AUDIO VISUAL FOR A COURSE ON HEARING AIDS

Reg.No.M9309

AN INDEPENDENT PROJECT SUBMITTED IN PART FULFILLMENT FOR THE FIRST YEAR M.Sc. (SPEECH & HEARING), UNIVERSITY OF MYSORE, MYSORE.

ALL INDIA INSTITUTE OF SPEECH AND HEARING, MYSORE - 570 006.

MAY 1994

CERTIFICATE

This is to certify that the Independent Project entitled: AUDIO VISUAL FOR A COURSE ON HEARING AIDS, is the bonaf ide work in part fulfilment for M.Sc., in Speech and Hearing, of the student with Reg. NO.M9309.

Director

All India Institute of
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Mysore
May, 1994

CERTIFICATE

This is to certify that the Independent Project entitled: AUDIO VISUAL FOR A COURSE ON HEARING AIDS has been prepared under my supervision and guidance,

Mysore
May 1994

Dr. (Miss) S. Nikam
GUIDE

D E C L A R A T I O N

This Independent Project entitled: AUDIO VISUAL FOR A COURSE ON HEARING AIDS, is the result of my own effort under the guidance of Dr.(Miss) S. Nikam, Director, and HOD-Audiology, All India Institute of Speech and Hearing, Mysore-6 and has not been submitted earlier at any University for any other Diploma or Degree.

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INTRODUCTION AND DEVELOPMENT OF HEARING AIDS

SLIDE:

A. Chart showing the development of hearing aid from cupped hands to the electronic hearing aid.

Hearing aid plays a vital role in the rehabilitation of the hearing impaired. From the time it has been developed hearing aids have undergone numerous modifications. The history of hearing aids began with the hand cupped behind the ears. One of the first hearing aid devices used were animal horns and broken seashells. These were later modified and used as ear trumpets and cornets. Hearing aids in the form of acoustic canes and fans were also used to make the hearing aid less conspicuous. Acoustic chair (or throne) containing a mouth piece, resonant box and hearing tube was used by King Goa (John) of Portugal. These hearing aids helped the users to hide their hearing loss as well as provided them with amplification. Besides these, ear inserts, artificial eardrum, bone conduction hearing aids like

Fanifero, Audimet have also helped individuals with conductive hearing loss. The major development of hearing aids was from electric to vaccum to transistor to the latest electronic hearing aids. It has changed from large horn shaped ones to miniaturised ones keeping in mind the cosmetic value and at the same time improving its quality by having excellent fidelity and very low distortion products.

BASIC COMPONENTS OF A HEARING AIDS

SLIDE	AUDIO
X. Body level hearing aids	The four basic components of a hearing aid are microphone, amplifier, receiver and power supply (battery).
3. Microphone	The microphone responds to acoustic sound pressure variations and converts them into electrical voltages which are analogous to the acoustic signal. The exterior portion of the microphone consists of a thin and flexible diaphragm which is connected to a movable iron piece by a pin. When the sound waves fall on the diaphragm, it vibrates along with the iron piece inducing an electric voltage in the coil. This is then amplified by an amplifier. The magnetic microphone is used in many hearing aids as it has a broader frequency response, good vibrational characteristics and is less easily damaged by dropping.

4-Amplifier

It is a device which amplifies by means of a transistorized circuit, the electrical signal produced at the microphone. The energy increase is usually on the order of 50 to 300 times fay one transistor. Typically 3 or more transistor amplifiers *are* coupled to one another in successive stages in a hearing aid.

5.. Receiver

The receiver transduces the electrical current to sound pressure. There are two types of receivers used with hearing aids, the air conduction type and the bone conduction type. The bone conduction vibrator is placed behind the ear, on the mastoid bone. It is used in conductive hearing loss. Most ear level hearing aids have internal receivers ie. the amplified sound is converted to mechanical energy within the physical enclosure of the aid and then conducted to the earmold by means of a small plastic tube.

6. Power supply (Battery)

The battery provides the power to drive the amplifier for the amplification process. The most commonly used hearing aid battery *are* the mercury cell or silver oxide cell. Generally, the hearing aids work on 1.5 volts. As the battery voltage decreases, the volume control has to be increased correspondingly for the user to get requisite amplification. Once S/3 of the full range of volume control is reached and if the sound is inaudible or weak, a fresh battery has to be used.

Additional parts of hearing aids are:-

7-8 On-Off Switch

On-off switch is a device in hearing aid which makes and breaks the circuit depending on the position it is placed. The advantage of the on/off switch is that it helps to avoid unnecessary battery drainage.

Volume control	It is a device by means of which the sounds can be made louder or softer. The markings on the volume control could be either numbers, colours or arrow marker. It is recommended that the volume control be set at l/3rd level. Below this there is not much of amplification. Volume control close to its maximum level produces a distorted sound.
Tone control	A tone control is generally thought of as a circuit designed to provide high or low frequency emphasis. If high frequency emphasis (HFE) is desired, a high-pass filter network (low frequency filtered) is used. Conversely, for low frequency emphasis a low pass filter network is employed. They are marked as H, N and L on the hearing aid.
Telephone Pickup	Many hearing aids are or can be equipped with a special circuit to enhance its use with a telephone. The circuit consists of a magnetic induction pickup coil mounted inside

the case which converts the magnetic fields into electric signal. It is then amplified and again transduced into an acoustic signal. Aids with this component have either a two-OK— three position switch that allows use of the microphone alone (M), the telecoil alone (T) or both together (M/T).

9. Cord or tubing

Body type hearing aids with external receiver require a cord to deliver the amplified electrical signal to the receiver. Cords are light, flexible, insulted wires. Cords can be either 2 pin, 3 pin, single cord or pseudobinaural cords (either V cord or Y cord). In behind the ear hearing aids flexible plastic tubing are used for conduction of sound energy.

Output control

This screw adjustment imposes a limit to the maximum amount of sound the hearing aid will transmit. This output limiting may be achieved in the aid through either peak clipping or compression, the latter also referred to as automatic gain control (ABC).

TYPES OF HEARING AID

Wearable hearing aids are available in different styles, which are named according to their location on the user .

10(a)Body worn hearing aids

The term body worn refers to a small rectangular instrument usually worn on the chest. Either it may be clipped to an article of cloth, such as a shirt pocket, or harness strapped around the chest. The microphone, amplifier and battery on the aid *are* within the case. A flexible cord leads from aid to external receiver.

(b)Behind-the-ear hearing aids

Another term for behind-the-ear is post auricular. In this hearing aid model, all components of the system-microphone, amplifier, receiver and battery-are contained within a small, slightly curved case, designed to fit behind the ear of the wearer. Its advantages include elimination of cloth noises, improved localisation and cosmetic appeal.

(c) Eye Glass hearing aids

In this style of hearing aid, all components are built within the temple bar of an eye glass frame. Xt is usually not recommended for young children because of its bulk and the problems associated with maintaining two sensory aids concurrently.

{d) In-the-Ear hearing aids

In this style, all parts of the hearing aid, including the battery are contained within a plastic shell that its entirely into the outer ear.- An in-the-canal aid is an even smaller version of this style. These aids *are* cosmetically appealing. Because of tiny controls, lack of flexibility of electroacoustic parameters, difficulty in inserting and/or removing the hearing, aid from the ear, miniature batteries, these aids have not been used widely with children and very elderly individuals.

11- CROS

Contralateral routing of signals (CROS) hearing aids are used with unilateral hearing loss. In the basic CROS design a microphone is placed on the side of the head with the bad ear, delivering amplified sound to the better ear. A non-occluding or open earmold is necessary with CROS to allow natural sound to reach the good ear and to reduce amplified low frequencies.

12. CROS arrangement in eye glasses

The slide depicts the original CROS arrangement in eye glasses. A microphone is located in the eye glass temple on the side of the bad ear. The sounds picked up *are* routed through a wire to an amplifier and receiver in the opposite temple, from where the amplified sound is delivered to the good *Bar.*

CROS helps in localisation and the hearing sounds from the side of the poor *ear* due to elimination of head shadow effect.

13 BICROS

BICROS utilises two microphones, one on each side sending signals to one receiver. It is used in cases with one ear unaidable and the other aidable ie. a profound loss in one *ear*, a moderate loss in the other. In open BICROS, an open earmold is used.

14 HICROS

CROS aids which are used with individuals having high frequency hearing loss are called MICROS. Its advantages are better discrimination, comfortable amplification, increased high frequency gain without talerance problem and more natural soundi-ng speech.

15. Power CROS — CROS aids used to achieve the benefits of ear level amplification, instead of a body worn aid, is called POWER CROS. It is used in severe hearing loss cases who cannot get enough amplification with a conventional ear level instrument without feedback.

CRIS CROS — It is the name for a binaural POWER CROS. It is used for the same reason as POWER CROS, but by those who want binaural amplification. The microphone on the left side routes signals to the right *ear* and vice versa.

16. IROS — Ipsilateral routing of signals (IROS) can be used only for mild loss requiring little amplification. The principle exploits the benefit

of an open ear mold by coupling a conventional at-the-ear hearing aid to the ear with the open mold. Binaural application of this is BIROS.

17. FROS

Front routing of signal (FROS) places the microphone on the eye glass near the midline or front of the temple bar thereby separating the microphone and receiver. These can be used by individuals requiring a little more amplification than provided by IROS.

18. MINICROS

These *are* CROS aids without *ear* molds or sound tube. It is used with patients having normal hearing sensitivity in one e*ar* and loss in the other. It alleviates problem of over amplification.

19. FOCAL CROS

FOCAL CROS principle is to place the effective sound pick up inside the concha of the unaidable ear thus giving additional benefits to the unilateral CROS user.

20. MULTICROS

It is achieved by putting an on-off switch on each microphone of a BICROS aid. By manipulating these switches, user can change aid from CROS to BICROS to conventional monaural aid.

21. UNICROS

It consists of S receivers, 2 volume controls and one microphone located on the side of the poorer ear. It is a combination of monaural aid for poor ear and high CROS for better ear. It is used in asymmetrical hearing loss.

22. Bone conduction hearing aids

Bone conduction aids are similar to body level aids except for the receiver. In these aids a vibrator is placed on the mastoid. These aids are used in congenital malformations like atresia.

Based on the number of hearing aids worn, they are classified as -

23 Monaural hearing aids

The directing of the amplified sound to a single ear is referred to as monaural amplification. In monaural fitting separate aids are fitted for each ear. It may be body worn or ear level type of hearing aids. Its advantages are that suitable amplification may be given for each ear separately and that it is affordable. However, it does not help in localisation of sounds as well as discrimination of sounds.

24. Pseudo Binaural or Y cord hearing aids

The division of the amplified sound to the two ears is called a Y cord fitting, or pseudobinaural. It is a monaural aid delivering sound to both ears through two receivers. Its advantages are that both ears receive auditory stimulation, better speech discrimination, lower initial cost and lower operating cost through less battery consumption than binaural aids. It can be used only when the loss is symmetrical.

25 Binaural hearing aids

When the sound, by separate microphone, amplifier, and receiver, is directed to each *ear*, this is referred to as a binaural hearing aid. Its advantages *are* improved SRT, improved discrimination, particularly in noise, better localisation of sound and improvement in UCL. Binaural aids, however, are expensive.

EARMOLDS

SLIDES	AUDIO
	The ear mold, sometimes called the earpiece, is a plastic insert designed to conduct the amplified sound from the hearing aid receiver into the ear canal as efficiently as possible. The functions of the ear mold include comfort to the wearer, to carry the hearing aid output clearly and often with controlled modifications into the ear canal.
	The purpose of the ear mold is to deliver the amplified sound directly from the receiver into the ear canal.
	The different types of ear molds are
26 .Receiver mold	They are solid mold with a metal or plastic snap ring for the external receiver to fit onto the ear mold.

These molds are designed to set as deeply into the ear as the diameter of the receiver will allow. It can be used in body level as well as ear level hearing aids.

27. Shell mold

These molds have a full canal and a thin shell covering the bowl of the ear with or without helix. They are used with internal receivers. It is used when fitting Very high gain ear-level hearing aids.

28. Skeleton mold

These molds consist of canal and a thin frame around the bowl of the ear. The concha rim sustains the mold in the *ear.* It has 2 variations - the "3/4 skeleton" - in which the central portion of the concha rim has been removed and the semi "skeleton" which has no concha rim. These molds are used with moderate gain hearing aids.

29. Canal mold	This is the most comfortable and cosmetically appealing mold which consists of the canal portion of the ear. It is used for moderate gain hearing aids.
30. Canal lock mold	These molds consists of the canal as well as the lower one half of the concha rim which permits retention in small or straight canals and aids in insertion and removal of mold from the ear. It is used in moderate gain hearing aids.
31. All-in-the-ear mold	These hold an All-in-the-ear hearing aids. The ear mold itself forms the enclosure for the hearing aid components.

Each ear mold is custom made. The materials used in making earmolds are acrylic, silicone, vinyl and polyethylene. Molds can be either hard mold or soft mold depending on the materials used. In some cases with certain audiometric configurations, special ear molds or ear molds with certain modifications are recommended to provide a pathway for amplified sound to escape. The special *Bar* molds are called open, non-occluding ear molds and the modification made is termed a vent. A vent, depending upon its length and diameter, can alter the response of the hearing aid.

32. ELECTROACOUSTIC CHARACTERISTICS OF A HEARING AID

Electro acoustic characteristics of a hearing aid is nothing but the method of expressing hearing aid performance.

SLIDES	AUDIO
Acoustic gain	It refers to the amount of amplification that is added to the input signal by the hearing aid. Hearing aids are described as having mild (approximately 25 to 40 dB), moderate (approximately 40 to 55 dB) or high (more than 60 dB) gain. It is measured as an average of the amount of gain provided at frequencies of 1000, 1600 and S500 Hz, When a 60 dB SPL input signal is presented. The gain control is set at full-on for this measure.
Saturation sound pressure level (SSPL) Maximum power output	The highest output level delivered by a hearing aid is known as its maximum power output (MPO) which is operationally defined as a frequency response curve known as SSPL 90 (SSPL when the input is 90 dB). To measure SSPL 90, gain control is set to full-on with 90 dB input into the

aid. The average output at 1000, 1600 and 2500 Hz is calculated and referred to as the "high frequency average" SSPL 90. The curve also yields peak SPL and the frequency at which it occurs.

The output of the aids can be limited by S ways. Peak clipping and compression.

Frequency response

The relative amount of gain provided by the hearing aid at different frequencies constitutes its frequency response. It is obtained over a wide range of frequencies (200-5000 Hz) with an input of 60 dB SPL at the reference test gain position of the aid.

Frequency range

This expresses the low high frequency limits of usable amplification.

Distortion

Hearing aids are subject to several types of distortion that occurs when the input-output relationship of the system is not linear. The most common type of distortion is harmonic distortion which is one of the effects of nonlinearity in which new frequencies not present in the input are created which are whole number multiples of the fundamental frequency. Harmonic distortion is measured at 500, 800 and 1600 Hz with gain control and input levels varying depending on whether the aid incorporates peak clipping or some form of compression.

Other types of nonlinear distortions are transient distortion, inter modulation distortion, frequency distortion and extraneous distortion.

HEARING AID SECTION

SLIDES	AUDIO
33. Comparative procedure prescriptive procedure	There are two predominant approaches to hearing aid selections - the comparative and the prescriptive procedures. The comparative procedure compares hearing aids with each other as the basis of selection. The prescriptive procedure focusses on the determination of electroacoustic characteristics for a hearing aid and frequency gain function which is necessary for an individual.
34. Comparative procedure Carhart's procedure	This procedure aims at finding a hearing aid which is of utmost use in everyday listening and in adjusting to the hearing. The procedure is as follows: * Audiological and otological examination are made.

* Custom made ear molds are used.
* A number of hearing aids are selected depending on certain preselection hearing aids and 3-4 hearing aids are selected for clinical evaluation.

Clinical evaluation procedure includes-

* Unaided pure tone (AC and BO, SRT, DS and tolerance limits are measured.
* Patient is made to wear each hearing aid. Gain control is adjusted so that the speech level at 40-60 dB HTL is at most comfortab1e 1eve1.
* Aided gain for speech threshold and tolerance limits are measured. DS in noise and quiet are also recorded.

By comparing the test results of different hearing aids, one aid is prescribed to the patient.

35.Prescriptive procedure Threshold based proce-duce.Loudness based procedure

In the loudness based procedure, a measure of upper limit of comfortable loudness can be made at seven frequency regions. The stimuli are calibrated in SPL. A frequency gain function is derived which amplifies speech with an input of 70 dB SPL to a point in the middle of the range between the hearing thresholds in SPL and the UCL contours. At each frequency SSPL 90 is specified constantly 12 dB above the UCL.

If patient is unable to make loudness judgements, the threshold based prescriptive procedure is used. Initially assessment of hearing loss for puretone is made. Simple prescription rule ie 4/10 rule is used here which specifies that the gain desired at any frequency is 0.4 times the hearing loss at that frequency. It is observed that preferred listening levle typically increases at the rate of 3-5 dB for each 10 dB of hearing loss. Thus the entire speech spectra, can be amplified to the patients preferred listening level.

other prescriptive procedures ->

36 I. LYBARGER'S PROCEDURE

Lybarger's half gain rule (1944) For SN loss; Real ear gain=l/2 PTA (at 1000 Hz, 2000 Hz, 3000 Hz, and 4000 Hz) For conductive loss: Real ear gain=l/2 PTA+ 1/4 (AC-BC threshold at each frequency.

in this rule, an individual's pure tone thresholds obtained are multiplied by 0.5 between 1 KHz and 4 Hz to get the prescribed real ear gain. Lybarger has given the half gain rule for both conductive and sensori-neural hearing loss.

37 II. PRESCRIPTIVE GAIN OUTPUT (P0G0)

by McCandless and Lyregaard (1983) 6ain=l/E HTL at IK, 2K 3K & 4 KHz

This is a modification of the Lybarger's half gain rule. PoGo is predominantly individualised to sensorineural hearing loss or sensory loss with recruitment. Additional gain is required for

= *1/2* HTL-10 at 250 Hz

= 1/2 HTL-5 at 500 Hz

$$\frac{UCL_{500}+UCL_{1000}+UCL_{8000}}{3}$$

38.III. BERGER's METHOD (1984):

1/2 HTL at 500 Hz, K, 6K. Gain= 0.59 to 0.67 HTL at IK, 2K, 3K.

For clinical use, the prescribed real *ear* gain is as follow:

Freq. in Hz	Gain
500	0.3 x HTL
1000	0.63 x HTL
2000	0.67 x HTL
3000	0.59 x HTL
4000	0.53 x HTL

those with conductive hearing loss which is not yet provided for in the procedure. It involves 3 steps

*Calcuation of requiredcharacteristic gain and MPO from audiometric information.

*Implementation of the requried gain and MPO by selecting and Adjusting the hearing aids by dispenser.

* Verification of acoustical performance.

Berger, Hagberg, Rane recommended using the half gain rule at 500 4 Hz, 4 KHz, 6 KHz and an additional gain between 1 KHz and 3 KHz. This gain is also called an operating gain and is the real ear gain. The criteria of using real ear gain is that, it makes the amplified speech energy equally loud between 500 Hz and E000 Hz. A little less gain is recommended at 4 KHz and 6 KHz. So that a high SPL would not cause damage to the cochlea.

6000 0.53 X HTL For conductive hearing losses: Additional gain = 0.2 x (AC-BC) threshold not greater than 8 dB.	For conductive loss cases, additional gain has to be provided.
39. IV. LIBBY's Method (1985). Insertion gain=l/3 HTL +/- C (severe to profound hearing losses) C=correction factor =5dB at 250 Hz, IK, 2K 3K, 4K, 6K =3 dB at 500 Hz. For conductive hearing loss cases. Insertion gain=l/4 HTL <1000-4000Hz).	Libby's method is used with mild to moderate sensori-neural hearing loss and in patients who are unable to respond intelligently ie MR, Aphasics etc. This method involves the 3 steps of preselection, implementation and verification. It is based on listening level of the individual.
40 V. National Acoustic Laboratories (NAD Procedure) Byrne and Dillon(1986)	This procedure is based on predicability of required frequency response and overall

Gain=x+0.31xHTL+K where K=frequency dependent constant dependant on gain type prescribed.

X=5% of the sum of hearing threshold levels at 500 Hz, 1000 Hz, 2000 Hz.

0.31xHTL=0.3 times the hearing threshold level (puretone) at the frequency considered.

K values for real ear measurements:

Freq (Hz)	K values
250	-17
500	-8
1K	+1
1.5K	+1
2K	+1
3K	-2
4K	-2
6K	-2

gain from the audiogram. NAL procedure aims at making all parts of the frequency. Spectrum .of the speech equally loud when hearing aid is worn at preferred listening level.

OBJECTIVE METHODS

SLIDE	AUDIO
41.l. Computerised probe measures. FONIX-computer controlled Real time . analyser (1988)	Using computerised methods, the clinician can visualise the electroacoustic characteristics of a hearing aid. FONIX 6500 real time analyser has a video display attached to it. It identifies various electroacoustic characteristics. The prescriptive formulae - NAL, PoGo, BERBER, LIBBY's 1/2 gain, 2/3 gain and 1/3 gain formulae can be used.
422. MADSEN I BO (1000)	The insertion gain optimizer ISO (1000) is used for hearing aid selection. It gives the display of insertion gain and frequency response. The prescriptive formulae NAL, PoGo, BERBER, LIBBY's 1/2 gain, 2/3 gain and 1/3 gain can be used. Insertion gain curve provides a basis for hearing aid selection.

ISO (1000) system offers a compact, high resolution, high speed and extreme test accuracy. It is efficient and designed with maximum user comfort.

COUNSELLING

SLIDE	. AUDIO
	A hearing aid can be thought of as a miniature public address system. Its main function is to amplify sound in a way that is appropriate for your particular hearing loss. Hearing aids consist of microphone, amplifier, receiver and power supply.
43 Battery	The battery must be inserted into the aid with its positive and negative terminals in their appropriate locations. It is advisable to remove the battery when the aid is not in use. This will extend battery life. If hearing aid seems weak in power, requiring you to turn the volume control higher, a weak battery is the most likely cause. Try a new one.

44-Connectitm of hearing aid to earmold.

With a BTE, connect the aid to the plastic earmold tubing. With body worn aid, the hearing aid cord is connected to the external receiver which is then snapped onto the earmold.

45 Volume control

Volume control should be set to a constant position as recommended by the audiologist. Volume control can be adjusted by the patient depending on the loudness of voice, environmental noise etc.

Telephone use

The telephone receiver should be placed near the microphone of the aid when you need to use your hearing aid to help you better on telephone. Switch on the aid to 'T' position. Volume may have to be turned up higher than usual.

Acoustic feedback occurs when sound amplified by the aid escapes out of the *ear* canal around the outside of the hearing aid and is picked up by the microphone and reamplified. It may occur when hearing aid is not properly inserted into ear or earmold does not fit *ear* tightly or when volume control is very high. Check for these when feedback is present.

Cars of hearing aid:

Water should not enter the aid. Earmolds should be regularly cleaned to prevent clogging of wax.

Do not drop the hearing aid on hard surfaces, it will damage its internal circuit.

If the aid stops working, check for the battery and the earmold to see if there is clogging of wax. Put a new battery if needed and clean the mold. If the aid still does not work take it to the manufacturer.

BIBLIOGRAPHY

Anita, V. (1993): "Insertion gain measurement for hearing aid selection - An audio visual script", Unpublished Independent Project, University of Mysore.

Ayers, E.W. (1953): Cited by Madsen, P.B. (1986) "Insertion gain optimization", Hearing Instruments, 37, 28-32.

Barr, R.M., Hamilton (1983) : "The cupped hand as an aid to hearing", British Journal of Audiology, 17, 27-30.

Berger, K.W. (1976): "From telephone to electronic hearing aid", Volta Review, 78, 83-89.

Berger, K.W., and Millin, J.P.: "Hearing aids". In Audiological Assessment. Edited by D.E. Rose, Englewood Cliffs, N.J., Prentice-Hall, 1977.

Berger, K.W.; "History and development of hearing aids". In amplification for the Hearing Impaired. Edited by M.C. Pollack. N.Y; Grune and Stratton, 1980.

Berger, K.W. (1981): "The earliest known custom earmold", Hearing Aid Journal, 2, 17, 11-12.

Briskey, R.J. s "Binaural hearing aids and new innovations". In Handbook of Clinical Audiology", Edited by J.Katz, Baltimore, Williams and Wilkins, 1976.

Carvel, W.F. :" Hearing aids : Historical and technical Review", In Handbook of Clinical Audiology. Edited by J. Katz, Baltimore, Williams and Wilkins, 1976.

Carver, W.F.: "Development of the hearing aid and the hearing aid Industry", In* Hearing Aid Assessment and use in Audiologic Habilitation2 Edited by W.R. Hodgson and P.H.Skinner, Baltimore; Williams and Wilkins, 1977.

Dalsgaard, S.C. (1976): Cited by Madsen, P.B. (1986): "Insertion gain optimisation". Hearing Instruments, 37, 28-32.

Dalavy (1968): "Review of CROS", National Hearing Aid Journal, 6.

Harford, Earl and Dodds, Elizabeth (1974) : "Version of the CROS Hearing Aid", Arch, Otolaryng, 100, 50-57.

Harpreet, S. (1982) : "Individual aids for the Aurally Handicapped", Unpublished Independent Project, University of Mysore.

Hodgson, W.R.: "special cases of Hearing Aid Assessment: CROS aids". In Hearing Aid Assessment and Use in Audiologic Habilitation. Edited by W.R. Hodgson and P.H. skinner, Baltimore, Williams and Wilkins, 1977.

Karteen, R.E.: "Body and the over the ear hearing aid". In Handbook of Clinical Audiology. Edited by J.Katz, Baltimore, Williams and Wilkins, 1972.

Kasten, R.N.: "Electroacoustic characteristics". In Hearing Aid Assessment and Use in Audiologic Habilitation. Edited by W.R. Hodgson and P.H.Skinner. Baltimore, Williams and Wilkins, 1977.

Martin, M.C. : "Hearing Aids", In Audiology and Audiological Medicine. Edited by H.A. Beagley, K.Y., Oxford University Press, 1981.

Musket, H.C.: "Maintenance of personal Hearing Aids", In Auditory Disorders in School Children. Edited by R.J. Roeser and M.P.Downs, N.Y., Thieme Medical Publishers, 1988.

Niemoeller, A.F., Silvenr.ah, S.R., Davis, H. : "Hearing Aids", In Hearing and Deafness. Edited by H. Davis and S.R. Silverman, N.Y; Holt, Rinehart and Winston, 1970.

Pollack, M.C.: "Electroacoustic characteristics", In Amplification for the Hearing Impaired. Edited by M.C. Pollack, N.Y; Grune and Stratton, 1980.

Pollack, M.C. and Morgan, R.: "Earmold technology and Acoustics", In Amplification for the Hearing Impaired. Edited by M.C. Pollack, N.Y: Grune and stratton, 1980.

Ross, M.: "Hearing aid evaluation". In Audiological Assessment. Edited by D.E. Rose. Englewood Cliffs, N.J? Prentice Hall, 1971.

Sanders, D.A.: "Hearing aid Orientation and Coun sell ing"[1]. In Amplification for the Hearing Impaired. Edited by M.C.Pollack, N.Y; Grune and Stratton, 1980.

Shailashree, C.N. (1991): "Insertion Gain Measurement for Hearing Aid Selection - An Audio Visual Program for the "Curious", Unpublished Independent Project, University of Mysore.

Silverman, S.R., Davis, H,: "Counselling about hearing aids". In Hearing and Deafness, Edited by H.Davis and S.R. Silverman. N.Y; Holt, Rinehart and Winston, 1970.