INTRODUCTION

In this report I present a short term analysis of a variable pitch, echoing device used as a mobility tool for the blind. This device, the Kay ultrasonic mobility aid, Type 8A9, is manufactured by Ultra Electronics Limited, Western Avenue, Acton, London, W.3, England.

Dr. Leslie Kay of Christchurch, New Zealand, first introduced the concept of this frequency modulation ultrasonic mobility aid around 1960. He based this aid in part on the analogy of the bat orientation system—a principle of ultrasonic radiation and detection that is used by bats while traveling in darkness to avoid hitting obstacles and to find food. The device soon afterward received wide scientific and popular recognition.

DESCRIPTION OF DEVICE

The 8A9 Kay ultrasonic aid for the blind consists of the following:

1. A torch unit complete with rechargeable battery
2. An earpiece complete with a cord and earclip
3. A spare rechargeable battery
4. An extension lead to connect the torch with an external 9-volt dry-cell battery (for use in circumstances where battery charger cannot be operated)
5. A leather carrying case for the torch unit, battery, and extension lead from the torch to the battery
6. A battery charger
7. A leather case for the battery charger

Editorial Note: The torch is a transmitter-receiver unit shaped like a flashlight with a long handle. It contains transistors, correlated components, and ultrasonic transducers in the forward part which are protected by an external wire mesh. When in operation, the torch transmits a beam of ultrasonic radiation.

The work for this report was performed by the author independently.

A former Navy man, the author is now employed as an engineer for an industrial manufacturer. Totally blinded in 1966 as the result of an automobile accident, he has since completed 15 weeks of rehabilitation and mobility training at the Greater Pittsburgh Guild for the Blind and 30 days training at Seeing Eye, Inc. To date, he has been working constantly with both cane and dog guide.
sonic energy. This beam upon striking an object is reflected back to the device and is picked up by the receiver. Since this beam is ultrasonic and cannot be heard by the normal ear, the frequency is reduced to within the normal range of hearing and becomes an audible sound. The pitch of the sound that is produced is actually proportional to the time interval between the sending and receiving of the beam. This interval varies in accordance with the distance of the object that is detected. An object that is detected at close range, therefore, will return the beam sooner, the interval between sending and receiving will be shorter, and the tone of the output signal will be in a lower pitch. For objects detected further away, the time interval increases and the pitch of the tone becomes higher. The variable sounds produced by the energy returned from objects detected may be interpreted by the user to determine approximate distance, texture of the object, and contour of the object.

EVALUATION PROCEDURE

The apparatus was assembled and operation of the controls was verified to be in good working order. The first work with the torch unit was done in the interior of my home. Work was principally concentrated on locating objects and openings and estimating distances. Outside work began on my residential lot, which is heavily wooded with trees and bushes. A sighted companion was used during the initial outside trial. With a fair degree of confidence established in the instrument, independent trials were conducted on the residential lot and one quarter of a mile of the surrounding neighborhood. Battery life and charging procedure experience were accumulated during these trials.

Independent travel, utilizing the torch as the only mobility aid, was conducted for a variety of situations involving travel along paved asphalt roadways, equipped in the main with curbing but no sidewalks. Experience was gained in discriminating and locating landmarks. Usage was broadened to a greater degree by independent travel in known areas remote from the immediate neighborhood, such as parking lots, random traveling with no recognizable travelways, narrow, steep exterior stairways, and complex interiors complete with naturally located objects and people. The torch unit was used for mobility in the working business environment and it was exposed to only a narrow variety of environmental conditions. The majority of these conditions included warm, dry weather in either daytime or nighttime. However, a minor amount of work in cool, damp, and rainy environments was performed.

Total estimated usage time was about 25 hours. Total time was accumulated over a 6-month period consisting of approximately 1 hour of usage per week. Weekly usage was spaced at intermittent intervals of 20 to 30 minutes per trial.

All discussions, remarks, and conclusions were drawn from the above experience.
McClung: Evaluation of 8A9 Ultrasonic Aid

DISCUSSION

Perception of Objects

Isolated Objects

Objects with no echoing background can be easily located and traced utilizing either short range sounding (under 7 ft.) or long range sounding (up to 20 ft.). The location of an isolated object is virtually exact since a high contrasting sound is detected when the beam encounters the edge of the object. With no echoing background the rebound signal is practically nil. Regular objects (such as autos, buildings, poles, etc.) can be easily traced for exact outline of form. Irregular objects (such as trees, bushes, people, etc.) can be readily judged for general contour (width, height, and general outline).

Superimposed Objects—The Detection of Objects with a Reflective Background

The accuracy of detecting objects with a reflective background is proportional to the distance of the object from its background. For example, it is practically impossible to detect a flat plane such as a sign that is mounted closely adjacent to the side of a building. As the offset distance of such an object increases from its background, the contrasting echo is more readily detectable. The greater the degree of contrasting pitch of the echo, the more accurately the superimposed object can be located and traced. The same remarks with regard to form as apply to regular and irregular isolated objects apply to superimposed objects.

General

The prime requirement of safely detecting an object, before the user collides with it, is in the main fulfilled. There remains the problem of completely scanning the potential collision area. Slow, careful scanning, such as an “X” pattern, in front of a user yields practically 100 percent safe mobility. However, this slow method of progress is not generally acceptable to the well-mobilized blind person and would be utilized only in areas that are totally unknown or known to have obstructing objects that might strike the user above the waistline. Travel over more conventional travelways such as sidewalks, roads, corridors, etc., can be conducted with a fair amount of speed (1 to 3 m.p.h.), while utilizing a short horizontal sweep of about 2 to 3 ft. in width and aimed at a ground level approximately 4 to 5 ft. in front of the user.

This method of scanning the travelway was found to yield auxiliary information such as projecting branches and other minor and major objects located below the waistline. Even such minor projections as a weed in the travelway could be distinctly detected in time to avoid collision.

As with most mobility tools, the unit’s best usage as an object detector depends on a great deal of concentration while traveling. Since the receiving
Bulletin of Prosthetics Research—Spring 1968

earpiece covers one ear and the user's mind is intently concentrating on this signal, all other audible sound information is very definitely reduced to secondary importance. I would estimate that one loses as much as 30 to 40 percent of available secondary sounds falling on the single exposed ear. This loss generally consists of minor, low volume background sounds. Any background sounds of medium to high volume consistency are readily discernible. Despite this masking effect, the auditory system seems uniquely able to discern and register any sound of primary importance, such as potential safety hazards, etc.

Static observation yields a fascinating amount of information to the user. The unit provides object detection by scanning in a far greater degree than any other apparatus used to date. The user knows for a considerable distance where open spaces exist, where objects are located and their general form. He can measure each with respect to another and virtually obtain an audible pattern of his surroundings. Only a sighted observer could exceed the unit's performance in this respect.

The user will find it fascinating to realize that this information can now be “read” on an independent basis. To know the width, height, and outline form of trees, buildings, etc., and each in relationship to the other, is an exciting revelation. An interesting auxiliary piece of information under the topic of object detection should be noted—the fact that overhead wires can very sharply be located and the direction in which they are strung is readily discernible. This could provide an important locating and directional device for persons in unfamiliar territory.

**Distance Measuring Ability**

**Short Range**

With practice the user can become quite accurate in measuring ranges to objects less than 7 ft. away. At a distance of 7 ft., estimating accuracy was good for ±1 ft. A shorter range of about 4 ft. generally yielded an accuracy of about ±6 in. At shorter ranges distance estimating ability seems to be of lesser importance than object detection.

In explaining this point of view, take the example of a user utilizing a typical 2 to 3 ft. horizontal scan at a directed range of 4 to 5 ft. As the user approaches a closed door mounted flush in a wall he will detect the wall at about a 6 ft. range. With the range continuing to close, at about 3 ft. the user will simultaneously direct the torch beam at waist level and fairly accurately locate the door knob, since it represents a projecting object about 3 in. offset from the door. At this close range, object detection generally becomes more important than range estimating, since either the object is to be located for use or veered around to avoid collision. If the user intends to locate the object for use, he will continue to close the range and will be able to estimate contact within ±2 in. The distance
measuring ability at very close ranges (under 1 ft.) is not as accurate as one might suppose. One would think that the short range would give extremely accurate estimations of about ±\(\frac{1}{2}\) in., but in truth the pitch becomes such a low frequency tone that discrimination of tonal variations can only be estimated to about ±2 in. These remarks are all related to a mobile person. If one should stand and estimate static distances, he can probably increase his accuracy as much as 50 percent.

**Long Range**

The estimation of distances utilizing long range echoing is poor. However, there seems to be no real reason to desire a high degree of accuracy while utilizing this type signal. Its primary value seems to be in object location, such as landmarks. The fact that landmark location is very accurate and that an estimate of the distance to the landmark is somewhere between 10 and 30 ft. is very useful information. As the user closes on such objects he can commence distance estimating when within the short range capability and is then working quite accurately in both locating and estimating the distance to the object.

**General**

The ability of the instrument to indicate distance as a function of varying pitch provides the user with more than just a distance measuring device. It allows him to obtain a three dimensional aspect of objects. As an object is traced for contour, the user can also discern, due to pitch variations, the form of the object. For example, a tree can be located with respect to the user, its shape determined by scanning. While scanning, the pitch will vary as the beam sweeps across the object, telling the user what portions of the object are closer to him and what portions are farther away from him. A three dimensional auditory picture is thereby obtained by the user.

**Discrimination of Material**

There seems to be a certain amount of ability to determine the difference in some materials. In particular a strong, short, and hard sounding echo is obtained off glass surfaces. This is especially noticeable when a fairly large area of glass is set flush into a surrounding wood surface. The surrounding wood surface does not give as strong a rebounding signal as does the glass. Contrasting surface textures also offer some differences in echoing. A flush mounted smooth garage door surrounded by a rough exterior house trim such as shingles, etc., offers a much stronger signal rebound than does the surrounding texture.

Many attempts were made to discriminate between an asphalt driveway surface and the lawn surrounding it. This is important in mobility so that the user may travel an intended path. The typical sweep speeds synchronized to the user's stride rate did not yield any differences between the two surfaces.
However, it seemed that as the sweep speed was increased to about double
the typical stride rate, a small amount of difference could be detected as
the beam crossed from asphalt to lawn and straight line travel was consid-
ensibly improved utilizing this method. The same effect was observed while
traveling along the edges of asphalt pavement having no sidewalks but
equipped with curbing. The ability to maintain contact or location of the
curbing was fairly accurate at slow speeds (1 to 2 m.p.h.) and scanning fairly
close to the user's feet at a range of about 2 to 3 ft. However, as mobility
speed increased (2 to 3 m.p.h.) and the range extended to about 6 ft.,
accurate location of the curbing on each sweep was very poor at the regular
sweep speeds. By doubling or tripling sweep speeds it was found that contact
with the curbing could be maintained to a far greater degree. This effect
is undoubtedly due to a greater transient dynamic as the beam passes over
the curb. The faster sweep rate produces a more discernible contrast between
the slight variations in pitch. Undoubtedly, the additional “looks” at the
curbing also helped to reinforce the sensation of its location.

Certain shapes of smooth objects were found to give a distinctly different
rebounding echo. For example, small diameter iron pipe rails along stairways
are quickly and accurately located, due to their characteristic echo. The
echo from such a surface is best described as a small, hard, short ping as the
beam scans across it. Telephone wires, lamp posts, and telephone poles also
reflect this type of characteristic sound. It is felt that since all of these objects
are of a circular form, the echo obtained from them may be more due to
their form than to their material. In any event, this characteristic sound
serves as a valuable addition to the auditory spectrum.

False Echo Analysis

Since the transmitting and rebounding signals are in a wave form, there
exist certain areas that tend to reflect a reinforced signal which is received
by the user as a much stronger contrasting signal than the typical areas sur-
rounding it. The user may determine in error that this stronger signal is
indicating some object other than the area being scanned. In particular,
while scanning along a corridor the rebounding echo from the sides of the
corridor give a fairly weak signal, due to the low angle with the wall. While
concentrating on this weak signal, the user will generally encounter the end
of the corridor, at which point a corner on each side is located. When the
beam strikes into the corners they reflect a very strong echoing sound, even
stronger than the wall at the end of the corridor. At first this contrasting sig-
nal tends to confuse the user, but with practice he can begin to interpret this
false echo for what it really represents, that is, a corner or projection that
allows echo reinforcement. In this manner the user can stand in a room, and
by scanning all four walls he can very quickly locate and estimate the dis-
tance to each one of the four corners, giving him good orientation to his
surroundings.
Another type of signal that may not technically be called a false signal, but is certainly one that tends to be lost to the user, is the sudden appearance of an object crossing at a very short range, such as a person moving rapidly in front of the user while the user is working at the more typical 5 to 7 ft. range. The sudden, very low frequency echo rebounding from the person tends to be hidden or ignored in the higher frequency echoes from the long range material. This same type of hidden or ignored signal is often encountered while traveling in close proximity to other persons. When the user does detect this sudden encroaching, very low frequency signal, about the best that he can do is to stop abruptly to determine what object has suddenly located itself in his path. This of course leads to short halting advance in travel. The inability to detect people moving obliquely from the side or rear into the scanning beam is of course no fault of the instrument itself, but certainly does not allow much freedom for traveling among persons under crowded conditions.

As mentioned before, the incident angle at which the beam strikes material being scanned affects the strength of the rebounding signal. The weak signal obtained when traveling at good speeds (3 to 4 m.p.h.) due to the user scanning at maximum short range and at a fairly high sweep rate causes detection of short dropoffs to be very difficult. This can be a serious difficulty in that curbs cannot be accurately detected at intersections. It is more than probable that the user will step off the curb and discover it by kinaesthetic rather than auditory detection. However, this may not be too important in the light of such facts that only the agile user would be traveling at such speeds and probably experiences the very same thing when using a mobility cane. For example, my mobility cane measured according to prescription stride is a length of 42 in., but as my experience increased with the cane and my travel speed increased, I soon began to overrun curbs. My cane was first extended to 51 in., then later to 54 in., in an endeavor to overcome this difficulty. Even with the rather lengthy additions, I still oftentimes overrun curbs when traveling at high speeds. Obviously the detection of curbs or down steps is greatly enhanced if the user can anticipate such down steps in advance and slow his approach so that a more accurate scanning can be executed.

**CONCLUSIONS**

I am basing all my conclusions on the fact that my evaluations are of a short term period and will undoubtedly be altered somewhat as depth of experience is gained. I am also very aware that the successful utilization of this apparatus depends upon a fair degree of hearing acuity. It is my opinion at this time that the apparatus represents only a fair means as a primary mobility tool. It does not compare in mobility accuracy to the mobility cane or dog guide. However, it does offer some major advantages and benefits.
A considerable amount of environmental information can be realized while utilizing the apparatus. This can be of such immense satisfaction to the user that he could come to prefer it to the above mentioned mobility devices. This preference would have to go before a desire to perform at reasonable speeds in a high degree of accuracy and safety. It is doubtful that the person intent on traveling to and from particular locations for specific purposes would find the instrument satisfactory. The advance rate would be too slow and embarrassing dislocations and collisions would probably result. However, in the hands of a user whose intent is merely walking for pleasure, he would find such an instrument a very interesting and satisfactory device during his casual strolls.

The instrument is also quite good when used in interior, fairly uncrowded residential environments. Its ability to accurately locate objects, estimate distances, and give considerable background information greatly enhances its usage for this purpose.

I cannot help but theorize as to some tremendous advantages that could be gained from utilizing such an instrument that might be equipped with as much as triple sending and receiving devices as now employed. Each set of heads might operate over a different frequency band. Such an instrument might yield an extreme amount of information of all the area being scanned and would reduce the scanning chore considerably. It is reasonable to assume that one might obtain a three dimensional sonic picture of the scanned area. I would therefore recommend additional work in this area if thought practical that such an approach be undertaken.