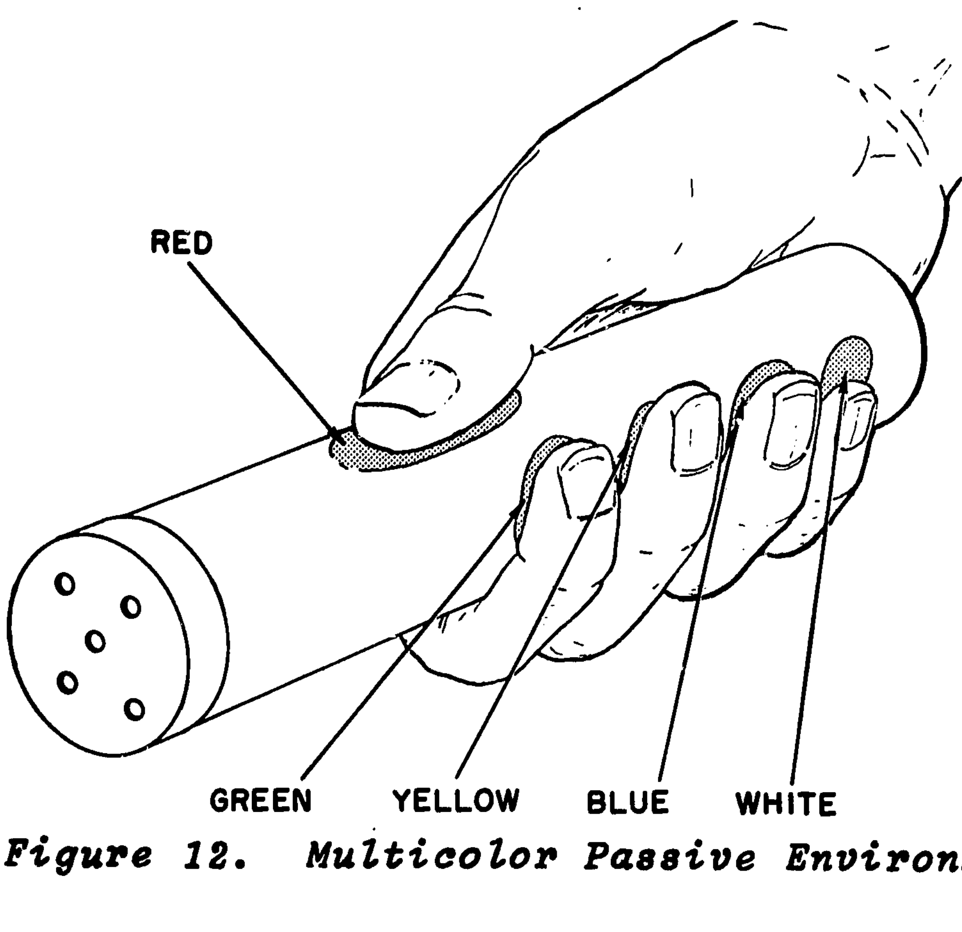

Figure 12. Multicolor Passive Environment Sensor.

under the guidance of a capable instructor, the blind should be able to recognize quite a number of colors with this simple device. The number of colors recognizable should not be limited to the number of filters available. Seldom do we encounter a surface that contains only one color. Hence, we should expect the multicolor sensor to give different amplitude or frequency responses through the various filters. We should not expect to "feel" red alone or green alone, but red should be "stronger" than green or vice versa.

TRANSDUCERS

I believe that use of the earphone as a transducer for the passive sensor should be considered only as a testing device to determine if the sensor is functioning properly. The transducers used thus far in demonstration models have been exceedingly inefficient. They consist of little more than voice coils from radio loudspeakers with damping added. The bimorph transducers, as used by Professor John G. Linvill (1, 9) of Stanford University, and described in this conference by Bliss, Crane, and Gardiner (5), appear to offer much greater flexibility. The electrical transducer of the type used by Kuliszewski (8) may be even more useful.

To a large extent environment sensing information for the blind is limited by the type of transducer used. The tactile transducer cannot provide signals more rapidly than a few hundred cycles per second. Thus, if a frequency modulated signal is used the environment must be scanned slowly or small objects will certainly be missed. An amplitude modulated signal can carry all the information needed for sensing the environment, even with rapid scanning, but most tactile transducers will not transfer this information to the brain. Whether an electrical shock transducer will have a large enough information capacity remains to be seen.

We can obtain a rough indication of how rapidly a transducer should respond by considering a typical scanning operation. Suppose that a hand-held sensor with a 0.5-degree beam scans a 90-degree sector in 0.5 second. Then, in order to detect an object 1 centimeter wide at a distance of 2 meters, a response must be obtained in less than 0.017 second. This does not present a serious problem if the output is a simple amplitude modulated signal which varies directly with the light intensity received by the photocell. It corresponds to a frequency of less than 60 cps. However, one burst of frequency modulation lasting only 0.017-second duration on a center frequency of 200 cps could easily be missed. In fact, it would almost certainly be missed unless the electronic circuitry provided a special transient response. This simple example serves to illustrate the need for better input transducers. That a passive sensor can collect the information needed is demonstrated by the fact that a recorder will show the sharp discrimination needed (Figure 1), and the ear can detect the output change in the form of "clicks" as the sensor passes small objects if the output carrier is sufficiently high. Amplitude modulated noise, as provided by the 931-A photomultiplier in particular, provided sharp discrimination.

I have shown a number of positions where transducers might be located. These positions are by no means the only ones. Although I feel that a transducer which moves along with the sensor as it scans the environment is desirable, I have no proof that this is really better than one which does not. Hence, the hand-held sensor could be coupled to the chest or head, etc., if more convenient connections were available there.

Before leaving the subject of transducers I should like to mention the fact that the medical profession seems to have seriously neglected the design of transducers for providing inputs into a human being. Last year's International Conference on Medical Electronics, for example, was devoted exclusively to *output* transducers. This, to an electrical engineer, is like trying to determine the contents of the proverbial "black box" without comparing outputs with inputs - a hopeless task! Certainly in studying the nervous system better input transducers are needed, and I suspect that much could be learned by studying the reactions to inputs through better transducers for every one of our senses.

TESTING PROCEDURES

Testing an environment sensor and thus determining how it can best be used, or how it should be modified, is certainly an important part of mobility research. The testing procedures which I feel should be followed result from the study of what the sensor should, in theory, be able to do for a blind person. We do not yet have a passive sensor which provides all the outputs that are needed; so testing on present models is for the purpose of determining how the next model should be made.

First, we must make certain that the sensor provides a recognizable change in output as it passes edges of steps, corners of buildings, and the intersections of walls and floors inside buildings. It should also detect the corners of a room if good environment perception is to result. If it will respond to these environment changes, it should also provide different responses for different textures, shaded areas, etc. After the sensor is working properly a considerable amount of practice is needed in order to solve each of the eleven problems listed earlier and, of course, other problems could easily be added.

I believe that mobility problems should be divided into two groups: (1) those which are for safety in following well-known paths, and (2) those which allow the selection of new paths. Such problems as obstacle and pitfall avoidance, steps-up and -down, avoidance of low bridges, and avoidance of moving vehicles are in the first group (Problems 1, 2, and 6 through 11). The problems of recognizing a particular objective and of navigating to a position having specified bearings from known objectives offer the possibility of following new paths (problems 3, 4, and 5). If progress can be made in solving this second group, then the blind will begin to develop something similar to what Gibson might call "perception" of the environment (6).

An outline of some proposed laboratory tests with a passive sensor using a tactile transducer might be as follows (11):

OUTLINE OF LABORATORY TESTS

Judgment of Objects and
Events Via Tactile Stimulation

Initial Experiments Proposed

Discrimination Studies

Number of discernible changes in vibration provided by the sensor:

1) As a function of scan rate

2) As a function of object/background contrast (type of object held constant)

3) As a function of frontal, lateral, and plan position

Recognition Studies

Recognition and identification of objects as a function of size and form in frontal, lateral, and plan positions

Learning Studies

Rate of learning of familiar and unfamiliar objects and sizes in frontal, lateral, and plan positions

The studies of brain development also indicate that the use of environment sensors should vary considerably with different subjects (15). The recently blinded adult, for example, should be aided in using his already highly developed brain functions, while the child must be given a chance to develop new functional capabilities. This seems to mean that an adult will require very careful and complete instruction in the use of the sensor, while the child should be allowed to develop as much as possible on his own initiative. My personal feeling is that a properly designed sensor will be used effectively by a blind child if he can be persuaded to wear it, say in a pair of spectacles, for a reasonable length of time. This type of test also implies that, if the child cannot use the sensor effectively after an appropriate trial, then the sensor is not properly designed.

CONCLUSIONS

Passive environment sensors are in their early or rudimentary stages of development. The work reported here is the result of spare time activities only. Consequently it has not been possible to make some of the modifications that clearly should be made. The recent interest expressed by other agencies than the United States Air Force may lead to more serious consideration and development of passive sensors. The development of a really effective transducer for coupling environment sensing information into the nervous system would provide a strong stimulus for more work on passive sensors. A more careful study of the possible uses of passive sensors for other purposes than as a mobility aid for the blind may also contribute to their development.

SUMMARY

Passive environment sensors, particularly those which make use of ambient light, can be exceedingly simple in design. In earlier papers the author concluded that sufficient information concerning one's environment could be obtained by such a sensor to permit a blind person to move about safely (2, 3). Admittedly a great deal of learning is involved, and some subjects may react negatively to this. However, since a working model has been built and demonstrated, even skeptics agree that the passive sensor has possibilities.* This paper explores some of the desired refinements for the passive sensor. The transducer for coupling information into the nervous system, in particular, is in need of improvement. Several possible improvements are suggested and the desirable characteristics of an ideal transducer are outlined. Considerable emphasis is placed on the manner in which an environment sensor should be tested. The ultimate test, in the author's opinion, would be to attach the sensor to a blind child, preferably by means of something resembling eyeglasses, and give him no instructions whatever concerning how it should be used. If the child can learn to sense his environment on his own volition, then the sensor is properly designed. If he cannot, then some-

* A working model of the Passive Environment Sensor was built by Mr. Robert L. Lucas of Santa Rita Technology, Inc., Menlo Park, California, and demonstrated during the week of 11 May 1964 at AFCRL and the Massachusetts Institute of Technology. An improved model, which he calls "BLES" for "Bishop-Lucas-Environment-Sensor" is now available for test.

thing is wrong with it. There are, of course, many intermediate tests which must be conducted before this final test can be made.

ACKNOWLEDGMENTS

I am deeply indebted to Mr. Robert L. Lucas of Santa Rita Technology, Inc., Menlo Park, California, both for the loan of his two BLES units for demonstration and for the interest which his units have created in passive sensors both at AFCRL and elsewhere. Mr. Lucas' work on Contract AF33(657)-11591, which provided the necessary preliminary development work for the sensor, was under the supervision of Mr. John Teegarden, Communications Branch, Air Force Avionics Laboratory, Research and Technology Division, Air Force Systems Command, United States Air Force.

Dr. John Coules provided important references and suggestions used in the preparation of this paper, as well as the suggested outline for testing passive sensors.

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AN AMBIENT-LIGHT OBJECT DETECTOR AND ITS POTENTIAL EXTENSION TO CONVEY OBJECT SHAPE INFORMATION*

J.C. Bliss, H.D. Crane, and K.W. Gardiner
Stanford Research Institute
Menlo Park, California

INTRODUCTION

Since it is not presently practical for an electronic travel aid for the blind to extract and convey all the information that can possibly be determined from the visual world, the designer seeks to choose and convey only the most important information. Unfortunately, we have no clear-cut evidence of relative importance on which to make a selection; obtaining such evidence may require extensive use and evaluation of many radically different types of devices. In fact, it may be that several fundamentally different types of devices are needed to match not only the requirements of different individuals, but also of different situations encountered by a single individual. For example, a busy person interested only in getting from A to B in the most efficient way has different needs from someone interested in leisurely exploration of his surroundings.

Based on intuition, our assumption is that objects more distant than some short range (say, six feet) are not of primary interest in efficient travel. Thus, we feel that the simplest and most useful information that can be conveyed to the busy traveler is the existence or absence of an object within this selected range and within a field of view wide enough for his body to pass. Our approach in object detection has been to augment rather than supplant the cane which would still be very important for the detection of step-downs.

Given the problem to detect objects within a field of view large enough to walk through and up to a fixed distance away, one can consider both active and passive systems. (An active system transmits a signal and extracts information from the reflections or echoes it receives as a result of the transmitted signal.) We have chosen to concentrate on passive systems that rely on ambient light for operation. Besides potentially requiring less power, we feel that a passive system offers the greatest promise for extension to a wide area system conveying object shape as well

* This paper will be presented at the National Aerospace Electronics Conference, Dayton, Ohio, in May 1965.

as object detection information.

PRINCIPLE OF OPERATION

Consider a wide area photocell placed behind a lens so that it collects the central portion of the light from the lens. For a uniform luminous field total photocell illumination decreases as the photocell is moved axially away from the lens because less light is captured, as shown in Figure 1 (top). If the photocell conductance decreases as total illumination decreases, then photocell conductance will also decrease monotonically as the photocell is moved away from the lens.

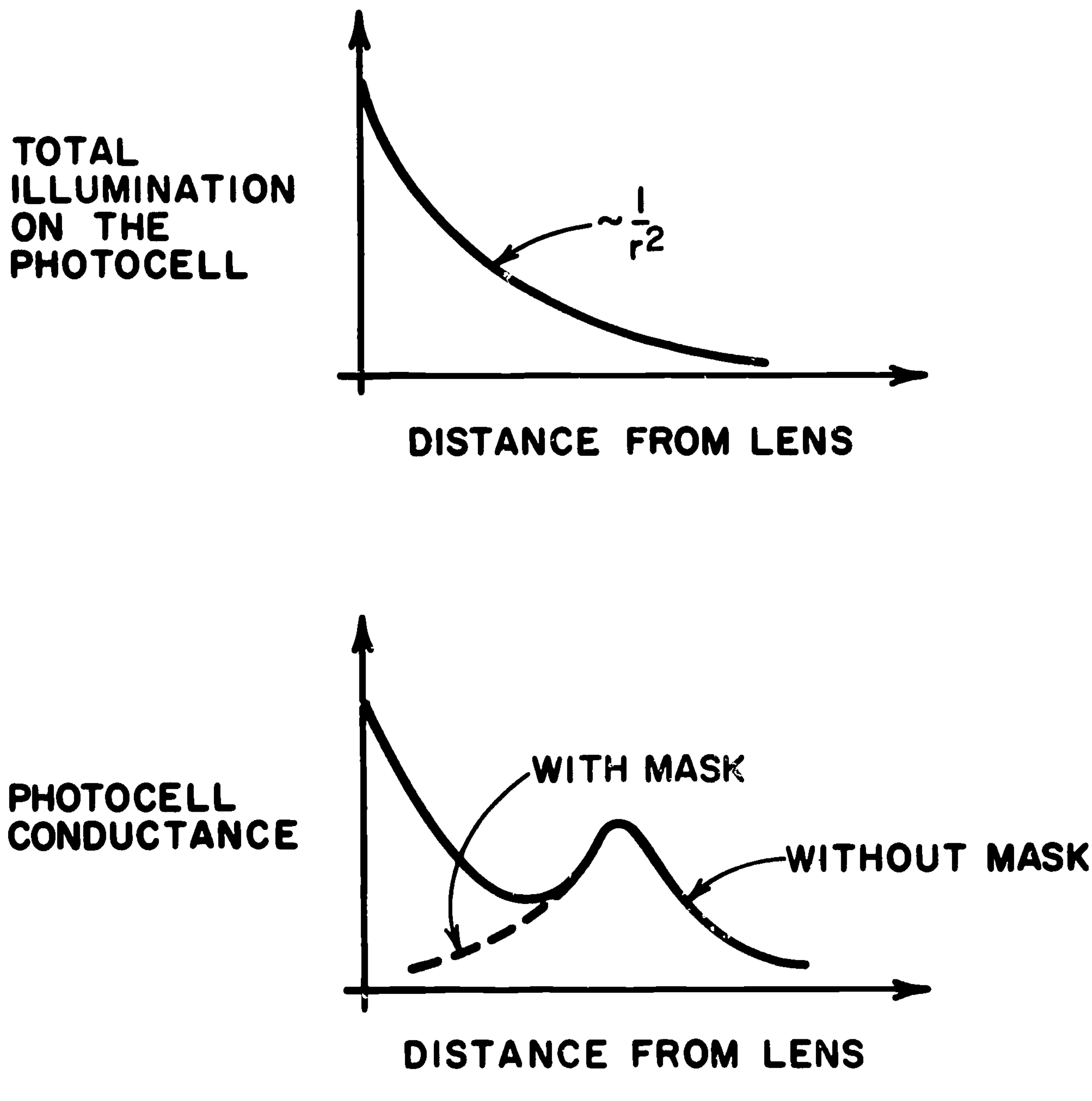

Figure 1. Photocell Illumination and Conductance as a Function of Distance from the Lens.

Typical photoconductive cells are sensitive to illumination distribution as well as total illumination. For example, consider the cell of Figure 2, which consists of a rectangular patch of photoconductive material on an insulating substrate with electrodes across two ends of the rectangle. A given amount of light results

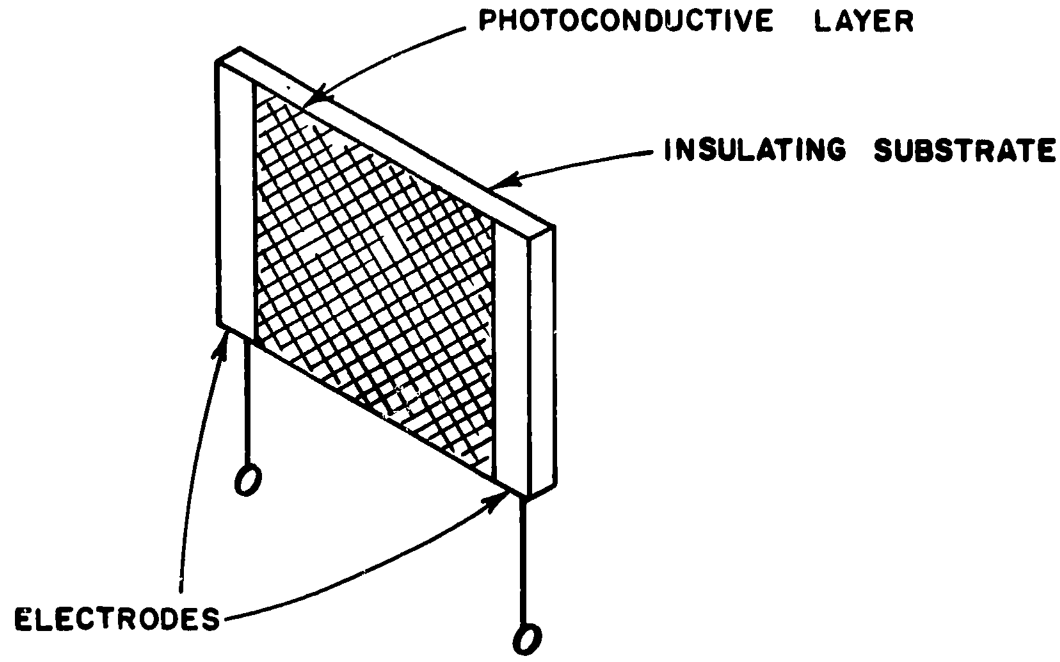

Figure 2. Photocell Configuration.

in a greatly different photocell conductance when uniformly distributed over the cell than when concentrated in a narrow, uniformly illumination bar parallel to the electrodes. This sensitivity to light distribution results from the configuration of the photocell and/or a nonlinear relation between conductivity and illumination for photocell material.

Thus, with a nonuniform illumination field the photocell conductance depends on light distribution as well as total illumination as the photocell is moved away from the lens. Since the light distribution patterns are similar for symmetrical locations on either side of focus, the photocell conductance will have a local maximum or minimum at the in-focus image plane, as shown in Figure 1 (bottom). In this figure a local maximum is shown at a distance from the lens corresponding to the position of the in-focus image plane of an object that is a fixed distance from the lens. For different object positions the local maximum shown in Figure 1 (bottom) will be shifted to the right or left corresponding to the shifts in image position. Whether a maximum or a minimum exists is a complex function of the light distribution pattern, the geometry of the optical arrangement, and the point relation between conductivity and illumination for the photocell material. Analyses determining parallel plate photocell conductance as a function of lens to photocell distance for several ideal objects are given in a separate paper (1).

If the photocell is axially vibrated about some fixed position behind the lens the photocell conductance versus lens to photocell distance function becomes an operating characteristic, as shown in Figure 3. For illustrative purposes only the photo-

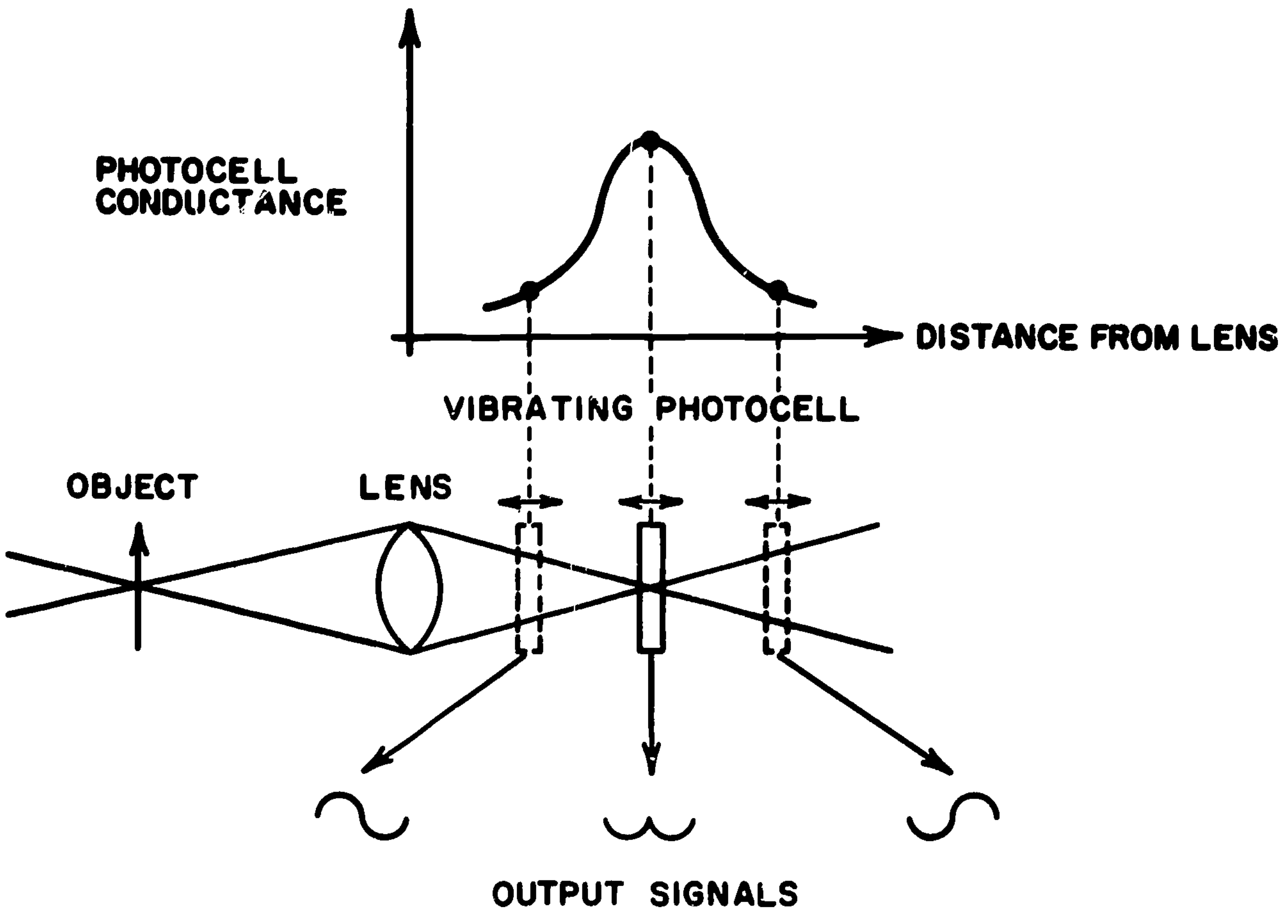

Figure 3. Vibrating Photocell Signals as a Function of Distance from the Lens.

cell in Figure 3 is shown vibrating about three different average positions. Actually the average position of the photocell is fixed and for different object positions the operating characteristic shifts to the three positions relative to the photocell shown. Thus, for various object positions, the following photocell signals are obtained:

> *Region 1:* For near objects photocell conductance varies primarily at the vibration frequency, increasing as the photocell moves toward the lens and decreasing as the photocell moves away.
>
> *Region 2:* For in-focus objects the photocell conductance varies primarily at the second harmonic of the vibration frequency.
>
> *Region 3:* For objects slightly further than in-

focus objects there is a region in which the photocell conductance varies 180 degrees out of phase with the signal obtained in Region 1 above.

Region 4: For very distant objects the photocell signal varies primarily at the vibration frequency in phase with the signal obtained in Region 1 above.

As thus described there is no simple way of distinguishing between near objects (Region 1) and very distant objects (Region 4). However, introducing a mask - an opaque strip parallel to the electrodes between the lens and the photocell - extends the phase of Region 3 to include much of Region 4. The mask reduces the illumination of a strip across the photocell as the photocell vibrates toward the mask, thereby reducing the conductance of the cell for positions near the lens (see the dotted characteristic shown in Figure 1 [bottom]). With this modified characteristic near and in-focus objects can be distinguished easily from distant objects by synchronously detecting the phase of the photocell signal and detecting the presence of a second harmonic in the photocell signal.

THE EXPERIMENTAL MODEL

Figure 4 shows the lens, mask, photocell, and photocell vibrator for the experimental model now being tested. The lens is an F/0.95 16 millimeter camera lens with a 2.54 centimeter focal length. The mask is a black wire positioned so that its shadow

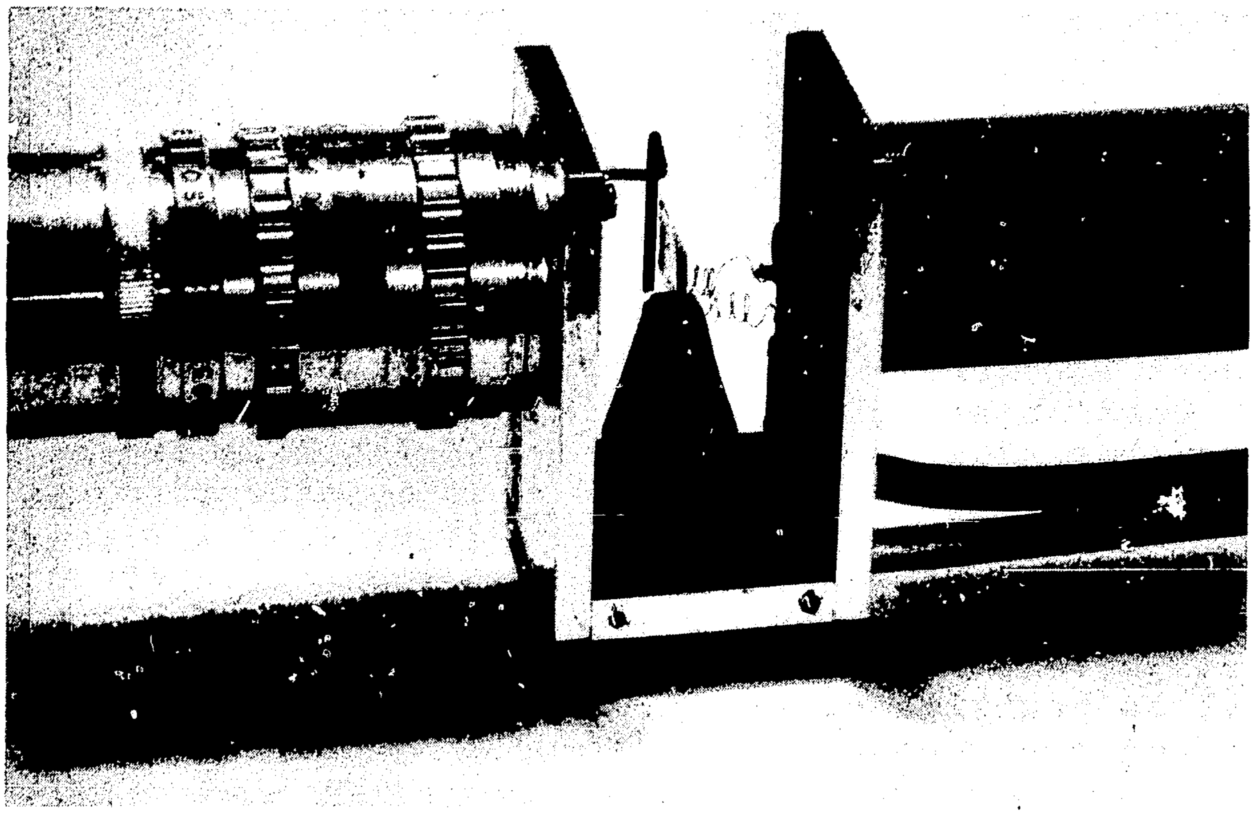

Figure 4. Interior of Experimental Mobility Aid.

falls parallel to the photocell electrodes. The photocell consists of a photoconductive layer of cadmium selenide on an insulating substrate.* The sensitive surface is 1/4 by 1/2 inch. Figure 5 shows the complete system in use.

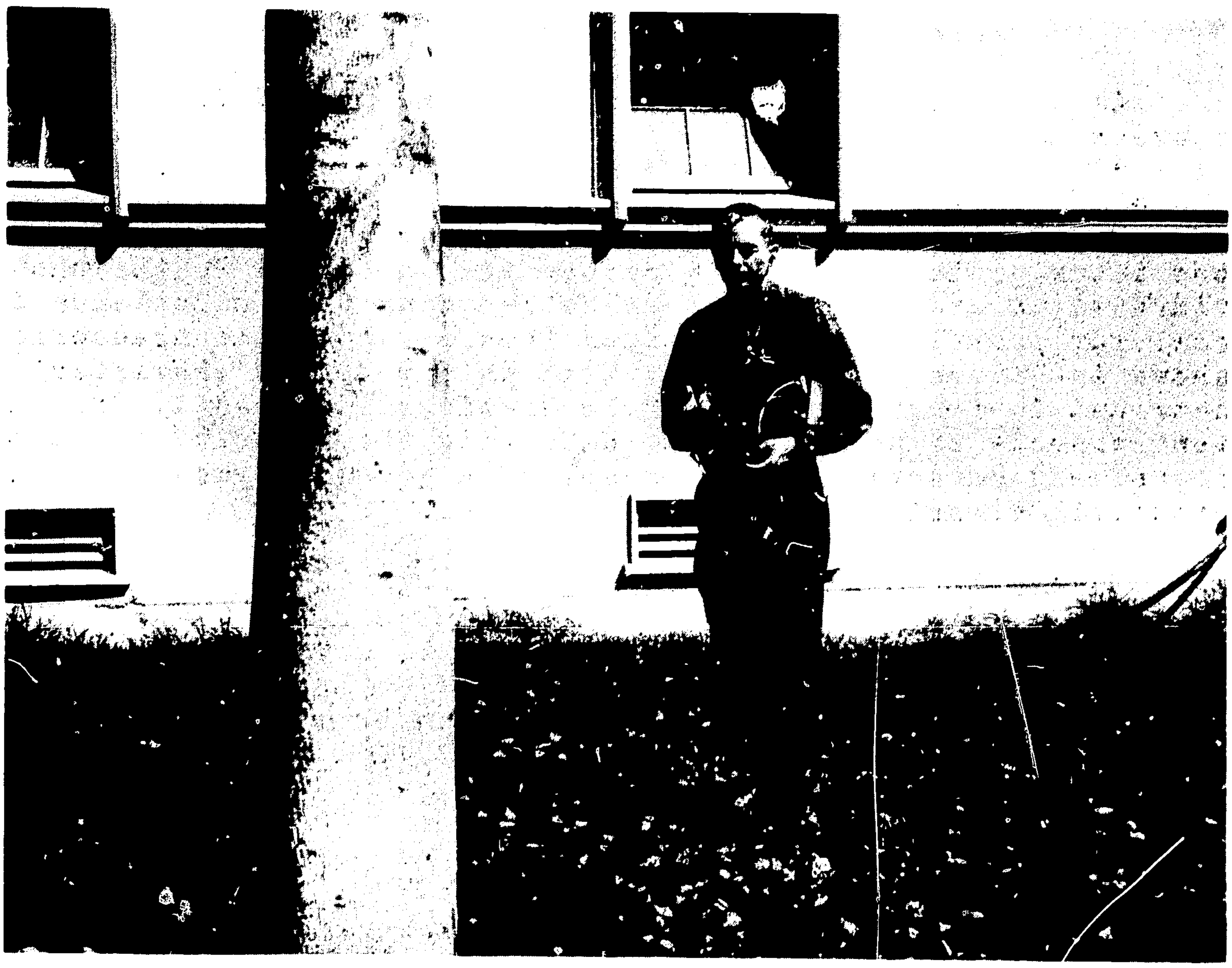

Figure 5. Experimental Mobility Aid.

Figure 6 illustrates actual signals obtained for distant objects, in-focus objects, and near objects, respectively. The electronic system used in the experimental mobility aid to distinguish between distant objects and near objects is shown in Figure 7. The signal analysis circuitry consists of a high gain clipping amplifier, the output of which is gated in synchronism with the photocell vibration, and biased so that only positive signals are passed. Thus, for an output to occur the amplifier signal must be positive at the instant in time specified by the gate pulse and correspond to the phase of a positive signal (from

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* Supplied by Opto-Electronic Devices, Inc., 660 National Avenue, Mountain View, California.

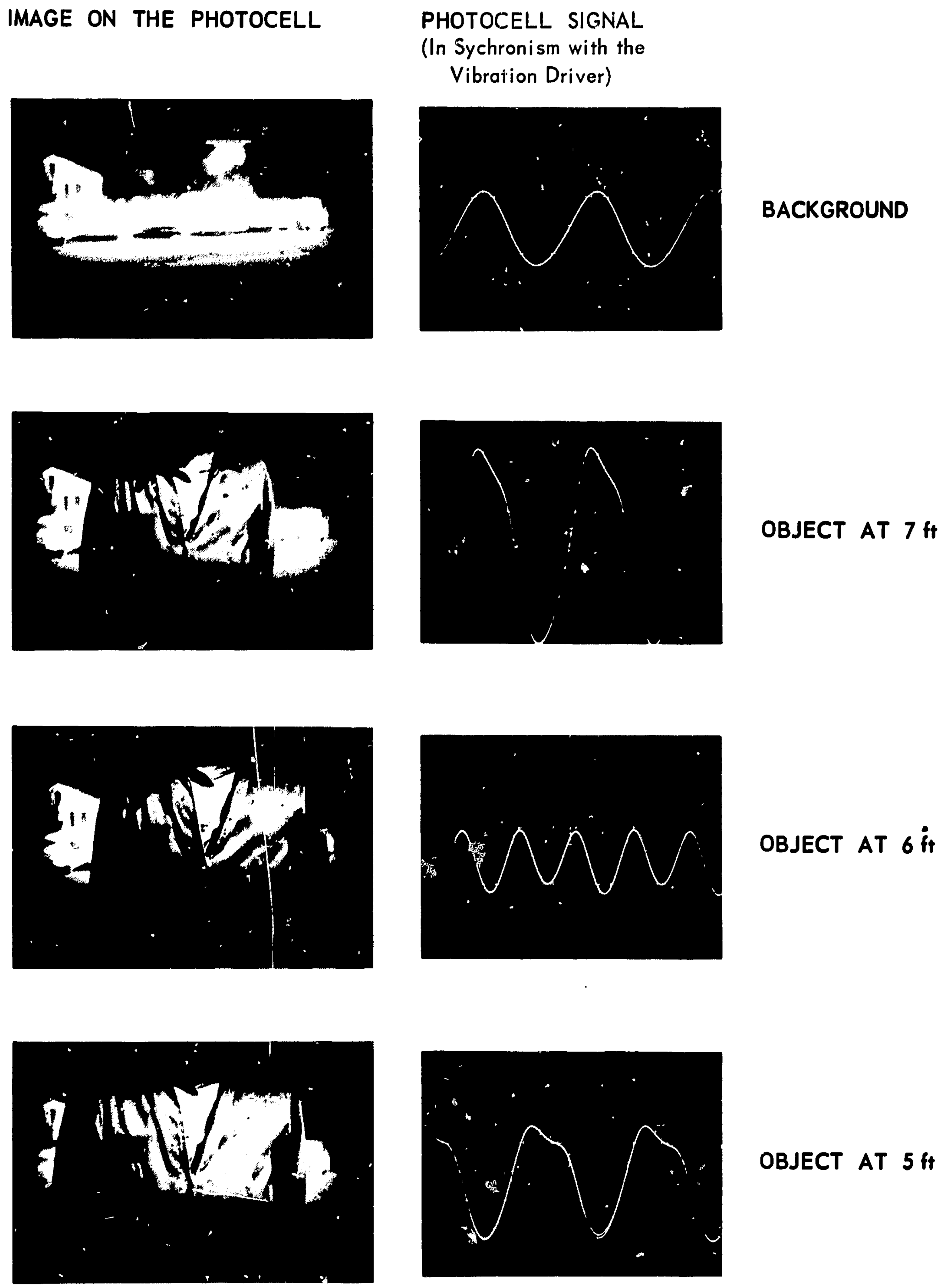
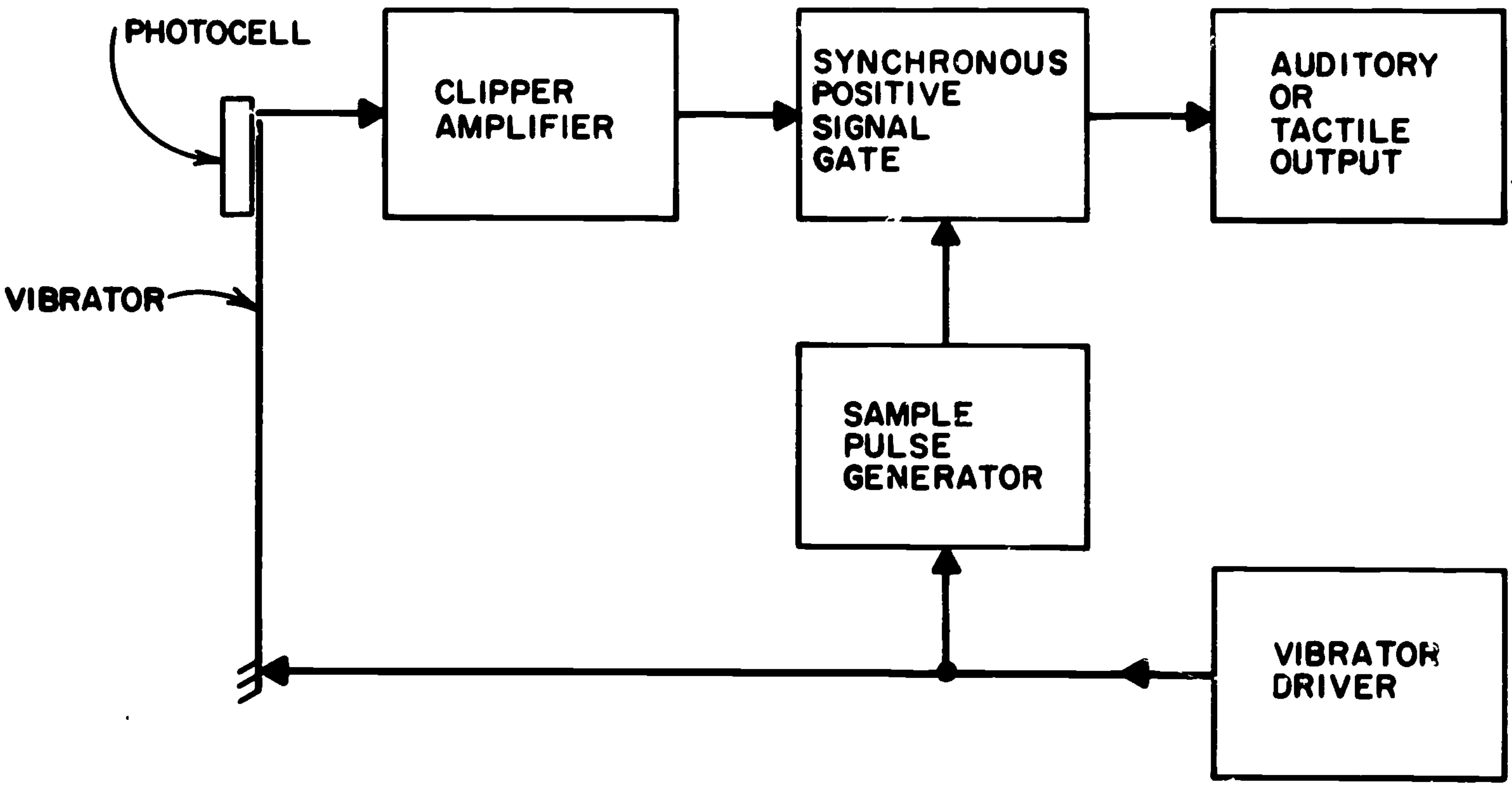
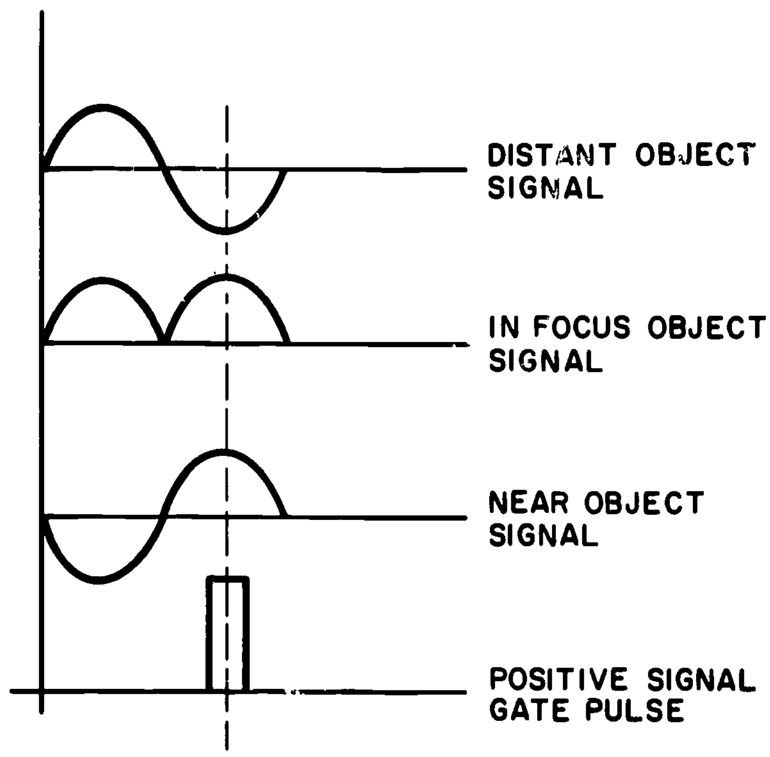


Figure 6. Signals from a Vibrating Photocell for Different Objects. (Lens focussed at 6 feet)



(a)



(b)

Figure 7. Electronic System for the Experimental Mobility Aid.

a near object) or the phase of a positive second harmonic signal (indicating an in-focus object).

The advantage of the clipping amplifier system used over an automatic gain control system is that a rapid response can be achieved over a wide dynamic range of light levels. This electronic system has essentially no delay, the output commencing with one vibration cycle or 5.8 milliseconds after the appearance of an object in the detection field. However, as a result of this rapid response, when the device is rapidly scanned from dark to bright areas, an occasional click is obtained at the output due to blocking in the amplifier.

The amplitude of photocell vibration is such that the range of distance adjustment for object detection is from about 2 to 8 feet.

No attempt has been made as yet to miniaturize the circuits or minimize the power consumption. In the experimental model 13 transistors are used for signal processing and 7 transistors are used in the photocell vibration driver. The photocell is vibrated at 172 cps with a piezoelectric bimorph. Twelve 1-1/2 volt penlight batteries are used and they have a life of about 20 hours with this circuit.

Auditory and tactile outputs are available in the experimental model. The auditory output is a small earphone; the tactile output is a piezoelectric bimorph vibrating against the finger tip. Both outputs receive essentially the same 172 cps signal.

In this experimental model no attempt has been made to make the system operable under 60 cps illumination. While artificial lighting is usually sufficiently intense to generate adequate signals, the 60 and 120 cps components cannot be handled with the present system.

PERFORMANCE

The experimental model has been used to detect people, automobiles, textured surfaces such as grass, asphalt paving with visible granite gravel imbedded in the surface, posts, trees, properly illuminated step-ups and step-downs, crosswalks, and one's own shadow. However, no behavioral experimentation has yet been performed to determine the best way to use the device or to evaluate its usefulness as a mobility aid for the blind.

In operation the device produces an essentially binary auditory or tactile output whenever the field of view has sufficient texture or contrast within the selected distance. The contrast required to activate the device is quite small. For example, a single black electrical cord can be detected against a shady background. Performance is good in both sun or shade with no adjustment of the optics or the circuits.

POTENTIAL IMPROVEMENTS AND EXTENSIONS

The present experimental model demonstrates the feasibility of detecting objects within a selected range with a passive electro-optical technique. While we feel this is already of potential significance, certain relatively simple extensions are worth considering for development into a practical mobility aid. For example, some additional features that could be incorporated into the device are:

1) An additional output could be provided to indicate the dc component of the photocell signal. Changes in light intensity could thereby be determined, from which additional information pertinent to mobility could be deduced.

2) Independent outputs could be provided to differentiate between close-in objects and objects just at the edge of the range, by distinguishing electronically between the phase corresponding to a close-in object and a second harmonic signal corresponding to an in-focus object.

3) By using two photocells at slightly different axial positions two independent ranges could be obtained simultaneously with only a slight increase in electronic circuitry.

In addition to these relatively simple modifications, this range-gating technique could be extended to provide not only object detection but a crude outline of the object shape as well. Since the optical symmetry property about focus is a point function over the photocell surface, we could extend the same system to an array of photocells and obtain an output from each image point in which a contrast boundary occurs within the selected distance. (An alternative approach would be to translate the array of photocells circularly in a plane perpendicular to the lens axis. Then only those cells near a contrast boundary would give an alternating signal.) By coupling each photocell output to a corresponding tactile stimulator, a dynamic tactile image would be formed corresponding to the edge outlines of only those objects at a fixed distance in the field of view.

In order to investigate the ability of people to perceive tactile images of simple geometric shapes or outlines, we have conducted experiments with arrays of up to 96 tactile stimulators. This work is described in detail elsewhere (2). Briefly, we have found that shapes as complex as the letters of the alphabet can be easily learned tactually. In one set of experiments, a blind subject has learned to read at a rate of 25 words per minute from an array of only 32 piezoelectric bimorph stimulators. For the purpose of object edging, as noted above, an array of such stimulators could be arranged, each stimulator being coupled to a photoconductive cell by a simple circuit. Stimulator arrays of this type can be inexpensively manufactured using modern circuit techniques. The demonstrated feasibility of these various techniques should stimulate further study of shape perception as well as object detection for mobility aids of the future.

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TRAVEL PATH SOUNDER

L. Russell
Consulting Engineer
Cambridge, Massachusetts

The writer has designed an ultrasonic probing device intended for use by cane travelers. Figure 1 shows how the instrument is used: it is worn at the chest by means of a neck strap. The device emits short pulses of sound at 40 kc/sec (15 pulses per second), inaudible, of course, to humans. Echoes are received from objects ahead of the user, and their range is established by a time delay measuring circuit within the instrument. When there are no echo

Figure 1. Travel Path Sounder in Use.

producing objects ahead of him within 6 feet the device makes no audible sound. As an object is approached (another pedestrian for example) the detector begins making a clicking sound at the moment the object is 70 inches away. The loudness of the clicking increases according to an inverse range law as the object is approached and until it is within 30 inches, at which time a beeping sound is emitted along with the clicks.

The instrument is intended to complement the cane, not to replace it. There is a substantial segment of the blind population (known as "cane travelers") who use the cane to travel about unaccompanied. This is especially true of those who have received training in cane mobility, i.e., who have learned the educated use of the cane in conjunction with auditory and other cues in a systematized scheme of travel.

The ultrasonic probe creates a "second cane" which is invisible and longer than the physical cane. One immediate benefit is to protect the walker from bumping into objects above the waist that the cane might miss, for example, a low branch or the tailgate of an unloading truck. A second benefit is the advance warning given the user of other pedestrians which avoids the occasional embarrassment of encountering them with the cane. It is hoped (but certainly is not as yet proved) that after some experience with the instrument the user may find it valuable as a general purpose navigational aid, that it will help him find doorways, thread his way through crowds - in short, that it will give him a substantially greater feeling of "contact" with his immediate surroundings and of added protection against the infrequent, but annoying, unexpected collision.

Instrument readout is effected by a tiny loudspeaker at its top. The loudspeaker can be set at low volume so it is nearly inaudible to the passerby and will not make the user feel conspicuous. A fairly low volume setting with respect to ambient noise is adequate for the user since the device is only inches away from his ears. The detector is not itself visually conspicuous since it is small and (hopefully) attracts little more attention than the small camera or set of binoculars often carried on a neck strap by a sighted person.

The use of an auditory readout is not without disadvantages, since anything which occupies the hearing of a blind person engages what may be his most useful remaining sense. What can be said is that the intrusion is kept to a reasonable minimum by avoiding earphones which might mask the normal hearing, and by making the instrument completely silent except when it must warn the user of an object obstructing his path within a prescribed nearby zone.

The cane traveler, by definition, has one hand already occupied, and the writer has felt that the use of the remaining hand for carrying the probe would not be desirable. This has been avoided by chest mounting.

Because street evaluation of the device in its present form has taken place for only a few weeks, it would be premature to say that a mode of operation has been established for its use; yet at least the beginning of an operating scheme is evident. A cane traveler wearing the device for the first time is told that he must use his cane in the accustomed way and detect the presence of nearby walls through the usual "pressure" sensations, that is, he is to discard nothing which contributes to his present mobility. He is told, further, that the instrument remains silent much of the time. When it does start ticking as he walks, however, it means he is approaching something and no longer has a clear path for more than two or three steps ahead. Unless additional cues indicate otherwise, he should turn slightly until the ticking stops and then proceed in the new direction. If the ticking does not resume, he is passing safely by an object, and after it appears that he has gone far enough to clear it he may turn back on his former course.

This scheme will guide the traveler safely around stationary pedestrians, lampposts, parking meters, and the like. The writer's observation of a person using the device is that an illusion is created not of a safety shield in front of the walker, but, curiously, of a barrier placed around each obstacle. For example, as he approaches a bicycle parked against the side of a building he stops fairly abruptly four or five feet from it and then veers around it as though an invisible wall had arrested his travel and deflected him from the hazard.

The beeping sound which occurs when the obstacle is within 30 inches is intended to serve as a fixed inner range mark and warn the user that the obstacle is now only a step away - virtually close enough to touch.

A brief history of this project would be helpful in explaining how this particular range sequence evolved. Mr. John K. Dupress of Massachusetts Institute of Technology has collaborated with the writer in serving as a subject and evaluator for this device. He has been blind since World War II, is a very mobile cane user, and does considerable traveling unaccompanied. The study of mobility devices and other sensory aids has been the area of his professional interest.

In the summer of 1963 Dupress tested an earlier prototype device for some 200 hours; the readout was a series of beeps of pitch inversely preportional to range. He found that the knowledge of absolute range was not available to him in such a display, and that this was bothersome, especially when someone cut across his path at something less than the maximum range.

A more complicated range display was then designed which broke the path ahead into four range zones: clicks for 50 to 70 inches, 4000 cycle chirps for 40 to 50 inches, 320 cycle buzzes for 30 to 40 inches and 800 cycle beeps for 20 to 30 inches. The user, who could readily distinguish the four sounds from one another, thus had the absolute range definition missing in the earlier model. It was found, however, that this arrangement, though it may have solved one problem, created another: the rapid sequence of changing sounds was startling. An object like another pedestrian might pass at close range at three miles per hour and would go through the outer three zones in about one-half second. Even if he passed to one side before reaching the innermost zone, so that no collision occured, the sound of his transit through the outer zones frightened the user.

It was Dupress' suggestion that the outer three zones, 30 to 70 inches, signal the presence of an object by a clicking sound and that the amplitude of the clicks build up as the object moved in from 70 to 30 inches. The build-up of click loudness creates a natural sense of closing rate. At 30 inches the 800 cycle warning beeps begin. This close range warning is considered by Dupress to be a useful - in fact virtually an essential - feature, since it fixes abruptly and unmistakably the instant the user must almost certainly stop, then proceed, if at all, with great caution for he is very close to walking into something.

It is to be emphasized that only a limited amount of testing has been done with the detector in its present form; the routine has been to test for two weeks, make a change, retest, change again, etc. When it appears that the unit is reasonably optimal with respect to sensitivity, beam width, range code, etc., a more elaborate evaluation plan may be worked out.

Although it is easy to theorize, perhaps to excess, about the man-machine communication problem associated with the object detector, a few remarks may still be in order.

A guidance device with auditory display has the purpose, in the writer's view, of enhancing the usefulness of a blind person's hearing. His hearing already provides him with much useful travel information: the obstacle sense to warn of nearby hard surfaces, some ability to echo-locate by finger snapping, the recognition of a pedestrian's approach through the sound of footsteps, and so on. Nature is rather haphazard, however, in delivering such aid. The pedestrian may stand still, or wear sneskers, or a high street noise level may obscure all useful sound cues. Some objects like a parked motor scooter almost never provide auditory cues in time for a walker to stop.

The object detector provides auditory messages to be added to the traveler's natural cues, but unlike the latter the instrument messages are carefully organized, metered, and tailored to a very specific travel area.

The device echolocates with much greater sensitivity than the unaided user because it uses high power and a short wavelength to detect smaller and more distant objects. It focuses its attention on the forward direction only and timing circuits exclude from its presentation echos from further than six feet, there being, consequently, fairly precise and dependable bounds on the volume under scrutiny. A limiter in the circuit trims all echos to a uniform level and the warning that diverts the walker from a bicycle handlebar is the same as that for a lamppost or brick wall. All hazards are considered equal, if any object is detected at all the traveler should be warned. He should not have to strain his hearing to perceive the close, small objects which may be as dangerous as the larger one further away. The 30-inch warning sound is instantly recognizable for it must define the moment a high object is a specific distance away with the same dependability as the cane detects the step or curb.

It is clear that gathering information is one part of the detector's job; processing it for display is the other. In the late 1940's, the gathering or acquisition of information was a substantial technical problem and it was not uncommon to hear the relative merits of optical, ultrasonic, and infrared probes debated from the standpoint of their sensitivity resolution, etc. By now, however, that part of the problem appears to have been solved substantially and it is the cybernetic function that appears the more formidable. This is not a novel observation; it has become clearer and clearer to most workers in this field. The instrument grasps the picture - how do we get it to the man?

The present instrument does fairly extensive processing of the received data - "codifying" might be a more meaningful term - before displaying it. The output sounds are only two in number and contain almost no quality or character that could provide additional information. All complexity and fine structure are stripped away, and the instrument communicates only by these several sounds. The writer calls this a language system, for the display consists of a language of certain discrete sounds. In direct contrast to this system, is the analogue system which presents the entire "environment picture" or analogue thereof and counts on the user's hearing to sort things out, categorize nearby hazards, and the like. The analogue system strips no information from the acquired data; the language system strips away almost all of it. It is a question of giving either the headlines or the text.

The instrument thus may perceive a complex echo pattern but gives the user only a beep when an object is very close. Is it right to deprive him of other information which is there for the taking? Indeed, the beep doesn't even suggest whether the near echo is more likely to come from a wall or parking meter. Yet we may have done the user a service of sorts, for we have not taxed his hearing. He has not had to strain to perceive that something was within the critical 30-inch boundary. He has not had to slow down to study a complex sound and decide whether he must change direction. The language system approach, in short, appears to offer speed, freedom from strain, and a minimum of interference in hearing natural sounds.

A MOBILITY AID FOR THE BLIND

G. Chardon
Consulting Engineer
Druten, The Netherlands

Our present technical knowledge allows us to construct many elaborate instruments which enable the blind to communicate. But if one wishes to give mobility to the blind person, one is confronted with quite another problem, for being blind means not only that one cannot see light, but also one major information channel to the brain has disappeared. The eye is, in effect, part of the brain and cannot be replaced by any other organ. We must be prepared to accept the fact that any guide, no matter how elegant, can give to the brain only a very small part of the information that is collected by the eyes.

Now it is very easy to design a guide which will detect objects, but it is very difficult to find means within the design to to tell the blind user all the facts about those objects. If we assume that obstacles are distributed in space around the blind person at equal mutual distances, it will follow by simple mathematics that their number increases with the third power of their distance from him, i.e., the third power of the range of the guide. This fact prompts the remark that any guide must contain some means of discrimination so that a division can be made between necessary and unnecessary information for the user. Since it is impossible to provide the blind person with all the information in the environment, we must content ourselves with giving him that information which is of vital importance. This means, first of all, giving information about obstacles in his path. It means also some way of enabling him to find his house, or a street crossing, or a bus stop, or (in a building) a specific office, without difficulty.

The principle of the device is not new at all. In its simplest form there is an oscillator which produces such a frequency that the wavelength of the radiated wave beam is in the order of one or two centimeters. The velocity of propagation is not important: sound waves, ultrasound waves, or radio waves are all suitable. The wave is reflected from an obstacle, if present, and is heard again at the device output. There is thus, in the presence of an object, a distance reaction resulting in a two-way coupling between sender and receiver - direct coupling electrically. Depending on the length of the wave, the resulting coupling will vary from maximum to minimum, and will differentiate the distance to the obstacle by half a wavelength. A small movement of the guide, a half-centimeter for example, is sufficient to tell the guided person that there is an obstacle in the direct vicinity.

At large distances the noise disappears, for the detection path becomes equivocal. At near distances, the Doppler principle provides the means for the signal heard by the user. Owing to the relative motion of the emitter and the object detected, the emitted wave and the received wave do not possess the same frequency. Both enter the device and the resulting beat frequency reveals to the guided person that an object lies ahead.

This holds true only if the user approaches an object. If both maintain the same distance - as when walking with other persons who are maintaining the same speed of walking - no signal is generated to the user. Nor is one necessary in this case, since no collision is likely. Should someone stop, however, and thus present an obstacle, a beat signal will be generated.

The present instrument uses sound waves, but I hope soon to achieve better results with radio waves. It would be possible to use them now; in fact our police forces employ similar instruments for speed control. As yet, however, the equipment is large and cumbersome.

In one experiment which I conducted using higher frequencies than those in the present unit, the whole apparatus was built into a pair of spectacle frames. In this unit, the eyeglass lenses are removed and replaced by perforated metal discs. Ultrasonic waves pass through the discs with little attenuation. A beam width or aperture of about 20 degrees can be realized easily.

I regard this improved model as a real step forward. With the device it is possible to estimate the distance to an obstacle with fair accuracy. The best solution to the problem is, however, as yet uncertain.

Another device has been developed in conjunction with the guide to help solve the problem of finding a specific house or crossing a known space with accuracy. To achieve this we have designed a small sound source which acts as a "marker." This device can be mounted at any desired point. The pitch and interruption frequency of the marker can be varied in many ways so that one marker is not mistaken for another. The "beeping" sputnick-like signal of the marker can be distinguished easily from the beat signal normally produced by the mobility aid. The current consumption of the device, at about 0.01 volt, is about 1 watt, but of course the energy consumed depends on the desired range of the device. Ultrasonic frequencies suffer much absorption in the air, and therefore one cannot expect to achieve long ranges with these frequencies in the marker. On the other hand, small beam lengths are necessary to avoid a walking speed that is too fast for the blind user. We can have a narrow beam and much better separation by using slow lead times. For this reason, we expect much improvement using radio waves.

There are two ways to achieve a favorable beat frequency. One is to emit a slow beat note, the other is to increase the guided person's walking speed. As you know, this latter solution is a very happy one.

Now a short note on results. It is imperative, in my opinion, to realize certain improvements in the device. Some I have mentioned already. Certainly we should conduct trials on a much larger scale so that we can avoid disappointment of blind users, who are often inclined to expect too much of these instruments at first. Very good results have been obtained using the simple device I described above using sound waves; even better results are obtained using the spectacle type of guide. In some trials we have run, a number of blind persons were soon able to walk at a normal pace without mishap in a room space in which several obstacles were arranged. Some felt the earphone was a disadvantage (as you would suspect), and we are working to eliminate that complaint. The spectacle type of guide seems to me to be the most happy solution to the problem, for the normal range of hearing is retained without distortion, while the ultrasonic beat signals are heard with a gain of one and without a phase difference.

It is my opinion that a blind user wearing the spectacle frame device could set out for work and return to his home without other aid, especially if critical points of his route were laid out with the markers described above.

In summary, I would say that one of the most important features of the instrument is that it automatically differentiates between moving and stationary objects. The moving object is detected while the stationary object is not. This may be important in such tasks, for example, as crossing highways - if it would turn out that the capabilities of the user permit such a use of the guide. The aid itself can also be moved to detect stationary objects. There is thus a built-in data reduction system which presents selected and useful information from the environment to the user.

THE FAMILIARIZATION OF THE BLIND WITH THE VISUAL CHARACTERISTICS OF SURROUNDING OBJECTS BY MEANS OF PHOTOELECTRIC DEVICES EQUIPPED WITH A SOUND SIGNALIZATION

Rostislav Muratov
Typhlotechnical Laboratory
Institute of Physical Defect
Sverdlovsk, USSR

The exclusion of an important means of communication with the enviornment from the activities of man's life such as sight causes the blind to be considerably limited, compared to the seeing person, in using the familiarity with visual characteristics of surrounding objects independently, as well as in his reaction to the environment on the basis of this knowledge.

In his everyday life, the blind person has to be satisfied with information on the visual characteristics of objects received mostly from the words of those who are able to see and, only to a small extent, from other senses still in his possession. Thus, for example, the blind can be informed about an electric light being lit through the heat he can feel when he brings his hand close to the lamp, but for information about distant objects he must turn to a sighted person.

The conceptualizations of the blind of phenomena occurring in the world around them are much poorer than the sighted in many respects because of this lack of visual information. In general, visual information includes information about the presence or absence in a given direction of a bright or dark object, the relationship between the degrees of brightness of different sections on the surface of an object, the location of the edge between these sections, their location in relation to each other, their relative sizes, and also the color of the object.

Nevertheless, it is possible to extend the potentialities of the blind individual to receive independent information on the visual characteristics of objects by placing at his disposal technical devices imitating the elementary functions of the eye. In order to create such equipment it is necessary to examine vision from the physical aspect, considering it as a process of reception of a number of signals indicating the amount of light entering the eye from given directions. This simplification of the idea of vision is permissible for the purpose of creating a model of the visual process by mechanical means.

It is necessary, first of all, to find a mechanical means to react to visible light somehow, then to find a method of registering the direction of the light in relation to the body of the user.

Modern technology has at its disposal many types of electric devices that change parameters under the influence of light. Among such devices are the so-called photoconductors which, under the influence of light, change their electrical conductivity. If a simple optical system (e.g., a simple positive lens) is put in front of the photoconductor (which imitates the crystalline lens of the eye), this combination would represent the most simple model of an eye. It is capable of reacting to light by changing the amount of electric energy originating in the photoconductor and the source of electric energy which can activate a sound, or a tactile stimulator, which by sound or vibration can notify the blind user of a certain amount of light entering the "artificial eye."

The direction of light is inferred from the sensations occurring in the muscles of the hand directing the device at the object observed. It is possible to achieve a high degree of accuracy in the aiming of the device.

In many cases it is not only desirable to get information concerning the presence of an object in a given direction, but also to judge its brightness against its background. This is possible if the device is equipped with an audible output signal whose pitch depends on the brightness of that point in space toward which the device is directed. A bright object would be identified by a high tone of the signal, and a dark object by a correspondingly lower tone. Such a signal can be obtained in a more complicated device through the addition of electronic circuitry. Using transistors, other small parts, and compact batteries as components, it is possible to reduce the size of the device to that of a pocket flashlight.

A portable photoelectric detector for the blind, with a changing tone signal output, named the *phonoscope*, has been designed by the author at the Sverdlov Typhlotechnical Laboratory of the Scientific Research Institute of Physical Defects of the Academy of Pedagogical Sciences of the RSFSR.

Figure 1 shows a diagram of one of the versions of the phonoscope. The device has two alternative light receivers. The first (with lens) is used for the observation of remote objects and of objects so large that it is impossible to examine them in a single simultaneous sweep. The second receiver contains light conductors made from organic glass and is used for the observation of small objects by direct contact.

The use of the phonoscope is very simple. After pressing the

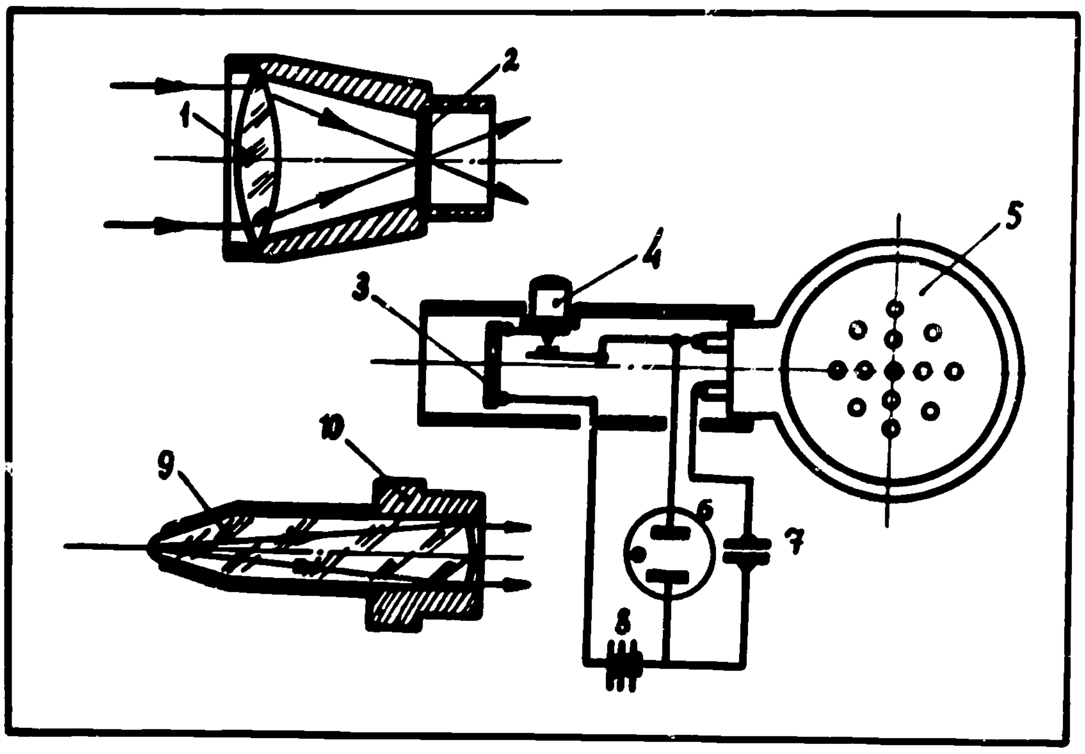


Figure 1. Diagram of One of the Versions of the Phonoscope. 1) Lens of the Objective of the Light Receiver Used for Observation of Remote Objects. 2) Diaphragm. 3) Photoconductivity. 4) Stop Switch. 5) Piezoelectric Sound Source. 6) Neon Lamp. 7) Constant Capacity Condensator. 8) Electric Charge Battery of 60 Volt. 9) Light Conductor of the Light Receiver for Touch Examination of the Object. 10) Case for the Light Receiver.

start button the device is directed by hand toward the object to be observed. First, in order to determine the location of the object, wide swings are made through the air by the arm holding the device. Then the shape of the object is outlined by small zigzag movements.

When the line of sighting is displaced from the surface of the observed object to a background of different brightness, against which the shape of the object is projected, the pitch of the sound signal changes accordingly. Similarly, when aiming the device at a dark section of the surface of the object, a lower tone of the signal is heard and vice versa.

A consecutive scanning of all points of the surface of the "observed" object is possible by systematic movement of the hand of the user.

The principle of hand scanning, on which devices of this type are based, permits a detailed examination of the surface of objects, estimating the brightness and other visual characteristics of an individual object, as well as determination of the sum of relative locations of objects in space. In this way the blind user armed with the photoelectric device is capable of imitating some functions of the eye, and mobilizing his hearing and his motor senses. However, as practice has shown, equipping a blind person with this device for his independent use without a preliminary, methodically organized training has always led to unsatisfactory results. After receiving such a device and trying to use it independently for the first time, the blind person finds himself swamped with a number of signals. He is not capable of analyzing them consciously when several objects are present. In order to use the device without assistance, some preliminary training is necessary in the handling of the device, as well as in the differentiation and understanding of the signals.

Our conviction concerning the possibility of forming images about visual characteristics of objects by the blind with the help of photoelectric typhlodevices, based on the principle of hand scanning, was conclusively confirmed by a series of experiments. When the program and the sequence of the experiments was being planned, it was necessary to consider the lack on the part of the subjects of any knowledge of how to use these devices, as well as the different degrees of difficulty in solving the selected problems. As a result, the sequence of experiments was established in accordance with the principle of "from simpler to more complicated" problems, and with the intention of using the experimental process for the creation of efficiency in operating the devices.

The great variety of problems in the life of the blind naturally could not be offered to the subjects during the experimental period. For this reason we have used the method of selecting elementary components characteristic of all problems of a practical nature to be solved with the help of the phonoscope.

It is possible to reduce these simple problems to a comparatively small number of exercises which are solved in the same manner in different fields of activity. Using this method it was possible to substitute a great variety of real objects by a limited number of special test objects which imitated real objects by having the same visual characteristics.

The choice of the shape of test objects used in experiments (see Figure 2) has been dictated by considerations based on the assumption of presence of these elementary forms in the shapes of all real objects in the environment.

Vertical lines, horizontal lines, tilted lines of different intersections, curvilinear and rectilinear outlines of different sections of the surface of objects determine, in their totality,

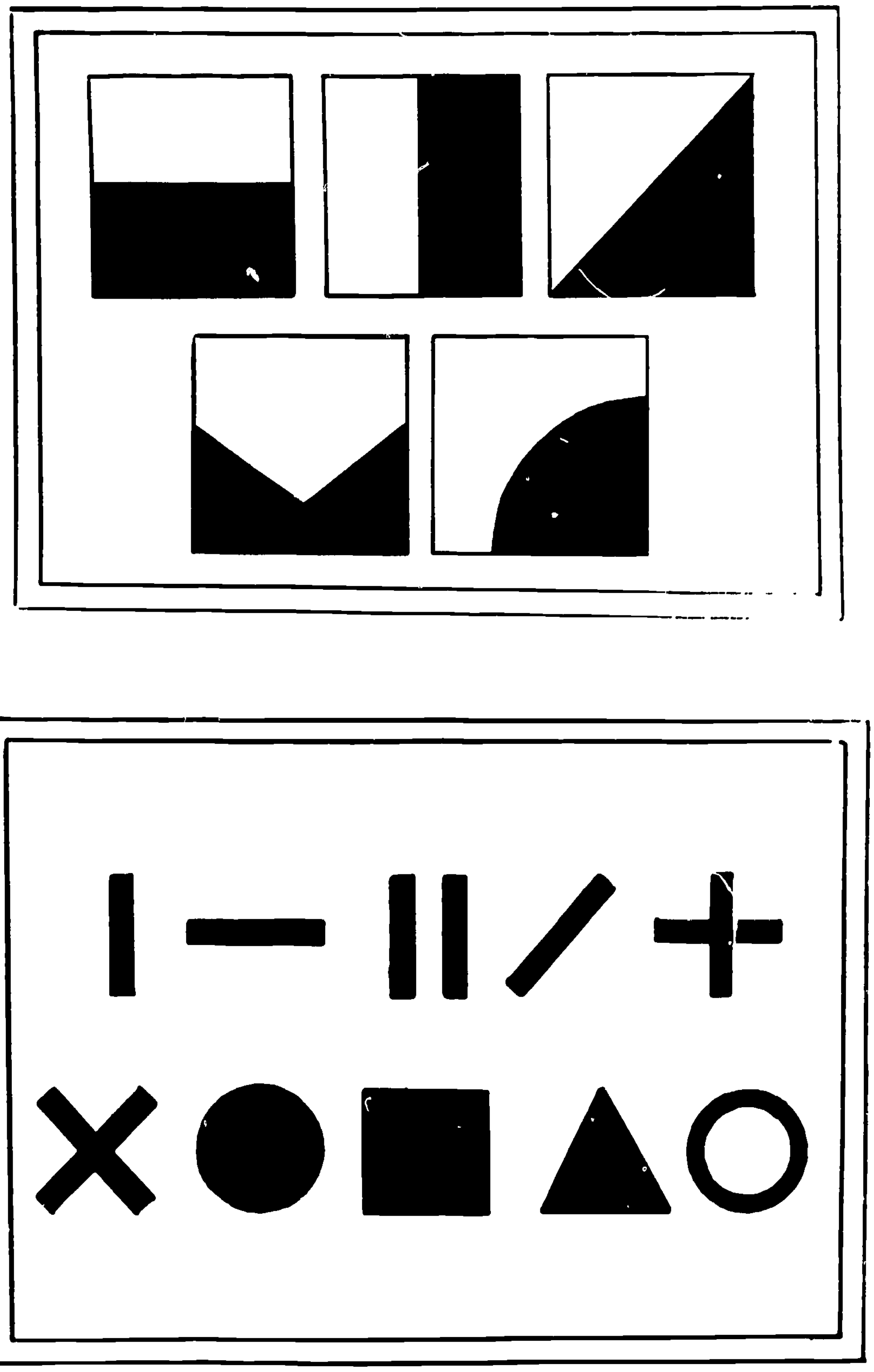


Figure 2. Shapes of Test Objects Used in Experiments.

the shape and characteristic differences typical of every concrete observable object.

It is our opinion that the ability to recognize all the test figures determines the possibility of recognizing all the complications of their combinations. The maximum purity of the experimental figures is guaranteed by the process of abstraction of test figures from real objects.

A training of participants in the manipulation of the device was carried out along with the experiments. Before each experiment, familiarization of the subject with the models of figures by using the sense of touch was conducted. In this way the process of familiarization with a figure is reduced to a relatively simple comparison of its tactile image formed as a result of touching the contours of the figure with the idea of the locations of bright and dark sections on its surface which are indicated by the changing pitch of the audible signal from the device.

An extremely important skill on which the successful solution of the whole problem depends, is developing precise coordination of the direction of aiming the device in relation to the body of the person using it. To determine the accuracy of aim at a remote object we shot a pneumatic sport gun at a lighted target. The gun sight was replaced by a photoelectric receiver and tone generator (see Figure 3). The lighted target is made much the same way as a regular shooting target, but it has an opening in the rear center in which a lighted electric bulb is placed; the bulb protected from the bullet by a thick glass plate.

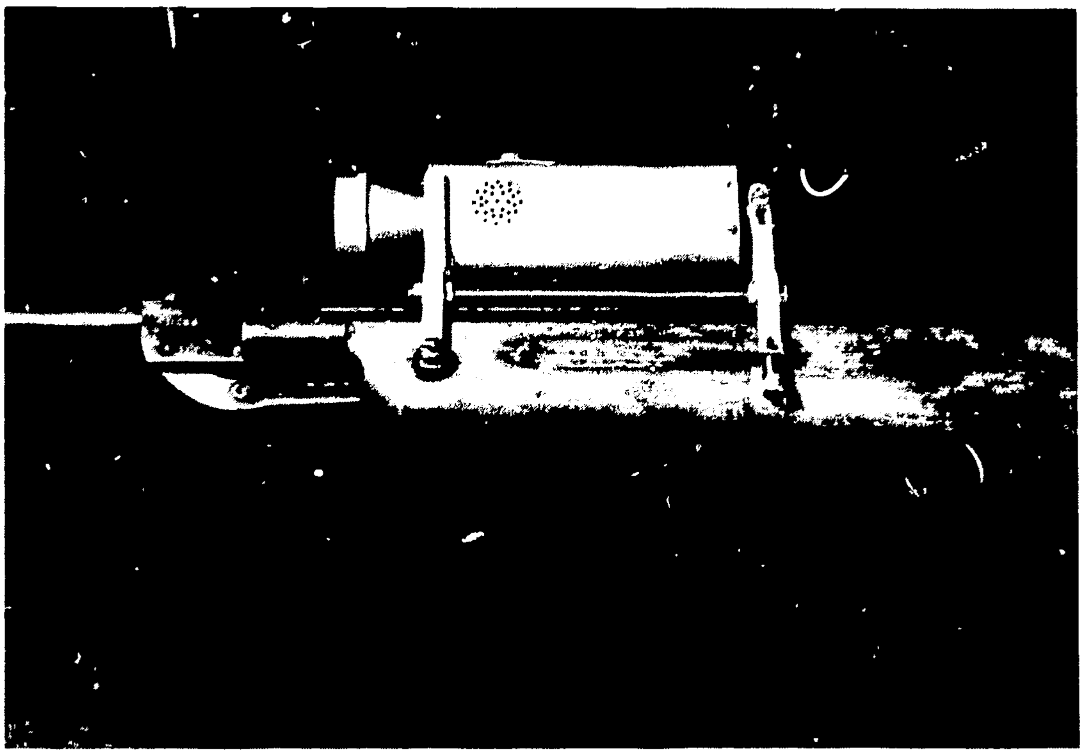


Figure 3. Photoelectric Receiver and Tone Generator Mounted on Air Gun.

This gun with photoelectric sight, aside from its purely sporting interest, has great value as a device to permit the blind to develop the habits of coordination mentioned above. The details of these experiments are contained in a paper by the author already published and will not be repeated here.*

Briefly, the conduct and content of the experiments were as follows.

The first and basic problem in orientation by visual characteristics is to determine the presence or absence of a bright or dark object in a given direction. The practical significance for the blind person is not so much this fact itself as the use of this information for further action (for example, to select the direction of movement).

The one-to-one correspondence of the brightness of surrounding objects depends also on the blind person's ability to form images of the total distribution of bright and dark sections on the surface of the object, with an evaluation of the relative brightness of each of its sections. Ideas formed regarding the relationship of the brightness of different sections on the surface of the objects cannot serve as the sole ground for formation of an idea of brightness of the objects. It is necessary, also to form an idea of the length and location of the several bright sections of the surface. The characteristic brightness of an object acquires authenticity and concreteness only when taken together with the information about the configuration of these sections and the location of the borders dividing them.

To form a more complete idea of observed objects, it is neccessary to judge these objects accordingly to relative size. Because this is so, the question arose: what is the usefulness of typhlodevices for the comparative measurement of objects by angular dimensions and by length?

In addition to the solution of theoretical aspects of the problem described above, a further refinement in the use of the devices by the subjects took place during this series of experiments. Experiments have shown that the tactual and distant interpretation of object location is carried out by the blind with the photoelectric typhlodevice with complete reliability and, according to our current estimates, with satisfactory results for all practical requirements.

In many cases, in order to form an idea about the shape of the test figure, it was enough for the subject to recognize the

* Izvestia APN, RSFSR, Vol. 90, 1957.

presence of one characteristic of a familiar figure, the exposure of which was enough to form an instantaneous recognition of the whole figure. Evaluating the practical aspect of the experiments, it is possible to assert in principle that the completion of the series of tests offered to the subjects will make it possible for them to solve many concrete cognitive problems arising in the everyday experience of blind persons.

In daily life a blind individual gains experience while orienting in his environment. He perfects his methods of orientation and develops a minimum exchange of necessary information about the environment. A systematic development of these habits of orientation is highly important. This condition is satisfied to a large extent, by programs of education and training for blind children.

The development of habits and training in orientation through a most systematized and methodically based system is represented in the school program for geography. As a result of the creative efforts of theoreticians, as well as those engaged in practical teaching, efficient methods of teaching and a rational sequence of presenting the educational material had been worked out. Yet, in spite of this, many individual features of presentation of educational material can be reorganized and improved by the introduction of photoelectric typhlodevices into the teaching of geography. New information of a visual character is opened to the blind student and this will lead to a better assimilation of educational material.

To prove these assertions we have conducted a series of experiments in the use of photoelectric typhlodevices in micro- and macro-orientation in some sections of the geography program. The sequence of presentation of practical problems was maintained in the new test program, to prevent blind pupils losing confidence in their knowledge of handling the device. The principle of gradual complication of problems and their understanding, even with the introduction of new elements, was used as a basis in preparing the test list.

Following is a short description of tests which brought particularly interesting results. Foremost to deserve attention is one of the tests carried out indoors - a test to determine the possibility of the blind student reading a contour map.

The way we see it, the main importance of this test is not in an absolute recommendation of the use of the photoelectric signalizer for the reading of geographical maps by the blind, but in giving the blind the chance to interpret a specifically difficult object situation, represented by conventional signs on paper, i.e., to decipher a complicated picture and a drawing inaccesible by touch.

An ordinary school map of the European part of the USSR with the scale of 1:15,000,000 (see Figure 4) was used as the test object. On the map, in India ink, were drawn the White, Baltic, Black, Azov, and Caspian Seas; the Volga with the Kama river, and its tributary the Tchusova; the rivers West Dvina, Neva, Svir; the lakes Ladoga and Onega; and White Sea - Baltic Canal. The cities of Moscow and Sverdlovsk were shown as dots on the map.

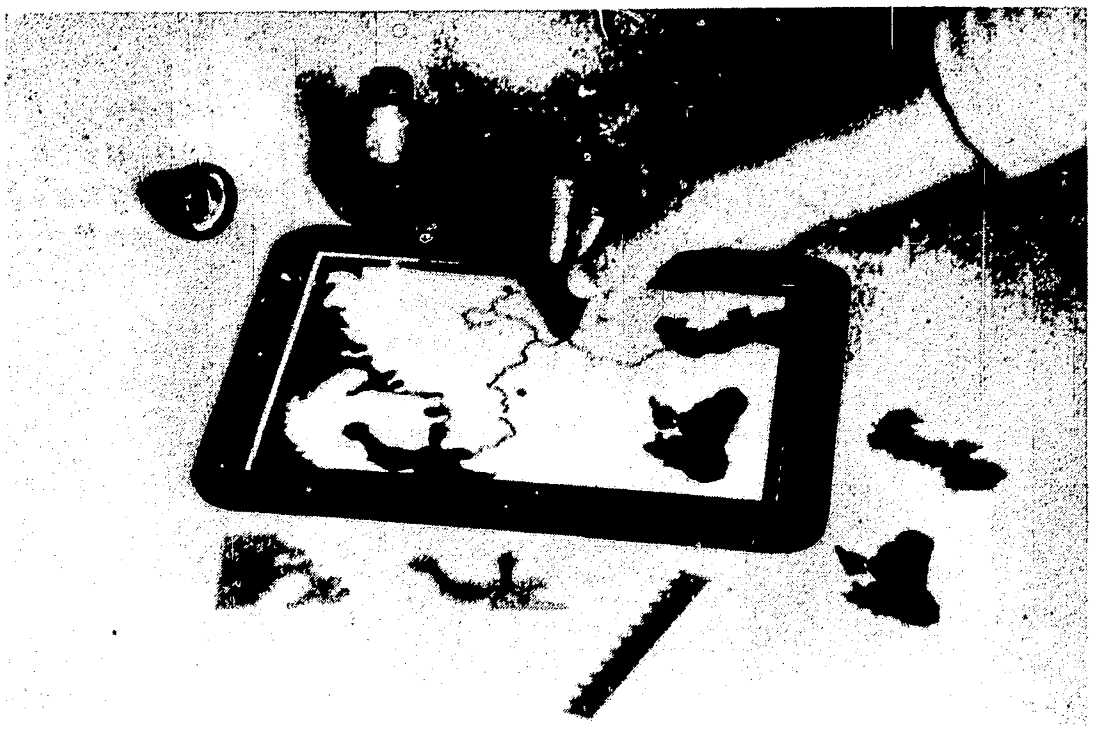


Figure 4. Student Scanning Map with the Photoelectric Signalizer.

The map was given to the student in a holder with a transparent top made of a thin cellulose film. With the help of the photoelectric signalizer, equipped with a headpiece for the audible output, the test subjects (who were the pupils of a school for the blind who had not previously studied geography) scanned the whole surface of the map. They determined the shape and the location of the seas, moving from the Black Sea to the Caspian, then along the rivers to the Baltic, and from there through the lakes to the White Sea. The pupils were then given shapes of the seas cut out of metal, and asked to put them on the surface of the map according to the picture of the seas drawn on the map. One of the most accurate solutions to the problem is shown in Figure 5.

On the same map the student, with the help of a brailled scale rule, measured the distance between the cities of Moscow and Sverdlovsk, after he first found their positions with the aid of the photoelectric device. The best time for this problem was 18 minutes.

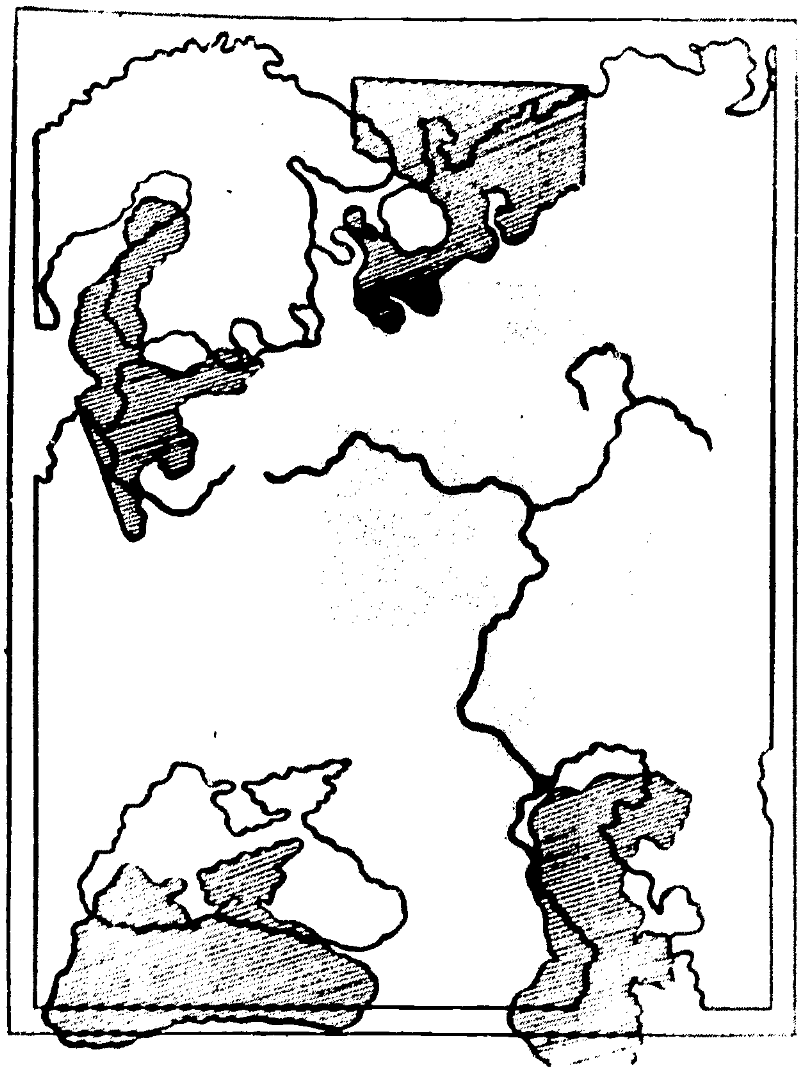


Figure 5. Shapes of Seas Placed over Map with Aid of Photoelectric Signalizer by Blind Test Subject.

The successful execution of this test by the blind shows that although covered by a transparent barrier and, therefore, inaccessible to tactile perception, the pictures and drawings are identified with the photoelectric device without any difficulty.

Much more difficult, but more important from the point of view of results obtained, is a test conducted outdoors to determine the possibility of the blind describing the shape of a remote object, which could serve as reference for a subsequent sketching of this object.

The aim of the test was to determine the practical use of photoelectric typhlodevice in finding one's bearings on the ground. The purpose of the test was to determine the possibility of recognizing the selected object, and singling it out from the surrounding objects. As a matter of fact, this requirement for orientation meets the necessity of recognizing the object which serves as a reference point through its visual characteristics, inasmuch as its acoustic and tactile observation is excluded.

The requirement of the task was to recognize a given object at a distance of 50 to 60 meters, and to determine its shape. A large enough object in the surrounding area (tree, building, etc.) was chosen as a reference point. In order to fix the obtained image of the shape of the object, the blind observer drew on paper the shape of the reference point in the form of a raised drawing.

The accuracy of the conception of the shape of the reference point was determined by comparing the drawing with a photograph of the object. Figure 6 shows an object chosen as a reference

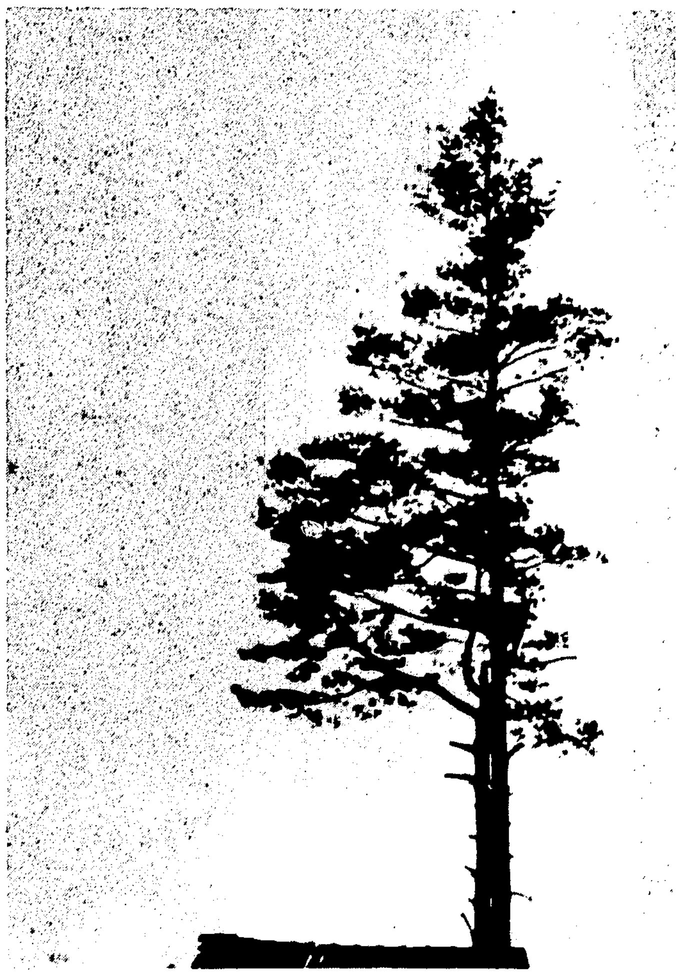


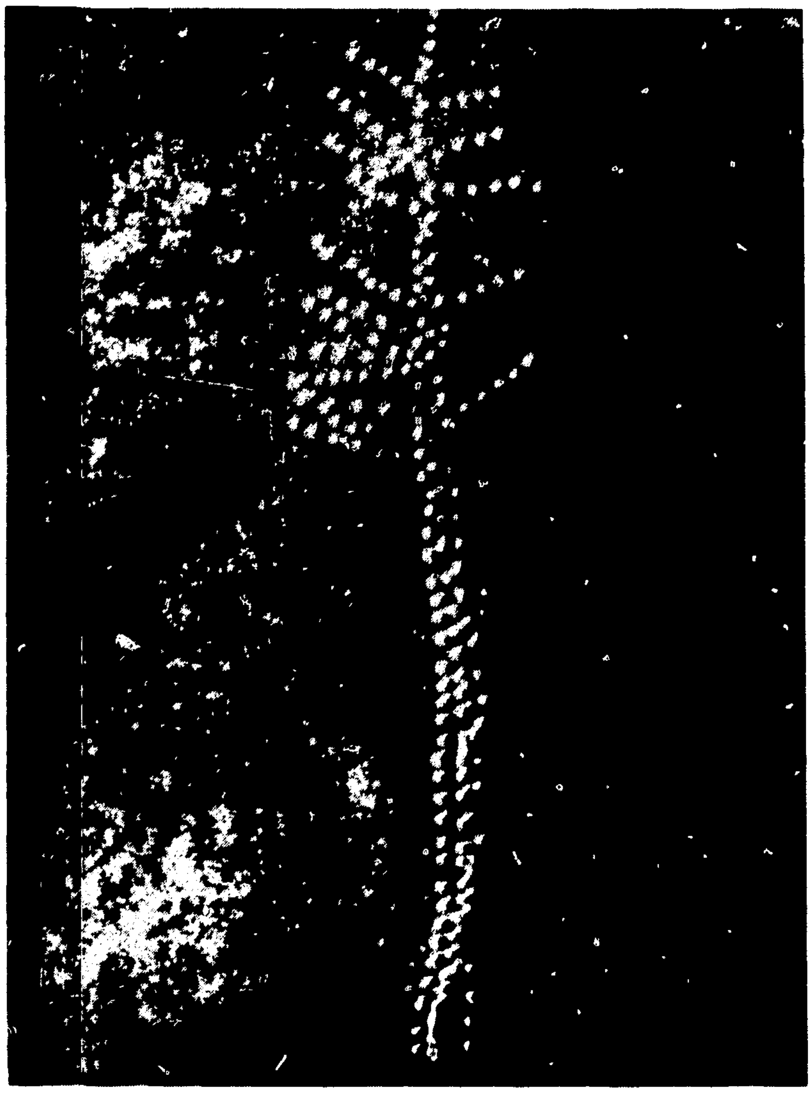
Figure 6. Tree Chosen as Reference Point for Outdoor Test of the Photoelectric Signalizer.

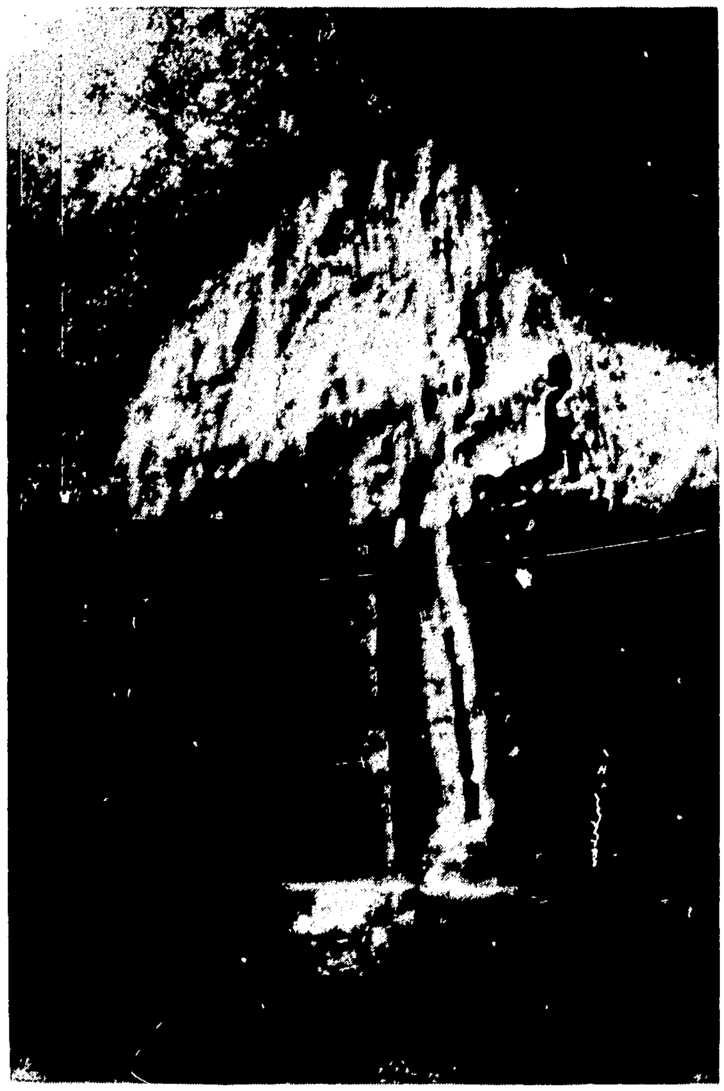
point - a lone standing tree - and Figures 7 and 8 show the drawings of this object made by the blind.

The accuracy of conceptions formed by the blind of the observed object is evident from the likeness of drawings to the photograph of the reference point. Similarly, in the test involving a geographic map the accuracy of the conception of the blind students of the location of seas in relation to each other is seen by comparing it to the location of the seas on the map.

We determine the accuracy of any man's perception of a natural phenomenon by the relationship of the incoming information to the quantity of information comprehended by him.

Using the above correlation, it is probably possible to express the quantity of the compensatory effect of the use of the





Figures 7 and 8. Drawings of Reference Point by Blind Subject.

device for the blind. The "compensatory effect" is to be understood as the degree of accuracy, expressed in percentage, multiplied by a coefficient of proportionality which depends upon the conditions under which the device is used and upon those requirements, so far as the quantity of information is concerned, which obtain in a given condition.

In our experiment of distant observation of the reference point it is possible to determine the compensatory effect resulting from the use of the phonoscope as 100, if one is content with information on such characteristic visual signs as the location of the tree in relation to other trees, growth of branches chiefly on the left side of the tree, a conical form of the tree top, the absence of branches on the lower part of the tree trunk, etc. All this is clearly evident from the drawings made by the blind.

Thus, the compensatory effect can be determined by counting, for example, the number of details of the reference point when observed with normal vision and the number of details discovered by the blind after scanning the object with the help of the phonoscope. Using this method for the determination of the compensatory effect of the device for the orientation of the blind, it is possible to evaluate the advantages of possible industrial production of other types of devices designed for orientation: photocollators and audio or ultrasonic locators.

Incidentally, the knowledge of the amount of the compensatory effect resulting from the use of the device cannot fully determine the success of the device when used by the blind. It is also necessary to consider another important factor, namely the ease with which the device can be used, for this factor makes many ingenious technical gadgets and innovations unworkable.

Finally, it should be mentioned that among the easily accomplished observational operations by the blind with the help of the phonoscope there should be included the location of the sun and the moon, observation of clouds, determination of heights of large objects, determination of relative locations of reference points in relation to each other, and many other problems connected with orientation.

It might be supposed that with a sufficient degree of skill in handling the phonoscope the realm of its use would be limited only by the resourcefulness of the blind user and his persistence in overcoming all difficulties.

SECTION II

Special Problems of Mobility Training

Chairman: *T. Drake*
Royal National Institute for the Blind
Devon, England

MOBILITY TRAINING IN A PROGRAM
OF SOCIAL AND VOCATIONAL REHABILITATION

T. Drake
Royal National Institute
for the Blind
Devon, England

In Great Britain provision is made for newly blind persons under the age of 65 to have a residential course of adjustment, orientation, assessment, and prevocational training. The process of rehabilitation commences with the realization and full acceptance of blindness by the individual, and continues until such time as he is restored to society and to full time gainful employment. When this has come about he will also have been restored to himself, regaining self-esteem and self-respect which diminished with his loss of physical competence and independence.

Our policy at these residential centers is to teach useful and necessary skills and techniques; to demonstrate by experience that blindness is no bar to a considerable number of active recreational and leisure time pursuits; and to assess and channel the trainees into suitable training and employment. Friendly and understanding counseling is an integral and important part of the proceedings. The building-up and regaining of good health and morale is an essential by-product of the course, which in turn brings about a more positive motivation to tackle the various subjects and activities in the program. Attitude is all-important. Determination and tenacity are qualities which must be developed if a blind person is to succeed in the art of living and functioning without sight. He must learn and develop new skills and techniques and accept the inevitable frustrations of blindness, overcoming feelings of self-consciousness or a hypersensitivity which may adversely influence personal relationships with the sighted community.

It is not the purpose of this paper to deal in detail with all aspects of such a course. I propose to discuss only one of the new skills which must be acquired by a newly blind person, namely that of independent mobility. By gaining new skills, a fuller, happier, and more independent mode of life slowly develops. The acquisition of competence in its turn brings about a gradual return of self-confidence, and surely nothing is more necessary for free movement in lone mobility than self-assurance and self-confidence.

Before coming to the center most of our clients have been suffering from the demoralizing effects of blindness, unemployment, and dependency. For others, mental and physical health has been impaired and neither stimulation nor motivation toward self-help in mobility has been present. At the center, with many others like himself, there is a competitive spirit abroad, and there is a challenge to the individual to try and to do at least as well as the next man. Blind members of the staff set and example which the new client tries to emulate. The atmosphere is one of busy and purposeful activity. A full program of work and recreational activities goes on all through the week, including evenings, and organized leisure time activities occur over the weekend.

Very soon the newcomer throws off his introspection, and begins to take an interest - to participate in the work program and in many of the social activities. A busy life, with its accompanying achievements, brings about a happier spirit, a raising of morale, and a more hopeful outlook for the future. These changes in turn bring about an improvement in physical and nervous health, and so the cycle continues. To the client who was formally of a serious turn of mind, and who had been a keen reader, the acquisition of braille skill is going to mean much. To the more practical minded the wide variety of craft and manual work will appeal. To the housewife the regaining of housecraft competence may be her prime concern. To all, however, the gaining of independent mobility is a common goal. To get about alone, whether on foot or by public transport, without having to be escorted, should be the burning ambition of every blind person, and I think it is safe to say that the loss of independent mobility is perhaps the greatest loss of all during the initial stages of blindness. It deprives the individual of his freedom to come and go as he pleases, and accentuates dependence - more than any other aspect of blindness.

All physical movements are performed by a combination of muscle and eye, and in adult life the neuromuscular system has been developed to function through the medium of vision. To retrain this system to function without sight takes a long time, much practice, and calls for many qualities in the individual.

He must train himself to reorganize his remaining faculties and to adopt a new mobility technique. He is helped in this training by those who understand such things, but the whole process of training is an active one, by the individual himself, from the very early days of his rehabilitation. A newly blind person must be encouraged to move about alone, and he must not be discouraged by the overprotective and misguided assistance of his family and friends. Inevitably, some bumps and frustration will be encountered in the early days, but small achievements will lead to greater effort and more determination to extend the range of movement.

The vast majority of registered blind persons - and this applies to those coming to our centers - have sufficient residual vision to enable them to maintain full mobility. In these cases a full peripheral field of vision still remains, only the loss of central acuity has been suffered. No training and no special techniques or equipment are required here. Another group of registered blind people have both a peripheral field and acuity loss, but still retain useful general vision for guiding purposes. Once they become accustomed to their limited vision they are also capable of getting about reasonably well without much training and with only the occasional use of the white cane in extremely difficult travel conditions.

Yet another group of registered blind persons have good acuity but a considerably restricted field, giving a pinpoint of tunnel vision. Much depends upon the degree of loss here; in severe cases they need special mobility training. They will certainly need to adopt the white cane, not so much as a probe and guide, but to indicate their disability and so avoid bumping into people on the crowded pavement, which they are apt to do. Retinitis pigmentosa and glaucoma are two conditions leading to severely restricted field, and of course the factor of good illumination is important, especially to the former condition, with which special night mobility training must be given.

A further group of registered blind persons have a fraction of normal vision ('count fingers' or 'hand movements'); these people need some mobility training, but their remaining sight enables them to see sufficiently well to avoid bumping into obstacles. They can also see curb outlines and walls and buildings, at least at close quarters. When the route is a familiar one, therefore, these people can manage quite well with the white cane when confidence has been restored. With the cane, curbs and steps can be detected, and the functions of an occasional probing guide and a symbol of blindness are also available. It is only when we come to the group of totally blind people, and those with only light perception, that the cane really comes into its own as a protector, guide, and probe tool, and where a more definite technique in its specific usage is required.

In Britain the long cane, used in America and some other countries, has not been wholly adopted. No definite technique has been evolved and laid down for its use, and it is still left to the individual to adopt whatever length or type of cane he prefers. The length is still a matter of personal choice. It must naturally be related to the height of the individual, but it is usually long enough to contact the ground a few inches in front of the feet (but not so far in front as the American long cane).

The details of technique are as follows. The essential part of a mobility training program is the development of the other senses and an awareness of the importance of echolocation to a blind person. This is demonstrated at the center. The tapping of the cane or the clicking of the heels on the ground bring back echoes from nearby objects, and this provides valuable information. This ability to "hear" objects is much more developed in the congenitally blind, and is never so acutely developed (and therefore useful) in the adventitiously blind. Weather conditions greatly influence the mobility of a blind person, for snow deadens sound, and there are no echoes to guide him. Strong winds confuse and mislead the hearing sense. Traffic, footsteps of pedestrians, machinery noise, and any fixed known sound such as church bells or a clock which chimes, can serve as points of navigational aid. A sense of smell is a very useful aid to mobility. The sense of touch through the cane and the feet, and also that of the sun and wind on the face, can give assistance in orientation and navigation.

Mobility instruction at a residential center will be one subject in a full working day's program. We have totally blind, partially sighted, and fully sighted officers covering this instruction, and we think all have a contribution to make.

Indoor mobility cannot be gained without the power of concentration and visualization. Not all newly blind people have these faculties. Some cases of postoperative brain tumor, severe head injuries, and other neurological conditions, may prevent a person from orientating in space or forming a mental image of order and layout. These people may not be considered suitable subjects for extensive outdoor foot travel and mobility training. It is important to know who can and who cannot benefit from mobility training. For those who cannot, constant effort can only bring frustration and demoralization. The reason for the failing must be explained and the person must then accept the situation just as he has had to accept his blindness. He may, in time, by constant repetition, be able to get about the house, but he will be unreliable and unfit for outdoor travel.

When a person has the ability and faculty to develop his mobility, then he must be given the benefit of skilled and understanding counseling and instruction. He must be taught to stand correctly, with head and shoulders back, in a relaxed and well-balanced manner. His training will include route learning, sound location, and cane technique. Indoor handrails are not provided, and few special aids or safety devices are used. The person must learn to adapt himself to the conditions as they are, and not to expect special aids, for he will not encounter them outside the center. When he is familiar with and can move around the workshops, grounds, and immediate precincts of the center, the range is gradually extended beyond the center to busier roads and the town. At first he will tend to use the contact method, feeling curb, walls, and buildings with his cane, but on the busy pavements he is expected to steer a central course in which his cane, held aslant across him, will be tapping the ground in front of his feet for his protection and guidance. He will hear people walking on his right and left side, and he will know that he is taking a middle course; he is also aided by hearing the buildings on his nearer side, and the traffic moving on the road. His attitude is to accept help readily from others in crossing roads. When being guided by a sighted person, he will always hold the guide gently on the upper arm, in this way leaving himself free to follow every movement of the guide. He should never clutch tightly or become a drag on his guide.

Physical fitness reactions include not only good muscular tone, but good poise, balance, and generally good perception through the other senses. This is considered of paramount importance in mobility to a blind person. At the center much is done in recreational activities to develop such fitness. A walk of at least 2 to 3 miles every day is organized. Over weekends, many long treks of 10 to 12 miles are arranged. Swimming is done all year round, either at the baths or on the nearby beach. A weekly dance is held at the center. A daily keepfit class is held in the gymnasium. Tandem cycling is also encouraged, and it is enjoyed by some. Boating and fishing expeditions and visits to places of interest are frequent. To help the training of sound location, darts are played, with direction given by tapping on the board. Ten pin bowling is also played, the guide being given by tapping on the center pin. Clock golf is played on the lawn by means of tapping in the hole to locate its position.

It is not claimed that in a short course like this (12 weeks) very comprehensive mobility training can be given. We try to launch clients with a good basic knowledge and understanding of techniques required. A suitable mental attitude and sufficient self-confidence should enable them to continue self-improvement upon their return home. Over a much longer period of time their performance will improve, their range will increase, and by experience they will improve their technique.

In sum, in our program of social and vocation rehabilitation, we hope to bring to the client an awareness of his mobility potential. The greatest loss to a newly blinded person is loss of independent mobility. His greatest gain, perhaps, occurs when some measure of independent mobility can be restored.

THE VALUE OF FENCING IN MOBILITY TRAINING

Leo Riley
St. Paul's Rehabilitation Center
Newton, Massachusetts

I hope some of you will ask "Why fencing? Why would *anyone* teach a blind person to fence?" I can tell you that we have done it at St.Paul's and that it is an extremely valuable part of our mobility training program, which is based primarily on the Hoover cane technique. Our fencing program could not have succeeded without our coach, Mr. Lawrence Dargie, who has helped me greatly in preparing this paper (he should be listed as a co-author), and you will not succeed in understanding the role of fencing in mobility training unless you let me take you through the details of how it is done.

According to Dargie, teaching fencing to blind persons is a challenge. It is hard work. It demands concentration and constant attention to details. These qualities, perhaps, are found in every fencing coach. But in addition one must be able to express oneself distinctly and lucidly; one must have the knack of getting blind students to visualize. Remember, you cannot *show* a blind person how to do something. At this point I want to emphasize that most trainees at St. Paul's have no useful vision. Some of them such as the victims of retinitis pigmentosa present special problems, but their remaining vision is occluded while they are fencing.

Each trainee has three fencing lessons a week. Each lesson is a group lesson and lasts 50 minutes. All trainees have one lesson together on Saturday morning. This is followed by two lessons with smaller groups of 6 to 8 students each. The other lesson is given Wednesday morning, again in groups of 6 to 8. The course lasts for 16 weeks. Therefore each trainee has 2 hours of group instruction per week, a total of 32 hours maximum during the course.

Dargie teaches the French classical style of fencing, with a light grip, blades in contact, and phrasing. With this style the object is to hit and not be hit; to maneuver the opponent and his blade so that an attack can be launched with the minimum of risk of oneself and the maximum threat to the opponent. He makes certain modifications for blind fencers, but these are few and minor. Only the foil is used; this is the French foil without a strap. This is done to gain the maximum development of the sense of feeling or touch in the fingers.

The target is limited. The belt line rather than the groin line is the lower line of the target. This serves two purposes. First, in a mixed group of men and women the target will be the same for everyone. Therefore sex will make no difference in competition or technique. The second reason has to do with time: only so much can be taught, and limiting the target thus eliminates the need for low line parries.

During the 16 weeks at St. Paul's, the trainees learn the "on guard" position, straight thrusts, parries, counters, changes of engagement, double changes of engagement, the beat, disengagements; and the combinations of these such as double change, beat, disengage, and lunge.

For footwork the blind fencers are taught, and use (besides the lunge), the advance, retreat, jump forward, jump back, balestra, and back lunge. The hand work and footwork, of course, are eventually combined.

Can people who are blind really accomplish all this in 40 hours spread over 16 weeks? They do! But to accomplish this effectively the fundamentals must be learned correctly. Not *almost* learned, not nearly right, but *all* right, *all* correct. This is fundamental to any success with blind students. Dargie emphasizes the on guard position, straight arm, and lunge. The correct lunge depends on the correct on guard position; on a lunge, a one-inch deviation of the hand, pommel, or feet will make an eight-inch deviation at the tip of the blade, and an eight-inch deviation of the point of a foil reaching for a target can mean a miss. So we are talking in terms of correct positions with less than one inch of variance.

The on guard and lunge they use are no different from the ones used by many coaches. They are no different from the ones expounded in the established books on fencing instruction.

The students stand in a comfortable position with the feet together. They then swing their toes (right toes assuming right-handed fencers) out to a *90 degree angle*, right heel against the left heel. With hands turned out, they are in the preparatory position for going on guard.

The students then take the on guard position. First, the heels *must* be in line with the feet at right angles. Second, they go on guard initially in position 6, which guards their right side, or "outside" (assuming a right handed fencer), with the tip of their blade pointing just over their opponent's head. In this position, with a good 6, the fencer's outside line is closed and as long as the blades remain in contact on the outside of each other the fencer, by this "feel," knows he is protected. He need only to parry in position 4 to close the inside line if his opponent disengages or changes engagement.

With a light grip a fencer will get the "feel" of the pressure on the blade, and by this "feel" will know whether his opponent's line is opened or closed. This takes time to develop, but his entire offense depends on this "feel." He will know as soon as he changes engagement whether his opponent closed the line or not, and if he did close the line, how and with what action. He can also tell by the "feel" whether his opponent is in position 4 or 6, guarding his inside or outside, changed engagement, or countered. He will know whether his opponent is making a simple straight arm attack, or by the absence of blade contact, a disengage.

By the "feel" of blade against blade he will be able, before the 16 weeks are up, to tell if he is lined up correctly with his opponent and if his distance is too long, too close, or just right.

With blind students the lunge is always the same, whether it is initiated from position 4 or from position 6. Right arm is straight (and it is always straight before the lunge starts), pommel tight against the wrist, with the right hand directly in line with the right toe. When the lunge is completed the right toe is pointing at the target, the right arm and hand are in line with the right toe, and the pommel tight against the wrist, making the foil an extension of the arm and hand. This lunge will produce a touch provided the opponent does not parry which, of course, he has the right to do.

If the blind fencer misses the target (just a small factor such as heels not in line, or the pommel away from the wrist, or the right toe turned in can cause a miss) he then has to determine immediately on which side of the target (inside or outside) his blade passed, whether his blade was short of the target, and also why he missed.

Sometimes these decisions are simultaneous. Through experience he knows his main faults, and thus on which side he probably missed. For example, if a fencer turns his right toe in, he will have a tendency to lunge inward. Knowing this he would realize that his blade passed to the outside of his opponent. This is not always the case. Perhaps the opponent moved to one side or out of line. Then by swinging the foil in a horizontal plane, while still on the lunge, he can locate the opponent and recover. He is then faced with another decision which becomes automatic with experience: was the miss due to faulty mechanics, or because the opponent changed position? If it is his mechanics, then he must correct them. If it is the opponent who is out of line, then the blind fencer must make a change in his alignment. He does this by first moving the toe of his *left* foot. He moves the toe to the right if his blade passed to the outside of the target, and to the left if his blade passed to the inside of the target. He then picks up his right foot and moves it into the correct alignment with his left foot, heels in line, 90-degree angle. This method serves two purposes: it makes any correction relatively small, and because the left heel does not leave the floor it maintains the same relative position and distance of the fencers.

Basically, that's all there is in teaching blind people to fence. But the "basics" and the "all" have to be correct. The theory and the practice of each movement and each combination should be explained to the blind student. This permits him to grasp the correct concept; it helps him to visualize. Each position, motion, and action must be described to him so he can visualize it and thus grasp it.

From the basic maneuvers the blind fencer progresses to combinations and strategy. During the last two weeks of the course it would be difficult for sighted people to believe that the two fencers competing with each other were blind. They would see a crossing of blades and several changes of engagement to sound out the opponent. They would see straight parries of positions 4 and 6 intermingled with counter parries to offset the changes of engagement. Perhaps there would be a few cautious lunges, a quick thrust. Then the bout opens up. The fencers retreat, advance, jump back. Each fencer tests, reacts, plans. There is a quick change of engagement followed by a disengage lunge - the opponent retreats as he parries. The aggressor recovers and does a balestra. The opponent counter parries, holds, then launches an attack of his own. The play is back and forth: the feint, the surprise, the search, the set-up, the all out attack - all are present when two blind persons fence. They cover as much distance as two sighted fencers, and because we do not use fencing strips or mats at St. Paul's, there is the added handicap of possible sideward movement. A fencing mat would help the competitive blind fencer to stay in line, but it would detract from his hearing the movement of the feet of his opponent. A mat is not desirable at St. Paul's for the blind trainee who is taking up fencing to develop his other senses.

You might ask "How do blind fencers compare with sighted fencers?" As far as his ability is concerned you have just to put on a blindfold and fence with one. You probably would be surprised. It has been tried by sighted fencers and frequently the blind person won. Of course, a sighted fencer has all the advantages when, without a blindfold, he fences a blind individual.

How do the blind fencers compare with sighted fencers as far as progress is concerned? We believe that given an equal amount of instruction the blind person will be a better technician and fencer at the end of 16 weeks than a sighted person. There is logic behind this statement. A sighted person making a mistake in one of the fundamentals in the execution of an action can *see* what the results *will* be. Therefore he usually makes another mistake instead of correcting the first in order to, say, score a point. The blind fencer cannot do that. He does not know if his lunge will hit or not until *after* it is completed. If the mistake is his, he must correct the mistake to be effective on his next lunge. This continual correction of mistakes, this constant striving for perfection, will tend to make the blind fencer, in a given period of time, a better fencing technician than the sighted fencer.

Much of what the blind fencer learns is immediately applicable to travel with the Hoover cane, since he learns to consider both the foil and the cane as extensions of his arm and hand, while the practice he gets in coordinating footwork with arm work, as well as in developing the proper light touch and feel, helps greatly to restore the confidence he lost when he lost his sight.

SKIING AS A SPORT FOR THE BLIND

H. van Dyck
Rehabilitation Consultant
Antwerp, Belgium

INTRODUCTION

It is hardly necessary to devote much time here to the advantages of sport as such. I want to remind you, however, of a few other benefits of sports, like the stimulation of the whole body, better blood circulation, better breathing, and so on. It is obvious that these advantages are just as important for the other handicapped as they are to the blind, but some advantages are especially important to the blind. As we know, sports are a means of relaxation from the heavy physical and mental pressure under which the majority of blind people labor. We know that all day long they live under a strain of concentrating more than anyone else on whatever they are doing. It is seldom that they have the opportunity to move about freely and to relax completely.

It is not hard to understand, therefore, why the advantages of sport for the blind are especially great. We must not forget that sports can also play an important part in acquiring self-confidence and self-assurance, which the blind need very much. There are some practial advantages, too, such as the development of the sense of direction, the courage to move about by one's self, and so on. Such physical exercise or sport is, therefore, not a luxury but rather a necessity for the blind. From experience, we know that those handicapped persons who are sportsmen are best able to make the most of their lives and to adapt themselves well to their jobs.

I should now like to emphasize some of the special advantages of skiing as a sport. These include physical, social, and psychological advantages. Skiing always takes place in the mountains. This means a great change in height and climate, both of which are beneficial to every organ. They are subjected to the curative effects of oxygen and sunlight. The change in climate and environment has a soothing effect and the complete peace of the mountains in winter is a sharp contrast to the strain under which the physically disabled live. Town dwellers cannot imagine this complete sense of restfulness. This is even more true of the blind who, relying on their hearing so much, suffer more than the sighted from the noises which assail us from every side as part of our everyday life in this modern age. In skiing, there is more emphasis on development of physical strength and on quick reaction than on the strain of concentration.

Skiing also enables the blind person to widen his social scope. It provides contact with other persons, including blind persons, from other countries simply because it has become an international sport. Such contact with others is vitally important for the general outlook of the blind person and helps him in moving about socially with ease.

Then there are psychological advantages, for skiing demands the utmost in courage, command of oneself, and so on. Self-assurance and self-confidence follow naturally from the exercise of these abilities and faculties. I should emphasize once more that skiing means a respite from the strains of everyday life, allowing other factors to emerge and become developed. This is especially important for the blind.

METHODS

Skiing has only recently become a sport and a means of relaxation for the blind. The systems for teaching them to ski have been compiled by the pioneers in several countries and under many different circimstances. These instructors rely both on their great experience in the sport and on their extensive experience with the special problems of the blind to develop the special techniques needed. Let us consider the Swiss system, developed in the main by the Swiss Union for the Disabled.

Even at the beginning of the course of training, much emphasis is placed on balancing exercises. They are emphasized again and again, and they are done without the aid of ski poles. Otherwise, no special system of techniques is used, the blind being instructed in the various techniques much as are the sighted. For orientation, extensive use is made of the so-called clockwise identification technique. The technique is used not only by the blind, but by the military as well. In this system, the person is considered at the center of the hands of the clock. Twelve is in front of the person; six behind him; three on the right side and nine on the left. The instructor can give accurate instructions to the blind person about which direction to choose. If he says, "Half-past one," the skier then knows that he has to go in a diagonal direction to the right; "Turn to nine" means turning in a right angle to the left, etc. The blind person can thus always orient himself in the desired direction.

In the French system, very little use is made of balancing exercises. It is also curious that here practically no exercises are done without the aid of ski poles. On the other hand, a particularly elaborate system has been worked out for the various positions of the body and for the various positions in which the skis have to be placed. The orientation is made by a comparison to the braille cell, and to certain braille symbols. Since the blind are well acquainted with the braille symbols, they can form a clear picture in their minds of what is wanted. There are some descriptions in French which explain the system in great detail, for those who are interested.

When the ski course was initiated, a little bell was tied to one of the ski poles of the guide or instructor so that the blind person would find it easy to follow the sound. Experience taught that this was unnecessary and sometimes even a hindrance. The silence in the snow of the mountains is often so intense that with just a little practice it is not hard at all to follow the guide. Indeed, the sounds of the skis and the ski poles generate sufficient noise for orientation. Following along a track made by another is also not hard, after some practice. They can be followed by touch alone, or the feel of the blind person's skis guide him along the track made especially for him by the instructor. It should be obvious that this holds only for walking or climbing and not for going down the slope.

Going down the slope can be done in a variety of ways. The instructor can go down with the blind skier either on his right or behind him. He may either give instructions on the way or he may go down first and stop, calling out the instructions for the blind person to follow. In the latter case he must of course stay within hearing distance - about 60 to 70 meters (roughly 60 to 70 yards). Before going down, the instructor must describe the territory over which the blind person has to pass with great accuracy, including all unevennesses in surface, and all positions of the skis. In this way, the blind skier gets a clear mental picture of the territory in front of him.

ORGANIZATION

To guarantee the success of the sport of skiing for the blind, certain prior conditions must be met. The ski area must be outside the main skiing centers. The terrain must be even and, if possible, free of vegetation. Small steep slopes can be present, but there should also be plenty of gentle slope areas where ample opportunity is available to practice various ways of skiing, ascending, descending, and so on.

The instructors must be thoroughly familiar with the territory beforehand so that the blind person has nothing to risk if he should take the wrong direction by accident. Instructors must be widely experienced in the sport and, if possible, should have knowledge of and experience with the special problems of the blind. It is of the utmost importance that the blind pupils have complete confidence in their instructor; otherwise they will never have the courage to follow him without reserve. Where advanced pupils are concerned, no great experience of this sort will be required. Above all, all instructors must use the same terminology. This is absolutely essential under all circumstances. Breaking this rule may have serious consequences for the handicapped, for they may make a wrong move at a crucial moment.

For beginners, it would be advisable to have one and certainly not more than two pupils per instructor. For more advanced pupils, one instructor or guide is sufficient for two or three adults. Naturally the skier must be in good health and not handicapped in such a way as to make his efforts fruitless (I am thinking here, for example, of persons with heart diseases).

CONCLUSION

In summary, I would like to say that however improbable it may sound at first, skiing is a wonderful sport for the blind and partially sighted. It can certainly be recommended that this splendid sport be developed further for them; that techniques be improved and tested; and that international contacts be encouraged. I am convinced from experience that any blind person who tries this marvelous sport will become an enthusiastic supporter of it and will try to convince others of its interest and value.

MOBILITY PROBLEMS AND THE USE OF THE CANE FOR BLIND PERSONS

W.J.J. Kooyman
Mobility Instructor
Huizen (N-H), The Netherlands

In discussing the mobility problems of blind persons, we must keep in mind that there are significant differences among the several subgroupings of such persons. Thus there are real differences between the congenitally blind and the adventitiously blinded; in the several stages between total blindness and the partially sighted; and among those who are deaf in one or in both ears. Sex and age are also important variables.

What characterizes the mobile blind person? What demands must he meet to be mobile? Three factors are involved here. They are:

1) the blind person must be oriented to his environment

2) he must possess a well-developed motor skill repertoire

3) he must have sufficient motivation to *want* to be mobile.

Even a well-oriented blind person who has much motor skill training may not be mobile if he lacks the will or the wish to be independent, or lacks self-confidence, or is fearful and nervous about the tasks involved.

For our purposes I have defined "orientation" as the ability to receive many kinds of stimuli from the environment and to use them effectively in determining location and direction. This may be done by using long range senses like vision and hearing, or by short range senses like touch, smell, and taste. To be oriented, however, means to the blind person that primarily hearing, and secondly touch, must compensate for his lack of vision. The sense of smell can occasionally be turned to use in mobility, but taste is not often important for this purpose.

Why is the sense of hearing so crucial? The question will answer itself if we describe what the ears of the blind person must do. His ears must help him to localize the source of sounds, and allow him to estimate their direction and his distance to them. They must also help him to follow a moving source of sound, i.e., to identify approaching and disappearing sources of sound. He must then listen selectively to these sounds in order to avoid obstacles in his path.

Thus, if the hearing capability of the blind person is impaired, he will be seriously hampered in his attempt to orient himself in space. He can still recognize guidelines and the nature of the terrain on which he walks by using his cane to follow hedges, railings, gutters, ridges, and walls, or to identify asphalt, brick, tile, grass, and sand; but it is clear that he can only be mobile in the simplest situations.

As this paper concentrates on the problems of mobility, we shall now sum the most common difficulties that blind persons face in getting about. Most difficulties arise in acoustic orientation because of the difficulty of the proper interpretation of sound. Motorized traffic does not present much of a problem, but the relatively silent bicycle is much more so. Furthermore, obstacles at eye level like branches and sun awnings are difficult to detect; and problems commonly arise in complicated street and traffic situations in which many obstacles are present at once.

There are, moreover, some problems peculiar to certain subgroups of blind persons. Thus the newly blinded child or adult may not be consciously aware of sound cues of importance to his mobility for some months, resulting in a lack of "obstacle sense." After a time he learns to use these stimuli more effectively. At first he may also react too slowly to warnings his cane may give him, and he will often bump into obstacles that he has already detected with it. Furthermore, these persons are often unaware of their deviation from an original line of travel so that deviations in travel paths take place: one-third or one-half turns can be made without awareness that a change has taken place. This lack of "turn awareness" may also have something to do with a lack of awareness of proprioception. Proprioceptive cues, combined with a conscious awareness of body posture and equilibrium, make up what we call the "body scheme."

There may be, first of all, some difficulties in obstacle detection, i.e., the capacity of the blind person to "hear" certain obstacles in time to avoid collision with them. Today we know that this is purely a function of reflected sound. In a number of situations, however, it may be impossible, or almost impossible, to utilize this capability. Among these may be mentioned 1) when the sound produced by the traveler is too well damped by rubber soles or a rubber cane tip; 2) when there is a high ambient noise level due to wind or traffic; 3) when the character of the ground surface is highly absorbent (e.g., snow, loose sand, short soft grass); 4) when obstacles are too small or too low (e.g., lamp posts, traffic signs, young trees, ladders, curb stones, wastepaper bins); 5) when the surface density of the obstacle is low (e.g., bicycles, leafless shrubs, railings); 6) finally, when the angle the obstacle subtends to the ground is below 90 degrees and the reflected sound from it does not reach the ear of the traveler.

Another common problem is both tactile and acoustic in nature. Often blind travelers will have difficulty detecting deviations of the street itself along the path of travel. The traveler may think the street is straight, for example, when it may in fact be laid along a long or faint curve or corner.

The crossing of busy streets and roads remains, in spite of the measures taken to insure safety and in spite of all the techniques developed to circumvent difficulties, a hazardous undertaking.

The blind or severely visually impaired traveler who is deaf or whose hearing is impaired in one ear is a special case, for he lacks an important part of the total capability of hearing. Often he can compensate somewhat for this decrement by turning his good ear in the direction of the sound he detects. This effort results, however, in a more or less twisted trunk or body posture, and is frequently responsible for off-course deviations in the path of travel. The reason is, of course, that such a traveler cannot orient acoustically on his deaf side and, in fearing to move in that direction, he overcompensates in his movement to the opposite side. Such behavior is a consequence of the general fact that he will experience difficulty in localizing the direction and distance of sound sources.

Sex and age are also factors in mobility. Most girls and young women have a negative emotional attitude toward the white cane, feel conspicuous using it, and prefer to travel without a cane and with a sighted companion as guide. Intellectually or rationally, they know they are wrong, but they suffer from a false sense of shame in carrying the cane. This reluctance is also common among younger clients of rehabilitation programs who have a small degree of remaining vision. Thus the difference between older and younger clients in rehabilitation programs is in mental attitude. Indeed, above the age of about 45, it is problematical whether such persons can be made mobile and feel oriented in their surroundings. Being too careful, being unwilling to take risks, personal restraint, lack of suppleness, and fear are the main hindrances here.

In Holland our experience shows that about half of our rehabilitation clients have the greatest difficulty in detecting obstacles aurally, even after months of training. Furthermore, only about 20 percent become skilled at such detection. Similar figures obtain for the ability to localize sound sources: only 25 percent of the clients become skilled at doing so, the rest ranging from a reasonable degree of skill to none at all.

SECTION III

Social and Demographic Research

Chairman: *Milton D. Graham*
American Foundation for the Blind
New York, New York

BLIND PEOPLE AND THE MARKET FOR MOBILITY DEVICES

Eric Josephson
Department of Research
American Foundation for the Blind
New York, New York

I should like to begin with a paradox. The purpose of this meeting, I take it, was to exchange information about devices that will make blind people more mobile. Yet we seem to be moving toward what has been called the "sedentary society." Now the sedentary society is of course one in which people chiefly sit. The best example I know is my own country where most sighted people are "mobile on wheels" but where few use their legs to walk. Whether Europeans will also become less ambulatory I don't know; you know your own countries better than I do. But in the United States, according to a fairly recent government survey, only about one-third of our citizens walk for pleasure; the rest sit and, I suppose, wait. As Herbert Collins has written, "Not only is the chair the conspicuous container of modern man, but sitting is the symbolic posture of the age of science and technology." I quote this statement because I consider it ironical that scientists and technologists are now trying to develop instruments that will make blind people less sedentary and more mobile.

But mobility for what? As our friend John Dupress has said, "Only when more blind people secure jobs, fulfill their interests, and are integrated into society will they have a readiness and capability for travel." There is another side to this coin. One might turn it around and say that the more mobile they are the greater their chances of becoming integrated in society. The problem then is how to help blind people achieve greater mobility when they may lack the necessary incentive and when their sighted contemporaries are becoming increasingly immobile. But perhaps, thanks to the new technology which you represent, blind people will be the last ones on earth to remain mobile. Everybody else will be sitting. And that, I think, would be the final irony.

Now my assignment is briefly to describe general characteristics of blind people that affect their mobility and to identify markets for the mobility devices that you are developing and testing (1). Although Dr. Graham has just said some kind words about how unparochial we are in America, I am afraid that my frame of reference is somewhat restricted, which is simply to say that most of the research that I am familiar with concerns blind and visually impaired persons in the United States. It would, therefore, be presumptuous of me to make general statements about blindness all over the world. I stress this because we do not know whether the experiences of blind people in America are unique or not. However, I suspect that many of them are not and that mobility problems are pretty much the same for blind persons in all urbanized industrial societies.

What do we know about them? Unfortunately, reliable data on the number and characteristics of blind persons are extremely hard to obtain. With the exception of the United Kingdom and perhaps a few other countries which maintain fairly comprehensive and up-to-date nationwide registers of their blind citizens, most countries rely on estimates of blindness which are subject to considerable error. In the United States, barely a dozen states have established adequate registers of their blind inhabitants, and even in these states there is reason to suspect that many blind people are unreported. For nationwide figures, although once upon a time blind persons were enumerated in the census, this is no longer done; and we now have to rely on educated guesses about the size of the blind population.

To complicate matters further, blindness is subject to varying definitions in different countries. In the United States the legal or official definition of blindness includes all persons who have 20/200 visual acuity or less in the better eye with correction, or a comparable visual field defect. In ordinary terms this means anything less than 10 percent of "normal" vision, and persons who fall into this category are eligible by law to receive various services and benefits. As in other countries our definition is arbitrary, and it includes some people with useful vision and excludes many others who may be "functionally" blind.

We estimate that there are approximately 400,000 legally blind persons in the United States. This figure is probably an underestimate, however, since many blind people are unaccounted for; a recent government sample survey suggests there may be twice as many with less than 20/200 visual acuity. As a matter of fact, adopting a "functional" or behavioral definition of blindness - inability to read newspaper print even with glasses - still another government study reports approximately one million severely impaired persons in the U.S. It is possible, however, that many of them could have their vision improved with surgery or with optical aids.

This confusion about the definition of blindness and visual impairment complicates the task of describing the blind and identifying the markets for mobility devices. But a functional definition of blindness would seem to me to be most appropriate for the development and marketing of such devices, since in the final analysis it is *functions* that these devices are intended to serve. Unfortunately, it is just as hard to get people to agree about the criteria for a functional definition as it is to reach a consensus about a clinical determination of blindness.

Whatever the definition, blindness is not a major health problem in Western countries. Oddly enough, however, it may be increasing, after a fairly long period of decline. Thus it has been estimated - with how much accuracy I cannot say - that three-quarters of a million sighted Americans now living will eventually lose their vision unless the prevention of blindness becomes more effective. The reason has to do with a general aging of our population, by which I mean not so much that people live longer but that more people who in earlier periods would have died early in life now reach old age; hence the increasing probability that some of them will become blind. This is the explanation for the reported increase of blindness in the United States; my guess in that the same trend is making itself felt in Europe.

Now for some of the major characteristics of blind persons. The little we know is based primarily on sample studies of the *known* blind population; the lists from which these samples are drawn are frequently biased or incomplete. But the alternatives - making a complete register, or screening the total sighted population - are prohibitively expensive and complicated as well, at least in the U.S. To illustrate, we recently conducted a survey in a large American city and screened a random sample of 10,000 persons; we wound up with about 15 cases of blindness. This is probably the only unbiased sample of blind people that has ever been drawn in the United States, but the cost of such screening is enormous. This is not meant as an apology for the little we know but as an explanation as to why it is so little.

In any case, we know that many blind people are old. In the United States we estimate that half of all blind people are 65 years of age or older. We also estimate that approximately half of all blind persons become blind at 50 years of age or over which means that they have been more or less normally sighted travelers until fairly late in life when blindness struck them. I think the traditional distinction between congenital and adventitious blindness is important for the development and marketing of mobility devices. What I mean to suggest here is that the planning and distribution of such devices should take into account the different mobility experiences that the blind person has had, the age at which he became blind, and what he did with the sight he had before, if any.

Next, the degree of blindness. Relatively few people are totally blind, at least according to our American studies. The evidence we have suggests that no more than one-quarter of all blind persons have suffered total loss of sight and at least one-third have some - although not necessarily good - travel vision. Here, I would think, is one of the most important characteristics of blindness to consider since this entirely sightless fraction of the blind population probably constitutes the single most important potential market for mobility devices. There are of course some totally blind people who cannot use the most effective mobility devices and there are others with limited vision who certainly are also in need of such devices. But in any case this distinction between persons who have no useful vision and those who do have some is crucial for any discussion about the demand for mobility devices.

Another characteristic worth mentioning is that many blind people suffer from more than one physical impairment. Precisely because they are so old, they are more likely than others in the population to suffer from chronic conditions or ailments besides loss of sight. In one American study of blind persons 20 years of age and over, nearly two-thirds reported some other chronic condition or ailment. Not all of these conditions are equally disabling, but in varying degree they impose further limitations on activity and mobility and hence must enter into any calculation of the benefit provided by mobility devices.

Perhaps most important for the development of such devices, significant numbers of blind persons appear to have serious hearing difficulties. Thus in one study of blind veterans in the U.S. 30 percent reported hearing difficulties. In another study of blind adults, more than one-quarter claimed that they were "deaf." These of course are subjective reports; they have no clinical significance.

Does such information have any value? Much of our knowledge about blindness is based on what blind people themselves tell us in interviews; a word in defense of such interviews is in order (2). To begin with, they have many obvious limitations. If I go down the street in Rotterdam today and a man tells me he has difficulty with his eyes, he may or may not be blind. As a matter of fact, our own studies show a fairly low correlation between what people report about their visual impairment and what clinical validations reveal. Does this then rule out subjective reports? I would argue that it does not and that they have an important place in research on blindness. The reason, as I shall explain later, is that blindness is not just a sensory loss; it is perhaps even more a social and psychological phenomenon. Hence the importance of what blind people themselves think and feel about their impairment and their experiences with it.

I would go even farther and argue that the usual dichotomy between "subjective" and "objective" data is almost meaningless, given our present state of knowledge about and techniques available for measuring blindness. Let me illustrate, In the recent study which I mentioned earlier, we sampled the population at large in order to screen for the presence of blindness and other visual impairments. Since it would have been prohibitively expensive to arrange professional ophthalmological examinations for the 10,000 persons in our sample, we had to find some practical alternative. We decided therefore to start with what people themselves told us about their vision. As a next step our interviewers conducted very simple but reasonably "objective" vision tests in households where people had reported some trouble with their eyes. (The interviewers were trained by an ophthalmologist.) Finally, for purposes of validation we obtained information about our subjects from physicians.

What did all this add up to? Very briefly, we found (as I noted earlier) that what people themselves said was by no means a reliable predictor of what more or less objective vision tests might show. For example, we asked respondents in our study whether or not they were able to read ordinary newspaper print with or without glasses and then went a step further and actually gave them an example of newspaper text to read. We were then able to compare their reports with what they actually did. Approximately one-fifth of those who said they could not read newspaper text actually could do so; conversely one-quarter of those who said they could were unable to do so in our test. In other words, so far we had demonstrated the unreliability of the interview as a source of data on visual loss.

But that was not the end of it. We next took our own measures of visual acuity and compared them with what clinicians reported. Without going into the thorny problem of establishing criteria for comparing visual acuity tests conducted by different observers, let me say simply that with regard to distance acuity we found perfect agreement in only about one-fifth of the subjects who had been examined both by our interviewers and by physicians. Now, should we have concluded that our own observations were largely unreliable? Although some ophthalmologists I know in the United States would not appreciate this, I think there is reason to believe that they are not much more reliable than were our household interviewers. In our study physicians differed in vision testing procedures, not only as compared with our own household testers, but among themselves as well (3). Our purpose, however, was not invidious comparison between ophthalmologists and household interviewers; rather we hoped that our fairly simple vision tests might provide a check against self-reported disability, and in this respect we were fairly well satisfied.

In what may strike you as a digression, I have tried to show that while personal reports of visual loss are subject to considerable error, truly objective reports are also beyond our reach (4). What then are subjective reports good for? Perhaps above all, they are useful in helping us to learn about the impact which blindness has on daily lives and how blind people feel about their impairment. Thus some people who are blind according to the best measures available do not regard themselves as such; that is, they do not consider themselves blind according to the stereotypes of blindness in the society. Conversely, some people who are not blind behave as if they were. How can we find out about such things except by asking as well as observing them? Granted that the method has serious limitations; but until something better comes along, we must use it.

Now for a few remaining characteristics of blind persons. Even among those of working age, few are employed. In America, according to our studies, the proportion of gainfully employed blind people is only half as great as among the sighted population. Many blind people in the U.S. are wards of the state; that is, they are dependent on the government for financial aid and other services. Many, therefore are poor. In one study half of the blind respondents reported an annual income of less than $2000, which is very low by American standards; the corresponding proportion in the general population was one-eighth. I mention this because few blind people can themselves afford expensive devices of any kind, let alone pay for essentials such as medical care.

At this point I wish to turn to the general problem of activity and mobility among the blind. A recent American government study of the severely visually impaired shows that they are more limited in activities, such as housework and employment, than in mobility. But it should be obvious that activity itself is a function of mobility, and the result is that many blind people find themselves in an enforced state of idleness - engaged in purely sedentary activities such as listening to radio, television and recorded books.

Who then travels? In the United States most blind people do not travel extensively. According to a recent study conducted for the Seeing Eye dog guide organization and limited to those most likely to achieve some degree of mobility, i.e., persons under the age of 55, less than one-quarter achieved a high degree of travel efficiency (a composite of frequency, extensiveness and independence) (5). As you would expect, even within this relatively vigorous group, mobility declines with increasing age and with decreasing vision; the older the blind person and the less vision he has, the less frequently and extensively he gets about. Another study of the severely visually impaired indicated that perhaps as many as one-third are seriously limited in mobility. I mention this to show that it is not only the "clinically" blind who face difficulties in getting about or could be helped by mobility devices.

How do blind people travel? Although (according to several American studies) as many as one-third claim that they travel unaided, the fact is that most blind people need some kind of help, either in the form of a sighted companion or a cane. It is interesting to note that in the United States only about 1 percent of the blind population use guide dogs The Seeing Eye study reported that cane travelers perform better than blind persons relying on sighted travelers, and that guide dog users do best of all. But few do well. Our evidence for this last statement is not just that few travel frequently or extensively (i.e., outside their immediate neighborhood), but that most blind persons are extremely dissatisfied with their own travel performance. Indeed, according to blind people themselves, mobility restrictions are the most important problem they face, more important than poverty or the need for medical care. This is what they have told us and it is probably one of the most important statements we can make about blind people. In America perhaps the chief reason for this state of affairs is that very few blind people have ever received any mobility training worthy of the name. In one study, only 15 percent reported that they had ever received any form of travel training. In other words, the majority had to fend for themselves.

So far I have tried to sketch some of the major characteristics of blind persons and indicate some of the difficulties we face in learning about those characteristics. In view of the limitations of our data, we can make only the most general kind of statement about the demand for mobility devices.

What are the questions that future research should answer? Dr. Hyman Goldstein, on the staff of our National Institute of Neurological Diseases and Blindness, has listed three kinds of data which we need (6). First is information on the number and characteristics of blind people. Or, more precisely, what are the markets for particular devices? Second, we need data on what Dr. Goldstein refers to as "the minimum sensitivity required for effective use of devices utilizing the specific modalities." For example, what hearing and other sensory losses are associated with blindness? Finally, we need controlled, "longitudinal" studies of the use of particular devices by blind people. What experiences do they have with the devices? Are they satisfied with and significantly helped by the devices? These are the questions that need answering.

The question I suppose you want me to answer - although I do not think I can - is who needs devices? Within the blind population of any country, which is not very large to begin with, there is no single market for mobility devices, just as there will probably never be a single device that will meet the mobility requirements of all blind travelers. This is why we can make no precise statement about the demand for such devices. However, it seems obvious that the market for them is concentrated, although not exclusively located, among blind persons under 65 years of age, those with least vision, those who are otherwise in reasonably good health - especially with regard to hearing -

and those with the capability and motivation to use the devices. A very rough idea of the relative size of this market within the total blind population is suggested by data from nine American states which have been coordinating their blindness registers. In these nine states in 1962 blind persons aged 20 to 64 with less than 10/200 visual acuity, that is, the most severely impaired, amounted to less than one-quarter of the total blind population. I am not suggesting that this comprises the total market for mobility devices, but I think it includes most persons in need of such devices. Therefore, when talking about the market within the "official" blind population, we are dealing with only a fraction of it, at least in the United States. On the other hand, as I have said earlier, what we are beginning to learn about the functionally or less severely blind population suggests that there may be others not regarded as blind who may also need such devices.

To go a step further, the problem is not just that we lack precise data about the number and characteristics of blind people but that we do not have enough information about their capabilities and their motivations to use the devices. Even if we knew more than we do about the demography of blindness, this would not tell us how blind people might cope with particular devices in everyday situations. It is just such longitudinal studies - that is, observations of blind people in action with a variety of devices over a sustained period of time - which are most needed. And I think I am safe in saying that there have been no such studies to date.

Are there any examples of market research? One of the very few worth discussing is the study reported by J.A. Leonard and A. Carpenter in a recent issue of the American Foundation's *Research Bulletin* (7). In it they describe the trial of an acoustic obstacle detector with small groups of blind boys and older blind men. Since most of you are probably familiar with their report, I think there is no need to describe it in detail. However, one of their conclusions is worth quoting: "We strongly recommend that before any further work on the development of acoustic blind aids is undertaken, the mobility needs and requirements of the potential users of aids be investigated and that specifications for the acoustic aid be considered in relation to the results of such an investigation." Now this statement, from one of the very few actual field tests of a mobility device, is an appeal for precisely the kind of research that we are discussing today.

Another and quite different example of market research is the study mentioned earlier, the Seeing Eye dog guide organization's investigation of the potential demand for dog guides. That study indicated that only 1 percent of our blind population presently use dog guides and that perhaps another 1 percent could use them - which gives you some idea of the limited market for a specific mobility aid.

According to the Seeing Eye study, a major deterrent to the wider use of dogs is general apathy among blind persons regarding the problem of mobility. As I remarked earlier, the dog guide study was concerned with blind people who were most likely to achieve some degree of mobility - that is, people under the age of 55. Yet even in this selected subgroup most travel infrequently, get about poorly, and are highly dissatisfied with their travel performance. Most important, they turned out to be pessimistic about the opportunities for improving that performance. In my opinion, this is one of the most important psychological aspects of mobility, and the question is whether such apathy will hinder the marketing of complex mechanical devices with all that is novel and unique about them.

Further illustration of this problem comes from our experiences in providing blind people with reading aids. In one of our studies a significant number of blind readers indicated that they were not interested in new-fangled reading devices, such as multitrack tape recorders. At least that is what they said to us. Whether in fact blind people will actually reject such new devices when they are made available is another matter. It is very likely that they will not; at least most of them will not. But in any case it suggests that considerable effort must be made to inform and educate potential users of the devices.

Perhaps even more important is the danger that some blind people may reject new devices because of their fear that the stigma attached to blindness will then be reinforced. In American society the stigma is one of dependence and inferiority. That is, blind people are seen by many of their sighted compatriots as dependent and inferior as far as normal social functioning is concerned. The question I am posing is whether mobility devices will reinforce that stigma and thus defeat their very purpose by exaggerating the uniqueness of the blind traveler.

In this connection we have evidence that some blind people prefer to struggle about unaided rather than use a cane or a dog or rely on a sighted companion and thus draw attention to their disability. So too we have heard that some blind people refuse to accept such aids as talking books lest they be categorized as blind. In other words the effectiveness of a mobility device is not just a technical matter; it is also connected with the attitudes toward blindness in the society and by the manner in which blind people themselves react to those attitudes. I am not saying that mobility devices will inexorably add to the stigma of blindness; I am just raising the possibility that they might and that some blind travelers may gain this impression. That of course would be merely another ironical aspect of the tremendous aid that mobility devices would represent.

It becomes very important therefore to consider the psychological as well as the physical impact which mobility or any other devices may have on their users. In this connection Edward Bennet has summed up the concepts which are relevant to the analysis of product acceptance in this area. "First, what kind of 'personality' does the design or product have? In this 'personality' loaded with pleasant or unpleasant factors? What are those factors? Second, what are the personal reactions of the users, or potential users, to the product? Do the person's attitudes toward himself change with use of the product? Are the users satisfied or dissatisfied with it? What specifically are the high points in their individual reactions? Third, what are the personal reactions that the users, or potential users, think all other users, or potential users, have toward the product? What do the users see as the general acceptability of the product, aside from their own particualr feelings?" (8). If this statement suggests an application of motivation research to the study of mobility devices and their users, it may make more sense in a field where motivations and psychological reactions are so crucial, rather than in the determination of why consumers prefer Brand X soap to Brand Y.

Although I have stressed the psychological effect of mobility devices, I think there is always a danger of reading too much psychology into the problem. The marketing of mobility or any other devices that help blind people is not just a matter of how they feel about the instrument. Above all it is a question whether the device works and helps them in their daily lives.

I am afraid I have raised more questions than I have been able to answer. This is due to the primitive state of our knowledge about blindness. Those of us interested in the behavior of blind people have our work cut out for us if we are ever to provide you with the information you need to distribute mobility devices and to determine their effectiveness.

REFERENCES

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2. Especially as objections to the technique were raised at the meeting.

3. Wide variation among physicians in arriving at a diagnosis, along with errors and inconsistencies in diagnoses, have been reported in two papers by B.S. Sanders. See his "Completeness and Reliability of Diagnoses in Therapeutic Practice," paper presented at the statistics section of the American Public Health Association, November 14, 1963, and "Sources and Validity of Medical Statistics with Special Emphasis on Diagnoses," in Proceedings of the Social Statistics Section, American Statistical Association, Washington, D.C., 1963.

4. While variation between vision testing devices have been explored, little or no attention has been given to differences among different observers using the same device. See U.S. National Center for Health Statistics: Comparison of Two Vision-Testing Devices. PHS Publication No. 1000, Series 2, No. 1 U.S. Government Printing Office, Washington, D.C., 1963.

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WANTED: A READINESS TEST FOR MOBILITY TRAINING

Milton D. Graham
Department of Research
American Foundation for the Blind
New York, New York

INTRODUCTION

In the course of a recent comprehensive study of 867 male adults, whose loss of vision was 70 percent or greater, I had occasion to examine the data on mobility for the first 100 subjects. These data suggest that our approach to mobility research and to mobility training has been too restricted in most cases (1).

Where our emphasis has been on the optimum swing of the arc of the cane, or the teaming of gait of dog and man, or some other such significant variable, we have lost sight of man as an information processing unit and as a psychosocial being with certain capacities and limitations, some of which are inherent in his sensory loss and some of which are imposed upon him by the social milieu in which he finds himself. In short, *why* a man with a major sensory deficit gets around is as important as *how* he gets around. Why blind and severely visually impaired people get around at all is a constant source of wonder to people with no first-hand knowledge of them (2).

Those of us who are acquainted with them have hunches why they travel well or poorly. A few mobility trainers (it is a very small group) have experience with them; some rule-of-thumb observations have come from that experience. But nowhere is there a body of theory that explains and delimits mobility for that population who, since they are human, are most complex and who also happen to have little or no useful sight. There is no commonly accepted readiness test that will predict within reasonable limits the possible success a person will have who is about to start mobility training (3). This is like accepting everybody for college whether or not he has passed a college board examination or has a history of accomplishment (i.e., good grades) in the academic world.

We have no "entrance exam" for mobility training, yet without doubt mobility is one of two or three most crucial problems that a blind or severely visually impaired person has. Without a standardized readiness test we cannot reach the large numbers of blind people who might benefit from mobility training; now we cannot even tell within reasonable limits what success the relatively few mobility trainees will have before they start the course.

Some intake procedures do exist for selecting condidates for mobility training and, in a few cases, to some degree of sophistication. One center requires a general physical examination, an ophthalmological examination, and a social work service report (4). Such thoroughness is rare, even rarer than the mobility courses taught by professionally trained personnel. But the basis of selection is too often intuitive: this person will probably succeed in learning independent travel because he wants to, because he seems to be healthy, etc. Mobility trainers are themselves aware that some more sophisticated selection process is necessary. One said recently, "What is needed is a professional interpretation of each prospect's intelligence - that is, his type, his potential, his limitations, and why he is as he is. With this information a competant mobility specialist could decide what training would be of most help to the trainee" (5, p. 285).

Can a readiness test be devised for better selection of mobility trainees? I think it can, but only after a good deal of research and experimentation. The data below suggest some possible avenues of exploration before the construction of a readiness test is attempted.

LIMITATIONS OF THE DATA

The data used here to suggest aspects of mobility worth considering for further research were collected in three out-patient clinics of the Veterans Administration in Boston, New York, and Washington. The subjects were blinded veterans whose loss of sight from injury or disease was service connected and hence compensable. The examinations were five in number and were identical in all three clinics: a general physical (precoded for record purposes), an ophthalmological exam, an audiological exam, a psychosocial exam, and a health perception test. Physicians administered the first two, qualified professional personnel the last three. The exams were then checked for accuracy, completeness, and internal agreement. Fifteen IBM cards of data for each subject resulted.

Let it be said at once that the group examined were "not typical blind persons" (what group is?), because they are adults, males, adventitiously blinded, once mentally and physically fit enough to be inducted into military service, and so on. For the purpose of identifying some aspects of mobility such "typicalness" is not necessary at this point; we want to find North America, not the Sewanee River.

For this purpose the sample of 100 is excellent. It is made up largely of males of employable age and in the peak years of activity. As blinded veterans they are probably the most favored group of blind people in the world; there was made available to them extensive rehabilitation training, medical care, prosthetic aids, other equipment, and financial support in the form of compensation for injury or loss. It is fair to say that in mobility, as in other problem areas, they have been given every advantage. The data will suggest that those advantages have contributed to the subjects' well-being.

Besides the advantages offered these men, the sample reported on here is important in another way: two out of three of them do not associate themselves with any agency, private or public, for the blind. Those of us in research are convinced that the ratio of blind and severely visually impaired persons in the general population known to agencies is about the same ratio: of three persons whose functions are limited by their visual condition, one is known and two are unknown. Yet almost all our research is on the population known to the agencies, not the much larger "hidden" population.

The bias of such research is obvious. In that respect the present sample is probably more unbiased than most sample populations drawn by researchers in this field.

In summary, then, the sample reported here is not "typical" of the adult blind population known to agencies for the blind, but it is probably much more typical of the "hidden" adult blind and severely visually impaired population in the USA whose functions are affected by their visual condition.

METHOD OF PROCEDURE

A mobile person is an active person. Starting with this premise, the activities of the sample of 100 were examined and scores computed for purposes of comparison (6). The activities were given weights according to frequency of participation and kind of activity; that is, whether it was sedentary or active. For example, a higher score was given to fishing once a week in the summer time than to listening to the radio an hour every day; the mobility implications are clear here.

After the participation scores were computed for each person, they were put in rank order from lowest to highest, and divided into quartiles. Thus of the sample of 100, the First Quartile (Q_1) contains those 25 subjects with the lowest scores, and the Fourth Quartile (Q_4) those with the highest scores. The shorthand descriptions of Q_1 and Q_4 will be used throughout the rest of this paper.

Having identified Q_1 and Q_4, it became possible to describe certain of their characteristics, and to compare these characteristics for what light they may throw on the central question: How can we predict within reasonable limits whether a person can benefit from mobility training? (7).

PSYCHOSOCIAL CHARACTERISTICS

Age Distribution

The average age of the group of 100 is 46.03 years which reflects the general average age of most veterans, with World War II veterans predominating (see Table 1 and References 8, 9). As might be expected, in the Q_1 group (low activity) there are twice the number of persons over 55 than there are in the Q_4 group (high activity). But there are also twice as many persons in the Q_1 group who are under 40. This suggests that the younger, less mobile group must have other difficulties that keep them from being active. So it is safe to say that *age alone is not an overriding factor in determining mobility,* even though it is important.

Age at Loss of Sight

The data as shown in Table 2 suggest that the commonly accepted rule-of-thumb has some credence: that the younger the person at the time of losing his sight the more active he is likely to be, or conversely, a person losing his sight in later years (say, after 50) is likely to be less mobile. But again, this factor is not conclusive: age *alone* does not determine mobility readiness.

Stability of Family Condition

From other studies we know that the family generally is important in the decision-making process of a blind person perhaps even more so than in the case of a sighted person (10, 11). We know, for instance, that where the family is supportive, cataract surgery is more likely to take place (12). Since independent travel can be called as much of a risk-taking process for a blind person (13, 14), it would follow that a supportive family is important for encouraging mobility. Our data suggest this is so. When compared with the Q_1 group, the Q_4 group contains fewer single, never married persons, considerably more married only once and living with present spouse (Table 3), and more dependents (Table 5). Most striking is the fact that 92 percent of the Q_4 group consider themselves head of their household, against 56 percent for the Q_1 group. Conversely 32 percent of the Q_1 group consider somebody else head of the household (24 percent their wives), against 4 percent of the Q_4 group (Table 4). The Q_4 group thus appears to be more the picture of the head of household, father and breadwinner, as later data will support. For *independent* travel, this stability of family condition is undoubtedly important (remember the Q_1 groups suggests some overdependence, with 32 percent calling someone else head of their household, which is almost triple the number the U.S. Census Bureau quotes for the general population and eight times the number of the Q_4 group). While too much cannot be made of these scanty data, the implications are clear:

indepedent travel is risk taking, a stable family is more likely to be supportive provided it is not overprotective.

ATTITUDES TOWARD BLINDNESS

Severe visual impairment in the adult years introduces radical changes in a person's way of life. How realistically he accepts those changes is crucial to his continued well-being. In social research we speak of a person's "attitudes" as being key items to adjustment. Accordingly, we had a panel select eleven pairs of statements (half negative, half positive) involving acceptance of blindness. The Q_1 group (low activity) were consistently twice as negative in the attitudes as the Q_4 group (high activity). Especially significant were the scores on "self-image" items like "A blind man cannot be head of his household." Here the Q_1 group were twice as negative. Like age and family conditions, attitudes toward blindness undoubtedly affect mobility patterns. Those attitudes, not singly, but in concert with other factors may determine mobility patterns.

INTELLIGENCE

Does intelligence affect mobility? There are opinions on both sides of this question. Unfortunately the present data are very inconclusive, since the Army General Classification Tests (AGCTs) were obtainable only on 41 subjects of the sample of 100; 15 of which were in Q_1 and 8 in Q_4 . Because of the average length of the total examination (2-1/2 to 3 hours) in the out-patient clinics, it was deemed unwise to attempt to administer an intelligence test to the 867 subjects. Beyond that difficulty, no "culture-free" intelligence test was readily available that would meet the objections of some groups that existing tests discriminate in favor of white, middle-class subjects. For these reasons only existing AGCT scores were used. The results are completely inconclusive in this sample and would be of benefit for neither discussion nor speculation. Whether intelligence affects mobility patterns or not is still an open question as far as our data are concerned.

EMPLOYMENT SITUATION

The data on employment and work patterns are quite clear: 40 percent of the Q_1 group are in the labor force while 84 percent of the Q_4 group are in the labor force; 24 percent of the Q_1 group work 40 hours or more a week, 40 weeks or more a year while the figure for the Q_4 group is 68 percent (Table 6). Also occupational mobility figures are consistent (Table 7). Since blindness, 24 percent of Q_1 have been downgraded in the job, to 8 percent for Q_4; 8 percent of Q_1 have moved laterally (that is, the present job requires as much skill as the job before blindness) while 20 percent of Q_4 have moved laterally.

FINANCIAL SITUATION

It follows that the family income situation is much the same (see Table 8). Two highly significant differences are to be found on household income (which is the total income for all members of the family from all sources). First, the 100 blinded veterans in the sample have a considerably higher average annual income than the general population: the 1963 average (15) given by the U.S. Census Bureau is $6200, for the sample of 100 it is $9000 for the Q_1 group $7435, and for the Q_4 group $11,540. Other figures confirm this picture: 12.4 percent of all veterans in 1960 had a household income of $10,000 or more as against 16 percent of the Q_1 group and 48 percent of the Q_4 group. High income and a high degree of activity (of which independent mobility is an integral part) are obviously closely related as indicated below. Now it can be said that on the basis of age, family condition, employment, and income there are decided differences between the Q_1 and Q_4 groups, differences that affect activity and mobility patterns.

HEALTH CONDITIONS

Certainly health conditions can be expected to influence activity and mobility. As can be seen in Table 9, the number of compensable disabilities (that is, those injuries or diseases incurred in military service for which the Veterans Administration gives compensation) is two in addition to blindness for 80 percent of both the Q_1 and Q_4 groups. However, 12 percent of the Q_1 group have five or more compensable disabilities while the Q_4 group is 4 percent. In Table 10 other major impairments (not service connected) show the same distribution: three or more impairments for the Q_1 group 16 percent, for the Q_4 group 4 percent. Chronic physical conditions (Table 11) mentioned by the veterans show 68 percent of the Q_1 mentioning none and for the Q_4 group 80 percent (16). Psychological complaints, listed in Table 12, indicate that the Q_1 group has 24 percent with no or insignificant complaints and the Q_4 group has 60 percent for the same categories. Clearly the physical and psychological complaints of the Q_1 group are more numerous and more severe than the Q_4 group as might be expected. Physical inability to get around and psychological inability to undertake risks directly affect mobility, but not entirely. It must be remembered that the Q_4 group contains about 20 percent multiply impaired with one or more chronic conditions and/or moderate to severe psychological complaints. Except for the obvious extreme cases (like the bedridden or mentally disturbed), physical and psychological health is a contributing factor but not an overriding factor in determining mobility patterns.

MOBILITY PATTERNS

Ordinarily, blind and severely visually impaired persons get around independently in three ways: they use what vision they have, if any, they use guide dogs, or they use canes (17). (A few blind people use no aids and using a sighted guide cannot be called independent travel.) The data show (Table 13) that the Q_4 group (high activity) contains more totally blind persons (60 percent to 48 percent for Q_1) and that those who have some sight use it regularly, whereas 20 percent of the Q_1 group say that they use their travel vision only occasionally. The use of dog guides (Table 14) is 4 percent for the Q_1 group and none for the Q_4 group. The difference is significant, however, on use of the long cane (sometimes called the Hoover cane or typhlocane [18]). Only 16 percent of the Q_1 group use the long cane as against 40 percent for the Q_4 group (see Table 15). The major implication of these figures is that most blinded veterans do not travel independently to any degree: about one-third say that they have had any training of any kind in independent travel, and only 16 percent say that they *never* use a sighted guide. We know this to be true of nonveterans (17) but it is surprising in a group that were offered free training courses and equipment; still only about 1000 veterans have benefited from the travel training at Hines VA Hospital. This points up the critical need for more and better mobility training courses, if independent travel is to be practiced by any number of blind people (19).

How important independent travel is to blind people is suggested by income (Table 16) and employment figures (Table 17) of the Q_1 and Q_4 groups. The average national income is \$6200, for college graduates \$9700, for Q_1 \$7435, for Q_4 \$11,540, for those in Q_1 with travel vision \$7900, for those with travel vision in Q_4 \$11,800, and for long cane users (all of whom are in Q_4) \$11,500. Other studies have led us to expect higher wages to go with increased vision, but the exceptionally high income of the long cane users further emphasizes the role that independent travel plays in personal income. The same may be said for employment. For comparative purposes here are percentages of persons *not* in the labor force for one reason or another:

	percent
Nonveterans (1960)	19.9
All veterans (1960)	7.2
Sample of 100 blinded veterans	39.0
Q_1 (low activity)	60.0
Q_4 (high activity)	16.0
Long cane users	20.0

Several interpretations of these data can be made.

1) The household income figures of all blinded veterans groups exceed the national average, the Q_4 group and the long cane users probably significantly so.

2) As other studies have led us to believe, vision results generally in higher income, but long cane users (who have no travel vision by definition) approach this high income level very closely.

3) Having vision is not so important as how it is used. The household income of the Q_1 group members (many of whom do not regularly *use* their travel vision, much as we found in Table 13) who have travel vision is only slightly higher than the whole group.

4) According to the employment figures, the percentage of long cane users in the labor force is double that of the Q_1 group, and is only slightly less than the Q_4 group.

The important point in this discussion is not that the long cane is a valuable aid to mobility (which it is), but that it requires extensive training. The results of extensive training with guide dogs, canes, and (in the future) electronic guidance devices (19) would probably result in similar findings: high activity level, considerable mobility particularly among the totally blind, an employment level close to the national average, and a household income considerably above the national average (20). And of these desirable aspects of life, mobility is probably the key element in the success of blind people. If they can overcome the restrictions that visual impairment puts on travel, they can expect to approach national averages on employment and income.

To conclude this discussion, the factors that determine mobility patterns of blind and severely visually impaired persons need to be made as explicit as these data will permit. They are: age, family situation, health, use of travel vision, and mobility training. *No one of them singly appears to determine mobility patterns, but taken in combinations they do determine mobility patterns.* Some logical combinations that would impede mobility are: (1) over 50 years of age, with multiple impairments, plus no travel vision, and no travel training, or (2) living alone with few social contacts, plus multiple impairments, chronic conditions, some (but little used) travel vision, and no mobility training. Some such combinations would materially affect mobility patterns.

As an exercise involving the multiple factors that may possibly determine mobility patterns, 12 cases were taken from the entire group of 100 who had indicated that they participated in *no* outdoor recreational activities. The following are specific data on each case.

Case No. 1 age 58; 5 compensable disabilities, 5 additional impairments; not in labor force involuntarily; 1 other member of household; no travel vision, no travel training.

Case No. 2 age 62; 2 compensable disabilities, no other impairments; retired; living alone; no travel vision, no travel training.

Case No. 3 age 47; 1 compensable disability, no other impairments; out of labor force involuntarily; with 2 other members of household; uses vision to travel in family territory only occasionally, no travel training.

Case No. 4 age 27; 1 compensable disability, no other impairments; institutionalized; no travel vision, no travel training.

Case No. 5 age 52; 1 compensable disability, no other impairments; not in labor force involuntarily; lives alone; no travel vision, no travel training.

Case No. 6 age 38; 3 compensable disabilities, no other impairments; out of labor force involuntarily; 6 members in household; uses vision in both familiar and unfamiliar territory regularly, trained with guide dog and Hoover cane.

Case No. 7 age 58; 4 compensable disabilities, no other impairments; retired, 1 other member in household; no travel vision, no travel training.

Case No. 8 age 50; 2 compensable disabilities, no other impairments; not in labor force voluntarily; lives alone; uses vision only in familiar areas regularly, no travel training.

Case No. 9 age 47; 1 compensable disability, no other impairments; working; with 9 other members of household; no travel vision, no travel training.

Case No. 10 age 50; 2 compensable disabilities, no other impairments; working; living alone; uses vision regularly in both familiar and unfamiliar territory, no travel training.

Case No. 11 age 38; 1 compensable disability, no other impairments; working; with 3 other members of household; uses vision only occasionally in familiar territory, no travel training.

Case No. 12 age 67; 2 compensable disabilities, no additional impairments; retired; lives alone; uses vision regularly in both familiar and unfamiliar territory, no travel training.

CONCLUSION

These cases suggest strongly that multiple factors are at work in the formation of a mobility pattern. Certainly these multiple factors would have to be considered in the formulation of any readiness test for mobility training. That mobility training programs are needed for blind and severely visually impaired persons, especially for those with some remaining vision, the multiply impaired, and the old in good health, is often said. That some more rational procedure for selecting persons for mobility training is absolutely necessary is not said, nor is any need voiced for a performance test or tests of persons who have completed a mobility training program (a subject that requires separate consideration at another time). Until such tests are devised, experimented with, and standardized, it is not likely that there will be any successful attack on one of the two main problems facing blind and severely visually handicapped people today: mobility.

NOTES AND REFERENCES

1. A noteworthy exception is to be found in Finestone, Samuel, I.F. Lukoff, and M. Whiteman. The Demand for Dog Guides and The Travel Adjustment of Blind Persons. New York: The New York School of Social Work, Columbia University, (Research Center), 1960, who say, "...a total rehabilitative approach is necessary because of the complex social, motivational and skills aspect of travel training." (p. 99).

   Also mentioned in Planning for Statewide Mobility Services for Visually Handicapped, Interim Report to VRA, Society of St. Vincent de Paul, St. Louis, Missouri, 1962, (p. 35).

2. "Blind" is defined here as no useful vision for mobility purposes, that is, total blindness or light perception only. "Severe visual impairment" is defined as some useful vision (light projection upwards), but loss to the extent that some function of the person is vitally affected. See discussion in AFB Research Bulletin No. 3, 1963, pp. 111-130, for details.

3. See Planning for Program of Statewide Mobility Services for Visually Handicapped, Interim Report to VRA, Soci-

ety of St. Vincent de Paul, St. Louis, Missouri, 1962: "Mobility training is undertaken only when there is a readiness on the part of the blind person which can be evaluated as such by the mobility specialist and others who have responsibility for the intake process." (p. 25).

4. Central Rehabilitation Section for Visually Impaired and Blinded Veterans, VA Manual M-2, Chapter 9.04 (c), October 1961.

5. "Teaching Orientation and Mobility to Mentally Retarded Blind Persons" Thomas J. Murphy, New Outlook, Vol. 58, No. 9 November 1964, (pp. 285-287).

6. The activities comprising the battery were: reading frequency; attendance at theaters, concerts, films, political rallies, sports events; frequency of visiting others; participation in organizations, club, societies, church; voting in presidential elections; outings away from home, vacations, weekend trips, day trips; outdoor activities, swimming, boating, fishing, hunting, skiing, riding in automobiles for pleasure, picnics, camping, and gardening; hobbies.

7. Since the sample is so small, standard statistical tests of significance were not carried out; some rough estimates were made intuitively.

8. "Veterans in the U.S. 1959, Employment, Income, Family and other characteristics" - <u>Research Monograph</u> No. 5, Office of the Controller, Veterans Administration, July 1961.

9. Veterans in the U.S.: 1960, Supplementary Reports, 1960 Census of Population, P C (S1)-31, Bureau of the Census, December 14, 1962.

10. <u>Planning for Program of Statewide Mobility Services for Visually Handicapped</u>. Intrim Report to VRA, Society of St. Vincent de Paul, St. Louis, Missouri, 1962: "...familial attitudes toward the blind person can substantially affect the orientation and mobility program which the blind person is undergoing." (p. 41).

11. <u>Households and Families by Type</u>: (1964) Current Population Reports, Population Characteristics, P. 20 No. 130 July 27, 1964, Bureau of the Census.

12. <u>Resistance to Cataract Surgery</u>, Irving Miller, AFB Research Series No. 12, (1964).

13. "Assessment of Risk-Taking Behavior," Paul Slovic. Psychological Bulletin, Vol. 61, No. 3, March 1964, pp. 220-233.

14. Personal communication from staff of VA Hospital, Hines, Illinois.

15. Income of Families and Persons in the U.S: (1963) Current Population Reports, Consumer Income, Series P-60, No. 43, September 29, 1964, Bureau of the Census.

16. Chronic Conditions Causing Limitation of Activities, U.S. July 1959-June 1961, Health Statistics, U.S. National Health Survey, Report B-36.

17. This is corroborated in Finestone, Samuel, I.F. Lukoff, and M. Whiteman. The Demand for Dog Guides and the Travel Adjustment of Blind Persons. New York: The New York School of Social Work, Columbia University, (Research Center), 1960. who say, "...a total rehabilitative approach is necessary because of the complex social, motivational and skills aspect of travel training." (p. 99).

18. Specifications for the Long-Cane (Typhlocane), Veterans Administration, April 28, 1964, 5 pp. text and engineering drawings.

19. See the report of Dr. Bruce Deatherage, "The Evaluation of the Haverford - Bionic Instruments Obstacle Detector," in L.L. Clark (ed) Proceedings of the Rotterdam Mobility Research Conference. New York: American Foundation for the Blind, 1965, pp. 201-234.

20. This is confirmed by a study of leisure time activities which has been conducted by Dr. Eric Josephson, Department of Research, American Foundation for the Blind.

TABLE 1

AGE DISTRIBUTION
(percent)

Ages	Total Population		Blinded Veterans Research Project Sample		
	Nonveterans[1]	Veterans[2]	Total (N=100)[3]	First Quartile[4]	Fourth Quartile[5]
18-24	17.2	6.8	1.0	-	-
25-29	6.7	13.4	3.0	4.0	-
30-34	4.5	17.2	6.0	4.0	-
35-39	3.2	19.4	16.0	24.0	16.0
40-44	7.8	14.6	23.0	16.0	36.0
45-49	12.0	8.3	21.0	20.0	20.0
50-54	12.3	5.1	12.0	4.0	16.0
55-59	11.5	3.0	8.0	12.0	12.0
60-64	6.0	5.3	1.0	4.0	-
65 and over	18.7	6.9	9.0	12.0	-

1 Veterans in the U.S. 1959, Employment, Income, Family and other characteristics - Research Monograph No. 5 Office of the Controller, Veterans Administration, July 1961.
2 Veterans in the U.S. 1960, Supplementary Reports, 1960 Census of Population, P C (S1)-31, Bureau of the Census, December 14, 1962.
3 Sample of 100 blinded veterans of present study.
4 Twenty-five blinded veterans with lowest activity scores.
5 Twenty-five blinded veterans with highest activity scores.

TABLE 2

AGE AT LOSS OF SIGHT
(percent)

Age Grouping	Blinded Veterans Research Project Sample: Total (N=100)	First Quartile	Fourth Quartile
10-19	12.0	16.0	8.0
20-29	56.0	56.0	64.0
30-39	21.0	16.0	28.0
40-49	7.0	8.0	-
50-59	3.0	4.0	-
60-69	1.0	-	-
70 and over	-	-	-

TABLE 3

FAMILY CONDITIONS: MARITAL STATUS
(percent)

Marital Status	Total Population		Blinded Veterans Research Project Sample		
	Nonveterans	Veterans	Total (N=100)	First Quartile	Fourth Quartile
Single - Never Married	18.3	13.1	16.0	12.0	8.0
Married Once Spouse Present			57.0	68.0	88.0
Married More Than Once - Spouse Present	72.6	82.4	17.0	12.0	-
Married Once - Separated			1.0	-	-
Married More Than Once - Separated			1.0	4.0	-
Married Once - Spouse Absent			-	-	-
Married More Than Once - Spouse Absent	9.1	4.5	-	-	-
Married Once - Widower			1.0	4.0	4.0
Married More Than Once - Widower			-	-	-
Married Once - Divorced			3.0	-	-
Married More Than Once - Divorced			1.0	-	-

TABLE 4

FAMILY CONDITIONS: HEAD OF HOUSEHOLD
(percent)

<table>
<tr><th rowspan="2">Head of Household</th><th colspan="2">Total Population</th><th colspan="3">Blinded Veterans Research Project Sample</th></tr>
<tr><th>Nonvet-erans</th><th>Veter-ans</th><th>Total (N=100)</th><th>First Quartile</th><th>Fourth Quartile</th></tr>
<tr><td>Veteran Head</td><td>73.5</td><td>81.4</td><td>75.0</td><td>56.0</td><td>92.0</td></tr>
<tr><td>Spouse Head</td><td rowspan="3">17.1</td><td rowspan="3">12.0</td><td>7.0</td><td>24.0</td><td>4.0</td></tr>
<tr><td>Parent Head</td><td>8.0</td><td>8.0</td><td>-</td></tr>
<tr><td>Sibling Head</td><td>4.0</td><td>-</td><td>-</td></tr>
<tr><td>Lodger</td><td rowspan="2">9.4</td><td rowspan="2">6.6</td><td>3.0</td><td>4.0</td><td>-</td></tr>
<tr><td>Group Quarters</td><td>3.0</td><td>8.0</td><td>4.0</td></tr>
</table>

TABLE 5

FAMILY CONDITIONS: NUMBER OF DEPENDENTS
(percent)

Number of Dependents	Blinded Veterans Research Project Sample		
	Total (N=100)	First Quartile	Fourth Quartile
0	27.0	32.0	12.0
1	22.0	20.0	32.0
2	16.0	16.0	12.0
3	16.0	16.0	12.0
4	9.0	4.0	16.0
5	5.0	4.0	4.0
6	2.0	-	4.0
7	2.0	4.0	4.0
8	-	-	-
9	1.0	4.0	4.0

TABLE 6

EMPLOYMENT STATUS
(percent)

Total Employment Status

	Total Population		Blinded Veterans Research Project Sample		
	Nonveterans	Veterans	Total (N=100)	First Quartile	Fourth Quartile
Employed	74.6	87.4	51.0	36.0	80.0
Unemployed in Labor Force	5.5	5.4	6.0	4.0	4.0
Not in Labor Force	19.9	7.2	39.0	60.0	16.0
No Information	-	-	4.0	-	-

TABLE 6 (continued)

Project Sample Employment Status

	Blinded Veterans Research Project Sample		
	Total (N=100)	First Quartile	Fourth Quartile
Never worked since service, discharged before 1955	10.0	16.0	4.0
Never worked since service, discharged 1955 and after	1.0	-	-
Not worked since 1950, out of labor force	7.0	12.0	-
Worked since 1950 but not since 1960, out of labor force	11.0	4.0	8.0
Worked since 1950 but not since 1960, in labor force	1.0	12.0	4.0
Worked since 1960, not working now, out of labor force	8.0	20.0	-
Worked since 1960, not working now, in labor force	5.0	-	4.0
Working 40 hours or more a week for 40 weeks or more a year	43.0	24.0	68.0
Working 40 hours or more a week, less than 40 weeks a year	4.0	4.0	4.0
Working less than 40 hours a week, more than 40 weeks a year	4.0	4.0	4.0
Working less than 40 hours a week, less than 40 weeks a year	2.0	4.0	4.0
No information	4.0	-	-

TABLE 7

OCCUPATIONAL MOBILITY
(percent)

Occupational Changes	Blinded Veterans Research Project Sample		
	Total (N=100)	First Quartile	Fourth Quartile
No Change	21.0	28.0	24.0
Upward	21.0	16.0	20.0
Downward	13.0	24.0	8.0
Lateral	15.0	8.0	20.0
Impossible to Determine	7.0	4.0	8.0
Unemployed	23.0	20.0	20.0

TABLE 8

ANNUAL FAMILY HOUSEHOLD INCOME

Total Household Income (percent)

	Total Population		Blinded Veterans Research Project Sample		
	Nonveterans	Veterans	Total (N=100)	First Quartile	Fourth Quartile
$1000-1999	16.9	5.7	2.0	4.0	-
2000-3999	22.3	13.2	6.0	8.0	4.0
4000-5999	25.0	25.6	10.0	12.0	-
6000-7999	25.1	38.4	26.0	36.0	20.0
8000-9999			16.0	16.0	28.0
10,000-14,999	10.8		31.0	16.0	28.0
15,000-24,999		17.1	3.0	-	20.0
25,000-Plus			2.0	-	-
No Information	-	-	4.0	8.0	-

Average Household Income (dollars)

Nonveterans	$ 3215
Veterans	5109
Total (N=100)	9000
First Quartile	7435
Fourth Quartile	11,540
All United States, 1963	6200

TABLE 9

HEALTH CONDITIONS:
NUMBER OF COMPENSABLE DISABILITIES
(percent)

Number of Compensable Disabilities	Blinded Veterans Research Project Sample		
	Total (N=100)	First Quartile	Fourth Quartile
1	57.0	64.0	68.0
2	21.0	16.0	12.0
3	6.0	4.0	4.0
4	7.0	4.0	12.0
5	3.0	8.0	-
6	4.0	-	4.0
7	1.0	-	-
8	1.0	4.0	-
9	-	-	-

TABLE 10

HEALTH CONDITIONS: OTHER IMPAIRMENTS
(percent)

Number of Other Impairments	Blinded Veterans Research Project Sample		
	Total (N=100)	First Quartile	Fourth Quartile
0	91.0	80.0	92.0
1	2.0	4.0	4.0
2	-	-	-
3	1.0	4.0	-
4	1.0	-	-
5	3.0	8.0	4.0
6	2.0	4.0	-

TABLE 11

HEALTH CONDITIONS: CHRONIC CONDITIONS (percent)

	Blinded Veterans Research Project Sample		
	Total (N=100)	First Quartile	Fourth Quartile
None Mentioned	75.0	68.0	80.0
One or More Mentioned	25.0	32.0	20.0

Number of Chronic Conditions Mentioned*

First Quartile

1- nervous disorder

1- high blood pressure

1- chronic bronchitis

1- other respiratory

1- peptic ulcer

1- other digestive

1- other musculoskeletal

1- other

Fourth Quartile

1- diabetes

2- high blood pressure

1- other circulatory

1- other

* Chronic Conditions Causing Limitation of Activities, U.S. July 1959-June 1961, Health Statistics, U.S. National Health Survey, Report B-36.

TABLE 12

PSYCHOLOGICAL COMPLAINTS AS REVEALED BY CORNELL MEDICAL INDEX (percent)

	Blinded Veterans Research Project Sample		
	Total (N=100)	First Quartile	Fourth Quartile
No Complaint	35.0	20.0	48.0
Not Significant	8.0	4.0	12.0
Mild	32.0	32.0	24.0
Moderate	9.0	16.0	4.0
Severe	16.0	28.0	12.0

TABLE 13

MOBILITY: TRAVEL VISION
(percent)

	Blinded Veterans Research Project Sample		
	Total (N=100)	First Quartile	Fourth Quartile
No Travel Vision	53.0	48.0	60.0
Regular Use			
Use in familiar places regularly	15.0	16.0	16.0
Use in unfamiliar places regularly	-	-	-
Use in both familiar and unfamiliar places regularly	20.0	16.0	24.0
Occasional Use			
Use in familiar places occasionally	9.0	8.0	-
Use in unfamiliar places occasionally	-	-	-
Use in both familiar and unfamiliar places occasionally	3.0	12.0	-

TABLE 14

MOBILITY: DOG GUIDE USERS
(percent)

	Blinded Veterans Research Project Sample		
	Total (N=100)	First Quartile	Fourth Quartile
Never used	88.0	88.0	80.0
Use to use	8.0	8.0	20.0
Use now	3.0	4.0	-
No information	1.0	-	-

TABLE 15

MOBILITY: LONG CANE TRAINING*

	Blinded Veterans Research Project Sample		
	Total (N=100)	First Quartile	Fourth Quartile
Never had, do not use cane	62.0	80.0	52.0
No training, use to use cane	3.0	4.0	8.0
No training, uses cane now	5.0	4.0	4.0
Training and uses cane	30.0	12.0	36.0
No information	-	-	-

* Specifications for the Long-Cane (Typhlocane), Veterans Administration, April 28, 1964, 5 pp. text and engineering drawings.

TABLE 16

INCOME CHARACTERISTICS OF LONG CANE USERS*

	Average in Dollars
Total (N=100)	9000
First Quartile	7435
Fourth Quartile	11,540
Long Cane Users	11,500
Travel Vision - First Quartile	7900
Travel Vision - Fourth Quartile	11,800

*National income average, $6200. U.S. Census Bureau, 1963.

TABLE 17

EMPLOYMENT CHARACTERISTICS OF LONG CANE USERS
(percent)

	Total Population		Blinded Veterans Research Project Sample			Long Cane Users
	Nonvet-erans	Veter-ans	Total (N=100)	First Quartile	Fourth Quartile	
In Labor Force						
Employed	74.6	87.4	51.0	36.0	80.0	70.0
Unemployed	5.5	5.4	6.0	4.0	4.0	10.0
Not in Labor Force	19.9	7.2	39.0	60.0	16.0	20.0
No Information	-	-	4.0	-	-	-

SECTION IV

Research and Development of Mobility Aids

Chairman: *Robert W. Mann*
Massachusetts Institute of Technology
Cambridge, Massachusetts

MOBILITY DEVICES: THE STATE OF THE ART

John K. Dupress
Sensory Aids Evaluation and
Development Center
Massachusetts Institute of Technology
Cambridge, Massachusetts

The following brief remarks may provide some perspective for a discussion of mobility device design criteria as well as estimates of potential applications and usefulness. First, what kinds of information are required for successful mobility? The traveler needs to know, when he takes his next step, whether the aperture is sufficiently large for his body to pass through and is unobstructed by objects. Second, he must know that the terrain where he places his foot presents a platform of sufficient area and strength to hold his weight safely. Third, if the terrain has changed its level, that is, there is a step-up or step-down, he must know with considerable precision how much of a change there is in order to identify landmarks for successful navigation from his place of origin to a specific objective. The traveler is not usually concerned with objects which lie outside the aperture. Mobility devices, therefore, are not really object detectors so much as detectors of a "no object" situation in the immediate forward path. When his intended travel path becomes cluttered with more and more objects a device must be so designed that the traveler can adjust the range to a distance slightly more than one step forward. For purposes of navigation there is a considerable amount of information which may be obtained by the individual's remaining sensory channels concerning features of the terrain as well as objects which serve as landmarks.

In summary, the information needed for mobility consists of a "no object" condition at the next step, a safe platform on which to step, and information for successful orientation and navigation. The state of the art of technology and the effort put into research on mobility devices will not allow us, at the present time, to construct a device which will provide all of the information previously mentioned. What are some of the limitations of present device design? The energy radiating devices must be very thrifty in their expenditure of energy. As a result a very small portion of the aperture is investigated by the device at any given instant and the "on" time of these devices extends for a very small percentage of the time - not more than 15 percent. Previous and present devices have generally left the sampling of the aperture by the sensor to the user. The device is generally hand-held. One exception consisted of a device which was machine scanned, but in a narrow search parallel to the ground. The azimuth information was then divided into five zones and coded for display purposes. As a result, however vigorous and sophisticated the user may be, only a portion of the aperture may be investigated with each successive step. In some devices range information is provided either in gross zones or, in one instance, in very small increments through an auditory display with changes of the pitch of sounds.

When the aperture some distance forward in the intended travel path becomes cluttered with objects this problem is generally handled by cut-offs in the device which allow objects to be ignored past a certain distance. Such complex and important situations have multiple targets in the intended travel path at varying distances: information concerning moving objects which the traveler may or may not intercept, objects which may extend into the aperture above or below the scan area, and numerous other difficult problems which are left unresolved in most present devices. Devices which are intended to survey the terrain frequently detect only that there is some kind of change in the terrain. They do not determine that the next platform is a safe one by which to rest the weight of the traveler. The information is not displayed in a fashion which will permit quick and safe movement by the traveler up or down to the next terrain level.

Although passive or ambient devices may have greater long range promise than energy radiating units, passive sensors presently being developed have an excessive "false alarm" rate. They are adversely affected by light reflections, they must be adjusted by the user to a wide variety of illumination conditions, and still lack sufficient acuity for a great many kinds of objects and terrain changes. Single element ambient sensors require overly critical adjustments of sensing aperture, amplifier gain, and the correlation of these two factors which does not affect adversely the display to the user. An automatically adjusted iris, coupled to automatic amplifier gain with a multi-element sensor, and considerable processing of the data, is probably necessary before ambient sensors are practical. Since the ambient sensor consumes power only in the processing of information, it is conceivable that a combination object and terrain change detector can be designed.

In summary, current devices must be thought of as a supplement to the cane. Or, in the case of navigational problems, as a supplement to the use of the guide dog. If the present devices therefore do not provide complete mobility capability, what kinds of information should they provide? One kind of useful information would be advanced warning data about objects which are in the intended travel path and beyond the probing of the cane. This would simply permit the individual to anticipate the object and give him more reaction time. Second, objects might be detected about where the cane is looking. Third, terrain changes might be detected prior to the probing of the cane. If the false alarm rate for such terrain change detectors is kept at a reasonable figure they could permit early warning data which would then be supplemented quickly by careful probing with the cane. The devices should not duplicate information provided already by the cane, nor should they hamper the use of the cane, the dog, or interfere with remaining sensory channels.

A great many arbitrary decisions have been made concerning the nature of the sensor, the amount of processing left to the device in the human, and the displays provided to the subject. These decisions have had to be made largely against the background of ignorance. We need a great deal of research on sensory processes and the kinds of information required in the mobility task. Such important choices as hand-scan versus machine-scan; the amount of the area of the aperture to be covered by the device at a given time; hand-held versus head-mounted devices; cutaneous versus auditory displays; monaural versus binaural auditory displays and sensing; single versus multi-modality displays; gross versus fine range data; and numerous other items must be settled by careful research.

In the course of the conference, the possibility of computer simulation will be mentioned. We must evaluate the present devices on a relatively small base of prior evaluation criteria and lack of standardized procedures. We must know a great deal more about the mobility of children and adults with and without formal training, exactly what the mobility task consists of, the use of devices in familiar as well as unfamiliar environments, and evaluations conducted both in the standardized maze situation and in realistic indoor and outdoor life situations. There must be a ready willingness on the part of evaluators, researchers, and rehabilitation specialists to modify both the devices and evaluation procedures. Devices are here. Extensive knowledge of mobility under conditions of sensory deprivation and sensory processes are still lacking. The acquisition of new knowledge must be largely restricted, therefore, to the painful hill-climbing technique in which some devices are chosen on the basis of very small scale evaluation. More extensive evaluation must be done and a body of experience must be built up over time.

There is one last topic which deserves consideration. We are at the point now where people are seriously considering sensing the environment with optical scanners or optical matrices of some kind, processing the information, and feeding the data directly into some part of the central nervous system. Electromagnetic radiation and modulated laser beams have been mentioned. There are serious proposals currently being put forth to create some kind of visual sensation. From the long range viewpoint the use of electronics and optics to create some kind of visual sensation sounds like an exciting dream. Components technology and systems design probably make the construction of a sensor and processor as well as display for stimulating for the central nervous system possible. What we do not know, however, is the coding which exists in an appropriate part of the central nervous system, the neurosurgical techniques for successful coupling into the nervous system itself, and, most importantly, safe radiation limits. All of these things have yet to be determined. Devices to provide visual sensation are a long way off. But this does not mean that we should ignore them completely. In the meantime, however, we should go ahead with our careful analysis of mobility device design criteria, applications, evaluation, and estimates of usefulness.

FOOTNOTE

In preparing this rough draft, two thoughts were omitted concerning applications for some mobility devices. Those devices which have a sensing capability of 20 or more feet, can supply useful orientation and navigation cues. Second, these distant sensors can, after sufficient experimentation, assist in developing spatial constructs for the congenitally blind. Experiments with congenitally blind children are a logical beginning. Silent objects at a distance frequently do not provide sound shadows and are undetectable under most conditions.

SUMMARY STATEMENT: SOME REMARKS ON MOBILITY THEORY

M.B. Clowes
Institute of Experimental Psychology
Oxford, England

Research towards improving the mobility of blind people is very heavily biased in the direction of improving the sophistication of existing transducers. Relatively little investigation of the human skills subsuming the effective use of such devices has so far taken place. It is usually assumed that the device will 'take' - like a graft - provided that the 'display' characteristics (e.g., its audio frequency range, discriminability, and so on) are *correctly* chosen. It can be argued, however, that in the absence of a clear understanding of the information processing being performed by a blind (or sighted) traveler, this choice (of 'correct' display characteristics) will remain arbitrary or at best pragmatic. As support for this view we might cite the research on blind reading aids, where more and more emphasis is being placed upon a knowledge of the skills which underlie the perception of complex patterns, e.g., the perception of speech (4).

Remarks of this kind are, however, valueless unless we can indicate the *directions* in which such an understanding might be sought and the *conceptual framework* in which it might be cast. I am quite convinced that the direction lies experimentally in the use of simulated environments as described by Professor Mann (2). I have an equally strong conviction that the framework lies in the descriptive systems currently being developed in research in language (1, 5). The conceptual framework of these linguistic models can readily be extended in an illuminating fashion to the study of apparently unrelated aspects of behavior, e.g., motor skills, problem solving, etc. (3).

To extend this kind of description - say that of Yngve - to give an account of mobility behavior (cf. verbal behavior) we need to assume 1) that the 'grammar' has been replaced by a similarly organized set of mobility plans and 2) that some method is provided by which corrective action can be taken if the mobility plan currently being developed, e.g., "getting to the garden gate" turns out to have gotten us to the garage door instead. The undeveloped parts of the mobility plan (i.e., those remaining in the push-down store) will then have to be altered. This of course happens in verbal behavior as when we find half-way through a sentence that it is impossible to develop a thought with the construction we are using. As in language behavior, we would expect the limited capacity of the push-down store to affect the kinds of mobility behavior which could be accomplished. In the content of transducers, e.g., sonic torch etc., we might then consider the additional push-down storage required to handle this display.

The ideas briefly outlined above are of course highly speculative, and are included only so as to indicate the absence of any sustained research into the nontechnological aspect of sensory aids.

One of the important side effects which would flow from the development of an understanding of these psychological processes would be to bridge the gap between sensory aids research and vocational rehabilitation. Indeed it seems possible that a direct consequence might be to show (i.e., prove) that the main improvements in mobility are to be obtained from a redeployment of existing skills (based on hearing, tactile kinesthetic sense) rather than the proliferation of further transducers.

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SECTION V

Evaluations in Field Laboratory for Performance Parameters of Subjects Using Mobility Aids

Chairman: *Ivo Kohler*
University of Innsbruck
Innsbruck, Austria

THE ESTABLISHMENT OF A CENTER FOR SENSORY AIDS EVALUATION AND DEVELOPMENT*

Robert W. Mann
Massachusetts Institute
of Technology
Cambridge, Massachusetts

INTRODUCTION

Organized technical research directed toward the amelioration of sensory deprivation is of quite recent origin. However, we are already confronted with systems and devices proposed and, to some extent, realized, which are intended to improve the access of the blind and deaf-blind to printed and graphical material (6), and to improve the mobility of those with sensory deficits.

But there remains a vital need subsequent to the creation of a novel approach or device: that of systematic evaluation of its real utility to the blind. Intertwined with this evaluation phase is a process of redesign, then product engineering, to make the device widely available at minimum cost to its prospective users. As evaluation proves positive and engineering refinements are incorporated, contact must be established with potential user agencies and information exchanged to ensure the successful transfer of the new capability into the hand of its prospective beneficiaries. Thus to bridge the gap between initial feasibility and practical realization a coordinated process of evaluation, development, liaison, and education must be conducted.

For the past four years an ad hoc group of engineers, scientists, statisticians, psychologists, and sociologists has met to discuss overall problems of sensory impairment, including the evaluation and development of already extant processes and devices. (The members of this ad hoc Committee on Sensory Impairment are listed in Table 1.) From these discussions have emerged several points upon which the members of the group are in general agreement:

* While reported to the Rotterdam Mobility Research Conference in August 1964 as a proposal, the Center for Sensory Aids Evaluation and Development was established effective September 1, 1964 by a contract between the Vocational Rehabilitation Administration of the Department of Health, Education, and Welfare of the U.S. Government and Massachusetts Institute of Technology as the host institution.

1. The modern technologies of detection, display, and communication have, as yet, hardly been brought to bear upon the problems of those with sensory deficits. As an obvious example, there are not yet blind people in the streets carrying detectors which provide mobility improvements over the cane or dog.

2. Current efforts on novel devices and processes at a number of laboratories in this country and in Europe show sufficient promise to warrant a sustained program of further development, testing, and evaluation.

3. This development and evaluation cannot now be undertaken by any existing organization. On the one hand, due to the implied scope, scale, and mandatory continuity, it is not a proper activity for a university laboratory or department. Furthermore, present appraisals of market potential make such an effort unattractive to commercial organizations. Consumer demand develops only after the demonstration of real utility.

4. Unless such development and evaluation is carried out potentially useful processes and devices will never become available to those who need them. It thus appears important to obtain government and/or foundation support for a center to fulfill these functions.

5. Since a significant fraction of the current research is now being carried on in the Boston area this appears to be an appropriate site for such a center, thus maintaining close contact with that original research which spawns innovation. The Boston area also provides access to nationally significant agencies for the blind and to the many facilities which the academic and medical institutions in and around Boston already possess.

6. The primary objective of the center would be to solicit research laboratory apparatus at the feasibility demonstration stage, evaluate their potential, and succor really promising devices to the point where their manufacture and distribution to the handicapped could be transferred to extant agencies. Depending upon the type of device or process, the center program might entail testing and evaluation under controlled conditions, with representative samples of the blind population, the selection of promising and rejection of less promising and redundant approaches, the development of training techniques to facilitate the introduction of the device, the organization of recommendations on the assets and limitations of the device, and the concomitant engineering development, including that production engineering necessary for small scale production.

The center is thus seen as a needed supplement to other research, training, and rehabilitation efforts. It would not attempt to provide facilities or research effort in areas of research already served by other laboratories or institutions.

7. Since these objectives require a wide spectrum of skills and facilities, it appears wise to create a center which can draw upon the resources of several universities, laboratories, and institutions. The group meeting at the Massachusetts Institute of Technology (MIT) has included faculty from Brandeis, Harvard, and Tufts, and MIT faculty and staff representing the Electrical and Mechanical Engineering Departments, the Psychology Department, and Lincoln Laboratory. The current group is by no means exclusive, and others may well wish to join either now or at a future date. Members of this local group have expressed an interest in serving the center and are proposed as a steering committee which will meet monthly to formulate policy for the center and to aid and advise the center staff on the implementation of its tasks (see Table 2).

8. In order to broaden the professional and geographical base of the center's representation, and to augment the consultative access of the center, a scientific advisory committee is proposed (Table 3). The members of this committee would be chosen nationally from among research and rehabilitation personnel of academic, institutional, and industrial organizations which have demonstrated interest and competence in fields related to sensory impairment and rehabilitation. The scientific advisory committee would meet semiannually to review, with the steering committee, the investigations and plans of the center staff. In addition to its advisory function the committee will help to ensure effective liaison and communication between the center program and sensory aids research and rehabilitation elsewhere in the nation.

9. Under the provisions of a proposal submitted to the Vocational Rehabilitation Administration (VRA) of the Department of Health, Education and Welfare, of the U.S. Government, the center professional staff will be comprised of managing director, a design engineer, an experimental sensory psychologist, and supporting staff. (The present center staff are identified in Table 4.) The expansion of the staff beyond this initial nucleus is anticipated as other sources of support are made available.

10. The center's staff, facilities, program, and accessability to the sponsoring institutions will encourage and ensure student participation in its activities under the supervision of associated faculty. It would, in fact, be a specific intention of the center to involve students, in the context of theses and projects, in the engineering and psychological work of the center, especially through use of special center facilities.

11. The center will require access to the facilities listed below. Wherever possible it should attempt to make use of exist-

ing facilities at one of the participating institutions or to contract work to appropriate concerns.

a) Machine, electrical, and electronic shops;

b) computer facility with provision for video and audio input and output;

c) reading and writing devices for punched cards, punched tape, and braille;

d) equipment for the recording and playback of visual, auditory, and other displays;

e) laboratory and field sites appropriate for testing and evaluation of mobility devices and navigational aids.

THE PROGRAM OF THE CENTER

Evaluation Procedures

The crucial element in evaluation is the availability of subjects. To evaluate a wide variety of devices from the very simple to the very complex, the center will establish and maintain close contact with all agencies for the blind in the greater Boston area. Arrangements will be made with agency staff members for cooperation in the testing of specific devices and for the recruitment of appropriate subjects.

Specialized devices intended for specific occupations are best evaluated by blind persons who hold jobs in the area of specialization. In fact, some vocational aids must be tested on the job. Devices in the area of education should be field tested in an educational or rehabilitation facility for the blind. General purpose devices must be evaluated by blind persons who range from the newly blinded to the congenitally blind who may never have seen. The center staff, therefore, will recruit a substantial number of subjects who will then be tested with devices under the direct supervision of the staff psychologist.

After more than five years of experience at the American Foundation for the Blind, during which period there was close cooperation with government agencies and private rehabilitation and educational facilities, the present managing director believes devices can be evaluated in two stages. There should be a preliminary evaluation with as few as three to five subjects. This preliminary evaluation is designed to determine the facility with which the device may be used with a minimum of training, the amount of adaptation required of the subject, the learning time to reach a plateau of performance without stress or fatigue, and the reaction of the subject as to whether he can perform the task as well or better with alternative means. Based upon the data gathered from this preliminary evaluation, a number of devices will then be taken to the second stage.

In the second stage a larger number of subjects will be used (30 or more), and these subjects will be chosen in accordance with the type of device involved (educational, vocational, reading, and mobility aid), and the amount and variety of training, skill and experience needed to perform the task. The most complex devices such as reading machines and mobility aids will invariably require more evaluation over time, and redesign or modification, to bring the device to a more useful state.

The diagram of Figure 1 describes the organizational relationship between the several groups and various functions of the center.

The above tasks, sponsored by the proposed VRA contract sponsorship, do not include the mobility area during the first year, but the center hopes to secure funds from other sources for this very important category of sensory aids.

The staff psychologist will begin her duties with a careful review of all previous evaluation procedures, and a thorough study of all available reports. In addition, part of the travel budget for staff will be used for field trips for the staff psychologist to those rehabilitation facilities which have had experience in the kinds of devices which the center will evaluate.

Since much work remains to be done in the selection of evaluation criteria, the standardization of testing, and the criteria for subject selection, the staff psychologist and members of the steering and scientific advisory committees will attempt to build upon the body of available data. Cooperation from rehabilitation and research facilities in this country and abroad has been excellent in the past and we anticipate a continuance of these arrangements.

Selection of Devices for Evaluation

There are several sources from which devices may come to the center for evaluation. The products of research and development facilities (university, commercial, and individual) and references from government agencies will be screened by the staff. Appropriate specifications and a working prototype, where possible, will then be made available to the members of the steering committee for a final decision concerning the desirability for undertaking a formal evaluation.

In many instances requests for evaluation are from individual

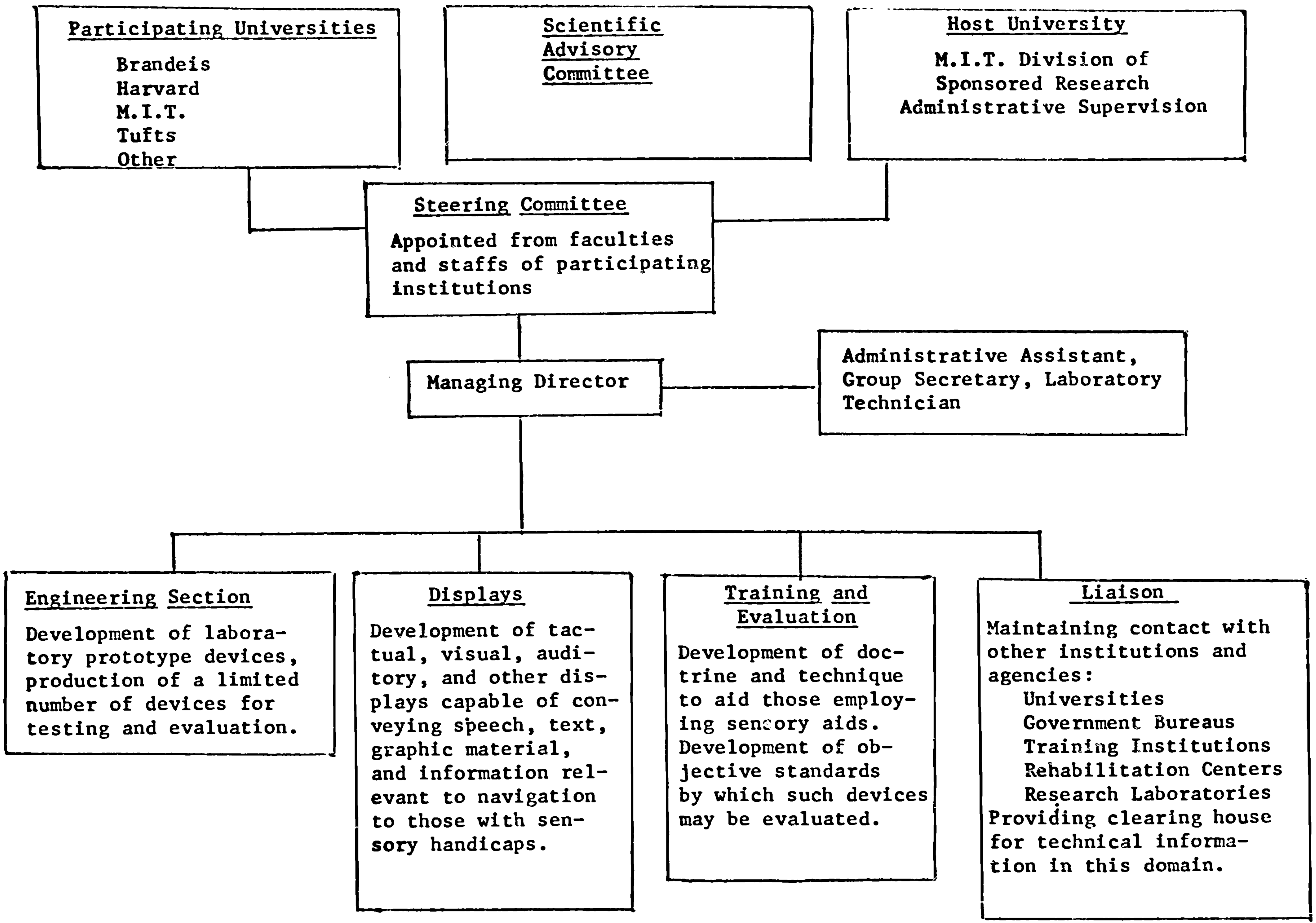

Figure 1. Sensory Aids Evaluation and Development Center Organizational Structure.

inventors whose thinking has not progressed to detailed specification or a working prototype. A great deal of duplication of individual effort unfortunately exists. The task for which the device is intended may often be performed by blind persons without devices or with the use of existing devices. Some devices will have already been evaluated with negative results. The staff will respond to inquiries without imposing extensive evaluation procedures, keeping the steering committee informed on such routine matters.

In conjunction with rehabilitation facilities and special information sources such as the International Research Information Service of the American Foundation for the Blind, the center staff will keep informed of devices of both national and international origin which may make a contribution to the rehabilitation of the blind and deaf-blind. After screening by the steering committee, negotiations will be undertaken to secure permission for evaluation of these devices.

Tasks for September 1964 - August 1965

Within the context of the facility and as part of the overall program of the center, the following specific tasks will be undertaken under VRA sponsorship during the first year (1 September 1964 to 31 August 1965). These devices and processes will be evaluated, redesigned when necessary, and recommendations made concerning usefulness and reliability.

High Speed Electric Braillewriter

The electric braille embosser designed and developed by the Engineering Projects Laboratory group in Mechanical Engineering (MIT-EPL-ME) under VRA sponsorship will be evaluated (2, 5).

The proposed evaluation and development center will negotiate with existing agencies for the blind to secure a production facility and distribution center so that these high speed braillewriters will become available to blind persons. Staff members will consult with any interested agency in interpreting the production engineering data and in providing any other specialized information required to implement the original research and production engineering.

In addition to the implementation of the braillewriter research, special one- and two-hand keyboards and other inputs to the braillewriter will be evaluated and production engineering will begin for those items which receive a final positive evaluation.

Monotype Typesetting Tape to Input
for Braille Translation Programs

Monotype tape is used in the publishing industry for those books which require special symbology (physics, mathematics, etc.) or contain a considerable variety of type fonts (elementary school texts, etc.).

The evaluation and development center staff will take research programs and equipment (8) developed by the Electrical Engineering Sensory Aids Group at MIT and will try to make the program economically feasible for incorporation into services for blind and deaf-blind persons. Arrangements have been made with the W.P. Saunders Company of Philadelphia to secure a medical dictionary for translation. Other published material will also be secured in Monotype form. Particular attention will be paid to school texts since there are already 15,000 blind school children and that figure is expected to double in less than two decades.

Teletypesetting Tape to Input
for Braille Translation Program

Teletypesetter tape is used for setting up type for such publications as major newspapers, most high school and elementary textbooks, and many magazines. The speed of the computer could make newspapers available to the deaf-blind within the same day a newspaper is published.

Center staff will undertake a feasibility study of a program for Teletypesetter conversion to Grade 2 braille developed by a graduate student in the Mathematics Department at MIT (3). Portions of newspapers, magazines, and textbooks will be translated, existing computer programs will be improved, and cost estimates will become available for various kinds of publications. At the end of the production feasibility study arrangements will be made with existing braille production facilities, should the results be positive.

Typesetting Tape to
Spoken Word Conversion

The Veterans Administration has sponsored research at Haskins Laboratories to develop instrumentation which can read Teletypesetter tape and convert this form of stored information to the spoken word.

Center staff will negotiate with the Veterans Administration to conduct a feasibility study of this special instrumentation to determine acceptance by blind persons. Should this form of output prove satisfactory, an analysis will be made of the economic feasibility of the Haskins Laboratories instrumentation versus photo storage table look-up instrumentation.

At the end of the feasibility study staff members will confer with the Veterans Administration, Haskins Laboratories, the Library of Congress, and interested agencies for the blind, to secure their views concerning this special library facility.

Collapsible Canes

Several collapsible canes developed in the context of undergraduate laboratory coursework in MIT-EPL-ME and elsewhere will be evaluated (1).

Inertial Guidance Device

The hand-held inertial navigational device developed at MIT-EPL-ME which tactually indicates deviations from a straight line path has had cursory evaluation at St. Paul's Center, Newton, Massachusetts, and will be studied further (1, 2).

Radio Frequency Compass for Navigation
of the National Research Council in Canada

An initial prototype of the National Research Council of Canada radio compass was completed last year and at least two advanced prototypes were constructed during the first half of this year. Plans are being formulated in Canada for a preliminary evaluation (7).

Precision, Self-Leveling
Compass for Navigation at the
Swedish Royal Institute of
Technology

One working prototype of the precision, self-leveling compass was demonstrated at the International Congress on Technology and Blindness held during June 1963 (4). Engineering drawings are available from Sweden.

Carpenters' Level, Centering Device,
and Other Vocational Aids of VRA

The vocational aids are available in working prototype form in the Division of Services for the Blind, VRA, or at the agencies which developed the devices.

"Beeping" Ball

A prototype of the "beeping" ball to facilitate the play of blind children has been constructed at MIT-EPL-ME and given some preliminary evaluation at Perkins School for the Blind.

Anticipated Tasks for
Second Year Program

During the second year the following items are tentatively scheduled for evaluation and production engineering when the evaluation is positive.

1. Moving braille belt displays which can serve as read-outs for various forms of high density braille storage (optical, magnetic, or punched hole), or as research instruments. The braille belt display is an MIT-EPL-ME project.

2. Quadrant searching optical probe (MIT-EPL-ME) which converts optical images to vibrotactile stimuli.

3. Deaf-blind communications device (MIT-EPL-ME) to permit perception of speech without physical contact with the speaker by a deaf-blind person.

4. Extension of the teletypesetter and monotype tape programs to take advantage of smaller computers and photo storage devices, and to develop additions to the computer programs to handle a wider variety of publications. In addition, we hope that a spoken word output will supplement the braille. The spoken word output would then require development to incorporate the results into the new tape cartridge system and voluntary reader program of the Library of Congress and of voluntary services such as Recordings for the Blind (New York City). The typesetting publishing tape utilization project will constitute the major part of the effort during the second year.

A number of vocational aids as yet unspecified will undoubtedly become available during the second and subsequent years.

Third to Fifth Years

Since we hope to have mobility device evaluation and development facilities, staff, and procedures, funded by other agencies or foundations than the VRA, we will not discuss this important area in any detail now.

Communications among researchers is improving so rapidly that we can be certain of an increase in interest to develop devices which may be useful to blind or deaf-blind persons. In cooperation with the Royal National Institute for the Blind, the American Foundation for the Blind, and government information sources, we expect to locate useful prototypes which can be recommended for further development, immediate adoption, or combination with older devices.

It is not possible to predict this far in advance which of the devices currently in the research laboratories will be deemed useful three to five years hence. Planning already under way in England, Russia, and the United States for new research will also result in prototypes requiring evaluation.

We can observe, however, that there is a growing body of basic research and some applied research directed toward developing print and handwriting reading machines for industry. It is probable that part of the effort can result in a useful reading machine for the blind. These new machines will be able to process a variety of type forms and handwritings and produce word output instead of spoken letters, complex sounds, or other difficult-to-comprehend information. The center staff will endeavor to take advantage of this research by evaluating the state-of-the-art and recommending the adoption of such machines at central library facilities. Their complexity and expense will probably prohibit their ownership by individual blind persons.

TABLE 1

AD HOC COMMITTEE ON SENSORY IMPAIRMENT

Dr. R.G. Domey
School of Public Health
Harvard University

Mr. John K. Dupress
formerly Director of Technological Research
American Foundation for the Blind, Inc.

Dr. Hyman Goldstein, Chief
Biometrics Branch
National Institute of Neurological Diseases and Blindness

Dr. Milton D. Graham, Director
Department of Research
American Foundation for the Blind, Inc.

Professor Richard Held
Department of Psychology
Massachusetts Institute of Technology

Dr. Eric Josephson
Research Associate
Department of Research
American Foundation for the Blind, Inc.

Dr. Irving Lukoff
Associate Professor of Social Work Research
University of Pittsburgh

Professor Robert W. Mann
Department of Mechanical Engineering
Massachusetts Institute of Technology

Professor Samuel J. Mason
Department of Electrical Engineering
Massachusetts Institute of Technology

Professor A. William Mills
Department of Psychology
Tufts University

TABLE 1
(continued)

Dr. R.B. Morant, Chairman
Psychology Department
Brandeis University

Dr. Oliver Selfridge
Lincoln Laboratory
Massachusetts Institute of Technology

Professor Marianne L. Semmel
Psychology Department
Brandeis University

Professor Thomas B. Sheridan
Department of Mechanical Engineering
Massachusetts Institute of Technology

Dr. Benjamin W. White
Department of Psychology
Cornell University
(formerly) Lincoln Laboratory
Massachusetts Institute of Technology

TABLE 2

MEMBERS OF THE STEERING COMMITTEE

Dr. Richard M. Held
Professor of Experimental Psychology
Massachusetts Institute of Technology

Dr. Samuel J. Mason
Professor of Electrical Engineering
Massachusetts Institute of Technology

Dr. A. William Mills
Assistant Professor of Psychology
Tufts University

Dr. Ricardo B. Morant, Chairman
Department of Psychology
Brandeis University

Dr. Oliver G. Selfridge
Lincoln Laboratory
Massachusetts Institute of Technology

Dr. Marianne L. Semmel
Associate Professor Psychology
Brandeis University

Professor Thomas B. Sheridan
Associate Professor of Mechanical Engineering
Massachusetts Institute of Technology

Professor Robert W. Mann
Professor of Mechanical Engineering
Massachusetts Institute of Technology
Chairman of the Steering Committee of the Center for Sensory
Aids Evaluation and Development

Mr. John K. Dupress
Managing Director
Center for Sensory Aids Evaluation and Development

Dr. Leo Riley
The Catholic Guild for All the Blind

Dr. Edward J. Waterhouse, Director
Perkins School for the Blind

Dr. John F. Mungovan, Director
Massachusetts Division of the Blind

TABLE 3

MEMBERS OF THE SCIENTIFIC ADVISORY COMMITTEE

Dr. Edward E. David, Jr., Director
Computing and Information
Bell Telephone Laboratories

Dr. Emerson Foulke
Department of Psychology
University of Louisville

Dr. Robert H. Gibson
Associate Professor of Psychology
University of Pittsburgh

Professor John G. Linvill
Stanford University

Dr. Mark R. Rosenzweig
Professor of Psychology
University of California, Berkeley

Dr. Robert A. Bottenberg, Chief
Mathematical and Statistical Analysis Branch
Air Force Personnel Research Laboratory
Lackland Air Force Base

Dr. Wilson P. Tanner, Jr.
Sensory Intelligence Laboratory
University of Michigan

Dr. Milton D. Graham, Director
Department of Research
American Foundation for the Blind

Dr. Robert A. Scott
Russell Sage Foundation

Dr. Carson Y. Nolan, Director
Department of Educational Research
American Printing House

Professor Irving F. Lukoff
Associate Professor of Social Work Research
University of Pittsburgh

Dr. Hyman Goldstein, Chief
Biometrics Branch
National Institute for Neurological Diseases and Blindness

TABLE 4

CENTER PROFESSIONAL STAFF

John K. Dupress - Managing Director

Director of Technological Research
American Foundation for the Blind
December 1958-December 1963.

Research Associate
Massachusetts Institute of Technology
July 1961-present.

A.B., Princeton University, 1949.

Graduate and undergraduate courses in Engineering, Psychology, Physics, and Mathematics at Princeton, Lehigh, and University of Connecticut.

Member of Rehabilitation Codes Subcommittees on Visual Impairment and Communicative Disorders; Committee on the Technical Material, Library of Congress; Committee on Computers and the Blind, Association of Computer Machinery; Advisory Committee, American Center on Research and Rehabilitation for the Blind; Research Committee of the Blinded Veterans Association; Ad Hoc Committees on Braille Research and Sensory Impairment Research of Massachusetts Institute of Technology.

Fourteen publications and more than 20 lectures before professional societies and universities.

Murray Burnstine - Design Engineer

Division of Sponsored Research staff engineer, Sensory Aids Groups, M.E., Massachusetts Institute of Technology, November 1963-present.

Assistant in Legal Medicine
Department of Legal Medicine
Harvard Medical School
June 1960-November 1963
Research on fatal highway collisions.

Research Assistant, Department of Neurosurgery, Wayne State University, 1959-1960. Instrumented cadaver impact tests, developed a patent weighing scale for metabolic study. Designed, built, and clinically evaluated a system for localizing brain tumors.

Chevrolet Test Laboratory, General Motors Research Laboratory,

TABLE 4
(continued)

1953-1959.

Student Assistant
Wayne State University
Department of Engineering Mechanics
1947-1953.

B.S. Mechanical Engineering
Wayne State University, 1953.

M.S.E.M.
Biomechanics
Wayne State University, 1960.

Registered Professional Mechanical Engineer, Michigan.

Registered Professional Mechanical Engineer, Massachusetts.

Seven publications and 13 lectures before professional societies and universities.

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TWO SENSORY AIDS TO AUGMENT
THE MOBILITY OF THE BLIND*

Ivo Kohler
Institute for Experimental Psychology
University of Innsbruck
Innsbruck, Austria

In the remarks which follow, two aids designed to augment the mobility of blind persons will be described. The first is a sonic device which operates within the normal span of hearing of the human ear. The second is a vestibular stimulator to guide the traveler's direction of movement remotely.

THE SONIC DEVICE

It is by now a well-known fact that blind persons can detect obstacles at a distance without using object cues of smell, temperature, or noise generation. The ability to detect objects is known as the "obstacle sense of the blind." Many investigations have shown that the obstacle sense is based largely on auditory factors (1, 2, 4, 5, 6). Sound which is generated by blind persons themselves, or which is already present in the environment, is modified by echo effects and echo interference effects in the neighborhood of sound reflecting surfaces. The modifications are received at the ear and transformed into typical obstacle sense cues.

A blind person equipped with a sonic device operating within the normal hearing range appears to show a significantly improved obstacle sense. With such a device the ear continues to play its *normal* role, detecting modification of direct and reflected sound and interference effects. In contrast with the natural situation, in which random and chance variations in sounds caused by sources of variable output, like footsteps, conversation, clearing the throat, and ambient noise, there is substituted a strictly defined and constant "unit-signal," which gives easily identified cues of obstacles by reflection and interference effects, and permits more reliable inferences about them. Since the transmitted signal is constant, the modifications the sound undergoes before it is heard are of immediate and objective importance (7).

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* This paper was prepared from notes written for an oral presentation at the Conference. The sonic device was demonstrated in a film entitled *Warning in the Dark*, shown at the meeting.

Our own experiments have shown that an optimum signal can be obtained neither by carrying the device in one's hand nor by using only the upper frequency ranges. The optimum condition obtains if the sound source is stable. This means that the device must be carried in a stable manner, namely on the blind person's chest or throat. The sound beam must not be too narrow; on the contrary, it must be as wide as possible and include as great a solid angle as possible. This condition may be attained by providing a suitable wave guide or screen.

The best sound signal appears to consist of a mixture of low and high frequencies. There are many reasons for this. Chief among them is that a suitable compromise must be arranged between technical demands and the capability of the human ear. High frequencies, say in the range of 5 kc/sec, are efficient from the technical point of view, but are unfavorable to use because the best sensitivity of the human ear is relatively low, in the range of 2 to 3 kc/sec. The sensitivity of the human ear decreases, moreover, with advancing age. Thus, it would be better to choose a signal which covers several frequency bands and includes low frequency sounds, thereby suiting the signal to any normal ear. Low frequencies are advantageous also for detecting surfaces which are oblique to the traveler; high frequencies are incident upon such a surface at such a large angle that they are not reflected back to him. The use of complex (i.e., composite) sound signals is recommended further because each component of the signal is reflected back in a different manner (according to its wavelength, size of the obstacle surface, and its distance), and the ear can thus utilize not only intensity differences for reflection from nearby objects, but also the harmonic composition of the sound (i.e., its timbre). It is to the latter type of modification that the human ear is most sensitive (5).

Figure 1 is a schematic of a sound generator or "clicker" which meets the above requirements and has given good results.

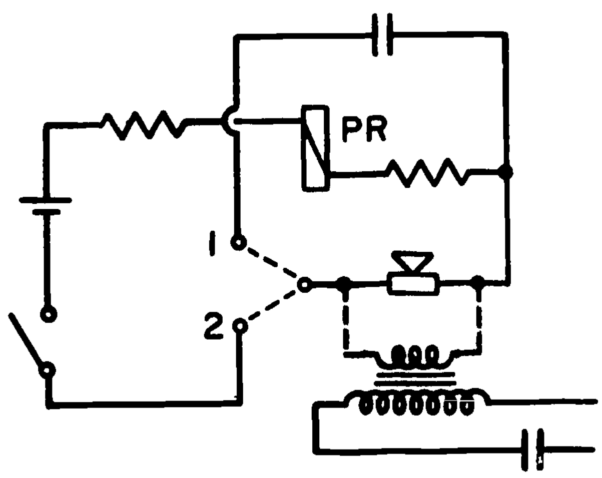

Figure 1. Circuit of a Sound Generator or "Clicker." The box labelled PR is a polarized relay. If a crystal output transducer is used in place of a common loudspeaker, the alternative circuit joined by dotted lines is used. Position 1 of the relay is the charging position. Position 2 is the short circuit or discharge position of the relay.

Figure 2 shows the waveguide and sound shielding. Figure 3 and 4 show how the device is carried on the chest and fastened to a necktie or collar. In the latter case the sound generator is

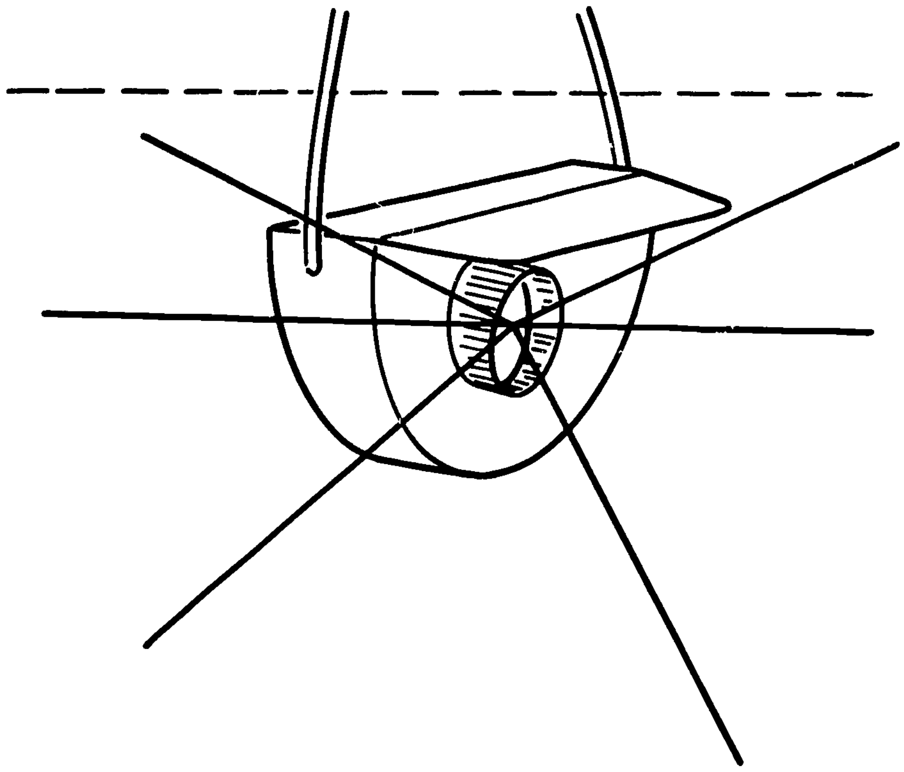

Figure 2. Waveguide and Sound Shield Arrangement. The sound shield prevents direct sound from the generator reaching the ears of the user.

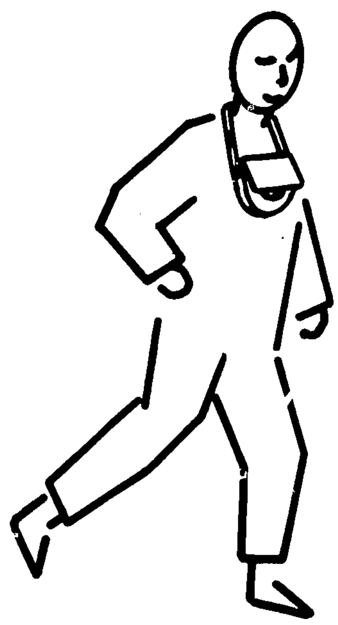

Figure 3. Placement of the Sound Generator on the Chest of the User.

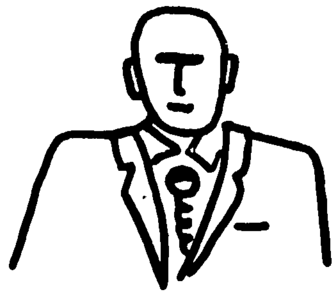

Figure 4. Placement of the Sound Generator on the Necktie of the User.

separated from the rest of the unit and is carried inconspicuously in one's pocket. Figures 5 through 8 show some of the situations in which the device was tested so that we could define the limits of the capacity to avoid obstacles based on the methods described above.

Figure 5. Using the Sound Generator: Crossing a Forest.

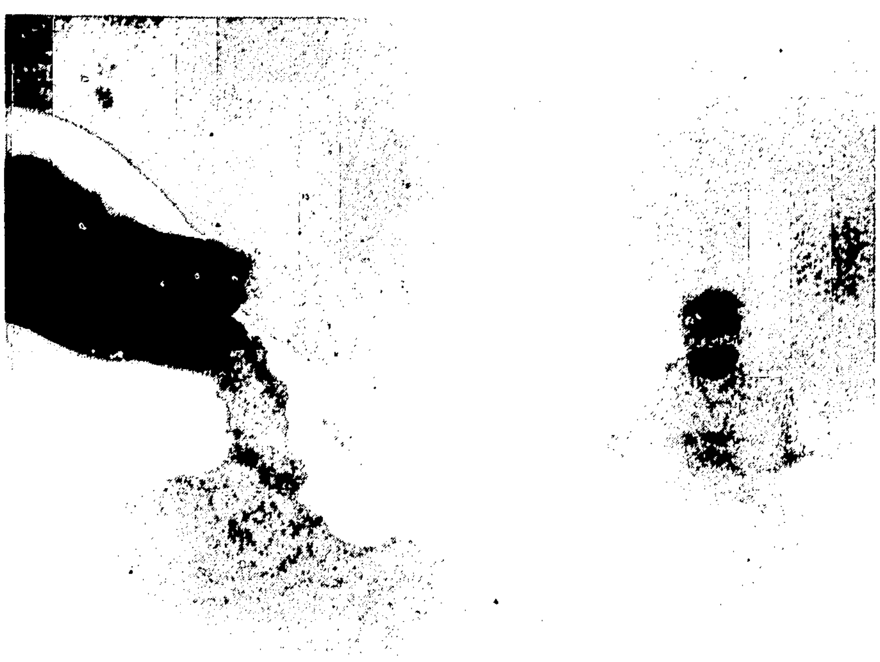

Figure 6. Using the Sound Generator: In Difficult Mountain Areas.

Figure 7. Using the Sound Generator: Swimming. The Waterproof Sound Generator is Fixed at the Head.

Figure 8. Using the Sound Generator: Steering a Cart.

It should be mentioned that after some training with such devices, the unaided or natural sense of obstacle avoidance is refined considerably, and the traveler reacts more positively when approaching obstacles. The sonic device can therefore be recommended for an intensive initial training of blind and severely visually impaired persons in detecting obstacles by auditory cues. After such training, the device may be dispensed with altogether for continuous use.

THE VESTIBULAR STIMULATOR

The principle underlying the development of the vestibular stimulator was based on the well-known fact that a small electrical stimulation of the vestibular organs disturbs the sense of equilibrium of the human in a well-defined way. The phenomenon can be demonstrated in the following manner (the schematic of the device and its method of attachment to the traveler is illustrated in Figure 9). The device consists of a battery from which current flows through the electrodes attached to the ears of the user. A potentiometer and two switches control the current flow, which is kept in the range of a few milliamperes and may be directed in either direction. The master switch is operated by the user himself, turning on the device when he feels his equilibrium is good; note the position of the foot placement in Figure 9. Normally, with his eyes closed, a sighted subject cannot maintain

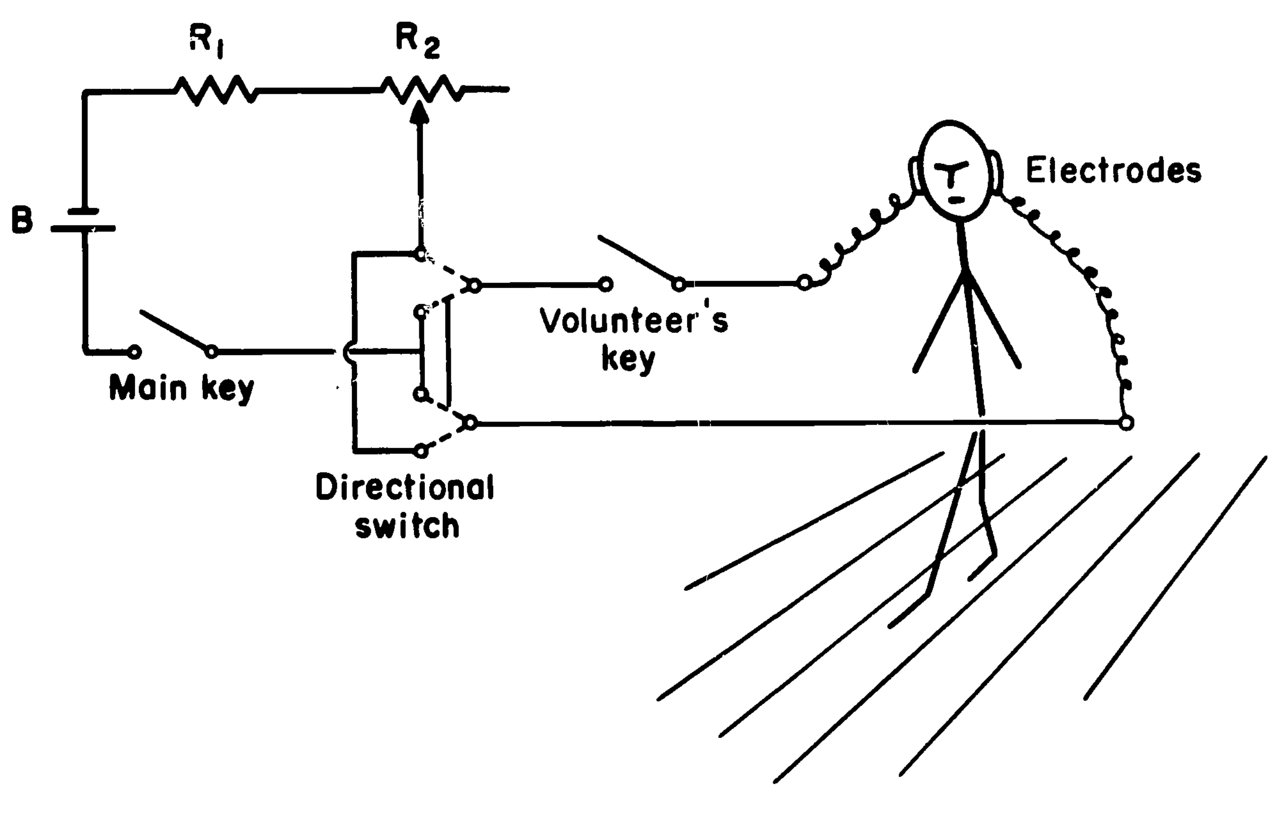

Figure 9. Circuit and Use of the Vestibular Stimulator. A 30-volt battery is used with a 10 to 50 kilohm protective resistor, and a user-adjusted potentiometer of 50 kilohm resistance.

equilibrium in this position, for his tendency to fall to the right or left is strictly dependent on which side of his head has the *positive* electrode.

The most interesting application is that made to a person who is moving (on foot, bicycle, swimming, skiing, even driving an automobile). Experience to the present allows us to say that a 1 or 2 second impulse to one ear results in a deviation of the travel path to the side on which the positive electrode is located.

We plan to study this phenomenon in depth, collecting quantitative data on time delay, duration of the impulse, degree of deviation from the undirected travel path, and interdependencies among these factors. We shall also study the use of the device in a wide variety of travel situations.

Practical applications of the system can be foreseen in guiding blind travelers from a distance without the use of speech. This would be particularly important for sports, in skiing, swimming, or bicycling.

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PSYCHOLOGICAL AND TECHNICAL ASPECTS OF GUIDANCE AIDS FOR THE BLIND

M. Chavanon
Union Des Aveugles De Guerre
Paris, France

PSYCHOLOGICAL ASPECTS

The problem of providing guidance aids for the blind has two different aspects, psychological and technical.

The psychological aspect is the most important, for every blind person has different requirements according to his age, his sensorial abilities, his reflexes, and his physiological capabilities.

Blind Children

Blind youths attending education centers acquire self-confidence very quickly under the guidance of educators and this allows them to participate in the games of their sighted fellows. We actually saw, in a blind education center, that some youths ran round a running track, jumped over obstacles, climbed trees, played with balls equipped with small bells, etc. It is a fact that these children have acquired possibilities of guiding themselves, in going from one place to another depending only on cues they interpret themselves, and that guidance aids are useless to them.

Blind Adults

These can be classified in two categories. First, the visually deficient who sometimes need help from another person. This category of blind persons generally has some perception of light which allows them to see the passage of a shadow, of a car, the edge of a pavement, etc.; in certain conditions they can move about without any help. Guidance aids will perhaps be of help to them, but will only be of interest if expected to give better results than those gained by their unaided efforts. Second, those blind persons, whose vision is of a maximum of 1/20, and who require the constant help of someone else. We have found that the recently blind who are unable to adapt themselves, old people, or people incapacitated for some other physical reasons, will need more than the guidance aids to enable them to move about alone with safety.

TECHNICAL ASPECTS

In this section we will give a summary of experiments done in France in 1959 and 1960. Although the performance of the apparatus described has been slightly surpassed, it does not appear that very tangible progress was realized regarding blind guidance aid implementation. The laboratory test instrument was constructed in one housing containing electronic components with a 4 to 5 volt supply and a sweep frequency of 5 kc/sec. Two types of ultrasonic beams were used. One was made of eye glass frames of 50-millimeter (2-inch) diameter in which lenses had been replaced by electrostatic diaphragms. The other was made of a torch with a frontal diaphragm of 50-millimeter (2-inch) diameter. Both devices, used alternatively, gave the same results in performance tests. In each case, the electronic components and the rechargeable battery supply were located in a cylindrical box of small diameter that could be held in a pocket; the output transmitted the display signal to an earphone. The detection of an obstacle such as a smooth wall, or a grating could be made at a distance of 3 meters (9 feet), which could be reduced to 2 meters (6 feet) for obstacles of a soft surface texture.

The range of the beams was about 25 degrees. To make sure of his safety in a range wider than 25 degrees, it was necessary that the user impart a sweeping of the angle of view and to take a bearing; apart from the 25-degree angle of view, however, some particularities of diffraction occurred which made the echo useless. The distance from the user to the obstacle was given by a low pitched sound at 3 meters (9 feet), and by a very high pitched and intense sound at 50 centimeters (30 inches).

From these experiments, it seems that the torch beam is of small practical value, and the blind user's hand is not free: he needs it to hold a cane, which is still indispensable to spot unevenness of the pavement; the other hand must be free at all times for such tasks as holding a door handle or other objects. It is also necessary that cue noises be heard with a sufficiently sharp tonality to exceed all other surrounding noises. It is a must that no guiding aid prevents the blind from his normal means of hearing. It is also important that the sounds received from any aid should be modulated so that the blind user does not suffer from monotony, which would be prejudicial to its successful use. With all the different aids presented up to the present, the blind user has to sweep a definite angle with the beam to allow him to find out the position of obstacles cropping up in front of him. This operation necessitates a continual strain for the blind user. It appears to be necessary, therefore, to have a guiding aid equipped with four beams which could scrutinize the space ahead of the user in a panoramic way. Each beam channel could generate a different note, and the user would know of the panoramic obstacle without making any movement of the instrument.

THE EVALUATION OF THE HAVERFORD-BIONIC INSTRUMENTS OBSTACLE DETECTOR

Bruce H. Deatherage
Sensory Information Project
TRACOR, Inc.
Austin, Texas

INTRODUCTION

During the Mobility Research Conference held at the Massachusetts Institute of Technology in October of 1961, Professor Benham of Haverford College reported on the development of a new model of an obstacle detector for the blind (1). This report is on the evaluation of that instrument, the Model G-5 Obstacle Detector (hereafter called the "O/D"), and it is divided into six sections: selection of subjects, tests, training, evaluation trials, results, and recommendations.

SELECTION OF THE SUBJECTS

Subjects were selected to obtain a group of adults which would approximate the characteristics of a veteran population with respect to age, sex, and education. Various agencies and institutions in the Austin (Texas) area were approached to secure a list of potential subjects. These agencies were: the Texas State Commission for the Blind; Travis Association for the Blind (Lighthouse); Texas State School for the Blind; The University of Texas; the Veterans Administration Regional Office; and the Texas Blind, Deaf, and Orphan School for Negroes. The individuals whose names were supplied from these sources were interviewed, the project described briefly to them, background material obtained, and schedules arranged for participation in the experiment. As an additional source of subjects, the Texas Lions Camp at Kerrville was quite useful; at this institution, training in the use of the long cane is given over a 12-week period.* Each subject's physician was queried in order to obtain information about visual acuity, angle of visual field, cause of blindness, age of blindness, etc.

* Subjects at this camp are dissatisfied with their present mobility aid, or are not using a dog or cane and would like to learn to use a cane. These subjects were added to the study because of the heightened motivation for a mobility aid.

The subjects and the background information concerning them are shown in Table 1. The mobility figure is based on the Mobility Aids Scale rating which classifies blind persons in terms of how much assistance they require when traveling (2). This rating system ranges from 1 (greatest mobility) to 15 (least mobility).

TABLE 1

BACKGROUND INFORMATION ON SUBJECTS

Subject	Age	Sex	Years of Education	Age at onset of Blindness	Cause of Blindness	Travel Aid	Mobility Score	Source of Training
A	29	M	12	9	Disease	Cane	2	Lighthouse
B	42	M	14	24	Disease	Cane	2	Self-trained
C	30	M	0	12	Disease	Cane	2	Kerrville L.C.**
D	26	M	8	18	Accident	Cane	5	Kerrville L.C.
E	34	M	16	32	Disease	Cane	2	Kerrville L.C.
F	33	M	14	14	Accident	Cane	2	Lighthouse
G	21	M	18	9	Accident	Cane	2	Kerrville L.C.
H	50	M	12	17	Disease	Cane	2	Kerrville L.C.
I	25	M	16	4	Accident	Cane	5	Self-trained
J	58	F	13	43	Disease	Cane	7	Kerrville L.C.
K	27	M	7	Infancy	Congenital	Cane	7	Kerrville L.C.
L	31	F	9	Infancy	Congenital	Cane	5	Kerrville L.C.
M	40	M	6	26	Disease	Cane	7	Kerrville L.C.
N	34	M	18	19	Disease	Dog	3	Seeing Eye***
O	56	M	7	23	Disease	Dog	2	Seeing Eye
P	41	F	14	29	Disease	Dog	9	Seeing Eye
Q	41	M	16	Infancy	Congenital	Dog	3	Seeing Eye
R	22	M	16	9	Disease	None	1	---------------
S	18	M	10	4	Disease	None	2	---------------
T	14	M	5	10	Disease	None	1	---------------
U	22	M	15	3	Accident	None	1	---------------
V	19	M	10	14	Disease	None	2	---------------
W	43	M	7	18	Disease	None	4	---------------
X	18	M	9	13	Disease	None	4	---------------
Y	14	M	5	Infancy	Accident	None	1	---------------
Z	20	M	12	2	Disease	None*	2	Lighthouse

* Also cane

** Kerrville Lions Camp (having about half completed the mobility course)

*** "Seeing Eye," Morristown, New Jersey

It may be noted that the 26 subjects represent a heterogeneous group in terms of each of the descriptive variables. They range in age from 14 to 56 years and in educational level from no schooling to graduate work at the university level. All, however, meet the criterion of total blindness. The age at total blindness ranges from infancy to 43 years, and the causes of blindness include a representative proportion of accidents, diseases, and congenital abnormalities. The least representative variable, perhaps, is that of mobility level, for this group as a whole is a fairly mobile one. In part, this sort of selection is inevitable; those who refuse to venture into unfamiliar environments would generally not be willing to participate as subjects in research. Of the 26, it was possible to complete every phase of the evaluation procedure on 14 subjects, and a major portion of the evaluation procedure on 19 subjects. Those who withdrew from the project did so for a variety of reasons. For example, several moved away from the city, one suffered a heart attack, and one was stopped by a spouse who objected to his participation. No subject verbalized a dissatisfaction with the O/D as the reason for withdrawal.

ADMINISTRATION OF TESTS

In order to explore the possibility that personality variables are predictors of response to the O/D, and also to provide a source for future work with an empirically derived predictor scale, three psychometric instruments were administered.

Each subject was individually administered the WAIS Vocabulary Test (Wechsler, 1955) and the California Psychological Inventory (Gough, 1957) before any training with the O/D. After completion of the initial training phase, the Emotional Factors Inventory (Bauman, 1958) was administered. The results of these tests are reported in Table 2.

TRAINING

Training subjects in the use of the O/D followed generally accepted procedures developed over a period of years by experts in the field of learning. The procedure used in the present study may be described as a variation of the "behavior shaping" technique which has been used successfully in widely divergent areas of training such as teaching pigeons to play ping-pong and instructing students of mathematics in set theory. In such a procedure a subject is first trained to perform successfully relatively simple tasks; as he becomes more proficient, the tasks become increasingly more difficult. At each stage of difficulty the subject receives training until he can perform the task relatively well, and then he is shifted to a more difficult and complex task. This continues until the subject is able to perform an extremely complex task - such as using the O/D in a crowded

TABLE 2

SCORES ON THE PERSONALITY TESTS*

California Psychological Inventory

Subj.	Dominance	Capacity for Status	Sociability	Social Presence	Self Acceptance	Sense of Well Being	Responsibility	Socialization	Self-Control	Tolerance	Good Impression	Communality	Achievement via Conformance	Achievement via Independence	Intellectual Efficiency	Psychological-Mindedness	Flexibility	Femininity
**B	32	16	22	30	18	42	35	38	41	23	25	27	30	18	37	11	3	20
C	24	12	18	24	14	13	21	30	15	8	13	18	16	4	22	9	1	16
D	27	18	29	28	20	42	32	41	38	25	31	26	32	18	40	13	9	16
E	28	24	28	37	25	40	35	43	34	24	23	27	33	16	42	13	7	18
F	38	22	25	40	21	39	35	33	34	29	16	27	29	23	45	15	16	23
G	38	23	32	46	25	42	35	44	30	30	20	28	34	21	47	13	9	18
H	28	22	29	39	21	40	36	37	41	28	32	28	36	22	43	9	9	18
**J	26	15	22	24	17	38	37	51	40	20	24	28	34	16	40	13	2	20
K	12	5	14	14	12	21	31	32	23	9	7	26	17	9	24	2	3	23
L	31	17	22	28	21	21	25	28	21	14	18	25	23	15	27	10	4	23
M	24	10	22	21	17	9	18	24	10	4	11	18	14	4	16	5	1	19
N	35	22	28	36	24	37	35	29	35	23	22	28	27	17	40	13	8	25
O	20	10	18	24	16	18	21	25	13	4	10	19	15	2	19	5	1	15
P	39	25	31	44	21	43	39	38	35	26	19	28	35	18	42	15	9	22
Q	29	18	27	34	23	36	34	38	19	19	13	28	27	13	41	7	6	12
R	21	15	25	35	23	38	28	31	33	17	26	25	23	19	34	11	7	21
S	25	21	26	39	20	35	33	41	26	26	10	28	22	23	38	12	12	16
T	24	8	18	25	16	22	19	27	19	7	11	26	15	12	21	7	6	17
U	21	24	22	43	23	26	27	28	15	16	8	26	21	17	39	14	17	17
V	18	8	20	33	15	23	14	18	15	8	4	22	11	9	24	9	6	10
W	28	12	25	31	18	39	30	42	34	17	27	26	30	13	34	8	3	16
X	15	15	13	31	17	30	17	26	20	15	13	24	18	11	20	13	11	16
Y	22	14	21	27	17	26	23	34	24	11	20	21	21	14	30	10	11	18
Z	21	11	22	20	13	35	28	42	36	16	22	28	26	14	34	9	4	22
Means	26	16	23	31	19	31	29	34	27	18	18	25	25	15	33	10	7	18

WAIS Est. and Emotional Factors Inventory

Subj.	WAIS Est. Vocab.	WAIS Est. I.Q.	Sensitivity	Somatic Symptoms	Social Competency	Attitudes of Distrust	Feelings of Inadequacy	Depression	Attitudes Regarding Blindness
**B	56	112	3	2	1	0	1	1	0
C	36	92	17	2	15	10	12	12	14
D	30	87	3	2	4	2	1	0	9
E	60	118	0	1	4	3	1	0	1
F	72	135	9	6	7	2	3	0	3
G	76	147	3	2	5	1	1	0	1
H	74	143	0	1	0	3	2	0	1
**J	43	104	2	6	11	3	4	1	4
K	60	117	17	5	19	11	10	9	8
L	65	123	13	8	3	11	8	6	6
M	15	70	--	--	--	--	--	--	--
N	70	129	2	1	4	4	2	0	3
O	26	92	17	2	15	10	12	12	14
P	63	123	2	3	5	2	2	1	2
Q	--	---	--	--	--	--	--	--	--
R	70	130	4	5	2	6	5	3	0
S	55	114	10	4	7	2	2	0	5
T	42	88	18	7	13	17	15	11	16
U	74	142	13	7	11	8	10	2	6
V	30	91	12	6	7	4	5	2	6
W	25	82	--	---	--	--	--	--	--
X	25	85	14	15	11	8	8	8	10
Y	--	---	7	6	8	11	7	4	11
Z	35	94	--	--	--	--	--	--	--
Means	49	109	8	5	7	6	5	3	6

*Entries are raw scores. These scores may be converted to standard scores through use of the copyrighted Profile Sheet published by Consulting Psychologists Press, Inc., Palo Alto, California.

**Subjects A and I failed to complete the tests.

store - relatively well. The basic characteristic of this approach is that the subject masters each level of difficulty and then proceeds to a more complex and difficult task, until he is performing the desired task at a preselected criterion level.

Subjects received training in three increasingly difficult stages. In the first stage the subject remained stationary and located three different target objects at varying angles and distances. The purpose was to familiarize the subject with the O/D without his having any sense of danger. The criterion of learning was four successive correct trials for each target at each of two distances (five and ten feet).

Stage two required the subject to move, to detect obstacles, and to avoid them. This stage of training comprised three levels of difficulty, and the criterion for learning was four successive correct trials. In the first level the subject was required to walk between two rather easily detected targets. The second level required the subject to walk between two targets of medium difficulty while avoiding a third, easy target, which was placed before or behind the two targets. The third level of the second stage required subjects to traverse a path in which the three target objects were randomly spaced.

Finally, in the third stage of learning, subjects traversed indoor and outdoor courses which were made increasingly more difficult as performance improved. The indoor course was a large empty room.

It quickly became evident that this training was insufficient, because subjects became confused in narrow corridors where signals were received from nearly every direction. An additional period of training was instituted, made up of four successively more difficult levels.

EVALUATION TRIALS

The test procedure was made up of three main parts: pre-training performance with the customary mode of travel (without O/D), a training series to acquaint the subjects with the instrument and to provide practice in the use of the O/D under various conditions and with various obstacles, and a post-training test series to determine the effectiveness of performance. The pre- and post-training series used two test situations: a standardized indoor and outdoor obstacle course, and a relatively unfamiliar city block. Three training sessions were conducted: a laboratory series with a definite schedule and a standard set of obstacles, a free and unsupervised period with the O/D for two weeks, and ten one-hour supervised sessions in the use of the O/D under field conditions. It probably would have been better to give ten hours of supervised field training immediately after the laboratory and before the unsupervised period to prevent errors in the use of the O/D and unnecessary collisions which might give rise to negative attitudes toward the O/D. Only after the unsupervised session, however, did we think it necessary to provide further training in order to emphasize speed.

Pre-Learning Series

To obtain a base line of performance for evaluating the O/D, a pre-training series of trials, in which each subject used his customary travel aid while blindfolded, was conducted on two standard obstacle courses: 1) a concrete outdoor sidewalk, 85 by 4 feet bordered on both sides by grass; and 2) an indoor corridor 95 by 5 feet. Eight obstacles, varying in width, height, and material were used (See Appendix A). Five trials were given to every subject on each obstacle course. Appendix B shows the order of the trials and the placement of the obstacles on each trial. Both errors (collisions) and time were scored. An error was counted when any part of the body touched an obstacle. Time was measured from the moment when the subject was placed on the starting position and given the signal to begin walking, until he had walked to the end of the obstacle course (85 and 95 feet, respectively). The following instructions were read to each subject at the beginning of the first trial:

"Walk down (up) the hall (sidewalk, making sure you don't step off the walk) at your usual pace trying not to touch any of the obstacles with any part of your body. I will let you know when to stop."

At the end of each trial the subject was disoriented by the experimenter walking him around randomly for several turns. During this time, an assistant would move the obstacles noiselessly for the next trial. Twenty-five subjects took the pre-learning series. One subject (M) did not take this series as he had suffered a slight heart attack.

First Post-Learning Evaluation

Soon after the blindfolded subject had completed the first series of training sessions, he was brought out to the standard obstacle course. The procedure here duplicated that in the pre-training series, with the exception that the subject now used the O/D. Five trials were given on the indoor and outdoor course in the same order and with the same placement of obstacles as in the previous series. A second post-learning series was given, after a practice period which included the free use of the O/D for a period of two weeks (the subject was instructed to use the O/D for at least one hour per day). Nineteen subjects were available for this series of tests. Six subjects of the original 25 left town before the first post-learning tests (because the school year ended) and only 14 were available for the second evaluation series (4 left the Kerrville Lions Camp and 1 left the School for the Blind).

Field Training Under Supervision

In this session each subject spent about one hour per day for ten days walking with the O/D in six semifamiliar and unfamiliar areas accompanied by a trainer. The role of the trainer was to coach the subject in the proper use of the O/D, to emphasize the avoidance of obstacles, and for the first time in a training session, the subject was instructed to walk as rapidly as possible. Whenever the subject held the instrument or scanned improperly, the trainer pointed out the proper procedure. The trainer assisted the subject to use range switches properly, helped him to maintain motivation by the use of praise and encouragement, and reassured him in the avoidance of any danger. The trainer noted collisions (number and kind) and reported comments made by the subject. In view of the differences in operation from instrument to instrument, the same O/D was ordinarily used by any one subject (unless failures in operation occurred).

Unfamiliar Obstacle Course

Following the supervised training session, each subject was then evaluated on his use of the O/D in an initially unfamiliar city block (except for one subject [R] who was quite familiar with this area). Four trials were given to each subject on this same block, i.e., walking up and back twice in a counterbalanced order with the O/D and with customary mode of travel. The subject walked the entire length of the block as quickly as possible, entering and leaving a store in the middle of the course. The experimenter walked to one side a step or two behind the subject without comment (except to avoid danger), noting time and collisions. For one subject, the first trial was with the O/D, the return trial was with the customary mode of travel, and the final return trial was with the O/D. For the next subject, the order of trials was reversed: customary mode, O/D, O/D, and customary mode. Fourteen subjects traversed the course.

Speed Session

The final evaluation session of the O/D was on the standard obstacle course used in the first two evaluation sessions. The subjects were instructed on *each* of the ten trials (outdoors and indoors) to walk as rapidly as possible, to locate a "hole" and not to be concerned about the size or kind of obstacle. After all trials were completed, the subject was again interviewed concerning his reactions to the O/D and his suggested changes, if any. Eleven subjects were available for this part of the study. Three subjects (S,V,X) had left the school for the blind at the end of

the school year and prior to this test.

Summary of Sessions

The following sequence of training and evaluation summarizes the procedure used for each subject:

1) Pre-learning (base performance on obstacle course)

2) Training A (laboratory)

3) First post-learning evaluation (obstacle course)

4) Unsupervised use of O/D (two weeks, at least one hour daily)

5) Second post-learning evaluation (obstacle course)

6) Field training under supervision (ten hours)

7) Field evaluation (unfamiliar course)

8) "Speed" evaluation (obstacle course).

The subjects who completed the entire series took a total of about 30 hours of supervised training and at least 10 hours of unsupervised practice.

RESULTS

Table 3 summarizes the data on the obstacle course for all blind subjects before training (with customary mode of travel) and after training (with O/D). Nineteen subjects completed the first post-learning evaluation and 14 of these subjects were available for the second post-learning tests following two weeks of unsupervised use of the O/D.

There were wide individual differences in pre-learning performance. Errors ranged from a mean of 0.2 to 5.4 on the outdoor course and from 0.4 to 5.6 on the indoor course. The highest number of errors occurred for the subjects who used neither cane nor dog as a travel aid. As a matter of fact, all nine of these subjects but one exceeded all the rest of the subjects in number of errors. They also took the longest to walk the obstacle course. As would be expected, the subjects with dogs were consistently the fastest on the course. It is interesting to note that it made no difference whether the subject walked indoors or outdoors. The means for time and errors were practically identical. The rank order correlation for errors between the two courses was .90.

TABLE 3: MEAN ERRORS AND TIME (SEC.) ON THE OBSTACLE COURSE WITH CUSTOMARY TRAVEL AID (PRE-LEARNING) AND WITH THE OBSTACLE-DETECTOR (POST-LEARNING)

Subj.	Travel Aid	Pre-Learning Outdoor Errors	Pre-Learning (85') Time	Pre-Learning Indoor Errors	Pre-Learning (95') Time	First Post-Learning Outdoor Errors	First Post-Learning (85') Time	First Post-Learning Indoor Errors	First Post-Learning (95') Time	Second Post-Learning Outdoor Errors	Second Post-Learning (85') Time	Second Post-Learning Indoor Errors	Second Post-Learning (95') Time
A	cane	0.8	43	0.8	55	2.2	99	2.0	119	1.8	66	2.6	106
B	cane	1.2	75	1.2	69	1.6	103	1.0	117	2.2	106	1.8	147
C	cane	2.0	44	2.2	44	2.0	89	1.2	63	1.2	59	1.4	59
D	cane	1.4	50	1.6	68	1.4	62	1.8	50	1.4	58	1.6	70
E	cane	1.4	58	2.2	73	1.4	217	1.6	223	1.6	137	1.2	123
F	cane	2.2	99	2.6	98	1.6	162	1.0	203	1.8	116	1.2	126
G	cane	0.6	52	0.4	56	1.0	184	1.6	255	1.8	132	1.8	223
H	cane	2.2	50	1.6	57	2.0	137	3.0	136	2.0	207	2.6	192
I	cane	1.6	39	2.2	36								
J	cane	0.2	47	0.6	75	1.0	147	1.0	192				
K	cane	1.0	39	0.6	36	3.2	137	1.4	173				
L	cane	0.2	51	1.2	60	2.4	138	2.4	135				
M	cane	(See page 206)											
N	dog	1.4	21	1.1	24	2.2	87	2.2	120	2.0	159	0.8	132
O	dog	1.4	31	1.4	34	1.8	114	1.6	141	2.2	160	1.2	132
P	dog	0.4	33	0.6	31	1.2	161	2.0	165				
Q	dog	0.2	29	0.6	27								
R	none	2.4	71	2.0	122	1.2	145	1.6	133	1.4	148	0.6	100
S	none	5.4	40	5.6	51	2.2	230	2.2	162	2.4	263	3.0	162
T	none	3.4	63	2.4	116								
U	none	2.8	67	3.2	135								
V	none	5.2	57	4.8	53	2.0	227	1.8	159	2.0	237	2.0	194
W	none	4.8	54	4.3	62								
X	none	4.8	52	3.4	54	2.6	144	2.8	99	2.4	82	2.0	83
Y	none	0.4	78	0.2	61								
Z	none	4.0	81	3.6	77	3.0	122	2.4	151				

Overall Evaluation

The most direct test of the efficiency of the O/D is to compare the performance of the subjects traversing the course without and with the O/D. Table 4 shows the results according to the mode of travel. Only the errors and time for the first post-learning tests were used for this analysis, since more subjects were available for this series. In addition, the means for the two post-learning series were 1.8 and 143 seconds outdoors, and 1.8 and 141 indoors. For the second post-learning tests, the means were 1.9 and 140 seconds outdoors, and 1.7 and 132 seconds indoors.

From Table 4, it is seen that the mean scores for all 19 subjects before and after training show little change in the number of errors, but an almost threefold increase in the time to traverse the obstacle courses.* It took, on the average, 2.01 and 1.97 errors on the two courses before training and 1.89 and 1.82 errors with the O/D. The time to walk the course with the usual mode of travel was 50.8 and 59.8 seconds. With the O/D, it took, on the average, 142.4 and 147.2 seconds to walk the same course. It seems as if the O/D resulted in a decrease in efficiency so far as time was concerned, and with practically no gain at all in avoiding obstacles.

These results, however, are misleading. Inspection of Table 4 shows clearly that the five subjects who customarily use no aid did much better with the O/D with respect to errors. On the average, they cut their errors almost in half when using the O/D: from 4.36 to 2.20 outdoors, and from 3.88 to 2.16 indoors. Significantly, all five subjects did better with the O/D, but time was much poorer. For those subjects using a cane or a dog, the O/D was of little help. In fact, they did somewhat poorer with the O/D. The increase in errors for these subjects and the overall increase in time may be due to a) insufficient training with the O/D, b) the difficult and somewhat unrealistic obstacle course, c) low motivation for those subjects already using a travel aid, d) too little emphasis on speed, and e) the subject's interest in exploring the environment rather than avoiding obstacles. Further training was therefore provided, as described above.

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* Despite the experimenter's encouragement to move along at their usual rates, the subjects tended to pause and "examine" obstacles detected with the O/D. The new experience evidently aroused their curiosity and led them to explore, rather than to traverse the course without regard for the objects encountered.

TABLE 4

MEAN ERRORS AND TIME (SEC.) ON THE OBSTACLE COURSE WITHOUT (PRE-LEARNING) AND WITH THE OBSTACLE DETECTOR (POST-LEARNING) ACCORDING TO TRAVEL AID *

		Pre-Learning				First Post-Learning			
		Outdoors		Indoors		Outdoors		Indoors	
Travel Aid	N	Errors	Time	Errors	Time	Errors	Time	Errors	Time
Cane	11	1.20	55.3	1.36	62.8	1.80	134.1	1.64	151.5
Dog	3	1.07	28.3	1.03	29.7	1.73	120.7	1.93	142.0
None	5	4.36	60.2	3.88	71.4	2.20	173.6	2.16	140.8
All Ss	19	2.01	50.8	1.97	59.8	1.89	142.4	1.82	147.2

* The seven subjects who had not taken the post-learning tests are not included in this comparison.

Speed Trials

Eleven subjects were retested on the same obstacle course under instructions to walk as rapidly as possible. Table 5 shows the errors and time for these subjects. A comparison of the results under these conditions with those on the first post-learning series (Table 6) shows clearly the significant decrease in time with little increase in errors. The time was cut almost in half. Compared to the pre-learning series, the subjects took about 14 seconds longer, on the average, during the speed trials. Thus, there is no doubt that the instrument can be as effective as the cane so far as speed is concerned. The two subjects in the speed trials who customarily use a dog (AC and TT), however, still do much better with the dog than with the O/D.

TABLE 5

MEAN ERRORS AND TIME (SEC.) ON THE STANDARD OBSTACLE COURSE UNDER "SPEED" INSTRUCTIONS (WITH O/D)

	Outdoors (85')		Indoors (95')	
Subject	Errors	Time	Errors	Time
A	0.4	64	1.4	95
B	1.1	64	1.4	99
C	2.0	57	1.8	88
D	2.2	77	2.4	71
E	0.4	52	1.2	54
F	3.8	47	2.8	54
G	2.4	64	2.2	54
H	2.5	65	2.0	70
N	1.8	62	1.6	60
O	2.6	136	1.8	124
R	1.8	61	1.6	60

TABLE 6

MEAN ERRORS AND TIME (SEC.) ON THE OBSTACLE COURSE UNDER NORMAL (PRE-LEARNING AND FIRST POST-LEARNING) AND SPEED TRIALS (N=11)

	Pre-Learning				First Post-Learning				Speed Trials			
	Outdoor		Indoor		Outdoor		Indoor		Outdoor		Indoor	
	Errors	Time	Errors	Time	Errors	Time	Errors	Time	Errors	Time	Errors	Time
Mean	1.54	54.0	1.55	63.6	1.67	127.2	1.69	141.8	1.95	68.1	1.84	75.4
SD	.57	20.6	.64	26.6	.39	44.5	.61	60.0	.97	22.6	.33	22.0

P. 2/3

Field Tests

The final overall evaluation consisted of the comparison of the performance of the subjects on a relatively unfamiliar city block without (using customary mode of travel) and with the O/D. Table 7 shows the results for the 14 subjects who were available for this part of the study. On the average, the subjects made fewer errors in their customary mode of travel, and took longer than they did with the O/D. The overall picture is again somewhat misleading. Except for one subject (R) who was familiar with this city block, the subjects who customarily use no travel aid did far better with the O/D on both errors and time. All the other subjects walked faster with their customary aid. Here again, it is possible that with more training in semifamiliar and unfamiliar situations and with greater emphasis on speed and avoidance of obstacles, these subjects might improve their performance considerably with the O/D.

Obstacle Collisions

In the standard obstacle course, a contact of any part of the body with an obstacle was scored as an error. Eight obstacles varying in size, color, and surface were used. Analysis of the errors on each obstacle may indicate the difficulties of the "instrument-man" system in detecting and avoiding certain kinds of obstacles. Table 8 shows the total errors occurring on each obstacle in the pre-learning and speed trials. Since there are a different number of subjects from series to series and a different number of trials on the obstacles (six trials on the white and black walls, four trials on the doorway, and ten trials on all the others for both indoor and outdoor series combined), the percent errors were calculated on the basis of the total trials for that particular obstacle. This adjustment allows direct comparison within any one series and between the different series.

The pre-learning data show that the most difficult obstacles to avoid (above 40 percent errors) were the doorway, poles, and "person" for the subjects with a cane; the "person" for those with a dog; and the garbage can, doorway, poles, and wood box for those who walked unassisted. In general, narrow openings (doorways), for those with a dog and cane, and both low obstacles and narrow openings, for the unassisted, are most difficult to avoid. On the other hand, the white and black walls offered little problem.

With the O/D, the narrow opening and low obstacles still presented quite some difficulty in avoidance on the post-learning trials. On the speed trials the garbage can and the doorway were hit in almost half the trials.

TABLE 7

TOTAL ERRORS AND TIME (SEC.) ON THE FIELD COURSE WITH CUSTOMARY TRAVEL AID (WITHOUT O/D) AND WITH THE OBSTACLE DETECTOR

Subject	Travel Aid	Without O/D		With O/D	
		Errors	Time	Errors	Time
A	cane	1	180	4	205
B	cane	2	436	3	488
C	cane	1	490	4	510
D	cane	2	421	3	433
E	cane	1	165	0	175
F	cane	2	195	6	285
G	cane	3	319	3	353
H	cane	2	359	1	449
N	dog	1	298	3	460
O	dog	1	450	4	511
R	none	1	420	5	423
S	none	7	1215	4	420
V	none	5	1050	3	420
X	none	7	838	5	465
Mean		2.6	488	3.4	399.8

p. 215

TABLE 8

TOTAL ERRORS ON EACH OBSTACLE FOR ALL AVAILABLE SUBJECTS IN THE PRE-LEARNING, THE TWO COMBINED POST-LEARNING, AND SPEED TRIALS

	Pre-Learning						Post-Learning		Speed	
	Cane		Dog		None					
Obstacle	Errors	Per Cent	Errors	Per Cent	Errors	Per Cent	Errors	Per Cent	Errors	Per Cent
Garbage Can	22	24	6	20	54	54	136	49	53	48
White Wall	8	13	2	11	17	28	18	11	6	9
Black Wall	14	23	3	17	12	20	21	13	7	11
Doorway	19	48	4	33	23	58	54	48	20	45
Poles	37	41	5	17	41	41	84	30	26	24
Chair	16	18	1	33	32	32	89	30	24	22
Person	46	51	13	43	34	34	52	19	10	9
Wood Box	16	18	1	33	44	44	94	34	26	24
Wire Basket	18	20	1	33	38	38	118	42	30	27

Subject's Evaluation

At two points during the experimental procedure each subject was given a structured interview in order to obtain his reaction to the O/D as a travel aid and to elicit suggestions about it. The first interview was administered after the initial training phase and the post-learning trials, and the second after the two weeks of free use.

We will examine both the formal evaluation of the O/D which the subjects were requested to offer and also the various comments and suggestions which they made about it. In Table 9 are shown the subjects' responses to the three evaluation questions in the first and in the second interview. It is clear that there are marked differences among subjects in their reactions to the instrument. For example, at the time of the first interview, 23 percent of the subjects had no desire to own an O/D, 9 percent did not care, and 68 percent expressed a desire for ownership. At the time of the second interview, the comparable figures are 33 percent, 27 percent, and 40 percent. For those who took part in both interviews, 10 did not change their opinion about owning one, 2 changed from "yes" to "no," 2 changed from "yes" to "don't care," and 1 changed from "no" to "yes." These differences in reaction to the O/D suggest that it would be extremely useful to be able to predict those who would and those who would not respond positively to such an instrument. In a later section, one step toward the attainment of such individual prediction will be presented.

Though the samples are too small for much confidence in the findings, it should be noted that those subjects who presently use guide dogs were the most positive toward the O/D, those who use no travel aids were the most negative, and the cane users fell in between the other two groups.

Subject's Comments and Suggestions

One portion of the interviews requested the subjects to respond to open-ended questions concerning the O/D, their reaction to it, and their suggestions about its strong and weak points. The Questionnaire items are presented below with a summary of the comments given in reply. The number of subjects out of the 22 queried who gave each response is indicated in parentheses.

Where do you think you would be most likely to use it? In what sort of situations would it be of help to you?

Familiar situations	(6)
Street and other crowded places	(6)

TABLE 9

SUBJECT'S EVALUATIONS OF THE O/D

	Interview I			Interview II		
	General Evaluation	Usefulness	Would you Want one?	General Evaluation	Usefulness	Would you Want one?
A	indifferent	not useful	yes	unfavorable	not useful	yes
B	favorable	of moderate use	yes	very fav.	very useful	very much
C.	favorable	useful	yes	indifferent	of moderate use	don't care
D	favorable	of moderate use	yes	favorable	of moderate use	don't care
E	favorable	of moderate use	yes	favorable	of moderate use	yes
F	indifferent	of moderate use	yes	indifferent	of moderate use	yes
G	favorable	not at all useful	no	favorable	not at all useful	no
H	favorable	not at all useful	not at all	unfavorable	not useful	no
J	favorable	very useful	yes			
K	favorable	not at all useful	no			
L	favorable	of moderate use	yes			
N	unfavorable	of moderate use	no	favorable	useful	yes
O	favorable	of moderate use	don't care	indifferent	of moderate use	don't care
P	very fav.	useful	yes			
R	unfavorable	not at all useful	no	unfavorable	not at all useful	no
S	favorable	useful	yes	indifferent	of moderate use	no
T	favorable	useful	yes			
U	favorable	not useful	don't care	indifferent	not useful	don't care
V	favorable	of moderate use	yes	favorable	of moderate use	no
X	unfavorable	not useful	yes	favorable	of moderate use	yes
Y	very fav.	useful	yes			
Z	very fav.	of moderate use	yes			

Places without steps	(2)
Indoors	(2)
General travel	(1)
Where there are parked cars	(1)
Where there are no moving objects	(1)
Where there are no crowds	(1)

Where do you think you would be least likely to use it? In what sort of situations would it be of no help to you?

Crowded places	(6)
Familiar territory	(7)
Crossing a street	(5)
Where there are stairs	(4)
Unfamiliar places	(3)
Indoors	(3)
Places with low hanging limbs or signs	(1)
Where there are moving objects	(1)
Outdoors	(1)

What, in your opinion, are the best features of the Obstacle Detector?

Extended range so you can pick up distant objects	(16)
Can take it anywhere (unlike a dog)	(2)
Small enough not to be noticeable	(2)
Less clumsy than a cane	(2)
Would detect an unfamiliar object in a familiar place	(2)
The radio attachment	(1)
Easy to charge and maintain	(1)

Economical to operate	(1)
Easy to travel with	(1)

What, in your opinion, are the worst features of the Obstacle Detector?

Inability to determine step-downs and low obstacles	(10)
Too heavy and tiring	(9)
Arrangement of range settings	(6)
Won't pick up some objects (black, dark, glass)	(5)
Unreliability; range varies with strength of batteries	(5)
Charging takes too long	(3)
Won't pick up high obstacles, overhangs	(3)
Must walk slowly to use it effectively	(2)
Don't like the noise it makes	(1)
Hard to tell the width of objects	(1)
Can't identify the material objects made of (unlike cane)	(1)
Conspicuous	(1)
Doesn't help you go in a straight line	(1)
Feel insecure because it is intangible	(1)

Could you think of any changes that might be made in the instrument which would improve it?

Make it less bulky	(10)
Incorporate with a cane	(8)
Switches should be easier to use	(7)
Make beam or something to detect curbs, steps, small objects	(3)

Smaller transmitter	(1)
Should be a way to turn it off while still holding it	(1)
Add a reflector to give a four-foot wide patch	(1)
An automatic scanner	(1)
Make it more attractive so it wouldn't be conspicuous	(1)

Do you have any other general comments about the Obstacle Detector?

It's of some help, but it needs to be worked on	(7)
It's a good idea	(1)
Would be useful before other travel aids are learned	(1)
Not useful until after experience with other travel aids	(1)
I found it a very interesting and unforgettable experience	(1)
Hope it will be perfected and made available to blind people	(1)
It would be very good for deaf-blind people	(1)

The consistent reactions which stand out most clearly may be summarized as follows. On the positive side, the O/D is seen as useful in familiar situations and in flat places without step-ups or step-downs; the extended range provides information about distance not available with other travel aids; it is easy to carry around; and with a few changes it would be in much demand. On the negative side, some are afraid to trust it in crowded places or in crossing streets; the problem of stairs and curbs and step-downs is not solved by the O/D alone; the switch arrangement is seen as unreliable both in terms of objects it will detect and in terms of variations in the strength of the beam as the battery loses strength; and it is felt to be too heavy to use comfortably for more than a short period of time.

Individual Differences

The primary reason for obtaining much of the background data and scores on the psychometric instruments was to explore the possibility of isolating those variables responsible for differential reactions to the O/D as a travel aid and differential aptitude in learning its use.

In the analysis of results which follows, three points should be noted. First, the total sample is a relatively small one and thus generalization to the total blind population is somewhat hazardous. Second, a related point is that a cross-validational study is badly needed in order to eliminate chance findings and hence verify those relationships which are valid. Third, because of the variations within the group in terms of the number of steps in the total procedure which were completed, the number of subjects on which the various Pearson product-moment correlations is based varies between 11 and 19. In each instance, however, the reported significance levels are computed on the basis of the actual number of subjects involved. The first analysis, presented in Table 10, concerns the interview scales on which the subjects indicated their general evaluation of the O/D, their notions about its usefulness, and their desire to own one if it were made available. Each of these ratings was quantified as a simple ordinal scale and correlations computed between the ratings and each other variable.

An examination of Table 10 reveals a few interesting relations which are suggestive for future research. In the first place, a subject's response to the O/D on the first interview (following training) was not a particularly good predictor of his response to it at the time of the second interview (following an opportunity to try it out on his own for two weeks). General evaluation on the two interviews correlated .07, usefulness on the two interviews correlated .63, and desire to own one correlated .49 on the two interviews. With those relations, it is not surprising to find somewhat different patterns of correlations for the two interviews as shown in the table.

One consistency was the relationship between mobility scores and evaluation; the less mobile the subject, the more positive his evaluation of the O/D. It is also interesting to note the rather substantial negative relations between number of errors in the post-learning trials and both general evaluation and ratings of usefulness. The more errors the subjects made, the less positive they were toward the instrument. One possibility which might be suggested is that learning procedures which progressed carefully enough to avoid failure experiences for the subjects would result in the avoidance of the development of negative affect toward the O/D. With respect to their desire to own an O/D after experience with it in the training period, those subjects who wanted one tended to be less well educated, less self-ac-

TABLE 10

CORRELATIONS BETWEEN PERSONALITY VARIABLES
AND SUBJECTIVE EVALUATIONS OF THE O/D

First Interview	General Evaluation	Usefulness	Desire to Own O/D
Age	x	.44*	x
Education	x	x	-.39*
Mobility Score	.44*	.57**	x
Self-acceptance	x	x	-.41*
Femininity	x	x	-.38*
Verbal I.Q.	x	x	-.56*
Post-learning			
outdoor errors	-.54**	-.41*	x
indoor errors	-.51**	-.50**	x

Second Interview	General Evaluation	Usefulness	Desire to Own O/D
Mobility Score	.43*	x	x
Social Presence	x	-.48*	x
Pre-learning Indoor Time	x	-.44*	x
Post-learning Outdoor Errors	x	.47*	x
Learning (first stage) time to criterion	x	.43*	x

* = $p < .10$

** = $p < .05$

X = Correlation not statistically significant

cepting, more masculine and outgoing, and less intelligent.

At the time of the second interview, after free use, very few of the predictor variables are related to evaluation of the O/D. The few ralations that are found are primarily with respect to ratings of its usefulness. Those subjects who found the O/D most useful tend to be deliberate, patient, literal minded individuals. They tend to take a short amount of time in the pre-learning indoor trials, a relatively long amount of time in the first stage of learning, and tend to make more errors on the post-learning outdoor trials. The latter findings do not make much conceptual sense and tend to suggest chance relations which may possibly stem from insufficient training.

The second major problem of individual differences is that of efficiency in learning the use of the O/D. Correlations with learning and performance variables are shown in Tables 11, 12, and 13.

TABLE 11

CORRELATIONS BETWEEN PERSONALITY AND LEARNING VARIABLES

	First Stage			Second Stage			Third Stage		
	Errors	Time	Trials	Errors	Time	Trials	Errors	Time	Trials
Dominance	x	x	.44*	x	x	x	.45*	.43*	.43*
Psychological - Mindedness	x	x	x	x	.45*	x	x	x	x
Flexibility	x	x	x	x	.62*	x	.45*	.45*	.46*
Somatic-Symptoms	x	x	x	x	.60*	x	x	x	x

* = $p < .10$
** = $p < .05$
x = Correlation not statistically significant

TABLE 12

CORRELATIONS BETWEEN PERSONALITY VARIABLES AND OBSTACLE COURSE PERFORMANCE

	Pre-learning				Post-learning			
	Outdoor		Indoor		Outdoor		Indoor	
	Errors	Time	Errors	Time	Errors	Time	Errors	Time
Age	-.60***	x	-.59***	x	x	x	x	x
Education	x	x	x	x	x	x	x	.59***
Mobility Score	-.44*	-.45*	-.43*	-.43*	-.66***		-.56**	--
Responsibility	-.49**	x	-.39*	x	-.41*	x	x	-.41*
Socialization	-.40*	x	x	x	x	x	x	x
Good Impression	-.39*	x	-.45*	x	x	x	x	x
Achievement via Conformance	-.47**	x	-.44*	x	x	x	x	x
Flexibility	.40*	x	.42*	.41*	x	x	x	x
Femininity	-.49**	x	-.47**	x	-.53**	x	-.47**	x
Social Presence	x	x	x	x	x	.42*	x	.43*
Self-Acceptance	x	x	x	x	x	x	x	.42*
Communality	x	x	x	x	x	x	x	.49**
Intellectual Efficiency	x	x	x	x	x	x	x	.46**
Somatic Symptoms	x	x	x	.44*	-.44*	x	-.50*	x
Att. vs. Blindness	x	x	x	x	x	x	x	-.54**
I.Q.	x	x	x	x	x	x	x	.59***

* = $p < .10$
** = $p < .05$
*** = $p < .001$
x = Correlation not statistically significant

TABLE 13

CORRELATIONS BETWEEN PERSONALITY VARIABLES AND PERFORMANCE ON THE FIELD COURSE

	With O/D		Without O/D	
	Errors	Time	Error	Time
Dominance	x	x	.67**	x
Capacity for Status	-.48*	x	x	x
Sociability	-.57**	x	.59*	x
Social Presence	x	x	.53*	x
Self Acceptance	-.49*	x	x	x
Responsibility	-.45*	x	.55*	x
Socialization	x	x	.55*	x
Tolerance	x	x	.67**	x
Achievement Via Conformance	-.51*	x	.61**	x
Achievement Via Independence	x	x	.52*	x
Intellectual Efficiency	x	x	.58*	x
Sensitivity	.56**	x	x	x
Somatic Symptoms	.46*	x	x	x
Social Competency	.52*	x	x	x
Attitudes of Distrust	x	x	.67**	x
Feelings of Inadequacy	.51*	x	-.52*	x

* = $p < .10$
** = $p < .05$
x = Correlation not statistically significant

With the learning variables in the three stages, shown in Table 11, relatively few relations were found with the predictor variables. Briefly, those who were most efficient in learning tended to be more retiring and inhibited, more peaceable and serious, more deliberate and cautious, and to have fewer somatic symptoms than those subjects who were least efficient in learning the use of the O/D.

Table 12 presents data relevant to the obstacle course performance. First, it should be noted that there is no relation between the number of errors made in the obstacle course and length of time required to traverse it. For the four pairs of errors and times shown in Table 12, the correlations are .18, .20, -.10, and -.28. Therefore, the findings will be discussed separately for errors and time. Those subjects who made the fewest errors in the obstacle course trials tended to be older, less mobile, more planful and responsible, more serious and industrious, more cooperative and enterprising, more capable and efficient, more deliberate and cautious, more patient and persevering, and to have more somatic symptoms, than those who made the most errors. With respect to time, however, those who went through most quickly tended to be less well educated, more mobile, more immature and lazy, more literal minded and simple, more conservative and conventional, more impatient and changeable, more confused and defensive, to have fewer somatic symptoms, to have more problems in adjusting to their blindness, and to be less intelligent than those who required the greatest amount of time to get through the obstacle course. It would seem that the best adjusted individuals use the O/D very effectively with respect to avoiding obstacles but that they also require a somewhat greater amount of time to move down the pathway.

Finally, in Table 13 are presented the correlates of performance on the street travel trials with and without the O/D. The correlation between errors with and without the O/D was -.20. Interestingly enough, two distinctly different patterns emerge with respect to those subjects who are most effective in using the O/D vs. those who are most effective without the O/D. Those individuals who made the fewest errors in traversing the course using the O/D tended to be more ambitious and active, more outgoing and enterprising, more outspoken and sharp-witted, more planful and responsible, more capable and cooperative, less neurotic and emotionally unstable, to have fewer somatic symptoms, to feel more socially competent, and to have fewer feelings of inadequacy and inferiority, than those individuals who made the most errors in using the O/D. Those who did well with their traditional mode of travel aid tended to be more retiring and inhibited, more awkward and conventional, more deliberate and moderate, more immature and lazy, more defensive and demanding, more suspicious and aloof, more anxious and cautious, more easygoing and unambitious, more distrustful of others, and to have greater feelings of inadequacy and inferiority, than those subjects who made relatively more errors with their traditional mode of travel.

These findings suggest that those blind individuals who have mastered the use of the O/D sufficiently well to utilize it most efficiently in a real-life situation are more effective psychologically and better adjusted than are those individuals who are unable to do so. The possibility of predicting effective O/D users on the basis of scores on these personality tests seems very promising.

CONCLUSIONS AND RECOMMENDATIONS

On the basis of the present series of studies on the effectiveness of the obstacle detector with a select group of totally blind subjects following a particular training schedule, the following conclusions and recommendations are offered:

1. There were wide individual differences in pre-training performance on a standard obstacle course. The highest number of errors and the longest times occurred with those subjects who normally walk unassisted. The most effective were those blind subjects who used a dog. In between the two groups were the cane users.

2. Using the obstacle detector on the standard obstacle course, all subjects, on the average, took about three times longer to walk than with customary aid. Errors with and without the O/D were about the same. Analysis of errors and time according to mobility aid showed that subjects who walk unassisted made far fewer errors with the O/D than without it. For those subjects using a cane or a dog, the O/D was of little help and probably was even a hindrance. It is possible, however, that the opportunity to "explore" slowed these subjects.

3. After considerably more training on the use of the O/D, the subjects reduced the time to walk the obstacle course significantly when instructed to proceed as rapidly as possible, while errors remained about the same.

4. On the field tests, this group, on the average, made fewer errors but took somewhat longer with the customary mode of travel than with the O/D. Again, however, the subjects who normally walk unassisted did far better with the O/D in the field trials.

5. An analysis of the collisions on the standard obstacle course showed that the subjects, in general, had most difficulty in avoiding narrow openings and low obstacles.

6. During the training sessions, the subjects had great

difficulty in detecting obstacle C, the flat black wall 24 inches high. Often it could only be detected when the subject was within a few inches of it.

7. The effectiveness of the O/D varies with the degree to which it is charged. A recently charged O/D, for example, would pick up a signal at 10 feet. The same instrument, when considerably discharged, would pick up the same object at a maximum of 5 feet on the same range setting.

8. Cane users and "unassisted" blind subjects were about equally effective in the first part of the training sessions, but toward the end of the sessions the cane users made fewer errors and took less time. This difference might have been due to better motivation, previous use of a travel aid (cane), or better acceptance of "blindness" and need for aid.

9. Most of the subjects complained about the location of the far range button. It was inconvenient to use.

10. About one-half of the subjects indicated a desire to own the O/D. Those who presently use guide dogs are the most positive, those who travel unassisted, even though apparently they were helped the most, are the most negative, and cane users fall in between.

11. A number of personality variables were found to be significantly related to evaluation, learning, and performance. With cross-validation data, it should be possible to predict response to the O/D with greater than chance accuracy on the basis of psychometric information. This is a first step toward the establishment of prescription criteria.

APPENDIX A:
CATEGORIES OF OBSTACLES

There are eight categories of obstacles. Below is a list of the obstacles and their dimensions.

1. and 2.	Doorway and Walls	Two masonite panels (1 foot 3 inches by 5 feet) set in thin wood frames and standing upright on a wooden base. Wall A has one white side (painted) and one natural side. Wall B has one black side (black felt) and one natural side. The doorway obstacle is made by placing the panels directly across from each other with 2-1/2 feet clearance between them. When the doorway obstacle appears in a trial, the two panels are counted as one object, and there will be only seven obstacles listed for that trial. When the wall obstacles appear in a trial, the two panels are counted individually and set at varying positions along the course. There will be eight obstacles listed for these trials.
3.	Poles	Two wood poles 2 inches in diameter and 5 feet high, set in wooden bases 1 foot in diameter and 2 inches high. The poles are always used together, centered in the course with 2-1/2 feet clearance between them. Pole A is painted aluminum. Pole B is left natural.
4.	Wooden Box	Eighteen by 18 by 12 inches, constructed of plywood.
5.	Chair	The chair is an ordinary straight back chair of average size.
6.	Garbage Can	A metal can about 2 feet in diameter and of average height.
7.	Person	An assistant who takes a position in each trial.
8.	Wire Basket	Twenty-four inches high, 1 foot in diameter.

APPENDIX B:
BASE LEVEL OF PERFORMANCE

Name______________________Date________Mode of Travel_______

Time of Day________Weather Conditions____________________

INDOOR TRIALS

INDOOR TRIALS

Trial #1 Object	Position	Errors	Time to Traverse Course
1. Garbage can	R. 20'	______	
2. White wall	L. 30'	______	
3. Poles-centered	2-1/2' apt. 35'	______	
4. Chair	R. 45'	______	
5. Person	L. 45'	______	
6. Wood box	L. 50'	______	
7. Wire basket	M. 55'	______	
8. Black wall	L. 75'	______	

Start at 0'mk. at East end; Finish at 85'mk. at West end.

Trial #2 Object	Position	Errors	Time to Traverse Course
1. Black wall	L. 10'	______	
2. Wire basket	M. 30'	______	
3. Wood box	L. 35'	______	
4. Person	L. 55'	______	
5. Chair	R. 55'	______	
6. Poles-centered	2-1/2' apt. 65'	______	
7. White wall	L. 70'	______	
8. Garbage can	R. 80'	______	

Start at 0'mk. West end; Finish at 85'mk East end.

APPENDIX B: (continued)

Trial #3 Object	Position	Errors	Time to Traverse Course
1. Chair	R. 10'	______	
2. Doorway-centered	2-1/2' apt. 15'	______	
3. Wood box	M. 20'	______	
4. Person	R. 40'	______	
5. Poles-centered	2-1/2' apt. 55'	______	
6. Garbage can	M. 65'	______	
7. Wire basket	R. 70'	______	

Start at 0'mk. East end; Finish 85'mk. West end.

Trial #4 Object	Position	Errors	Time to Traverse Course
1. Wire basket	R. 20'	______	
2. Garbage can	M. 25'	______	
3. Poles-centered	2-1/2' apt. 35'	______	
4. Person	R. 50'	______	
5. Wood box	M. 55'	______	
6. Doorway-centered	2-1/2' apt. 60'	______	
7. Chair	R. 65'	______	

Start at 0'mk. West end; Finish at 85'mk. East end.

APPENDIX B: (continued)

Trial #5 Object	Position	Errors	Time to Traverse Course
1. Black wall	R. 10'	______	
2. Wire basket	R. 25'	______	
3. Wood box	L. 25'	______	
4. Person	M. 30'	______	
5. White wall	R. 30'	______	
6. Poles- centered	2-1/2' apt. 55'	______	
7. Garbage can	M. 65'	______	
8. Chair	L. 75'	______	

Start at 0'mk. East end; Finish at 85'mk. West end.

REFERENCES

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SOME GENERAL REMARKS ON MOBILITY INSTRUMENTATION RESEARCH

Paul A. Kolers
Massachusetts Institute of Technology
Cambridge, Massachusetts

I had thought that I could use my time best by commenting, from the point of view of a psychologist, on some of the things I heard during the conference. The comments below are of several kinds, and later I'll mention a few experiments already accomplished. First I'd like to speak about the point of view that informed them.

What has impressed me most in this conference is the wide range of backgrounds from which the audience comes. Such a wide range makes it extremely difficult to talk coherently on any one theme. Some here have a very limited training in science but a keen awareness of the phenomenology of blindness. Others may have particular training in engineering, but not much training in science, nor in general theory, etc. This is of some significance because any activity in which one engages follows from a set of assumptions. Assumptions do inform and guide our activities, whether the assumptions are conscious or not, and our assumptions are created by our training and experience.

Many of us find the computer a particularly happy metaphor to use when trying to understand some of the higher cognitive processes - those processes that used to be called the "higher mental functions." We use the computer entirely as a metaphor; nobody really believes that people think the way a computer works. People think with a head many times smaller than a computer, and clearly this difference in size indicates at least some difference in process. Nevertheless, the computer is a very handsome metaphor as a guide line. It can be particularly useful, because in writing programs for a computer, one is forced - as no other metaphor forces one - to examine his assumptions quite explicitly. The computer is a stupid machine. It does only what it is told; the intelligence which is exercised must rest with the programmer and not with the computer. This contrast with our behavior vis-a-vis one another, for it is so often unnecessary to be quite explicit, and one can suggest what he means and the respondent will "fill in" or supply information to himself to make a message comprehensible.

There was some discussion here of the point that the computer is not a perfect analogy for the higher mental functions because the computer program deals with large scale events. I would like to suggest that the "plan" of which Dr. Clowes speaks, a general sense of orientation, the intention of a set of assumptions - all of these large scale psychological phenomena that the computer manifests or makes explicit for us, apply equally to the blind and the sighted. Orientation in space, for the blind, is only a special aspect of orientation in space for the sighted. Now, we know quite a good deal about orientation in space for the sighted, and we find the computer program is a particularly happy metaphor for expressing our notions. To reject this usage because your principal concern is engineering the tool to enable a blinded individual to execute the intention or the plan that he may have in mind - misses the point. Really, however, there are two problems. One is the problem of accounting for orientation in space generally; the other is the exploitation of tools for accomplishing the end created by the plan. Most of the discussion in this conference is, of course, concerned with tools.

Having defended the computer, I should like now to go on to talk about another set of assumptions: those that seem to me to have informed the discussion here about the necessary tools. The principal thing, I would say, is that the toolmakers assumptions imply what the philosophers sometimes speak of as naive realism. As a psychologist, I was astonished at the terrible naivete of the instruments I have seen demonstrated. They seem to fall into two classes: there are things that buzz or click as passive elements responsive to light signals; and there are things that emit audio frequencies and take a somar-like return. What I should like to point out to you is that supplying information of this kind reduces the person dependent upon the tool to the state of existence of the earthworm (if it is a visible output), or perhaps even the cave fish (which lost the sense of sight, but still retains auditory acuity). The earthworm is a very fine light detector. If you shine a light on one side of it, it turns in that direction, and if you shine a light on the other side of it, it turns in the other direction. The only information that the earthworm is capable of responding to is "yes" or "no," "light" or "not light."

If I were blind, I think the thing I would like least to have is sound buzzing in my ears or tools vibrating in my hand that are supposed to tell me how far away some object is. I would suggest to you that this kind of information is the *wrong* information to give a blinded person. The reason is this. To give information of this kind, namely range information, on the assumption that it is best for orientation, presupposes the kind of naive realism that I mentioned a moment ago. It presupposes that our perception of objects is built up out of a series of very primitive physical dimensions. What seems to be implied is that you would enhance the orientation and mobility of the blind if you could provide more *dimensions* of information. I would suggest that as you increase the number of dimensions of information you will handicap the blind still more, because you will so overload him with essentially irrelevant information that he will be able to do nothing except monitor the detectors.

Perception does not work in that simple quantitative way. Perception is categorial, that is to say, we see objects in terms of their category membership. or their set membership. Thus, if I see an object coming towards me I do not solve the differential equation of its speed and I do not worry about its general dimensions. I do not do any of these things in terms of the physical variables that your machines are trying to measure. What I *do* do is to name the object specifically, and then assign attributes to it. (You do the same thing; it is not my eccentricity.) What your machines must do, if they are to provide an appreciable aid to the blind, is to simulate what the signted do. You must begin with linguistic categories, or with perceptible categories, with objects or things or the names of things - and go on from there. Knowing what something *is* provides much more information about it for the limited amount of space we have available in our heads for computing range, direction, and the like, than all manner of quantitative discrete data.

Another thing I find objectionable in these instruments is that there is an assumption built into them that the various senses of man are equivalent in terms of their information processing abilities. You seem to assume that a man who has lost his eyes can be provided alternative information through his ears, by presenting him with buzzers out of phase, or in phase, or of variable pitch, or amplitude, or what have you. This is not the case, however, for the senses themselves operate in different categorial units. The eye, for example, is particularly good at locating objects in space precisely, but it is very, very poor in telling you about temporal differences in the sequential occurrence of these objects. The ear is just the opposite. It is extremely poor in telling you where something is, and yet very skilled in telling you about temporal differences in information to the two ears, or even about two tones to one ear. Supplying the blind with buzzers that are (I find) very annoying, in order to tell them when they are approaching an object, and at what speed, seems to me to be an inefficient way to proceed.

There has been some talk that we do not know well enough what the blind want to know. This is certainly true. I know of no paper, I know of no investigation, that has systematically studied either blind people in complex environments, or sighted people temporarily blinded in equivalent environments, and experimentally found what kind of information enhanced mobility, and what kind of information was of no use to mobility.

There is an old prejudice in psychology, you know, that says that if you want to know what a man really thinks, you must not ask him a direct question. This is a terrible prejudice. It may be appropriate for the areas of emotional experience that many of us often try to disguise in one way or another. But in terms of the rational activities of everyday life it is not often appropriate. But in the present context it may be, and I would suggest that asking a blind man in an open questionnaire what kind of information he wants is not the best way to go about getting that information. One of the things that has impressed me enormously is the great range in particular skills that our blinded colleagues manifest in their daily lives. To try to generalize about the blind by asking free questions of this sort is likely to provide so wide a range of information that it is going to be useless. On the other hand, if one approaches the problem experimentally by providing different kinds of information in different kinds of environment and testing for its usefulness, one can answer experimentally the question of what the blind really need to know, not what they say they need to know.

We are then faced with another question: what do we want to tell them? Do you really want to tell them only that something is coming - buzz-buzz-buzz, or click-click-click? I think we want to tell them something other than that. We want to tell them what is there and what its presence signifies. One's perceptions, as I have said, are not mirror copies of the environment outside of our skins. Our perceptions are no more veridical, no more faithful to some external reality, than they are unfaithful to that reality. The objects that we perceive in the environment are psychological representations of *things* out there. What these psychological representations are is different for each of us. The important thing to remember is that they are *only* psychological representations, that they are not mirror images. Consequently, providing this multidimensional array of information is not really going to be a useful method for solving the problem of mobility. It removes what is human and leaves what is primitive.

We have heard that what characterizes the mobility of the blind is some higher order representation in their heads of the environment in which they find themselves. We heard the words "images," "maps," or "schemata," among others. And yet we know very little about these things. They are the basis not only of blind perception but of sighted perception.

A particularly interesting book published by Kevin Lynch, Professor of urban design at the Massachusetts Institute of Technology, called *The Image of the City*, studies in great detail the way sighted people find their way about very complex urban environments, and how different the different urban environments can be. You know how impossible it is to be lost in Paris. Yet I assure you it is very easy to get lost in Boston. This has to do with the existence of landmarks and our ability to orient ourselves with respect to identifiable objects in space.

The blind must also carry about some image of the environment, some representation of the environment. We should like to know how this representation is formed, what is there that we can do to enhance it, how we change it, how we make it flexible to accommodate variations in the environment. In the modern world, after all, buildings are continually being torn down and others continually being raised up. The principal way images are formed is through action. If you repeat a series of actions a sufficient number of times, you very soon come to have a picture in your head, a vivid image of this set of actions you have engaged in. A psychologist at the University of Toronto named George Mandler, tried the experiment of presenting his subjects with an array of toggle switches. Above each column of switches there is a small light. This matrix is programmed so that the toggle switches have to be pressed in appropriate sequence; when they are so pressed with the correct switch in each row and in each column, the light on the top goes on. The task is to turn the lights on as quickly as one can. In the first few trials, of course, one operates entirely by chance. There is no information provided in the matrix to tell which switch to hit. You then go through it more and more quickly until at the "start" signal a college subject can go through such a matrix in about 15 seconds and get every light to come on.

Mandler did the experiment of varying the amount of practice that his subjects were given on this matrix. Some subjects would practice on it just to the criterion of doing it exactly right three times. Another group of subjects was given as many trials again as they required to reach three perfect trials. That is to say, they had 100 percent overtraining. (There were other conditions in the experiment I won't go into.)

The principal result was the following. The subjects tested to the criterion of three perfect trials were subsequently asked: What is the pattern on the board? All the responses were in terms of pointing at particular switches. The subjects who were trained with 100 percent overlearning would just draw a design in the air and say, "The pattern is this." Mandler then rotated the matrix by 180 degrees and tested his subjects to find how many new trials they needed to trace the rotated version of this matrix. Those who had been trained for three perfect trials only, required almost as many trials again to master the matrix perfectly, while those who had learned the matrix to 100 percent overlearning told Mandler that they had a picture of it in their heads and were able to solve the problem by operating on this image.

Here we see that by repeating a very simple action, one can generate a new kind of psychological representation, different from the things found in simple contact.

An experiment I did looked to see whether there were not further changes in these representations. I asked college students to recite the alphabet backwards. They began, after their initial shock of being asked to recite the alphabet backwards, by looking off into space and mumbling a little bit to themselves, then saying "Z," "Y," "X," looking off into space again, mumbling a little bit to themselves, continuing with the next set of letters in sequence, and so on until they had gotten all of the letters. I had them do this 60 times. Harvard students were able to say the English alphabet backwards in approximately 40 seconds on their first try. After 60 trials they were able to say it backwards in about 5 or 6 seconds. When I asked them subsequently how they had done the task, they said that during the first trials they would call up a picture of the alphabet in their minds, grab some letter for the picture either in the middle or near the end, read forward to themselves from this picture, then recite those letters backwards, and carry on in that way. In subsequent trials they were able to do this with more and more skill. By the time, they said, they had reached their 20th or 25th trials, they were no longer calling up some picture of the initial alphabet. They were able to recite the new set of letters backward, in less and less time. By the time they had finished 60 trials, they were able, as I said, to recite the alphabet backwards in just a few seconds. As one subject said to me, "I can call it *off* faster than I can call it *up*." That is to say, no image at all was present.

So, here are three different kinds of psychological representation of objects or events in the environment: the representation that comes from contact; the higher-order representation that permits one to operate on an image; and the representation, beyond imagery, where the behavior exists in its own right as a "unit."

Professor Mann has described some of the things we hope to do with the new computer facility we have. Since he has done so, I won't repeat what he has said. I want only to tell you of one set of experiments that I think is particularly ingenious that he did not mention. These are being conducted by a graduate student, Lawrence Black, who is doing them for his thesis. Black tied a pointless pencil to four potentiometers by some string. The pointless pencil was permitted to move through a radius of about two inches. When activating these four potentiometers and other electronic devices, the effect was that when the pencil was moved laterally in either direction the phase relation of tones to the two ears was shifted. When the pencil moved one way off the midline, the right ear led the left by an increasing amount of time; when the pencil moved the other way off the midline, the left ear led the right by an increasing amount of time. Movement in the vertical dimension created changes in pitch of the tone fed to the two ears. With this method, Black very soon found it possible to "write" messages to blindfolded subjects. One can move the pencil around in space and the subjects have a picture in their heads of what is being done. You can write letters, draw geometrical shapes, or any number of other things. The speed of transmission is too slow to permit the system to be a useful tool in presenting information (about three letters per second). I mention it to you now merely as another method under study, for getting at some of the processes involved in image formation and the representation of environmental objects.

Finally, I would like to encourage you to pay more attention to the organism you are trying to help, and less attention to the tools you are using. I think to begin with a transistor and make a man adapt to it is not probably the best way to proceed. I think it might be a little better to exploit some of the more subjective properties of human beings.

APPENDIX I:
VETERANS ADMINISTRATION FOR
THE LONG CANE (TYPHLOCANE)*

GENERAL

Purpose

These specifications were developed to provide a standard cane for use by persons who have a severe visual impairment or who are totally blind.

Definitions

The Long Cane is a cane specifically designed to serve as a mechanical object detector and environmental perceptor to facilitate physical orientation and self-dependent mobility for persons having severe visual impairment or blindness. (See Figure 1.)

The Shaft refers to the main portion or "body" of the Long Cane and extends from the base of the crook to the tip end of the cane. (See dimension "B," Figure 2.)

The Crook refers to that portion of the upper end of the Long Cane which has been bent or curved to form an arc or "hook." (See dimension "C," Figure 2.)

The Grip refers to that portion of the Long Cane which has been adapted for grasping by covering with leather, plastic, rubber, or other suitable material. (See "A," Figure 3.)

The Tip refers to the element located at the lower end of the Long Cane and is that portion which normally contacts the floor or ground. (See "B," Figure 3.)

The Shaft End refers to the lower end of the shaft into which the tip is fitted.

Types

1) The rigid one-piece shaft, or "Long Cane" type canes.

2) The multipiece shaft, or telescopic and folding type Long Canes.

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* Permission to reprint these specifications has been granted by the Veterans Administration.

Application

The specifications shown in Part "A"shall apply only to the rigid one-piece shaft type Long Cane. Specifications for the telescopic and/or folding type Long Canes will be developed and included at a later date.

PART A: SPECIFICATIONS FOR RIGID ONE-PIECE LONG CANE

Materials

Metal Parts

All metal parts of this Long Cane shall be fabricated from drawn aluminum tubing having the alloy formula 6061-T6. The chemical composition, mechanical properties, and tolerances for this tubing shall be such as to conform to General Services Administration (G.S.A.) Federal Specifications WWT-700/6B. The nominal dimensions of the tubing shall be:

1) Outside diameter (o.d.), 0.500 (inches)

2) Wall thickness, 0.062 (inches)

3) Inside diameter (i.d.), 0.375 (inches).

The Grip

The grip shall be a standard rubber golf grip of the type known as the "Grip-Rite" manufactured by the Fawick Flexi-Grip Company, Box 111-C, Akron 21, Ohio; or equal.

The Tip

The tip shall be made of opaque white nylon rod, nylatron rod, or equal.

Plastic Cap Closure

The plastic cap closure for the open end of the crook shall be of suitable white plastic or rubber material.

Design

In general the Long Cane shall be designed so as to include a crook, shaft, tip, and grip formed in accordance with the specifications outlined below and in the attached drawings.

The Crook

Beginning at a point approximately 3-3/4 inches from the unthreaded end of the initially straight shaft, the tubing shall be bent to form an arc of 180 degrees on a 1-inch internal radius. The end of the crook shall extend, tangentially to the arc and parallel to the shaft, for a distance of approximately 1/2 inch. (See "C," Figure 2.)

The Crook Cap

The open end of the Crook "C" shall be fitted with a white plastic or rubber cap to cover any rough edges of the metal tubing. The cap shall be designed with walls of uniform thickness (approximately 0.062 inches thick) with the covered or closed end having approximately twice the wall thickness. (See detail "1," Figure 3.)

The Shaft

The shaft or body of the Long Cane shall be the straight section of the cane extending from the arc of the crook to the plastic tip. (See dimension "B," Figure 2.) The tip end of the shaft shall be threaded on the *inside* for a distance of 8 inches. The threads will be 7/16-20 UNF threads matching those cut on the tip. (See dimension and detail "D," Figure 2.)

The Tip

The tip shall be machined from opaque white, nylon, nylatron, or equal in accordance with the dimensions shown in Figure 4. The tip shall have an overall length of 3-1/4 inches and have 7/16-20 UNF threads applied to one end in accordance with the measurements and design shown in Figure 4. The unthreaded end shall be ground with a 1/8-inch chamfer.

The Grip

The grip shall be fitted on to the cane so as to extend downward on the shaft from a point 1/4 inch above the point at which the shaft begins to form the crook. The closed end of the golf grip shall be drilled or cut to provide an adequate hole to permit the application over the crook. The length of the grip shall be reduced to 8-1/2 inches beginning at the crook end. (See "A," Figure 5.) All material excess to the 8-1/2 inch length is to be removed from the end of the grip having the lesser diameter. (See "A," Figure 5.) The grip, cut to proper size, will be applied to the cane so that the flat surface lies in the same plane as the crook and faces "outward" for a right handed user. (See "B," Figure 5.)

Length

The length of the Long Cane shall be measured from the top of the crook to the extreme end of the white plastic tip *after* the cane has been assembled. Only 2 lengths will be required - 48 inches and 54 inches. (See dimension "C," Figure 3.)

Weight

The complete and assembled canes including the grip, crook end closure, and nylon tip shall weigh as follows:

1) For the 54-inch cane - approximately 10 ounces

2) For the 48-inch cane - approximately 8 ounces.

Accessories

Accessories for each completed cane shall include one package of Scotchlite Reflective Tape or coating containing one white adhesive strip 2 inches wide and 36 inches long and one red adhesive strip 2 inches wide and 6 inches long for covering the shaft of the cane.

Each cane will be furnished with one tip as part of the completed cane; and two additional tips as spares.

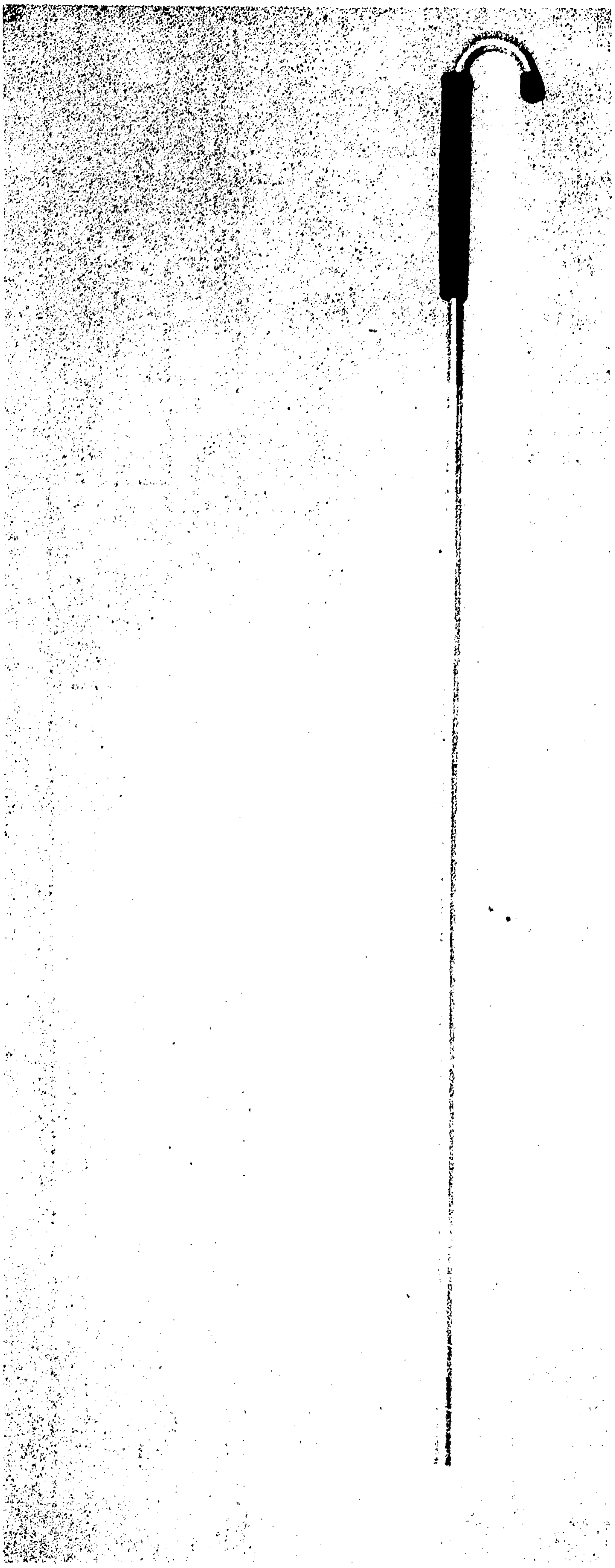


Figure 1. Rigid One-Piece Long Cane.

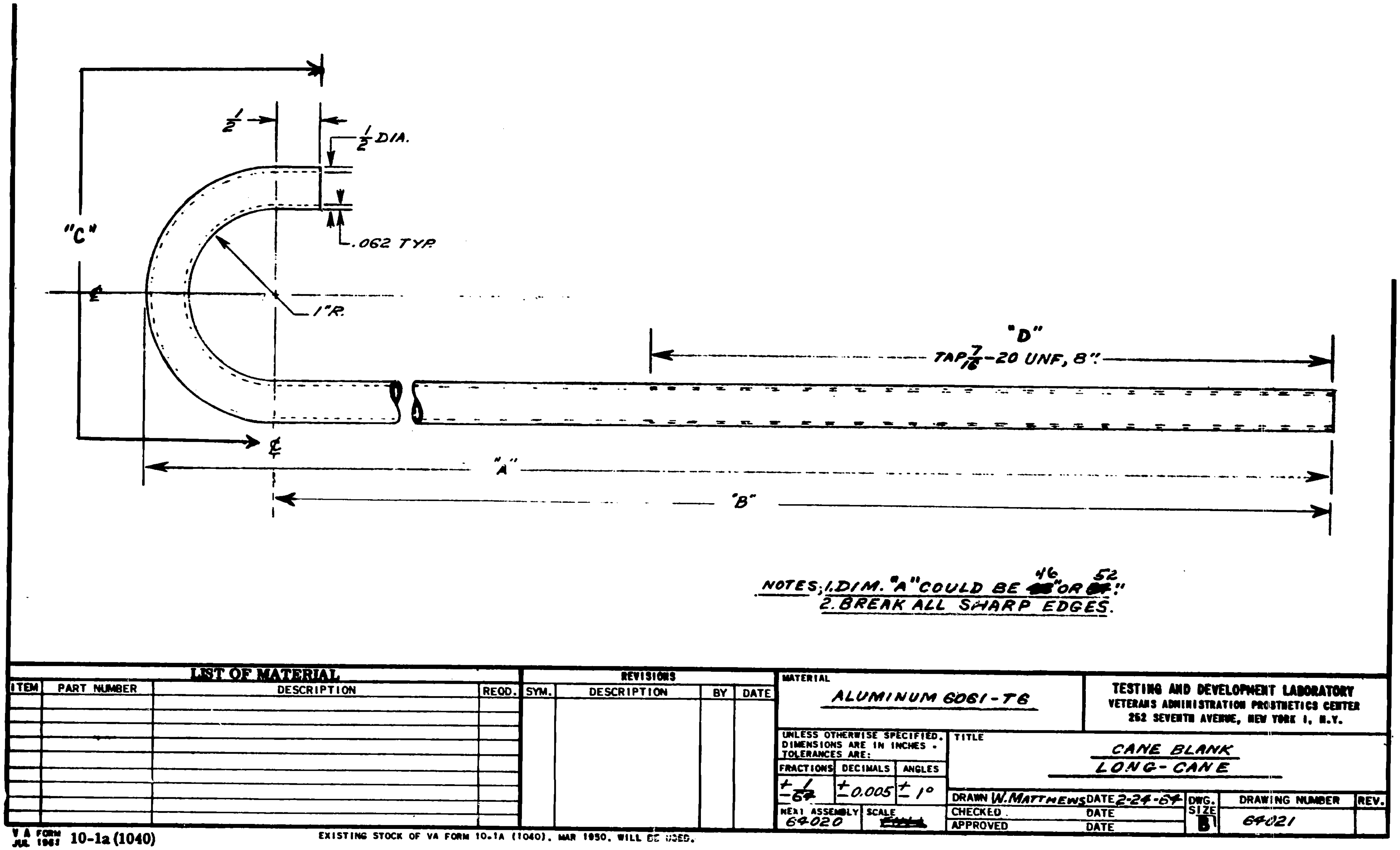
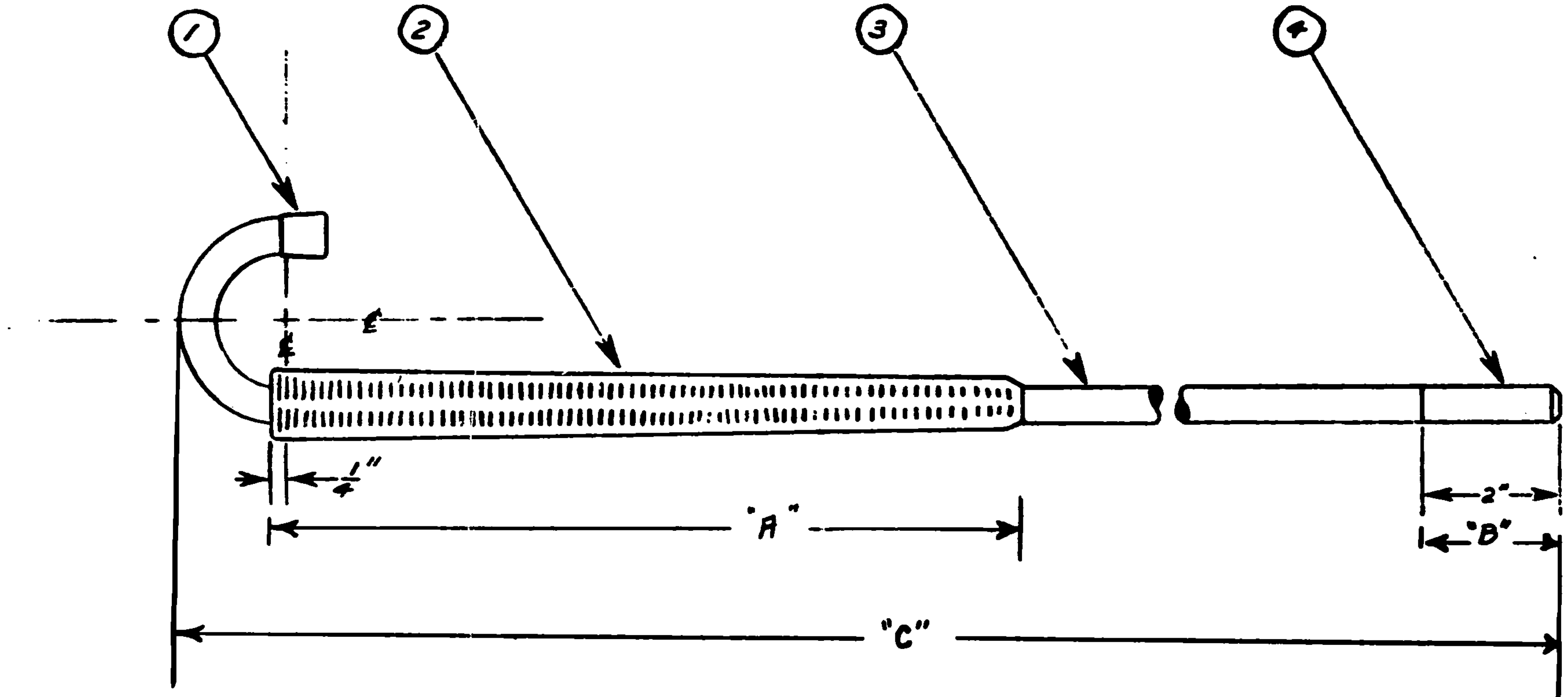


Figure 2. Cane Blank - Long Cane.



LIST OF MATERIAL

ITEM	PART NUMBER	DESCRIPTION	REQD.
1	COMM.	PLASTIC CAP FOR 2 PIECE ALUM. CANE (SEE SPECIFICATIONS)	1
2	COMM.	GRIP, RUBBER, GOLF CLUB	1
3	64021	CANE BLANK, ALUM. 6061-T6 ¾ IN. O.D. .062 WALL THICKNESS	1
4	64022	TIP, NYLON OR NYLATRON, WHITE	1

REVISIONS

SYM.	DESCRIPTION	BY	DATE

MATERIAL: SEE DETAIL DWGS	TESTING AND DEVELOPMENT LABORATORY VETERANS ADMINISTRATION PROSTHETICS CENTER 252 SEVENTH AVENUE, NEW YORK 1, N.Y.
UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES - TOLERANCES ARE: FRACTIONS / DECIMALS / ANGLES	TITLE: ASSEMBLY LONG-CANE
NEXT ASSEMBLY / SCALE	DRAWN W. MATTHEWS DATE 2-25-64 / CHECKED DATE / APPROVED DATE / DWG. SIZE B / DRAWING NUMBER 64020 / REV.

Figure 3. Assembly - Long Cane

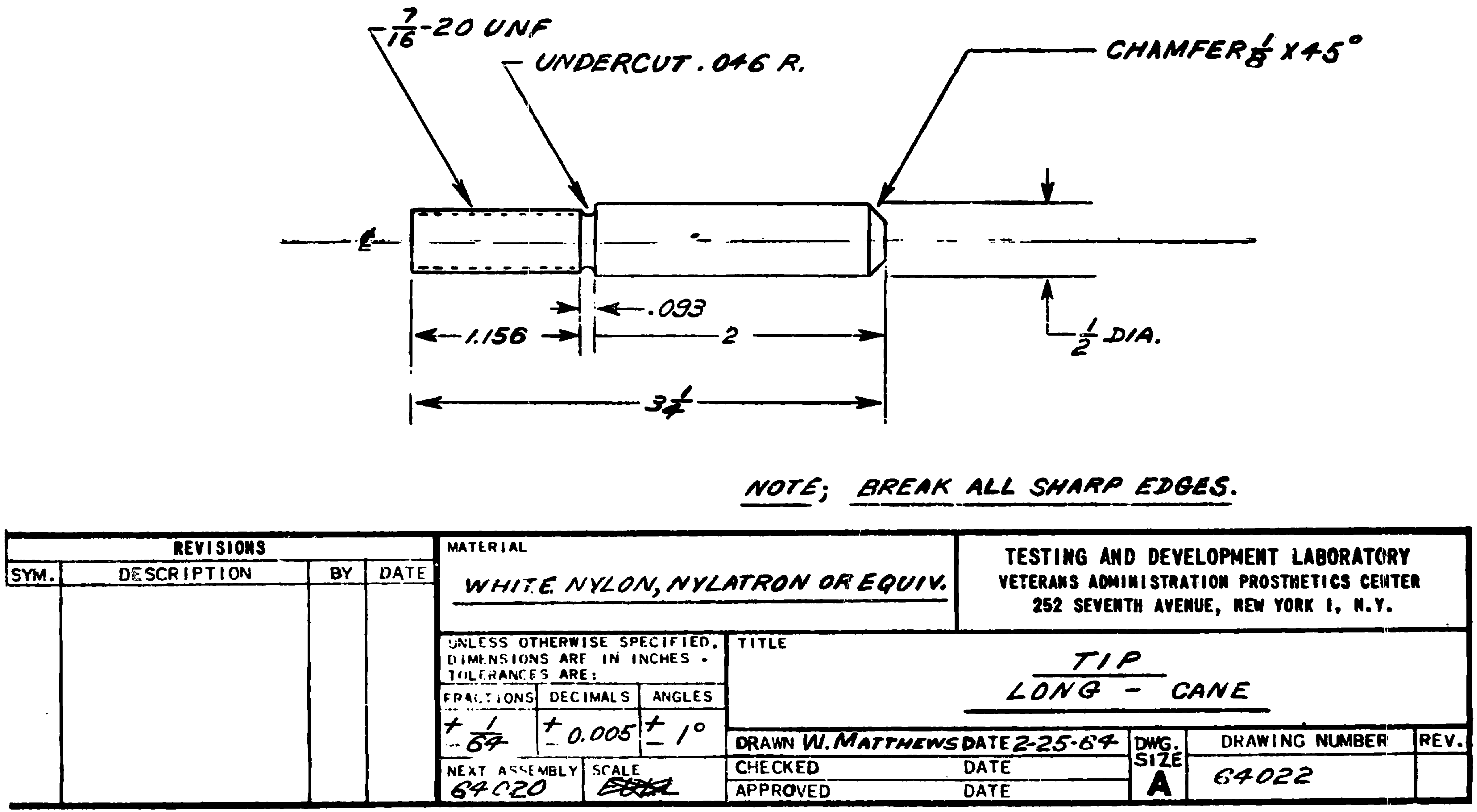


Figure 4. Tip - Long Cane.

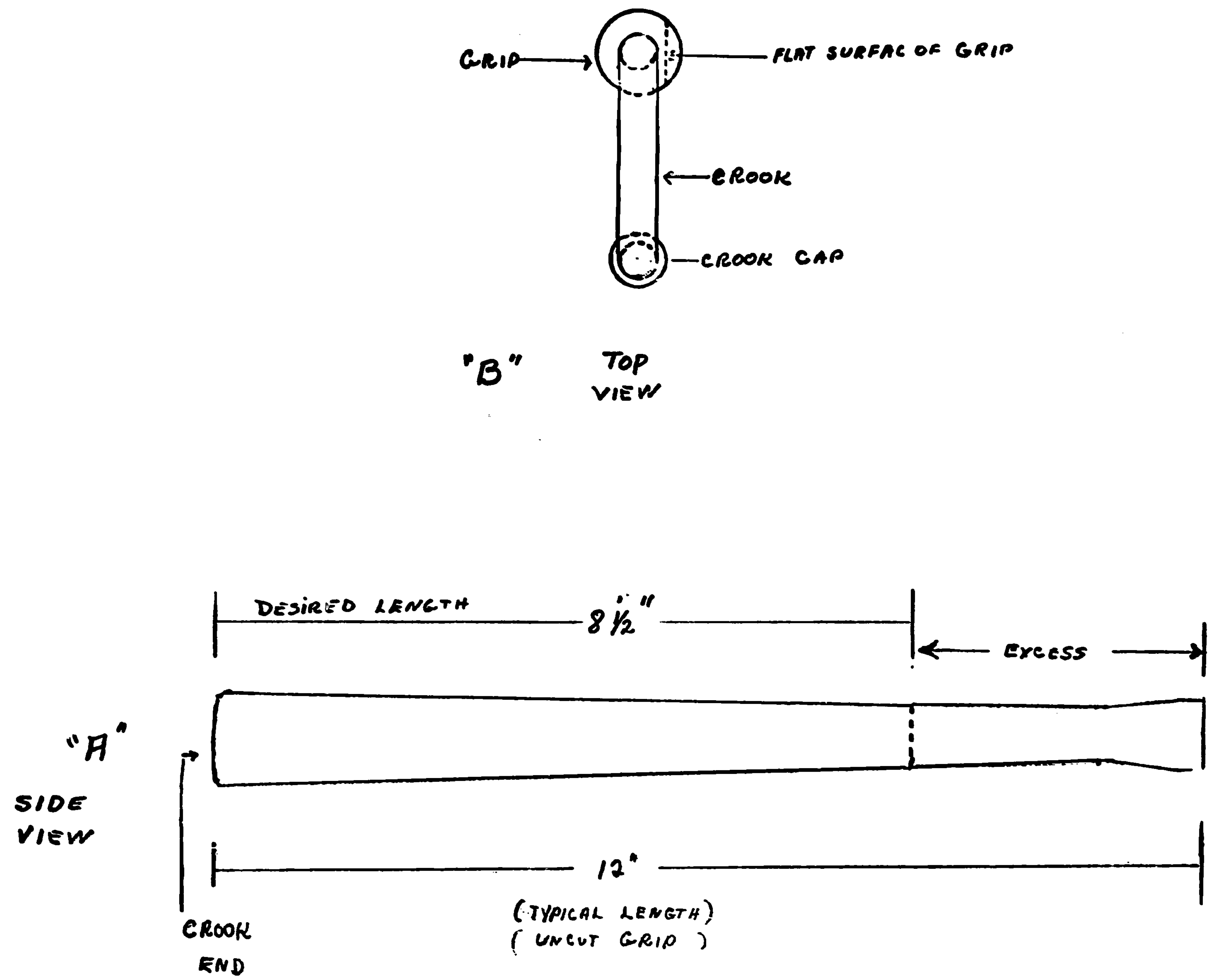


Figure 5. A) Side View, and B) Top View of Long Cane.

APPENDIX II:
THE TECHNIQUE OF CANE TRAVEL

W.J.J. Kooyman
Mobility Instructor
Huizen (N-H), The Netherlands

INTRODUCTION

These instructions and illustrations are meant as a manual in cane technique for students in institutes for the blind. This implies that it will be principally young persons who will profit most by this kind of instruction. Moreover, a difference will be drawn between congenitally blind students and those who are not born blind. A further distinction will be drawn between instruction for boys and for girls. This last difference is not made on the grounds of techniques and capabilities, but rather on the basis of a mental disposition.

Congenitally blind persons can acquire the technique of cane travel easily unless they show obvious characteristics of disorientation. Moreover, they possess youthful vitality, courage to take risks, adaptability to new situations, perseverance, and the ability to concentrate. The main thing, however, is that they possess the ability to detect objects at a certain distance. For those who are not born blind but overcome the first shock of blindness, the problems of fear, a lack of obstacle perception, and sheer nervousness, form a hindrance. With perseverance and courage, however, they are often able to equal their congenitally blind comrades both technically and physically. These instructions are meant only for normal blind children (that is, those with no other disabilities).

The main aim of cane technique is to enable the blind person to travel independently to office, shop, school, to visit friends, etc. This aim is highly important and needs no further explanation.

In this outline, no one special technique is discussed exclusively, but rather a number of them are outlined, each in conjunction with the situation in which they are used. As there are no set rules, students are free to make their own alterations after they have learned the techniques. Every blind person has his own personality, motor talent, behavior, and temperament. A warning must be given, however. The reader must not think that learning these techniques gives a complete guarantee and complete protection against all dangers and problems on and along the road. There exists no technique of cane travel which gives complete protection against collision or harm, and the instructor should not be allowed to tell the student otherwise. It is certainly not intended to discourage the beginner with this fact however for practice has proved that serious accidents and bodily injury are exceptional rather than usual. The risks taken in the course are as small as possible, and the safety measures are effective, at least if the student does not execute exercises recklessly.

Another common presumption is that if the technique is mastered, and the student possesses the mental capabilities required for cane technique, he can walk everywhere and for as long as he likes. First of all, he must know his whereabouts. That is to say, every route must be explained to him, either orally or by practice. One cannot go everywhere with a cane, for there are situations which make it impossible for a blind person to reach his destination without some help. In very crowded and narrow old town centers, with their very heavy traffic, numerous obstacles, buildings under construction, canals, marketplaces, and so on, we have some natural examples. Yet cane travel in towns and centers can be well executed. Routes with insurmountable difficulties must be avoided by making use of detours which also lead to the target area.

The exercises given in this outline are divided into Lessons. It is not necessary, however, to stick to the order in which they are given, and the instructor is free to select the order of difficulties and the duration of each exercise. The order he selects depends on so many different and local factors that he must be given a free hand in arranging them. Not all problems are dealt with, but the most frequent situations are described. Certainly, after such training, the blind person can be mobile.

LESSON 1

Aim

To investigate the orientation possibilities of each student, and to examine the further development of these possibilities.

Before starting lessons it is useful and necessary to know whether the student has an immediate understanding of the situation in which he is placed during training, and also whether he can solve the problems presented during that training. To discover whether the student has a good orientation, he must be placed first in an empty room or hall, to make it possible for him to execute the following tasks.

Procedure

A. Place the student with his back against the wall facing the instructor, who is making some kind of sound. When the sound stops, the student points toward it, and walks in the direction of the sound for 30 meters (90 feet). The instructor controls whether his deviation is too great in the right or left direction.

If the deviation is constantly one-sided the instructor tells him so, and the student can then correct himself during his locomotion.

B. The pupil is again placed against the wall, and the following instructions are given: "Walk 5 steps straight ahead, turn 90 degrees to the left, walk 5 steps further, turn 90 degrees to the right, walk 5 steps, turn 90 degrees to the right, walk a little further...." and so on. It is necessary to ask the student after one turn, and again after further turns, from whence he started. This routine can be varied in different ways.

C. The same procedure is followed as in B, but now using half turns (180 degrees) to the left and right, and also whole turns (360 degrees) to the left and right, including all the former variations.

D. The student is made to walk at an angle to the left or right (with respect to the wall), forwards and backwards, also using turns of different degree.

E. Here he walks prescribed figures including a square, a triangle, a circle, a rectangle, and a figure eight. The sides of perpendicular figures must be executed with the same number of steps. It is not necessary to imitate the figures exactly, for it can soon be seen whether they are well-formed in principle. Every now and then during these exercises, the client is asked where his starting point was situated. After repeating the figures with the help of the instructor, the student must then be able to make them by himself.

The instructor will discover quite soon that there are certain students who have difficulties with left and right, with pointing to the starting place, with an imperfect understanding of the figures involved, and with a lack of "turn awareness." These people are disoriented, and it is better to postpone teaching them cane technique to a later date. If it appears that no progress is made after intensive training, they may not be suitable for training in cane travel at all.

The best canes for teaching cane technique are:

1. Those that have a length sufficient to reach from ground level to breastbone height.

2. Those that are light but strong, preferably made with metal or some other synthetic materials.

3. Those that have a round metal ball on the tip so that the cane can be pushed along, if necessary.

4. Those that are collapsible or telescopic.

Never use a rubber tip, because it produces no sound and makes it difficult to detect surface irregularities.

LESSON 2

Aim

To give instruction in techniques of cane travel required in several different situations.

One begins by walking along clearly palpable, straight guidelines, *at slow speed.* A guideline is defined as an existing border: street and bank, pavement and lawn, pavement and road, walls of gardens, fences, hedges. The blind person can make use of these guidelines, and they can be of great help in his orientation and determining his direction of travel. The pupil must always begin with a *slow* speed that can be increased when he becomes more experienced.

Procedure

Technique I

Although later in his training the student may hold the cane in any way he prefers, it is desirable to teach him the following grip at first. The knob of the cane rests against the ball of the thumb, and the shaft rests on the bowed middle finger. The thumb lies on the upper part of the shaft, and the index finger is stretched along the outside part of the shaft. The arm hangs relaxed alongside the body. The swinging movements of the cane are made mainly by the wrist. The underside of the forearm may also be used, though to a lesser degree.

Standing in one spot, the student practices swinging the cane; that is, he turns a semicircle with the tip of the cane from left to right and back. The breadth of the movement should not surpass the width of his own shoulders. Moreover, the tip of the cane should not lift up higher than about 5 cm (2 inches) above the ground, and should touch the ground with a short tap at the end of every swing. *The right and left hand are both trained.* When the student has made this movement several times, locomotion can start in coordination with the swinging movements just learned.

The instructor will try to find a quiet and safe place for training that has a clear and noticeable guideline. This may be in a gymnasium, a long corridor, or an empty hall indoors, or a quiet garden walk, road, or playground outdoors. When, for example, the guideline is on the *left*, the student takes the cane in his *right* hand, in the manner described above. The student begins with his right foot, and immediately swings the cane to the left, touching the guideline at the end of the swing. Simultaneously with putting the right foot down, he touches the guideline to the left. The breadth of the movement to the left guideline may be greater than that to the right in order to keep contact with this guideline. When moving the left foot forward, the cane swings to the right, touching the ground at the same time as when the left foot is put down, and just at the spot on which the right foot will come down on the next step. Thus the user is sure that this spot will be safe, since he has already reconnoitered it. The movement of the swing is not wider than the edge of the right shoulder. Then the right foot starts again and so on.

This movement is made on every step and the ground is touched before putting down both the left and the right foot. *The following points must be kept in mind:*

1. The cane must be held properly.

2. The movements of the cane must be made in the main by the wrist although a slight movement of the forearm is not prohibited.

3. During the swing the tip of the cane must not lift up higher than about 5 cm (2 inches).

4. The movement of the swing to the guideline may be wider than the swing to the side where no guideline exists.

5. The tapping of the cane must not result in firm beats; they must be short and light and the tip of the cane must not be punched into the ground, hindering a graceful movement.

6. The free hand must not be used as a bumper. This hand should be put into a pocket, or the instructor can give the student something to carry.

7. The tip of the cane must touch the ground in *front* and *not* beside or behind the body.

8. The cane tip should not be permitted to touch the ground for a long period; if it does the point will be, on the next step, behind the traveler.

9. Tapping should be used to detect obstacles by producing an echo (see below). Further, the character of the tapping sound can indicate the texture of the surface on which the student is traveling, whether it be asphalt, grass, sand, gravel, tile, or whatever.

10. The movement must be exercised with the cane held in both the right and the left hand.

This technique can be used in town centers where many obstacles can be expected on the pavement. This point will be discussed later.

When the guideline is to the *left*, it is preferable to hold the cane in the *right* hand. In this way, the shaft of the cane is at an angle to the body, thus giving greater protection. Later on, when the student is following a sudden bend in the road, it is advisable to keep in constant contact with the guideline, so that holding the cane in a constant position insures more safety against bumping into obstacles.

In this manner we advance to the second technique.

Technique II

When, as mentioned above, the traveler is entering a side street, it is necessary to keep in constant contact with the guideline which in such situations may disappear suddenly to the left or right. If the guideline is to the right of the traveler, then the cane is in his left hand. When he feels that the guideline is coming towards him or going away from him, then he does not move the cane any longer, but instead taps on every step against this guideline, holding the cane slanting in front of him as a protective measure. In this way the traveler will not loose the guideline and can continue on his way. Should the guidelines be high but not homogeneous, as in the case of railings, hedges, and bushes, then he must apply Technique III.

Technique III

When tapping against high and open guidelines, the tip of the cane will repeatedly pierce or be caught in the railings or branches of fences or bushes. This will cause damage to the cane and hamper the traveler's progress, since he has constantly to tear the cane out of each obstruction. Instead of using the cane in the opposite hand, he now takes the cane in the hand on the side of the guideline. When swinging the cane toward the guideline, he turns his hand, holding the cane *inwards*, so that the palm of the hand is turned outwards toward the guideline, and his forefinger is now on the inside of the shaft. Thus a longer length of the cane will touch the open guideline smoothly.

This technique avoids the piercing and hooking of the cane mentioned above. Note that in touching the high guideline, the cane tip remains as low as possible. This technique must be learned in the near vicinity of the training school, outdoors. If the guideline is both high and *homogeneous* in nature, as in following walls and fences, then Technique I is applied since no hooking or punching is possible.

Due to his youth, his vitality, and his energy, the congenitally blind person is apt to walk *swiftly*, and will often reach the *same speed* as the sighted. The swinging movement learned in Technique I, that is, tapping the ground on *every* step, would be so rapid with this increased speed that the rhythm would become unpleasant and difficulties would occur in coordination. To overcome this, we use Technique IV.

Technique IV

This technique is used not only while traveling at a higher speed along high guidelines, for example, but also during locomotion *without* guidelines. The student starts with his feet together and with the cane in his right hand (with no obstacles in front of him). He puts his right foot forward, at the same time swinging the cane to the left, tapping the ground at the end of the swing, at the same time when the right foot comes down. The next step follows with the left foot, but the tip of the cane *remains to the left,* pointing toward the ground so that the cane gives some protection to his body. Only when his right foot is put forward on the third step does he swing the cane swiftly to the right and tap the ground with it *at the same time* as the right foot comes down. This must be repeated during the following steps. This means that the ground is touched only left and right when the *right foot comes down.* Thus there is no touching and no swinging when the left foot is put forward.

The practical result is that the cane is held at a constant slant, protecting the front of the body, only leaving this position when swinging to the right. The rhythm of the swing is reduced 50 percent in comparison with Technique I. Technique IV is less fatiguing and the rhythm of swinging is now quieter and easier. This technique can also be applied when walking on broad pavements or where no use of guidelines is necessary.

Finally, the user can keep the cane completely still, tapping the ground only when he requires an echo.

Technique V

This technique can be used by *advanced* or *experienced* cane travelers, and is a favorite method on quiet roads having no obstacles. Note that the tip of the cane is as near as possible to the ground and is slanting as far as possible in front of the body (see Figure 1).

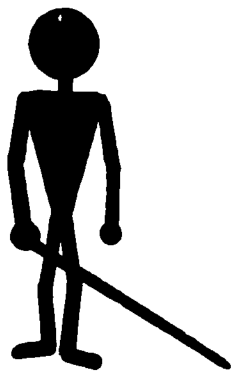


Figure 1. Correct Cane Position for Advanced or Experienced Cane Travelers.

LESSON 3

Aim

To teach the student the difference between the several species of ground on which he walks, such as asphalt, bricks, tiles, concrete, gravel, grass, heather, sand; and whether the path is sloping, ascending, bulging, or hollow.

Note: Leather soles are preferable on shoes to be used in these exercises, since the character of the surface can be discerned more easily than with thick rubber soles. Whether the surface of the road or the path is smooth, bumpy, or rough can aid considerably in orientation.

Procedure

When the student walks on a tiled pathway or sidewalk, then he can feel surface changes immediately by shuffling his foot or by scraping his cane. In this way, he can prevent deviations from the right path and not enter walks from garages, gardens, gravel paths, and so on. It is also important to train the student on winding roads, as these tempt him to deviate from his original direction. It is advisable to seek out differing road or path surfaces in the neighborhood of the training center, and to inquire of the student during his training periods what kind of road surface he is traversing. A special lesson should not be dedicated to this identification, since it should be made constantly throughout all the lessons and training periods.

LESSON 4

Aim

To learn to observe obstacles by means of cane and hearing, the immediate reaction to such observation, and to pass obstacles safely.

Note: The speed of travel must be such that if the student notices an obstacle with his cane or through hearing, he has time to stop. The length of the cane provides an ample margin of safety. Obstacle perception is the name given to the capability of hearing the presence of an obstacle at a distance. Most congenitally blind persons have little difficulty in noting obstacles because they have had much experience in such detection during childhood; a special lesson is not necessary for them. It is advisable, however, to ask the student during the training period whether he "heard" a car, a tree, or a wall, and to make him point at these obstacles. He should stop as soon as he hears the obstacle, after which the cane can be utilized. This theme runs through these lessons as a continuous thread. The ability is not so evident in persons blinded later in life. For these persons special training is certainly advisable.

Procedure

In a very quiet room the student is requested to walk slowly toward a wall, tapping the ground with his cane. Try to inhibit the clacking of the tongue or snapping of the fingers, since this is apt to become a habit difficult to unlearn for street use. The cane or footsteps produce enough usable echo for his navigation and the blind person should act as near normal as possible. As soon as he hears an echo, the student *must stop* and point at the obstacle. After this, take more difficult situations with more sound sources and with less homogeneous and massive obstacles (e.g., trees and poles). Not all obstacles can be detected in time. There are situations when it even becomes impossible, as for example, in noisy traffic or during a snow storm. If the obstacles are too small (thin traffic signs), too low (under knee height), and less homogeneous (bicycles or railings), or are slanted so that reflected sounds do not reach the ear, then obstacle perception becomes impossible.

Training the Student to Detect
Obstacles with the Cane

As soon as the cane touches an unknown obstacle, the student must stop immediately, but the cane must remain in constant contact with the obstacle. After this contact, the student must detect with his cane, or if necessary with his hand, the height and width of the obstacle in order to know what kind of obstacle it is. If it is small and low (wastepaper bin, pram, toy) then he should touch the sides and pass it and return to the guideline. If the obstacle is big (car, motorcycle, bicycle, or barrow), then for better orientation the hand can be used. If he knows what it is, then on passing it he must keep a constant contact with the obstacle. He must make sure that after passing the obstacle the original direction of travel is maintained. Indoors this can be done by placing benches, chairs, or chests diagonally across the direction of travel. Outdoors this can be done by utilizing existing obstacles or even by placing obstacles deliberately on the path. An attempt should be made to find most types of obstacles during training and to let the student detect and pass them safely. The following points must be kept in mind especially for detection of obstacles:

1. *Stop immediately* when the cane touches the obstacle, for a few more steps can cause harm;

2. The recognition of shape and kind of obstacle;

3. The need for constant contact with the obstacle when passing;

4. If the path is to the right of the obstacle the latter should be passed on the right side, which is the less dangerous route since it avoids stepping from the pavement.

During cane travel, surrounding sounds are also of importance, and the instructor will do well to draw attention to specific sounds related to the obstacles to be expected. Nor should smell be neglected, lest a chemist, baker's shop, greengrocer's, or tobacconist be missed. Persons engaged in conversation while standing still are obstacles in themselves, but they can hold other obstacles like bikes and prams. The noise of playing children should enhance the alertness of the student to toys in his path. The noise of street repairs and trucks unloading are also warning signals. Finally, the smell of gasoline or oil characterizes parked automobiles.

LESSON 5

Aim

To train the student in maintaining the desired and original direction a) if the guideline suddenly disappears or is interrupted, or b) if it is not present at all.

Procedure

A. Use a road or path on which guidelines such as walls, hedges, and fences are interrupted occasionally by garage entrances, garden paths, or small lanes (Figure 2). (At first most students are apt to follow these pathways and get lost in gardens and lanes.) Assume the student is walking on the right side of the pathway, making use of a guideline to his right. When he feels no guideline he should maintain his original direction, for at least five

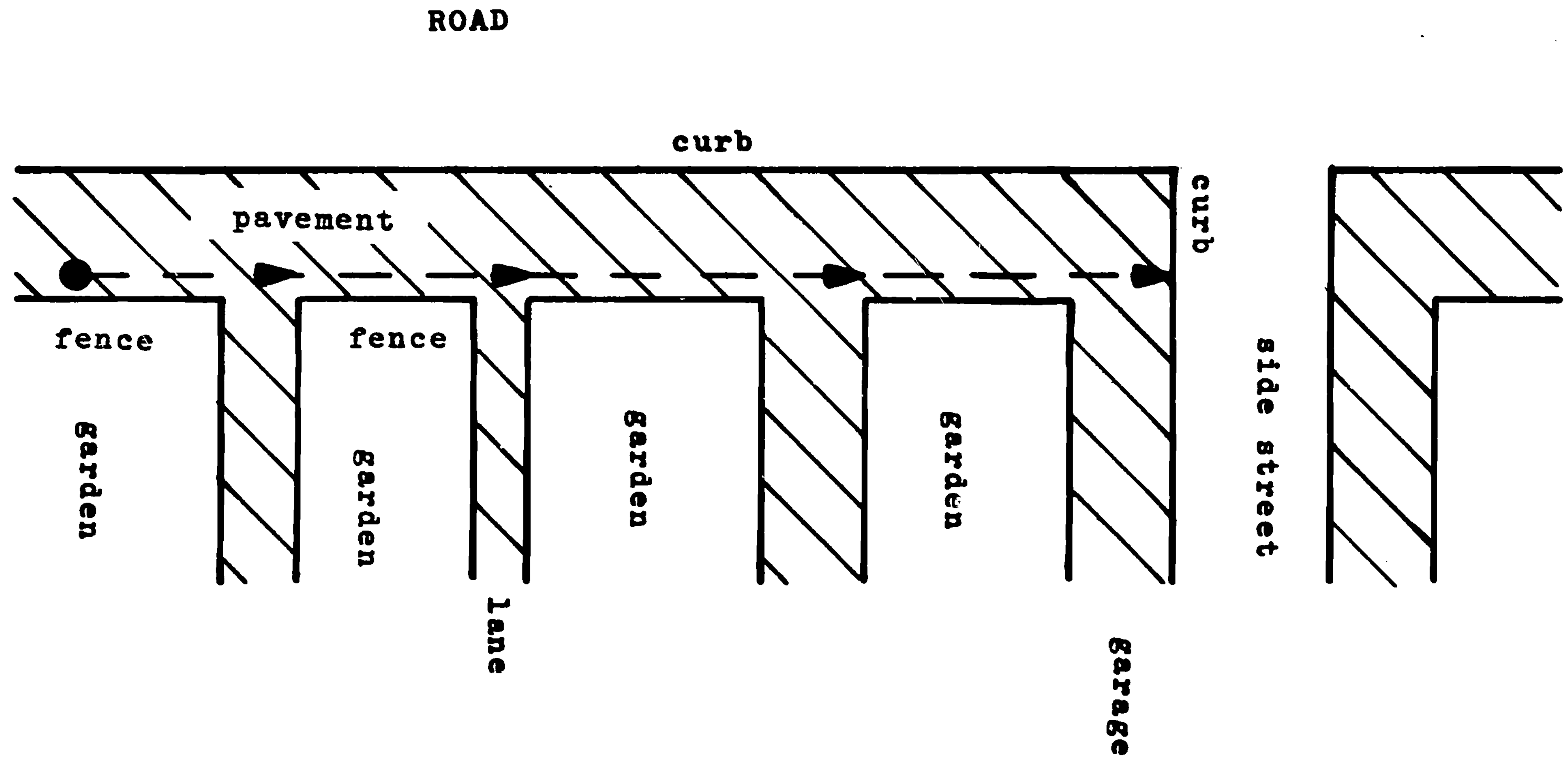


Figure 2. Procedure A: Using a Road or Path on which Guidelines are Frequently Interrupted.

strides. If the guideline is sensed again, he can proceed on his way. If he does not sense the guideline after five steps then he must correct himself and go right (when he has deviated too far to the left) and can rediscover the guideline. He must be told beforehand that the guideline will be interrupted. The lack of guidelines can also mean a side street. This can be discovered through the transverse interruption of the pathway by the curb.

B. Seek a broad pavement or a broad and quiet road, for training in a straight line without guidelines, and place the student in the middle of such a road (Figure 3). The first steps are taken

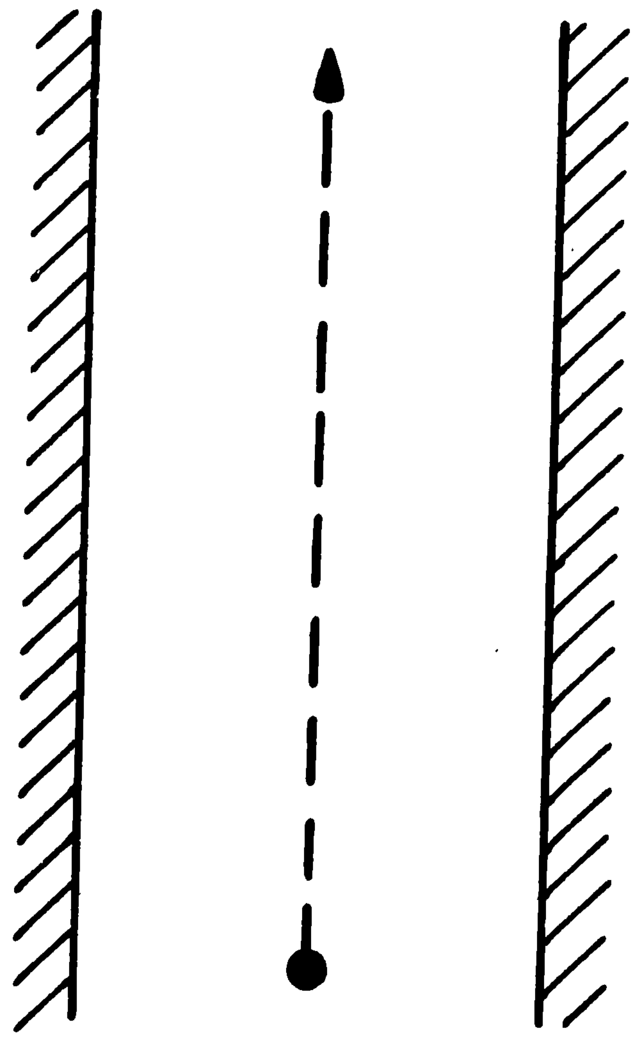


Figure 3. Procedure B: Using a Broad, Quiet Road for Training Cane Travel in a Straight Line without Guidelines.

together by student and instructor along the direction chosen; the student then continues on his own way. By using the echo of his footfalls or by tapping his cane and using information about the road surface he has sufficient means to orient himself. On pavement the student can try to maintain his path with the aid of sounds from pedestrians, traffic, and so on. If he persists in a constant deviation he must be told to which side and what correction is needed. If he walks to the right, it is not particularly dangerous; but if he walks to the left he runs the risk of walking into moving traffic. Pedestrians walking in front of or beside the student can be an important aid in maintaining the right direction.

LESSON 6

Aim

To train the student along discontinuous, odd-shaped, or running guidelines.

Note: In and near the centers of cities, the situation is quite often such that the alignment of buildings, gardens, or dwellings is odd, with frequent indentations, protrusions, steps, gates, etc. These constitute a real problem for the blind traveler, because following such a guideline would make his travel distance much longer than necessary and would contribute to a certain confusion. Particularly along the curb, trees, lamp posts, and traffic poles provide such frequent interruptions that it is not a preferred line of travel.

Procedure

The student is placed, once again, in the middle of the pavement, and the instructor gives him the correct direction by walking some steps beside him. The student then attempts to walk in a straight line, avoiding odd-shaped guidelines. In all probability, an unconscious deviation will take place. If the student deviates to the right, his cane will touch the guideline and he may be able to follow this for some time. If the guideline disappears, and then reappears, he has rediscovered the correct direction. Should he bump against the the guideline in front of him (see Figure 4) then he must attempt to keep in contact with the guideline, to go to the left and at the corner go right again in order to continue along the correct pathway. Should he deviate to the left he will note that his cane tip touches the curbstone or even the roadway, and that he is about to step off the pavement with his left foot. In this case he has been walking across the pavement, and the curbstone gives a north-south orientation; if he is on a side street or by-road, the curbstone will give an east-west orientation. Such deviation to the left can be corrected by making some steps to the right, and by starting once again, placing both feet parallel to the curbstone and continuing directly forward.

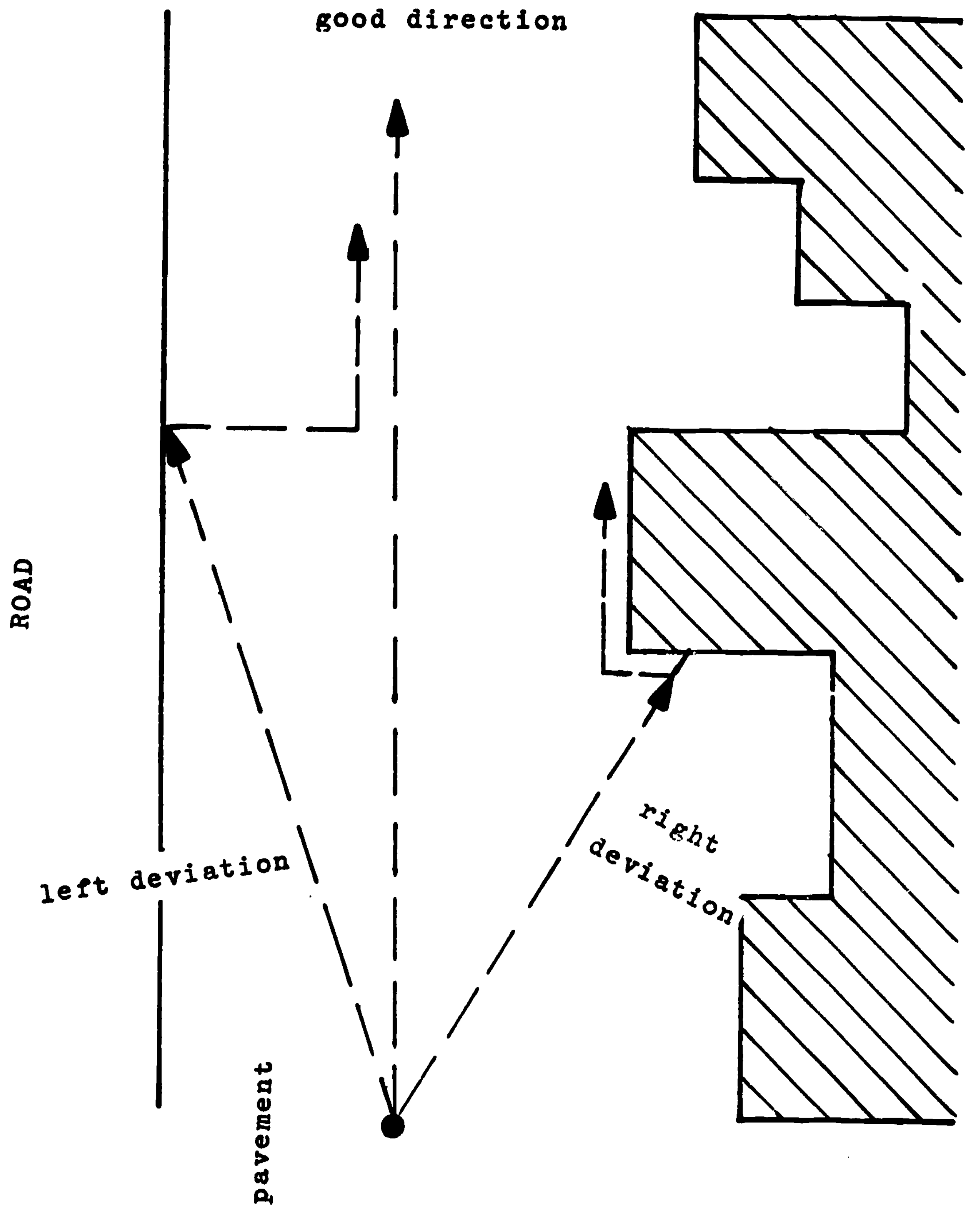


Figure 4. Procedure for Training for Travel Along Discontinuous, Odd-Shaped, or Running Guidelines.

LESSON 7

Aim

To teach the student how to cross streets by himself if these are not thoroughfares.

Note: The crossing of roads is a rather risky adventure, but the blind traveler will be repeatedly compelled to do so because of lack of assistance. There are some methods that give the blind traveler the greatest possible safety. Still, there are streets and thoroughfares which remain so dangerous that corssing them without help would be an irresponsible act. Most often, if he waits a short time, help will be offered.

Procedure

If the student is walking on the pavement of the right side of the street and wishes to cross the street he will stop, turn his back to the guideline, and walk to the curb of the pavement, holding his cane aslant in front of him. With both feet on the curbstone, he stretches his arm and the cane forward, with the tip of the cane to the ground. He waits and listens to right and left to see whether traffic is approaching. The arm and cane are then lifted to a horizontal position (note Figure 5). After waiting

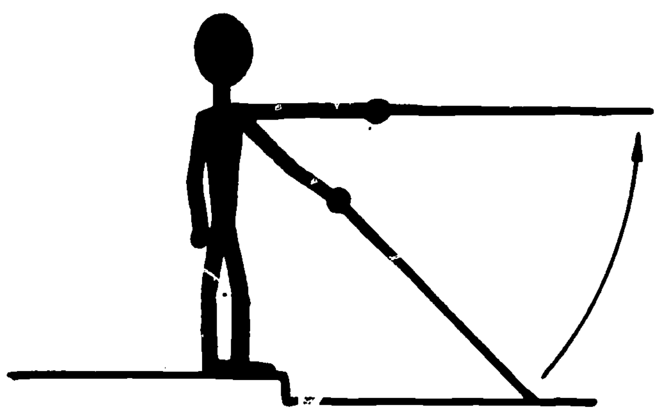


Figure 5. Correct Cane Technique for Crossing Street without Assistance.

for at least five seconds, and determining that *no approaching traffic can be heard,* he will cross the street *in a straight line,* holding his cane in a horizontal position. When he is halfway across, he may put his cane down in the usual position (i.e., aslant in front of him), but his arm must remain stretched out, downwards. *The arm and the cane form one line.* In this way, he can find the opposite curb easily. Once reaching the opposite pavement, he must find the guideline again and follow this to the left or to the right. During his traversal of the road he must *not stop* in the middle of the road, nor may he go back. He must walk quietly, without hurry, but decisively, *looking straight ahead*, until the opposite side is reached. The student's attention should be drawn to the fact that he must not look either to the right or the left during his passage. Should he turn his face toward the source of traffic noise he is apt to create the impression that he is sighted and is looking at traffic. Note: care should be taken that during the last few steps before reaching the opposite side the cane is stretched down to detect the curbstone and to avoid injuring others with its tip. In the Netherlands, bicyclists are the greatest danger because they cannot be heard approaching. It is of the greatest importance that everyone understand the meaning of the outstretched arm and cane. Stretching the arm out horizontally makes sense when the cane is light and is not otherwise properly visible. Arms that are thick and dark will certainly be more visible and will highlight the cane. In this manner bicyclists are compelled to avoid the cane and so avoid injuring themselves by tangling with it. Held properly, the cane cannot be inserted into bicycle spokes, since it is lifted up horizontally as illustrated in Figure 6.

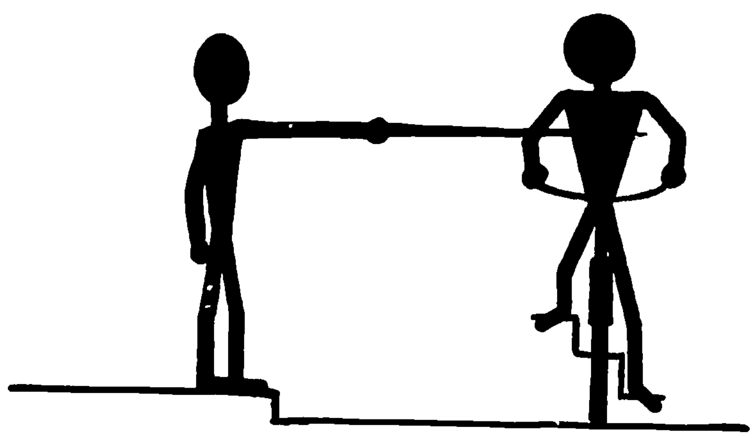


Figure 6. Correct Cane Technique for Warning an Approaching Cyclist.

LESSON 8

Aim

To learn to cross side streets that must be passed on the route.

The technique discribed in Lesson 7 should be used if the student must pass a number of side streets on his route. To increase his safety he should go into the side street for 10 to 15 meters (30 to 45 feet) before crossing the side street. This may seem a rather roundabout way, but it is desirable for the beginner in the name of safety. Traffic coming around the corner has thus a greater margin for reaction.

Procedure

The student walks along the guideline at his right hand. When the guideline stops the student walks until he discovers the curbstone of the side street. When he has reconnoitered the curb he returns to the guideline. Keeping the cane in contact with the guideline, he rounds the corner and enters the side street for 10 to 15 meters (30 to 45 feet), stops, turns his back toward the guideline, walks to the curb, and proceeds as in Lesson 7. On the opposite side he walks the same distance *back* and then rounds the corner to the *right* (see Figure 7).

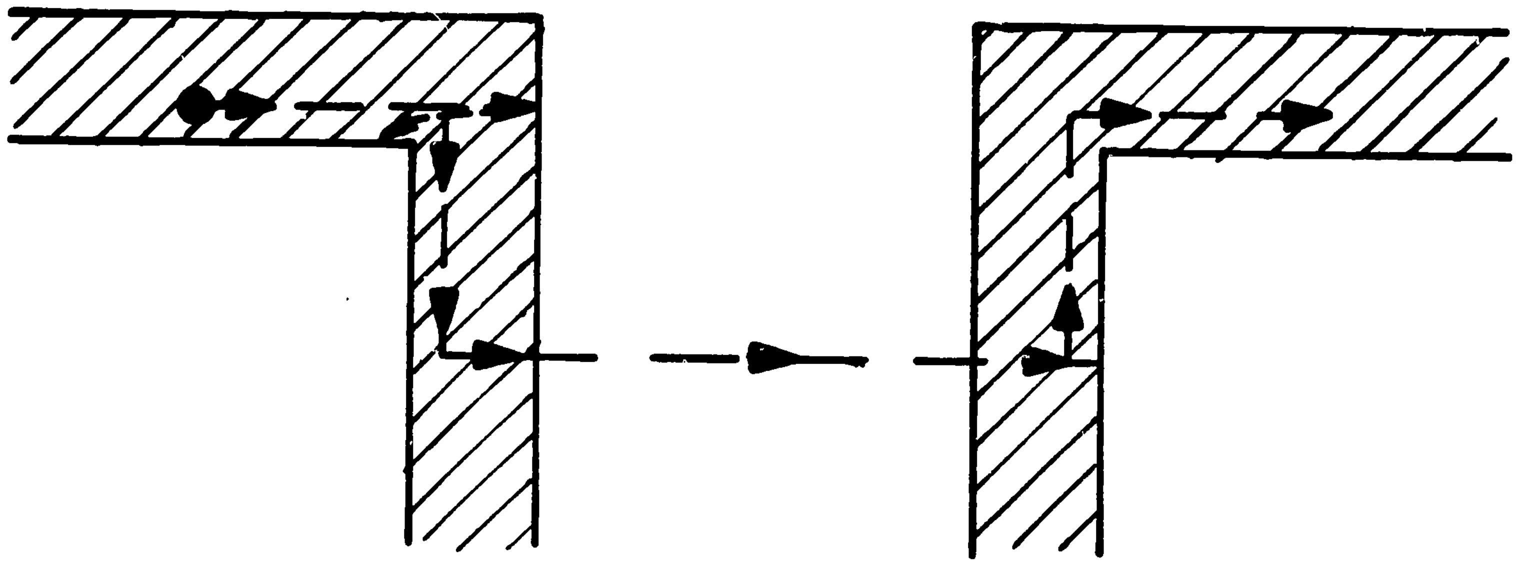


Figure 7. Route for Beginner when Crossing Side Street with Rectangular Corners.

Note: Advanced students do not follow this roundabout way, but rather the following routine. When the guideline disappears the student walks toward the curb, puts out his cane and arm, and crosses the street as described in Lesson 7. The difference is that he now walks on a *slant line* to the *right* to avoid deviating to the left and the attendant danger of walking into the middle of the main road (Figure 8). Although crossing at an angle is not desirable, it is allowed in this case out of practical considerations. Not every side street has a rectangular corner; some have obtuse or sharp angles (Figure 9). Such situations should be discussed thoroughly with the student beforehand.

LESSON 9

Aim

To teach the student to reach a target area which is on the

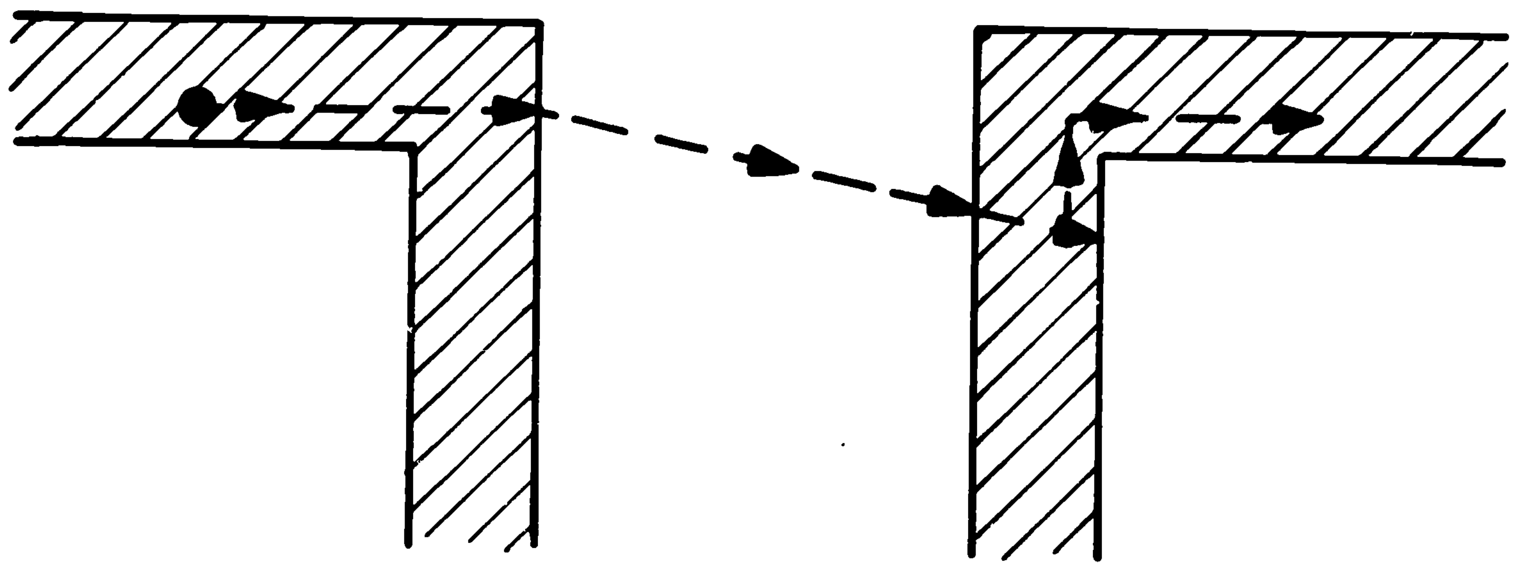


Figure 8. Route for Advanced Student when Crossing Side Street with Rectangular Corners.

opposite side of the road safely.

It should not be the intention of the instructor to describe every situation in which the student will find himself in practice, nor would this be possible. Rather, a number of problems are dealt with below, which gradually increase in difficulty. These are illustrated by Figures 10 through 13. Note that although a swift and direct route is not always used, this is due to the fact that *safety* is made a primary consideration, even at the cost of a longer route.

Procedure

Situation 1
(Figure 10)

The traveler is on the pavement on the right side of street A and he wishes to proceed to a house on street B. The student knows that he must cross the street in order to reach the side street on which his goal is situated. He proceeds as in Lesson 7 and crosses the street (Route I). Now, while walking on the left hand pavement of street A, he notes side street B, since the left hand guideline stops. He rounds the corner of street B, crosses it, and walks on the right side to reach his target, the house. The student was walking on the left of street A and had to cross twice. This is not objectionable so long as the streets are not crowded. If they are crowded with shops and small pavements, then

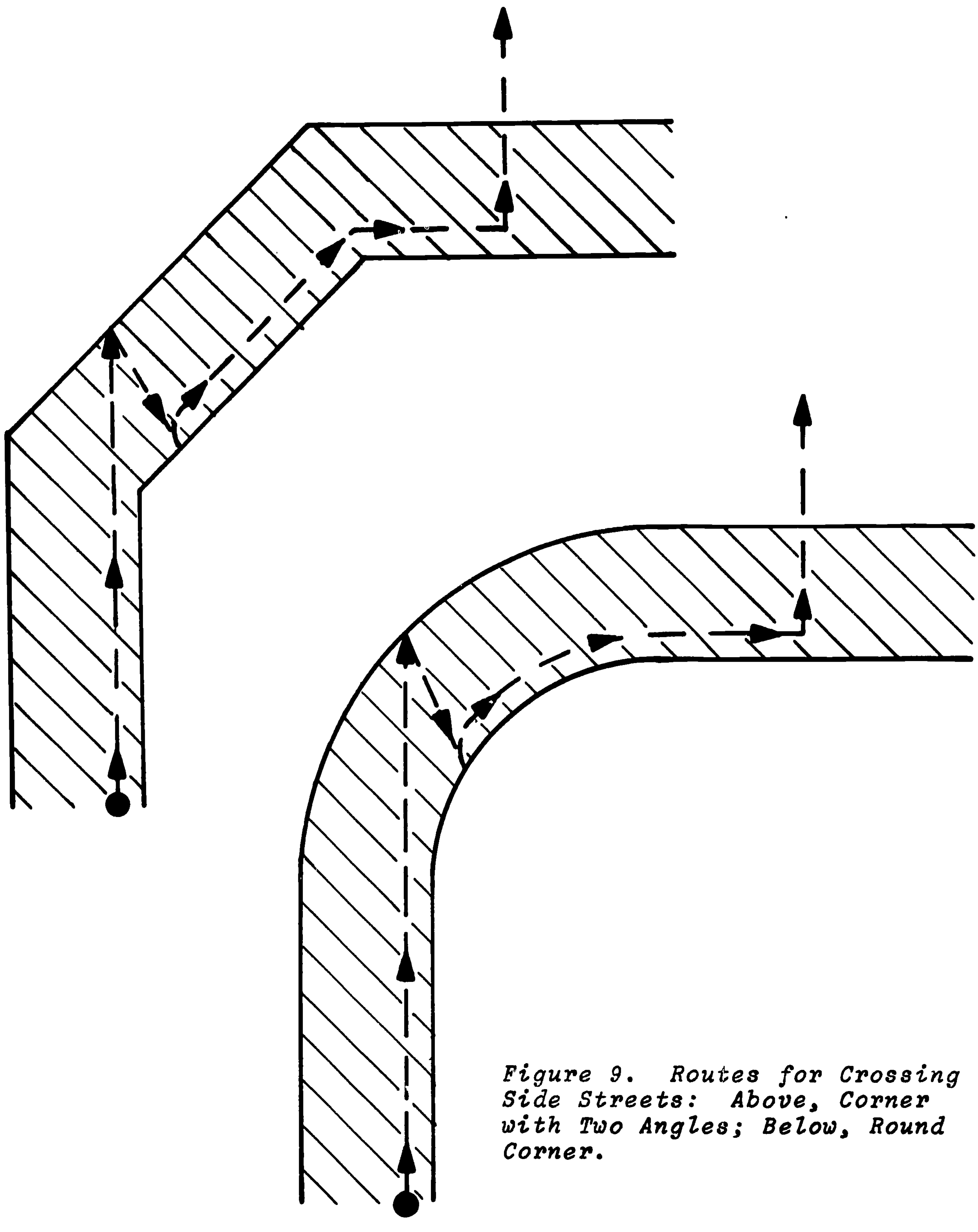


Figure 9. Routes for Crossing Side Streets: Above, Corner with Two Angles; Below, Round Corner.

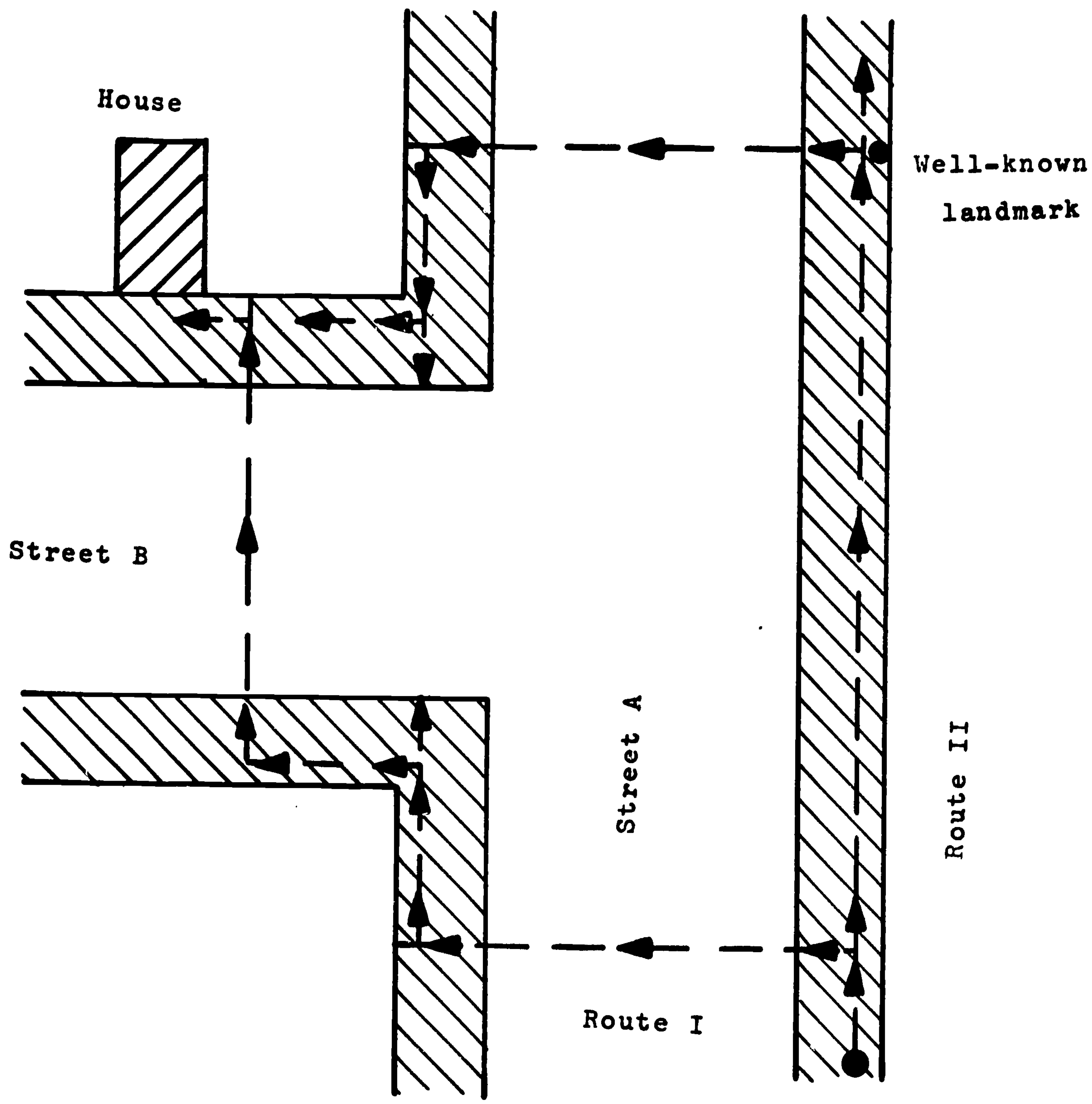


Figure 10. Situation 1.

it is recommended he walk to the right of the street as long as possible. In this case he remains walking on the right side of street A (Route II), until he passes the side street (which he may know from certain cues), crosses street A, walks back on the pavement on the right side, rounds the corner to the right into street B, and thus reaches his destination. Here the student has kept constantly to the right and has crossed the street only once. Route II is thus a bit longer than Route I, but it is safer.

Situation 2
(Figure 11)

The student finds himself in street A, on the pavement, on the right. He must shop in a location on the right hand side of street C. He can reach the shop in two ways, but he must choose the best route according to the situation.

Using Route I the student remains on the right side of street A, and rounds the corner of street B. After 20 to 30 meters (60 to 90 feet), he crosses street B, goes back on the opposite side of street B, and rounds the corner of street C in which the shop is located. In this route the path has been mainly to the right and only one crossing is involved.

If the student chooses Route II he immediately crosses street A, continues on the left side, and after rounding the left hand corner, crosses street C after 20 to 30 meters (60 to 90 feet), and reaches his destination. With this route the student has walked mainly on the left and has had to cross twice.

Situation 3
(Figure 12)

This is a road with a four-way crossing. Walking on Routes I and II involves equal distances and two crossings. Using Route I the student walks constantly on the right side, and using Route II he walks constantly on the left side. Which route is preferable depends on several circumstances as, for example, whether pavements are under repair, whether obstacles are present, whether guidelines are difficult, and so on. In any case, before crossing the street it should be entered for 10 to 15 meters (30 to 45 feet).

Situation 4
(Figure 13)

When a village or neighborhood circle has many off-streets the student can make a choice between two routes when they are equal in length. If one route is considerably shorter than the other the shorter should be chosen if the risk is not proportionately greater. Here many factors play a role and they must be known to the student in order to make a choice. Crossing the square directly is in most cases impossible. The student is obliged to use the pedestrian crossings (zebras) that are provided in town, and he must know their positions. For this he requires the help of others since he cannot see traffic lights. This problem is dealt with in another lesson. He can ask help of passersby if he does not wish to or cannot reach his destination by himself. This will also be dealt with below.

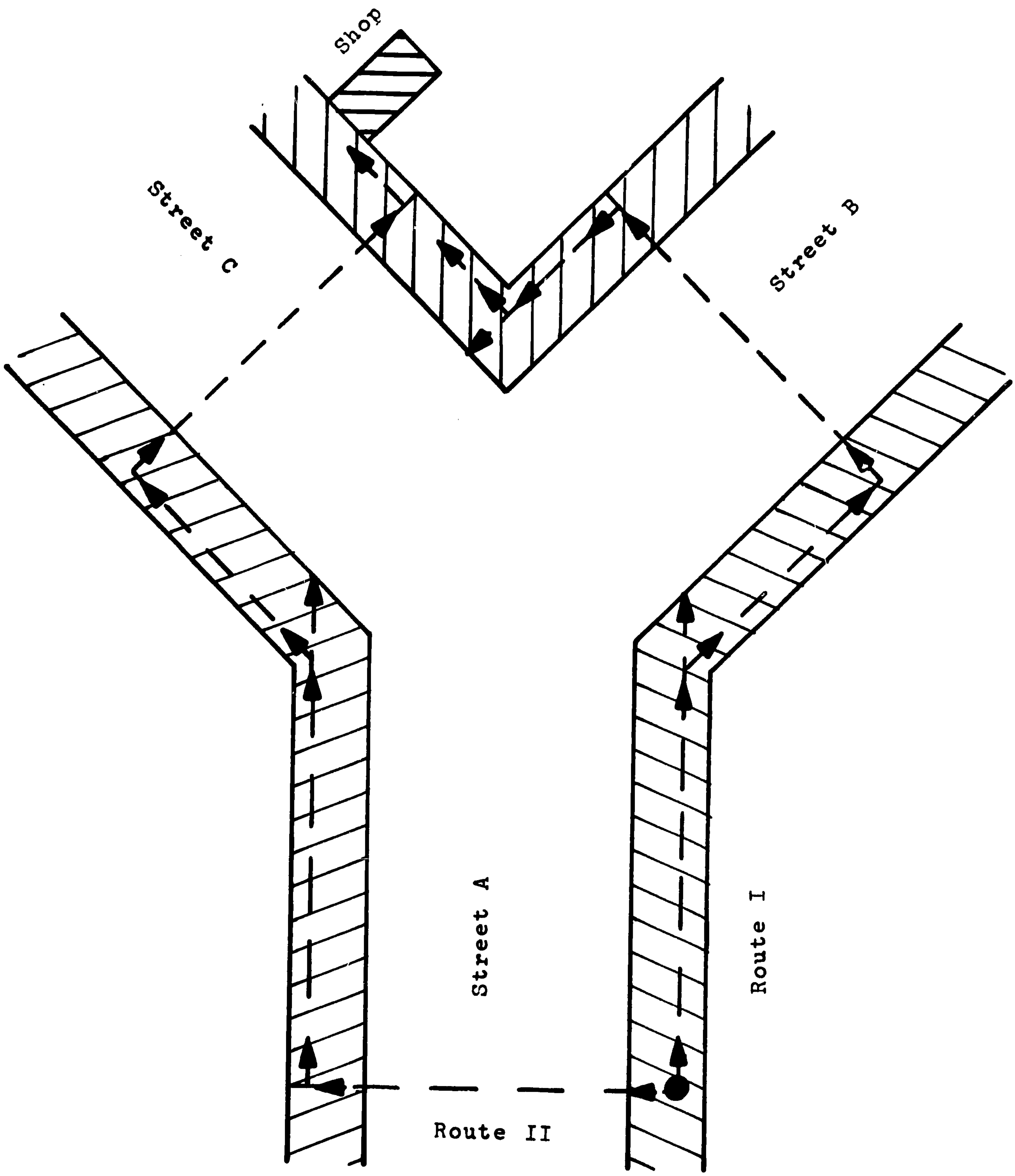


Figure 11. Situation 2.

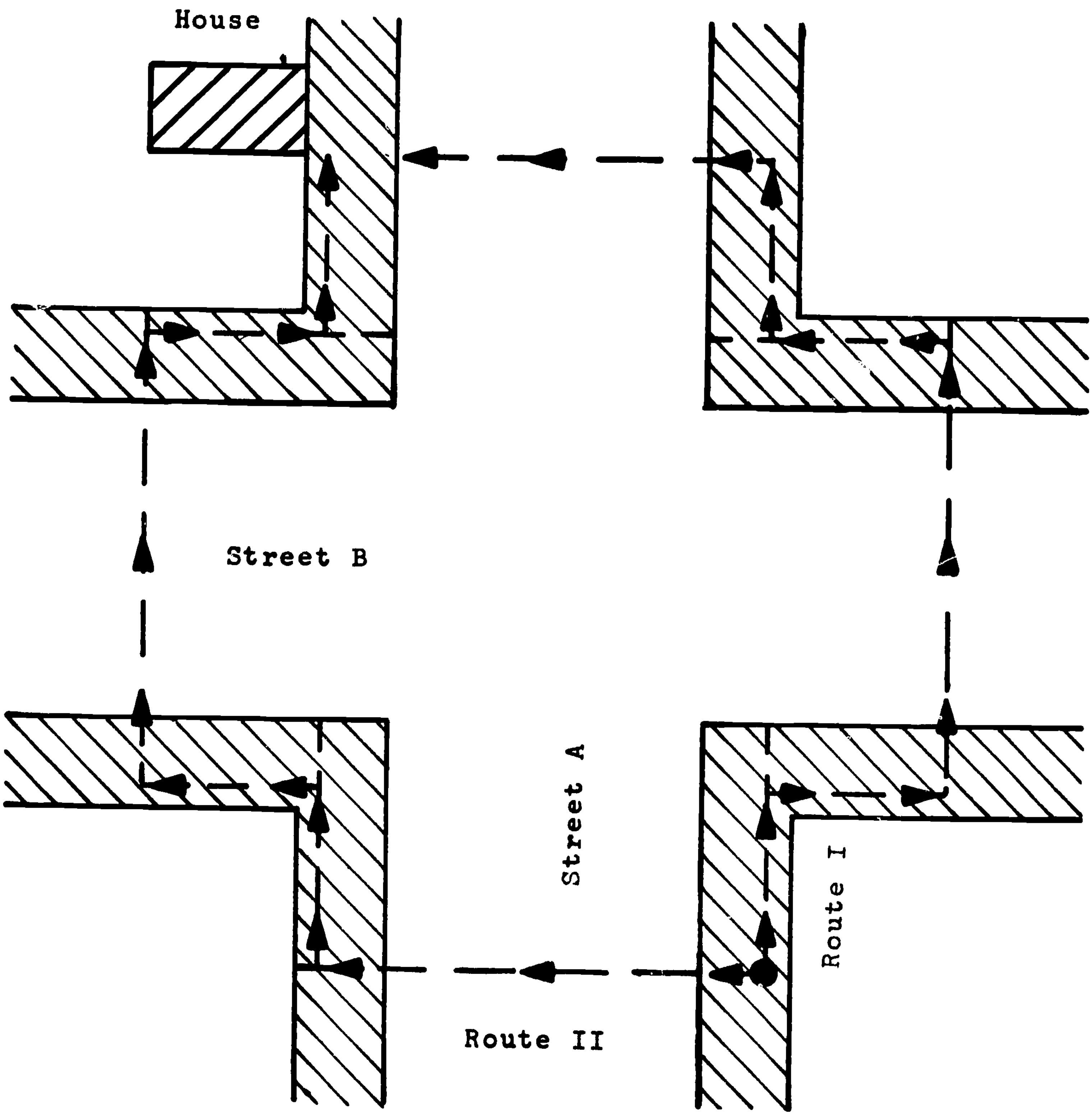


Figure 12. Situation 3.

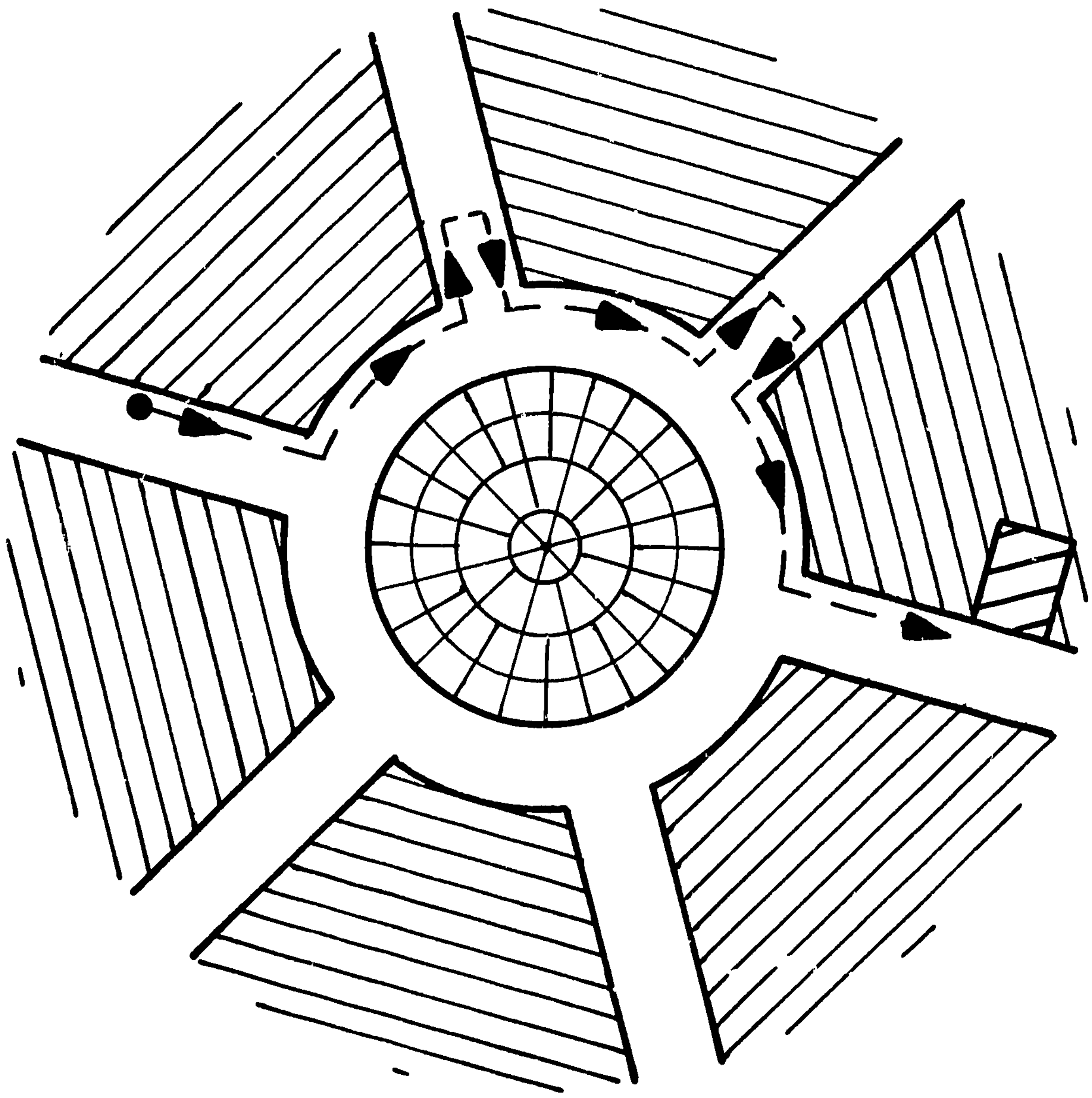


Figure 13. Situation 4.

LESSON 10

Aim

To teach a student to cross roads with the pedestrians, and how to ask for help correctly.

When at first a student feels unsure and frightened about crossing, it is undesirable and even dangerous for him to cross roads by himself. Similarly, on crowded streets or on thoroughfares it is irresponsible to attempt crossing by oneself. It is then the student must ask for help. As a rule help will be offered him when he is standing on the curb with his cane stretched out. He should *never refuse* help in crossing, but should accept help even if he feels sure of himself; people become easily disheartened when help is constantly rejected.

Procedure

It is often the habit of sighted persons to take the blind person's arm and to propel him forward to the opposite side of the street. This method should not be used. The student should firmly but courteously disengage himself from the grip and, instead, grasp the elbow of the person assisting him. In this way, he will cross the road one step *behind* his helper and will have a somewhat longer time to react should sudden danger arise. During the crossing, or preferably sooner, he can tell the helper exactly where he wants to go. When he reaches the other side he should thank the person for the help offered. When crossing, even with help, he should stretch out his cane so that is is visible. If the student should wait in vain for help, it may be requested by a passerby when his footsteps are heard approaching. Many students have the habit of speaking with the head turned aside. The instructor must make sure that the student turns both body and head toward the sound of footsteps, and then asks the passerby for help. At crossings, and in general in complicated situations, the student must explain clearly where he wants to go, and not ask for help with vague words or gestures. If the student walks for a considerable distance with his helper, he can keep contact with him by holding his elbow against the arm of the helper. In this case the cane need not be held straight out.

LESSON 11

Aim

To learn handling of the cane when ascending and descending stairs.

This lesson is designed for high steps in and out-of-doors, as on flights of steps or stairways of public buildings (stations, post offices, large shops); such stairways are usually broad and the handrail is difficult to locate. The cane will be found helpful in discovering the first and last steps.

Procedure

When the first step of the stairs has been found the student holds the handle of the cane between thumb and forefinger, stretches out his arm, and lets the cane hang loosely downwards. He starts up the stairs, keeping to the right as much as possible while the tip of the cane taps against the next higher step. When the tapping is no longer heard the student knows and can feel that he has reached the top step. Odd and unnecessary movements of the foot are thus superfluous.

Another method is to grasp the cane midway in its length and to tap regularly some steps higher until the highest step is reached. This method should be used several times also on stairs with landings.

Going downstairs, the student grips the head of the cane firmly and taps constantly with the tip of the cane on a lower step until the bottom is reached. To descend stairs safely he must push the cane in front of him on the floor without swinging it until he feels the first step. Again, when help is offered, it should *not* be rejected.

LESSON 12

Aim

To avoid or lessen the difficulties of travel in the city.

Walking in noisy cities, which are full of traffic, irregular guidelines, and often unsurveyable pathways, is an extremely arduous task. Obstacle detection is hampered and the intense concentration required demands much nervous energy. On many routes cane travel is even impossible, for one does not wish to undertake too much risk or to be a danger to others. Such situations should be avoided either by making a detour or by using a bus or streetcar. Some situations which arise in cities are described below.

Among the general facts about cane travel on crowded pathways to be kept in mind are 1) never walk too quickly - slow down to a normal speed, and 2) swing the cane as little as possible to avoid harm to passersby. When the cane is swung do it carefully. Put the tip of the cane down as low as possible and across the front of the body to discover obstacles from which echoes would normally be heard. Keep to the right as much as possible and follow the stream of pedestrian traffic.

Procedure

Situation 1

Walking on a narrow pavement in a shopping center. Such pathways are full of obstacles on the side nearest windows such as bicycles, shoppers, and exhibited wares. Fortunately the side nearest the curb contains fewer obstacles. On a narrow pathway the student can choose in which hand he wishes to grasp his cane. Going forward carefully, he *taps the cane once every step*, swinging it to the right and left, following the guideline of the curbstone or the guideline of the shops according to the side of the pathway selected. Alternately, he can follow the curbstone on his left, holding the cane in his right hand and shuffling the tip of the cane along the curbstone, thus protecting his body.

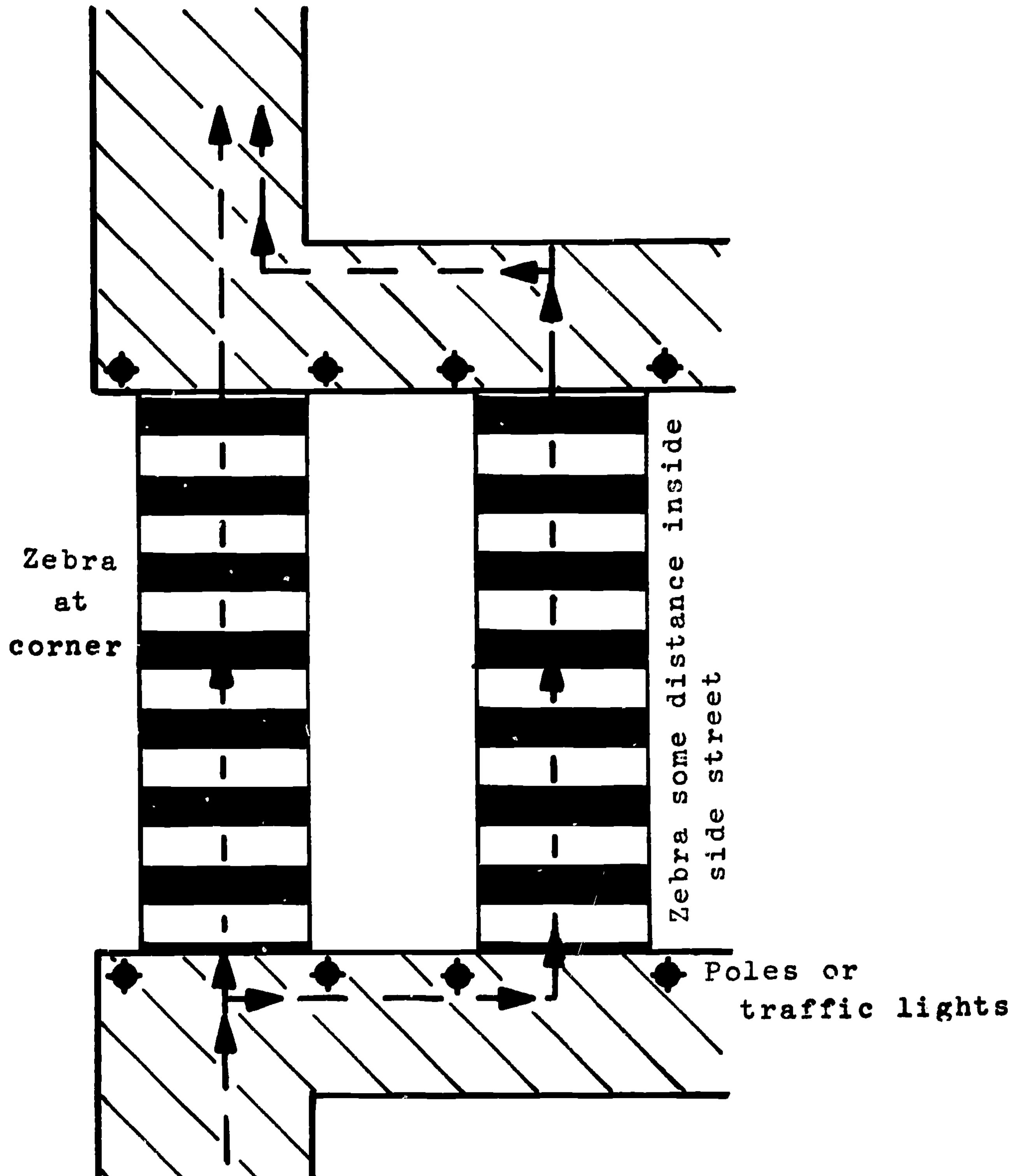


Figure 14. Situation 3: Crossing Roads with the Traffic Light on Pedestrian Pathway.

Situation 2

Walking on a broad pathway with protruding guidelines such as chairs and tables of restaurants. These are often crowded routes with many pedestrians. Follow the stream of the pedestrians, listening at the same time to their footsteps; this can be an important aid. Avoid swinging the cane. If the student deviates too much to the right or left, he should correct as explair d in Lesson 6. On the left side of the pavement the student should keep to the right as much as possible. If he walks on pavements on the right side, then he should not try to follow an irregular guideline, but try rather to walk in the middle of the pathway. He will thus avoid going against the stream of pedestrians.

Situation 3
(Figure 14)

Crossing roads with the traffic light on the pedestrian pathway (zebra). The student should be advised beforehand of the existence of traffic lights or pedestrian crossings at corners; he should also be advised of local circumstances.

Assume the student is walking on the right hand pavement, whether or not he uses a guideline. The road crossing will be discovered by the curb ending. Assume further that the pedestrian crossing is some meters around the corner. The student turns to the right for some meters, following the curb with his cane. He should wait until the passersby advise him he can cross. When rounding the corner he should be aware that traffic lights, signposts, and poles can be found in his way if he follows the curbstone too closely. He should not cross the road on his own account. When his cane is stretched out and downwards, normally help will be proffered. He should accept this help and should cross the road in the manner described in Lesson 10. If the pedestrian crossing is situated right at the corner of the street and not some meters inside the side street, then he should stop as soon as he detects the curbstone and proceed as above.

FINAL REMARKS

All of the situations described in this outline are based on *Dutch* circumstances and experiences. It should be noted that other problems of cane travel will occur in other countries with their own special situations. With the assistance of these lessons, both special and local problems will be overcome easily. We have not covered every problem that will arise, but this we said in our Introduction. Still, it is hoped that the information here will be found useful in teaching the principles of cane travel to those who desire to be independent travelers.

APPENDIX III:
FORM FOR EVALUATING MOBILITY TRAINING AND PERFORMANCE

Berdell Wurzburger
Orientation-Mobility Project
Alameda County School Department
Hayward, California

INTRODUCTION

In March, 1963, when I accepted the position of Head Orientation and Mobility Instructor for the Alameda County Superintendent of Schools Office in a demonstration project for teaching travel skills to adolescents, there were no available forms for evaluation of this training. I designed the first one rather informally for my own use in starting the instruction. Later it was revised (see below) and we plan to continue to revise it as the need may occur.

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Strengths and weaknesses of each student's technique are analyzed and instruction is directed to correct the weaknesses and to maintain the strengths. These reports remain a permanent record for this pilot project.

ITINERANT INSTRUCTION IN ORIENTATION AND MOBILITY FOR BLIND ADOLESCENTS IN PUBLIC SCHOOLS

The Alameda County Superintendent of Schools Office has been awarded a Federal grant under the auspices of the Office of Vocational Rehabilitation, U.S. Department of Health, Education, and Welfare. This grant, RD-1168-D, was given for the purpose of demonstrating the feasibility of using qualified itinerant instructors to teach orientation and mobility skills to blind students in junior and senior high schools.

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All blind junior and senior high school students will be given an opportunity to participate in the program. The older students are given priority, but all blind students will be given their chance to participate.

The major portion of the instruction is conducted off the school campus. The possible areas to be learned and traveled independently are manifold. The students learn the neighborhood in which they live, the route to and from school if it is a reasonable distance, the techniques of crossing busy streets adequately and safely. There are many other facets in learning to be a truly independent blind person and these are added as skill and confidence increase.

The necessary parts of independent travel for the blind can be narrowed down to two phases:

1) Orientation: By the use of his or her remaining senses to be able to maintain one's position in his environment.

2) Mobility: The skill of moving from one known place to another known place.

A blind person uses his memory to keep order to the sequence of streets. The names of streets which are controlled by stop signs, those controlled by traffic signals, which ones are wide, which are narrow, are facts to be retained regarding areas which the blind person has traveled and with which he is becoming familiar.

A blind person uses a kinesthetic sense to realize if he is walking an incline or a decline, or if he is turning or walking a fairly straight course. The inner ear plays no small part in this skill. The use of odors may help confirm his or her location. For example, if one knew that on a certain corner a gasoline station was operating, the smell of gasoline and the ring of the driveway bell would serve to substantiate this location.

To ensure a safe passage through his environment, the student uses a long fiberglass cane to detect obstacles in his path. The cane will detect curbs up and down, stairs up and down, the type of surface being walked upon, and do this job with enough time lapse so that the user can react to the tactile information being supplied by the cane tip and shaft.

The cane by itself is only an antenna of sorts for it cannot hear, it cannot smell, it cannot think, and most of all, it cannot see. It merely supplies information for the user to receive, sort, and apply. The canes used in this orientation-mobility instruction are provided at no cost to the students.

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Alameda County School Department
Rock La Fleche, Superintendent of Schools
224 West Winton Avenue, Hayward, California

MOBILITY SKILLS - CANE AND PROPER USAGE

Student's Name ______________________ School ______________________

1. Student introduced to cane (material, length, what it will or will not accomplish) Date ____________

	Date	Yes	No
2. Grip - correct			
too tight			
too loose			
index finger maintains proper position			
correct thumb position			
3. Wrist action - proper			
too rigid			
too relaxed			
wrist pronates or supinates			
Cane tip - proper control			
bounces too high between taps			
drags between taps			
4. Arm position - proper			
off center to cane hand side			
over-centered			
arm and hand carried too high			
arm and hand carried too low			
hand too close to body			
elbow away from body			
elbow against body			

	Date	Yes	No
4. Arm position (cont'd)			
elbow straight			
elbow bent			
5. Arc - correct			
cane tip being dragged			
cane tip too high			
arc too narrow: left ___ right ___ both ___			
arc too wide: left ___ right ___ both ___			
student's body stays behind arc			
student clears properly before stepping off curb			
student uses narrower arc in congested areas			
arc widens in unfamiliar areas			
arc is correct when following shore line or curb			
if arc incorrect, is it consistently so			
other arc fault - describe: ______________________________			
6. Does student get out of step often			
if so, at what moment:			
after cane strikes object			
when cane sticks in grass or other material			
after stepping up or down from curb			
other - describe: ______________________________			
7. Does student's cane detect drops or other changes in terrain			

	Date	Yes	No
8. **Gait and** body carriage - correct			
gait too slow - cautious			
gait too rapid - reckless			
gait slows in pace when in unfamiliar area			
gait slows when in congested area			
shoulders are properly aligned			
"cane hand" shoulder turns too far forward			
there is unusual body posture			
If so, describe: ______________________________			
head is not in normal position			
if so, describe: ______________________________			
gait is constant			
if not, describe: ______________________________			
slow gait increased in pace as ability increased			
when not in use, arm is relaxed			
when not in use, arm is rigid			
carrying any large object (such as briefcase) causes unusual variation in gait			
if so, describe: ______________________________			
student maintains fairly straight line walking down the street			
student has a zig-zag line of travel			
if so, is it caused by improper arc			
other causes - describe: ______________________________			

	Date	Yes	No
9. Stairs			
student locates stairs adequately and safely			
ascends and descends without handrail			
traverses stairs using "no touch" method			
traverses stairs using "touch" method			
too much shuffling of feet to get tactile information			
has proper posture in descending stairs (shoulders slightly back of line of balance)			
stair techniques should receive more attention			
if so, describe: ____			
____			
10. Automobile and bus travel			
uses proper safety techniques for entering and leaving / auto			
any problem in placing cane in car or bus			
locates bus seat graciously			
enters and leaves bus quickly and safely (should enter and leave by front entrance)			
pays his own fare in bus meter			
portions of student's technique need attention			
if so, describe: ____			
____			
11. Street crossings			
uses sounds available to him			
heavy traffic sounds cause student anxiety			
uses sounds to keep line of travel correct			
veers when crossing streets: right ___ left ___			
has difficulty in telling when traffic signal changes			

	Date	Yes	No
11. Street crossings (cont'd)			
indicates tension during street crossings			
uses landmarks in street crossings			
relies on traffic sounds			
finds proper position for starting by finding straightedge, etc.			
seems more relaxed and proficient when crossing a street that is familiar			
has unusual body position when poised for crossing			
if so, describe: ______________________________			
12. Contact with the public			
solicits too much aid in familiar areas			
solicits too little aid in totally unfamiliar areas			
denies or accepts aid graciously			
solicitation of aid has diminished as ability increases			
if so, describe: ______________________________			
exhibits feeling of being "noticeable" when moving about in sighted society			
if so, describe: ______________________________			
if information is desired, takes the dominant position and gets the data without a lot of verbal exchange			
reorients himself if he becomes disoriented through any cause			

	Date	Yes	No
13. Orientation in unfamiliar areas			
has difficulty remembering street sequences			
has difficulty reversing _ familiar route			
has difficulty remembering turn sequences			
uses sun to aid in confirming direction of travel			
uses wind and absence of wind as indicator of the type of structures alongside him as he walks			
retains a normal amount of landmark information (i.e. gas station on certain corner, bakery two doors north of a corner)			
uses odors in confirming his orientation			
14. Miscellaneous			
student possesses some degree of object perception			
uses object perception to an advantage			
reflexes are adequate to react to cane and other stimuli to ensure safe movement			
student has an adequate concept of his environment			

if so, what evidence: ______________________________

____

____
signature and title

BW/h
8-64

APPENDIX IV:
MOBILITY: A QUESTIONNAIRE*

Don Liddle
Birkbeck College
London, England

A good deal has been written, over the years, about mobility and blindness, a fair proportion of it in the pages of the *New Beacon*. The study of particular aspects of the subject, for instance "facial vision," has often been quite fully documented, all the way from anecdotes marveling at the uncanny powers possessed by some blind people to reports of carefully conducted scientific experiments. One also finds a number of well-thought-out descriptions by individual blind men and women of the problems they encounter in traveling and the methods by which these problems are overcome. It does seem to me, however, that most of the available literature on this subject has been written by people who are not themselves blind, but who sit down, as it were, to think the thing out logically: "Take away sight, what does that leave? Right, let's start from there." I have not come across any discussion of mobility which approached the subject from the other end, i.e., by asking a large number of blind people what the difficulties of travel are, and how they cope with them.

Obviously the best way of doing this would be to go out and interview a suitably large number of people, but the difficulties involved in doing this are equally obvious. I have therefore tried to do the next best thing, to ask at least some of the relevant questions below in the hope that readers who do not have any useful "travel vision" may feel inclined to help me to get together a body of data based not on theory but on actual personal experience. Many of the questions may strike you as not very profound and perhaps rather unnecessary. As a blind person myself, I tend to feel that I could probably predict a lot of the answers. Perhaps I should be right in assuming that what I find awkward others also find awkward, but how much more useful to have some actual evidence on such points, rather than so many assumptions.

* Reprinted from The New Beacon, Vol. XLVIII, No. 566 (June 1964), pp. 491-493. Readers who are interested in a full analysis of the data from this questionnaire may find them in a forthcoming issue of the Research Bulletin of IRIS. Those not already on the mailing lists of IRIS to receive this publication may request this special issue from us.

ly too often one comes across a tendency to lump us all togeth- as "the blind," who all know each other, are all highly musi- l, etc. It may well be, however, that as we are dealing here h questions of perception, rather than of personality, we can pect to find problems and solutions common to most people.

I do hope that when you have read over these questions, and ve given some of them a little thought, perhaps when out walk- g, you will take up a Stainsby or Perkins, braille frame or pewriter, and have a go at them, after first putting down your ne, age, and age, when you became blind.

A number of the questions will not apply to those who travel h a guide dog, or to those who use neither dog nor stick, but should be very grateful for answers to the questions that do m applicable. I hope that an account of the results will ap- r in a future issue of the *New Beacon*, provided, of course, t the information can be based on a reasonable number of re- es.

1. When walking outdoors by yourself, do you prefer to wear shoes with nails or steel tips, so that they make a certain amount of noise, or shoes that make very little noise, e.g., rubber soles and heels?

2. Do you carry a stick and, if so, do you just *carry* it, or do you use it? If you use it, do you normally just tap it on the pavement, or do you use it to touch the wall, fence, etc.?

3. Which do you prefer to be walking alongside, fence, wall, railings, or hedge? In what order of preference would you put the other three?

4. Do you usually keep towards the inside of the pavement, or more towards the outside, following the curb?

5. If you are ever out alone, without a stick, how do you get on, and how does it feel?

6. What weather conditions (not necessarily those which do, or even could, occur together) do you find the most trying from the point of view of getting around?

7. Given reasonable weather conditions, what sort of places do you find awkward to negotiate? Perhaps you would care to list several, in order of decreasing difficulty, and to add a few thoughts on the origins of the difficulties.

8. Remembering that this is all confidential, and that no names will be mentioned, would you say that you get all

the help you want in getting about, or that you get rather more help than you want, or that sufficient help is forthcoming but of the wrong kind? Any other comments?

9. Is it your impression that you "naturally" walk in a straight line, or that keeping on course demands a conscious effort to correct a tendency to veer off?

10. Would you be prepared to say that when it comes to getting about, hearing and the use of a stick do essentially the same job, the stick simply supplying information for the hearing to use? Or would you say that the two have different parts to play, that the stick takes care of some things, and hearing of other things? If so, what functions would you assign to each of them, forgetting for the moment that the color of the stick has any significance?

11. Do you think that you use your hearing more or less when getting about indoors, as compared with walking outside?

12. What is your own private theory about this "sixth sense" which is said to warn blind people of nearby obstacles?

13. Among the common obstacles to be met with outdoors, which do you find to be the greatest menace and why?

14. Some blind people can detect obstacles at quite surprising distances, others are not so lucky. What sort of obstacles do you yourself find detectable, and at what distances, roughly?

15. Have you ever been quite certain that there was something in your way, only to find that there wasn't? How did you explain this illusion?

16. Do you usually/ever find it helpful to make some additional noise, such as clicks with the tongue or fingers, when you think there may be an obstacle, but cannot be certain? If so, what sort of noise do you find the most useful?

17. Blind people are often supposed to have keener hearing and a more discriminating sense of touch than the average sighted person. Does your own experience lead you to feel that either or both of these suppositions is true in your own case?

18. Do you ever/often go for a walk by yourself, just for

the enjoyment, or is all your walking a means of getting somewhere?

19. How much of an effort, or how tiring, do you find getting about alone on foot?

20. As you will know, there have been a number of attempts to develop satisfactory "guidance devices," some of which are still making progress. Some of these devices use sound to indicate the presence of potential obstacles, others make use of the sense of touch. Such devices have usually included something resembling a torch, to be carried in the hand, a power unit, either on a sling or in the pocket, and a third part fitting in or on the ear, on the forehead, or on the chest. Assuming that both types were available here and now (which is, alas! only an assumption), and both at the same very reasonable price, would you wish to have such a device yourself? If so, which, that involving hearing or that using touch? (Let us also assume that they are equally efficient.) To what extent would you insist that such a device should be completely inconspicuous?

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too relaxed			
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Cane tip - proper control			
bounces too high between taps			
drags between taps			
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off center to cane hand side			
over-centered			
arm and hand carried too high			
arm and hand carried too low			
hand too close to body			
elbow away from body			
elbow against body			

	Date	Yes	No
4. Arm position (cont'd)			
elbow straight			
elbow bent			
5. Arc - correct			
cane tip being dragged			
cane tip too high			
arc too narrow: left ___ right ___ both ___			
arc too wide: left ___ right ___ both ___			
student's body stays behind arc			
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arc widens in unfamiliar areas			
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if arc incorrect, is it consistently so			
other arc fault - describe: ______________________________			
______________________________			
6. Does student get out of step often			
if so, at what moment:			
after cane strikes object			
when cane sticks in grass or other material			
after stepping up or down from curb			
other - describe: ______________________________			
______________________________			
7. Does student's cane detect drops or other changes in terrain			

	Date	Yes	No
8. Gait and body carriage - correct			
gait too slow - cautious			
gait too rapid - reckless			
gait slows in pace when in unfamiliar area			
gait slows when in congested area			
shoulders are properly aligned			
"cane hand" shoulder turns too far forward			
there is unusual body posture			
If so, describe: ____________________			
head is not in normal position			
if so, describe: ____________________			
gait is constant			
if not, describe: ____________________			
slow gait increased in pace as ability increased			
when not in use, arm is relaxed			
when not in use, arm is rigid			
carrying any large object (such as briefcase) causes unusual variation in gait			
if so, describe: ____________________			
student maintains fairly straight line walking down the street			
student has a zig-zag line of travel			
if so, is it caused by improper arc			
other causes - describe: ____________________			

	Date	Yes	No

9. Stairs

	Date	Yes	No
student locates stairs adequately and safely			
ascends and descends without handrail			
traverses stairs using "no touch" method			
traverses stairs using "touch" method			
too much shuffling of feet to get tactile information			
has proper posture in descending stairs (shoulders slightly back of line of balance)			
stair techniques should receive more attention			

if so, describe: ____

____

10. Automobile and bus travel

	Date	Yes	No
uses proper safety techniques for entering and leaving / auto			
any problem in placing cane in car or bus			
locates bus seat graciously			
enters and leaves bus quickly and safely (should enter and leave by front entrance)			
pays his own fare in bus meter			
portions of student's technique need attention			

if so, describe: ____

____

11. Street crossings

	Date	Yes	No
uses sounds available to him			
heavy traffic sounds cause student anxiety			
uses sounds to keep line of travel correct			
veers when crossing streets: right ___ left ___			
has difficulty in telling when traffic signal changes			

11. Street crossings (cont'd)

	Date	Yes	No
indicates tension during street crossings			
uses landmarks in street crossings			
relies on traffic sounds			
finds proper position for starting by finding straightedge, etc.			
seems more relaxed and proficient when crossing a street that is familiar			
has unusual body position when poised for crossing			

if so, describe: ______________________________

____

12. Contact with the public

	Date	Yes	No
solicits too much aid in familiar areas			
solicits too little aid in totally unfamiliar areas			
denies or accepts aid graciously			
solicitation of aid has diminished as ability increases			

if so, describe: ______________________________

____

	Date	Yes	No
exhibits feeling of being "noticeable" when moving about in sighted society			

if so, describe: ______________________________

____

	Date	Yes	No
if information is desired, takes the dominant position and gets the data without a lot of verbal exchange			
reorients himself if he becomes disoriented through any cause			

	Date	Yes	No
13. Orientation in unfamiliar areas			
has difficulty remembering street sequences			
has difficulty reversing a familiar route			
has difficulty remembering turn sequences			
uses sun to aid in confirming direction of travel			
uses wind and absence of wind as indicator of the type of structures alongside him as he walks			
retains a normal amount of landmark information (i.e. gas station on certain corner, bakery two doors north of a corner)			
uses odors in confirming his orientation			
14. Miscellaneous			
student possesses some degree of object perception			
uses object perception to an advantage			
reflexes are adequate to react to cane and other stimuli to ensure safe movement			
student has an adequate concept of his environment			

if so, what evidence:___________________________________

____

____

signature and title

BW/h
8-64

APPENDIX IV:
MOBILITY: A QUESTIONNAIRE*

Don Liddle
Birkbeck College
London, England

A good deal has been written, over the years, about mobility and blindness, a fair proportion of it in the pages of the *New Beacon*. The study of particular aspects of the subject, for instance "facial vision," has often been quite fully documented, all the way from anecdotes marveling at the uncanny powers possessed by some blind people to reports of carefully conducted scientific experiments. One also finds a number of well-thought-out descriptions by individual blind men and women of the problems they encounter in traveling and the methods by which these problems are overcome. It does seem to me, however, that most of the available literature on this subject has been written by people who are not themselves blind, but who sit down, as it were, to think the thing out logically: "Take away sight, what does that leave? Right, let's start from there." I have not come across any discussion of mobility which approached the subject from the other end, i.e., by asking a large number of blind people what the difficulties of travel are, and how they cope with them.

Obviously the best way of doing this would be to go out and interview a suitably large number of people, but the difficulties involved in doing this are equally obvious. I have therefore tried to do the next best thing, to ask at least some of the relevant questions below in the hope that readers who do not have any useful "travel vision" may feel inclined to help me to get together a body of data based not on theory but on actual personal experience. Many of the questions may strike you as not very profound and perhaps rather unnecessary. As a blind person myself, I tend to feel that I could probably predict a lot of the answers. Perhaps I should be right in assuming that what I find awkward others also find awkward, but how much more useful to have some actual evidence on such points, rather than so many assumptions.

* Reprinted from The New Beacon, Vol. XLVIII, No. 566 (June 1964), pp. 491-493. Readers who are interested in a full analysis of the data from this questionnaire may find them in a forthcoming issue of the Research Bulletin of IRIS. Those not already on the mailing lists of IRIS to receive this publication may request this special issue from us.

Only too often one comes across a tendency to lump us all together as "the blind," who all know each other, are all highly musical, etc. It may well be, however, that as we are dealing here with questions of perception, rather than of personality, we can expect to find problems and solutions common to most people.

I do hope that when you have read over these questions, and have given some of them a little thought, perhaps when out walking, you will take up a Stainsby or Perkins, braille frame or typewriter, and have a go at them, after first putting down your name, age, and age, when you became blind.

A number of the questions will not apply to those who travel with a guide dog, or to those who use neither dog nor stick, but I should be very grateful for answers to the questions that do seem applicable. I hope that an account of the results will appear in a future issue of the *New Beacon*, provided, of course, that the information can be based on a reasonable number of replies.

1. When walking outdoors by yourself, do you prefer to wear shoes with nails or steel tips, so that they make a certain amount of noise, or shoes that make very little noise, e.g., rubber soles and heels?

2. Do you carry a stick and, if so, do you just *carry* it, or do you use it? If you use it, do you normally just tap it on the pavement, or do you use it to touch the wall, fence, etc.?

3. Which do you prefer to be walking alongside, fence, wall, railings, or hedge? In what order of preference would you put the other three?

4. Do you usually keep towards the inside of the pavement, or more towards the outside, following the curb?

5. If you are ever out alone, without a stick, how do you get on, and how does it feel?

6. What weather conditions (not necessarily those which do, or even could, occur together) do you find the most trying from the point of view of getting around?

7. Given reasonable weather conditions, what sort of places do you find awkward to negotiate? Perhaps you would care to list several, in order of decreasing difficulty, and to add a few thoughts on the origins of the difficulties.

8. Remembering that this is all confidential, and that no names will be mentioned, would you say that you get all

the help you want in getting about, or that you get rather more help than you want, or that sufficient help is forthcoming but of the wrong kind? Any other comments?

9. Is it your impression that you "naturally" walk in a straight line, or that keeping on course demands a conscious effort to correct a tendency to veer off?

10. Would you be prepared to say that when it comes to getting about, hearing and the use of a stick do essentially the same job, the stick simply supplying information for the hearing to use? Or would you say that the two have different parts to play, that the stick takes care of some things, and hearing of other things? If so, what functions would you assign to each of them, forgetting for the moment that the color of the stick has any significance?

11. Do you think that you use your hearing more or less when getting about indoors, as compared with walking outside?

12. What is your own private theory about this "sixth sense" which is said to warn blind people of nearby obstacles?

13. Among the common obstacles to be met with outdoors, which do you find to be the greatest menace and why?

14. Some blind people can detect obstacles at quite surprising distances, others are not so lucky. What sort of obstacles do you yourself find detectable, and at what distances, roughly?

15. Have you ever been quite certain that there was something in your way, only to find that there wasn't? How did you explain this illusion?

16. Do you usually/ever find it helpful to make some additional noise, such as clicks with the tongue or fingers, when you think there may be an obstacle, but cannot be certain? If so, what sort of noise do you find the most useful?

17. Blind people are often supposed to have keener hearing and a more discriminating sense of touch than the average sighted person. Does your own experience lead you to feel that either or both of these suppositions is true in your own case?

18. Do you ever/often go for a walk by yourself, just for

the enjoyment, or is all your walking a means of getting somewhere?

19. How much of an effort, or how tiring, do you find getting about alone on foot?

20. As you will know, there have been a number of attempts to develop satisfactory "guidance devices," some of which are still making progress. Some of these devices use sound to indicate the presence of potential obstacles, others make use of the sense of touch. Such devices have usually included something resembling a torch, to be carried in the hand, a power unit, either on a sling or in the pocket, and a third part fitting in or on the ear, on the forehead, or on the chest. Assuming that both types were available here and now (which is, alas! only an assumption), and both at the same very reasonable price, would you wish to have such a device yourself? If so, which, that involving hearing or that using touch? (Let us also assume that they are equally efficient.) To what extent would you insist that such a device should be completely inconspicuous?