ASSISTIVE LISTENING DEVICES FOR THE DEAF: A REVIEW

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DEDICATION:

“TO NATURE AND HER CHILDREN”

Because to her who in the love of Nature holds,
Communion with her visible form, she speaks
A various language and she never betrays the heart that loved her,
To her destiny the road in never too long.
Her special gift is friendship and humanity
Which adds fragrance to life.
They create Love and Trust, most of all these two little things
brings joy and understanding and a “Heart of giving”
She has shown me that giving has much meaning,
especially when meant for the needy children.
She has taught me to train these children the way they should go and
I’m sure that when they grow old, they will not depart with her
O Nature let me share your silence in this world of sound.

CERTIFICATE

This is to certify that the Independent Project entitled "ASSISTIVE LISTENING DEVICES FOR THE DEAF" – A Review of Literature is the bonafide work done in part fulfillment for the First Year M.Sc., (Speech and Hearing) of the student with Register No. 8804.

Dr. N. Rathan
Director
All India Institute
of Speech and Hearing.

CERTIFICATE

This is to certify that the Independent Project entitled "ASSISTIVE LISTENING DEVICES FOR THE DEAF" – A Review of Literature has been prepared under my supervision and guidance.

Dr. M.N. VYAS AMURTHY

GUIDE.

DECLARATION

This Independent Project entitled "ASSISTIVE LISTENING DEVICES FOR THE DEAF" – A Review of Literature is the result of my own study under the guidance of Dr. M. N. Vyasamurthy, Department of Audiology, All India Institute of Speech and Hearing, Mysore – 570 006, and has not been submitted earlier at any other University for any other Diploma or Degree.

Mysore Reg. No. 8804

Date:

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INTRODUCTION

"Dawn speaks in Whispers and the long, low light seems to make the silence thicker, but the creeping shadows and enveloping hush are only a prelude to a new tomorrow, when once again the world will arise bright and clear.

New beginnings and brighter tomorrow are also the promise of a small miracle – Hearing help through Assistive Listening Devices and System".

The sensory apparatus of hearing is an indispensable tool for hearing and for the development of speech and language. Its functions are co-ordinate with the other sensory modalities like vision, touch, taste and smell, the former two being the most important. Those individuals who have been deprived of their sense of hearing might have to depend on the visual and tactile sense for communication. A prelingually deaf child has difficulty in comprehending and expressing through speech. With the invention of hearing aids the residual hearing of a hard-of-hearing child may be exploited to the maximum for the development of speech and language.

The hearing aids are the most widely used assistive listening device among the deaf.

A hearing aid consists of a microphone which converts the acoustical energy into electrical energy, an amplifier which increases the magnitude of the electrical signal, a receiver which transducers this signal back to its acoustical component. The power source is the battery. The volume and tone controls permits variations in the intensity level and the emphasis of high or low frequency components of the signal respectively. Thus a hearing aid merely amplifies the sounds of the environment including the speech of others. There have been modifications of the hearing aid such as frequency transposition aids to suit specific populations of the hard-of-hearing. The extent of assistance obtained from a hearing aid depends on many factors, one of them being the degree of hearing loss. Individuals with mild and moderate degree of hearing loss and good speech discrimination are able to utilize it to the optimum. The server and profound loss individuals with poorer speech discrimination do not benefit only through amplification through the auditory mode. They may also have to depend on speech reading information received through the visual and tactile senses. Hence other sensory aids which use the auditory, visual or tactual modalities or a combination of the three have been developed in recent years. They are called "Assistive Listening Devices and Systems" (ALDS).

The term ALD comprises of all systems which are meant to improve the communication ability of hearing impaired persons or to make them aware of the presence of environmental sounds. Although the personal hearing aid meets these criteria it is generally considered distinct from the assistive devices – Harriet Kaplan, 1987.

Another definition of an ALD given by Robert F.K. Zelski (1985) is "Assistive device are products designed to solve one or more specific listening problems created by a hearing loss". He grouped these devices into (1) Listening device eg. personal ALDS and group which use the auditory mode only. (2) Telephone devices eg. TTY's (3) Alert/alarm devices – eg. vibroalarm, burglar, smoke alarm, etc..

Assistive devices are designed to over come the problems that exists and encountered in the use of hearing aids. They unable better understanding of speech in difficult listening environments (Harriet Kaplan, 1987). The S/N ratio is improved by placing a remote microphone as close to the sound source as possible.

The signal enters the microphone at essentially the same intensity level at which it is spoken and is then processed so that energy is not during transmission to the listeners ears. Noise and other unwanted signals in the environment travel through the air to reach the microphone of the assistive listening system and thus they lose energy in the process (Harriet Kaplan, 1987). When the microphone of a personal hearing aid is located on the listeners head or body it is often equidistant from speech and noise. Under these conditions both the desired and underside signal might reach the hearing aid microphone at the same intensity level or at worst, the speech might arrive at an intensity level lower than that of the noise in which case the result is an unfavourable signal to noise ratio and poor understanding of speech. Listening through a hearing aid from a distance can be difficult even when environmental noise is minimum. As speech travels through the air from its source to the hearing aid microphone, the attenuation of the speech signal affects the short, soft high frequency consonant sounds more than it does the stronger, low frequency sounds (Harriet Kaplan, 1987). Therefore the speech becomes too soft for comfortable listening and is also distorted. With assistive listening devices with remote microphone distance listening is better facilitated (Harriet Kaplan, 1987.)

There are a number of ALDS, among them the frequency modulated system, infrared system, induction loop system, hardwire system are all auditory ALDS. Not all assistive devices are auditory. Visual and vibrotactile system are used by hearing impaired people who cannot benefit from amplification through the auditory modality. They include alerting devices such as flashing lights or vibrators which provide awareness of important environmental sounds, telecommunication device for the deaf (TDD's) which make telephone communication possible through the visual channel, and the close captioned decoder which has made T.V. accessible to millions of the hard-of-hearing people.

HISTORY OF ASSISTIVE LISTENING DEVICES SYSTEM

Educational programs for the deaf children and organization's for teachers of the deaf existed long before anything was available for hearing impaired persons. Training programs in speech reading for the hearing impaired adults became available around the late 1870's (Vaughn and Lightfoot, 1987). The first consumer organization in the field of hearing impairment was the National Association of the Deaf which started in 1880. The Alexander Graham Bell Association (AGBO) was organized in 1890. AGB provides information on speech reading, education advocacy, aids and devices and the psychological and social implications of deafness (Vaughn and Lightfoot, 1987).

Under the leadership of Ruth R Green, Green organized the 1st public program on ALDS. The league has played an active role in the development, evaluation and application of ALDS (Vaughn and Lightfoot, 1987).

In the year 1910, National Association for Hearing and Speech Action (NAHSA) was founded which served as the principal consumer organization advocating the availability of listening systems, on a national basis (Vaughn and Lightfoot, 1987).

Ears and the man, a book written by Pick Samuelson and Lehman in 1926 (cited in Vaughn and Lightfoot, 1987) expressed many of the needs for listening devices that only now are being addressed half a century later.

Between 1920 and 1930 many leagues on hearing societies were established. These groups provided classes in lip-reading and later they became the advocates for the installation of amplification systems in public places. (Vaughn and Lightfoot, 1987).

Large area ALDS debut:

HARDWIRE SYSTEMS:

1926 - One of the first group hearing aids was made by Radio-ear for the San Francisco League for the Hard-of-Hearing in 1926. This massive Hardwire system had upto 100 earphones which could be used when groups of hearing impaired persons attended lectures at the league. However the fidelity of these systems was not good. (Vaughn and Lightfoot, 1987).

1960 - The most recent accomplishment in “Hardwiring” is the feature of audio input that permits the personal hearing aid to be plugged into TVsets, video players, tape recorders and Frequency modular (FM) and infrared receiver (IR) and this was established in 1960. (Vaughn and Lightfoot, 1987).

AUDIO INDUCTION LOOP (ILP):

The ILA technology is as old as transformer technology. Loops have been used to help the hearing impaired for about

40 years. Audio loops were used in Europe earlier to their use in the United States and other countries (Vaughn and Lightfoot, 1987).

1950 - In the late 1950's systems made by N.V. Phillips Co., of the Netherlands were installed in public buildings in the States (Vaughn and Lighfoot, 1987).

1970 – In 1970 the Philips Co., discontinued the use of ILA. The hearing aid industry has greatly improved the performance of telecoils. Many now function with both the wide are loop system and with the newer neck-worn loops that have magnetic voice coil. Adaptors are also available now for newer telephones that do not have magnetic voice coils. These adaptors pick-up the acoustic voice and generate a magnetic field that couples with the telecoil in the hearing aid (Vaughn and Lightfoot, 1987).

Audio loops were introduced in the United States by Desmod Carron an Irishman. (Vaughn and Lightfoot, 1987).

RADIO FREQUENCY SYSTEMS:

1968 –In 1968 this system became popular in United States. Radio Frequency System consisting of both amplitude modulated (AM), FM were employed (Vaughn and Lightfoot, 1987).

HL Electronics (Phonic Ear, INC) developed and began manufacturing auditory trainers for use in education of hearing impaired students.

Scott-and Ruth Holden founders of HL Electronics were pioneers in FM development.

The original auditory training systems operated in the commercial 88-92 MHz frequency band (Vaughn and Lightfoot, 1987).

1970 – The AM systems were put to use in 1970. The users had to furnish their own receivers usually consisting of pocket size radio's

These produced too much distortion because of their small size and simple electronics. They also had little audio band-width and usually did not have sufficient output to be of benefit to the majority of hearing impaired listeners. (Vaughn and Lightfoot, 1987).

1972 – In 1972 a petition was put-forth by the phonic ear to the Federal Communication Commission to release 32 frequencies in the 72-74 MHz band for the hearing impaired. They also asked for the use of FM systems in locations such as theatres, placed of worship, concert and lecture halls and amusement parks other than the classrooms. (Vaughn and Lightfoot, 1987).

1979 – In 1979 the FM systems first used for concerts and theater by Buffalo Philharmonic during their orchestra concerts (Vaughn and Lightfoot, 1987).

1980 – In this year multiple FM transmitter system were installed in churches, courtrooms and public assembly rooms for use when there were several speakers or when translations into several languages were required (Vaughnand Lightfoot 1987).

1981 – In 1981 the Washington Ear INC put in FM systems in five local theaters in the district of Columbia. This system was used for the deaf and for the blind. For the latter group narrations of stage settings, costumes and performers were transmitted over the FM system (Vaughn and Lightfoot, 1987).

1982 – In 1982 the petition put-forth by the phonic ear was granted (Vaughn and Lightfoot, 1987).

INFRARED SYSTEMS:

1976 – In this year the 1st IR system were introduced in Europe by Sennheiser of Austria and Beyer Dynamics of Germany. These were meant for home entertainment. New fields of application quickly added. They were used for multilingual translations for international conferences. Simultaneous interpretation became possible. Museum guide systems also began using IR systems (Vaughn and Lightfoot, 1987).

1978 – In 1978 the IR systems was used for the hearing impaired population for entertainment purposes. The use of IR system was started in United States by the Infra Red Public Address System (IPAS) by Horst Ankermann and Cornelis Hofman in 1978. They used them in lecture halls, churches and entertainment parks. Hofman also helped design infrared products for use by hearing impaired individuals in person-to-person and telephone applications.

present efforts are focused on the installation of IR systems in college theatres and small towns in the United States of American. In the play entitled ‘children of a lesser God’ – Winner of Oscar award, IR system were used (Vaughn and Lightfoot, 1987).

During the 1950’s before audiologists manufactures began to encourage the broad use of FM auditory trainers, infrared and loop systems as personal communication devices, Thaddeus J.Zelski turned his body hearing aid into and ALD by putting the coil on the table and by holding the receiver in his hand and placing it close to the mouth of the talker (Vaughn and Lightfoot, 1987).

1979 – The term “Assistive Listening Device and Systems” was coined by Gerald I. Williams in 1979. (Vaughn and Lighfoot, 1987).

1983 – This term was shortened to ALDS by Anne F. Seltz and this term has been used by the consumers, professionals and manufacturers in 1983 (Vaughn and Lightfoot, 1987).

TELEPHONE DEVICES:

1876 – In 1876 Alexander Graham Bell planted his telephone device (Vaughn and Lightfoot, 1987).

1934 –In 1934 the telecommunication Act mandated that a communication service with adequate facilities was to be made available as for as possible to all the people of the United States (Vaughn and Lightfoot, 1987).

1982 – In 1982 the congress enacted the telecommunication for the Disabled Act. The Act included help for hearing impaired people (Vaughn and Lightfoot, 1987).

TELECOILS:

1947 – In 1947 Engineer Sam Lybarger discovered the phenomena of magnetic leakage in telephone receivers. This led to the development of the telecoil in hearing aids and permitted not only improved usage of hearing aids that were fitted with telecoils for telephone usage but also their later compatibility with wide area induction loop systems (Vaughn and Lightfoot, 1987).

TELEPHONE AMPLIFIERS:

1984 – In 1984 the American Telephone and Telegraph National Special Needs Center (NSNC) offered three types of Amplifiers, a amplifier headset, a super amplifier handset and portable strap on amplifier. They also supply TDD models, signaling devices, tone ringers, loud and auxiliary bells and other products aimed at meeting the special communication needs of people with hearing, speech, vision and motion impairments. (Vaughn and Lightfoot, 1987).

TELETYPEWRITERS:

1963 – In 1963 Robert Weitbrecht invented the modern which provided the link to the telecommunication systems. (Vaughn and Lightfoot, 1987).

1986 – In 1986 David Meyers promoted the study of the user of teletypewriters in federal agencies.

TELEVISION:

Television has given electronic eyes and ears to the people of the world. ALDS now make the sound of TV accessible to hearing impaired persons at a level consistent with their needs and those of companion listeners. Now there is more than "picture" TV – a new dimension in TV permits viewers especially the deaf to read the program script. Close captioned TV has made TV viewing accessible to hearing impaired viewers.

1979 – In 1979 the National Captioning Institute (NCI) was established by the United States Department of Education to bring access to TV viewing to Americas hearing impaired population. The late Frederick Schreiber a leader in the deaf community was the force behind this movement. (Vaughn and Lightfoot, 1987).

Companies involved in the manufacturing and developing of ALDS are continuing to improve the systems in regard to the ease of both installation and use. Industry is also dedicated to the development of hybrid and high technology modular systems that will reduce user costs. From 1987 the voices of hearing impaired talkers and concerned listeners has appeared to have 'caught the ears' of increasing numbers of professionals, industrialists, administrators and community leaders. The potential of millions of hearing-impaired listeners was at last realized.

Considering the present status, the ALDS are making it possible for many hearing impaired persons to functions well at home, in the work force at school and in the community. Contributors to the success of ALDS are many. They include the hearing impaired listeners themselves and the concerned talkers who wish to communicate effectively with them; the professionals, the manufacturers and distributors and the sound system technicians; the community leaders and administrators of public meeting places and health care facilities; and related organizations – consumer professional and services. Many of the ALDS models are used in education, service and also research programs. (Vaughn and Lightfoot, 1987).

While in the west the sensory aids, products of several years of research are probably confined to research laboratories, but the teachers have an option to choose (prosthesis or no prosthesis), in India there is no choice. Irrespective of the magnitude of hearing loss, the audiologist is forced to prescribe some hearing aid or the other. There are no devices either for laboratory, or school, or the clinic. However efforts have been initiated in knowing more about ALDS and its use in India.

Therefore it can be noticed that the ALDS are important and they assist the hard-of hearing in specification conditions of communication. Therefore this review has been undertaken, and the following are the topics which shall be dealt in detail in the following serial order.

1. Types of ALDS

   a) Systems that use the auditory mode.
   b) Systems that use the visual mode.
   c) Systems that use the tactile the deaf.

2. Telecommunication devices for the deaf.

3. Characteristics of educational amplification systems and their selection.

4. Conclusion.

Effort has been taken to review all the different kinds of ALDS their advantages and disadvantages and the recent development in this field. No attempt has been made to review the hearing aids or its modification and the cochlear implants.

TYPES OF ASSISTIVE LISTENING DEVICES AND SYSTEMS

The systems that use the auditory mode:

The various ALDS of this category are described in detail below:

1. THE HARDWIRE SYSTEM:

It is one of the oldest auditory training devices in which an audio signal is distributed to the student by direct electrical wiring. (Fig.I)

The teachers microphone is connected to an amplifier and the resulting amplified signal is the delivered to a series of headsets located in fixed positions. A wireless microphone may be substituted for the fixed microphone in order to give the teacher greater mobility. The individual balance control boxes allow the students to adjust the gain independently to each ear. It is also possible to have several external inputs to allow other audio aids such as a tape-recorder, television or phonograph to be used. Additional microphone wired to the amplifier may be distributed near the children so that self monitoring and child to child communication is facilitated (Bess, 1981).

Some hardwire systems consist of a microphone connected by a long cord to a listeners hearing aid via direct audio input or a neck loop. Signal intensity is controlled by the vol. control on the hearing aids. Such microphone can be passed to takers, placed on a small conference table, or worn by the hearing impaired person on his or her clothing. The concept of the listener wearing a microphone on the clothing is called "Self wiring" and was introduced by Vaughn and Lightfoot (1983). Other hardwire system consist of a remote microphone connected by a long cord to a amplifier worn on the body with the amplifier attached to earphones or to the persons hearing aid.

Advantages: These systems generally provided a wide frequency range, low distortion and high sound pressure output under the headsets (Calvert, D.R. – 1964).

Thus they offer of high fidelity signal. They may be adapted to the Childs hearing loss and are fairly reliable and simple to operate. They also cost less than FM systems. (Bess, 1981).

Disadvantages: The three major disadvantages.

1. **Microphone placement:** Children monitor their own speech and the speech of other children by using either the teachers microphone or special microphone placed strategically near them. If the teachers microphone is used, there is considerable distance between the child (sound source) and the pick up microphone, thus creating a potentially unfavourable S/N ratio. If the classroom is noisy self monitoring and child to child communication will be negatively affected by the poor speech to noise relationship that will develop. (Bess, 1981).

2. Lack of mobility for teacher and the student : When there are activities away from the desk units it becomes necessary

for the children to use an alternative system such as the personal hearing aid. (Calvert, D.R., 1964, Bess, 1981).

3. They lack flexibility, in that they seldom allow for individual adjustment of frequency and sound pressure output. (Bess, 1981).

   Other disadvantage included repair service which is not readily available (Calvert, D.R., 1964).

II. PORTABLE DESK AUDITORY TRAINERS:

It is used primarily for individual training. It is more portable than the hardwire systems because it can be placed on a des or carried to provide continued amplification (Fig. II). Most of these systems offer volume control, a tone control and a balance control and produces high fidelity signal. The microphone is located on the unit itself, consequently the acoustic output and subsequent S/N ratio and signal level will vary as the teacher changes location (Bess, 1981).

This unit as mentioned consists of a small amplifier into which are plugged headphones for the child and one or two microphones, a microphone is provided for the teacher and another for the child. The volume control for each microphone is helpful to counteract the differences in loudness of the teachers and the childs voices. Some auditory trainers have a 'boom' microphone where the childs microphone is attached to the headphones and is held in place just in front of his mouth by a metal boom so that he is constantly able to monitor his own voice. It also helps in more free hand movement for the child. (Bess, 1981).

Although these units are considered useful on a one to one basis, the disadvantages are similar to those of the personal hearing aid because of the varying distances between the pickup microphone and the sound source (Bess, 1981).

Advantages:

This aid is designed to facilitate in matching the amplification as closely as possible to the childs hearing loss. (Bess, 1981).

Some have the facility of an AVC which can be set so that individual children are never subjected to sounds which may be uncomfortably loud for them. (Bess, 1981).

An induction loop system may also be attached provided such a socket facility is available. (Bess, 1981).

They also have an auxiliary input socket to allow the use of the equipment with tape recorder, radio and TV (Bess, 1981, Harriet Kaplan, 1987).

S/N ratio is also increased (Bess, 1981, Harriet Kaplan, 1987).

Disadvantages:

It restricts the mobility of the child (Bess, 1981). They cannot be used anywhere other than in the classroom (Bess, 1981).

III. INDUCTION LOOP SYSTEM:

When either the auditory training or the Hardwire system is used the child must be seated. The teachers mobility is also limited because of the microphone she/he holds. Younger children cannot spend the day wearing headphones and restricting their mobility.

The heart of this system is the ‘loom’ or a coil of wire, that surrounds the space to which amplified sound is to be delivered. (Fig. III). The signal is picked up by a microphone or microphones, amplified and transferred to the coil. An electromagnetic field emanates from the coil which contains all the speech information. This electromagnetic energy is picked by a very small coil of wire in a hearing aid called the telecoil. The telecoil delivers the electromagnetic energy to the hearing aid receiver which converts it back to sound (Bess, 1981).

Areas of any size can be looped. If the areas are larger, larger coils and stronger amplifiers which must be used. Loops may be permanently installed or portable. Speech is head by anyone using a telecoil within the area of loop installation or within a fixed distance outside the loop area. The loop can also be worn around the neck (Bess, 1981, Harriec Kaplan, 1987).

Advantages: There is reduction of background noise and avoidance of feedback (Barr Hamilton, R.M., 1978 and Edward J. Bunker, 1982).

The child need not be near the teacher to hear her speech (Edward J. Bunker, 1982).

There is improved mobility for the teacher and the child (Mark Ross, 1969).

It is relatively in expensive and easy to install (Bess, 1981). Special receivers are not needed because the receiver is the telecoil of the hearing aid (Bess, 1981).

Provides greater frequency range and thus hear clearly and distinctly (Edward J. Bunker, 1982).

It is also useful for those hearing aid users who wish to hear a speaker and does not require to communicate with those about him for eg. listening to lecture (Edward J. Bunker, 1982).

It may be used in homes, fitted to TV sets, allowing the hearing impaired listeners to follows the program without other people having to endure uncomfortably loud sounds (Richard G. Pimentel, 1984).

Some radio microphone receivers worn on a belt or a pocket are also connected to an induction loop which goes around the persons neck (David L. Wessell, 1984).

Disadvantages: The major problem is the spillover of magnetic field generated in one coil can be received by a telecoil in the horizontally or vertically adjacent room (Borrild, 1968, Bellefluer and Mc Maramin, 1965). The farther the loop induction system the farther outside the loop the signal will travel for eg. a telecoil will receive signals emanating from a loop in the adjacent room. (Bess, 1981).

Flourescent light and other source of magnetic energy might interact with the speech signal by introducing noise into the system (Bess, 1981, Harriet Kaplan, 1987).

Many hearing aids have telecoil that are too weak or are inefficiently positioned resulting in poor reception of magnetically induced signal (Bess, 1981, Harriet Kaplan, 1987).

The hearing aids frequency response characteristics in the microphone and 'telecoil' modes can change significantly. The microphone output is greater than the telecoil output and so the listener would have to increase the hearing aid volume when using the telecoil (Bess, 1981).

The system may also generated high levels of internals noise (Bass, 1981, Harriet Kaplam, 1987).

They are also difficult to repair (Clavert, D.R.., 1964).

Specific problems with preschoolers (Mark Ross, 1969).

In using loop amplification with preschoolers there is more time free play and less time in group communication activities. Since the magnetic strength is equal in the room irrespective of proximity, a child will receive the teachers voice as loudly as those for whom she intends to talk. Hence the association between the auditory event and experiential event is lost.

If there is more than one microphone placed in the room, since the child has not learnt to listen selectively to the sounds required, he/she may be forced to hear all the sounds in the room thus leading to confusion.

The author also emphasizes the use of hearing aid instead of headpones. The latter leads to a decrease in frequency range offered, increasing the distortion.

IV. F.M. SYSTEMS:

It was found that by transmitting speech signals on a high frequency carrier wave many of the problems associated with the hardwire and induction loop units are minimized. The FM system offers improved mobility for the teacher and the student as well as the elimination of noise interference produced by over spill. (Bess, 1981).

Most of the FM system use microphones to pick up speech at its source and some have the option of direct electrical connection to a radio or television. The speech is frequency modulated on to a radio frequency carrier wave and is transmitted through the air by an FM transmitter. The FM receiver worn by the listeners, demodulates the speech, amplified it and delivers it to the ear via earphones (Fig. IV b) or the listeners hearing aid (Fig IV a). Some systems must interface with hearing aids and few others use earphones. Some have the provision of using their aids with a direct audio input or the neck loop (Bess, 1981).

The BTE, body worn and eyeglass aids can be provided with direct audio input. The ITE's are not available with this feature.

The components of an FM systesm is given in Fig. Va & Vb

The student receivers usually contain one or two environmental microphone that offer the capability of self-monitoring and child to child communication. The hearing aid receiver has external inputs that allow for battery charging and for use with other auditory device like the tape recorder or phonograph.

A number of techniques have been developed for 'dovetailing' the personal hearing aid to the FM wireless system. One method is to use an electrical coupling or wire connection between the FM receiver and ear-level aid (Bess, 1981 and Harriet Kaplan, 1987). A second approach is an acoustic adaptation in which the output from the FM receiver terminates adjacent to the microphone of the earlevel aid (Bess, 1981). Another approach has been to employ a magnetic loop that encircles the students neck. The output from the FM receiver produces a magnetic field that is then picked up by the telephone coil of the personal hearing aid. But he performance of these 'dovetail' system is limited (Bess, 1981). Yet another type is the silhouette conductor, a flat hearing aid shaped device connected to the FM receiver and worm against the mastoid bone between the head and the hearing aid (Harriet Kaplan, 1987).

An in expensive group FM amplification system was developed by William a Worner (1988) to enhance auditory learning in the classroom. The purpose of this system was to equalize the SPL level and distance ratio between the speaker and the listener.

This system was composed of an FM wireless microphone and receiver, a 25 stereo amplifier and a pair of stereo speaker. Results indicated that the system equalizes the SPL throughout the room, with the increased SPL falling in the range of 70-73 dB.

The federal communication commission rules allow the use of eight wide band and narrow band FM channels for communication purposes. The receiver and the transmitter should have the same frequency bands. There is no universal FM receiver. (Harriet Kaplan, 1987).

Investigations of the electroacoustic characteristics of the hearing aid is also important (Barry Freeman, J.Stephen Sinclair and Donald. E. Riggs, 1980). These authors have suggested that the ANSI 1976 procedures be used for assessing a hearing aid can be applied for the measurement of FM trainers. They noticed performance differences in the FM mode and EM (Environmental microphone) modes. They stress the need to assess these systems in both the modes before making use of the same in the educational set up.

Advantages: FM transmission is an excellent choice for outdoor situations and large areas, because the signal can be transmitted to about 300ft. (Charles. E.Neyman, 1983).

Increases the speech intelligibility (Suzan.M. Bankoski and Mark Ross, 1984).

It can be used as an interpersonal device (Bess, 1981).

It can be used in conjunction with a TV or radio (Richard. E. Pimentel, 1984 and David. L. Wessell, 1984).

It provides greater mobility and flexibility and it is capable of delivering a high fidelity signal to the students ear. This is due to their low distortion and broad band frequency response. (Bess, 1981).

This system can be used by profound hearing loss children and many FM receivers are adjustable to accommodate different degrees and configurations of hearing loss.

Personally sized inductances loops (mini loops) are available for use with an FM classroom amplification system and the students personal ear level hearing aid. The frequency response characteristics of five commercially available hearing aids were assessed. 1. Using hearing aid test equipment with the hearing and in microphone setting and 2. in a public school classroom with the hearing aid on telecoil setting and operating with an FM mini-loop system. The clinic and classroom characteristics of the conventional FM receiver insert earphone auditory trainers were also assessed. The results in this study showed that the personal hearing aid classroom performance could not be showed that gain provided by the environmental microphone circuit of the FM receivers insert earphone units was uniformly higher than that provided by the teacher microphone signal route. (Van Tasell, D.J. , 1980).

Disadvantages: Most of the FM system do not provide adequate child to child communication (Booth Royd, 1981.)

In addition the hearing impaired child may be given a hearing aid receiver with unknown response characteristics that may or may not be appropriate for his/her hearing loss. (Bess, 1981).

Booth Royd (1981) states that problems are also caused by interference from extraneous, signals. The instrument would pick up the transmission of nearby radio frequency band if there is faulty equipment.

Problems may arise when more than one class uses the same transmitting frequency. (Harriet Kaplan, 1987).

If the teacher turns the microphone off and the students leave their receivers on it is possible for these students to receive the speech of another from an adjacent class room. (Bess, 1981, and Harriet Kaplan, 1987).

V. INFRA RED SYSTEMS:

This system has not gained widespread popularity. It means the transmission of signals by infra red light. (Fig. VI).

The teacher utilizes and FM microphone transmitter and an FM receiver is attached to the infra red transmitter. The teachers speech is converted from an acoustic signal to an electrical signal and modulated into a radio frequency carrier wave by the FM microphone transmitter. This signal is received by an IR transmitter that modulates it into IR light frequencies that are emitted from radiators. Several light emitting radiators are usually placed throughout the classroom for uniform distribution. The modulated IR light is than picked up by a receiver and demodulated before it enters the hearing aid. One modification of this arrangement is to place a dual channel microphone in the centre of the room. The microphone is hard-wired to the IR transmitter eliminating the need for initial FM transmission from the teacher. (Bess, 1981).

Advantages: This system offers a fidelity signal with a broad frequency range. The frequency range extends from 100Hz to 8000 Hz (Mark Ross, 1982). The output is around 112 dB. (Mark Ross, 1982).

The system is reliable and durable.

Each unit has a master volume control mode selector switch and on the back of the aid, separate loudness balance and bass controls for each ear. Thus many patterns of hearing loss can be matched (Bess, 1981).

Infra red system are generally used for large area amplification and home television use. (Bess, 1981, Harriet Kaplan, 1987).

Unlike FM equipment, the IR receivers are universal and can be used with any infra red transmitter. (Bess, 1981).

Unlike radio waves the IR light does not pass through walls and so there is no spill over. (Bess, 1981).

Disadvantages: The IR systems cannot be used outdoors or in rooms without emitters. The pupils units can be set to function as ordinary hearing aids under these conditions. (Mark Ross, 1982, David.L.Wessell, 1984).

The IR light is absorbed by block curtains and walls (Mark Ross, 1982, Charless.E.Neyman, 1983).

VI. SELECTIVE AUDIO FILTER AMPLIFIER (SAFA):

Kostic designed an equipment which consisted of devices to provide visual, tactile and auditory feedback. The auditory apparatus is described below:

This apparatus is the SAFA. This consisted of twentyseven independent units processing a segment of the frequency spectrum from 95 Hz – 14354 Hz. The instrument is adjusted to match the childs audiogram. The selectors produce eight different patterns of amplification for groups of children with mild to severe hearing loss. The total signal is amplified by 40 dB and the flexible parts of each pattern can vary by 40 dB (Bessy, 1972). The adaptable amplification can only benefit children whose hearing is close to normal curve and who do not need amplification dynamics greater than 30 dB (Bessy, 1972).

The conviction on suprasegmental features as a pre-requisite to language development implies that the training with SAFA will enable a child to demonstrate a finer discrimination of the suprasegmentals of a particular language. (Geetha Krishnan, 1978).

From the above discussion it is apparent that a microscopic section of the population of hearing impaired children would alone benefit from SAFA. Even for these children it is not beneficial throughout the day and hence its usefulness is questioned.

The ALDS which use the auditory modes have been described in detail. In the next chapter the ALDS using the visual mode is discussed.

Systems that used the visual mode:

Most of the deaf children do not solely depend on the auditory mode. Because of their deficit in auditory mechanism they have to supplement it with other sensory mode like the visual and tactile mode. There are assistive devices, which use the visual mode to convey the information to the deaf cases. To mention a few there is the Uptons eye glass aid, the TDD's (which will be discussed in detail in the following sections), the closed captioned TV, the oscillograph, visible speech systems, the friction and nasality indicator, alarm or warning indicator etc., These devices are discussed in detail in the following pages under separate headlines.

1. The Uptons eye glass aid: (Fig. VII) – It is one of the few notable wearable visual sensory aid. It was built by Upton a deaf engineer in the year 1968 for his personal use. It is a compact feature extraction device which can sort out phonetic features such as voicing, friction and plosiveness. The device controls lights which responds to each of these features. The miniature incandescent lights attached to the users eye glass lease are positioned in such a way that a V-shape is created. When the listener attends the speakers face, the V-shape frames the cheeks and throat and lips thus giving him appropriate visual clues. The successive illumination of these lights helps the wearer perceive the cues. In a later improved version, Upton used small light emitting diodes instead of the lamps which were found to be rather distracting.

The LED is attached to the spectacle temple. Its reflections can be seen on a tiny mirror attached to the lens. The device looks like a pocket calculator (Bess, 1981)

The advantage is that its less distractive than other visual aids and has to be supplemented with speech reading for its full benefit (Bess, 1981).

The other visual sensory aids are as follows:

2. Oscillograph and Cathode Ray Oscilloscope (CRO): These were the earliest devices used. The speech waveform was displayed on its screen by means of a sutiable microphone. The intelligibility of such a display for speech sounds in training the deaf is very low. (Liberman et al, 1968; Sherrick, 1978). Lecil. L. Bridges and Roy M. Huckabee (1970) have found the oscillographic display of speech useful with the deaf in a fourtyfive minute session using this instrument on subjects with high frequency hearing loss and articulation difficulties. The subjects showed marked improvement in mastering several phonemes. The oscilloscope traces produce visual model patterns of the therapists speech which the client had to match. This display may however not prove useful for very young deaf children who are immature enough to understand how the instrument works.

3. Visible speech system: (Fig. VIII) – It was first invented by Melvillie Bell 1872. Later a more sophisticated analysis of speech stream was provided by the system developed by Potter. Kopp, and Green (1974). In this a graphic plot of sound frequency versus time is displayed with intensity represented by darkness of tracings.

Experiments by Kopp and Kopp (1963), Searson (1965); Stark (1968), House (1968) and Stark (1971) have indicated that the deaf children can learn to interpret the spectrographic patterns and improve control of their articulation. However Liberman (1977) pointed out that the spectrographic pattern are rather difficult to read. This is because the acoustic energy is not concentrated where the important linguistic information is and the patterns fluctuate from moment to moment. The rapidly changing format frequencies are physically indeterminate. So Liberman (1977) posits that for these reasons mentioned above the skin may produce a more efficient input channel than the eye.

A case report was published by Rachel.E.Stark (1971) in which the real time visual displays of speech in the training of profoundly deaf nonspeaking child was used. The findings are as follows.

The author used spectral displayes and real time amplitude contours of speech in tteaching speech production skills to a profound deaf child four and a half year of age. This child had a visual attention problem, a behavior problem and a poor academic record. In individual instruction he was 1st taught to produce features of speech, for eg. friction, nasal and stops which are present in vocalizations of six – nine months old infants and then combined these features in syllables and words. He made progress in speech although sign language and finger spelling were taught at the same time. Speech production skills were retained after instruction was terminated. The results suggested that deaf children are able to extract information about the features of speech from visual displays and that a developmental sequence should be followed as far as possible in teaching speech production skills to these deaf children.

It was also noticed that the child did use sing language but did not loose interest in speech instruction and his behavior, attention and speech skills improved.

Ling (1977) has pointed out that any visual sensory aid should supplement lip reading and not distract the def individual. The spectrogram and other visual patterns provide the subject with general acoustic information of speech sounds. 000000The lip reading provides cues to process the articulatory gesture and not acoustic characteristics. A deaf individual cannot pay attention to both the aspects at the time. Thus speech especially through acoustic channel is difficult. Attempts have been made to develop certain speech training aids to help the deaf process any one aspect of the speech spectrum either the supra segmentals like (pitch, intonation or length or duration of syllables) or certain segmental features like plosiveness, friction etc. These aids are discussed below:

4**. Intensity indicator: (Fig.IX) –** This divide is a part of the kostics apparatus. Individual units are also available. This display consists of five light bulbs. The extreme bulb on the right is marked "too loud" the extreme on the left is marked "too soft" and the middle three bulbs normal. By speaking into a microphone attached to the device, the child receives direct visual feedback of the intensity level of his voice. The child has to adjust his intensity level so that he activates the middle three bulbs and keep them lighted. The sensitivity of the instrument can also be adjusted. The indicator covers a field of approximately 40 – 80 dB. This range is divided into five grades of 10 dB each. A signal of 20 dB lights up the too soft bulb and a signal of 80 dB lights up the too loud bulb. The intermediate levels light up the middle bulbs.

This can be used with children and may be more beneficial for aged deaf children who can understand the concept of this instrument and cannot be used in outside day to day speaking situations (Geetha Krishnan, 1978).

5**. Friction indicator: (Fig.X) –** It is also a part of the kostics apparatus. Individual units are also available. This device consists of a microphone, a filter which cuts off signals below 2 KHz and a visual display. This helps the def individual monitor the intensity of friction. His task is to produce friction eg. /s/ sound and maintain the point with a specified limit. While it is not possible to differentially produced different fricative sounds with the help of this device, deaf children can make differentiation between friction and non-friction sounds. The intensity indicator can be connected along with this device so that the subjects learn to produce and maintain the required loudness for certain fiction sounds. This system can be used with older deaf children and in the day to day conversation it may not prove useful. Once the child learns to produce the speech sound it helps him/her to use it in words and sentences. (Geetha Krishnan, 1978).

6. Nasality indicator: (Fig. XI) - This also falls as a part of the kostics apparatus. Individual units are also available. Nasalization is a significant factor for differentiating consonant sounds such as /b/, /m/ or /d/, /n/ etc. Where the points or place of articulation is the same and the child gets very little speech cues on lip reading. Speech perception research has indicated that the effect of nasality is concentrated mainly in two bands of frequencies, those situation just above the laryngeal voice and those around 1 KHz. These two bands are extracted and amplified through an amplifier. The resultant signal triggers a light bulb when it reaches a certain level. The advantage and disadvantages are the same as mentioned for intensity and friction indicator. The above three indicators was deviced by Prof. Dj. Kostic at the Institute of Experimental Phonetics and Speech Pathology, Belgrade, Yugoslavia. They are also used with selective audio filter amplifier.

7. Speech movement indicators: - There are device recently developed, which indicates the positions and movements of the tongue and larynx in order to train and correct the speech of the hearing impaired. Such devices operate from the speech received (J.M. Pickett, 1981).

When the speech signal is used the spectrum is transformed into the normal vocal tract shape that would result in that spectrum. Certain features of the spectrum are located and a reasonable shape of the tract is determined to produce these features. The shape of the tract is displayed as the vocal tract cross-section by means of a curve. The analysis and display are virtually instantaneous and 'movements of the tongue' appear on the screen as the trainee speaks. Speech indicators that respond directly to articulation and phonation have been developed eg. the artificial palate. This consists of a number of electrical contracts in the mouth. The contacts of the tongue are signaled on a display. The contact shape and areas of the trainees tongue can be visualized and this provided a feedback about the movement of the articulator.

Another direct sensor is the **Laryngograph.** This responds to phonation of the vocal folds by monitoring the degree of contract between the vocal folds. During the production of voice the vocal cords move back and forth very rapidly, closing and opening, to modulate the air flow from the lungs, thereby producing the fundamental source-sound for the voice. A periodic wave is displayed on the monitor. This wave is then processed in order to yield, the pitch, the VOT and the normalness of the voice quality. This system may be used to train the deaf speakers for better production and intelligibility of their speech (Pickett, 1981).

Fourcin and Evelyn Abberton (1972) have used the laryngograph with the deaf persons. Their results indicated that this instrument may help the deaf person to control the pitch register, acquisition and control of pitch changes and timing and voicing. Hence it is an useful speech training tool.

Other visual sensory aids used as visual reinforcements include the following (cited by King and Parker, 1981):

1. The RNID teddy bear vocal stimulator: Each time the child utters the sound or word the eyes of the teddy bear glows.
2. Toy train with acoustical control. This consists of an engine with two wagons. This may be used in cases who are not able to find a cause and effect relationship to the phonetic utterance and the flash of a bulb eg. in the case of cerebral palsied children. Each time the child says a sound or word or sentence the train moves. Greater the length of utterance grater the distance traversed by the train. In this way this device can be used to train in speech for the hard of hearing children.
3. Sound activated monkey (SAM): It uses the same principle as that of the RNID teddy bear. It can be sued with deaf children and multiply handicapped and also the mentally retarded. If the utterance is short the monkey climbs a short distance if the utterance is long it climbs a longer distance. If the utterance is stopped the monkey comes down.

8. The V.S.F. indicator : (Fig. XII) – It is a teaching aid developed by the Royal Institute for the deaf for use by speech therapists, teachers of the deaf and others involved in language and speech development of both children and adults with nearing loss. The indicator can be used in conjunction with conventional auditory training units in providing a complementary system.

On the front panel are three light indicators arranged vertically coloured from the top red, orange and green, the red light responds to all voiced sounds, the orange light to ‘f’ ‘th’ and ‘sh’ sounds such as ‘f’ in ‘fat’ ‘th’ as in ‘that’ and ‘sh’ as in ‘ship’. The green light indicates ‘s’ sounds as in ‘sip’. This arrangement enables the reinforcements of correct sound in isolation. It also enhances articulation exercises for movement in time from one sound to the next. Each light indicator can be individually switched for single sound exercises, or any combination of two response patterns. (cited by King and Parker, 1981)

The other visual aids include:

THE VOISCOPE: King and Parker (1981). The voiscope is a visual display of certain speech patterns which can be used to help hearing impaired children and adults to improve their speech perception and production. It is based on a piece of equipment called the Laryngograph which was originally developed as a tool for speech research, the pattern which are shown are mainly related to timing and intonation rather than speech sounds (segments) in speech.

In early development of childrens languages, it is the intonation pattern – the way in which the voice goes up and down – which are the earliest recognizable features both in the child's understanding and in speech production.

When words are spoken in English its not simply a matter of making them louder. The main stress in a sentence or phase is conveyed to the listener by a change in the pitch of the speakers voice. The overall pitch of the voice, and the way in which it changes are important in early language development but are often very difficult for children with a hearing loss to hear or initiate speech. Profoundly deaf children may also have difficult with the overall timing of their speech, speaking too slowly, with the overall timing of their speech, speaking too slowly, with pause between words, or producing extra syallbles at the end of some words and not enough syllables for others. Much speech sound production may tend to emphasize rather than improve, these timing problems.

The result of the child's ability to make systematic and normal contrasts at this overall, prosodic level is not only that speech sounds are strange, but also that the meaning and intelligibility of spoken language are affected. A visual display of pitch and timing is therefore a useful aid in teaching hearing impaired children. One such aid is the voiscope which displays information derived from the laryngograph, a device which monitors vocal fold vibration. Two electrodes are held flat on either side of the larynx with a soft band. When the vocal cords vibrate to produce voice, a changing signal is detected which corresponds in rate to the vocal fold vibration. The signal (known as larynx) can be used is several ways. With a stereophonic tape recorder, it is possible to record speech on channel one and the laryngeal signal simultaneously on channel two, to provide a permanent record of the child's production. The larynx can also be displayed on an oscilloscope, and the wave form provides some useful patterns – the differences for eg. normal voice creaky voice and whisper.

The more useful display produced by the voiscope is the fundamental frequency display. In this, the frequency of a speakers vocal fold vibration governs the height of a trace which moves across the screen from left to right for upto four seconds. The display gives instantaneous visual information about pitch, timing and voice quality as the person speaks. But the child is taught in simple stages, and in appropriate language as to how to interpret the display features by feature.

Apart from the above mentioned visual speech stimulators there are also aids which help the deaf in day to day situations.

Listening to environmental sounds in the home is a major problem for many hearing impaired person and this problem can be solved by the use of **altering devices** (Fig. XIII – XVIII). The commonly monitored house hold sounds include the doorbell, the telephone ringer, a baby or in capacitated adult, the alarm clock and the smoke or fire detector.

A flashing light or vibrator may be attached to the devices sensors so that the individual is alerted when a given sound occurs. Hearing impaired people frequently use alarm clocks in this manner. In addition to visual and tactile alerting system, auditory device are available for certain purposes, notably for monitoring the telephone ringer for which a more audible loud gong or low pitched signal can be substituted. Certain alerting devices are provided either by batteries or by line current. The monitored signal can be transmitted via an FM carrier to a receiver in another room where it activates a flashing light. Additionally there are provision for the hearing impaired person to wear visual receivers on their wrists. (Harriet Kaplan, 1987).

Researchers have also made use of the TV for the benefit of the hearing impaired students. eg. close captioned TV decoder. This allows the viewer to read captions on the television screen while viewing the captioned programmes (even those live board casts captioned in ‘real time’). (Fig. XIX).

10. Close captioned TV for the hearing impaired: The TV is used as a mass media for relaying educational programmes for the normal children. This system has been modified of ruse with the deaf community also. Citizens of all ages whose hearing is impaired can watch the various TV programmes at the same time with the same understanding as the general population. Various TV programmes have been close captioned to suit the hard of hearing population in the Western countries. In India its usage is still in the primary stages.

Closed captions transforms the TV screen into a primary source of information and entertainment which has been availed by the normal hearing population. Closed captioning is a process in which the dialogue portion of a TV program is translated into captions (subtitles), converted to electronic codes and inserted in the regular broadcast TV signal in a portion of the picture not generally seen. In order to see the captions the viewers have TVs equipped with special decoding devices. In contrast, the open captions are broad cast as part of the program and appear on all TV sets.

The 1st experimental closed captioned broad cast aired was by the federal communication commission (FCC). There are various authorities which have facility to close caption the events or program. Those which have a regular programs are the following.

- National captioning Institute (NCI).
- Federal Communication Commission (FCC).

The recent progress in close captioning is 'Live captioning' of sports and important public events.

The term 'live' is used to refer to captions which are prepared from advance copies of speeches and stored in computer memory which is later replayed in pace with a speaker's actual delivery. The Live captioning has marked the final step toward 'real time' (simultaneous) captioning of national newscast, sports commentary, and public affairs events as they occur. (Doris. C. Caldwell, 1983).

Parents and educators have recognized that well-written captions directly attack communication problems faced by hearing impaired learners – reading, writing, vocabulary building, semantic understanding , grammar, and all elements of overall linguistic competence. Teachers and media specialists in schools for the hearing impaired in the Western countries have reported that the younger deaf children are highly motivated to read from the TV screen. Thus improved reading and comprehension through TV can lead to improved achieved in all academic disciplines. For the adult deaf the use of TV has increased their vocabulary. (Doris. C. Caldwell, 1981).

Thus this new access of close captioning, to the prevalent world of TV has extended a powerful influence on the lives of the hearing impaired viewers, thereby breaking down communication barriers and helping the deaf individual for mainstreaming in the society.

A study was conducted by Herbert.J.Oyer (1961) in which lip reading was taught through TV (closed captioned circuit) and they found that a few students, normal hearing students thritytwo in number dis show marked improvement in pre and post treatment scores on lip reading through TV. The authors also state that the generalization of the same in face to face situation is not the same but one can hypothesize that TV teaching of lip reading prepares one to perform more successfully on filmed tests and situations. The interest levels of the students was also high when lip reading was taught though TV. (Doris. C. Caldwell, 1981).

11. USE OF VIDEO'S FOR THE HEARING IMPARIED: The video tape may also be used in programmes for the deaf (David Altsehuler, 1970). Though it is quite costly it permits the individual to see himself as others see him and to evaluate his progress.

Advantages: - It is relatively free from visual disturbances and is continuous when compared to still pictures.

It is pictorial and dramatic and can provide instant socio perceptual feedback.

The professional worker with the deaf can evaluate both himself and the client.

It provides means of recording fast-moving inter-relational dynamic actions.

It can be played back instantly.

Cited by Doris.C.Caldwell, 1981.

Disadvantages: Its bulky and assumes a lot of space. Sufficient experience and proficiency are required to set it up for shooting.

It is expensive and should be handled carefully and studio room is desired.

-Its frame of action is limited. Sometimes more than one camera is required for shooting.

It is time consuming and planning is required.

The tape should be of good quality.

Cited by Herbert.J.Oyer, 1961.

Uses:- Useful for recording preplanned scripts. Can record natural ongoing actions, joint activity or dialogue eg. counseling sessions, demonstrations etc.

Also commercial and professional TV programs can be video taped and made use of later.

Can be used in remedial programs for the deaf.

Can be used in recording the deaf clients progress in communication training.

Cited by Herbert. J. Oyer, 1961.

12. TELETEXTS: This is another visual aid which makes use of the TV monitor. It is a new TV source for home information and captioning. This system delivers a wide range of news, listening, announcements and other national and local information which appear on TV (Joseph Blatt, 1982). This information is encoded in the TV signal and transmitted continuously. Therefore it can be displayed whenever the viewer chooses to. The hearing impaired people may derive special benefits from this system through ready access to information presented in text and graphic form. Teletext also offers advantages as a program captioning systems. It plays a powerful role in providing public information like weather forecast, news bulletin etc. A decoder can be used to caption the news items film etc. The size of the lettering can be varied, the language can be made simple depending on the viewers age and alternative vocabulary may also be provided for difficult words that appear. The placement of the captions can be varied within the frame thereby visually attributing the dialogue to different characters. The character size can be operated depending on the need and the size of the captioning can be varied as mentioned before. The list of characters with descriptions of their speaking styles can be operated based on the needs of the client. (Joseph Blatt, 1982).

13. COMPUTERS FOR THE HEARING IMPAIRD: - Recently, computers technology has gained a wide spread popularity in using these system for a variety of purpose, it the field of Science and Engineering and Education. (Margaret. S. Willthrow, 1981).

Richard.G.Stoker (1983) rightly remarked "No one can ignore the torrent of information abut microcomputers and their various accompaniments that streams in from the popular and academic press. The major thrust of the announcements is to pretend the approach of the computer revolution. What can this revolution have in the education of hearing impaired children? It is not an exaggeration to suggest that the microcomputer child will be remembered as the technological product that changed the course of history for the hearing impaired population. The micro-computer is infinitely patient, consistent and accurate teacher. With the advent of good software the computers will be able to deliver a quantity and quality of language input and language experience that had been impossible to provide for hearing impaired children. Thus this provision of consistent, individually tailored instruction provided by the computer will excel and become a critical factor in the educational experience of hearing impaired children. Amination, individualization and sophistication of language training program through computer will play an increasing role in promoting language learning for the hearing impaired".

Once the computer technology was well established in the market, these system were tried for use with the handicapped population, the hard of hearing in particular. Various speech computing aids were devised for the deaf in the recent years and are put into practice with these children. (Margaret.S. Wilthrow, 1981). In the country like United States of America, and Great Britain the use of computer technology for the deaf has gained popularity unlike in India where its usage is still under research.

A brief description of speech computing aids for the hearing impaired has been listed below:

1. Artificial speech and speech recognition systems: - (Margaret. C. Wilthrow, 1981). The technologies for automatic speech recognition and synthesis of sentences have been made use with the hearing impaired child. Oral communication can be greatly expanded by the use of these technology with the profound deaf children. Deaf speakers who cannot speak intelligibly can produce speech messages by typing into their synthesizer. The normal hearing individual may give the replay by speaking into a central speech recognizer which would send a written version of the spoken message to the deaf persons teletype. However this may not be used by the other deaf person who speech is not intelligible.

It is important for the speaker and the deaf person to have sufficient practice in the operation of this instrument. The lip and tongue movements seen on the speaker can be used to fill in those features of speech which are difficult for the electronic system to recognize. Such a system is the "Autocuer" developed by cornett (1965).

2. **Speech processor for the deaf**: A recognition system may be used by the deaf to receive their own speech, recognize their output and improve intelligibility by activating a speech synthesizer which talks. Such systems, though difficult to maneuver may be applied in speech training. Suitable recognition templates are stored in the recognizer for the deaf person to practice pronouncing. Apart from this a word recognizer can be programmed to act as a practice monitor. Sessions of practice is required for good speech production with this instrument. (Cited by Margaret. S. Wilthrow, 1981).

3. Computer-modeling of speech production: The computer modeling of the bio-mechanics of speech production is a special area which is currently developing. The development of models can be used as aids in speech training. A biomechanical model of the vocal fold physiology has been developed by Titze and Talkin, 1979 and they may be used as a display for voice training for the deaf. Computer-modeling of the articulation movements are also used with the deaf as speech training aids.

4. Computer assisted instruction for the hearing impaired (CAI):

About three-four decades ago, the educational institutions had begun to support, the use of computers for instructional purpose, communication skill and scholastic improvement and in recent years, this support has increased dramatically. (Margaret S. Wilthrow, 1981). The same does not apply to a country like India. Where the use of computers is slowly gaining importance and it may take years for its application to the deaf population.

In a survey conducted by Von Feldt (1978) in U.S.A. about eleven states used CAI for the deaf. A follow-up survey in 1980 revealed rapid expansion of the application of CAI technology.

Four basic approaches have been identified for computer assisted instruction in programs for the hearing impaired. (Janice. E. Richardson, 1981).

a) Large-scale, time-shared, dedicated systems such as the PLATO.
b) Intermediate to small scale time-shared systems such as TICCIT and CCC.
c) Small-scale special purpose systems such as DAVID.
d) General purpose micro computers such as the PET, APPLE and TRS-80.

These types are described below:

a) Large-scale, time-shared, dedicated systems:

The PLATO system is a complete teaching systems, assisting and managing. The learning process. In an individualized, self-paced, easy-to-use manner, PLATO can be used for diagnosis, drilling, testing, grading, tutoring and provide a multitude of creative activities for the learner. This system can be used by the young deaf and also, the aged deaf. The results using this system for teaching language skills to the hard of hearing has been rewarding.

b) Intermediate to small scale, Time-shared systems:

The computer curriculum corporation falls under this type. This corporation rents or sells, turn-keys system that provides individualized instruction in maths, reading and language arts. However the CCC system does not permit the user to develop lessons.

The TICCIT (Time-shared, Interactive, Computer controlled, Information Television) has also been used with the hearing impaired. This system also falls in the above mentioned category.

c) Small-scale dedicated systems:

This includes the DAVID systems which provides CAI support for deaf students (Von Feldt, 1978). It is a microbased systems which combined instructional television (color, audio, motion) with computer assisted instruction. Segments of televised programs are played one at a time followed by CAI interrogation, reinforcement, branching and performance gathering. This system is fast progressing and now-colour monitors, modified industrial video tape replay unit, audio amplifier microcomputer, keyboard, disc systems and printer can now be included into this system.

d) Microcomputers:

Included in this type of computer is the APPLE II, PET and TER 80. These machines are less costly, they are portable and tailored for each student. It allowed games, lesions, student programs, and visual data on students, software to operate programs and daily record of student progress to be stored into it. This system is more economic and feasible.

The computers however are costly and design and development efforts are expensive. However they can be used for training the hard of hearing child in language and also provide student to clinician interaction with these systems as they are more flexible and structured to the need of the client.

The computers have been used to train the hearing impaired in language abilities (Fletcher and Stauffer, 1973). The authors suggested that the computer may be used for a specific CAI, Curriculum and language acts for the deaf. They have suggested four main objectives of the curriculum for the deaf students. They are –

a) Recognize specified grammatical categories.
b) Recognize and supply various forms of given grammatical structures.
c) Select appropriate grammatical units to complete a specified structure.
d) Perform specified transformation on a given grammatical structure.

The author opines to the fact that teachers assistance is required in the design and usage of CAI for the deaf. This system can be used as in environment for interactive written communication which can be used interactively between the student and the clinician. The computer program can be developed to identify in correct sentences and give appropriate feedback about errors of spelling, syntax and semantics. A syntax file and dictionary file stores in the memory of the computer may allow for flexibility in terms of their usage for the hard of hearing children. The needs of each client can be tailored to deliver the quantity and quality of language input and language experience for the deaf child.

From the recent advances we may posit that the computers play an important role in training the hard of hearing child for speech and language development. In a few decades from now each family may have and access to a computer at home and train their deaf children with the same. Such a high flexibility can be given only by the computer and nothing else can equal it. Speech therapists and teachers for the deaf, have to assist the hard of hearing children with these instruments.

System that use the tactual mode:

Over the last several years, the growing interest in Assistive Devices for the hearing impaired has been well documented (Bergman, 1983; Vaughn and Lightfoot and Gribb, 1983; Mahon, 1985; Wylde and Davenport, 1986). This interest, in the form of research, publications and expanded dispending services has been commensurate with the development and availability of new products. Most recently, tactile aids have drawn considerable attention, particularly in respect to tactile response and performance versus that with cochlear implants (Irene Dercks, 1987).

While the use of tactile information by the hearing impaired is not a new concept (Spens and Teerio and Haas, 1986), recent technical advancements have resulted in the development of wearable tactile devices. The availability of these devices offers the profound hearing impaired new opportunities for the development of effective and meaningful communication skills as well as an increased awareness of their environment (Irene Dereks, 1987). Numerous research projects underway are exploring various aspects of the benefits, function and applicational of tactile aids. Some of the more important issues that are investigated are (1) The number of tactile channels for optimal enhancement of tactile communication; (2) Mode of delivery of the tactile information and (3) Location of the vibrators/stimulus from both a function and cosmetic view point.

The early research on tactile devices for the deaf attempted to develop effective substitutes for hearing (Gault, 1926 and 1980). It was soon found that the skin had very limited ranges of frequency response and frequency discrimination. A system that distributed the speech signal in each of five frequency bands to five vibrators, one on each of the five fingers, was developed by Gault and Crane (1928) (Cited by Pickett, 1985). In classrooms of the few schools for the deaf, vibrators were installed in some of the pupils desk tops with considerable enthusiasm for their effects, these were single channel devices (Cloud, 1933). They were also used in speech therapy (Carhart, 1935). However the user of vibrators in schools did not become widespread, because the advent of hearing aids solved the communication and training problems for many deaf children. At that time a very large portion of the deaf school population consisted of children with only moderate – to – severe losses, that often incorporated large conductive components. Thus, the hearing aids could provide more useful information than tactile aids for all but the more severely or profound deaf pupils. Later research showed that high-gain hearing aids worn by the profoundly deaf function primarily as primitive vibrators (Nober, 1967; Erber, 1972; Zeiser and Erber, 1977) (cited by Pickett, 1985).

Research on multichannel tactile aids was revived in the 1950’s due to the engineering development of relatively compact filter banks used for Vocoders (Pickett, 1985). Recently, there have been several projects to evaluate tactile aids that employed about 12-36 channels and corresponding stimulators (Engelmann and Rosov, 1975; Saunders, Hill and Simpson, 1976 and 1980; Sparks, Ardell, Bourgeois, and Kuhl and Weidmin, 1979; Brooks and Frost, 1983; Hoffman, 1984) (Cited by Pickett, 1985).

Present vibrators are large and consume too much power to make a large number of channels feasible in a wearable aid. The devices of Saunders et al (1976); Sparks et al (1979); and Hoffmann, (1984) (cited by Pickett, 1985) employ electrocutaneous stimulation to reduce the amount of wearable power required. Others are trying to study the power efficiency by incorporating about eight vibrators in a wearable aid (Durlach and Rabinowitz, personal communication, MIT, 1981). Aids using only one to three vibrators are also being assessed (Franklin, 1984; Proctor, 1984; (Cited by Pickett, 1985). (Summers and Peaks and Martin, 1981; Spens and Plast, 1983.

The tactile aids transmit the speech sounds into vibrations on the skin. This is achieved by means of a vibrator placed on the skin. The hearing impaired individual makes use of the various tactual information on pitch (Thomas, Reed, Francis, 1971) duration and other suprasegmentals.

These vibrators can be placed on different parts of the body. The most common site being the finger tips, palm and also the wrist. Some have placed it on the abdomen and sternum depending upon the number of electrodes used. Depending the number of vibrators used they may be divided into single channel devices and multichannel devices. They may also be divided as mechanical devices and electrotactile devices. Some of the aids are portable eg. Siemens monofonator and some are of the desk model.

The vibro tactile aids are intended to transmit sound information to the tactile sensory system, its signal processing schemes different from those of the conventional hearing aid (David Franklin, 1984). They are as follows:

The tactile sense the relatively insensitive to vibrations, much more power is required to drive tactile transducers to appropriate levels than is needed in hearing aids. The tactile system is unable to feel frequencies that are much above 1000Hz some kind of frequency lowering scheme atleast for the important upper frequencies (1000 Hz – 5000 Hz) must be included in the tactile aids processing.

The tactile aids help in sound awareness. The following may be expected from a single channel device (David Franklin, 1984).

1) Because the deaf can sense temporal structure derived from frequencies upto 1000Hz the deaf should be able to perceive voicing information (200 Hz – 300 Hz) and first formant information (250 Hz – 750 Hz).
2) Because speech has characteristic rhythm and amplitude changes that change relatively slowly they should be able to perceive and track speech rhythm and within the constraints of its just noticeable differences for loudness, they should be able to sense some changes of loudness.
3) Because most environmental sounds have characteristic rhythm and low frequency elements, the tactile sense should be able to readily identify these sounds. Hence the utility of these aids are –
    a) It should be useful for identifying speech and environmental sounds to the extend that each has characteristic rhythm and loudness patterns below 1000 Hz.
    b) It should be useful to the wearer in controlling his own speech rhythm loudness and to some extend pronunciation.
    c) The manner features of speech (nasality, voicing and fricative properties) are difficult to lip read because their production is difficult to see. Because manner features are well below 1000 Hz and since they are easy to feel this type of aid should be userful adjunct to lip reading.

d) A tactile aid cannot be expected to enable the user to comprehend speech to the extend that second and third formant are required.

Some of the vibrotactile aids are discussed below. They are subdivided under the categories such as single channel and multi channel tactile aids.

Single Channel Tactile Aids:

A device was developed by Boothroyd (1981) which consisted of a hand worn bone conduction vibrator attached to a mitt. The vibrator is connected by means of a cord to the output of a powerful wearable hearing aid. The cord runs along the length of the inner side of the hand and it can be easily hidden inside the clothing. The vibrotactile sensation received in addition to the limited sound stimulation through the hearing aid enhanced the speech reading abilities of the cases. This aid can also be used in natural conditions of speech.

Such single channel tactual sensory aids make use of a single vibrator transducer which limits the speech information since the frequency range is quite narrow. Thus, the wearer can differentiate only certain vowels and some suprasegmental information.

In order to aid the skin in resolving various frequencies (of speech sounds) Gault, 1928 devised a Teletactor an apparatus that provided five vibrators, one to each digit of the subjects hand. The speech sounds were altered and fractionated into five bands so that the skin would be confronted with a place code for frequency as it was through the ear. This device proved to be more informative than the single channel type.

Pickett and Pickett (1963) (cited by Vasantha, 1980) developed a device that represented the frequency bands of speech vibrations of a constant frequency to which the skin is very sensitive (300 Hz) each given band at one of the finger tips. When the speech sounds are spoken the frequencies in that given band were presented to the appropriate finger at a level of vibration proportional to the energy in the band. The frequency spectrum was therefore represented as a set of traces on the skin, with intensities in various traces varying with the spectral energy distribution for the speech. This aid is more sophisticated than those described earlier because the range of frequencies transduced is much wider and they also provided spectral shaping for the speech sounds. In this way the consonant sounds that are weaker in relation to the vowels are more emphasized.

Another speech training tactile sensory aid was also developed by Prof. Dj. Kostics (Cited by Vasantha, 1980). This tactile aid is a part of the Kostic apparatus. It consists of a set of ten vibrator boxes, an amplifier, a low pass filter and a microphone. The amplified signal from the microphone passes through the low pass filter, which cuts off all frequencies above 500 Hz. The resultant signal is then sent through a series of vibrating membranes placed in boxes. Each box is large enough to accommodate the five fingers of each hand of a deaf subject. By placing one hand on each of the transducer. With prolonged training along with speech reading, the profound deaf children were able to discriminate certain feature of speech such as duration of speech signal, syllable stress, speech rhythm besides feature like plosiveness friction and gross differences in fundamental frequency. The deaf child receives vibrations reflecting the activity of the vocal cords.

This device helps the profoundly deaf whose hearing remnants are confined to the frequency range upto 500 Hz which this device makes use of. It also serves to supplement the speech reading abilities of these children. Another vibro tactile device include the Siemens mono fonator (Fig.20). It is a portable type of tactile hearing aids. This unit consists of an amplifier a microphone, a vibrator with a securing strap and a head set. It has provisions for an on/off switch, gain control for the vibrator, gain control for the head set and a bass, treble tone controls.

The tone controls will allow the teacher to raise and lower the high and low frequencies to suit individual pupil. The frequency response of the head set is not adjustable. This device can be used for the detection of rhythm differences. It can also be used for training in discrimination. The vibrator can be used along with the hearing aid or the headphones hence the hearing aid is also important here. The rhythm can be expanded to short phrases and then longer ones in accordance with the childs own rate of progress. It is also proved useful to train in stress and speed which are difficult to detect through lip reading. it is used with profoundly and partially deaf cases and can be used in articulation training also.

The disadvantage is that it cannot be used for finer discrimination.

Another vibro tactile aid was devised by William Edmondson which consists of headphones with boom microphones attached and both have a head set of vibrators which tickle the skin of one hand, all five finger tips and two points of the palm. (cited by Vasantha, 1980). The speech signal from the microphone is processed and controls the vibrators providing information about speech intensity, pitch, nasality and the shape of the mouth. This aid offers the basis for comparison of two utterances being compared and monitored via the same sensory modality. Apart from auditory training it assists in increasing kinesthetic awareness and control of the vocal organs and with the production and monitoring of utterances and aspects of pitch and rhythm. A visual display along with the tactile stimulation may be used for training with younger children.

A remotely activated tactile communication aid for the hearing impaired was devised by Davis. W. Sparks (1977). It can be used with normal and hard of hearing population. The use of this aid in the laboratory and field studies indicated that both the groups were able to follow the instructions based on the code taught to them prior to experimentation. About 100% accuracy was obtained for both the groups in the laboratory set up. In the field study the normals on an average were able to receive the commands correctly 91% of the time. For the hearing impaired group it was 80%. The age groups used were normals 17-21 years and hearing impaired 8-14 years. So the percentage of responses should also be taken into consideration. The author suggests that this aid can be used in field sports like Hockey for the hearing impaired to get a clue to the referees signal than to his whistle.

Multi Channel Tactile Aids:

A multiple channel vibrator provides more useful temperospetial transformation of acoustic spectrum than a single channel vibrator.

Saunders (1973) (cited by Vasantha, 1980) employed electrical stimulation rather than mechanical vibration to the skin for the appreciation of information. He devised a twenty channel Vocoder which required only a small transducer. Much less electrical power was sufficient to drive the transducer. Hence the feeback was comparatively less. The twenty electrodes were arranged in the form of a belt which could be worn around the abdomen. The electrical stimulus consisted of pulse bursts, each consisting of thirtytwo biphasic consisted current pulses. They are repeated at the rate of 100Hz and the number of pulses in each burst determines the magnitude of the tactile sensation.

This device may not be unpleasant for the young deaf child though certain asthetic aspects were considered and this type of aid is still under investigation.

A study on the transformation of prosodic information via an electro tactile speech reading aid was conducted by (Kan W.Grant et al. 1986). In this experiment the author extracted the variations in voice, fundamental frequency from naturally produced speech a samples and transmitted to an electro cutaneous display consisting of ten electrodes arranged in a liner array along the forearm. Changes in fundamental frequency were encoded as changed in stimulus location. Speech reading performances with the without the electrocutaneous aid was examined for both sentence and connected discourse materials with one proficient hearing impaired listener and one normally hearing listener whose hearing was masked. After twenty hours of speech reading training in connected discourse tracking procedure, both subjects showed higher tracking rates and faster learning rates with the aid than without the aid. Results from closed set sentence identification tests, showed that patterns of intonation, stress and phrase structure which are not easily spread are readily available with the aid.

Another multi tactile aid is the multi point, Electrotactile speech aid (MESA) of Sparks et al (1979) (cited by Pickett, 1985). MESA provides thritysix channels of speech spectral information from a filter bank to thirtysix tactile stimulating location arranged horizontally along the abdomen. The First eight horizontal channels of the spectrum analyzer cover a low voice-pitch range, 86- 290 Hz, and the remaining twentyeight channels are logarithmically spared in frequency upto 1049 KMz. The amplitude in each channel is represented by one of the eight electrode stimulators spaced vertically at the appropriate horizontal position according to the frequency band of the channel for the vowels. The 288 electrodes (i.e. 36 x 8) are mounted in a belt worn on the subjects abdomen.

There are also aids having two the three channels. (Scott, DeFilippo, Sachs and Miller, 1977; DeFilippo, 1984, Cited by Pickett, 1985.

Kringleboth (1968) studied the use of a five channel tactile vocoder in training deaf children to produce better /s/ sounds and improved voice rhythm. He reported success with the /s/ training but no advantage over conventional methods for rhythm training.

Williemain and Lee (1972) (Cited by Pickett, 1985) designed a tactile aid that analyzed voice pitch and presented the pitch level in terms of vibration location. Criterial ranges of pitch such as high, okay or low, were established to correspond to 2-3 vibrators under separate fingertips. Brief pitch training sessions were carried out with twentysix deaf teenagers feeling their pitch in this way. It was found that desired changes in voice pitch could be attained within a few brief sessions of training with the tactile feedback.

Boothroyd (1983) designed a wearable pitch monitoring aid that represents a moving sensation along the wrist as voice pitch changes up or down. Some pilot trials with deaf children indicated that they could use the tactile movement to learn to make controlled changes in their voice pitch (Nancy McGarr and Arthur Boothroyd, Personal Communication, January, 1983).

A tactile optacon display of the speech spectral information in eighteen channels, 250-7700 Hz was tested us a speech modifying device with four two – four year old def children (Goldstein and Stark 1976 and 1980). The children were trained to increase their vocalization and to initiate the female experimenter seen in making syllables, such as /ba/, /ma/ and /da/. During the training sessions the children felt the vibratory patterns of their speech and that of the experimenter. A control group of children were trained similarly but without speech spectrum feedback. A statistical comparison of the vocalization of the two groups showed that the tactile group produced more utterances of consonant –vowel sequences than the control group.

Pickett and Williams (1985) studied speech perception via implanted electrodes and tactile aids. They concluded that neither approach can provide more than a modest aid to lip reading. Speech reception with multi channel implants were better than single channel implants. There was great inter subject variations which the same implant. However the tactile aid performance by highly practiced subjects seemed comparable to that of the better implant subjects.

TELECOMMUNICATION AIDS FOR THE DEAF

For speech or hearing impaired people, telephone communication is a challenge and frustration. They need special guidance and equipment in order to over come the problems related to communication at a distance. In Europe and Western countries until recently, telephone communication by the severely or profoundly hearing impaired population received very little emphasis (castle, 1977; McLeod and Guenther, 1977 and Stoffels, 1980). The various telecommunication aids sue the auditory mode, the visual or tactile mode. discussed below are the various telecommunication aids available for the deaf. Most of the aids are auditory in nature.

1. Hearing aids and telephone amplifiers:

a) **Telecoils**: Hearing impaired people who use the standard telephone usually depend on a hearing aid and/or amplified telephone handset. Many hearing aids have a special 'T' (Telecoil) setting that improves telephone communication. The small magnetic telecoil in the hearing aid is designed to work in conjunction with the magnetic leakage from telephone receivers. When the hearing aid is set on 'T' the magnetic field around the telephone receiver (handset) is picked up by the telecoil in the hearing aid. The magnetic signal is changed into sound by the hearing aid. When using the 'T' setting, sound is not picked up by the hearing aid microphone.

Advantage: Hearing impaired persons use the ‘T’ setting for telephone conversations because it increases the sound with respect to the noise.

The ‘T’ setting also eliminates the problem of hearing aid feedback caused by a loose earmold.

Disadvantage: With the ‘T’ setting the hearing impaired persons cannot hear their voice through the hearing aid but must monitor their speech production by listening their voices coming through the telephone receiver. Hence their speech sounds different than speech monitored through the ‘M’ setting. (Diane. E. Castle, 1981).

b) **Built in Amplifier**: This system consists of an amplifier built into the telephone system to amplify the speech emanating through it. This thereby assists the severely and profoundly deaf individual. The additional gain supplied by the amplified handset makes it easier to hear the other person without straining to listen, especially for long distance cells, when the hearing aid battery is weak or when talking with those having a soft voice. Any hearing aid setting can be used with the amplifier. The intensity of speech or sound can be increased by 25 – 30 dB by adjusting the volume dial on the handset (Hammer, 1964). (Fig.21).

c) **The portable Amplifier**: It is small battery operated, portable amplifier that slips over the telephone handset but it is useful only on telephones with sufficient magnetic leakage. The built in amplifier has more acoustic gain than the portable one. (Diane. E.Castle, 1981).

d) The adaptor: The portable battery operated adaptor is designed to strengthen the magnetic field and to permit use of the 'T' setting, when there is no sufficient magnetic leakage from the telephone coil. (Fig.22). Diene.E.Castle, 1981).

The author Alice.E.Holmes and Nancy.A.Chase (1985) have investigated the effects of a telephone adaptor to the telephone listening ability of 12 hearing impaired subjects. 37 – 77 years using an inductively coupled system. Subjects were evaluated using the unaided telephone, the telephone coupled with both the telecoil and a telephone adaptor, the telephone coupled with the telecoil of the hearing aid. Mean speech discrimination scores were determined for these three conditions in quiet and with competing background noise. Results showed that the subjects had significantly poorer acores when using the telecoil alone than when using the unaided telephone or the telecoil with the adaptor. Speech discrimination scores were also significantly poorer when the conditions were presented in a background of competing noise than in quiet.

These are the telephone amplification device and may be classified as those systems which makes use of the auditory mode.

There are other telecommunication device which can be used by the deaf. These devices make use of a visual display system of telephone conversations and they are described in the following pages.

Telecommunication Devices for the Deaf: (TDD's) Fig.23 – Before telecommunication devices for the deaf (TDD's) were available, a hearing impaired person with limited speech or listening skills had to rely on the assistance of another person to make a telephone call. Independent telephone communication between two hearing impaired people with limited auditory – oral communication skills was not possible until 1964. Robert Weitbrecht (1964) designed a coupler (acoustic modem) that transmitted and received type information from one location to another through standard telephone lines. With the aid of teletype equipment and the acoustic coupler the hearing impaired individuals had an opportunity to use the telephone without relying on their speaking or listening skills (Diane.E.Castle, 1981).

To communicate by the teletypewriter, one person dials the number of another person having compatible equipment. He then places the telephone receiver in a special coupler and waits for the other person to answer the telephone. The person receiving the calls places his or her receiver in a similar coupler and begins to type. Simultaneously the same words are printed out by the other teletypewriter. A hearing impaired person using this kind of equipment can have local and long distance telephone communication with any other person having a TDD. Difference models of the TDD's are available. Special features are incorporated in the various TDD's, they include, portability, paper printout of the conversations, display area for visualizing the type conversation, a memory for storing messages; coloured letter system, rental system from the telephone company and direct connection to the telephone line. (Diane. E.Castle, 1981).

The selection of a TDD is very personal and depends on the particular needs for the individual and the environment in which the TDD is used.

Electronic Handwrites:

For certain hearing impaired populations a communication device was developed which does not required typing skills. Electronic writing equipment is used with the telephone or direct wire connection is used to send and/or receive handwritten messages across the distance. This system is mainly used in hospitals, industry and business to speed communication.

Telephone coding systems:

Another approach to the independent use of the telephone is with the code system. The hearing impaired person may be able to detect the code through the use of hearing aid and/or a amplified handset. For hearing impaired persons who cannot detect sound through audition a visual code, indicator can be used. Speech codes or nonspeech codes can be used to give information on the telephone.

Speech codes:

The Yes-No code is used when the conversation has a specific topic of discussion and is brief. Its not a real conversation. Here the hearing impaired person initiates the calls, controls the conversation and has the responsibility for giving information and asking questions. The normally hearing person responds with a prearranged code.

A code system can be created, modified or expanded for the hearing impaired person who can discriminate selected words, numbers, letters or sentences.

Non-speech codes:

Those code system which do not required intelligible speech, such as the use of morse code or special code arrangement with the touch-tone telephone, can be used to send and receive information over the telephone (Hanagan, 1968; Levitt and Nelson, 1970). Once the code is learnt both people can participate equally in the conversation. Practice with the code system is essential and this required more times, patience and perseverance than other communication forms (Diane. E. Castle, 1981).

Speech indicator:

If the hearing impaired person cannot hear the other persons codes, a speech indicator shows the rhythm pattern for codes. It also shows when the dial tone, busy signal and ringing sounds occur. This equipment is portable, relatively inexpensive and connects to the telephone with a small rubber suction cup (Cited by Diane.E.Castle, 1981).

Radiopaging equipment:

This equipment is used by the normal speakers and also the hearing impaired. The radio pagers transmit voice or a tone and also vibro tactile signal. This kind of paging equipment would make it possible to contract a profoundly deaf child or adult at a distance from but within the radius of the equipment. The vibrating signal can be used as a coded telephone call to alert a hearing impaired person to telephone for more information, to go to a prearranged location or to perform certain activity (Diane. E. Castle, 1981).

Telephone device for the Deaf-Blind:

Several device have been specifically designed to make telephone communication possible for the deaf-blind. There are two such system currently available. They are the code com and the Braille TTY. Other devices are under development.

A code com is a nonprintable attachment to one telephone that converts sound signal into visual or tactile signals. Using a Yes-No code or morse code to receive information, the deaf person can seen or feel the pattern which a deaf-blind can feel the incoming message. To send a message the deaf or deaf-blind can speak or use morse code (Diane.E.Castle, 1981).

A Brailled teletypewriter allows a deaf-blind person to communicate with other standard TTD's by converting the incoming typed conversation into Braille while the outgoing message is sent in standard typed form. The deaf-blind person reads the telephone conversatio n by moving his/her finger tips across the raised dots on the paper.

Apart from these systems there are also telephone alerting systems alert the deaf or deaf-blind regarding the incoming calls by a flash of light or vibration. (Diane. E. Castle. 1981).

CHARACTERISTICS OF EDUCATIONAL SYSTEMS AND THEIR SELECTION

The various types of assistive devices for the deaf have been dealt with in detail. The various aids available for the training of the deaf child are therefore numerous and its left upto the clinician to select the appropriate for the deaf child. The clinician is therefore in a dilemma regarding the suitability of the assistive device for his clinical set up. The purchase of the assistive device depends on various factors. The clinician therefore has to consider the following factors in the selection of the assistive devices.

1. The need for the assistive devices.
2. The characteristic features of the assistive devices.
3. The selection procedures used for the deaf child in the usefulness of the assistive devices.
4. The cost effectiveness and also the facilities available for the purchase and repair of the ALD's and the accessories.

Desirable characteristics of education systems (Bess, 1981, Freeman, 1981):

According to the authors an amplification system is a hearing aid system designed to supply amplified sound to a group of hearing impaired children. Sound is taken from a single source, amplified, modified and then distributed to a group of listeners.

Bess (1981) gives the following characteristics of educational system they included the following:

1. **Hearing loss suitability**: The following should be considered
    a) The system should be appropriate for the childs hearing loss. It should be possible to adjust the gain, SSPL and frequency response so that these characteristics conform to the degree and configuration of the children hearing loss. Each child should be assessed with the amplification system.
    b) Education suitability: It should be appropriate to the educational needs of the child. The form of amplification that would best meet the educational needs should be selected. One should consider the following:

(i) **Signal to noise ratio and signal level:** Any amplification device should deliver the teachers speech at a favourable signal to noise ratio and at a sufficiently loud level. The speech signal should be louder than the noise that accompanies the message. For the hearing impaired child to perceive speech optimally the signal should be around 30 dB more intense than the noise (S/N = +30dB). Any ratio less than + 30 dB has been shown to produce a degradation in word recognition among the hearing impaired population (Olsen, 1977) (cited by Bess, 1981).

In order to have a favorable listening conditions and optimal speech perception the pick up microphone must be as close as possible to the sound source. As the distance between the sound source and the microphone increase the

S/N ratio becomes less favourable and the signal reaching the childs ears becomes less intense.

(ii) **Self monitoring and child to child communication**: To operate effectively in the classroom and to maximize learning potential, the child needs to hear his/her own speech clearly as well as the speech of others in the class room. For this the instrument must contain an open acoustic microphone. The system should amplify the speech of other children as efficiently as it amplifies the teacher's speech.

(iii) **Binaural reception:** It is an individual need and is also useful for effective self-monitoring and child to child communication. Ross (1977) states that in any situation in which the receiver unit of the class room system functions as a hearing aid, the binaural signal reception offers a greater possibility of increasing the childs perception of an auditory signal (cited by Bess, 1981).

2. **Simplicity and reliability**: A desirable system is simple to operate can be easily checked by the teacher and does not require a great deal of maintenance. In terms of reliability these systems should meet the electroacoustic specifications set-forth by the manufacturing company. Gain, SSPL, frequency and internal noise should be specified.

3. **Flexibility:** A flexible systems provides external controls for modifying the electroacoustic parameters thereby offering a sufficient number of input and output system and affords maxim mobility.
4. **Cost effectiveness:** The system should be affordable and the maintenance and repair cost should be reasonable. For this the school should also have a well defined monitoring system.

Bess, Judith (1981) Barry, Stephens et al (1981) have selected (i) school, (ii) equipment and (iii) listener factors as the three general areas for criteria of selection of classroom amplification system.

School factors: The five school factors considered by the authors included the following:

1. Identifying the acoustic environmental condition of the classroom.
2. Identifying the educational needs for the school program.
3. Providing for inservice training.
4. Development of equipment monitoring program; and
5. Identifying the personnel involved in selection of auditory equipment.

Equipment factors: After the various school factors have been indentified, the type of system that will be most beneficial to the educational program can be selected. The amplification equipment factors included the following:

i. Type of system required
ii. Service record of the manufacturer
iii. Ease of equipment operation
iv. Flexibility of the equipment and
v. Budgetary consideration.

The author (Fred.H.Bess, Judith, S. 1981) emphasize that certain factors must be considered in the selection of class room unit the way it serves a personal hearing aid. These include –

1. Coupling requirements of the unit to the child.
2. Frequency gain considerations.
3. Monaural Vs binaural amplification.
4. Potential over amplification and trauma to residual hearing and auditory discomfort.
5. Age of the user or listener.
6. Students and teachers attitude concerning the system.

(Sung and Sung, Hodgson and Angelelli, 1976).

Selection of appropriate devices: (Fred. H.Bess, Judith, 1981).

For the hearing impaired student, proper selection of amplification is extremely important to language and speech development. Unlike adults who have acquired their hearing loss later in life, hearing impaired children must develop language and speech through impaired ears. Because of the adverse effects of the hearing impairment, the amplification systems selected must provided the highest quality signal possible so that the child is provided with the best possible acoustic signal.

Properly selected amplification will have an impact on language and speech acquisition because the development of language and speech relies on the auditory modality. Properly selected amplification will also enhance speech intelligibility for the students, which may be a primary factor in their educational progress.

With the proliferation of assistive device and systems the consumer should receive professional help in selecting devices to meet his/her individual needs. The Gallaudent Assistive Devices programs was developed as a model to provide such assistance. This program follows certain protocols. During the 1st visit, a client is given the assistive device needs assessment questionnaire which is the modification of a checklist developed by Vaughn and Lightfoot (1983). The questionnaire identified the clients difficult communication situations, price considerations, cosmetic concerns, the capabilities of his/her existing hearing aids and any systems already in use in the client home or community. Specific system are then selected f or evaluation. If listening system is to be used the hearing and hearing aid evaluation are essential. Current informations on the degree and configuration of the clients hearing loss is obtained. This is useful to select a device with appropriate power and to adjust its frequency response characteristics when possible or necessary. This program also consists of procedures for electroacoustic evaluation of the system. If possible actual use trials with subsequent speech quality and intelligibility judgments and sometimes speech reading tests with and without the device is carried out.

After a system is recommended, the client is referred to an approved local dispenser for the purchase of the same with a money back trail provision. A follow up is also scheduled for counseling or modification in the performance of the equipment.

In India there is not specific program for the selection of the ALD. The amount of facilities given for the deaf in day to day communication for eg. the usage of telecommunication devices, captioned TV system and decoders and computer assistive teaching programmes are not widely used in our country. In the near future we could also make use of technical development for the deaf in India.

The researchers are paying attention to this aspect in India and in a few decades we could enable the deaf to enjoy the various technical facilities.

CONCLUSION

Assistive devices have been reviewed in this project. They have been classified and described. Their advantages and disadvantages have also been enumerated. Special attention was also given for the telecommunication device and was reviewed and described in detail. Finally a brief description on the selection and the characteristic features of the ALD's was also given.

The assistive devices can improve communication in noisy, reverberative situations or where distance is a factor. They are generally used in conjunction with hearing aids to supplement hearing aid benefits. Assistive devices can substitute visual communication for auditory when necessary and can monitor visually and vibro-tactilely important sounds in the environment.

Because of the increasing number of systems on the market in Western Countries, consumers help in selecting system to meet the individual needs. In India this problem does not exist because the number of such aids are limited. However various professionals concerned with the rehabilitation of the deaf must become familiar with the available equipment and establish programs to increase consumer awareness, fit or recommend appropriate system and persive follow-up activities.

This is essentially applicable abroad where the use and development of ALD’s is increasing. Researcher is however required to develop fitting protocols, comprehensive evaluations procedure and improved systems and finally the filed must establish standards for acceptable performance.

This review was undertaken to bring to our awareness the ALD’s used with the deaf, the research in this field of ALD and how these systems are used widely abroad. Such systems are not used in India due to a number of reasons, most of all considering the economic condition, tit is not possible to implement programs, or device instrument, however a few of the less costly and more useful aids could be used in the therapy clinics and also in educational set up and attempt at future facilities which the deaf can enjoy in our country in the near future.

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APPENDIX

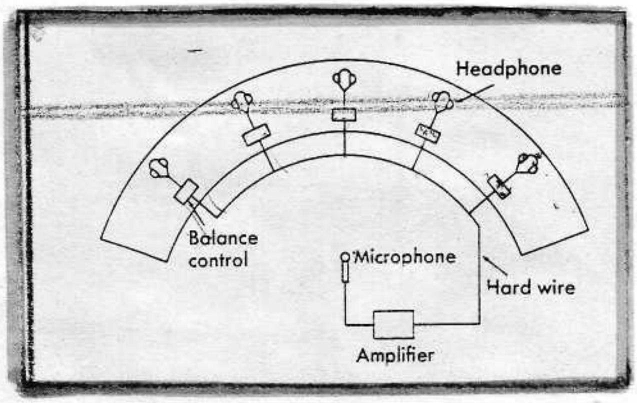


FIG 1 SCHEMATIC DIAGRAM OF A TYPICAL HARDWIRE SYSTEM

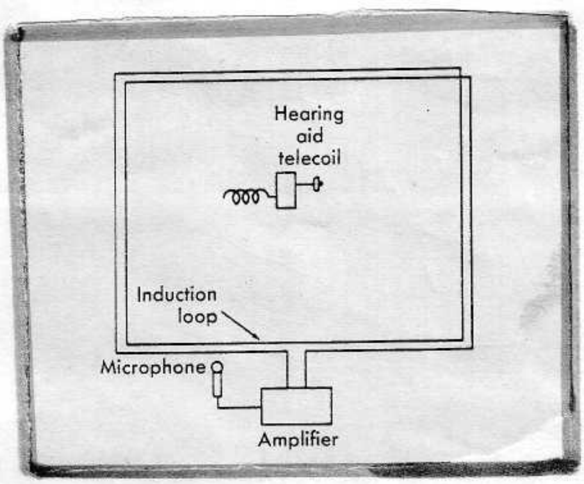
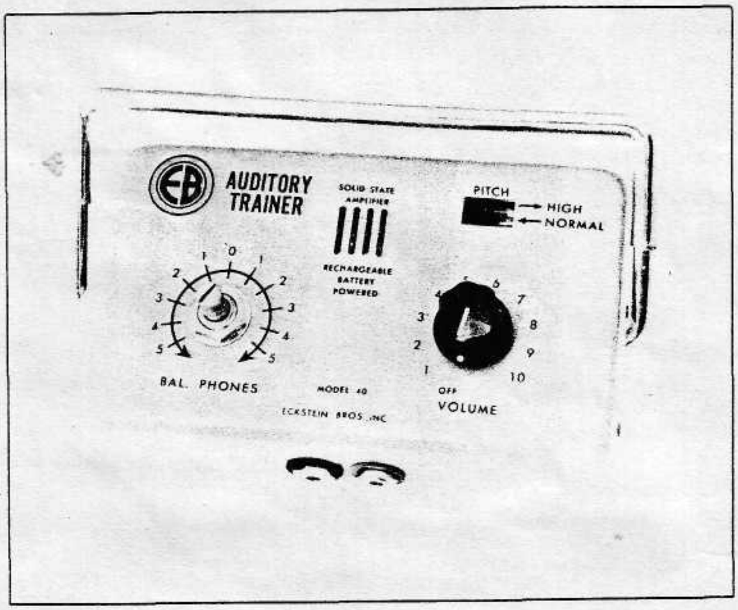


FIG. 3. SCHEMATIC DIAGRAM OF INDUCTION LOOP AMPLIFICATION.



PURPOSE	The Portable Auditory Trainer is a dual-purpose monaural hearing amplifier that can be used as an auditory trainer for hearing-impaired persons and as a speech trainer for the clinician who treats persons with speech disorders.

FIG. 2.

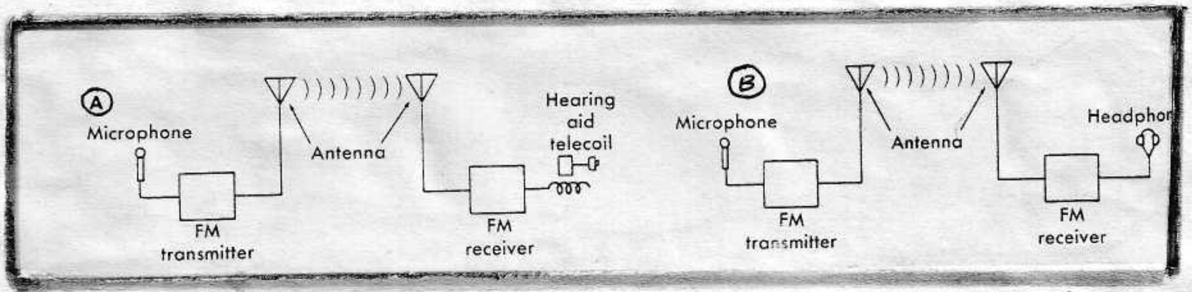


FIG. 4. SCHEMATIC DIAGRAM OF FM TRANSMISSION SYSTEM FEEDING TO A PERSONAL HEARING AID (A) OR HEAD PHONES (B)

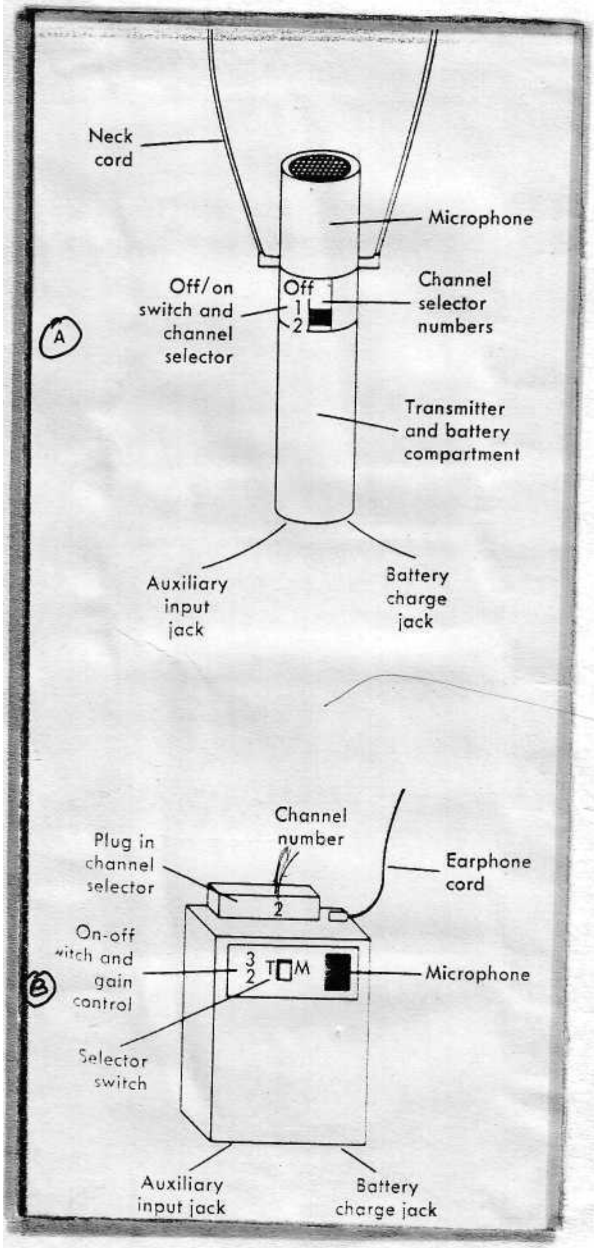
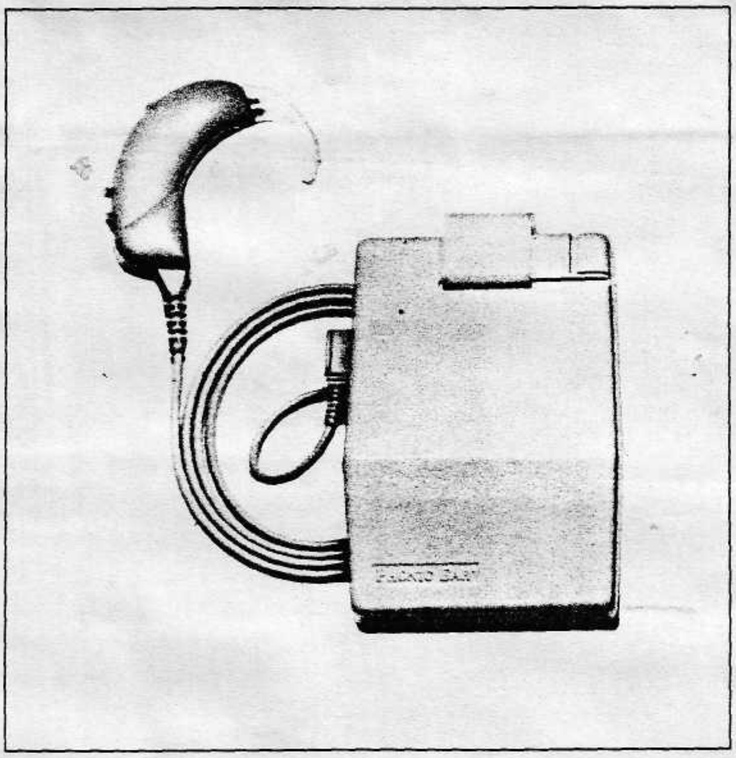


FIG. 5.

COMPONENTS OF A TYPICAL FM MIC-TRANSMITTER (A) AND HEARING AID RECEIVER (B).



PURPOSE

The [redacted] receiver receives and transmits the voice of a speaker and provides the signal to the wearer's hearing aid for amplification.

DESCRIPTION

The unit is designed to be used with audio input hearing aids or hearing aids with a microphone/telecoil (M/T) position. The hearing aid connects to the receiver with an audio input cord for audio input hearing aids or a receiver with a teleloop for hearing aids that lack audio input capabilities. This unit is recommended since a microphone and preamplifier are not needed to monitor one's own speech with most audio input hearing aids.

FIG. 5.C.

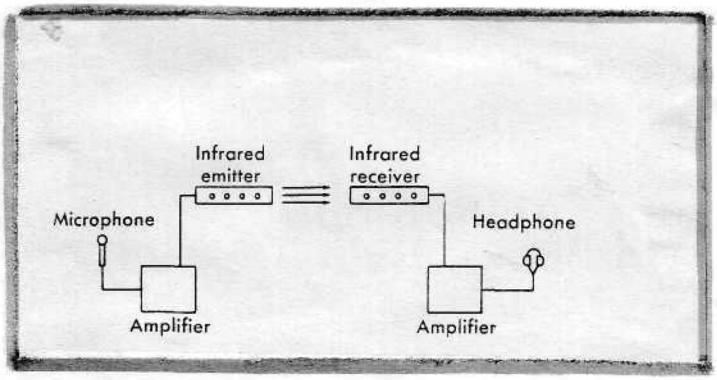


FIG 6.a

SCHEMATIC DIAGRAM OF IR AMPLIFICATION SYSTEM.

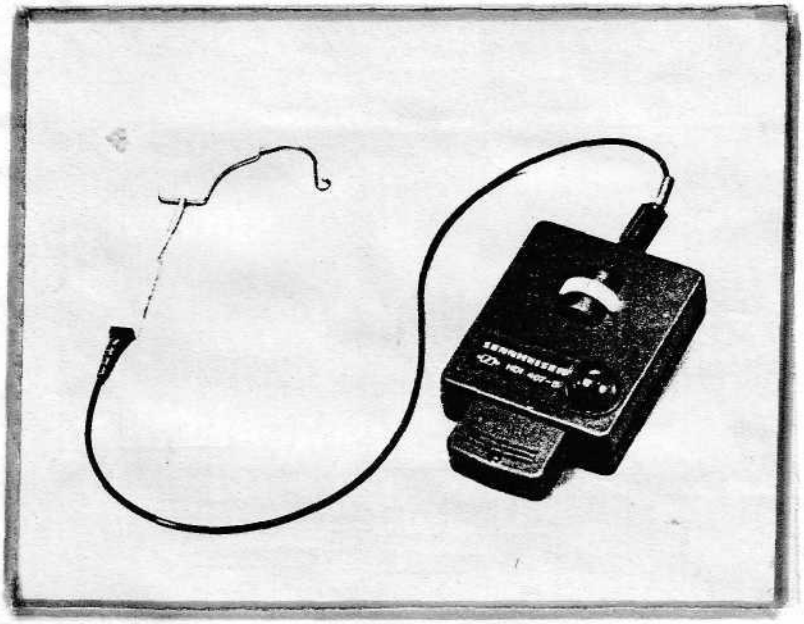


FIG. 6. b.

The infrared receiver is designed for people with severe hearing impairments who can wear their hearing aid compatibly with the receiver. This unit may be used in theatres, or for private radio or television listening, when equipped with the appropriate transmitter.

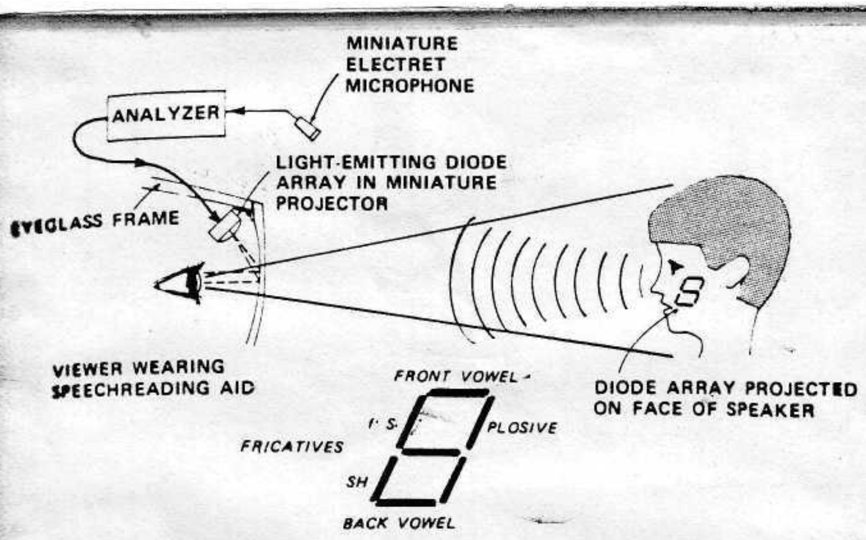
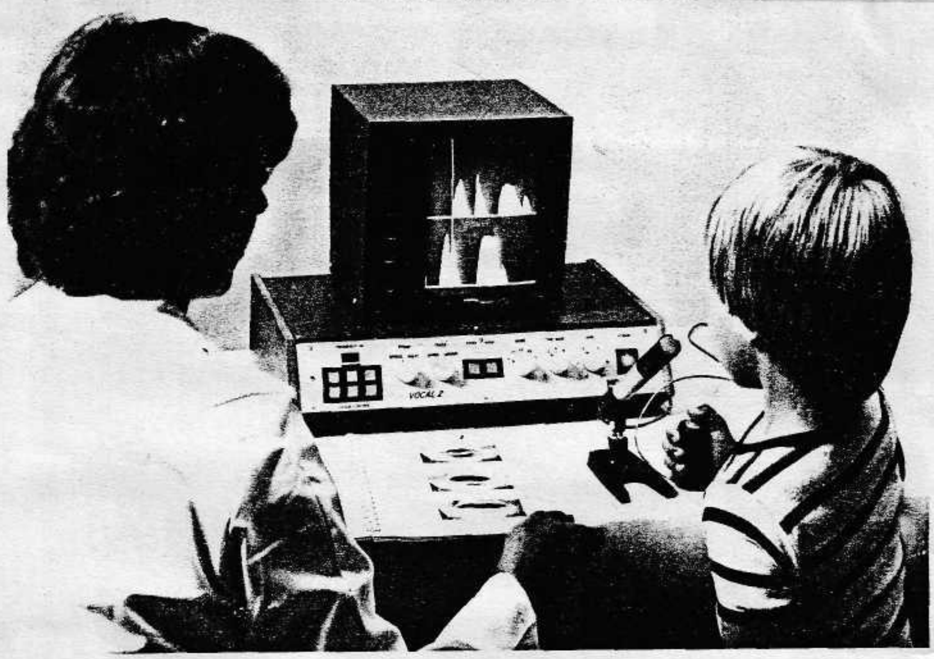


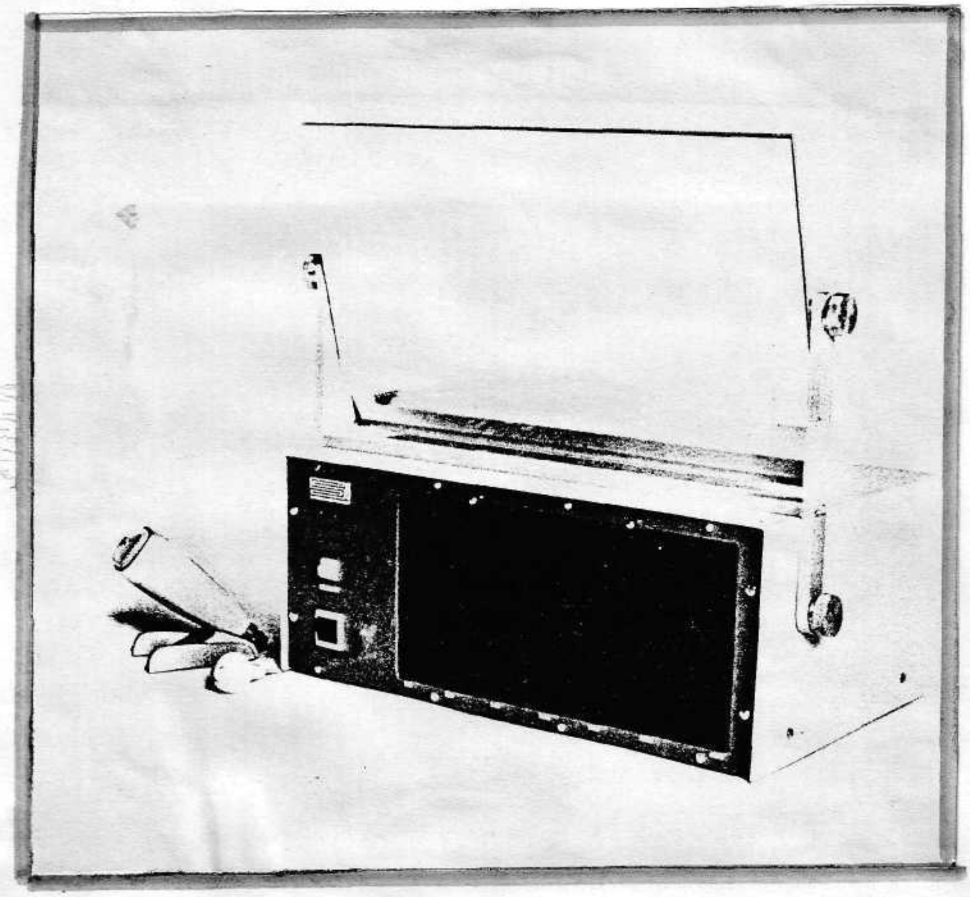
Figure 7. The Upton Eyeglass Speechreader system. The microphone and analyzer, worn by the hearing-impaired user, control activation of the red light-bars in a standard alphanumeric array of LEDs which are mounted as a small "projector" at the corner of the eyeglass frame. The lights are aimed at a tiny reflecting area on the rear surface of the eyeglass lens. The image of the light-bars appears in space before the wearer and can be placed in line with the person speaking. Each element is lighted only one at a time to indicate a sound pattern correlated with a class of speech sounds, as noted on the enlarged LED pattern.



PURPOSE The Vocal 2 Monitor receives sound (speech spectrum), which it then converts to electronic signals.

The Vocal 2 Control Unit can be used in the speech rehabilitation for such conditions as articulation, fluency, and voice disorders. It also is useful in working with hearing-impaired persons whose speech is affected due to a hearing loss. The system can be used for more accurate pronunciation in the development of a second language as well.

FIG. 8. a.



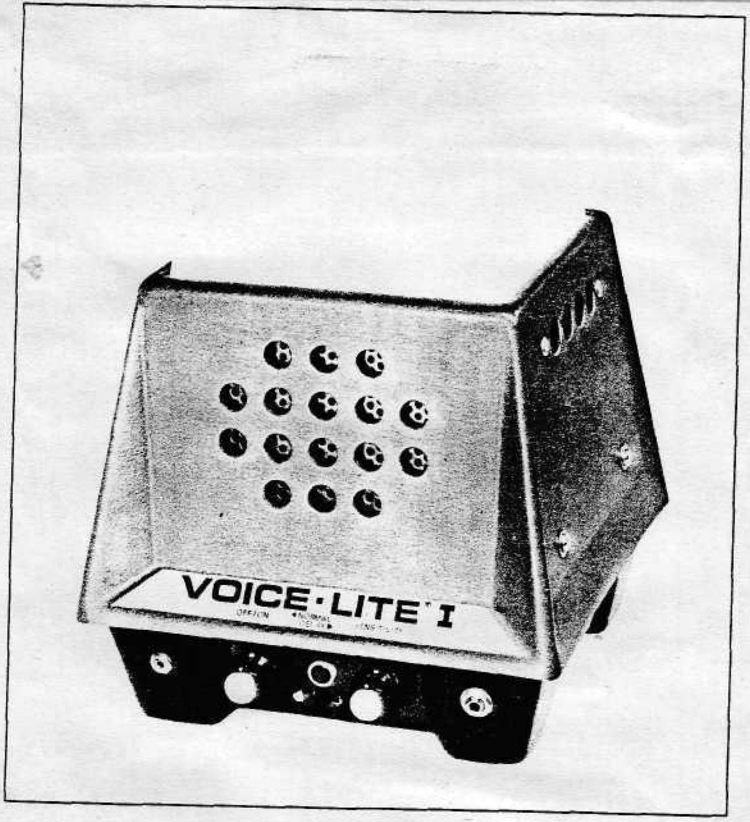
PURPOSE

The Lucia Spectrum Indicator is designed for training the articulation of profoundly deaf individuals. It is useful in teaching phonetics. The unit provides the physical properties of speech and sound via a spectrum of light on horizontal and vertical axes. This enables the client to "see" speech he cannot hear, thereby providing him with effective reinforcement for appropriate speech production.

FIG. 8. b.

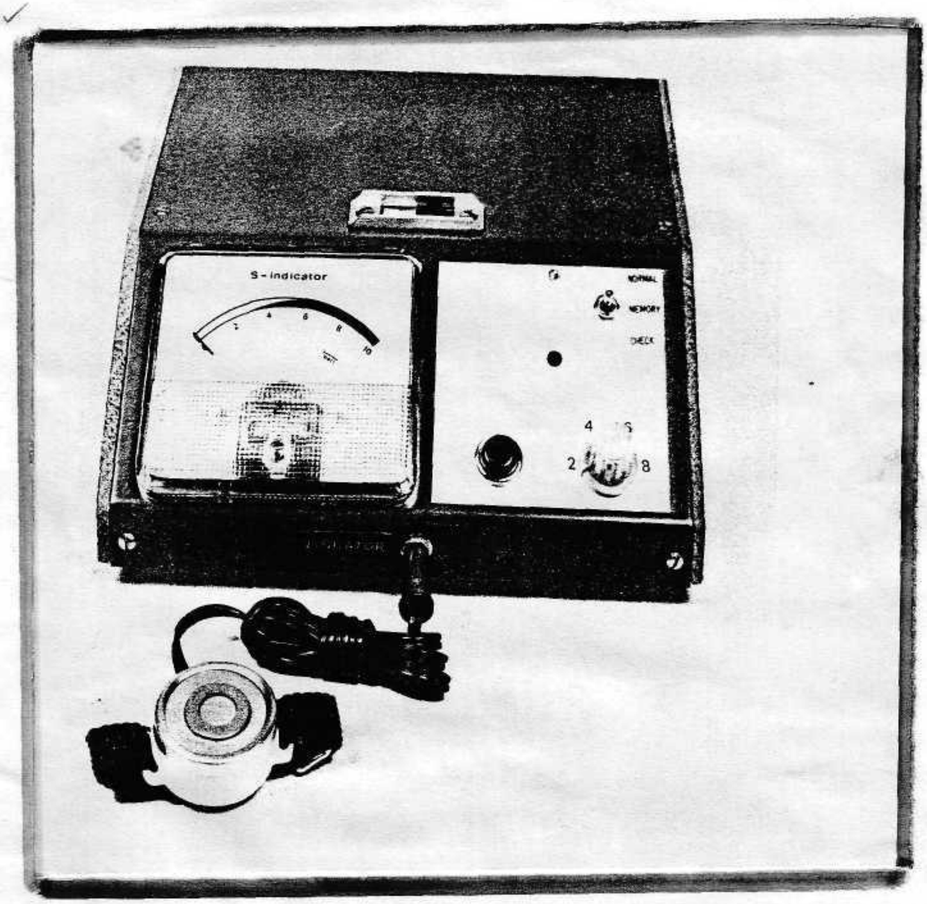
PURPOSE	The Vocal Loudness Indicator displays relative levels of loudness. The device provides motivating visual reinforcement and is useful for hearing-impaired persons who aim to increase their awareness and control of vocal loudness levels.

FIG. 9. a.



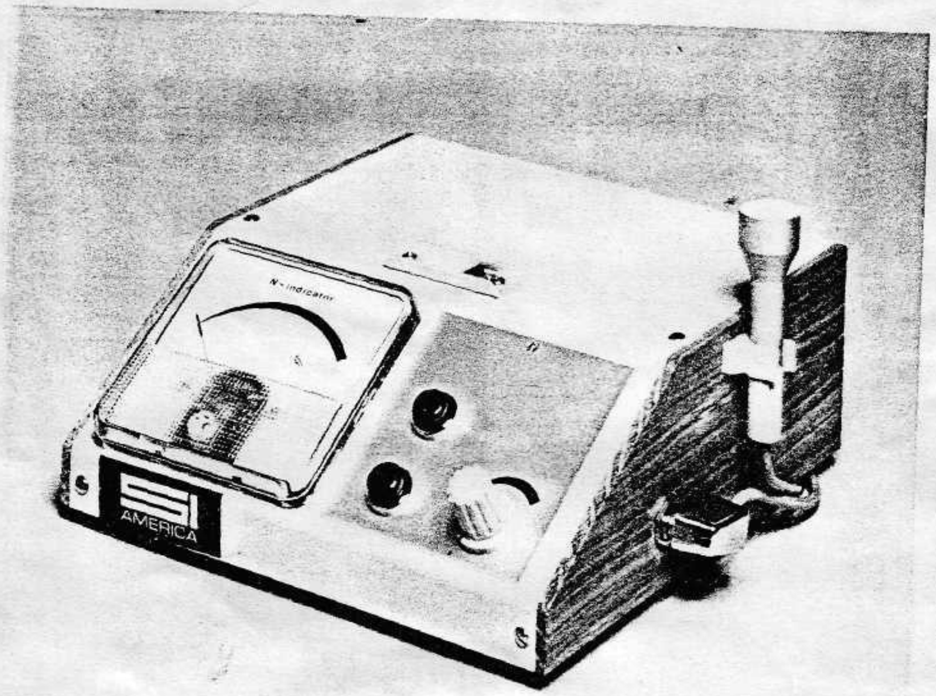
PURPOSE	The Voice-Lite I changes sound energy into light patterns of corresponding intensity and duration. It is normally used in client-therapist settings with autistic children or with persons who have undergone laryngectomies. The immediate reinforcement of light signals helps the user to learn oral articulation.
DESCRIPTION	A sensitivity dial on the unit can be set to respond to an individual's volume control problem in that the light will respond beyond a specific level of vocal intensity. It can also be applied to voices that are too soft. To show that voiceless sounds are also in the audible range, the plug-in microphone can be used, and the light will illuminate for both voiced and voiceless sounds. For persons learning breath control, a delayed light response is available. For light-sensitive deaf-blind persons, the unit can be used in a dark room to provide enough visual feedback for conditioning and learning. For the non-light-sensitive deaf-blind person, a tactile stimulator is available.

FIG. 9.6



PURPOSE	The Voiceless S-Indicator is designed for training the voiceless *s* sound. It is very useful in articulation therapy.
DESCRIPTION	The instrument contains a meter, a green lamp, and relay outputs to give visual indication of the quality of the *s* produced by the client. The instrument's circuitry uses a zero-crossing frequency-measuring technique that estimates the center of gravity of the energy on the frequency axis. It is recommended that this instrument be used with an auditory trainer so that auditory and visual feedback systems are both used in therapy. An optional wrist vibrator for tactile reinforcement of correct *s* production is available.

FIG. 10



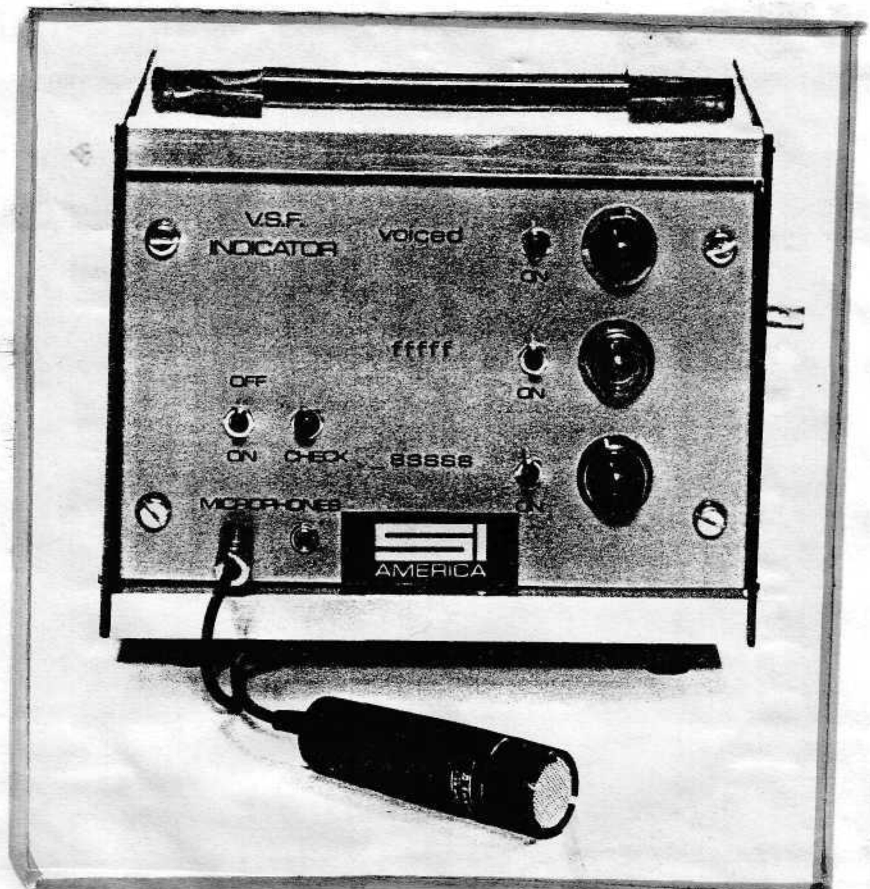
PURPOSE

The Nasality Indicator measures the vibrations at the ala nasi level as picked up by the contact microphone. It does not measure nasal emission. The instrument is particularly effective in training nasalization and denasalization of deaf and cerebral palsy patients.

DESCRIPTION

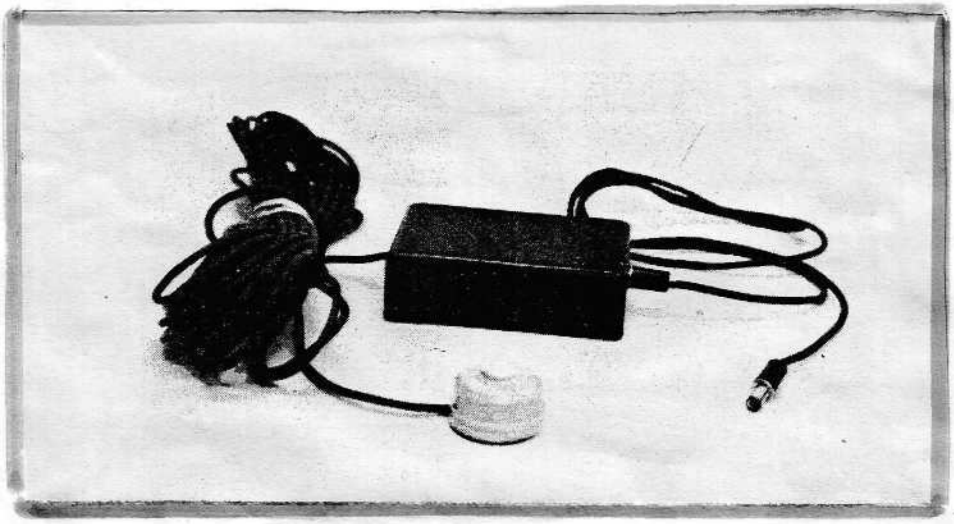
This unit includes a meter readout that can be set individually in relation to the patient's objective. An adaptor option is available so that the therapist can adjust the system through 1 microphone while using a second microphone for the student's tests.

FIG. 11



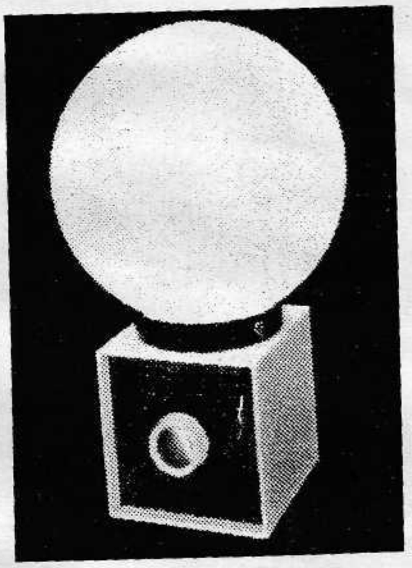
PURPOSE	The V.S.F. Indicator provides feedback on specific speech sounds to the hearing-impaired person with visual cues provided by lights.
DESCRIPTION	Voiced sounds are indicated by the top light on the unit; *f*, *th*, and *sh* sounds are indicated by the middle light; and voiceless *s* sounds are indicated by the bottom light. An On-Off switch for each light enables the therapist to work on an individual sound or articulation exercise. A VU meter is not provided. To be most beneficial to the hearing-impaired person, this unit should be used in conjunction with an auditory trainer.

FIG. 12



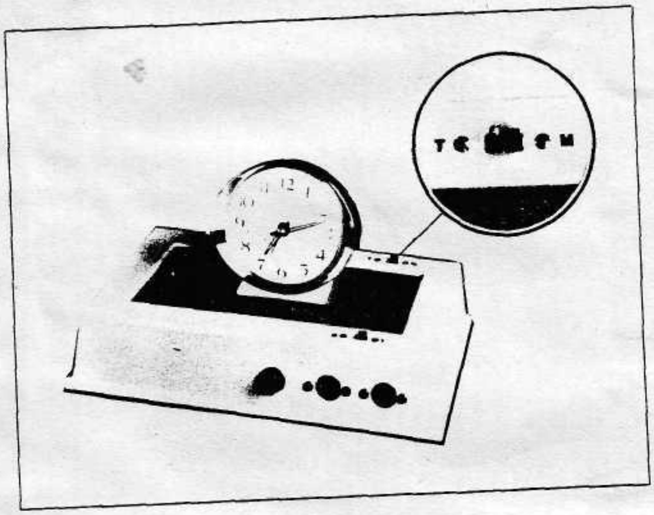
PURPOSE	The unit allows a hearing-impaired person to sense the doorbell is ringing through the vibration of the bed pillow. It also functions as a signalling and wake-up device.

FIG. 13



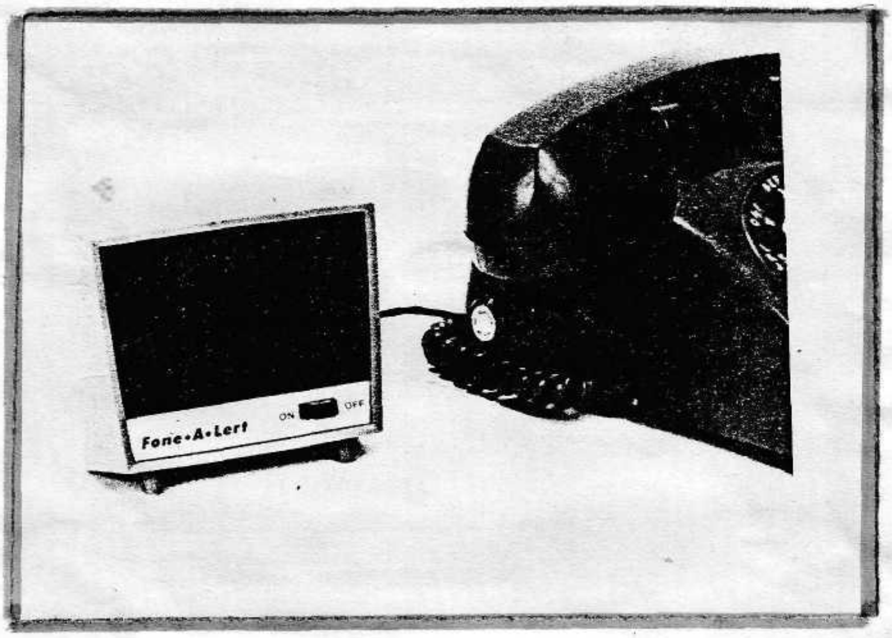
PURPOSE The sensitivity control on the Sound-Lamp can be set to alert an individual at home to a telephone or doorbell ringing, a knocking on the door, and other such sounds.

FIG. 14.



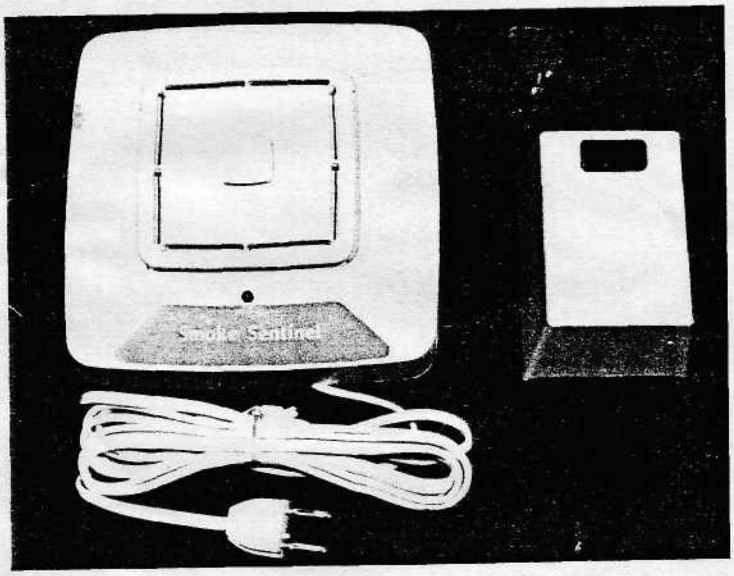
PURPOSE	The Alarm Alert can be used as a wake-up alarm clock, baby alarm/alert, smoke or fire alert, telephone or doorbell signal alert, or general emergency alarm.

FIG. 15.



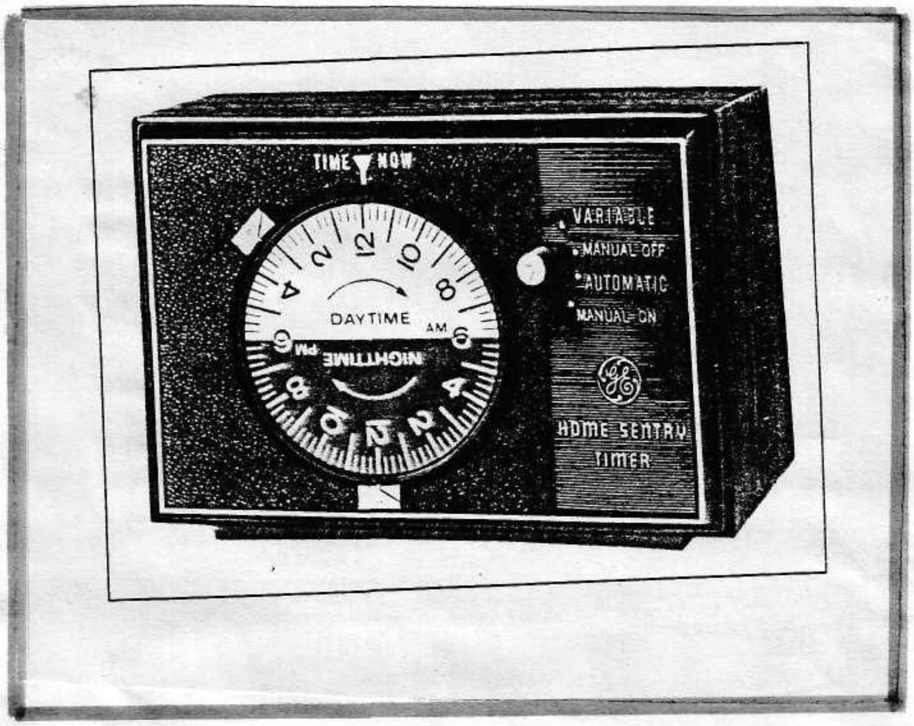
PURPOSE	The Fone-A-Lert produces a shrill signal that is audible to the hearing-impaired person anywhere in an apartment or house. In some instances (depending upon the degree of hearing loss), the signal can be heard without the use of an aid. The volume cannot be controlled.

FIG. 16.



PURPOSE	This smoke detector allows a hearing-impaired or deaf-blind person to be alerted to smoke or fire in the home.
DESCRIPTION	This photoelectric, nonradioactive detector can be connected by either a wiring system through the wall or a wireless system. The unit can be wired to give a warning by means of a vibrator or a lamp.

FIG-17.



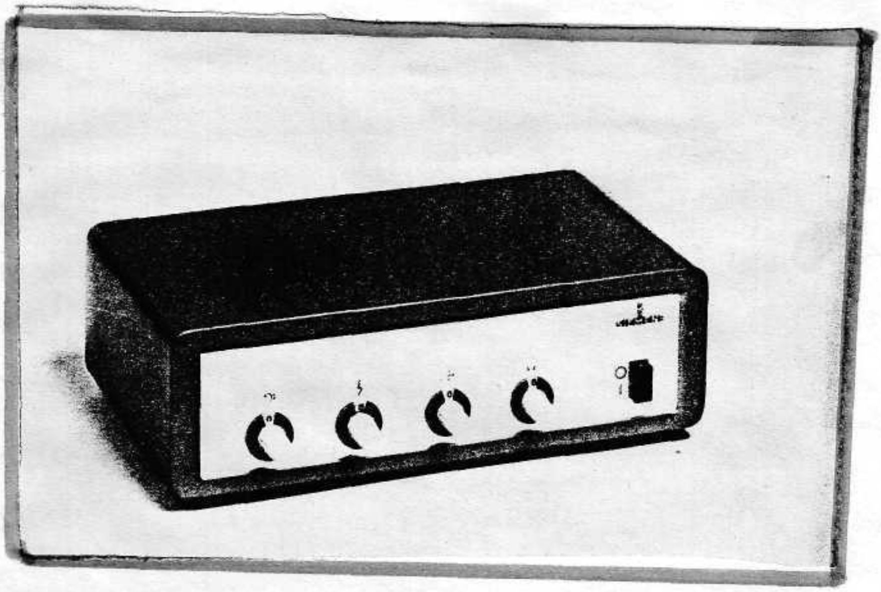
PURPOSE The Vibrating Alarm Kit awakens a person to a gentle vibration that is transmitted throughout the bed. The unit also provides the time of day.

DESCRIPTION The kit consists of a special electric timer, a heavy-duty vibrator, mounting board and brackets, and a set of instructions. The instructions are easy, and installation on all types of beds is simple.

FIG. 18

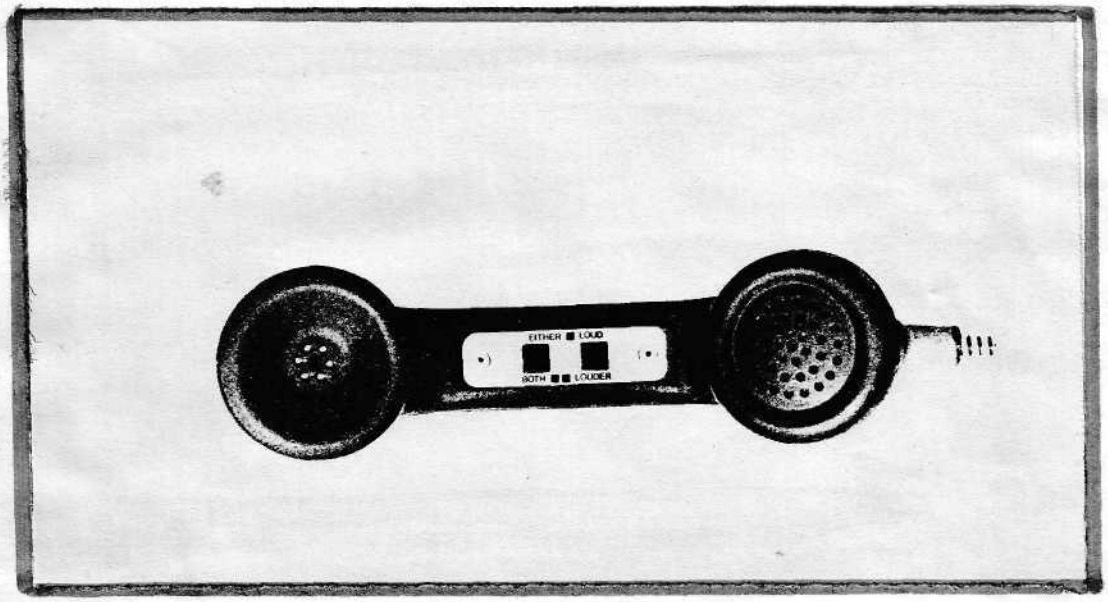
FIG. 19

A CLOSE CAPTIONED TV PROGRAMME



PURPOSE	Using vibration, the Mono-Fonator System helps to stimulate, control, and structure a person's speech. This system can be used as a vocal-auditory means of sensory training, providing vocal cues to individuals where amplification is of little benefit. It can provide the therapist with a controllable sensory input that gives reliable feedback for certain fundamental, distinctive features. The Mono-Fonator can be used to enhance therapeutic technique. The system assists in speech production training by providing additional information to help establish a same/different criteria (correct/incorrect) for production. In the case of an auditory deficiency (perceptual or hearing loss), it provides the necessary cues for controlling pitch, loudness, duration, inflection, and rhythmical patterns, and for learning production and coarticulation of vowel and consonant sounds. The Mono-Fonator is also useful in areas of autism, aphasia, auditory impercipience, mental retardation, and other centrally located dysfunctions. It can assist in the identification of many important auditory cues that are needed to correctly identify a vocal message.
DESCRIPTION	The unit consists of an amplifier, a microphone with table stand, a single vibrator with wrist strap, and a headset on an adjustable headband. The portable amplifier and accessories are housed in a carrying case. Separate tone controls for high and low frequency adjustments are provided for the vibrator. There are 2 separate output amplifiers for the vibrator and headset, each with an independent volume control. In principle, this unit is similar to traditional auditory trainers. However, it also provides a vibrator output.

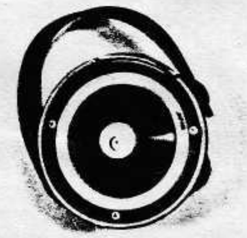
FIG. 20



PURPOSE The handset provides voice amplification for the hearing-impaired person. It is used commercially at public installations.

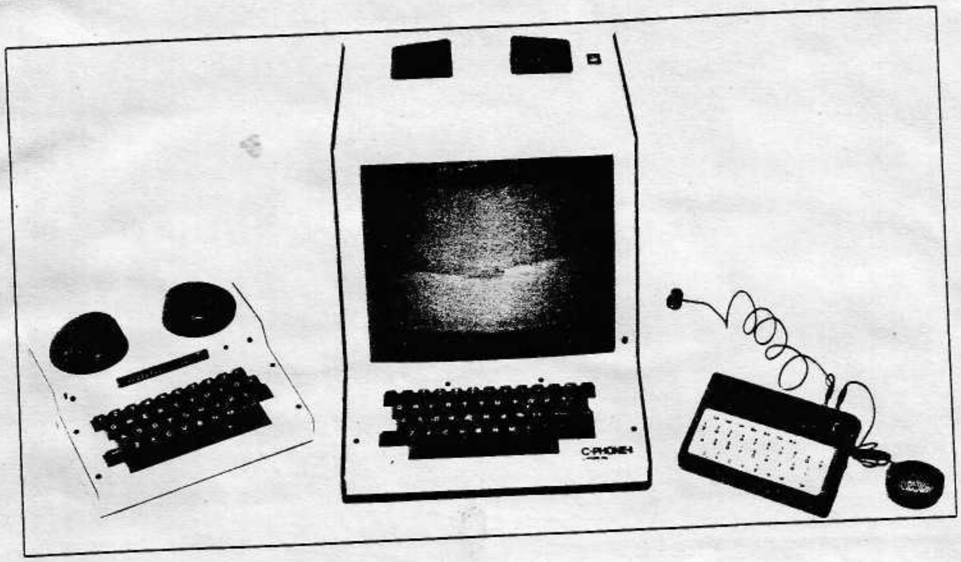
DESCRIPTION This unit in a telephone receiver has a two-button device that increases a telephone's amplification 10 dB when one button is depressed and an additional 10 dB when the second button is depressed at the same time.

FIG. 21



PURPOSE The coupler is designed to allow use of amplification with telephones that do not have electromagnetic coils.

FIG. 22



PURPOSE

The Mini-phone [redacted] permits hearing-impaired or deaf persons to receive and send telephone messages.

DESCRIPTION

This lightweight portable unit has a built-in telephone coupler with a 4-row keyboard. It includes an instant recall button for reviewing the last few words of the message. An auxiliary outlet will accommodate an optional paper printer.

FIG. 23.