MOBILITY DEVICES[a]

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INTRODUCTION

Many ways and means have been used by visually impaired persons to satisfy the basic desire to be mobile. From earliest times, animals, sighted people, and devices (such as sticks or canes), have been used to achieve varying levels of mobility. Basically, there are three (possibly four, if electronic travel aids are considered) common ways of getting about. The first is with the use of a sighted human guide. The other two most accepted and proven methods are with canes of varying lengths and dog guides.

I. CANES AND WALKING AIDS

Several types of canes and walking aids are manufactured to meet the varied needs and demands of visually impaired persons. The long cane, a folding or collapsible cane, a white wooden cane, and a support or orthopedic cane are most commonly used. They are fabricated from wood, aluminum alloy, Fiberglas, plastic, and stainless steel.

In addition to enabling a person to become mobile and to travel independently and extensively, a cane provides a measure of protection and travel safety. The distinction between the provision of protection and of safety by the cane, as two separate (although related) entities, may be questioned by some specialists, but one need only imagine the long cane in the hands of a trainee just learning to use the aid as opposed to one who has completed a comprehensive training course. If both had to travel in a large city, the cane would afford even the trainee some measure of protection against collision with obstacles and pedestrians. However, of the two users, only the person who had successfully completed mobility training would be equipped to use the cane safely in confusing, complex, and often dangerous travel situations.

The cane extends the tactual sense of the user to the length of the cane shaft or tip to provide information about the environment. In addition, the cane identifies the user as handicapped or visually impaired, and in some cases it provides physical support.

The Long Cane

After the work done with the cane by Richard E. Hoover at Valley Forge, agencies and mobility specialists themselves for many years fabricated or bought canes without any standard specifications. The need for uniformity in an acceptable long cane was apparent. Under the leadership of Russell C. Williams, the Veterans Administration in 1964 published "Specifications for the Long Cane (Typhlocane)," which helped to establish a model long cane.

Although this publication of specifications for the long cane was very useful, it was still not an adequate set of requirements or characteristics. In September 1971, a group of scientists, administrators, technologists, and mobility specialists met to draw up standards and specifications for the long cane and to develop acceptable techniques for its use under a variety of conditions (National Research Council, 1972).

Specifications

The cane is composed of four parts: the crook, the grip, the shaft, and the tip.

The pamphlet, "Specifications for the Long Cane (Typhlocane)", defines the *crook* as the upper end of the cane which is curved to form an arc or "hook"; the *grip* as that portion of the cane which has been adapted for grasping by covering with leather, plastic, rubber, or other suitable material; the *shaft* as the main part of the cane that extends from the base of the crook to the tip end of the cane; the *tip* as the element at the lower end of the cane that normally contacts the ground. Outside diameter of the tubing is 0.500 in. (13 mm), wall thickness is 0.062 in. (1.6 mm), and inside diameter 0.375 in. (9.5 mm).

The 1971 National Research Council (NRC) conference in Washington, D.C. adopted physical and functional characteristics for the crook, the grip, and the tip as well as for the shaft of the long cane. Desirable design features are:

1. Straight vertical axis of shaft

2. Slight taper of shaft from grip to tip
3. Various lengths to fit height of individual user
4. Sufficient length to provide the user with essential information in ample time to react to it but not to inhibit the user's physical freedom (ideally, to extend from the ground at the side of the foot in forward position to 1½ in. (3.8 cm) above the bottom of the breast bone)
5. Weight as light as possible without affecting balance or sacrificing other requirements; depending on length, 6 to 8 oz (168 to 224 g)
6. Low wind resistance
7. Enough rigidity to enable user to establish accurate distance and position of object detected; that is, without excessive whip or bend, maintaining original shape under stress
8. Must not conduct significant amounts of thermal or electrical energy
9. Adequate transmission of vibrations from the tip to the grip to provide best tactile and aural stimulus
10. Sufficient durability to withstand hard bumps and constant use without bending, and without shattering or posing other hazards if it should break
11. High visibility to motorists and pedestrians
12. Should make only minimal noise without using artificial damping devices
13. Good balance so that it is self-aligning when allowed to rest lightly in the palm of the hand
14. Acceptable appearance.

Although some agencies make their own long canes, many canes are purchased from commercial establishments. Various types are listed in the International Guide to Aids and Appliances for Blind and Visually Impaired Persons and in Aids and Appliances for the Blind and Visually Impaired (American Foundation for the Blind, 1977-78, respectively).

Advantages

The long cane is the most effective and efficient mobility aid yet devised for safe, independent travel by the majority of visually impaired people. The scanning system in which the user operates the cane supplies echo-ranging cues and force-impact data that give vital information about the immediate environment. It informs the traveler about the nature and condition of the surface underfoot, gives sufficient forewarning of downsteps or dropoffs to prevent falls or injury, and protects the lower part of the body from collision. The cane informs the user about various ground-surface textures which can be related to specific areas and destinations. It is a highly maneuverable aid that allows investigation of the environment without actual hand contact. The long cane is reliable, long lasting, and somewhat unaffected by unfavorable weather and temperature conditions. Most require no accessories, and virtually no maintenance except occasional replacement of a worn tip. The cane can be accommodated to most users' physical specifications and, in some instances, their disabilities.

Disadvantages

There are, however, some disadvantages peculiar to the long cane and its use. Primarily it does not provide adequate protection against collision to the upper part of the body. The long cane is non-collapsible, and storing it at social gatherings, in public or private transportation, presents a problem. There is also the danger of tripping pedestrians in congested areas. Cane tips do break or wear out and must be replaced; high winds sometimes interfere with maneuverability of the cane, and it is not a weightbearing or support cane. Although the scanning process employed is functional, the length of the cane limits the range and amount of information transmitted to and received by the user. In addition, learning to use the long cane involves extensive training. Fortunately a substantial body of training techniques have been developed, and graduate programs for orientation and mobility specialists have been founded at several colleges and consistently supported by Rehabilitation Services Administration, DHEW.

Folding or Collapsible Canes

Many efforts have been made to develop a satisfactory folding or collapsible cane. The first collective effort to discuss status, make recommendations, and set tentative standards was made by mobility specialists, researchers, and mobility consumers at a Mobility Research Conference of the Massachusetts Institute of Technology in 1963. The conference, sponsored by the American Foundation for the Blind, the Office of Vocational Rehabilitation, Seeing Eye, the Massachusetts Institute of Technology, and the Veterans Administration, resulted in a project aimed at development of a collapsible or folding cane (Bauman, Gerstley, Neuman, and Ochsner, 1963).

Specifications

The following standards were established for the folding cane:

1. Weight not to exceed 1 lb (0.45 kg)
2. Folded cane must fit into a coat pocket, 5 in. x 10 in. x 0.62 in. (13 cm x 25 cm x 1.6 cm)

3. Aside from collision damage, the cane must survive 5000 fold-extend cycles based on 1 yr of use by an active blind traveler
4. Assembled unit must provide a handle and tip with "feel" and sound-generating characteristics comparable to those of the standard long cane
5. While extended length cannot be changed by user, design must include provisions for supplying cane assembly in 2 in. (5 cm) increments of length, over a range of 36 in. to 70 in. (91 cm to 178 cm)
6. Should be easy to open and close
7. One-handed operation should be possible in opening, closing, locking, and storing procedures
8. Simple overall design with assembly of component parts that do not require specialized techniques
9. A realistic mass-market price of under $10.00.

Other requirements for consideration are:

1. Closest possible mechanical equivalent to the conventional long cane when extended (Massachusetts Institute of Technology, 1965)
2. Ability to be collapsed and expanded quickly
3. Tip should be sensitive, durable, and constructed so as not to stick or catch in cracks or on rough surfaces
4. Reasonable freedom from operational failure
5. Should be well balanced so as to center and align easily
6. Joints should be self-cleaning
7. A continuous metallic path along the cane axis, to provide the same vibrotactile information capabilities as a one-piece unit
8. Should not require retraining to use.

Types

The two basic types of collapsible canes are the folding cane and the telescopic cane. Each has two generally accepted classifications, the standard and the heavy duty.

The standard folding cane has a single inner elastic cord and a series of reductions in cane diameter from top to bottom. For example, the Mahler cane is 0.500 in. (13 mm) in diameter at the top, then 0.437 in. (11 mm), 0.375 in. (10 mm), to 0.312 in. (9 mm) at the bottom. While the standard version of this cane is light and compact, its single elastic cord does not permit as good tactile responses as the heavy-duty canes because the cane is held together less firmly. The tension in some cases is diminished to the point where a person with normal dexterity can fold the cane very easily, but tactile response is reduced. The elastic cord might be tightened, but then the life of the elastic is shortened, particularly if the cane is folded and unfolded frequently.

Although there are folding canes composed of seven and eight sections, a four-section cane is considered practical and convenient, and it folds to fit into a standard brief case. With seven or eight sections, the cane is even more compact when folded, but less rigid and durable. Folding canes with single inner elastic cords include the Rigid-Fold Cane, made of 0.500 in. (13 mm) aluminum tubing (Fig. 1). This has four sections with three joints, a grip with a flat side as a reminder, and a tip that can be oriented by rotating it 90 deg from the reminder grip (Noble, personal communications, 1977). There are also the Mahler Standard Folding Cane (Fig. 2) and the Hycor Autofold Cane (Fig. 3).

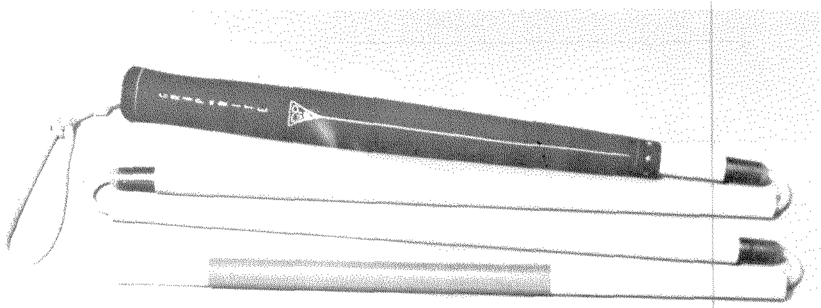


FIGURE 1.—Rigid-Fold Cane

The Mahler Heavy Duty Cane has a double band of elastic rather than the single elastic found in the standard folding cane. The two elastic cords provide greater tension, holding the cane together more securely. They also provide a safety factor in that it is unlikely that both bands of elastic will break at once. The cane is made of 0.500-in. (13 mm) aluminum tubing, and while it is stronger throughout, it is less compact. The joint design is different from that of the standard model.

The Hycor Cable Cane (Fig. 4) is also heavy duty. It features a plastic-sheathed stainless steel cable instead of an elastic cord. This cane has six sections, but because of its steel cable is very rigid when assembled. A toggle clamp inside the handle is used to apply tension to the cable in the fully extended position. The complicated handle sometimes gets out of alignment, or the tension has to be readjusted with an Allen wrench.

Hycor's Autosupport Cane is a larger diameter folding orthopedic or support cane intended for older people and those with low vision, who will not use a long cane but still need some kind of aid or iden-

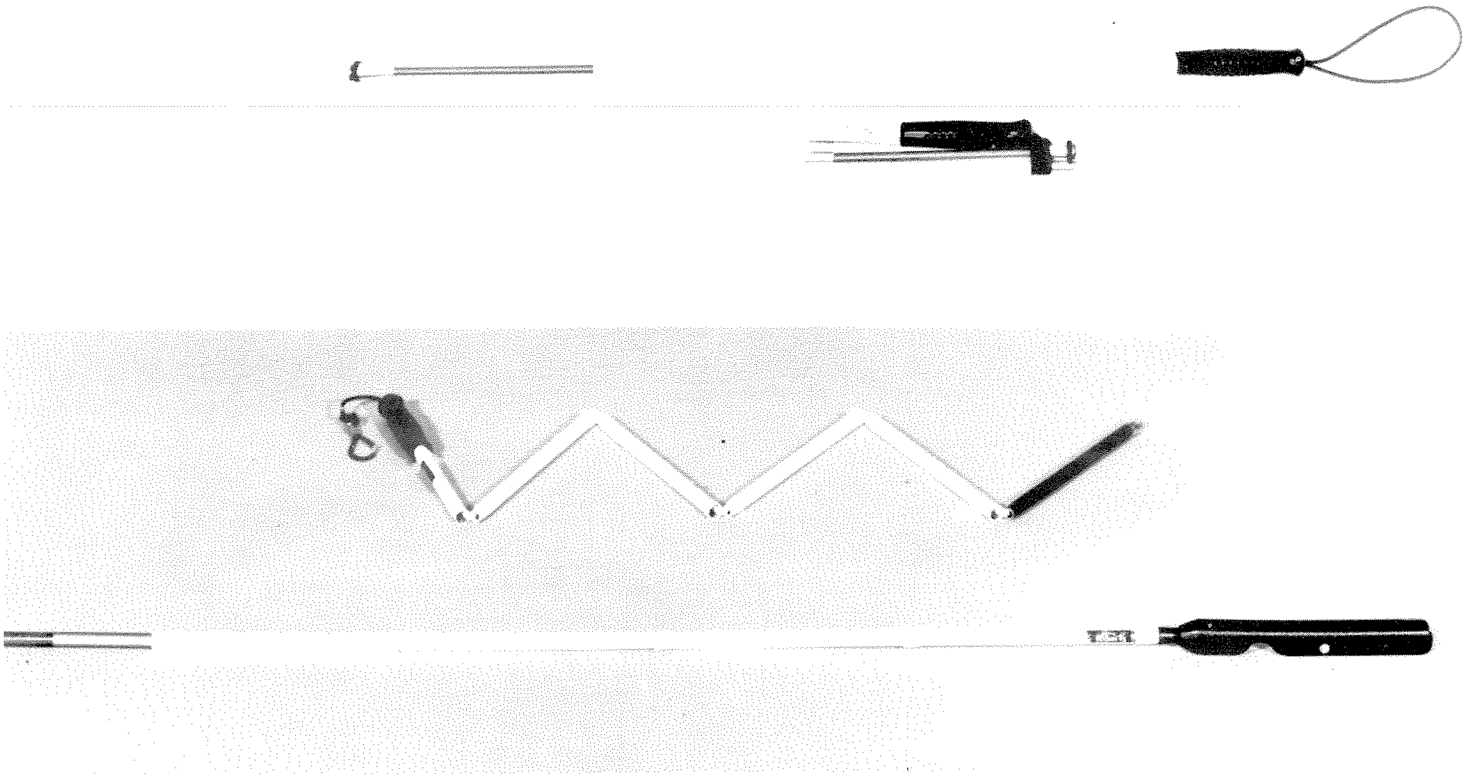


FIGURE 2.—Mahler Standard Folding Cane.

FIGURE 3. —Hycor Autofold Cane.

(middle picture)

FIGURE 4. —Hycor Heavy Duty Cable Cane.

(bottom)

tification (R. Stanton, personal communication, October 1, 1976). It folds into four sections, is self-opening, and is capable of supporting considerable weight.

The diversity of collapsible canes offers a greater opportunity for prescribing a cane for a specific individual, based on several variables:

1. The type of person to whom the cane is issued or sold
2. The kind of treatment the cane is expected to receive
3. Degree of visual impairment
4. Degree of travel activity
5. Number of sections and joints in the cane
6. Durability in fold-extend cycles.

A telescopic or heavy-duty cane would be more appropriate if the cane were to be roughly handled and subjected to undue impact loading (cumulative effects of percussion to joint and cable). If the user is very tall, or simply prefers a longer cane, a heavy duty cane might be more appropriate, whereas if the traveler is short or prefers a shorter cane, and compactness and lightness of weight are important, the standard cane might be the answer. Some people with residual vision tend to be more careful in using the cane, making relatively few contacts with obstacles. They may feel more comfortable with the features of the standard cane, and the single inner elastic cord cane would probably suffice.

Advantages and Disadvantages of Collapsible Canes

Some collapsible canes are more expensive, have poorer tactile response, and are not any easier to use. Their primary virtue is that they fold for ease in storing or carrying when not in use.

Some think that the folding cane has been fabricated to replace the long cane, but judgment of its advantages and disadvantages must be made on a comparative basis. Sometimes collapsing and extending the cane is difficult and time consuming, and the tension in the elastic or cable is difficult to control and maintain. The collapsible cane is not as sturdy or rigid as the rigid long cane. In addition, hinge and cable life are vulnerable under prolonged use because of the force necessary to extend the cane. Though even greater tension force in the cable is required to extend the cane, the cable is still under a certain amount of tension and the joints are subject to equal compression force in the extended state.

Frequently, when sections of a folding cane get bent, the joints are also damaged. If the elastic in a standard folding cane tears, it can be difficult or impossible to use the cane. On the other hand, if a long cane is bent the traveler can usually straighten it out for immediate emergency use.

Wheeled Canes

Many unconventional canes for the blind have been designed over the years. Some of the prototypes have been turned over to agencies for evaluation and recommendations, and there have been grants for further research and development. However, few such canes have had any apparent merit for use by blind and visually impaired people.

One old concept periodically revived is the attachment of a wheel or wheels to a cane. Two prototypes are described here for their historic interest only, rather than for reasons of practicality and utility.

In 1963, the Seeing Eye Cane was submitted for evaluation and field testing by the patients and staff at the Veterans Administration Hospital, Hines, Illinois. There was no need to carry the cane because it rode on a wheel and contacted obstacles in its path. Its purpose was to enable the user to maintain contact with the ground surface, to eliminate either the touch cane technique or the dog guide and the expense of acquiring and being trained with either. The cane was longer than conventional canes to help the user avoid kicking it and to avoid the need to lean forward at street intersections, stairwells, and similar situations. Among the obvious disadvantages was the fact that if the cane were leaned on, it would roll out from under the user. It was not practical in snow, ice or sleet, or other unfavorable environments, and because of its length it got in the way of other pedestrians.

Another wheeled cane, meant to be pushed along in front of the user, was submitted for evaluation to NASA, George Marshall Space Flight Center (Martin, 1970). In addition to being on wheels, this cane could carry other useful devices such as a tactile compass, a bell or horn to alert others, hooks upon which to hang packages, and a carrying basket. An additional wheel could be mounted beneath the handle assembly for additional weight support. More sophisticated devices such as miniature sonar transmitters and side-mounted sensing whiskers could be carried on the cane. Figure 5 is an artist's conception of the cane.

High-Visibility Canes

Some canes have been designed to provide visibility for the user during travel at night and under hazardous weather conditions, such as rain, fog, and snow. Two examples are the *Pathom Lucite Tube Cane* and *the Louchek Cane.*

The *Pathom Lucite Tube Cane* was designed to be used in hazardous weather such as fog, rain, and snow, and to be more clearly visible at night. Made of aluminum stock it had a flashing light encased in

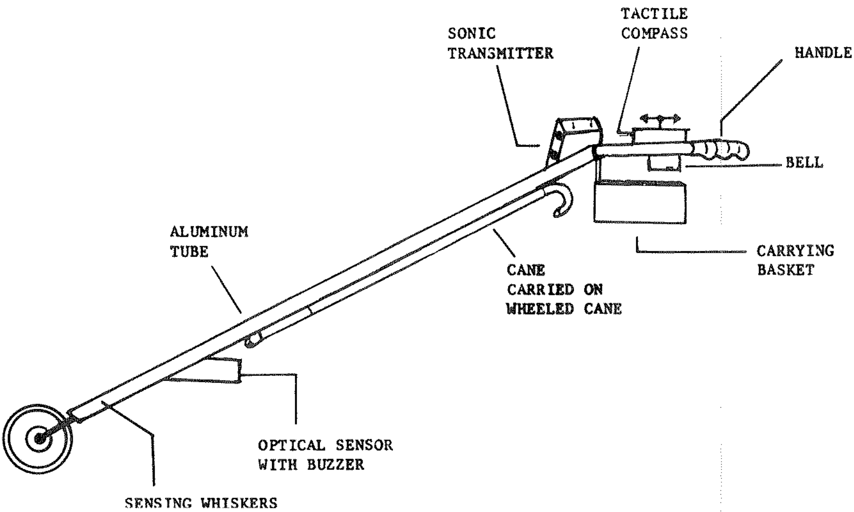


FIGURE 5.—Artist's conception of a wheeled cane with miniature sonar transmitters and side-mounted sensing whiskers.

Lucite above a fluorescent impact-resistant tubing that extended to within 7 in. (18 cm) of the bottom of the cane. An electromagnetic button in the handle of the cane vibrated when the light was flashing.

The red fluorescent glow in the Lucite tube reportedly could be seen by motorists more clearly and at a greater distance than the fluorescent tape on other canes.

The Louchek Cane (Louchek Products, 1976) is intended for use as a second cane for night travel (Fig. 6). The plastic tube contains a light bulb that shines down the length of the translucent cane. The bottom 5 in. (13 cm) of the shaft is painted red. The device is powered by two penlight AA batteries in the top of the cane. An on-off switch is countersunk 6¾ in. (17 cm) from the top of the cane.

The Louchek cane is heavier but considerably more flexible than a conventional long cane, a characteristic which seems to cause mobility specialists some concern but appears not to bother blind people who use it. Sunlight and artificial light render the cane light invisible, but it is effective in dark areas and can easily be seen by motorists at a distance.

Support or Orthopedic Canes and Crutches

The specialist is concerned with the needs of the completely ambulatory person traveling crowded areas and complex areas in towns and cities, but he must also assume greater responsibility for supplying appropriate and supportive aids to those whose ability to

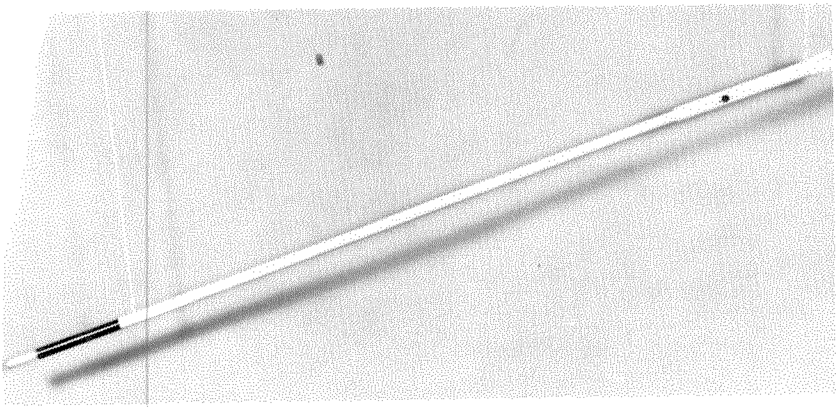


FIGURE 6.–The Louchek Cane.

walk or move about is restricted or limited.

The cane, or the use of cane-like objects for support, has been with us since the dawn of civilization and is a common walking aid within most people's experience. It is the most likely of all the mobility tools to be underestimated and taken for granted. Teaching the use of a support cane and learning to use it are not the simple tasks they appear to be. There are proper techniques and safety procedures to be observed. The reason for using a support cane must be taken into consideration as well as selection of the cane, and its tip (Murphy, 1965 and Bennett and Murphy, 1977).

Advantages

A support cane should provide assistance to mobility by broadening a person's base of support, and improving his balance. It provides some degree of sensory feedback by detecting irregularities of the walking surfaces, and offering increased stability on varying grades of surface (Murphy, 1965). It may help to prevent or alleviate a limp, and it also can help to make walking less tiring and energy consuming by contributing locomotion assistance through cane impulse (Bennett, Murray, Murphy, and Sowell, 1978).

The long cane can be used in concert with a support cane, crutches, or other mobility aids, including electronic aids (Figs. 7 and 8).

Disadvantages

A disadvantage of the support or orthopedic cane is that it cannot be used if a person requires underarm support or is unable to bear weight on the hands. There are few other disadvantages; its purpose is to afford support to the user, which it does in a very practical and efficient manner.

FIGURE 7.—Long cane used in concert with crutches.

FIGURE 8.–Long cane used in concert with a support cane.

Specifications

A support or orthopedic cane must be durable and long lasting, light in weight, and the proper length or adjustable. In addition, it should have a safe, firm, comfortable gripping surface, and a safety non-skid tip. It must be easy to handle, with maneuverability within the capabilities of the user, and be capable of supporting the necessary weight without breaking or shattering.

There are many types of support canes and crutches presently in use. A wooden orthopedic cane may be used for support and a white wooden cane of similar length for support and identification (Fig. 9). There are non-adjustable aluminum canes and those that can be adjusted to various lengths (Fig. 10). A straight-handled adjustable cane provides a firm grip for the user (Fig. 11). The adjustable offset cane places the user's weight over the center of the cane for maximum balance and control (Fig. 12). A cane-seat may be useful for cardiac sufferers, for older people, and for those with orthopedic and neuromuscular disabilities (Fig. 13).

Quad canes provide a broad base of support with equal weight distribution on all four legs. They are frequently used to make the transition from crutches to the cane or from parallel bars to the cane, and sometimes for supplementary lateral support. They can be nonadjustable, equipped with a small or large base (Fig. 14), or height-adjustable (Fig. 15).

The cane glider has two legs with wheels and two with rubber tips, and is useful for persons who have difficulty lifting the weight of the cane (Fig. 16).

Aluminum tripod canes offer a much larger surface of support than the support cane but not as much as the quad cane. They are manufactured in a standard model, height-adjustable, and an offset adjustable model (Fig. 17).

The possibility of the user tripping over the legs of quad or tripod canes (or of tripping other pedestrians) is much greater than with the support canes and crutches.

Forearm Crutches

In addition to the conventional crutches, aluminum forearm or Canadian crutches may be used by persons who do not require underarm support. The crutch cuffs are contoured to fit the forearm to allow more freedom of the hands. The handgrips can be released without danger of the crutches falling (Fig. 18). Made of aluminum tubing, they have rubber handgrips, large crutch tips, and adjustments in height may be made by cutting a single tube or by using telescoping tubing.

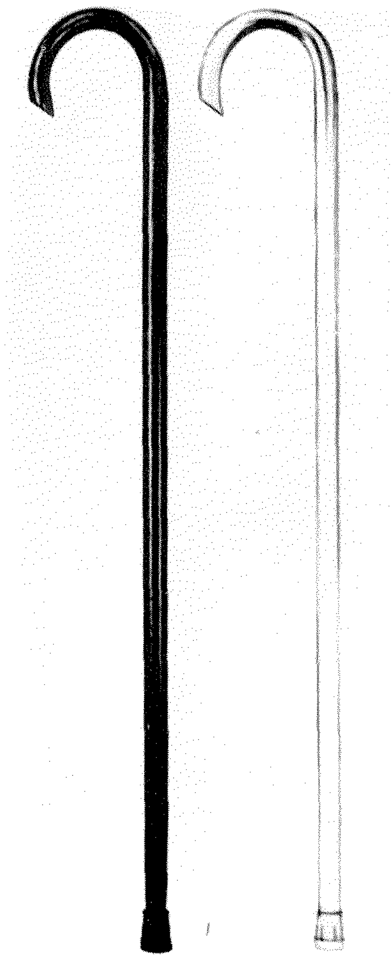


FIGURE 9.–Orthopedic cane – wooden.

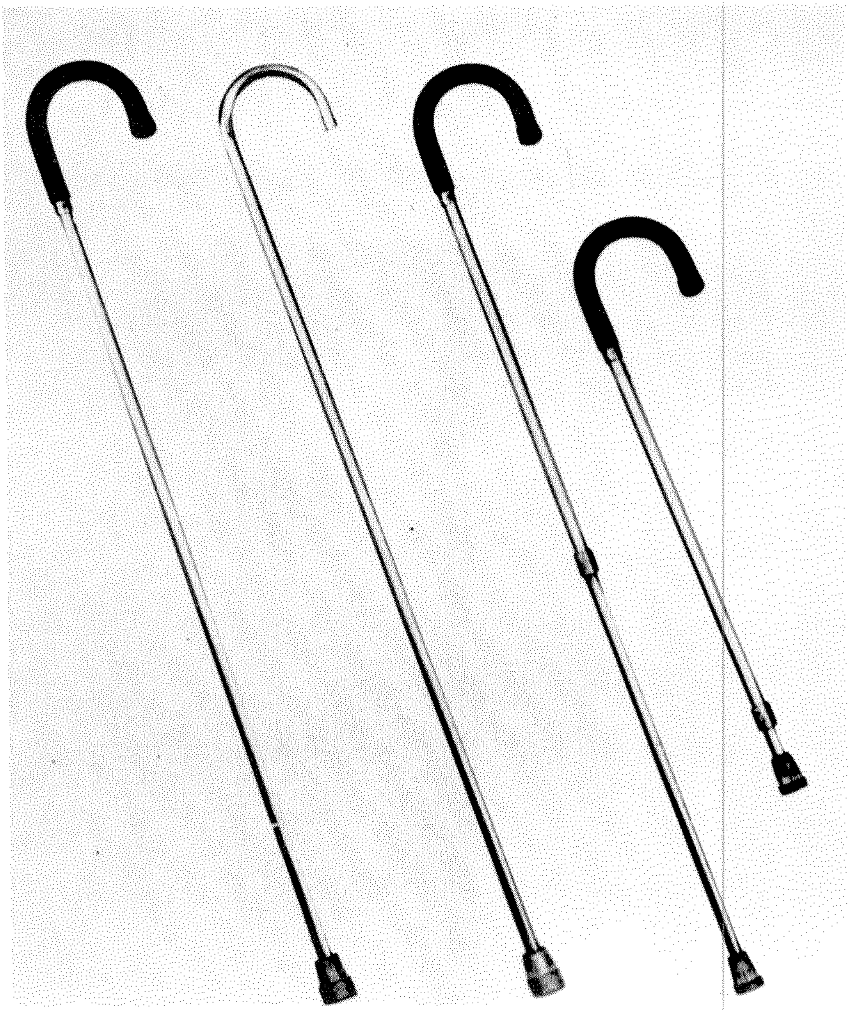


FIGURE 10.—Orthopedic cane – aluminum.

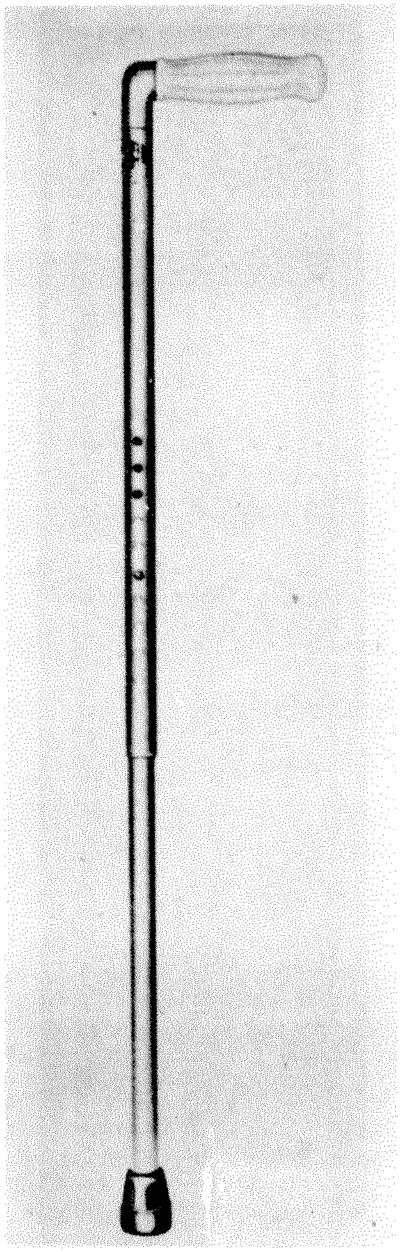
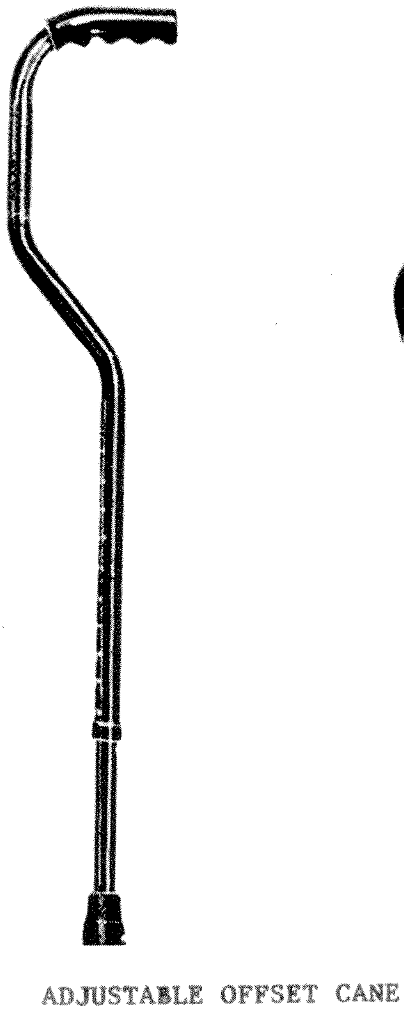


FIGURE 11.—Straight-handled adjustable cane.



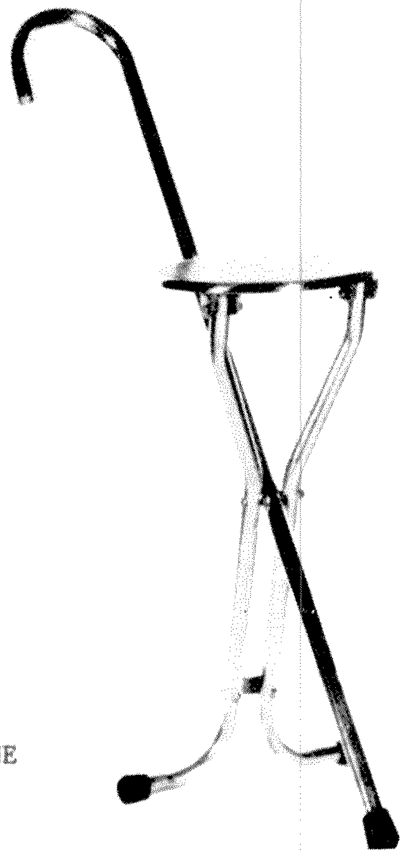


FIGURE 12. (left)—Adjustable offset cane.

FIGURE 13.—A cane-seat.

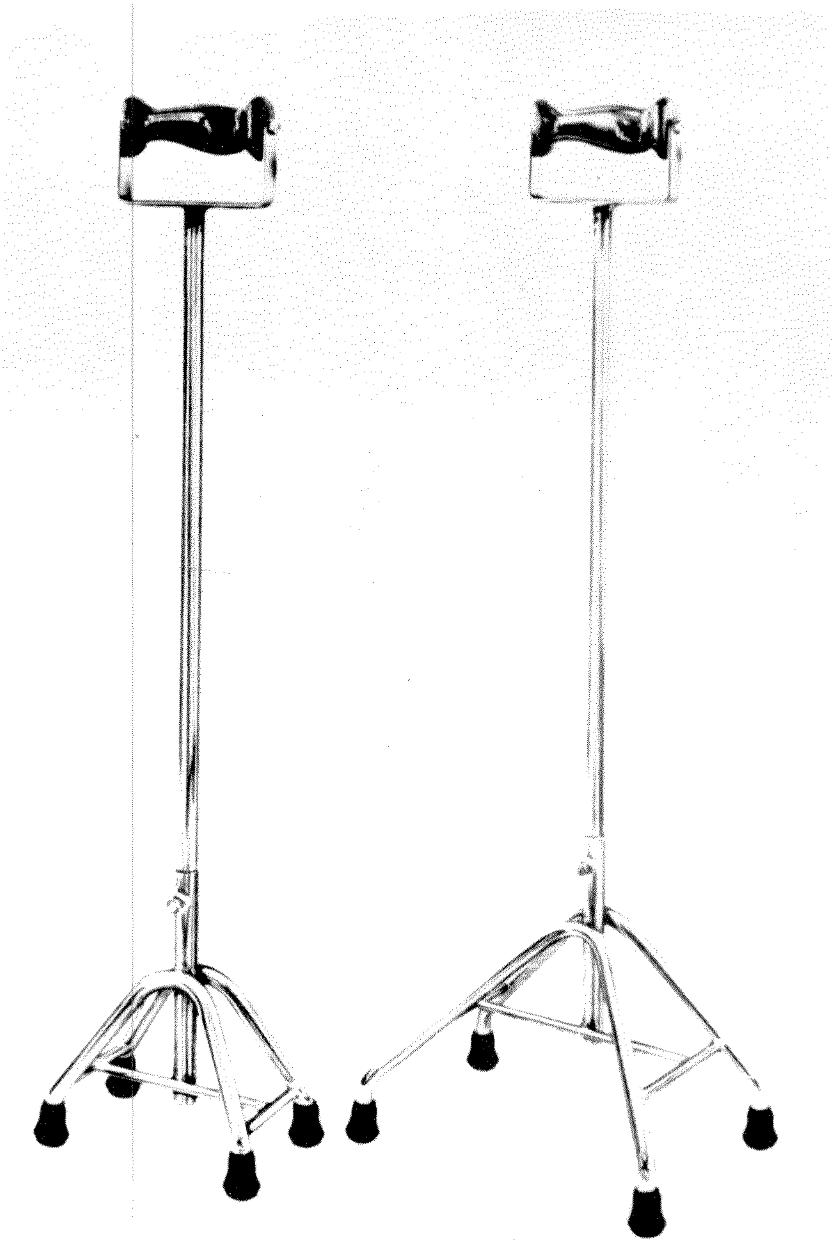


FIGURE 14.—Quad cane, with small or large base.

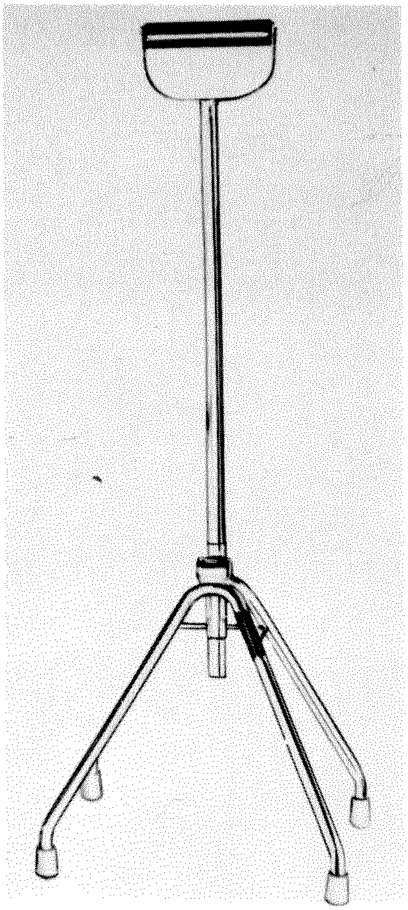


FIGURE 15.—Quad cane, height adjustable.

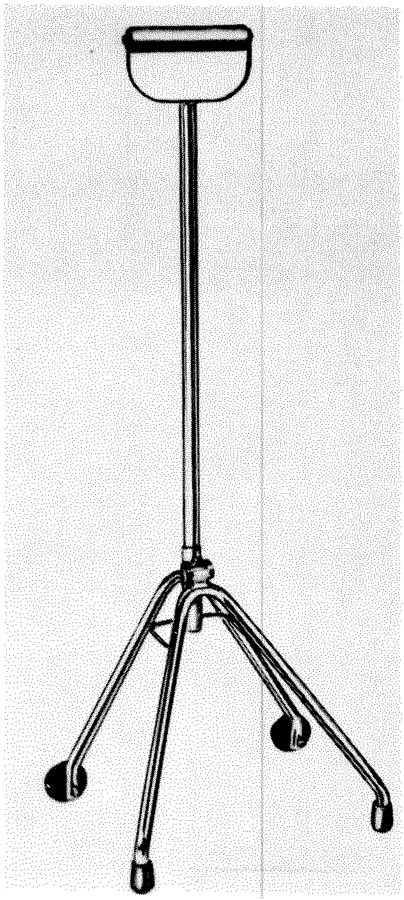


FIGURE 16.—Cane glider.

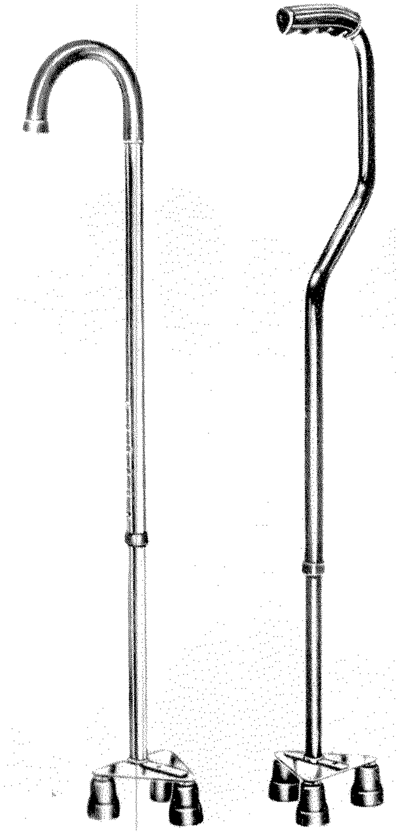


FIGURE 17.—Aluminum tripod canes.

FIGURE 18.–Aluminum forearm crutches.

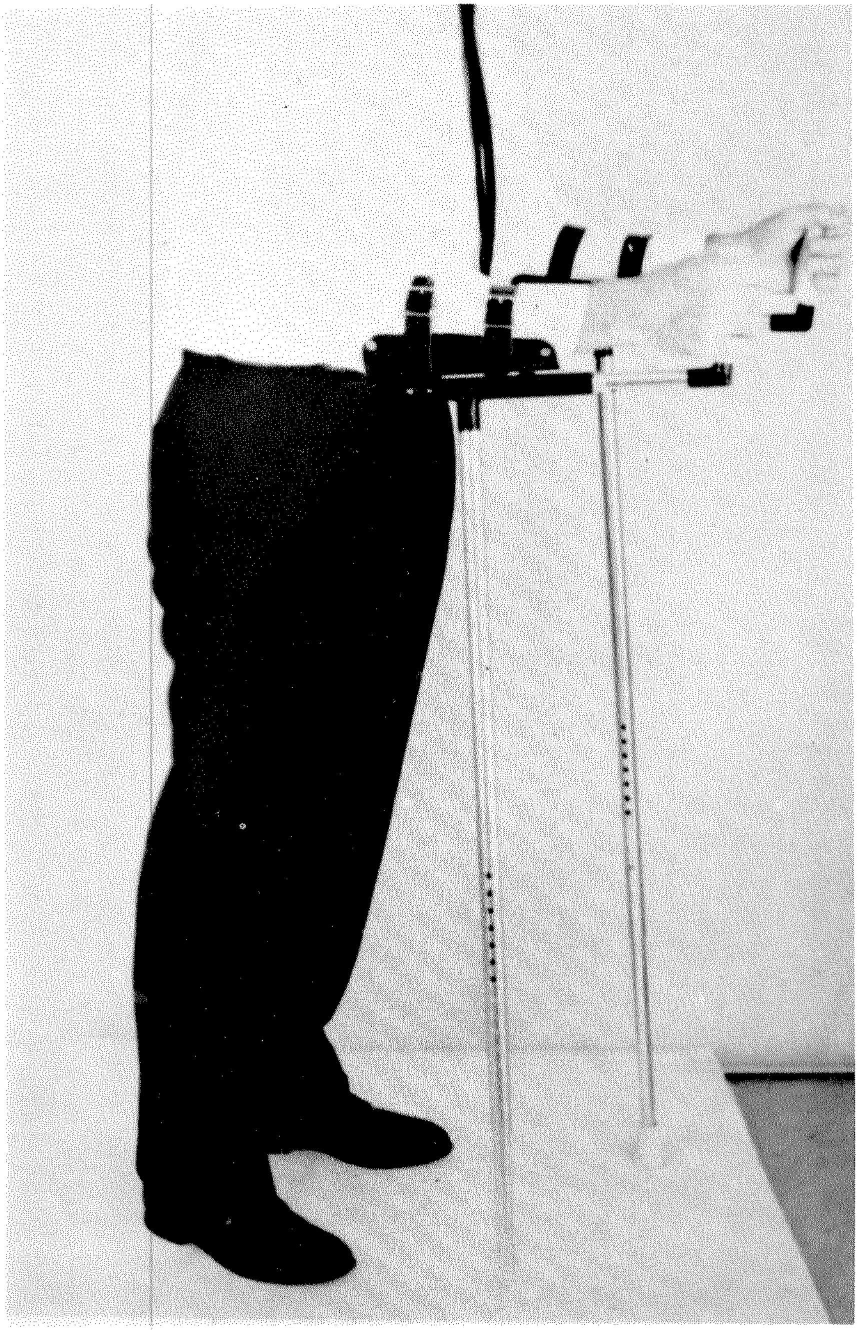


FIGURE 19.—Forearm Trough crutches.

Forearm trough crutches (Fig. 19) provide a more comfortable and safe method of crutch walking for persons unable to bear weight on their hands, or who have arthritic or deformed hands, or triceps weakness, forearm fracture, or extensive burns. The design of the shaped forearm trough enables body weight to be well distributed. Safety straps on the trough can secure the crutches to the forearm if necessary, but this attachment could be dangerous if one fell with forearm strapped to such a long lever arm.

Walkers

An important aid in rehabilitative, postoperative, and convalescent activities of many people is the walker (Fig. 20). It is commonly used in early stages of mobility training if one or both of a patient's legs are so disabled that full weight bearing is not possible. Adult-to-child range size-adjustable walkers are available. The aluminum tubing frame with plastic handgrips and rubber-tipped legs is light enough for most people to lift. Walkers can also be used in conjunction with electronic travel aids.

Some currently produced walkers found in a well-equipped facility include those illustrated and discussed here (J. A. Preston Corp., 1974).

A push-button adjustable folding walker has an aluminum tubing frame with a single push-button control for folding (Fig. 21).

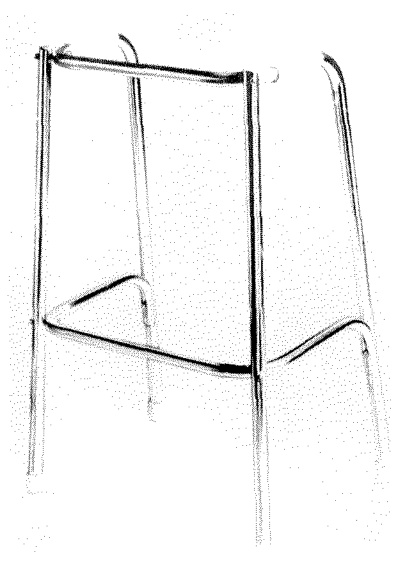


FIGURE 20.—Standard walker.

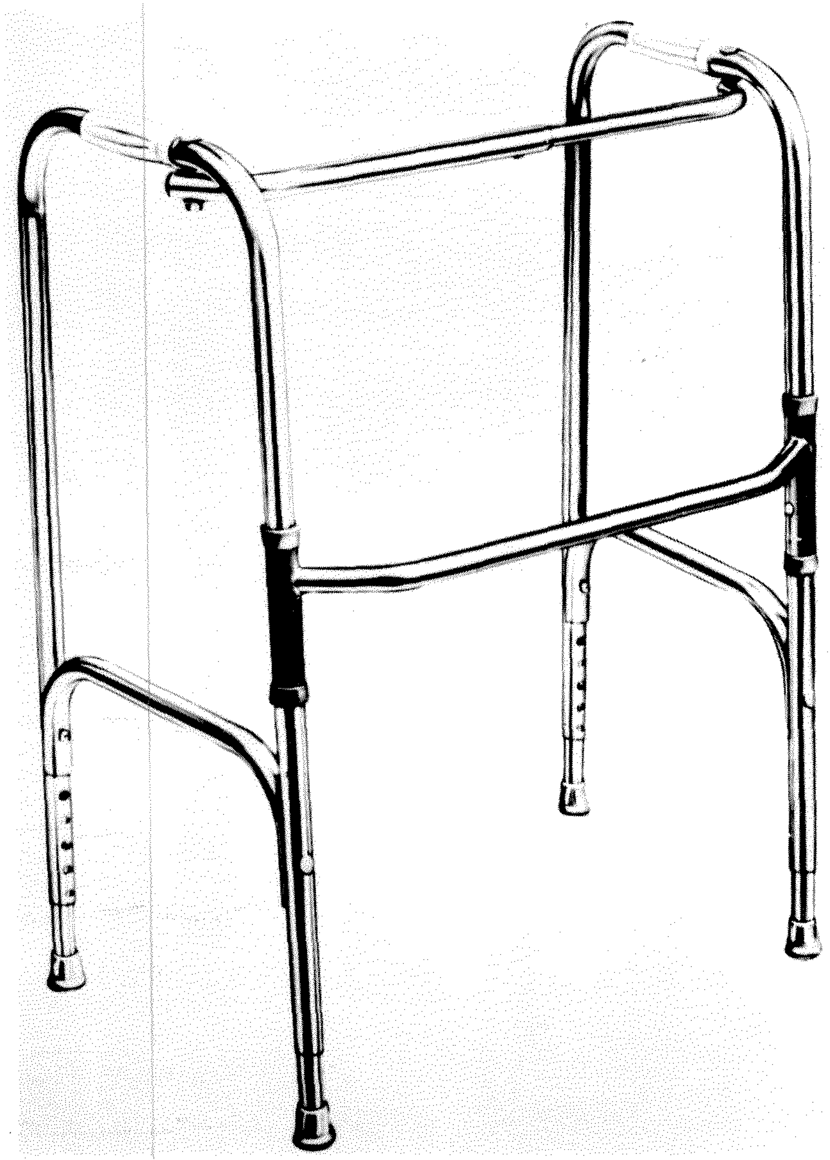


FIGURE 21.–Push-button adjustable folding walker.

A walker with crutch attachments is an adjustable folding walker that has a pair of removable, adjustable crutch attachments with arm pads to be used in very early stages of ambulation training.

A walking aid with wheels is designed for easy rolling, is height adjustable, and has a removable plastic utility tray (Fig. 22).

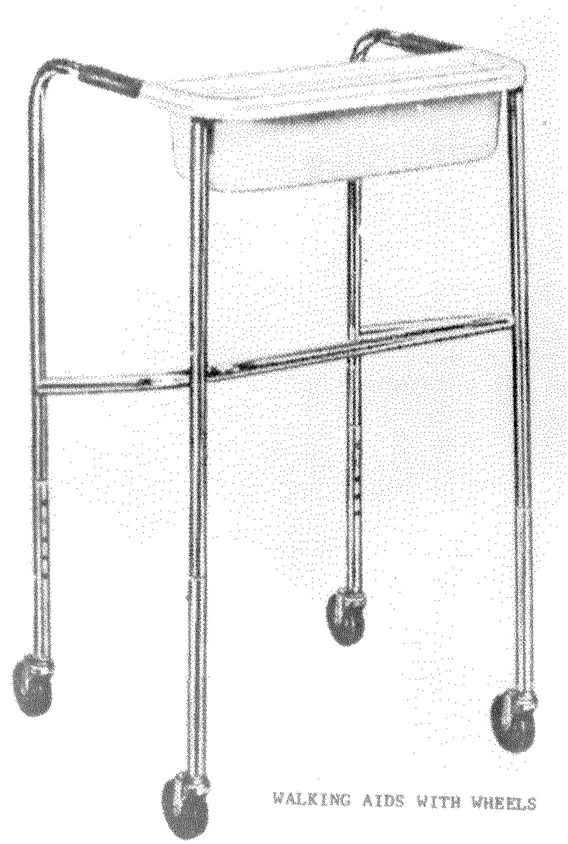


FIGURE 22.—Walking aid with wheels.

The walker-cane combination is made of lightweight aluminum, folds flat, and has push-button height and angle adjustments. It combines the features of a quad cane and walker to constitute an intermediate walking aid (Fig. 23).

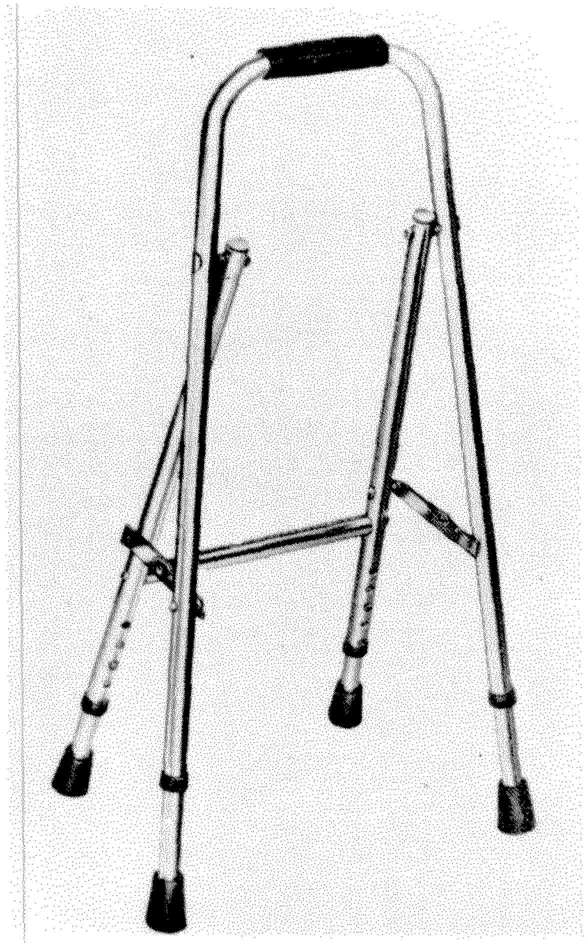


FIGURE 23.—Walker-cane combination.

The Walkamatic Reciprocal Motion Walker is an aid for relearning a reciprocal gait before using crutches, a support cane or a long cane. The walker has special swivel joints to allow reciprocal action. Each side moves forward in a controlled pattern (Fig. 24).

FIGURE 24.—Walkamatic Reciprocal Motion Walker.

Other Specialists Involved

It is important that mobility specialists who are inexperienced in the prescription and use of support canes, crutches, and other walking aids, seek advice from orthopedists, physiatrists, physical therapists, and corrective therapists who can recommend the appropriate aid for the particular disability. The therapists can also recommend conditioning and reconditioning exercise programs that will avoid damaging or overstraining weak muscles.

II. ELECTRONIC TRAVEL AIDS (ETA'S): HISTORY AND DEVELOPMENT

However resourcefully and widely the long cane is used, it does have disadvantages, the commonest of which is the inability of the touch technique to scan all the space through which the body travels. The body from the waist up is vulnerable to physical contact with objects or people (Suterko, 1967). More important is that the information the cane provides is transmitted at the moment of contact—not before. The mobility specialist who is aware of the virtues of the long cane must also recognize its shortcomings, so as to know when to seek remedies and supplements. Electronic travel aids (ETA's) and sensory systems offer some answers and alternatives.

Background

In the past, inventors sometimes designed devices that were decades ahead of the state of the art and technology. Several historical reviews document the research and development of electronic travel devices and sensory systems (Zahl, 1962; Bliss, 1966). One of the best is by Nye and Bliss (1970).

Noiszewski's Elektroftalm, built in 1897 (Starkiewicz and Kuliszewski), and D'Albe's Exploring Optophone, 1912 (Nye and Bliss, 1970), remarkable as they were, represent unorganized, random attempts by talented, visionary men working under the technological limitations of their times to try to contribute to the well-being of the blind.

As a result of studies by the Office of Scientific Research and Development during World War II, the first serious collective effort was made to develop ETA's and sensory systems (Zahl, 1950; Dupress, 1963). Haskins Laboratories, Stromberg Carlson, Brush Development Company, Hoover Company, The Franklin Institute, and the United States Army Signal Corps were the research centers involved with ETA's. In 1945 the National Academy of Sciences (NAS)-National Research Council (NRC) took over the task of improvement and development of sensory aids for blind and visually handicapped persons (NAS, 1968). Support was assumed by the Army and the Veterans Administration. In addition to the central laboratory for research and evaluation at Haskins Laboratories, mobility studies continued. Work was done on reading aids by Naumberg and Radio Inventions, and by Radio Corporation of America (RCA). Dartmouth Eye Institute, Perkins Institute, and Franklin Institute developed magnifiers for the partially sighted.

In 1950, before the Korean conflict, the Veterans Administration contracted with Haverford College to field-test 25 models of a Signal Corps sensory aid (a large hand-held device) designed by Lawrence Cranberg and produced by RCA (Benham, 1952; Benham and Benjamin, 1963). The contract called for an evaluation of the device and recommendations for the development of an improved ETA (Benjamin, 1968). Based on the recommendations, further laboratory investigation was conducted by Biophysical Instruments, Inc. (later Bionic Instruments, Inc.), initially as a subcontractor under a VA contract with Haverford and later as a direct VA contractor. This research and development project produced successive models, including the intermediate C-5 Obstacle Detector evaluated under VA contract by TRACOR (Deatherage, 1965) and culminated in the production model C-5 Laser Cane.

Since the early 1960s many conferences and meetings have been held at which electronic travel devices and sensory aids were discussed and demonstrated and many other factors in the environment-user-device interface widely explored. Examples are: in June 1962, the International Congress of Technology and Blindness in New York; in August 1964, the Rotterdam Mobility Research Conference; the Conference on the Ultrasonic Spectacles for the Blind, Chicago, 1970; the Conference on the VA-Bionic Instruments, Inc., C-4 Laser Typhlocane, Hines, Illinois, 1970; and the Conference on Travel in Adverse Weather, Minneapolis, 1975.

Following World War II, many sensory aids were built and exhibited representing various principles and systems. Some devices (e.g., "Optar", Kallman, H., 1950-1954) were *passive* aids which "peered" into space and responded to ambient light reflected from objects within range. However, most of the ETA's were *active* systems that radiated a beam or cone of electromagnetic or acoustic energy into the environment and operated when the reflected signal or echo was detected by the receiving mechanism of the device. At the present time in the evolution of sensory aids, it is estimated that more than 30 devices have been built or designed. Of these, only a small number have survived beyond the prototype stage and fewer still have survived to the field testing phase.

Three ETA's that showed promise in the 1950s and 1960s, the Lindsay Russell Pathsounder, the Bionic Laser Typhlocane (C-5 Laser Cane), and the Sonicguide, have been field-tested, used in training programs, and shown to be useful in dynamic travel situations.

Sensory aids are not the answer to all the problems that the blind or visually impaired traveler encounters. With one exception, the Laser Cane, ETA's are secondary devices designed to be used in conjunction with the only proven and accepted primary modes for independent travel, a dog guide or long cane. The user of an ETA must not expect the device to compensate for liabilities such as lack of orientation or poor cane technique and travel skills. A candidate for a sensory aids program should be one who has successfully completed formal training at a dog guide school, or an orientation and mobility training course in a blind rehabilitation center or agency (Miyagawa, 1974; Thornton, 1975).

Definition and Purpose

An ETA may be described as a device that sends out signals to sense the environment, processes the information received, and furnishes the user with certain relevant bits of information about the immediate environment. The device should probe the immediate area, sense the situation, and present the detected information to the traveler in an intelligible and useful manner. An ETA should, either of itself or in concert with a cane or dog guide, inform the traveler of objects in the travel path from the ground to the vicinity of the head, as well as forewarn of any surface discontinuities that might constitute a safety hazard (Farmer, 1975).

With the dog guide and long cane proven, accepted, and used extensively and effectively, why is so much money and effort spent on the research and development of sensory aids—particularly when specialists who are involved in the training and use of ETA's report that experience, evaluation, and consumer interviews show that demonstrating further improvement in mobility performance can sometimes be very difficult?

The answer lies in two separate but related areas; the functions that the aid was engineered to perform for the consumer, and the benefits that consumers feel they receive from using the device.

Functions Performed by ETA's

An ETA can provide a degree of sensory insight into the environment which, even under the most ideal circumstances, would not be possible using only a long cane or dog guide. A sensory aid detects and locates objects, whether hazards or landmarks, beyond the length of the blind person's arm or even beyond reach with an extended long cane. It provides information that allows the user to determine (within acceptable tolerances) the range, direction, width, height, and general shape of such objects and in many cases to identify them. Because an ETA permits "distant early warning" of an object or person without physical contact, it permits avoidance without embarrassment (e.g., passage around a quiet window-shopper without touching or risk of tripping). Freedom from physical contact also permits noncontact trailing and tracking, enabling the blind traveler to receive directional indications from physical structures (e.g., walls, edges of platforms) that have strategic location in the environment or to make noncontact trailing or tracking possible. With the Sonicguide it is even possible to achieve an additional degree of primitive object identification because the timbre of the auditory signal may give clues about the nature of the surface being detected (Farmer, 1975).

Benefits from ETA's

ETA users with long-cane experience particularly appreciate the early warning nature of the Laser Cane and experience fewer collisions (Advisory Panel for Evaluation of the Laser Cane, 1974). Some say the additional detection range of the beams is a convenience in searching for landmarks or scanning the environment. Many have a greater sense of well-being and believe that because they feel safer and more secure, they move about with less tension. Some indicate that, for the first time in their experience as travelers, they have the option to avoid or make contact with objects, or just to use them for orientation or reference points. There are many times when contact *is* desirable and it is gratifying to know when one is within range of the target and can follow the electronic beam to within cane reaching or hand-touching distance.

Airasian's (1973) evaluation of Binaural Sensory Aid trainees reported that, although use of the device did not seem to increase independent travel or shorten travel time or improve travel patterns, the users rated it quite favorably as a mobility aid. Trainees reported better mobility on a wide range of travel skills with reduced travel stress, and travelled in a wider variety of areas than before training. Trainees claimed a better understanding of the environment, more accurate location and identification of objects, and better distance determination.

A blind man interviewed by Farmer (1975) on Laser Cane use reported that, being adventitiously blind, he had had to learn to listen more carefully and that there were gaps in his ability. He felt that the ETA tended to fill in the gaps in his hearing, so that he was more than twice as efficient in traveling with the aid than he had been without it.

Guidelines for Design

Before 1970, some investigators and developers went their separate ways without much communication and cooperation with mobility specialists. Many sensory devices designed failed to meet even the most fundamental travel needs of visually impaired consumers because of a lack of uniform guidelines.

While sensory devices differ in principle, design, display, and output, there are many like functions that they must perform as secondary travel aids. At present no one device meets all of the requirements for an ideal aid but guidelines for such an ETA can be set forth.

Benham (1952, 1953, and 1954) and Benjamin (1968) suggested that a device should detect obstacles, and indicate their approximate location and distance. It should detect down-steps and holes, up-steps and low obstacles, be small, lightweight, easily stored, and easily picked up and put down. Dupress (1963) felt that the readout from the device should be synchronized with other cues, that it should give the traveler additional navigation and orientation information, and that the data from the device should be simple enough for quick interpretation without extensive training. He also felt that the device should give no false cues and the traveler's attention should be readily secured without fatigue or accommodation.

Farmer (1975) stated that an electronic travel device must serve its intended purpose of helping and not hindering the basic mobility process. It should have specifications that manufacturers are required to meet. It must not, in any way, interfere with natural sensory channels or association with the environment. The aid should have (with a minimum of accessories, boxes, and connecting cords) the option of an auditory or tactile output, or a combination of these and other possible future outputs. It must be reliable and durable (at least in late evaluation and commercial models), reflecting good quality control that guarantees interchangeability among models of the same generation without ill effects. Parts should be interchangeable among modified versions of the same generation of models. Updated models should not render standard parts or batteries obsolete or unusable. Repairs should be infrequent but, when necessary, should be available quickly. The ETA should be waterproof and operate well in abnormal environmental conditions. The device should be designed to make the use of a wireless telemetry system (useful in mobility training and research contexts) economically feasible.

Rechargeable batteries should be accessible for removal and replacement. Batteries should have serial numbers and be dated. They should be capable of running continuously for 5 hrs or more and should have a life of from 3 to 5 yr. Chargers should be completely automatic, capable of charging at least two batteries simultaneously, and have audible controls (vibratory or tactile for persons with hearing impairments) which, when activated, would indicate whether the batteries were fully charged, charging, or completely flat.

Finally, but by no means least important, ETA's must be cosmetically acceptable.

Candidate Requirements

When ETA's are discussed at conferences and workshops, participants frequently want to know the requirements for entry to a sensory aids program, and if any prescriptive criteria for matching a person with an aid have been developed. At present, there is no standard list of requirements for participation, although agencies with ETA programs usually have their own guidelines by which they determine the eligibility of applicants for those programs. Little work has been done in developing criteria for matching a person to an aid.

The Veterans Administration orientation and mobility research specialists use a general set of candidate selection guidelines when explaining the ETA program to blinded veterans, their families, and VA personnel and to help referring agents who serve the veterans. The candidate who has light projection or less seems to profit most from the use of ETA's and is given priority in VA programs. However, it is likely that certain visually impaired persons with diabetes, retinitis pigmentosa, glaucoma, uveitis, and possibly other conditions, could benefit from the use of ETA's.

Considerations in Selection

When a mobility specialist screens, accepts, and undertakes to train a candidate to use an ETA, he must consider the travel history of the candidate, past and present level of competence and confidence with the primary travel mode, current and future travel needs, and whether travel is in unfamiliar as well as familiar areas. The mobility specialist must consider degree of activity or inactivity, and, if active, whether the activity is occupational, recreational, civic, or other. If occupational, is the person a professional person, or a factory, office or farm worker, or perhaps a student?

The mobility specialist must find out how the traveler feels about the device. Is the person sensitive to public reaction to the device? Is the device cosmetically acceptable? Is the signal output sufficiently private and personalized? It is valuable to learn the attitudes and reactions of family members, friends, and people in the neighborhood – these attitudes are very important to some visually impaired people.

Of major importance is the geographical area in which the individual lives and travels. Whether the area is urban, rural, residential, industrial, farm land, a new development, or a combination of these, is important in selecting a device that will enable the user to cope most effectively with that environment.

A person might have the ability and physical attributes to use a particular ETA well, but might not be able to tolerate the kind of display peculiar to that aid. The individual might prefer one output over another, or one which does or does not continuously monitor the environment. One user may want a play-by-play audio-tactile inventory of environmental events along the route while another might wish to be informed only about objects in the direct travel path.

The obvious factors to be considered in matching a person to an aid are auditory and visual acuity, motivation, and cost benefit to the individual in terms of time, effort, and money.

Although some ETA's are designed to respond to ambient light reflected from detected objects, most attention is presently focused on active energy-radiating systems. The energy used by these aids is either acoustic or electromagnetic.

Display of Environmental Information

Two opposing viewpoints about device display and output have been expressed by Russell (1965), developer of the Lindsay Russell Pathsounder, and by Kay (1974), developer of a binaural sensory aid, the Sonicguide Mark II. Both devices use ultrasonic acoustic energy for object detection and environmental sensing.

Russell believes that an aid should not burden the user with complex sounds but should simply display information indicating to the traveler whether the travel path is or is not clear; i.e., a "go-no-go" system. The Pathsounder, therefore, strips away all complexity from the signal by processing or codifying the echoes it receives. Russell refers to the display concept as a "language system," because the presentation consists of a language of discrete sounds. He suggests that it is a question of giving either the headlines or the text; he has chosen to give the headlines.

Kay's approach, on the other hand, has been to design an aid that displays the maximum amount of environmental information the auditory sensory channel could effectively transmit, and do this in such a way that the user could readily disregard both redundant and unwanted information merely by focusing attention on pertinent information (analog system).

Benjamin and his staff developed the Laser Cane, which employs electromagnetic (light) energy. While the Russell and Kay devices irradiate the forward and peripheral fields with an inherently wide ultrasonic cone to get environmental information, the Laser Cane emits three pencil-thin beams of invisible infrared (IR) light for target detection. Benham and Benjamin consistently advocated a "go-no-go" output to facilitate finding and following a clear path without attempting to study the environment.

An eyeglass-mounted mobility aid (Mims, 1972a) using an infrared source—a light-emitting diode (LED)—has been fabricated and evaluated on a small scale. This device, along with other active and passive aids, will be discussed later.

Types of ETA's

The Lindsay Russell E Model Pathsounder

The Pathsounder was invented by Lindsay Russell while a consulting engineer with the Sensory Aids Evaluation and Development Center (SAEDC) at MIT. Much of the early testing of the device (as well as development of the tactics for its use) was done by John K. Dupress (Russell, 1965). Dupress was then with the American Foundation for the Blind, and later with the SAEDC. The first Pathsounder field-tested was the H Model (Russell, 1969). In 1968, eleven Pathsounders were built, most for the three VA Blind Rehabilitation Centers (Russell, 1970). In 1974, the present E Model Pathsounder (Fig. 25) was made for distribution by the three VA Blind Rehabilitation Centers. It is a small battery-operated sonar device designed as a secondary ETA—intended to complement but not replace the long cane. Chest mounted, it warns the user of objects within the field of view above and below the waist, just outside shoulder width, and in the direct travel path. The Pathsounder emits bursts of ultrasonic waves into space at the rate of 15 pulses per second. The sonic cone has a maximum diameter of approximately 20-24 in. (50-61 cm) at a distance of 6 ft (182 cm) from the traveler's chest. The E Model Pathsounder, unlike the predecessor H Model, has two output signals – vibratory (tactile) and auditory.

With this device, if there is no reflecting surface within the irradiated zone, and hence no echo, there is no output. When the traveler is within 6 ft (182 cm) of an object, echoes from objects within the outer protection zone, 31-72 in. (79-182 cm), are detected by the receiving transducers of the Pathsounder. (Transducers are the electronic components which convert one form of energy to another, as a microphone converts sound energy to electrical energy or an LED converts electrical energy into light energy.) The information is processed or coded and displayed to the user by means of an output which can be auditory, vibratory, or both. The auditory output, while the target is in the outer protection zone, is a buzzing sound. It changes to a high-pitched beeping sound when something appears within the 32-in. (81-cm) inner protection zone. Echoes from objects further out than 6 ft (182 cm) are excluded from presentation

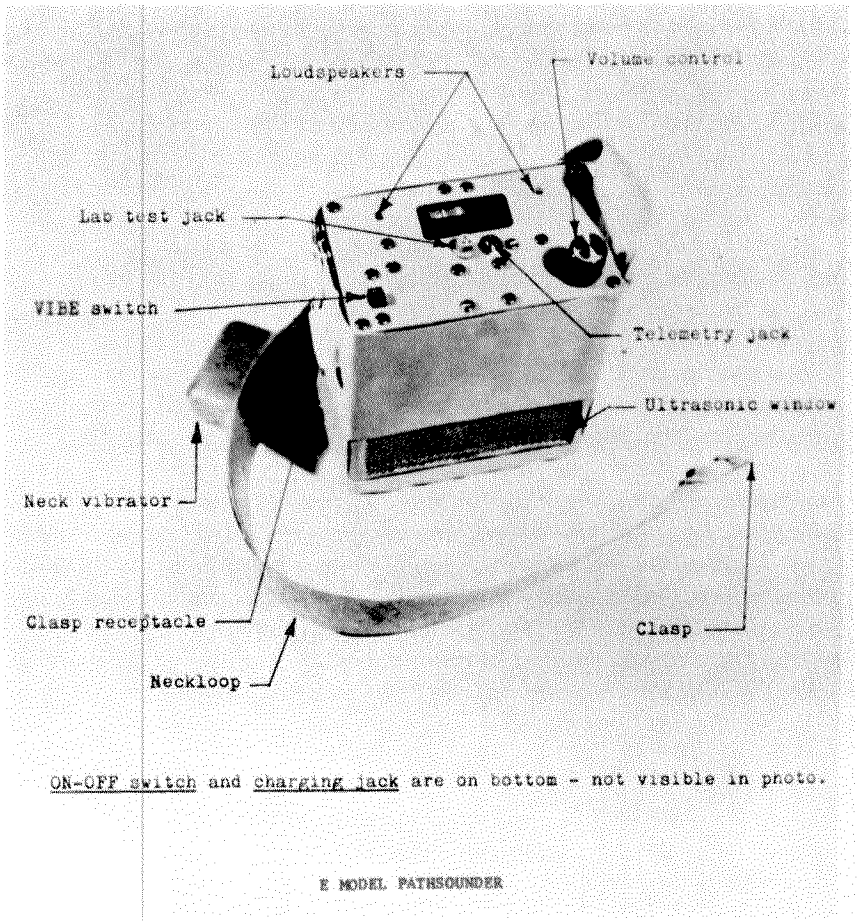


FIGURE 25.—E-Model Pathsounder.

by timing circuits. In accordance with the "go-no-go" concept, no special electronic attention is paid to the size of an object. Echoes from objects of varying sizes are reduced to a uniform level by a circuit limiter.

Vibratory signals indicate the presence of objects in the same two zones: when an object is detected in the outer protection zone, the entire unit vibrates rapidly on the chest ("chestvibes"), and when the object being approached appears in the inner protection zone, the chestvibes stop and a neckstrap transducer vibrates against the back of the neck ("neckvibes").

The vibratory system was incorporated not only to serve hearing-disabled blind persons, but also to replace an auditory signal in a noisy location where masking of sounds might take place, and as an inconspicuous private signal (Russell, 1974).

The ultrasonic waves that detect objects are emitted through the screened ultrasonic "window" in the front of the Pathsounder and would be blocked if covered by clothing. The unit does not usually hang vertically on a person's body but tilts upward, so tilt allowance is incorporated in the design. An arrow on the left side of the device indicates the direction of maximum sensitivity for a person of normal build and posture, and should point horizontally ahead. The device may be returned to the manufacturer for adjustment to accommodate individual postural differences.

The Pathsounder also has a simple ranging capability called "ramp," that produces a buzz when an object approaches or is approached, at first faint, then growing louder and still louder. When operating in a noisy environment, this feature should be set at full volume.

The external rubber sonar horns which transmitted the ultrasonic pulses and received the echoes from objects on the H Model Pathsounder were considered cosmetically unsightly by some users. The E Pathsounders have rubber horns, too, but they are now inside the unit. The cosmetic improvement makes the unit less sensitive to close objects such as clothing and other poor reflectors.

Factory Modifications

The E Model Pathsounder is still of experimental design but has been developed so that quick modifications can be made. For instance, the wearing of heavy clothing can block chestvibe signals, so the outer zone pickup can be connected to the neck vibrator to make the neckvibes stronger for inner zone objects.

Although the Pathsounder was developed to supplement the long cane (by providing protection to the upper part of the body and head and by giving a distant early warning), the aim has never been fully realized. Perhaps the restricted range, limited production units, and the fact that it is usually chest mounted are contributing factors against wide use in a dynamic travel setting. However, it can be a versatile and useful device to assist blind persons confined to wheelchairs (Fig. 26), who need upper-body protection, or those who must use crutches or walkers, to achieve varying levels of independent navigation.

The SE Pathsounder

Three prototype Pathsounder Special E (SE) units were delivered to the VA in 1975 (Russell, 1975), intended for use by multiply handicapped blind persons. The SE Model operates in the same way

FIGURE 26.—E-Model Pathsounder as a useful device to assist blind persons confined to wheelchairs.

as an E Pathsounder but consists of two units, a headset and a control box connected by two cables (Fig. 27).

The headset assembly is worn just *above* the ears, and the control unit may be held in a pouch or affixed to a wheelchair. By putting the transducers in the headset (transmitter in the right and receiver in the left), the scan and search patterns are easily performed by head motion in a natural manner. The two output modes in the SE Pathsounder are the auditory signals emitting from miniature loudspeakers inside the headpieces and a vibrator located in the control unit.

Pathsounders have an internal nickel-cadmium battery that operates for from 2 to 5 hr, depending upon usage. The E and SE Pathsounders' battery chargers have battery status capability that

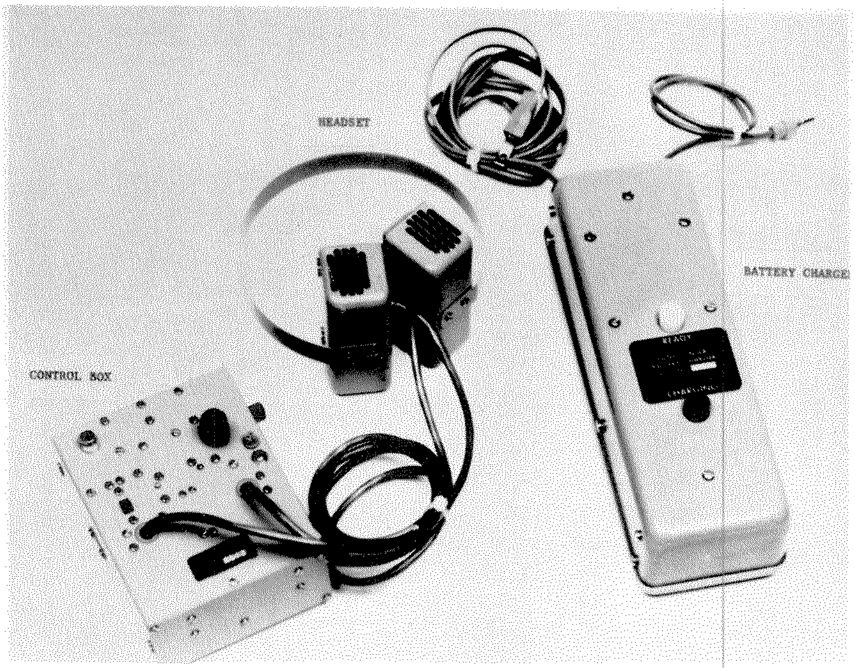


FIGURE 27.—SE Model Pathsounder. Control box is at left, headset in center, and battery charger at right.

automatically adjusts charge time to battery needs. They plug into a wall outlet, and can also be used for charging the H Model Pathsounder.

Limitations

The present Pathsounders are not waterproof, and if exposed to heavy rain they will not function. The aid can be restored to normal operation by being allowed to dry out for a day. There are no particular problems associated with hot weather use, but the battery loses strength rapidly at very low temperatures.

Training Methods

The Pathsounder is simple to operate, and should take only 20-40 hr of training to achieve an acceptable level of competence. Training methods and travel tactics are presented in the Pathsounder Instructor's Handbook Operating Instructions for the E and SE Pathsounder, and are appropriate for basic lesson plans. Baird (1977) discusses potential applications of the Pathsounder for exploration of the environment to help bridge developmental gaps in a blind child's life. Use of the Pathsounder seems effective for nonambulatory blind people and for training formats.

For the past 2 yrs, a mobility specialist at the Perkins School has been using the Russell Pathsounder with a 30-year-old deaf blind, spastic quadriplegic woman who uses a walker with wheels (C. Morse, personal communication, Nov. 19, 1976). Before using the aid, she used to bump into people and obstacles, and had to be escorted everywhere. She is now employed at Howe Press and has a degree of mobility and independence not possible before. Morse made certain adaptations to the aid, such as attaching a longer neck strap, so that it could detect furniture, low objects, and small children. The Pathsounder was also adjusted so as not to detect anything closer than one foot, such as the bar of the walker.

Baird (1976) has done some imaginative work with children using the Lindsay Russell Pathsounder. In working with small children, one of the best ways to communicate with them is to humanize and personalize the aid by giving it a name such as "Mr. Pathsounder." Outdoor settings were chosen, when possible, to eliminate or reduce feedback, and familiar sound-producing objects were used to sensitize the children to the signals of the device and to prepare them for constant signal output in congested areas.

In addition to being a good tool for concept development, the Pathsounder gave the children confidence and motivated introduction to the long cane. Also, the vibratory mode gave sensory input to the deaf-blind child and motivation to explore. The device was excellent for beginning orientation and mobility activities with a view to graduating to the Sonicguide.

Laser Canes and Other Aids Using Optical Principles

The Laser Cane

The Laser (Light Amplification by Stimulated Emission of Radiation) Cane, developed and manufactured by J. Malvern Benjamin and his colleagues of Bionic Instruments, Inc., is a product of the combined efforts of private enterprise and government. It evolved from a series of efforts using optical principles implemented with progressively better components. These will be reviewed briefly.

United States Signal Corps Obstacle Detector

Lawrence Cranberg designed a hand-held sensory aid for the United States Signal Corps in 1943, employing the principles of optical triangulation with light from an incandescent lamp to detect objects and determine their range,. and wrist position to estimate azimuth. If the Signal Corps aid were tilted downward, it could measure the slant height to the ground and thus allow the detection of curbs if the sudden increase in distance from the instrument to the pavement moved the returning image to the next row with more numerous holes on the rotating coding disc. Users, however, encountered difficulties because of comparable changes from the vertical oscillation of the body in normal walking and from the tendency to swing the arm. Many blind users objected to the distraction caused by the constant presence of a signal during this mode or to the attention needed to detect a sudden change in a fixed frequency.

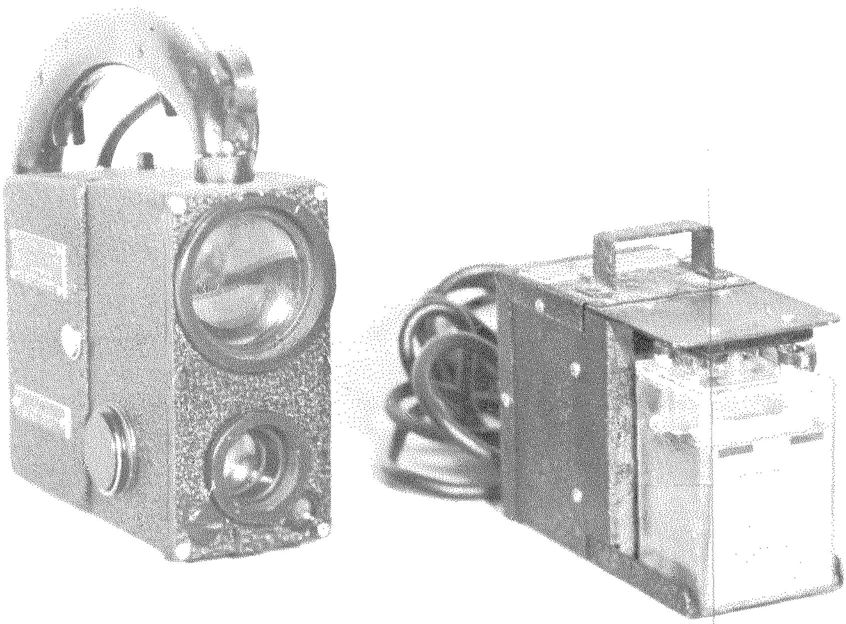


FIGURE 28.—United States Signal Corps Obstacle Detector.

RCA manufactured 25 of these experimental devices (Fig. 28). Benham (1952) evaluated them starting in 1950, and his recommendations became the specifications for a series of devices leading to the G-5 Obstacle Detectors subsequently developed by Bionic Instruments, Inc. for the VA.

The G-5 Obstacle Detector

The G-5 Obstacle Detector (Fig. 29) with a xenon flash lamp and Fresnel lenses had a tactile output and three ranges of 5 ft, 10 ft, and 35 ft (1.5 m, 3 m, and 10.5 m). The stimulator in the handle was activated whenever an obstacle came within detection range. In customary use, the aid was incapable of step-down detection, and would have to be used in situations known to be free from step-downs, or used with a cane if at all. Occupying the free hand of the traveler over an extended period of time is undersirable, so the optical triangulation system later was built into a cane-like device.

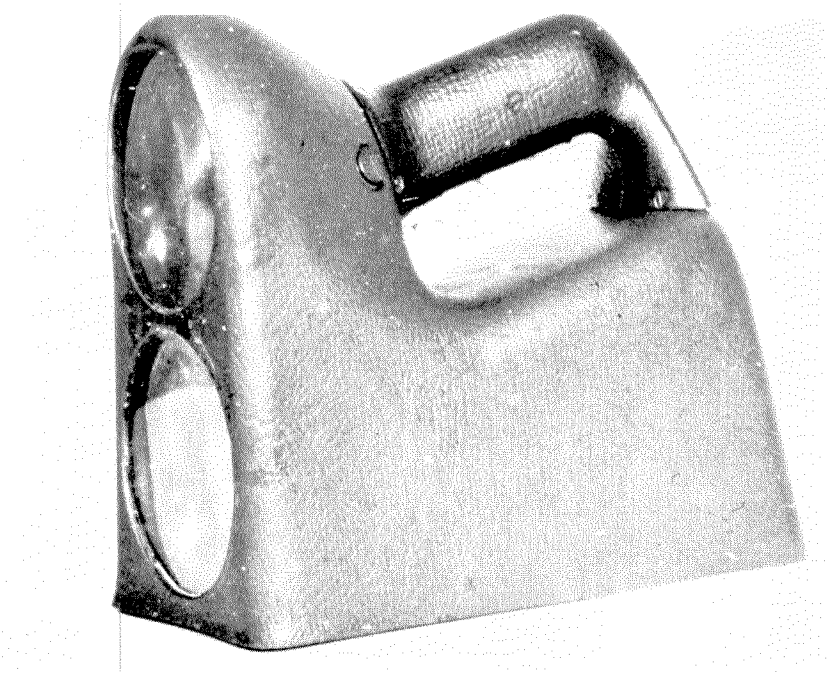


FIGURE 29.–G-5 Obstacle Detector.

The "flashlight" detector, with an early gallium arsenide light-emitting diode, the last of the hand-held aids designed by Biophysical Instruments, had a range of only 6 ft (182 cm) intended for use in a room, but it was not practical as a general-purpose travel device. However, by easily testing gallium arsenide light-emitting diodes, it was useful in the development of the laser canes using true GaAs room-temperature lasers when these first became available.

Early Laser Canes

Technical advances in miniaturized components such as integrated circuits, smaller batteries and especially intense solid-state, room-temperature, gallium arsenide lasers (which increased the light availability 1,000 times) made very compact housing possible. As a result, by 1966, the C-3 Laser Cane became the first true laser cane, and an evaluation by 50 blind users and their trainers led to the development of the improved C-4 Laser Cane (Fig. 30).

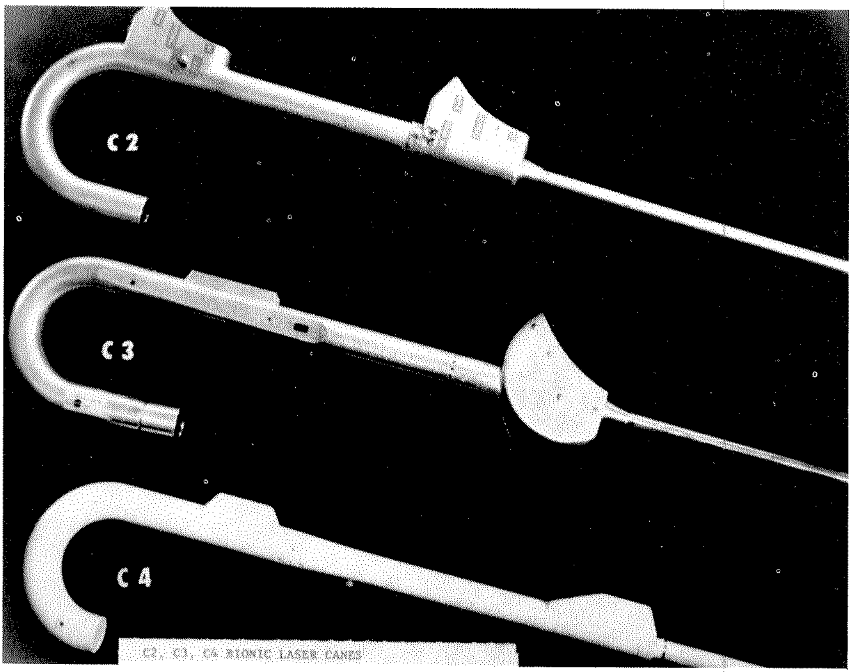


FIGURE 30.—C-2, C-3, and C-4 Laser Canes.

C-4 Laser Cane Evaluation

In 1971, an Advisory Panel for the Evaluation of the C-4 Laser Cane was created by the Subcommittee on Sensory Aids of the Committee on Prosthetics Research and Development, Division of Medical Sciences, National Research Council, National Academy of Sciences, funded by the Veterans Administration, to develop a protocol for training, evaluation, and followup procedures (National Academy of Sciences, 1973). Training and followup activities of the study were conducted by the orientation and mobility research specialists at the Palo Alto and Hines VA Blind Rehabilitation Centers.

Training, Evaluation, and Followup

Eight blinded veterans (four each from Hines and Palo Alto) were chosen as participants in the training and followup phases of the study in 1971-1972. The candidates were above-average travelers with travel experiences of 1 yr or more beyond completion of their basic mobility training course. The training lasted 5 wks, and at the end, each veteran was issued a C-4 Laser Cane to take home. (These had been tested by others but refurbished to incorporate past experience.)

Periodic telephone contacts were made with each veteran, and there were two visits to each participant's home, one after 4 to 6 mo and the final one after 12 to 13 mo. During the home visits, selected items from a questionnaire were administered, interviews taped, and video tapes made of travel performances with and without the experimental device and in familiar and unfamiliar areas. VA mobility specialists and private agency staff rated and evaluated the tapes and evaluated the travel performances. Evaluation results of the C-4 Laser Cane (National Academy of Sciences, 1973) formed the basis for the development of the improved, less bulky C-5 Laser Cane (Fig. 31).

The C-5 Laser Cane

The C-5 Laser Cane essentially combines a long cane (used in the same way) with built-in secondary electronic detection capabilities for distant early warning or "shorelining." The cane was designed to enhance the environmental-probing ability of the long cane to reduce tension while traveling, enabling the user to make more graceful progress.

The C-5 Laser Cane has three miniature solid-state gallium arsenide (GaAs) room-temperature injection lasers which emit 0.2 μs (microsec.) pulses of 9050Å (Angstrom), 40 or 80 times-per-second, and three photosensitive receivers. These beams are so narrow that they are only 1 in. (2.5 cm) wide 10 ft (3 m) from the source. Objects can, therefore, be located with a high degree of accuracy by discrete scanning. The upward projecting beam gives the user information about objects in the vicinity of the head, the forward beam detects objects in the travel path and immediate periphery, and the downward beam forewarns of down-steps (Fig. 32).

Using the Cranberg principle of optical triangulation, the device emits pulses of infrared light, which, if reflected from an object in the travel path, are detected by photodiodes located behind the receiving lens. The angle made by the diffusely reflected ray passing through a receiving lens is an indication of

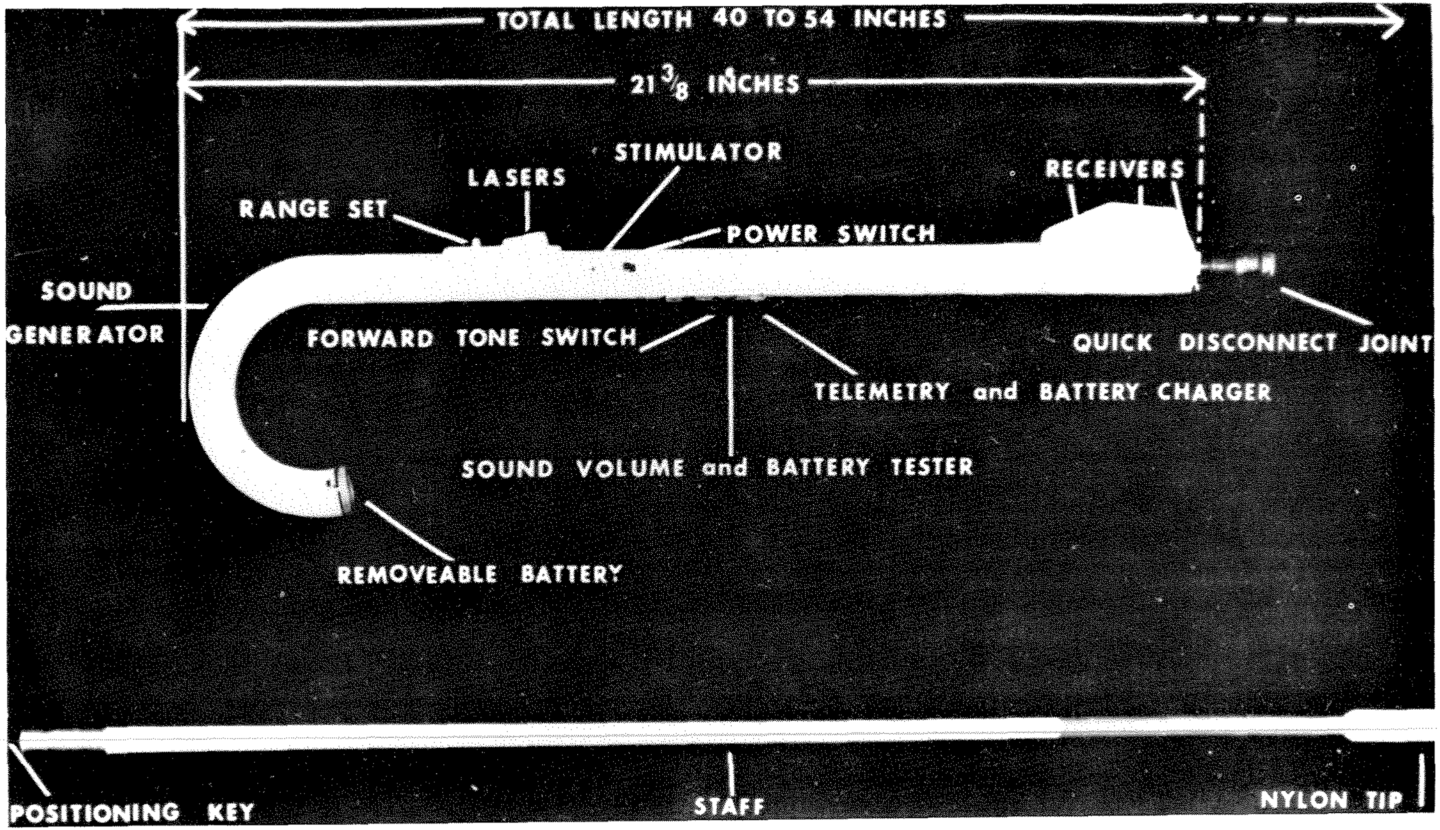


FIGURE 31.—C-5 Laser Cane.

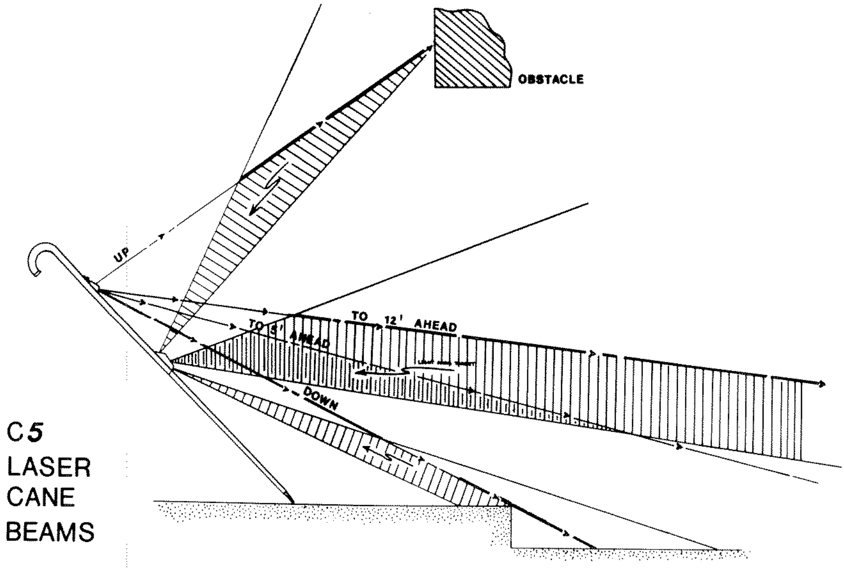


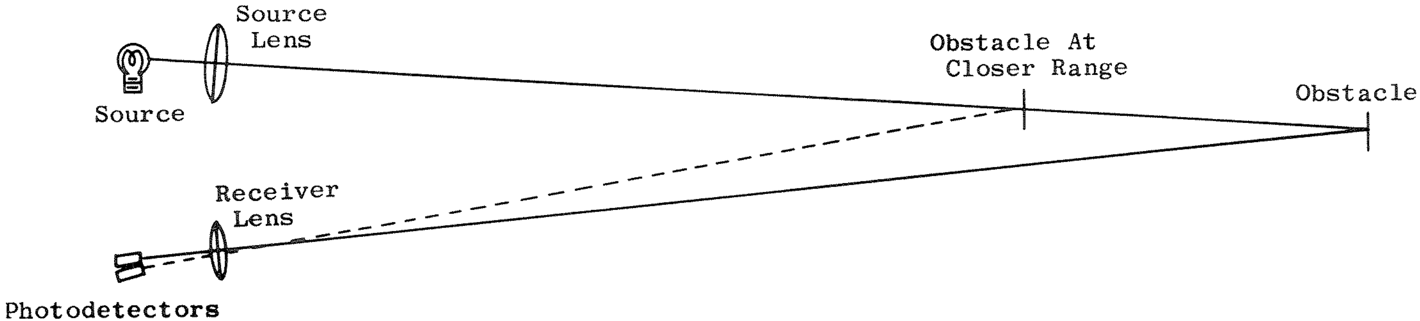
FIGURE 32.—C-5 Laser Cane in use (diagramatic).

distance to object detected (Fig. 33).

The signal emitted by the down-directed channel is a low-pitched, rasping 200 Hz tone designed to alert the traveler of down-steps of 6 in. (15 cm) or greater which appear about 3 ft (0.9 m) in front of the cane tip or 6 ft (1.82 m) in front of the user.

Usually, an electronic travel aid sends out a beam of energy and receives echoes or reflections from objects detected, before displaying processed information to the user. The C-5 *down* channel operates in a reverse mode. As long as light pulses are received by the down-channel receiving optics, the output is silent. When a pulse is *not* received, the down-channel signal is activated and the user is warned of surface drop-off.

The forward channel has both tactile and auditory output signals. The auditory signal is a medium tone of 1600 Hz, and may be switched on or off. The tactile output of the C-5 is a tiny, pin-like stimulator which vibrates against the index finger when an object is detected within the 5 ft to 12 ft (1.50 to 3.60 m) range. The forward beam will detect objects extending upward about 2 ft (0.60 m) from the walking surface. The forward channel has a range control which can be set to detect objects from a distance of 5 ft (1.50 m) to a maximum of 12 ft (3.60 m) from the cane tip. Range potential of electro-optical aids such as the C-5 vary according to the size, shape, color, or angle of approach to the object. Thus, when a maximum



Triangulation principle used in obstacle detectors. A light source is focused by a source lens on an obstacle. Two obstacles are shown at different ranges. Some rays from the image of the source appearing on the obstacle are focused by the receiving lens onto a photosensitive receiver. Obstacles at different distances reflect light to different receivers to discriminate range.

FIGURE 33.—C-5 Laser Cane triangulation principle used to discriminate range (diagramatic).

range is designated, it means that it was on the best possible target, a large and light-colored one.

The up-channel signal is a high-pitched tone of 2600 Hz activated by objects 30 in. (76 cm) in front of the cane tip and 6 ft (1.80 m) above it. In addition to detecting overhangs, the up-channel will respond to objects which extend from the walking surface up to head level. The forward-channel signal would be activated first; then at 30 in. (76 cm) from cane-tip distance, the up-channel signal would sound, and the user would hear both signals simultaneously (if the audio signal were on; otherwise the user would receive the tactile signal for targets ahead plus an audio signal if a high target appeared).

When in use, the C-5 is pivoted laterally like the conventional long cane with certain modifications of the long-cane technique to get peripheral information beyond the cane tip or to monitor pedestrians, guidelines, or automobiles. If the electronic elements fail to function, the traveler is still able to use the C-5 as a conventional, although somewhat heavier, long cane. The C-5 weighs approximately 16 oz (0.45 Kg) compared to the long cane which is approximately 8 oz (0.225 Kg).

The C-5 Laser Cane separates into two parts for easy carrying or stowage. The lower section contains no electronics and is light and tapered. The cane is available in lengths of from 42 to 54 in. (106 to 137 cm) in 1 in. (2.54 cm) increments. All the lasers and transmitting optics, two miniature electromagnetic speakers, the tactile stimulator, the laser-pulse drive circuits, the sound-output volume control, the receiving optics, and the printed circuit boards and other electronics are housed in the upper section.

A 6 V, 225 mA, nickel-cadmium rechargeable battery powers the C-5 system and is located in the crook. The battery is easily replaced, takes 12 hr to recharge, and lasts approximately 3 hr between charges. A small battery charger is included with the cane. The C-5 cane has no battery status control but has a battery test switch that generates a tone, the pitch is indicative of battery charge status.

Laser Hazard

When laser canes were introduced, hazard of radiation exposure to users was raised. However, studies indicated that gallium arsenide (GaAs) lasers used in the C-4 and C-5 are of such low power that radiation danger is negligible (Epstein and Meyer, 1970; Sliney and Freasier, 1969; United States Air Force, 1970).

Limitations

It is the nature of electronic travel aids to have problems, and to require compromises, and the laser cane is not excluded. It will not receive reflections from clear plate glass in windows and doors. Unless there is dirt on the glass or some object is within close range behind the glass, there is no warning. However, it will detect door handles, frames, and kick plates. The beam will not pick up low objects, and will fail to inform of gradual slopes. Glossy, highly polished surfaces both risk oblique reflection of the beam with failure of the forward-channel detection and increase the possibility of mistakenly activating the down-channel signal. Heavy precipitation (particularly snow) causes the up and forward channel signals to go off constantly. Under these circumstances, it is best to shut off the electronics and use the cane in the conventional long-cane manner. Because the IR beam is very narrow, one must be certain to keep it pointed in the direction of travel.

Training

Training to use the laser cane is more complex than that for the Pathsounder, but less so than for the Sonicguide. For persons who are already proficient with the long cane, the Veterans Administration training course, 4 hr, 5 days a week, takes from 3 to 5 wk to complete.

The teaching manual for the C-5 Laser Cane (Farmer, Benjamin, Cooper, Ekstrom, and Whitehead, 1974) is VA-oriented and is consistent with current ETA programs at the VA Blind Rehabilitation Centers.

At the Oakland Intermediate School District and Rehabilitation Institute in Pontiac, Michigan, several adults and youths were trained to use the C-5 Laser Cane. They confirmed findings that those who used the Laser Cane traveled with more confidence than they did with long canes, that their pace was speeded appreciably, and that their self-image improved (Goldie, 1976). Experience here also showed that young people have less tolerance for breakdowns and downtime than older VA consumers, who continue to use the Laser Cane faithfully despite electronic and mechanical problems.

Some students were hearing impaired and had trouble with traffic alignment. However, they used the Laser Cane to shoreline buildings to establish parallel relationships with them and the traffic, and to maintain more direct travel courses. They also used the canes to monitor pedestrians and trail them across streets.

The Sonicguide

The Sonicguide (Binaural Sensory Aid, BSA), was developed by Kay at the University of Canterbury, Christchurch, New Zealand, and is manufactured by Wormald International Sensory Aids Limited, Christchurch. Telesensory Systems, Inc. (TSI) handles assembly and distribution in the United States, Canada, and Brazil.

From its inception, the Sonicguide attracted international attention and study, and involved professionals from many and varied disciplines. The idea was conceived in 1959 but the technology for its instrumentation was not available at that time. Instead, Kay developed a sensory aid called the Torch (Kay, 1970).

The Torch

The Torch, a hand-held, ultrasonic environmental sensor with a one-channel or monaural system, explored the field of view with a wide sonic cone of approximately 30 deg on either side of the mid-line direction in which it was pointed. It weighed 9 oz (252 g) with all the electronics self-contained. It had two ranges, 7 ft (2.1 m) and 20 ft (6 m), and an auditory display delivered through an earpiece (Elliott, 1969).

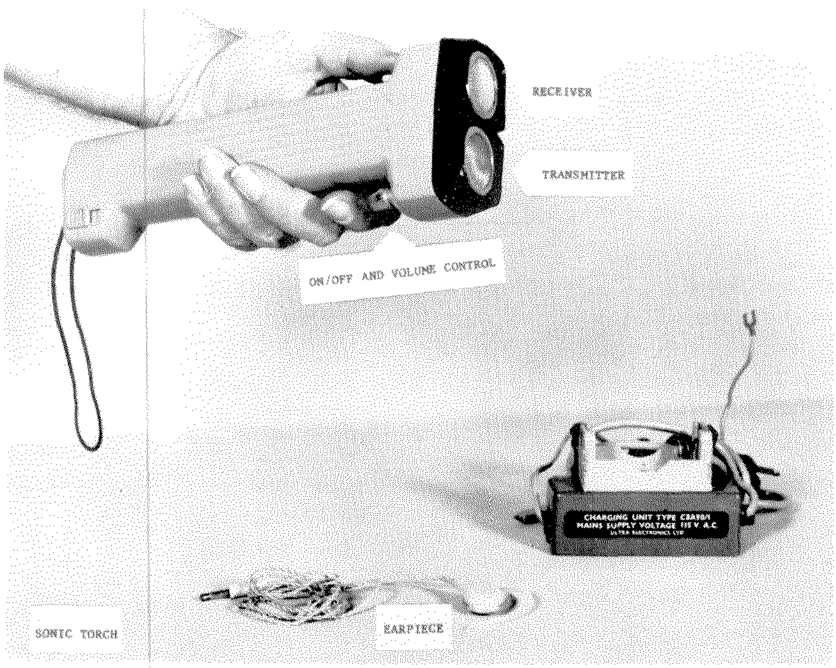


FIGURE 34.—The Torch.

The Torch has been evaluated in more countries than any other sensory aid, but it was unsuccessful in the sensory aids market because it was introduced and used as a primary travel aid. In addition, it was not accepted on a universal scale by the blind population because it was hand-held.

The Binaural Sensory Aids (BSA)

By 1966, Kay had added another channel on the principle employed in the Torch for a two-channel (binaural), head-mounted sensory aid known as the Binaural Sensory Aid (BSA). In 1969, limited training and field testing procedures were possible, and Robert Pugh, an American mobility specialist, trained four sighted persons (under blindfold) to travel using the long cane and the BSA.

The Canterbury Team, consisting of Leslie Kay; Robert Pugh; mobility specialist Nancy Bell; electronics engineer, Derek Rowell; and William Keith, a psychologist with additional training in audiology, conducted a year-long evaluation for long-cane travelers in New Zealand and dog-guide users in Australia.

Instructor's Courses

An international evaluation of the BSA in the United States and Britain was formulated and was ready for implementation by early 1971, calling for specialists formally trained to teach the use of the BSA to blind travelers in both countries. In 1971, binaural sensory aid instructional courses for mobility specialists were held at Boston College and Western Michigan University. The 4-week courses were attended by a total of 17 specialists.

International Evaluation

The BSA underwent extensive training and evaluation, with many agencies from the United States, Britain, New Zealand, and Australia participating. Not only was the device itself under scrutiny, but teacher training formats, teaching methods, teaching skills, length of effective training periods for teachers and trainees were also investigated. Questionnaires were sent to teachers and different ones to trainees (Airasian, 1973), and the response rate was 84 percent from the mobility specialists and 79 percent from the trainees. Survey results indicated that the BSA, with modifications, had potential for a certain segment of the blind population.

The Sonicguide Mk II

The Sonicguide exemplifies the analog system, collecting and displaying an abundance of environmental information to the user with the option of using all or whatever part of the messages one wishes to use, or is capable of using. As Russell suggests, the Sonicguide gives the text rather than the headlines delivered by such "go-no-go" devices as the Pathsounder and Laser Cane. The aid was designed to give the blind user greater perception of the environment through the auditory sense. It supplies the user with three kinds of information: (a) distance estimation, (b) azimuth or directional appreciation, and (c) interpretation of tonal characteristics which make object identification possible; the latter, providing rich information, however, only with much practice and experience.

The Sonicguide gives protection from above the head to about knee height. The sides of the body are more than adequately protected by the very wide sonic cone which exceeds 45 deg to the right and left. It does not, however, provide information about downsteps or very low objects in the travel path.

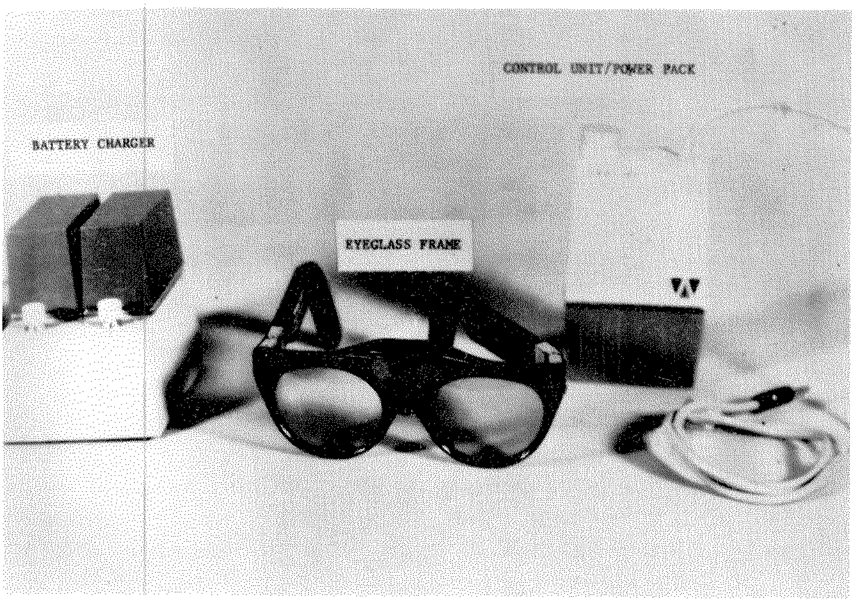


FIGURE 35.—The Sonicguide Mk II.

The Sonicguide Mk II is a secondary ETA to be used in conjunction with either a dog guide or long cane (Fig. 35). Some electronics, three miniature wide-band transducers (a central tiny ultrasonic transmitter located just above the bridge of the nose and two small receivers above and on each side of the transmitter), and two hearing-aid ear phones are housed in a pair of spectacles. A control box carries more electronics, switch, volume control, and a removable battery. The auditory output is directed into the ears by means of ear tubes that do not obstruct ambient sound. Because the right receiver is pointed somewhat to the right, it will detect the echoes of ultrasonic pulses from objects located to the right of the user's path more effectively than those to the left. Thus the corresponding signals delivered to the right ear will be louder for objects on the right. If the user turns his head toward the right, the volume in the two ears will change, becoming equal when the centerline of the head points directly toward the object.

The Sonicguide signals enable the user to estimate distance by relating it to pitch. It has a maximum of 20 ft (6 m) with specular targets (large, smooth surfaces like walls or plate glass) and an effective range of 12 to 15 ft (3.6 to 4.5 m) with diffuse objects (smaller or rough surfaces like trees or foliage).

Object Identification by Signal Timbre

The Mk II enables perception of tonal characteristics that give information about the nature of the presenting surface, whether it is specular or diffuse, as well as its range, direction, and dimensions. If a user "looks" at a smooth, round aluminum post, the reflected echoes will have a single-frequency, pure-tone quality. However, a tree presents many branches and leaves with multiple frequency components. The echoes reflected from these surfaces will be scattered, presenting an electronic image of the totality of a tree, through signals of a scratchy, harsh quality.

Power

The power supply is housed in a small control box, not much larger than a deck of cards, with an on-off/volume control knob. The control box is connected to the left temple of the spectacle frame by a flexible cable. A battery charger supplied with the Sonicguide accommodates two rechargeable, nickel-cadmium batteries. A battery charge lasts about 5 hr, and a 14 hr recharge will restore a totally discharged battery.

Sonicguide for Children

The Sonicguide Training Aid for Children is a version of the Mk II with a smaller frame and adjustable temples. The aid was designed for use in concept development, and as an environmental training aid to enhance spatial awareness and sound localization skills in blind children (Telesensory Systems, Inc., 1977).

Limitations

In addition to the fact that the Sonicguide does not offer protection from drop-offs, there are other limitations. High winds can affect reception, and the aid may lose sensitivity in heavy rains or have to be turned off in snowstorms because of almost constant, random echoes from snow flakes. There may also be ambient disturbances from neon signs, although they could be used as landmarks in areas frequented by a traveler. The Sonicguide output is auditory, and the signals quite possibly could be masked in certain very noisy situations.

Training

Because the Sonicguide is a complex ETA, the training period in the VA Blind Rehabilitation Centers is from 4 to 6 wk, 3 to 5 hr a day. Training methods and formats may be found in the training manual written by the Canterbury Team (Kay, Bell, Keith, Pugh, and Rowell, 1971) and in articles by Farmer (1975), Jackson (1977), and Baird (1977). Training manuals and aids are available from Telesensory Systems, Inc.

The New Hampshire Department of Special Education received a grant to develop a systematic approach to low vision distance training with severely visually impaired children and adults through the use of the Sonicguide (Carter, 1975). A 9-yr-old boy in this project still had some minimal residual vision in one eye. He scanned so rapidly that he was not able to use what little vision he had left, and had extreme difficulty in pinpointing exactly where or what things were. Use of the children's model Sonicguide enabled him to scan more effectively, to confirm the presence of an object, and to locate it (Carter and Carter, 1976).

The youngster also became more aware of the use of light and color in mobility, using the Sonicguide to look for light in a doorway or contrast between a dark frame and an opening. It was hoped that he would use the Mk II as a distant-information-gathering tool, for better assessment of various objects and colors and to interpret blurs.

ETA Training Courses

A 6-wk-postgraduate training course for specialists in the use of ETA's and teaching methods has been established at Western Michigan University, initially under a VA contract. It consists of practical exposure and experience with the Lindsay Russell Pathsounder, the Laser Cane, and the Sonicguide, and includes principles of operation, teaching methods, program implementation, and demonstration of less well-known devices.

Other courses have been held at Boston College and San Francisco State University. At the latter, emphasis was on use of ETA's for concept development in blind and visually impaired children.

Other Electronic Devices and Systems

Light Probes

Light probes are simple instruments consisting of photocells connected to an electronic circuit and in turn to transducers with one or more outputs. A light probe detects a light source and converts it into an audible or a vibratory output that varies in intensity or frequency with the intensity of the source. Attachments and accessories are often added to the probes to enhance their usefulness and versatility.

Mowat Sonar Sensor

The Mowat Sonar Sensor is a secondary ETA that can be used by dog-guide and long-cane travelers to locate bus-stop signs, benches, doorways, other landmarks, and pedestrians. It can be useful in concept development for blind children, for deaf-blind and geriatric blind persons, and potentially for those with low vision (Fig. 36). It was developed in New Zealand by G. C. Mowat, it is manufactured and distributed by Wormald International Sensory Aids, and it is available in the United States, Canada, and Brazil from Telesensory Systems, Inc.

The Sensor measures 6 in. x 2 in. x 1 in. (15 cm x 5 cm x 2.5 cm), weighs 6.5 oz (184 g), is hand held, has a vibratory output, and can be easily carried in a pocket or purse until needed. If an audible output is desired, an earphone is available. The device emits an elliptical ultrasonic cone 15 deg wide and 30 deg high, approximating the form of a human body. There is a single control, three-position slide switch on top of the unit to enable the user to operate the Sensor at two ranges. A longer range of 13.2 ft (4 m) may be selected by pushing the slide switch forward from the off center position. A shorter range of 3.3 ft (1 m) is attained by moving the control backward from the center position.

The Mowat Sensor is silent in free space and detects only the nearest object within beam range. When an object is detected, the Sensor vibrates at a rate which is inversely related to the distance from the object; at 13 ft (4 m) from a target, the aid vibrates at a rate of 10 pps and increases to a vibratory rate of 40 pps when the traveler advances to within 3.3 ft (1 m) of the target. The aid is powered by a rechargeable battery made in New Zealand, but 9 V nonrechargeable transistor batteries can also be used.

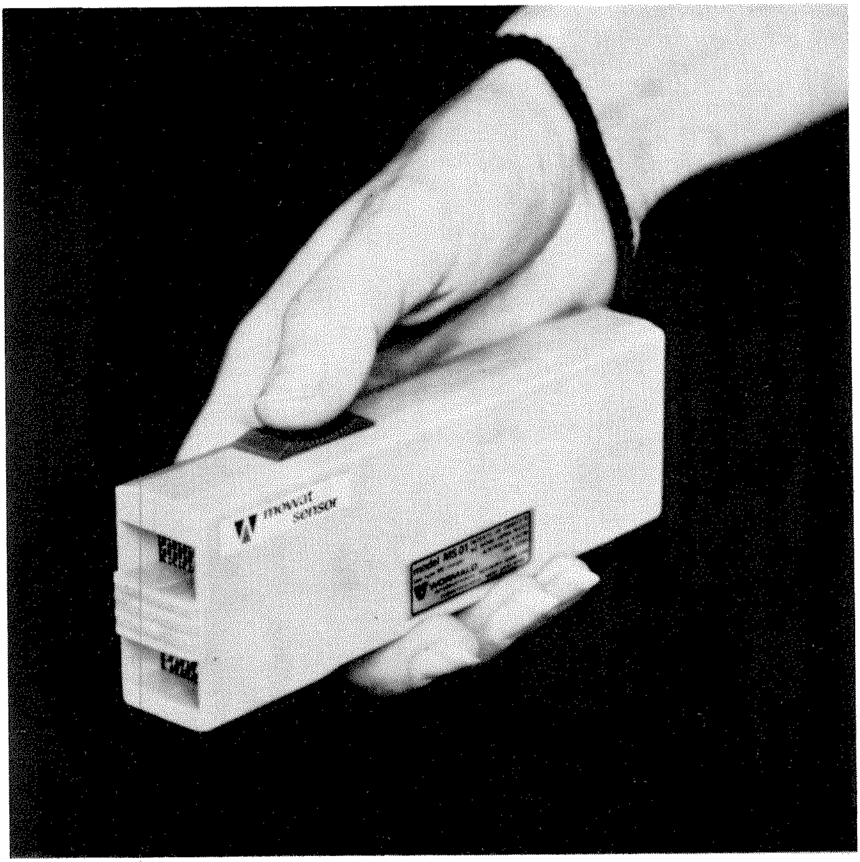


FIGURE 36.–Mowat Sonar Sensor.

The Nottingham Obstacle Detector

The Nottingham Obstacle Detector (NOD) is a small hand-held ultrasonic device that transmits pulses of high-frequency sound (40 kHz) in a narrow beam ahead of the user. Like the Mowat Sonar Sensor, it is useful in certain specific situations (Fig. 37).

FIGURE 37.–The Nottingham Obstacle Detector.

The aid has eight outputs, each note (the notes of the major musical scale) corresponding to a small range of obstacle distance: 0-12 in. (0-30 cm) will give an output signal of one tone, 12 - 24 in. (30-60 cm) will give an output signal of another tone, and so on. The maximum detection range of the aid, 7 ft (2.10 m), thus is subdivided into eight 12 in. (30-cm) zones, each with its own individual signal tone. The signal tones go down the musical scale as the target is approached. The device is silent when no object is within range. When there is more than one object in the field of view, NOD signals the presence of the nearest object (Armstrong, 1974; Heyes, 1975).

The NOD has an on-off control and a small loudspeaker to supply audio output. Provision is made for the use of an earphone with volume control if needed. The addition of an optional display, using tactile coding, is under consideration (J. D. Armstrong, personal communication, October 21, 1976).

A study indicated that users had no difficulty in learning the relationship between the major scale notes and the distance being represented. The aid is used mostly for location of landmarks and to avoid obstacles in difficult situations. It may also be useful in teaching concept development and spatial awareness.

The FOA Swedish Laser Cane

The Bionic Laser Cane inspired the work begun on the Swedish Laser Cane in 1972 by the Research Institute of the Swedish National Defense (FOA) (Benjamin, Benham, Bolgiano, and Meeks, 1967; Fornaeus, 1973; Fornaeus and Jansson, 1975).

The FOA Laser Cane has only one oblique, upward-directed channel. It is designed to be competitive in weight with the conventional long cane, approximately 8 oz (0.225 kg). Although in the developmental and evaluation stage and not yet in serial production, its cost is considerably less than the C-5 Laser Cane with three channels.

The single up channel has only an auditory output, and the optics are adjusted to detect objects approximately 6 ft (182 cm) in front of the user. Objects extending upward from the ground may be detected by the up channel at a distance of 20-39 in. (50-97 cm).

The lighter weight and lower cost of the cane are achieved at a sacrifice of output. Justification for designing a one-channel information transfer capacity (ITC) device was that the consumers could not use a three-channel device efficiently. However, there has not been significant evidence in the American experience with the Bionic Laser Cane to support this belief. Consumers trained in the use of the Bionic Laser Cane have had little difficulty in processing, and utilizing, three-channel information. The 16 oz (448 g) weight of the Laser Cane has never been a factor because users are taught to neutralize the weight of the cane by bending the elbow and relaxing the wrist instead of employing the straight-arm conventional long-cane position. The battery in the crook also raises the center of gravity, giving a comfortable balance.

The Mims Infrared Mobility Aid

The operating principle of the Mims Infrared Mobility Aid, optical triangulation, is somewhat similar to the Laser Cane. The developmental versions of the Mims Aid consist of two narrow cylinders attached to the temples of conventional eyeglass frames (Fig. 38). One cylinder contains a pulse-modulated light-emitting diode (LED) optical transmitter that emits a train of 20 μs pulses of non coherent

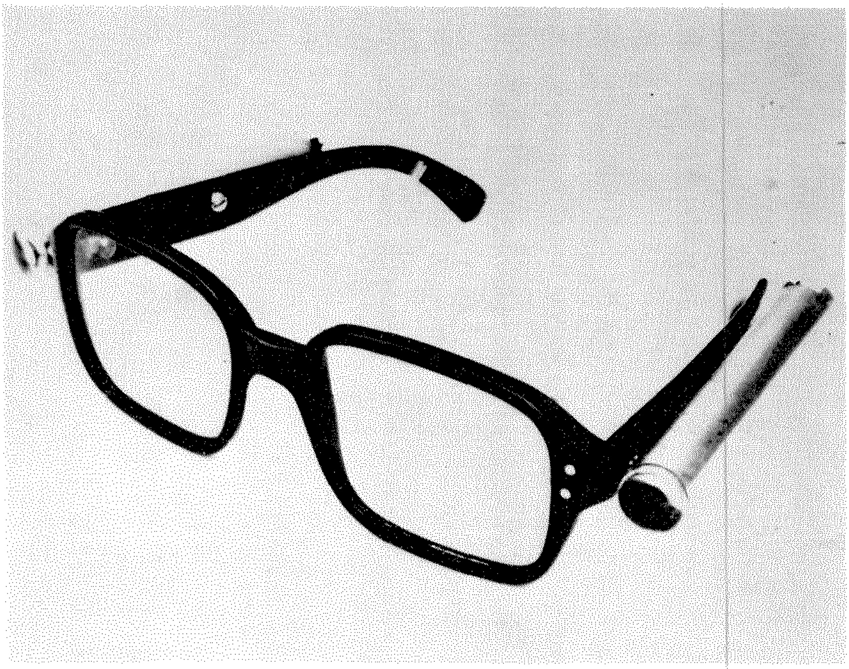


FIGURE 38.—The Mims Infrared Mobility Aid.

infrared radiation at a repetition rate of 120 Hz. The other cylinder contains a high-gain optical receiver and a miniature magnetic earphone. Both cylinders are completely self-contained and incorporate individual lens elements, batteries, and power switches. When an object illuminated by the infrared transmitter enters the field of view of the receiver, a signal tone is conveyed to one of the user's ears through a thin plastic tube. The tube does not block the external auditory canal (Mims, 1972a, 1972b, 1972c, 1974). No curb detection is provided, so the aid should be used with a long cane or guide dog.

Farmer and Whitehead (1973) recommended redesign of this ETA to extend the range and incorporate a three-zone detection scheme.

The Single Object Sensor (SOS) Bui Device

For those who feel that the information displayed by the Mk II Sonicguide is too complex for effective use, there is a head-mounted aid with capabilities between the "go-no-go" and the analog ETA. A new Canterbury Team is developing and evaluating a head-mounted aid, the Single Object Sensor or Bui Device (Fig. 39). It has the advantage of a limited environmental sensing capability with a very

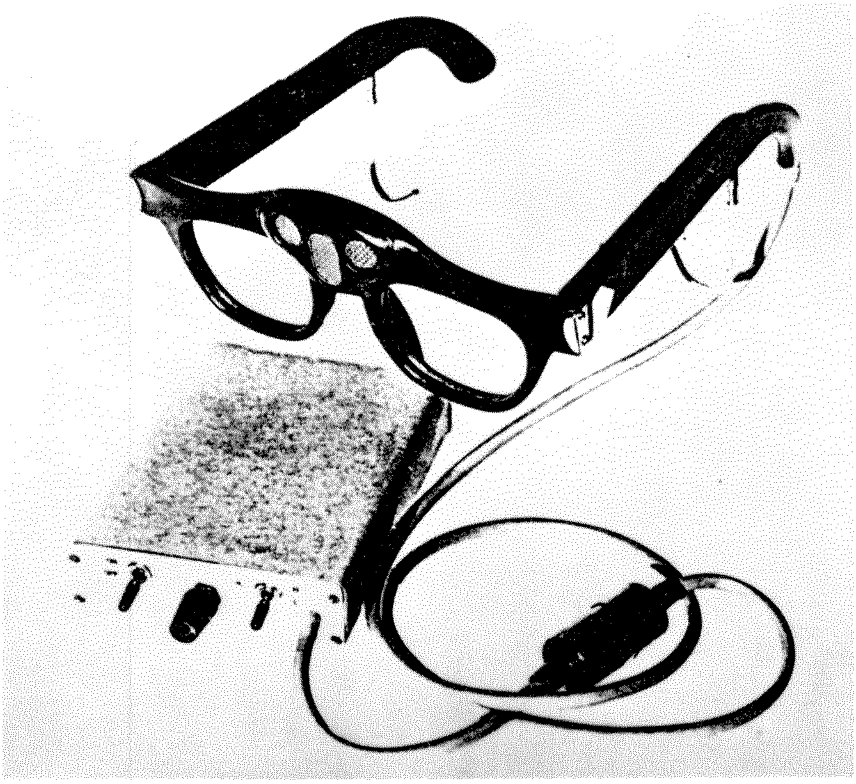


FIGURE 39.—The Single Object Sensor (SOS) Bui Device.

simple display (L. Kay, personal communication, October 22, 1976).

The SOS or Bui Device has binaural display with a comparatively wide beam of coverage (45 deg) for direction determination. The complexity of the display is considerably reduced, and the sensing of the environment is restricted to the nearest object. A vertical beam of 25 deg has been provided to warn the user of head height objects, but one must move the head up or down to detect higher or lower objects.

The basic sounds of the device are repetitive clicks with distance being coded in terms of the repetition rate. At 16 ft (4.8 m) from an object, a rate of 30 clicks-per-second is heard, while at 6 in. (15 cm), the rate is 1000 clicks-per-second. Some character recognition of signals is retained in the Bui Device but is much less pronounced.

An experimental model of the SOS has been undergoing laboratory testing and evaluation for a few years. It has not, as yet, been extensively field-tested. A monaural version of the SOS is also available.

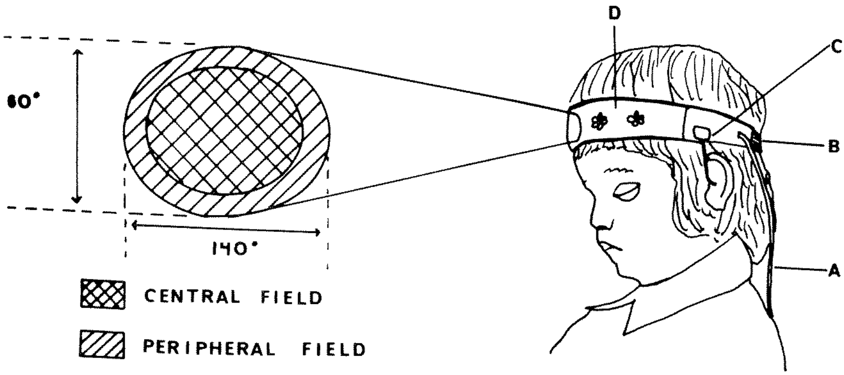


FIGURE 40.—A Canterbury Child's Aid.

A Canterbury Child's Aid (Fig. 40) has been developed and standardized, and a few are now being used in work with children in several countries. The components normally found in the frames of adult aids are placed in a durable, flexible, foam head-band which can be adjusted to fit any head size by a snap-on elastic strap at the back. For cosmetic purposes, the ultrasonic transducers are covered with a nylon monofilament material. The aid is designed for short range use so that a child can make better use of the sensing features (Strelow, Kay, and Kay, 1978).

III. EXPERIMENTAL DEVICES

ETA's now in use are designed to aid in orientation and mobility performance only. Research is in progress to try to develop a substitute for vision which may be useful not only for mobility but also in education, employment, and leisure activities.

Electrocortical Prosthesis

Brindley and Lewin (1968) implanted an array of 80 electrodes in the visual cortex of a newly blinded woman to demonstrate that electrical stimulation of the cortex could induce phosphenes (light spots or illusions of light).

Dobelle and Mladejovsky, in 1973, positioned an array of 64 platinum electrodes in contact with the visual center of the brain and succeeded in inducing phosphenes in two blind subjects, one of whom was able to identify simple geometric patterns and letters of the braille alphabet.

Prospects for a successful electrocortical visual prosthesis that would result in some useful vision, satisfy moral and medical considerations, and meet the approval of the consumer and scientific community seem remote for the immediate future because of the problems involved in electrocortical implantation: possible physiological risks (e.g., inducing epileptic seizures, or overheating of brain tissues by electric currents), the erosion or electrochemical effects of implanted electrodes, the great number of electrodes and multiple leads required for sufficient information transfer, discomfort to user, and subminiaturization limitations.

Technological advances have provided at least partial solutions for some of these concerns. Platinum electrodes embedded in Teflon have a slower erosion rate, subminiaturized cameras, components, and circuitry are now a reality, and the use of miniature computers to preprocess information might serve to reduce or bypass present hardware. (Sterling, Bering, Pollack, and Vaughan, 1971; Hambrecht and Reswick, 1977.)

A vision substitution system now under investigation consists of a lens and a subminiaturized camera that would be placed in an eye socket and attached to the eye muscles. A miniature computer in the temple of eyeglasses would convert light transmitted from the camera into electrical impulses and send the impulses to an array of electrodes implanted against the visual cortex to induce phosphenes that would provide some degree of visual experience (Dobelle, 1977). Other investigators (Dawson) have proposed intervention and stimulation at other points along the visual pathway. So far all are experimental.

Elektroftalm

The Elektroftalm is a portable, opto-electro-mechanical mobility aid that translates converted optical images formed on the photodetectors into mechanically stimulated tactile images displayed on the forehead of the user. Witold Starkiewicz has continued the work with the Elektroftalm in Poland, and evaluation of the device is currently underway at the Pomeranian Medical Academy.

The Tactile Vision Substitution System

The Tactile Vision Substitution System (TVSS) is an experimental device designed at Smith-Kettlewell Institute of Visual Sciences to present two-dimensional patterned information to blind users through the skin of the abdomen (Fig. 41).

In the test procedures with the TVSS, a fairly complicated obstacle course was devised for tests using blind and blindfolded sighted subjects. They were able to discern a clear passageway through these obstacles, walking quickly and accurately and avoiding collision

FIGURE 41.—The Tactile Vision Substitution System (TVSS).

with the obstacles solely by means of information provided by the portable system. (L. A. Scadden, personal communication, 1976).

Future development plans call for the design and construction of miniature mechanical stimulation matrices that will eliminate the use of existing cumbersome electrocutaneous displays. (C. C. Collins, personal communication).

CONCLUSION – ETA's

The impact of ETA's on the rehabilitation of blind people already has been widespread, and perhaps may have been a catalyst for the extensive introduction of mobility training programs. For example, the Sonic Torch has probably been more responsible for spreading interest in and knowledge of orientation and mobility and long cane skills, particularly outside of the United States, than any other event.

Walter Thornton, an Englishman blinded during World War II, who learned to use the Torch from Kay, said that it supplemented the cane and improved mobility performance in some travel situations (W. Thornton, personal communication, 1976). St. Dunstan's (an institution serving the war-blinded in Great Britain) asked Thornton and others to assess the training system in the United States for possible use in Great Britain. As a result, American specialists went to England to train mobility specialists, to develop mobility programs at various agencies, and to establish a course to train future instructors.

In the past 10 yr, 198 instructors have been trained and there are an estimated 5000 long cane travelers in Great Britain. The impact of ETA's was largely – even if indirectly – responsible for what has happened in Britain – it opened a door to a formal and professional approach to orientation and mobility with nonelectronic aids.

The BSA also gave rise to the establishment of mobility programs and the introduction of long cane skills in New Zealand and Australia. When Kay arrived at the training and testing stage with the BSA, he brought Pugh and Bell from the United States to train blind (and sighted blindfolded) persons to use the aid in conjunction with the long cane. Up to that time there were no trained mobility instructors or instruction of any kind in the use of the long cane.

Imaginative and resourceful specialists in the United States are now using ETA's to enhance mobility performance and to enrich rehabilitative training for children, youths, and adults.

The Future

It is true that ETA's, like most electronic devices, are far from perfect, and they are expensive. Jackson (1977) discusses sources of funding for training programs and individual users. They do, however, offer advantages to many visually impaired people, addressing many special travel needs.

A mobility specialist may question the future of electronic travel aids and sensory systems. The fact is that the value and potential for supplementary use of ETA's by properly selected and trained blind and visually impaired persons has been established. It remains for the proper authorities to help make them more easily available and for consumers and mobility specialists to use ingenuity and creativity in their use. Mobility instructors should play an active role in furthering refinement of the use of these devices.

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APPENDIX B

Editor's Note—The book will have three appendices: A. text of Veterans Administration Specifications for the Long Cane (Typhlocane); B. Guidelines for Selecting Candidates for ETA's; and C. A Training Format for Persons Using the Pathsounder in Conjunction with a Wheelchair, Walker, or Crutches. Appendix B only is included here, as follows.

The following general guidelines are offered to assist the referring agents. They are intended as guidelines and do not necessarily exclude a veteran from consideration or participation in the ETA program.

1. A candidate who is totally blind or one with light projection or less seems most appropriate for these devices.
2. A candidate should possess sufficient health and stamina to undergo a concentrated training program.
3. A candidate should be capable of perceiving and distinguishing the various signals (audible, tactile, vibratory, etc.) of the devices.
4. A candidate should be an active, independent traveler capable of utilizing an electronic travel aid.
5. A candidate should have successfully completed an O&M training program at an accredited blind rehabilitation center or agency or dog guide school.
6. A candidate should have a reasonable amount of independent travel experience after completing an O&M program before applying for the ETA program.
7. A candidate should be willing to participate in an evaluation and follow-up program after completing the training course.
8. A candidate should be aware of and in agreement with the policy that issuance of a device is contingent upon the successful completion of the training course.
9. A candidate should be aware of and in agreement with the policy that device issuance is on a loan basis until such time that it is no longer used or appropriate in meeting the veteran's needs.