# CALIBRATION OF AUDIOMETER : HOW-TO-DO-IT

## INSTRUCTION MANUAL

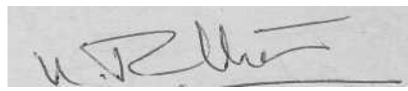
An Independent Project submitted in part fulfilment of III semester of M.Sc,Speech and Hearing, University of Mysore - 1980

**DEDICATED TO**

**All those who is serving the Speech and Hearing Handicapped.**

## CERTIFICATE

This is to certify that the dissertation entitled **"Calibration of Audiometer:How–to-do-it, Instructional Manual"** is the bonafide work in part fulfilment of III semester of M.Sc (Speech and Hearing) carrying 50 marks of the student with Reg. No. 2.



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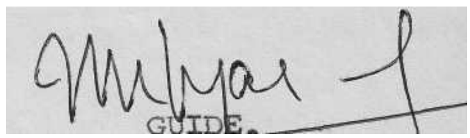
**CERTIFICATE**

This is to certify that this dissertation has been prepared under my supervision & guidance.



## DECLARATION

This independent project is the result of my own study undertaken under the guidance of Mr. M.N. Vyasamurthy, Lecturer in Audiology, All India Institute of Speech and Hearing, Mysore and has not been submitted earlier at any University for any other diploma or degree.

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# CHAPTER 1

# INTRODUCTION

"Checking calibration is necessary to be sure that an audiometer produces a pure tone at the specified level and frequency, that the signal is present only in the transducer to -which it is directed, and that the signal is free from distortion or unwanted noise interference" (Wilber,L.A 1978).

Precise audiometric calibration is essential in clinical Audiology where the results of audiological evaluations are critical for diagnosis, treatment and rehabilitation of hearing problems.

> "Without calibrated earphones and bone-conduction receivers it is impossible : (i) to know whether thresholds of patients are contaminated by faulty equipment, (ii)to know whether apparent chages in hearing over time for a patient are due to true differences in his performance or to variations in the equipment, and (iii)to accurately compare results obtained in one clinic or laboratory" (Wilber & Goodhill,1967):

Once the audiometric- is found to be in calibrated condition, the audiologist can confidently report his audiological findings. Two things can be done, when the audiologist cali-

brates his audiometer namely/he *can* find out whether his equipment agrees with the national standards and norms and (2) he can establish a reference point for his own equipment to determine if it changes over time.

Apart from the above needs for calibration it is true that any electronic equipment looses its precision and accuracy over a time. Because of the usage, constantly, the audiometers goes out of calibration. Therefore, it is necessary to calibrate the audiometer periodically. Audiometer looses its precision, because of irregular maintenance and care; dropping of earphones, exposure to excessive temperature , humidity dust.

Hardford, E (1965) has given an account of the nature of inaccurate calibration and the possible sources of error in the audiometer signal. The three parameters of the puretone intensity, frequency and time, may not meet the specified standards.

Parameters _of calibration

Following are the various parameters of audiometric calibrations:

1. Intensity calibrations
   (a) output sound pressure level.
   (b) attenuation linearity.
2. Frequency calibrations
   (a) Frequency analysis
   (b) Frequency response
   (c) Frequency bandwidth
   (d) Harmonic Distortion

3. Time calibration:

(a) Temporal parameters - rise time and decay time - SISI & ABLB unit calibration.

(b) Phase characteristics.

These are the various parameters grouped under intensity Frequency and time aspects of the sigial.

In, clinical audiometry, 3 auditory signals are made use: Pure tones, Speech and Noises. The mode of presentation of these signals is either air conduction through earphones; bone conduction through bone vibrator and under free field condition through loudspeakers. Therefore, output sound pressure levels and attenuation linearity are checked.

Calibration of audiometers may be of two kinds (1) Objective calibration, which make use of electronic measuring equipment. &( 2} Biological calibration, which is done using 'real ears (Human subjects). Hence they are called "real ear methods" Apart from these two, we have routine calibration check-up which is done daily and weekly.

Equipment used in objective calibration are given in the table.

TABLE 1

List of Equipment used for the calibration of Audiometer

| Parameter of Calibration | Suggested equipment |
|---|---|
| Intensity | Sound level meter<br>Graphic level recorder<br>Artificial ear<br>Artificial Mastoid .<br>Vaccume Tube Voltmeter<br>Condenser microphone.<br>Oscilloscope . |
| Frequency | Frequency analyzer<br>Frequency counter<br>Beat frequency oscillator<br>Oscilloscope<br>Wave analyzer<br>Artificial ear<br>Artificial mastoid<br>Distortion Factor Meter<br>Condenser microphone |
| Temporal parameters | Graphic level recorder<br>Beat frequency oscillator<br>Frequency analyzer<br>Artificial mastoid<br>Artificial ear<br>Condenser microphone |

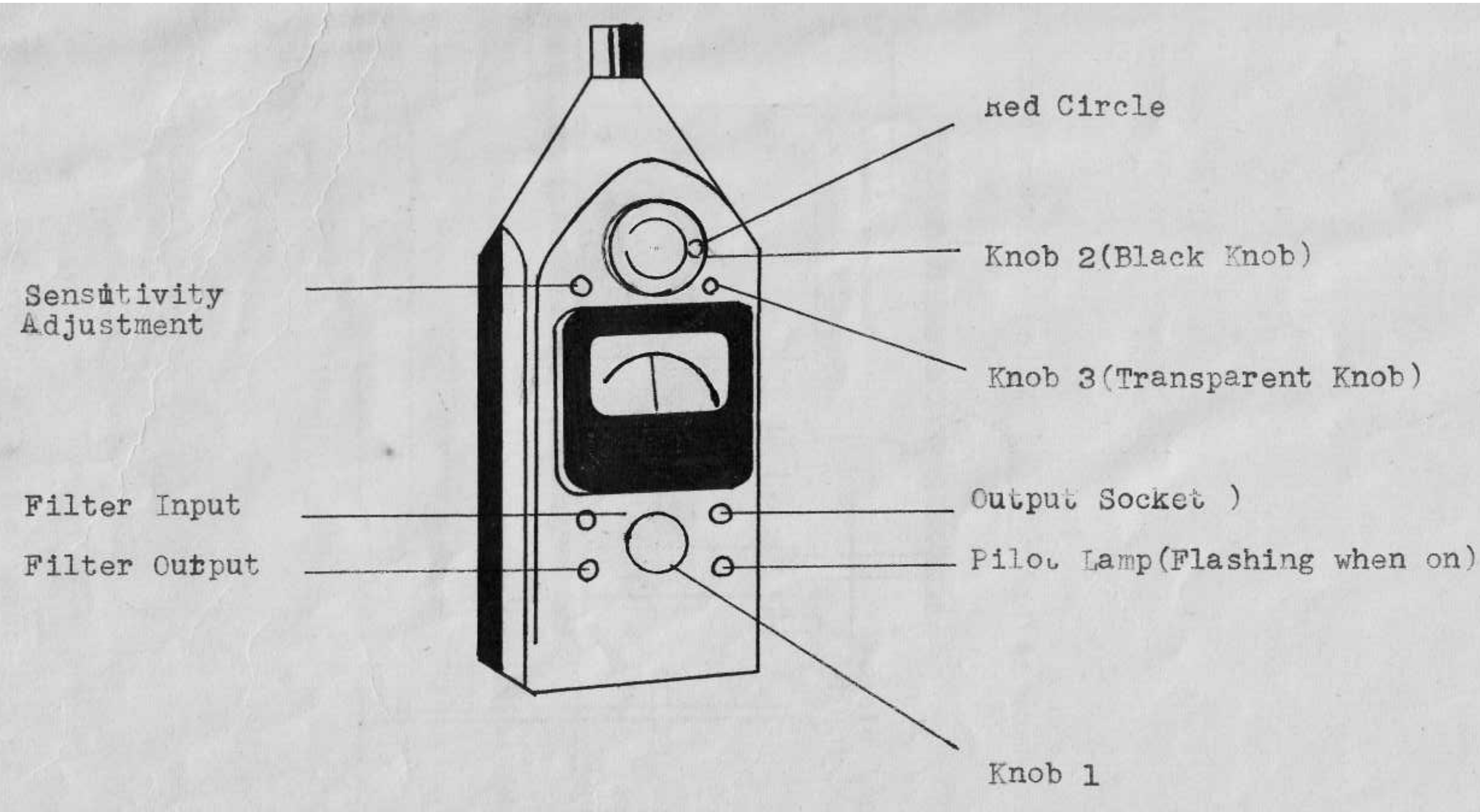



Fig.1 The Sound Level Meter with identification of knobs (B&K Type 2203)

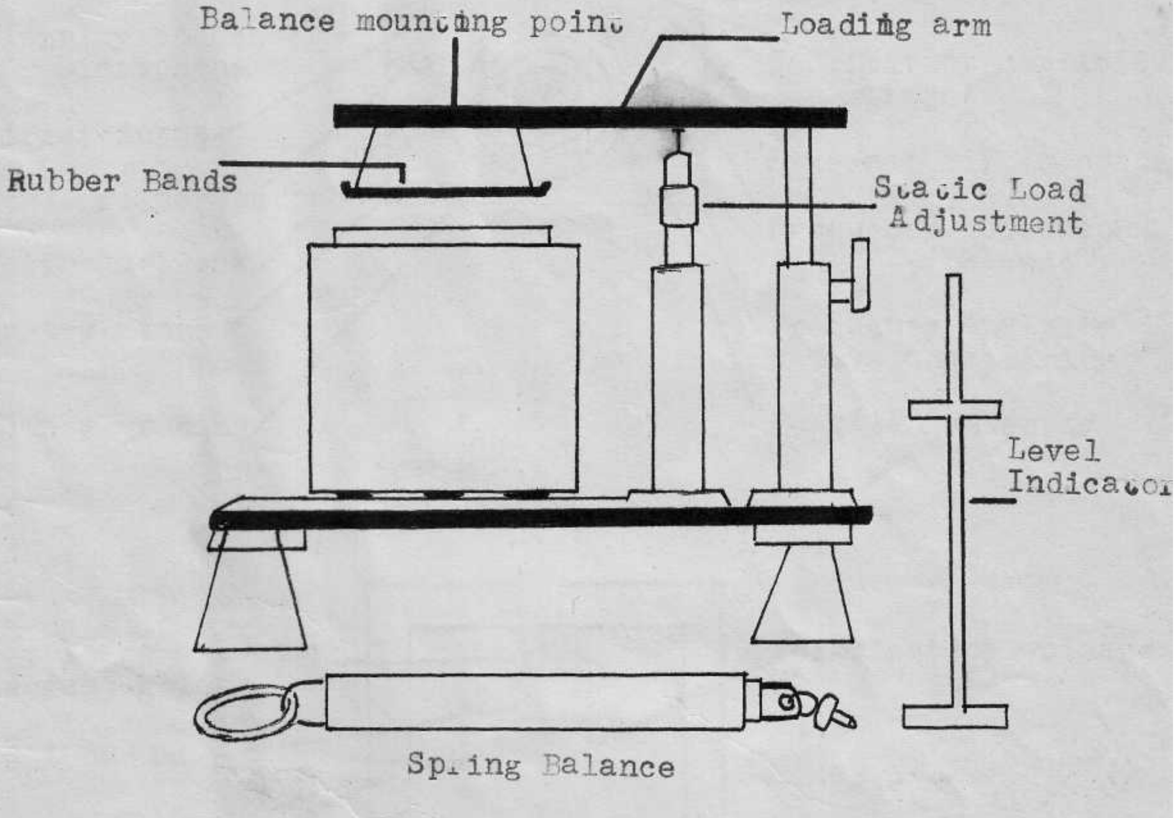



Fig. 2 Identity of the features and accessories of
Artificial Mastoid (B&K Type 4930)

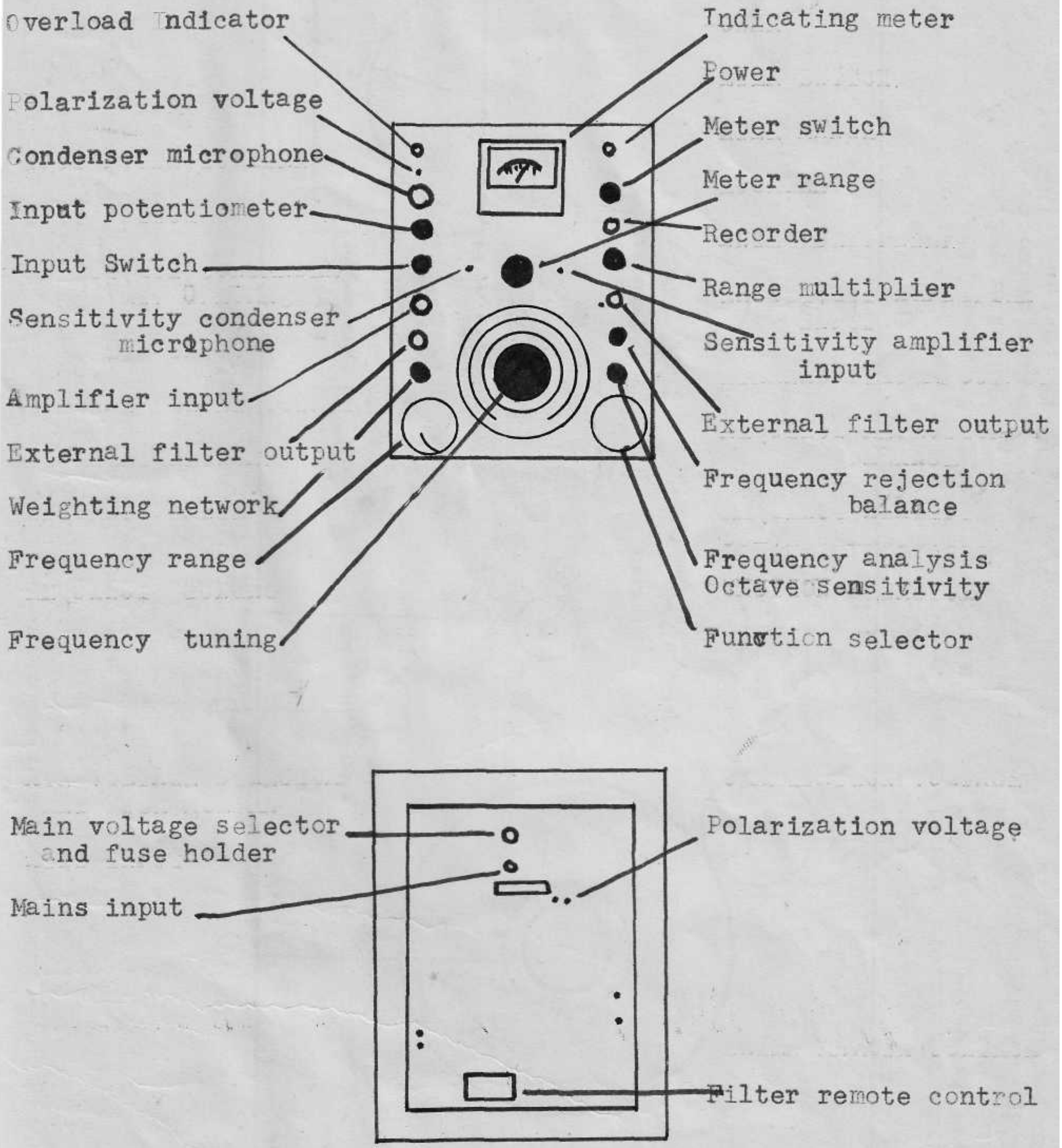
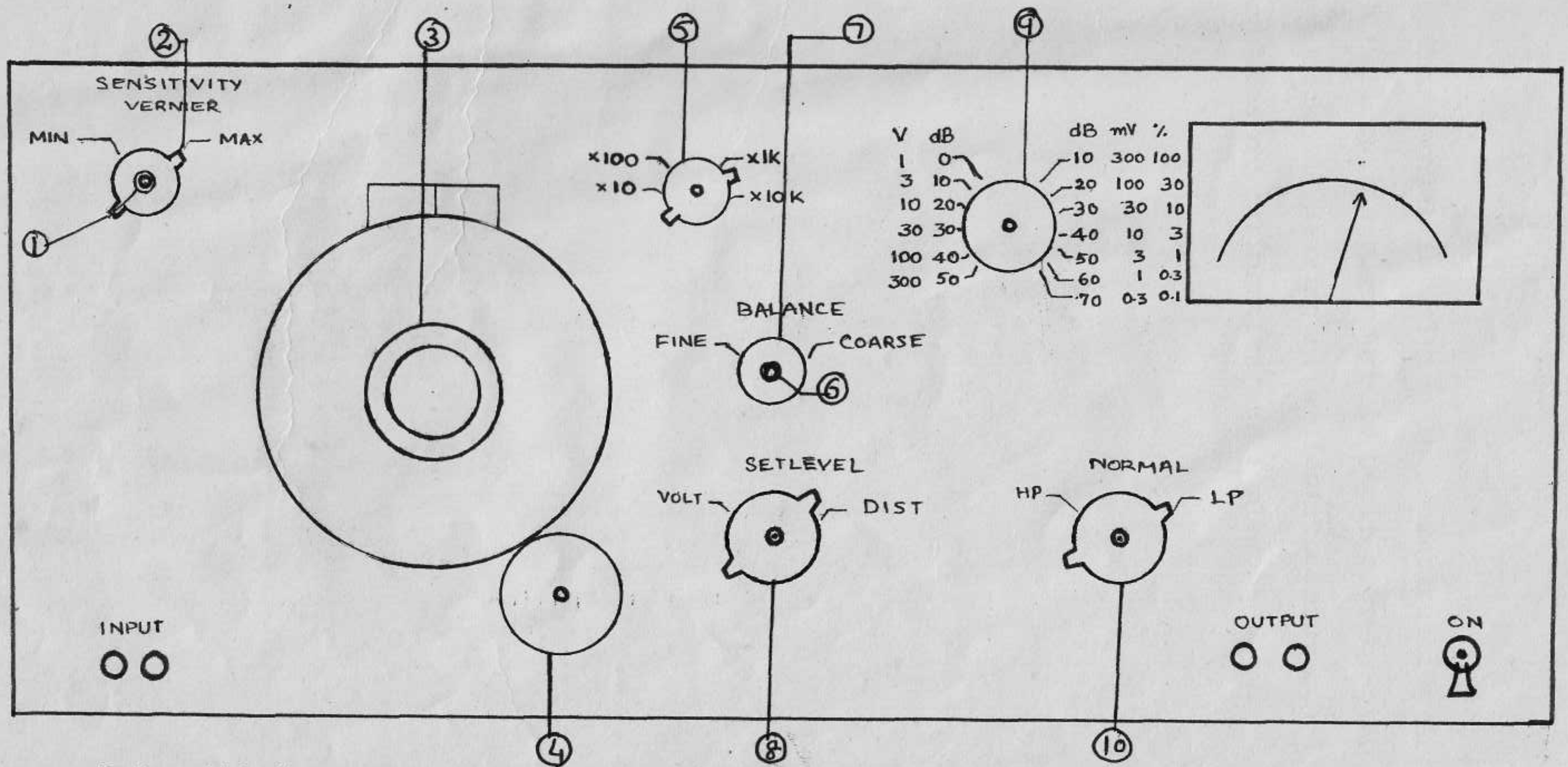



Fig.3 Front and Rear Panel of 2107

This manual is written in an instructional manner. Each calibration procedure is dealt step-by-step so that the Speech and Hearing clinicians students, can learn the procedures of calibration and implement them.




1. Sensitivity vernier potentiometer (Inner)
2. Sensitivity selector switch (Outer)
3. Frequency dial
4. Frequency dial vernier
5. Frequency range selector
6. Balance-coarse
7. Balance-fine
8. Function switch
9. Range selector
10. Filterselection switch

Fig.4 Front panel of Distortion Factor Meter (SYStronics. Model [illegible])

# CHAPTER II

## ROUTINE CHECKING OF AUDIOMETER

## PROCEDURE FOR DAILY AND WEEKLY CHECKS

Routine checks are subjective procedures employing simple tests throughout without the help of measuring instruments. These procedures are performed to ensure, as far as possible.

(i) that the audiometer is performing in a proper manner;

(ii) that the audiometer's calibration has not noticeably altered and.

(iii) that the audiometer's attachment, leads and accessories are free from any defect that may adversely affect the safety.

Routine checks should be done every week, in full on all audiometers in service. They may be performed immediately after possible damage has been sustained or before each period of use of equipment, which is not used regularly. In particular, some of the tests should be performed everyday before commencing the clinical examinations.

Care should be taken that :

(a) The operator with normal hearing, atleast in one ear, should perform the checks.

(b) these tests should be performed in sound treated room, or in satisfactory ambient noise conditions.

**Routine check Procedures**

1. Inspect the earphone cushions to make sure that they are not crackes or marked with crevices due to shrinkage.

2. Check the earphone cords (wires) for signs of worn or cracked insulation (damaged or badly worn, leads should be replaced) and straighten the twisted cords.

3. Inspect the front panel (face) of the audiometer for loose dials or for dials that are out of alignment, if there are such faults present, the dial readings will not be meaningful. Defective dial should be repaired immediately, and the audiometer should be recalibrated to determine the outputs at new-dial settings.

Check on the mechanical clicks in the attenuators frequently, selector and interruptor switch. Check the lamps and indicators whether functioning correctly.

4. Switch on the Audiometer and allow it to warm-up for 5-10 minutes. Carryout any setting-up adjustments

of the controls as given in the manual. On the battery powered audiometers, check the battery state, by specific method. Check that earphone and bone-vibrator serial number.

5. Place the earphone over your ears, and listen to the just audible tones by sweeping through at 10 or 15 dB HL. This test must be done at all appropriate frequencies and for both earphones as well as bone vibrator.

6. Test for tone-intermittency: While listening to the continuous tone, twist first one earphone cord and then the others back and forth a half turn and pull the cord gently at a place close to the earphone. If the tone becomes ' intermittent either the cord is defective or screws holding the cord may be loose. If cords are defective, replace the cord and if the screws are loose, tighten these screws.

7. Test for purity of tone: At high intensity level, listen for a change in the quality of tone. An earphone which is distorting will frequently be detected by an human ear at high levels where as such distortion may be inaudiable at lower levels of intensity.

8. Test the overshoot of tones Listen to the puretone at both moderate H.L and below the threshold of hearing. Interrupt the tone several times and listen for a 'click' or 'Splat' sound. If a 'click', sound is heard, there is a possibility of undesirable overshoot (due to the short-rise time of the signal) and the audiometer requires repair immediately.

9. Test for Attenuator - linearity: Set the intensity dial at minimum level (-10 dB HL) and the tone on continuously, increase the intensity in 5 dB steps,to maximum level. Each time the intensity is raised, listen carefully, for a uniform increase in the intensity of the tone. If there is no uniform increase in the loudness or if appears to change drastically, it indicates to a nonleniar attenuator. There is no need to check the linearity for more than one frequency or more than one earphone.

10. Test for extraneous noise : Set the intensity dial at about 40 dB, without presenting the tone listen for 'hum noise' by turning the intensity dial to maximum level. If this noise is detected it can be eliminated by providing ground connection to the chasis of the audiometer. Do the same test for speech circuit.

15. On self-recording audiometers, check mechanical operation and function of limit switches and frequency switches. Check that no extraneous instrumental noise is audible at the patient's position.

NOTE

1. The checks given in the steps 2,3,4,5,9,11,12 and 13 should be done daily.

2. The check procedure described above should be carried out with the audiometer set-up in its usual working situation. In case of two room situations, make use of a person to carry out the procedure. The checks will then cover, the inter-connections between the audiometers and the accessories in the test room. Additional connecting leads, and any plug and socket connections at the junction box. They should be examined as they are potential sources of intermittency or incorrect connections.

3. During subjective tests of Bone Conduction thresholds, the air conducted sound radiated from the back of the bone vibration may be heard at a high level to invalidate the test, especially at frequencies above 1.5 K.Hz.

11. <u>feet for cross talks</u> Disconnect the left earphone; set the intensity dial to 40 dB HL; the frequency dial to any desired frequent and the interruptor switch is kept on continuously. Listen through the right ear phone and if a pure tone is heard, there is a cross-over in the system. Similarly test the left earphone for cross talk.

    Cross talk indicates that there is leakage of the test signal from the intended earphone (Test earphone) to the contralateral earphone (non-test earphone). This defect may be due to faulty wiring. This problem may originate in the audiometers or in the jackpanel between the test room and control room. This defect should be corrected before any clinical test.

12. Check the bone vibrator placing on the mastoid for intermittency and purity of the tone using the procedure given in the steps 6 and 7.

13. Check that the patient's signal system operates correctly.

14. Check the tension of the head set, headband and bone vibrator headband. Ensure that swivel joints are free to turn without being excessively slack.

Therefore, wear earphones (disconnected) to attenuate this air conducted sound.

Routine checking procedures of other equipments: The General principle of the procedure for pure tone audiometers, should be followed during daily and weekly checks of Impedance Audiometer, Speech Audiometer, E.R.A. equipment etc.,

4. Steps to be taken on discovery of defects: Take imme-. diate action, to rectify any defects discovered during the above checks. Defects may be either the instrument is not in calibration or it requires repair. Audiologist should ensure that they are familial with local arrangements for repair and maintainance of electromedical equipment. If repair is undertaken, in local workshops complete calibration check should be done before equipment is returned to service. It is important to note that, replacement or shortening of headset cord, or altering the length of tubing on impedance audiometers, may alter the calibration in repairer or manufacturer, report the defect to the officer concerned.

When equipment is sent away for repair or calibration send it with correct earphones, bone vibrators etc., These items should not be interchanged between equipments.

Maintenance of Audiometer

Following are the suggestions to maintain the equipment in good condition, thereby reducing the delay and inconvenience resulting from equipment being inoperative or under repair. These points may be especially useful to students being trained in the use of audiometers.

1. Equipment leads which are allowed to become tangled. kinked or twisted may develop intermittent faults which can be trouble to trace. A little time spent in keeping the earphone and bone vibrator cords tidy will avoid unnecessary delay later in handling of the next case (patient).

2. Earphones and bone vibrators may be damaged., and their calibration affected by mechanical impact. These accessories should always be handled and stored carefully, avoid dropping them or placing them on the audiometer,. Hang them on the hooks provided in the room after the test.

3. Do not subject the equipment to dust, dampness or large ambient temperature changes. Place the dust covers over the equipment, when not in use. Audiometer should operate* correctly over a wide range of tempera—

ture and humidity. Large cycle changes will tend to shorten the working life of equipment.

4. If the audiometer is used to several patients during the day, it is wise to leave the instrument turned on throughout the day that it is to turn the instrument on and off for each test.

5. Headphones and Bone vibrators cannot be interchanged between audiometers, even if the same type, without affecting the calibrator. If these accessories are not permanently marked with the equipment's serial numbers, local markings (e.g., color-coded tabs) may be applied in order to prevent any risk of confusion.

6. Equipment and accessories should be preserved away, when not in Use, and adequate clean and dry storage facilities should be available.

7. If a fault does occur, the equipment should be clearly labelled, indicating the nature of the fault, before anyone else attempts to use it. Or the nature of the defect should be reported to the concerned authorities.

# CHAPTER III

## BIOLOGICAL CALIBRATION OF AUDIOMETER

Biological calibrations otherwise called subjective calibration, make use of human subjects, Generally these procedures are employed when the calibration measuring equipment are not available and therefore not used.

Here Audiologist empirically calibrates:

(i) the air conduction out-put level, and
(ii) the bone conductive out-put level

He finds out whether there is agreement between the intensity dial reading and the actual out-put of the earphone or bone vibrator. This calibration procedure is advised to perform atleast once in a month.

These calibration procedures should be done immediately after earphone or bone vibrator is dropped or receives mechanical damage. One of the short-comings with the biological procedures is that several human subjects are to be tested. Hence the method is time consuming and laborious.

In this section various alternative methods recommended by different authors are given and their limitations also listed.

I. Air conduction out-put calibration

The methods given here, are called 'Real ear methods' because they make use of human ears, to calibrate the earphone out-puts.

Method I

1. First of all, have a record of your thresholds obtained from a calibrated audiometer. This record serves as reference thresholds.

2. Then check your response with the audiometer to be calibrated. The threshold at a particular frequency obtained may be better or poorer than your reference threshold level. Thus, you can spot gross deviations in audiometer out-put for different frequencies.

**Limitations**

1. Since threshold is not a fixed point it may vary within the range of 10 dB from day to day.

2. Variation in the placement of earphones will have effect on the thresholds to vary within 10 dB, particularly at low frequencies.

**Method II**

1. Select about 10 normal hearing adults without any history of familial hearing loss, otological problems or noise exposures.

2. Test the one ear of each subject at all frequencies with the audiometer to be calibrated.

3. Then find out the average threshold at each frequency.

**Correction rule**

Average threshold at each frequency is used as correction factor in clinical diagnosis. For example at 1 KHz average threshold is +10 dB HL., the correction factor is - 10 dB. If a patient's threshold at 1 KHz is 35 dB HL, his correct threshold is 25 dB HL (35 - 10).

**Limitations**

1. Audult healthy group of normal ears will present an average threshold at -10 db HL at most of the frequen-

oies with the calibrated audiometer. But, they also present a -10 dB average threshold (-10 dB HL is the minimum intensity level in most of the audiometers) with the audiometer producing more out-put ( strong signals).

2. It is time consuming and laborious.

**Method III**

Loudness Balance Methods In this method, the out-put from a calibrated audiometer is matched against the out-put of an audiometer to be calibrated. The method is more practical with no serious limitations. She steps are as follows :

1. Requirements:

   (i ) A calibrated audiometer known to be accurate;

   (ii) Atleast three young subjects with normal hearing and negligible difference in hearing sensitivity between ears.

2. Detatch one earphone of the known audiometer (calibrated audiometer) and fix it to the headband of the unknown audiometer (audiometer to be calibrated),after removing one of its earphones.

3. Instruct the subject to match the loudness of the tones.

4. Place this headset on the ears of the subject.

5. Set the frequency selectors of each audiometers to 1 KHz and intensity dial of known audiometer to 40 dB HL and present the interrupted tones. When the signal is 'off' in the 'known' earphone, then signal should be presented in the 'unknown' earphone.

6. While this presentation of signals continues; without looking at the intensity dial, adjust the hearing level of the unknown audiometer until , the subject tells you that loudness of the tones are equal, or approximately equal.

7. Stop presentations and then note down the intensity dial reading of the unknown audiometer.

8. Similarly, get loudness balance at the other hearing levels, Eepeat the procedure at other frequencies. Also perform for other subjects.

Note: 1. Avoid simultaneous presentation of the signals from both audiometers.

2. The sensitivity of this procedure can be increased by training the subjects to listen carefully and match the tones.

Suppose the dial is set 40 dB HL *($A_{HL}$)* at 1 KHz and the subject matches the tone of the unknown audiometer when the intensity dial reads at 45 dB ($B_{HL}$).

Then the difference is ($A_{HL}$ - $B_{HL}$) i.e., 40 dB - 45 dB = -5 dB. Thus, there is difference in out-put at this frequency. Then the correction is -5dB at 1 KHz, which should be written on the calibration chart.

Correction rule

*The* correction Values are positive, if the hearing level of the tone matched is lesser than the hearing level of the known audiometer. The correction is negative if the hearing level of the tone matched is greater than the hearing level of the unknown audiometer.

This can be easily determined by the formula,

$$A_{HL} - B_{HL} = \text{Correction Value}$$

**Method IV**

Objective-biological calibrations Objective calibration of earphone outputs is made possible by the following method (Vyasamurthy *M.N,* 1977) even in the absence of the calibration instruments in a center. This procedure is both objective and "biological in its approach. It makes use of an electronic instrument to elicit the response without the co-operation of the subject; hence it is called objective method and employs human subjects for calibration, hence called biological calibration.

**Requirements**

1. An Impedance Bridge (Madsen 10 72, or 73)
2. A few subjects with normal hearing
3. Audiometer to be calibrated

Procedure: The steps are as follows s

1. Determine the subject's acoustic reflex thresholds ($ART_1$), at different frequencies using Impedance Bridge. Note down the $ART_1$

2. Detatch the earphone of the impedance bridge and replace it by a earphone of the audiometer, to be calibrated.

3. Now, determine the acoustic reflex thresholds ($ART_2$)for the same ear, same subject for different frequencies.

4. Find out the correction factor by subtracting $ART_2$ from $ART_1$ for each frequency.

5. Determine the reflex threshold ($ART_3$) for the same ear, same subject, placing the other earphone of the audiometer to the head set of the impedance bridge. Then find out the correction factor by substracting $ART_3$ from $ART_1$ for each frequency.

<u>Note:</u> The impedence bridge's balance meter needle should be nearly same while determining the $ART_1$ & $ART_2$ for the same frequencyand for the same subject. Same conditions should prevail while $ART_3$ is found.

<u>Examples</u>:

*1.* Suppose, $ART_1$ is 80 dB HL
and $ART_2$ at T KH*z* is 90 dB HL
Then the correction is s
80 dB - 90 dB =-10 dB HL i.e., 10 dB at 1 *KHz* should be substracted while plotting the audiogram.

2. Suppose $ART_1$ is 90 dB and $ART_2$ is 85 dB at 2 KHz
The correction os 90 - 85 = +5 dB EL, i.e., 5 dB at 2 KHz should be subtracted during clinical audiometry.

Validity of this method is found to be 100% when compared with the "Artificial Ear" method.

<u>Limitations;</u>

1. Does not permit to find out the attenuator leniarity of the intensity dial of the audiometer.
2. Calibration of output levels at 6 KHz and 8 KHz may not be possible as reflex is usually absent at these frequencies.

## II **Bone Conduction output Calibration**

In the absence of artificial mastoid for B.C calibration, Audiologist *can* keep check on the calibration, by employing the method recommended by Roach and Carhart (1971). This happens to be the most accurate approach available today.

### **Procedure**

1. Select 10 subjects with typical bilateral moderate sensorineural loss (hearing loss need not be equal in all ears).

2. Determine the air conduction thresholds of both ears of each subject at 250, 500, 1000, 2000, and 4000 Hz using well calibrated air conduction system.

3. Then, determine the bone conduction thresholds for some ear using the bone vibrator to be calibrated.

4. Find out the average A.C. thresholds and average B.C. thresholds at each frequency.

Correction Rule - Use the formula:
$Ac\ Th_{avg}. - B\ C\ Th_{avg} = Correction.$

For Examples (1) Average air conduction threshold is 60 dB HL and average bone conduction threshold is 45 dB *EL* at 1 KHz , the correction is +15 dB H*L* (60 dB - 45 dB0. That is 15 dB should be added to the obtained BC threshold of the patient, during clinical testing. (2) Suppose, the average BC is greater than the average AC threshold, then the correction is negative, because b.c. signal is stronger than the a.c. signal.

**Assumption of this method:**

In typical sensorineural hearing loss subjects, the a.c and b.c thresholds are equal. The difference is considered as error in the bone vibrator output.

**Limitation**

A slight conductive component might add to the air-bone differences in thresholds. Hence to that extent, accuracy of this method is limited.

# CHAPTER IV

# OBJECTIVE CALIBRATION OF AUDIOMETER

Objective calibration procedures make use of the electronic equipment, by which both electrical and acoustical calibration measurements are accurately accomplished.

The purpose of objective calibration is to ensure that the signal is referenced to a standard through the clinical or research investigations. In objective caxibration we can distinguish two kinds : viz., (1) Acoustic checks and (2) laboratory calibration.

Acoustic checks are done once in 3-12 months. Usually they are done, annually. However, the frequency of calibration check depends on the number of hours per day the audiometer is used. If the audiometer used throughout the working hours, calibration check may be done once in a month, regularly. In acoustic checks, the audiometer's output sound pressure levels,attenuatory linearity; frequency and distortion are checked. Laboratory calibration of the Audiometer should be carried out whenever the results of acoustic checks make the Audiologist suspecious of the test equipment, Proposed federal regulations (U.S. Dept. of Labour) for hearing conservation programmes recommended a complete laboratory calibration of audiometers once in 5 years and annual acoustic checks (Melnick W, 1978).

In this chapter the various objective calibration procedures are grouped under three subtitles namely :

1. Intensity calibration measurements.
2. Frequency calibration measurements and,
3. Time calibration measurements.

This classification is based on the 3 major parameters of acoustic signal : intensity, frequency and time. Bach calibration procedure, is dealt with the list of equipment required, connections between them and the procedure with illustrations (Figures).

**Intensity Calibration Procedures**

Intensity calibration of the auditory signals is of Primary concern to Audiologists. The purpose of intensity calibration is to precisely specify the intensity output levels of the signals and to ensure that these intensities are maintained throughout the clinical testing.

Two aspects of intensity measurements are, namely the output levels and attenuation linearity. The output levels of puretones, speech and noises are measured through earphone, bone vibrator, loudspeaker and insert receiver. These calibration measurement should be carried out at an intensity level high enough to avoid interference from ambient room noise. The output levels are then compared with the expected output levels specified by ISO-1964, ANSI-1969 standards.

Following the output calibration, attenuation linearity is checked, where the signal intensity is attenuated in calibrated steps. Then the corresponding change in output levels are taken into account to check the linearity.

In this section objective intensity calibration procedures are dealt for the signals ; pure tones, noise and speech - one by one.

**Puretones : Intensity calibration**

Intensity calibration of puretone signals is straight forward. As pure tones are presented through earphone and bone vibrator in audiometry, therefore, the air conduction and bone conduction output calibration is carried out.

Air conduction output calibration measurements are done at 60 dB HL dial setting and for bone conduction at 40 dB HL. The table 2 given below shows the expected output levels which are currently used for calibration of audiometer earphone and bone vibrator :

Table 2

**Expected output levels for calibration of Audiometer Earphone and bone vibrator**

| frequency Hz | Expected output levels | | |
|---|---|---|---|
| | For A.C. calibration *(dB* SPL) | For B.C. Calibration (dB) | **for** BC Calibration (dB) |
| 125 | 85.5 | - | - |
| 250 | 24.5 | 63.0 | 66.9 |
| 500 | 71.0 | 57.5 | 68.2 |
| 1000 | 66.5 | 43.0 | 62.7 |
| 1500 | 66.5 | 40.5 | _ |
| 2000_ | 68.5 | 40.0 | 56.0 |
| 3000 | 67.5 | 30.5 | - |
| 4000 | 69.0 | 35.0 | 42.0 |
| 6000 | 68.0 | - | - |
| 8000 | 69.5 | - | - |

Notes (a) Values in column 2 are expected when dial set at 60 dB HL and they are with reference to standard reference threshold sound pressure levels (ANSI 53.6-1969).

(b) Values in column 3 are 'Interim - Bone - Threshold calibration values' (MSI S3.13 - 1972).

(c) Values in column 4 are being used at AIISH, Mysore for B.C calibration (Mallika C 1976). standard reference threshold levels for air conduction (ANSI S3.6-1969 : Appendix 'D') are given in Appendix I (1).

**Air conduction output level calibration procedure using Frequency Analyzer.**

Equipment required;
1. Frequency Analyzer-( B & K Type 2107)
2. Preamplifier-(B & K Type 2627)
3. Artificial Ear-( B & K Type 4152)
4. Condenser Microphone (B & K type 4144)

**Connections:**

1. Connect the condenser microphone to the artificial ear.
2. Connect the pre-amplifier to the artificial ear.
3. Connect the other end of pre-amplifier into the CONDENSER MICEOPHONE of the Frequency Analyzer.

Note : (i) Switch on the analyzer and allow it to warm up for 10 minutes.

(ii) While connecting do not tighten unduly hard.

(iii) Keep all the cords as short as possible to avoid pick-up from stray fields.

[Figure ________ shows intrumentation set Up.]

Procedure:

1. Carry out the calibration of the Analyser as follows :

(i) Set the controls on the analyses to :

| | |
|---|---|
| **INPUT SWITCH** | **'Direct:** |
| WEIGHTING NET WORK | "20 - 40,000" |
| FREQUENCY RANGE | "20 - 63" |
| FUNCTION SELECTOR | "Selective Section Off" |
| FREQUENCY ANALYSIS OCTAVE SENSITIVITY | "20 dB" |
| RANGE MULTIPLIER | "XI (0 dB)" |
| METER SWITCH | "RMS Slow" |
| METER RANGE | "Ref" |

(ii) With these settings unaltered, adjust the SENSITIVITY AMPLIFIER INPUT with a screw driver until the needle deflects to the red mark on the indicating meter.

2. Adjust the analyzer to the sensitivity of the condensor microphone K - factor (+2.9 dB). Proceed as follows :

(i) Set the INPUT SWITCH to "Condensor Mic".

(ii) Adjust the CONDENSOR MIC SENSITIVITY with a screw driver until the needle deflects from the red mark on the meter to an extent of the K-factor value of the condensor microphone.

For example s for the condensor microphone type 4132, the K- factor specified is +1.9 dB. So, the needle should be made to deflect from the red mark to +1.9 dB on the lower dB scale of the metter.

3. Plug in the Audiometer and allow it to warm-up for 5-10 minutes.

4. Remove the right ear phone from the head band and place it on the artificial ear. Then adjust the clamping mechanism of the artificial ear to 0.5 Kg.

5. Set the frequency dial to lower frequency i.e., 250 Hz, to start with and present tone at 60 dB HL. Keep the intensity constant for all other frequencies.

6. Set the METER RANGE to slightly higher level than the expected reference SPL value. Adjust the RANGE MULTIPLIES until a deflection between *3* & 10 volts on the meter scale, is obtained. Thus overloading of the Analyzer is avoided.

   For example : at 250 Hz, the expected SPL reference value is 84.5 dB. So, adjust the METER RANGE to "+100 dB" and RANGE MULTIPLIER to "-20 dB". Adjustments of then two switches may be made to obtain the meter deflection between 3 & 10 Volts.

7. The measured level can now be read from the analyzer as follows:

   The reading is the algebraic sum of the METER RANGE level, RANGE MULTIPLIER position and meter defluction on the lower dB scale. Suppose, for measurements at 250 Hz the above 3 readings are as follows :

+100 dB, -20 dB and 13.5 dB respectively. Then, the Analyzer indication is +100-20 + 13.5 = 93.5 dB. Note down this reading.

8 Repeat the procedure for each of the frequencies and also for other earphones. Note the readings, as described above.

9 Correction Rule

Once the readings are obtained, enter in the calibration chart. Find out the errors in output by subtracting the standard output levels from the obtained readings for each frequency.

Enter the corrections to apply to intensity dial readings, so that the threshold to be recorded will be correct to the nearest 5 dB step.

The rule is : if the measured output level is greater then the expected output level then positive is the correction and if it is lower, then negative is the correction.

Correction = (Measured output) - (Expected output). For example, measured output level and expected output level is 93.5 dB and 84.5 dB respectively at 250 Hz. Then the correction is :

93. 5 - 84.5 = +9 dB

That is the earphone output is more (strong signal) than the actual dial reading. Therefore, 10 dB should be added to the obtained hearing level before plotting the threshold on the audiogram.

**Internal calibration**

Audiometer like clinical, diagnostic and research audiometers have "calibrating deck" in the circuit. This deck house a series of pre-set potentiometers (variable resistors) in two or three rows for air conduction and bone conduction calibration. Each pre-set potentiometers are in accordance with a each frequency. Its value can be varied by adjusting it with the help of a screw driver, until the Analyser indicates the expected output level. Thus, accurate intensity calibration can be accomplished by internal adjustments.

**Procedure is as follows:**

1. Remove the Audiometer from the cabinet.
2. locate the calibrating deck and its pre-set potentiometers for each frequencies (refer service manual of the audiometer).

3. Make the output level measurements, applying the procedure described earlier.

4. If the measured output is greater, reduce the value of the respective pre-set potentiometer by using a screwdriver, till the Analyzer indicates the expected output level. Suppose the output is less, increase, the value of the pre-set control till the Analyzer indicates the reference output level.

**Air conduction output level calibration - Using a sound level meter.**

Equipment required: 1. Sound Level meter ( B & K type 2203)with octave filter set (B&K type 1613).

2. Artificial Bar (B & K type 4152)

3. Condensor Microphone (B & K type 4144)

**Connections**

1. Connect condenser microphone to the artificial ear.
2. Connect artificial ear to the sound level meter.

Notes While connecting do not tighten unduly hard.

Figure 5 shows the instrumentation set up.

**Procedure:**

1 . Make calibration checks to make sure that SL meter is working properly, as follows :

(i) Pull out KNOB 1 and set to position "Batt". The meter needle should deflect to within the area

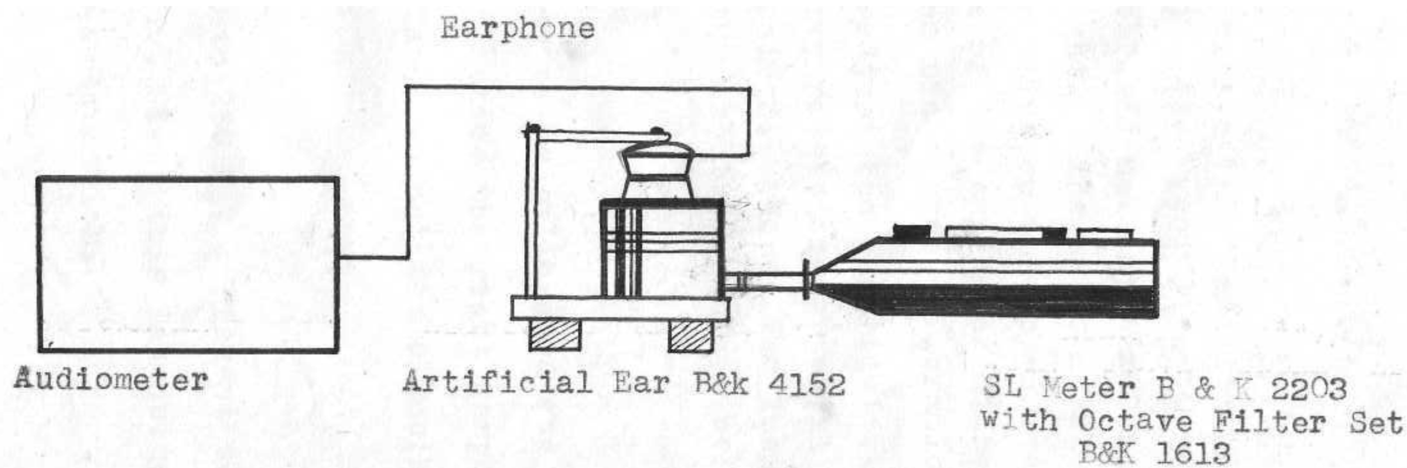



Fig.5: Block Diagram of Air-Conduction Calibration Set-up.

marked. "Battery". If it does not replace the batteries (See figure 1 ).

(ii) Set KNOB 1 to position "Lin" and turn KNOB 3 fully clockwise. Turn KNOB 2 fully anticlockwise so that the "Ref" mark appears in the red circle to the right. The meter needle should now deflect to a value on the upper red scale equal to K-value of the condencer microphone., obtained from the microphone calibration chart.

If it does not, adjust the sensitivity by means of the sensitivity potentiometer until said condition is obtained. Note: The instrument should warm-up for about 20 seconds before calibration.

2. Switch on the audiometer to be calibrated and allow it to warm up. Meanwhile, place the right earphone on the artificial ear. Then, adjust the clamping mechanism to 0.5 Kg.

3. Set the frequency dial to 250 Hz. Present the tone at 60 dB HI continuously. Keep this intensity level constant for all other frequencies.

4. Operate the SL meter to measure the output level as given below :

(i) Pull out the KNOB 1 (meter is 'on' now) and set it to position "Lin".

(ii) Rotate the KNOB 2 clockwise until a meter deflection obtained between 0 and 10 dB.

(iii) Now, set the KNOB 1 to 'External Filter - Slow'

(iv) Set the controls on the octave filter set to:

Weighting switch to "on" and octave selection to "250 Hz "

(v) Now, if required, rotate KNOB *3* anticlockwise to obtain a deflection between 0 *&* 10 dB.

Notes Do not use KNOB 2 at this stage, in order not to overdrive the input amplifier. The reading on the meter scale together with the value shown in the red circle gives output level of audiometer at 250 Hz.

5. Repeat the above step with other frequencies. But the octave selection (of the octave filter set) should be set to the respective weighting potentiometer. If the audiometer frequency is 500 Hz, it should *he* set to "500 Hz".

Note down the measured output level readings on the calibration chart.

Similarly find out the output levels with left earphone, placed on the artificial ear.

6. Compare the results with expected levels given in the ta*ble* 2 and find out corrections .

**Bone conduction output level calibration procedure using frequency analyzer.**

Equipment required: 1 . Frequency Analyzer ( B & K type 2107)

2. Microphone pre-amplifier

3. Artificial Mastoid (3 & K type 4930)

Procedure

1. Set the static load of the artificial mastoid to 550 gms (5.4 N ) as folllows:

Place the bone vibrator on the center of the rubber surface of the artificial mastoid, completely flush. Place the loading arm on the bone vibrator. Locate the 'level indicator' on the floor plate of the mastoid with its cut-away part of the steel disc flush against the intertial mass. Adjust the height of the black disc of the indicator until it is in level with loading arm. Raise the arm and remove the bone vibrator. Connect the spring balance into the tapped hole in the Arm at the balancing point. Pull balance upwards until the loading arm is once again in line with the level indicator. Now, set the static load to 550 gms by operating the static level adjustment. Level of the loading arm can also be adjusted by using the level adjustment (Refer the figure 2 showing artificial mastoid)

2. Put on the Analyzer, allow to warm-up and calibrate the Analyzer as follows :

(i) Set the controls on the Analyzer to :

| | |
|---|---|
| INPUT SWITCH | "Direct" |
| WEIGHTING RANGE | "20 - 40,000" |
| FREQUENCY RANGE | "20 - 63" |
| FUNCTION SELECTOR | "Selective Section Off" |
| FREQUENCY ANALYSIS | |
| 0CTAVE SENSITITITY | "20 dB" |
| RANGE MULTIPLIER | "x 1 (OdB)" |
| METER SWITCH | "RMS Slow" |
| METER RANGE | "Ref" |

(Refer the Figure 3 showing front panel of the Analyze

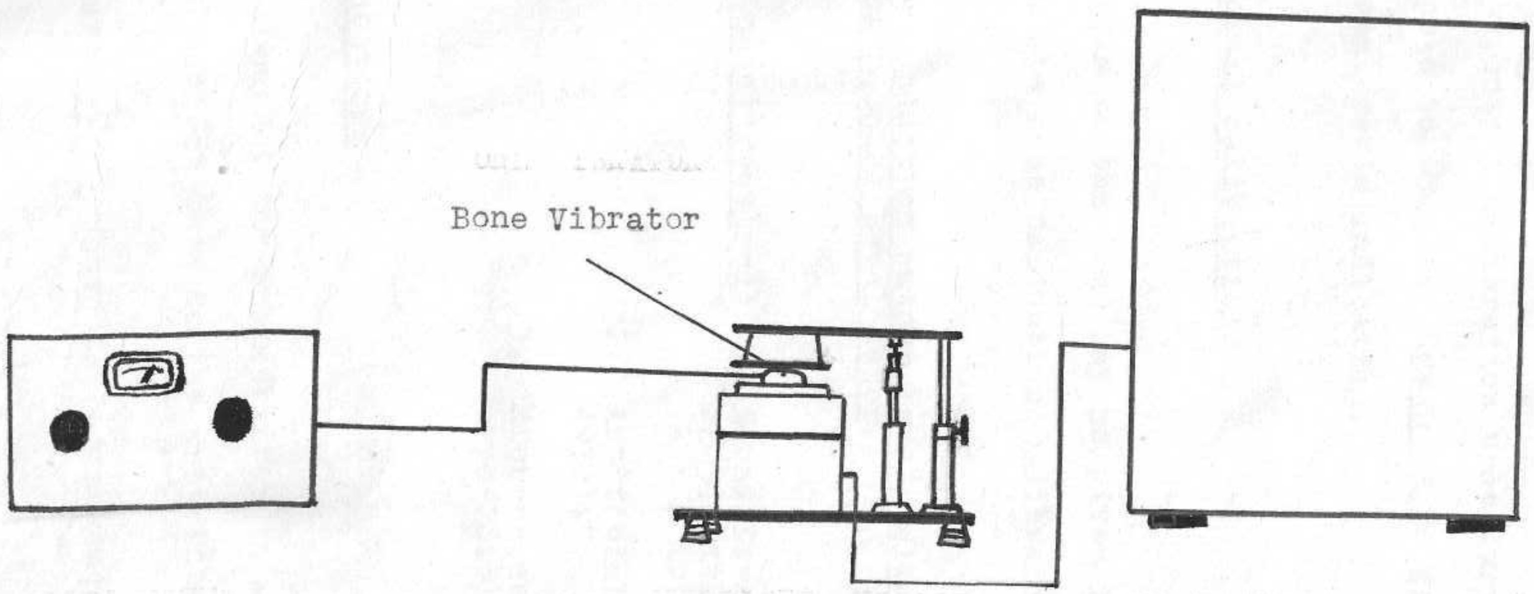
(ii) With these settings, adjust the SENSITIVITY AMPLIFIER INPUT with a screwdriver until the needle deflucts to the red mark on the indicating meter.

3. Connect the artificial mastoid using the Microphone pre-amplifier into the AMPLIFIER INPUT of the Analyzer.

Note: The INPUT SWITCH should be in "Direct" only. Figure 6 shows the instruments arrangement.

4. Place the bone vibrator on the artificial mastoid,

5. Set the frequency dial of the Audiometer to 250 Hz and present the tone at 40 dB HL, continuously. Keep this intensity level constant for all other frequency change made.




Audiometer . Artificial Mastoid Freq. Analyzer .B & 2107

Fig.6 Block Diagram of Bone Calibration Setup

6. Next, proceed in the same way, as given in 'Air conduction output calibration procedure using Analyser'. Steps 6 to 9 (see page 31) to get the output levels by Analyzer's indication.

**Internal calibration:**

Do this in the same way as given in pages 33 -34 for - accurate bone conduction calibration.

**Bone conduction output level calibration using a Sound Level Meter.**

Equipment required:
1. Sound level Meter (B & 1 type 2203) with octave filter set (B & K type 1613).
2. Artificial Mastoid (B & *K* type 4930).
3. Microphone preamplifier (B & K type 2615).

**Connections:.**

1. Connect the preamplifier to the SL meter.
2. Connect them to the artificial mastoid.

Figure 7 shows the arrangement of the equipment.

**Procedure:**

1. Make calibration checks to make sure that SL meter is working properly. Repeat the Step 1 given in air conduction calibration procedure using SL meter

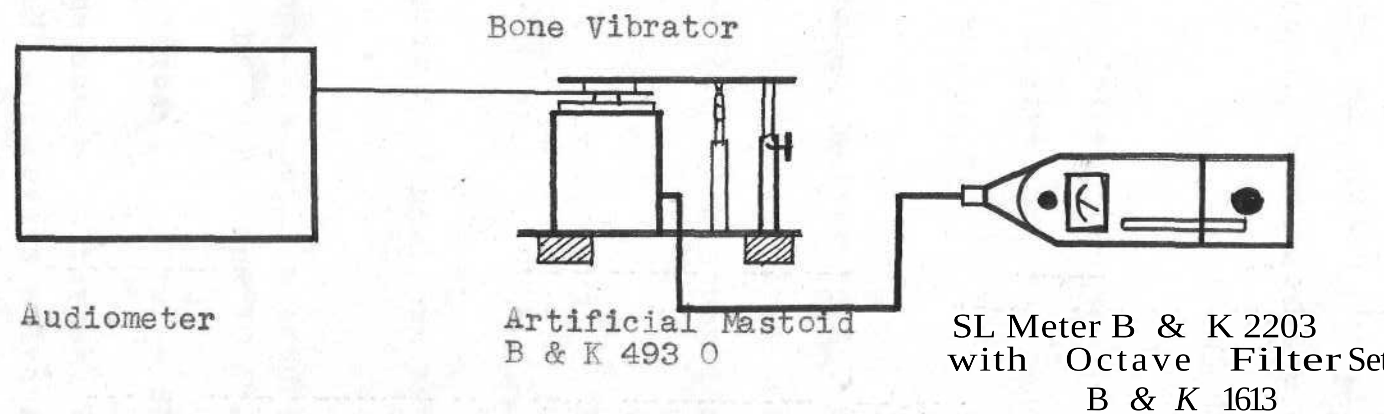



Fig.7 Block Diagram of Bone Calibration Set-up,

2. Switch on the audiometer to be calibrated and allow it to warm-up. Meanwhile place the bone vibrator on the artificial mastoid.

3. Set the statis load of artificial mastoid to 500 gms (5.4 N) as described in step 2 given in bone conduction calibration using Frequency analyzer.

4. Set the frequency dial of the audiometer to 250 Hz , Present the tone at 40 dB HL, Continuously, Keep this intensity level constant for all frequencies.

5. Operate SL meter to measure the output level as given below :

   (i) Pull out KNOB 1 (meter is 'on' now) and set it to position "Lin".

   (ii) Rotate then KNOB 2 clockwise until a meter deflection is obtained between 0 and 10 dB.

   (iii) Now set the KNOB 1 to "External Filter - Slow".

   (iv) Set the controls on the octave filter set to weighting switch to "0N" and octave selection to "250 Hz ".

   (v) Now, if required rotate KNOB 3 anticlockwise to obtain a deflection between 0 & 10 dB.

   Note: Do not use KNOB 2 at this stage, in order not to overdrive the input amplifier. fhe reading on the meter scale together with the value shown in the red circle gives output level of audiometers at 250 Hz.

6. Repeat the above step with other frequencies. Set the octave selection to the respective weighting potentiometer as the frequency is changed.

7. Compare the obtained output levels with the expected values given in the table 1 and calculate the corrections.

**Puretone:Attenuation Linearity check**

Following the output calibration proeedure, attenuation linearity must be checked. This check is enough either through earphone (air conduction) or through bone vibrator (bone conduction). Because the single attenuator attenuates the hearing levels for both. If two attenuators are present (as in Madsen OB 70 Audiometer) linearity check must be done separately. Linearity check should be done at any one frequency. Do the linearity check, after the output level calibration measurements having the same instrumentation and adjustments.

**Then proceed as follows:**

1. Set the attenuator to the maximum hearing level and note down the output level.
2. Decrease the hearing level in 5 dB steps, till the minimum hearing level. Each time the intensity is attenuated note down the output levels accurately.

There should be a corresponding decrease in output levels, as the attenuator is decreased by *5 dB* steps. Or according to the ANSI standards, the attenuator should be linear with 0.3 of the interval step (or 1.5 dB whichever is smaller). That means, when the dial is decreased by 5 dB, it must attenuate between 3.5 and 6.5 dB.

Note: (i) If the audiometer is provided with "+20 dB pad" - for 20 dB raise (for example as in Madsen OB 70 or Grason Stadler Audiometer)- check its attenuation.

(ii) If there is "vernier" which attenuates the hearing level in 1 dB steps, check its attenuator linearity.

**Speech - Intensity calibration**

A speech signal is characterised by rapid fluctuations in its intensity (frequency and time paramters). Therefore there is difficulty in specify in the intensity level in precise manner.

The present standards (ANSI S3.6 - 1969) specifies ".... sound pressure level of a speech signal at the earphone is defined as the r.m.s sound pressure levels....of a 1000 Hz signal adjusted so that VU meter deflection produced by 1000 H signal is equal to the average peak VU meter deflection produced by the speech signal". The ISO - 1964 standard defined audiometric zero for 1000 Hz as 6.5 dB SPL. Research showed that threshold of intelligibility for spondee words was on average 13 dB higher than audiometric zero for 1000 H .

Therefore zero dB HL for speech is 19.5 dB (rounded to 20dB). This 0 dB HL varied slightly depending upon the type of earphone used. (Refer Table 3 in the Appendix I ) . The allowable limites for calibration are ± 3 dB i.e., should be between 17 and 23 dB for the TDH -39 earphone.

If the Audiometer has the provision of speech audiometry Speech output level; attenuator linearity and harmonic distortion should be checked for calibration. In this section the calibration procedures for first two are given and the last one is given in subsequent sections.

**Speech - Output level calibration procedure**

Equipment required: 1. Beat frequency oscillator (B&K type 1022); OR a standard signal source (to produce 1000 H ), OR commercially available speech material recordings.(where the 1000 HZ puretone - calibration tone - is recorded before the test words).

2. Artificial ear (B&K type 4152)

3. Condenser microphone (B&K type 4144)

4. Sound level meter (B&K type 2203)

**Connections**: Connect condenser microphone to artificial : and then artificial ear to Sl meter.

**Procedure**

1. Make calibration checks of SL meter as given in Step 1. of the procedure for Air Conduction output calibration using Si meter (Page 34 ).

2. Place a earphone of the Audiometer on the artificial ear and adjust the clamping mechanism to 0.5 Kg.

3. Set the essential controls on the Audiometer for speech audiometry and intensity dial to 60 dB HL(preferably) or above.

4. Introduce the 1000 Hz tone (calibrating tone) either through microphone, phonograph or tape input,continuously.

5. Adjust the input intensity level until the VU meter can be monitored to 'zero'.

6. While the YU meter shows 'zero' note down the output level from the SL meter with 'linear' setting.

Obtained output level should be within 77 and 83 dB SPL (60 dB + 20 dB $\pm$ 3 dB).

Speech : Attenuator linearity check-up

Check the attenuation linearity with same equipment set-up, in the same way as given in pure tone - intensity calibration (Page 41 ).

Notes Carryout the subsequent speech testing with the TO meter showing at the same point during calibration check, made (Usually VU meter showing zero)*.

Volume Unit Meter calibration

Volume Unit (VU) meter accurately indicates the intensity variations of the audiotory signal. It is found on the front panel of the Audiometer. The TO meter is calibrated relative to the input signal which it monitors, VU meter helps the Audiologist to monitor the speech signal intensity and in adjusting the input calibration tone which proceeds the recorded speech material. VU meter should be stable so that there is no undershoot or overshoot of the needle indicator relative to the actual signal.

VU meter calibration procedures : The procedures dealt by L.A Wiber (1978) is given here.

Equipment required: 1. Audio oscillator
2. Electronio switch
3. AC millivoltmeter
4. linear attenuator

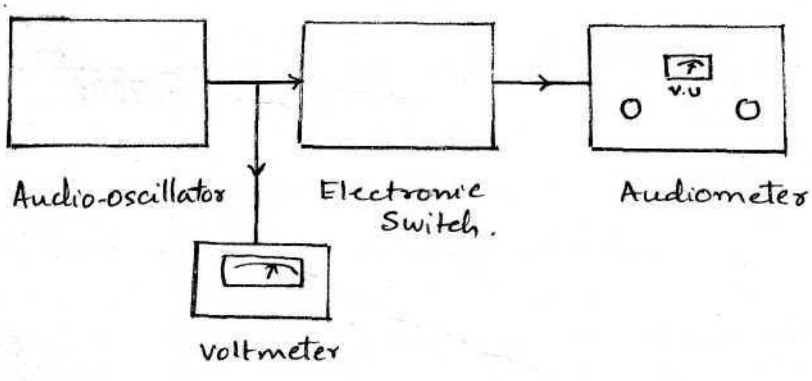



Figure 8 Block diagram of the set up for the VU meter calibration.

**Procedure I - To check for the overshoot or undershoot**

1 . Feed a puretone from the Oscillator through the electronic switch to the input of the audiometer.

2. Monitor the puretone by the voltmeter.

3. By activating the electronic switch to produce a rapidly interrupted signal, watch the VU meter to confirm whether there is any overshoot or undershoot with reference to the steady state signal.

**Procedure II - To check the response time of needle.**

1. A 270, 300, and 330 m.see tone is fed to the audiometer.

2. Observe the needle, and ensure that it reaches its 99% state of deflection in 300 m sec + 10% when the tone is on.

**Procedure III - To check the relative accuracy of the VU meter's dB scale.**

1. Insert a linear attenuator in the line between the oscillator and the audiometer input;OR

2. Reduce the output from the oscillator by a known amount (as mentioned by the voltmeter). Observe whether there is accurate indication of corresponding change due to the change in the input amount.

Note: Proper impedance matching should be made between the equipment used here.

## Speech : Sound field calibration

loudspeakers which are used for freefield testing should be calibrated for its output level and attenuation (attenuation linearity), periodically. Research studies have demonstrated that the hearing thresholds are on average 7 dB better in freefield situation than under earphones (Tilman, Johnson and Olsen 1966). Under earphones i.e. , in close field the zero dB hearing level for speech is 19.5 dB SPL (rounded to 20 dBO. Therefore the zero dB hearing level for speech under freefield can be considered as 13 dB SPL (20-7 dB). The **out-**put from the loudspeaker should be 13 dB SPL. This relation**ship** should give same Speech Reception Thresholds (SRTs) using spondee words under freefield (Soundfield) and earphone (closed field ) speech audiometry.

**Loudspeaker output level calibration procedure**

**Procedure**

1. Set the controls on the audiometer to freefield testing operation.
2. Place the SPL meter at the height of ear level and its microphone should be at the center of the subjects head position, which will be during testing position. Subjects position distance should be atleast 1 meter away from the face of the loudspeaker.

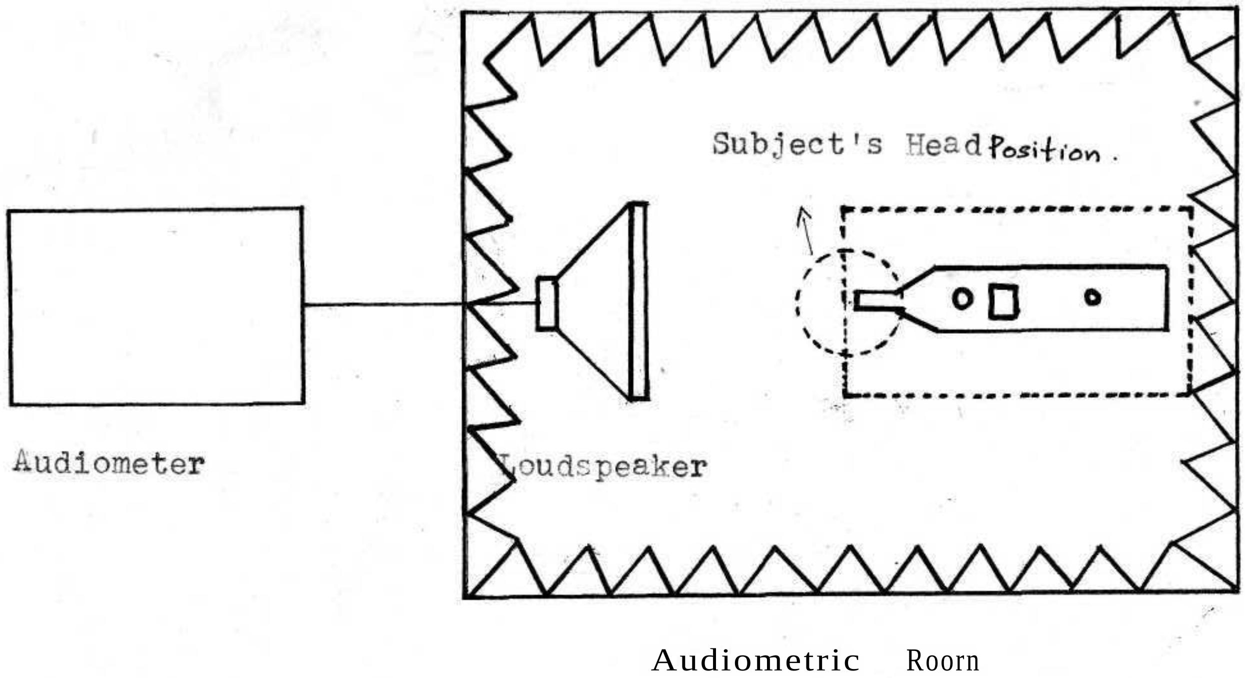



Fig.9 Speech: Free-Field Calibration Set-up.

Make use of the floor stand supplied with SL meter,

3. Present the white noise through loudspeaker at 80 dB HL (Preferably speech spectrum noise is used. It is a white noise with equal energy from 250 to 1000 Hz and a 12 dB/Octave fall off from the 1000 Hz to 6000 Hz ). The output from the audiometer to loudspeaker should be monitored to zero on the VU meter.

4. Set the SL meter to "Linear" scale and take the readings. The output level should 93 dB SPL ( 80+13).

5. Check the attenuator linearity of the loudspeaker in the same way as described earlier for air conduction calibration (Page 41 ).

Note: (1) The loudspeaker should be atleast 1 meter distance away from the patient's position.

(2) No object be present between loudspeaker and the microphone preferably, the examiner should be in the other room to avoid any reflection or absorption due to his presence in the testing room

(3) Puretones should not be used to calibrate loudspeaker in audiometric room situation because it create standing wave formation which will influence the meter readings.

**Noises : Intensity Calibration**

Noise signals like speech signals are characterised by rapid variations and intermittency which makes difficult to specify the intensity levels, precisely. This problem is faced while taking readings from SL meter. The meter needle fluctuates over a wide range of intensity, even in "slow" position Thus becomes difficult to decide the intensity levels.

At present the reference sound pressure levels used for puretone frequencies are "being made use for comparison during calibration of narrow band noise levels. And for white noise reference threshold SPL used for speech i.e., 19.5 dB (rounded to 20 dB) is used. However, ANSI has proposed standards, wherein increased attention to the masking stimulus is given (L.A. Wilber, 1978).

Both the noises i.e., narrow band noise (NBN) and wide band noise (white noise) produced by the audiometer, should be checked for the output level and attenuation linearity characteristics.

**Marrow Band Noise : Output level calibration**

Use the same equipment and procedure employed in pure tone airconduction output level calibration (Page 34 ).

**IMPORTANT**

"1. Measure the output at a higher hearing level to avoid interference by ambient noise. So, set the attenuator at 80 dB HL.

2. If the output is measured through insert receiver, using a 2.c.c coupler note that these outputs cannot be compared directly to that obtained through earphone (expected output SPLs) measured using a 6 c.c. coupler. Research has showed that thresholds very as much as 20 dB between insert receivers and TDH-39 earphones. Therefore, observe extreme caution in considering SPL values found for insert receivers.

**Narrow Band Noise : Attenuation Linearity check**

Same procedure holds good as done for pure tone Linearity check (Page 41 ).

**White noise : Output level calibration**

Use the same equipment and procedure employed in pure tone Output level calibration (Page 29/34-).

**IMPORTANT**

1. Present the white noise at high intensity level to avoid interference by ambient noise. So set the attenuator a1 80 or 90 dB HL.

2. As done in speech calibration, introduction of 1000 Hz into the audiometer is not needed. Present the white

noise through earphone. The output SPL will be 100 dB (if 80 dB HL is the presentation level).

3. Output should be measured with the SL meter in "linear" setting.

White Noise : Attenuation Linearity check

Same procedure as used in pure tone : Linearity check (page 41 ).

Narrow Band Noise : Output level calibration

Use the same equipment and procedure employed in pure tone : airconduction output level calibration (Page..29/34).

**IMPORTANT**

1. Measure the output at a higher hearing level to avoid interference by ambient noise. So, set the attenuator at 80 dB HL.

2. If the output is measured through insert receiver, using a 2, c.c. coupler note that these outputs cannot be compared directly to that obtained through earphone (Expected output SPLs), measured using a 6 c.c. coupler. Research has showed that thresholds vary as much as 20dB between insert receivers and TDH-39 earphones. Therefore observe extreme caution in considering SPL values found

**Narrow Band Noise : Attenuation Linearity check**

Same procedure holds good as done for pure tone : Linearity check (Page 41 ).

**Frequency Calibration Measurements**

**Pure tones : Frequency analysis**

Frequency Analysis can be done by the two methods viz, (1) by using Electronic Counters and (2) to display on an oscilloscope.

Because oscilloscopic measures are dependent upon visual determination, this procedure has its limitations, especially when minimal frequency differences are involved. Therefore the first method is considered here. ANSI (S3.6-1969) specifies, the tolerance level of $\pm$ 3% is allowed for each frequency. That if the dial reads 2000 Hz , the frequency out put must be between 1940 Hz and 2060 Hz At 4 KHz, it must / be between 3880 Hz and 4120 Hz and so on.

Frequency analysis can be done either by acoustic measurement or electrical measurement. In acoustic measurement,the "real ear method"is employed. Since, this method is complex electrical measurement is usually done, by using electronic counter.

**Procedure:**

Equipment required: Frequency Counter (For examples Timer/Counter Radart Type 203)

1. Set the controls on the counter to :

   FUNCTION "Count"

   RANGE "KHz Sec"

   The digital read out should display 3 decimal points (0.000),

2. Calibrate the counter by injecting a standard signal from a generator, check the readings on the digital read out. Readings should tally with signal frequency.

3. Connect the audiometer in question to the counter directly i.e., audiometer output to input of the counter. With this set up the electrical output is fed directly to the counter.

4. Set the frequency selector to 250 Hz, to start with and present the tone continuously. The output frequency will be displayed on the digital read out, immediately. Note down the frequency output against the respective output in the chart.

5. Repeat the procedures for other frequencies.

## Objective method of determining Masking Factor

1. Noise Band width measurement

The frequency characteristics of noise signal can be precise if defined by consideration of two parameters viz.,

(1) the band width in Hertz and
(2) the rejection rate dB/Octave

Measurement of bandwidth has got clinical implications for instance, to compute the masking factor, objectively is possible.

**Equipment.required**

1. Artificial ear (B & K type 4152)
2. Condenser microphone (B & K type 4144)
3. Audio frequency analyzer (B&K type 2107)
4. Level Recorder ( B & K type 2305)
5. Pre-amplifier ( B & K type 2618)

Connections

1. Connect the microphone to artificial ear and then to pre-amplifier.

2. Connect the pre-amplifier output and to the CONDENSER MICROPHONE of the analyzers.

3. Using a suitable cord connect RECORDER of Analyzer to INPUT of the level recorder.

4. Again, connect the Analyzer to the level recorder by means of mechanical shaft.

5. Plaice the earphone of the audiometer on the artificial ear and adjust the clamping mechanism to 500 gms.

**Procedure**

1. Check the sensitivity of the Analyser and then adjust the needle to K - factor of the condenser microphone, used here (See page 30 for procedure).

2* For bandwidth measurement, set the controls on the Analyzer to:

| | |
|---|---|
| FREQ. RANGE | "20- 63" |
| FUNCTION SELECTOR | "Auto" |
| WEIGHTING NETWORK | "20-40,000" |
| FREQ. ANALYSIS 0CTAVE SENSITIVITY | "30 dB" |
| INPUT SWITCH | "Condenser Mic" |
| RANGE MULTIPLIER METER RANGE | adjustment depends on the signal level. |
| METER SWITCH "RMS- Fast" | |
| FREQUENCY TUNING | "63 or 20" |

3. Set the controls on the Level Recorder to:

| | |
|---|---|
| POTENTIOMETER RANGE | "50" |
| RECTIFIER | *"RMS"* |
| LOWER LIM. FREQ. | "50Hz" |
| WRITING SPEED | "63 mm/sec" |
| PAPER SPEED | "3 mm/sec" |

Use the calibrated paper QP 1130 for recording.

4. Present the wide band noise signal at 80 dB HL.

5. Switch 'on' and MOTOR 'on' on the Level recorder for automatic recording. When the FREQ, TUNING- control is tuned clockwise from 63 to 20 mm the frequency dial the FREQ. **RANGE** switch automatically shifts to the **next** range.

Note : Stop the MOTORS once the full range is swept and recorded on paper for white noise (6 ranges). For narrow band noise, stop the MOTOR once the 3 frequency ranges are swept i.e., the Central range, one *range* below it and above it.

6. The band width of the noise is determined by the 1/2 power points i.e., the lower and upper frequencies at which the intensity is decreased by 3 dB re peak intensity. Cut out the paper where recordings done. One the recordings, from "3 dB down points" draw 2 straight lines vertically. The frequency distance between the two gives

the bandwidth. For example, if the bandwidth having " 3 dB down points" of 100 and 6100 Hz, then the total band width includes 6000 Hz (B.W).

7. Then determine the Level per cycle (LPC): level Per cycle = Overall intensity minus 10 times the logarithm of the band width.

For Example : the LPC of .white.,_noise would be, when the band width 6000 Hz overall intensity = 80 dB

LPC = OA SPL - 10 Log BW

LPC = 80-10 log 6000

= 80-37.8

= 42.2 dB SPL

Applying the same formula for a narrow band/with a noise band width 200 Hz, then LPC in :-

- LPC = OA -10 log BW

= 80 - l0 log 200

= 80 - 23

= 57 dB SPL.

(LPC of NBN is 14.8 dB greater than that of white noise)

**8. Determine the Effective Masking level (Z or E.L) as follows:**

(i) Find out the critical band width (C,B,W,) from the data of Hawkins & Stevens, (1950). The data are given in the appendix I Refer table 4 .

(ii) Find out_the energy in the critical band using the formula..

$$E \text{ in } C.B = LPC + 10 \log C.B.W$$

For example, the overall intensity of 80 dB of white noise and critical band (C.B) at 1000 Hz, then energy in C.B would be:

E in C B = LPC + 10 log C.B.W

= 42.2 + 18

= 60.2 dB SPL

**(iii) Find out the effective level (EL) of the noise by using the formula.**

EL = LPC + 10 log CBW - Threshold is quiet. The threshold is quiet is equal to the 0 dB SPL given by ANSI S3.6 - 1969 (Refer table 1 in appendix I).

Therfore EL = 42.2 + 18 - 6.5 (at 1000 Hz)

EL = 52.7 dB

The above formula may be rewritten as :

EL = E in dB - threshold is quiet.

9. Find out the Masking factor (M.F) as follows :

M.F. = OA SPL - EL

When OA is overall intensity level is the dial reading which was set to give the obtained overall SPL.

∴ M.F = 80 - 52.7
= 37.3 dB

Thus, we can find out the masking factor objectively, once we find out the band width. The masking factor value is used during clinical masking.

**Total Harmonic Distortion measurements**

Harmonic distortion is the result of the input signal (fundamental) being peak-clipped, a process that transfer the peak clipped energy into the frequencies which are multiples of the fundamental.

Harmonic distortion can be expressed in two ways, one in terms of percentage and the other in terms of dB, Distortion factor meter measures the harmonic distortion in terms of percentages. Basically, harmonic distortion is determined by introducing a pure tone at selected intensities and measuring via a coupler arrangement the intensity of the harmonies (multiple of the fundamental) of the input tone. The total harmonic distortion in percentage for each intensity is then calculated by the formula :

$$\% \text{ harmonic distortion} = 100\sqrt{\frac{P_2^2 + P_3^2 + \ldots + P_n^2}{P_1^2 + P_2^2 + P_3^2 + P_n^2}}$$

When P1 = amplitude of the input tone fundamental and $P_2$ ,$P_3$ ....$P_n$ = amplitudes of the various harmonies.

Harmonic distortion when expressed in dB, it is the dB difference between the fundamental and its respective harmonics.

Harmonic distortion measurements of puretones indicates the purity of tones. The maximum permissible total harmonic distortion is 3% ANSI specifies (proposed, standard) that the sound pressure level of any harmonic of the fundamental should be atleast 30 dB below the sound pressure level of the fundamental.

Distortion can be measured using either a frequency analyzer, distortion factor meter or a S.L. meter. Here distortion measurements using Distortion Factor Meter and S.L.Meter is dealt.

**Pure tone : Total Harmonic Distortion Measurement**

**Equipment required**:

1. Distortion Factor Meter (Systronics Type 811)
2. Sound Level Meter (B & K Type 2203)
3. Artificial Ear (B & K type 4152)
4. Condenser microphone (B & K type 4144).

**Connections**

1. Connect the microphone to the artificial ear
2. Then connect the artificial ear to SL meter
3. Connect the OUTPUT of the SL meter to the INPUT of the Distortion Factor Meter (D.F.M) using a suitble cord.

Note : (i) While making connections do not tighten the screws unduly hard.

(ii) Keep all the test cords as short as possible to avoid pick-up from stray fields, which affects the meter readings.

(iii) Check the calibration of SL meter, before use (See page 34).

**Procedure**

1. Set the controls of the Distortion Factor Meter (D.F.M)to:

| | |
|---|---|
| POWER SWITCH | "0N" |
| FUNCTION SWITCH | "Set level" |
| RANGE SELECTOR | "100%" |
| FILTER SELECTOR | "Normal" |

(See the Fig 4- showing front panel of D.F.M)

2. Set the controls of S.L. meter as follows :

   (i) Pull out the KNOB 1 and set it to 'Linear'

   (ii) Rote the KNOB *2* until the meter deflection 0 and 10 dB is obtained

   (iii) If necessary, rotate KHOB 3, anticlockwise to obtain a deflection between 0 and 10 dB.

3. Plug in the audiometer and allow it to warm-up for 5-10 minutes. Then present the tone at a higher level(say 70 dB HL) at frequency 250 H , continuously.

4. Then, make following operations on D.F.M for total harmonic distortion (THD) measurements(See the figure 4 of D.F.M).

(i)'First, get the full scale deflection or 100% on the meter, by adjustments with the SENSITIVITY SELECTOR (2) and VERNIER (1).

(ii) Set the fundamental frequency of the input signal by operating to FREQ. RANGE SELECTOR (5) and the FREQ. DIAL (3). For e.g., If an input signal is 250 H , set the FRIQ RANGE SELECTOR (5) to "x100" and FREQ. DIAL (3) to "2.5" on the circular scale. Thus it is adjusted to the fundamental frequency (2.5 x 100 = 250 $H_z$).

(iii) Set the FUNCTION SWITCH (8) to "Distortion" mode.

(iv) Adjust the RANGE SELECTOR (9) to give a convenient reading on the meter.

(v) Make the following adjustments to get the minimum deflection in the meter

(a) adjust the FREQ. DIAL VERNIER (4) to get the minimum deflection (by rotating it slightly either in clockwise or anticlockwise direction).

(b) then adjust 'coarse' and 'fine' or BALANCE control (6,7) so that you get still less and less minimum deflection on the meter.

(vi) Note down the distortion in percentage on the meter with reference to the scale you had sele– cted for convenient reading.

(vii)After this, without fail, reset the FUNCTION SWITCH (8) to "set level" and MANGE SELECTOR to "100".

5. Repeat the same procedire given in the above step 4 to measure distortion at other frequencies.

Note: (1) The maximum permissible THD is 3% for air condu- ction calibration. For bone conduction, the same holds good but except at 250 $H_z$, where allow able distortion is 6 to 12%.

(2) Use artificial mastoid for harmonic distortion of puretones through bone vibrators.

**Speech *i* Total Harmonic Distortion Measurement**

Equipment required: Use the same equipment set-up used for pure tone : distortion measure— ment,

**Procedure**

1. Set the essential controls on the Audiometer for speech testing and intensity dial to 60 dB HL.

2. Introduce a 1000 $H_z$ tone continuously, either through microphone, phonograph or tape input.

3. Adjust the input intensity level so that the VU meter can be monitored to zero.

4. Feed the output of the SL meter with "Linear" setting to the INPUT of Distortion Factor Meter.

5. Garry out the same operations on the D.F.M for distortion measurements - as given in the step 4, in pure tone :distortion measurement (Page 62,63).

Note that the output harmonic distortion should be written 3%.

**IMPORTANT** (i) Set the fundamental frequency to 1000 Hz (1x1000Hz) on the D.F.M because the input is 1000 Hz

(ii) The calibration tones 1000 H should not have more than 1% harmonic distortion. Therefore, first ascertain its purity

**Pure Tone : Total Harmonic Distortion measurement :Using SL meter with octave filter set.**

**Equipment required** : 1. Artificial Ear (B & K type 4152)

2. Condenser Mierophone(B & Ktype 4144)
3. Sound Level Meter (B & K type 2203)
4. Octave Filter Set (B & K type 1613)

**Connections**

1. Connect condenser microphone to artificial ear and. artificial ear to SL meter.
2. Connect SL meter to octave filter set.

**Procedure**

1. Make the following operations on SL meter with octave filter sets

   (i) Pull our KNOB 1

   (ii) Make calibration checks as outlined in page 34

   (iii) Set KNOB 1 to "Lin" position.

   (iv) Rotate KNOB 2 clockwise until a meter deflection between 0 & 10 is obtained.

   (v) Set KNOB 1 to "EXH. Filter - slow".

   (vi) On octave filter set, Switch to "on".

2. Place the earphone on artificial and set the audiometer's frequency dial at 250 Hz and intensity dial at high level (say 70 dB HL) present the tone continuously,

3. Set the octave filter set's OCTAVE SELECTION to "250 Hz" (Fundamental frequency).

4. Rotate the KNOB 3 counter clockwise to obtain a deflection between 0 and 10 dB, Note down the reading on the meter dB scale plus with the value shown in the red circle. This is the SPL of the fundamental frequency (SPL. F.F).

5. Then set the OCTAVE SELECTION to '500 Hz' (2nd harmonic) Keep frequency and Intensity constant. Then find out the SPL wof the 2nd harmonic (SPL Hz).

6. See whether the SPL of the 2nd harmonic is atleast 30 dB lower than the SPL of the fundamental.

7. Similarly, check the SPL at the 3rd harmonic ie.,1000 Hz ($SPL_{H3}$).

8. Note: 1. The difference between the SPL of the fundamental frequency and its harmonics should be atleast 30 dB.

   2. It is not necessary to find the SPLs for next harmonics. Measure at 2 and 3rd harmonics.

<u>Time calibration measurements</u>

Time measurements includes temporal parameters and phase of the signal. Here, only calibration measurement of temporal parameters is considered,

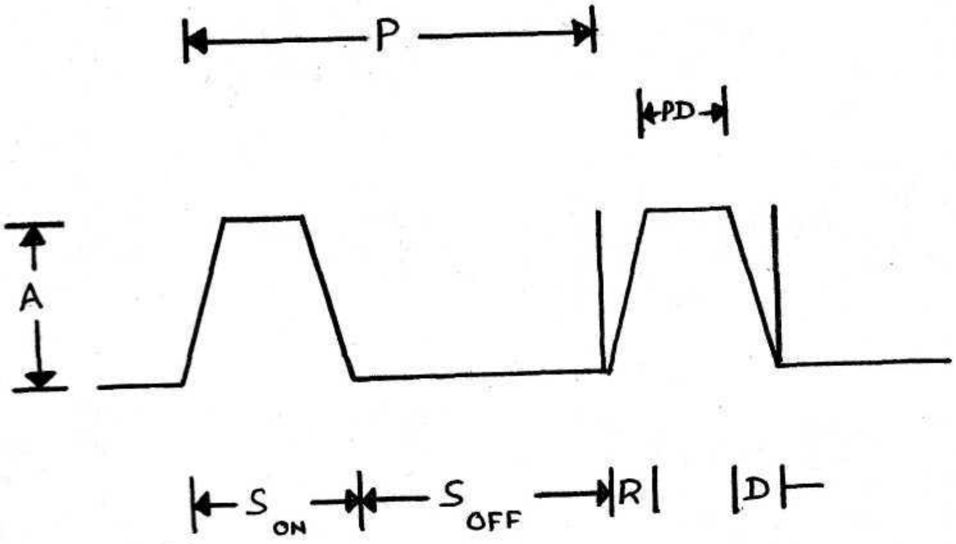
"Temporal characteristics in an auditory paradigm refer to the events of the signal set with regard to time" (Dirks DD et al, 1976). The various time parameters of signal sets are for example: Rise - decay times: period; duty cycle and equivalent duration. An illustration of various temporal parameters are given in figure 10.

Period of the signal set is combined on and off times. Duty cycle of the signal paradigms involves two parameters i.e., (on-time/period) x 100. Equivalents duration (T) is expressed by T = 2/3 r + p where 'r' is the rise or decay times and 'p' is the duration at the peak intensity, This is a useful method of specifying the signal duration.

Rise and decay times are usually controlled by interruptor smith, Rise and decay time refers to the time required for a tone to reach its maximum intensity of the onset (rise) and to reach its minimum intensity after off-set (decay). Rise and decay time are usually defined in m.sec.

ANSI (S3.6-1969) specifies that the time required for sound pressure level to rise from - 20 dB to -1 dB should be within 20 to 100 m.sec and the time required for the sound pressure level to decay by 20 dB should be within 5 to 100 M.sec,

Figure 11 shows equal rise and decay times of a puretone. There should be no unusually long rise and decay time (Pigure 12 ). Further, there should be no overshoot of




P= Period(100 msec.) PD=Peak DuratIon(20msec.)

1=0n Time(40 msec) S =0ffTime(60 msec)
ON OFF

R= Rise Time(10 msec) D=Decay Time(l0 msec)

A= Amplitude

Duty Cycle *(%* )=(0n Time/Period ) 100

Fig.10 Illustration ofSeveral Temporal Parameters of a Signal (Dirks, D. D.,et. al. . 1976)

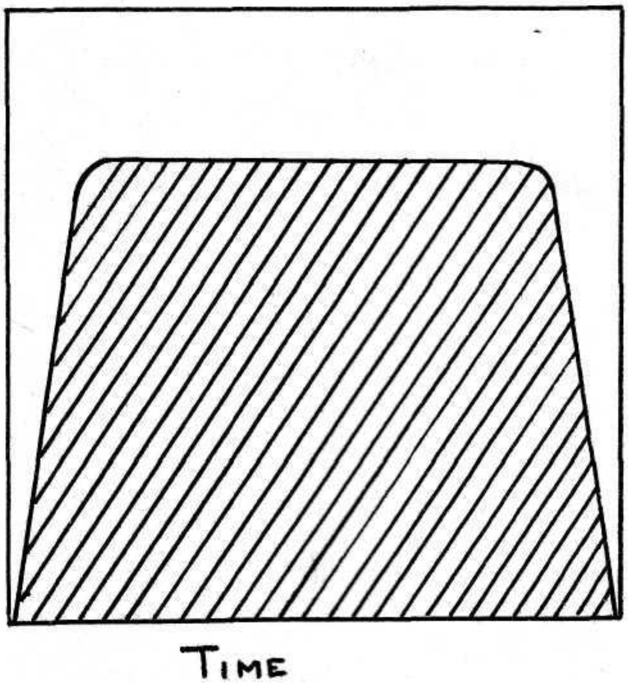



Fig.11 An illustration of uniform rise(on) and decay (off) times of a pure tone test signal with an ebsence of undesirable overshoot and uneven plateau(Harford.E. 1965).

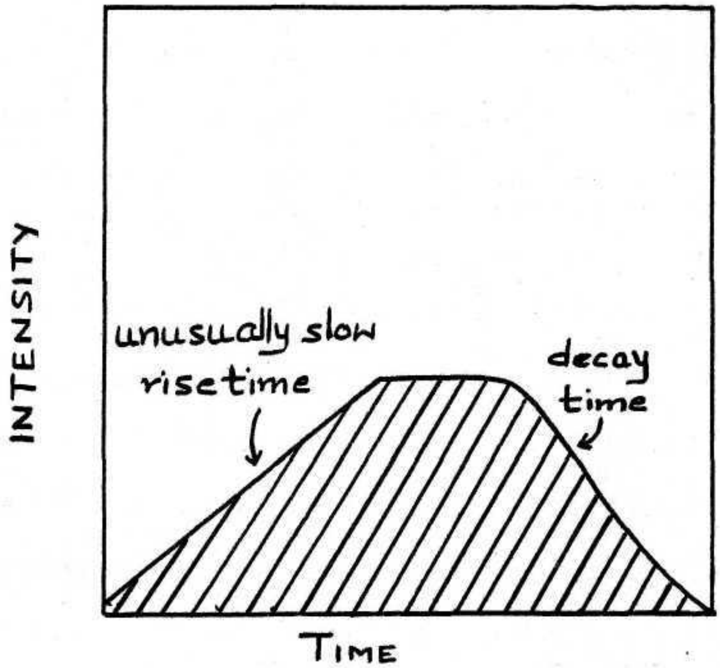



Fig.12 An Illustration of an unusually long rise time and a decay which is ' unequal to the rise time.A desirable rise and decay time isapprox. 100 msec Harford.E .,1965).

Fig.13 An illustration of unw-nted overshoot in the presentation of a pure tone test signal (Harford, E., 1965).

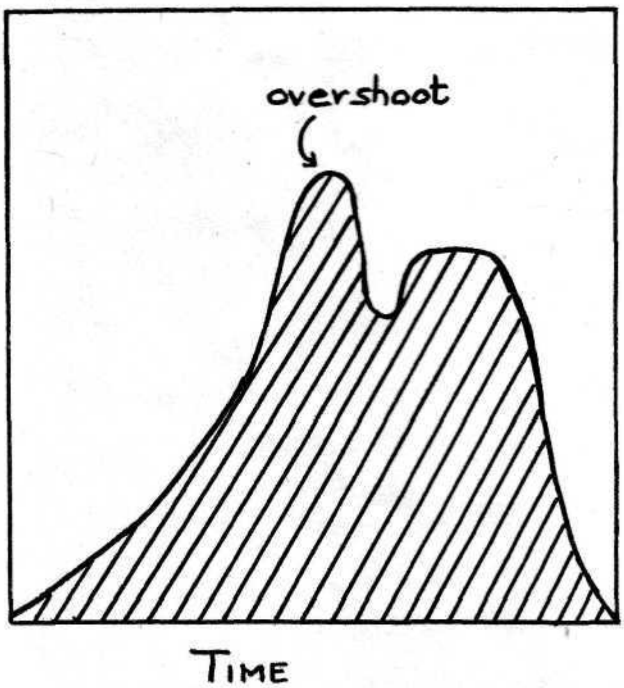
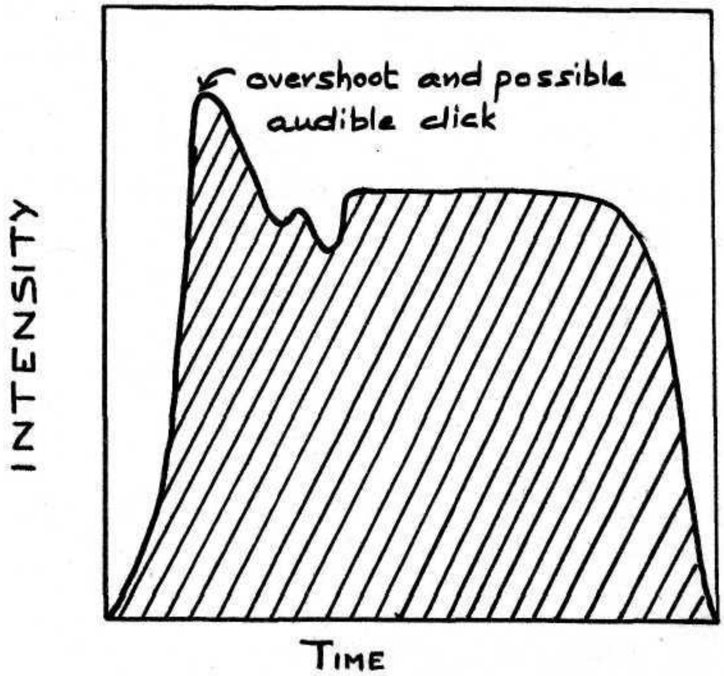



Fig. 14 An, illustration of an unaesiral short rise time with overshoot.This can lead to an audible click as the tone is presented (Harford,E., 1965)



the tone (Figure 13). fhe short rise and decay time (less than 5 m.sec) introduces "Click" or "Splat" sound at the onset or at the termination of the signal(fig 14)

Carhart and Jerger (1959) pointed out that slow rise time may fail to elicit maximum oneffect of the hearing mechanism and results in a poorer hearing threshold, And overshoot may result in better thresholds. Therefore,the precision of signal presentation is very critical for accuracy in audiometry.

**Tone Interrupter Switch Calibration_check**

Interrupter switch controls the rise and decay times of the tone, when it is pressed and stopped respectively, That can be checked as follows :

**Equipment required_is.**

level Recorder (B & K type 2305)

1. Connect the audiometer output directly to the INPUT of the level recorder.

2. Set the controls on the level recorder to:

POTENTIOMETER RANGE " 50 dB"

RECTIFIER RESPOMSE "RMS"

LOWER LIM. FREQ. "2 Hz"

WRITING SPEED "100mm/sec"

| | |
|---|---|
| PAPER SPEED | "30 mm/sec" |
| POWER | "ON" |
| MOTOR | "ON" |

With this setting, the calibrated paper will be moving.

3. While the paper moving, press the interrupter, present the tone for a few seconds and release it.

   Accordingly the Recorder, automatically records. And you will find the patterns showing temporal parameters of the tone presented as shown in the figure 10 .

4. Stop the signal and stop the "MOTOR", after getting a few similar recordings.

5. From the recordings, find out the rise-time and decay time as follows:


As shown in the figure above draw two straight lines from the peaks, on the recordings Mark length 1, $1_2$, and $1_3$ and measure the lengths in millimeters using a scale. Note down the paper speed used.

$$\text{Rise time} = \frac{\text{length } 1_1}{\text{paper speed}} \text{ msec}$$

$$\text{Decay time} = \frac{\text{length } 1_3}{\text{paper speed}} \text{ msec}$$

If the rise and decay times does not agree with the standards, the interruptor switch to be replaced or repaired .

**Short increment sensitivity index(SISI) Unit: calibration check.**

The validity of the SISI test depends on the precision of SISI pulse presentation. Its temporal parameters can be very critical in diagnostic audiometry.

**The SISI pulse - tone**

The SISI pulse 50 m. sec as its rise and decay time. Its peak duration is 200 msec. The amplitude or the increment should be 1 dB HL from the carrier-tone intensity level. The time interval between two SISI pulses is 5 seconds. The calibration measurement procedure is same as given for interruptor switch calibration. The recordings of the standard SISI pulse tone will be similar to the figure 10 .

IMPORTANT:

1. Check the intensity increments to see if the dial readings (1 through 5 dB) are accurate.
2. Check the output level at each frequency and at each increment setting.
3. Be certain about the damping characteristics of the level Recorder. If the SISI unit does not produce increments of precisely 1 dB at the point indicated on the dial, and if there is a variable potentiometer dial to control the output increments, mark the SISI dial to show the setting needed for the 1-dB increment
4. Listen to the unit to make sure there are no clicks or other distorting influences.

**Alternate Binaural Loudness Balance (ABLB) units Calibration Check.**

Procedure for calibration measurement is same as given for interruptor switch calibration check (See page 68 ) when the audiometer is set to ABLB unitv automatically the tone is presented to both the earphones, alternately. The peak duration of the tone in each earphone will be 400 m. sec with 30 EU sec rise decay time. When the signal is displayed on the recording paper, find out whether the temporal parameters of the tone is in agreement with the above given values.

# Appendicises

1. American National Standard Specifications for Audiometers (ANSI S3.6-1969)-Appendix 'D' Reference Threshold Levels for Air- Conduction.

The reference threshold levels recommended by ISO 1964 (and now adopted by ANSI) differ considerably from the American Standard Specification for Audiometers for General Diagnostic purposes, Z24.5-1951. Table G shows bath these values in terms of the Western Electric 705-A earphones and the 9-A coupler (the associated condenser microphone being used without a protective grill). The numerical values given in the 1951 specification have been shifted by 74 dB to put them on the reference basis of 0.0002 microbar, and have been rounded off to the nearest 0.5 dB to accord with present methods of representation.

| | Reference Threshold levels | | |
|---|---|---|---|
| Frequency | 1951 ASA | 1964 ISO | Differences |
| 125 | 54.5dB | 45.5dB | 9.0 dB |
| 250 | 39.5 | 24.5 | 15.0 |
| 500 | 25.0 | 11.0 | 14.0 |
| 1000 | 16.5 | 6.5 | 10.0 |
| 1500 | (16.5) | 6.5 | (10.0) |
| 2000 | 17.0 | 8.5 | 8,5 |
| 3000 | (16.0) | 7.5 | (8.5) |
| 4000 | 15.0 | 9.0 | 6.0 |
| 6000 | (17.6) | 8.0 | (9.5) |
| 8000 | 21 .0 | 9.5 | 11.5 |

The figures in parentheses are interpolations.

2. **ANSI S3.6-1969. Article 4.1.4.3: Accuracy of Sound Pressure Levels.**

The sound pressure produced by an earphone as referred to the standard reference level shall not differ from the indicated value of sound pressure level at any reading of the hearing threshold level dial by more than 3 dB at the indicated frequencies of 250 to 3000 Hz inclusive, by more than 4 dB at 4000 Hz, not by more than 5 dB at frequencies above or below this range. Measurements for compliance with this requirement may be made by combining an acoustical measurement of sound pressure level at a 70 dB setting with voltage measurements at other settings.

3. **ISO Recommendation - R 389, 1964 : Standard reference zero for the calibration of pure-tone audiometers**

This recommendation specifies a standard reference zero for the scale of hearing threshold level applicable to pure-tone audiometers, which it is hoped will help to promote agreement and uniformity in the expression of hearing threshold level measurements throughout the world.

The reference zero is expressed in terms of earphone - coupler combinations that are national standards in various countries. It is an average of fifteen determinations from various laboratories, prepared by the Technical committee ISO/TC43, Acoustics.

The following table (fable Z) gives the recommended reference equivalent threshold Sound Pressure Levels.

Table 2

| Frequency | Reference equivalent threshold sound pressure levels relative to $2x10^5$ N/m$^2$ ($2x10^4$ dyn/cm$^2$) | | | | | |
|---|---|---|---|---|---|---|
| Hz (c/s) | Decibels. | | | | | |
| 125 | 44.5 | 47.5 | 47.0 | 45.5 | 55.0 |
| 250 | 27.5 | 28.5 | 28.00 | 24.5 | 33.0 |
| 500 | 11.5 | 14.5 | 11.5 | 11.0 | 14.5 |
| 1000 | 5.5 | 8.0 | 5.5 | 6.5 | 8.5 |
| 1500 | 4.5 | 7.5 | 6.5 | 6.5 | 8.5 |
| 2000 | 4.5 | 8.0 | 9.0 | 8.5 | 9.0 |
| 3000 | 6.0 | 6.0 | 8.0 | 7.5 | 10.5 |
| 4000 | 8.0 | 5.5 | 9.5 | 9.0 | 11.5 |
| 6000 | 17.0 | 8.0 | 8.0 | 8.0 | 18.5 |
| 8000 | 14.5 | 14.5 | 10.0 | 9.5 | 9.5 |
| Pattern of earphone | Audio 15 | Beyer DT 48 | S.T.C. 4026.A | W.E. 705-A | T.D.6 |
| Type of artificial ear or coupler | CNET artificial ear | IBS type 9-A coupler (with PTB adapter) | BS 2042 artificial Bar | NBS type 9-A coupler | IU-3 type artificial ear |
| Country of origin of data | France | Germany | United Kingdom | U.S.A. | U.S.S.R |

4. **ISO 1.967 Supplement to ISO R.389 : Standard reference zero for the calibration of pure- tone audiometers Additional data in con.junction with the 9-A coupler**

This supplement gives the corresponding reference equivalent threshold sound pressure levels for eleven audiometric earphones referred to a single type of coupler, namely/ the National Bureau of Standards *(NBS)* Type 9-A coupler. This was prepared by working Group I of ISO/TC 43.

The following table (Table 3 ) gives the recommended reference equivalent threshold Sound Pressure Levels in the 9-A coupler.

*TABLE 3*

| Frequency | Reference equivalent threshold sound pressure levels relative to $2\times10^{-5}$ $N/m^2$ ($2\times10^{-4}$ $dyn/cm^2$) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | decibles | | | | | | | | | | |
| 125 | 48.5 | 47.5 | 51.0 | 45.5 | 54.0 | 44.0 | 44.0 | 46.5 | 46.5 | 51.0 | 45.0 |
| 250 | 28.0 | 28.5 | 30.5 | 24.5 | 32.0 | 25.0 | 25.0 | 26.0 | 26.0 | 28.5 | 25.5 |
| 500 | 12.0 | 14.5 | 13.5 | 11.0 | 14.0 | 11.5 | 11.0 | 10.5 | 11.0 | 10.0 | 11.5 |
| 1000 | 6.5 | 8.0 | 6.5 | 6.5 | 8.0 | 6.5 | 5.0 | 5.0 | 7.0 | 6.0 | 7.0 |
| 1500 | | 7.5 | 7.0 | 6.5 | 8.0 | 5.5 | | 5.0 | 7.0 | 6.5 | 6.5 |
| 2000 | 6.0 | 8.0 | 7.5 | 8.5 | 9.5 | 7.5 | 8.5 | 7.5 | 9.0 | 6.5 | 9.0 |
| 3000 | 8.0 | 6.0 | 8.0 | 7.5 | 10.0 | 8.0 | | 6.5 | 10.0 | 9.0 | 10.0 |
| 4000 | 3.5 | 5.5 | 10.5 | 9.0 | 11.0 | 9.0 | 13.0 | 13.0 | 13.5 | 9.0 | 9.5 |
| 6000 | 14.5 | 8.0 | 13.5 | 8.0 | 17.5 | 17.0 | | 11.0 | 8.5 | 18.5 | 15.5 |
| 8000 | 12.0 | 14.5 | 20.5 | 9.5 | 12.5 | 13.0 | 9.0 | 13.0 | 11.0 | 14.0 | 13.0 |
| *Pattern of earphone | Audio 15 | Beyer DT48 with flat cushion | STC W.E 4026A | W.E. 705-A | T.D6 | Permo-flux PDR8 $MX_{41}$/AR cushion | Permo-flux PDR1 Maico Dough-nut cushion | Perrno flux PDR1 ADC cast | Perrno flux PER 1 $MX_{41}$/AR Cushion | Perrno flux PDR 10 $MX_{41}$/AR Cushion | Telephonies TDH-39 Cushion |

*For these data to be valid the earphone is placed both on the ear and on the coupler with itsear-cushion 'with one exception. When calibrating the Beyer DT 48 earphone ort the 9-A coupler, the cushion is removed and an adapter/ described by *Mrass H.*, and Diestel H.G., in Acoustica, 9 61 (1959) is used.

7. The critical band width's from the data of Hawkins and Stevens (1950) are shown in the following table. (Cit. J.W. Sanders).

Table 4

Critical Bandwidths for 11 test frequencies

| Center Frequency | Critical Band width (CBW) | |
|---|---|---|
| | In Hz | 10 log CBW |
| 125 | 70.8 | 18.5 |
| 250 | 50 | 17 |
| 500 | 50 | 17 |
| 750 | 56.2 | 17.5 |
| 1000 | 64 | 18 |
| 1500 | 79.4 | 19 |
| 2000 | 100 | 20 |
| 3000 | 158 | 22 |
| 4000 | 200 | 23 |
| 6000 | 376 | 25.75 |
| 8000 | 501 | 27 |

Audiometers Date

Earphone . . . . . .. . .. . . . . . . .. . . .. . . Calibrated by

Bone vibrator

| Frequency Hz | | 250 | 500 | 1000 | 2000 | 4000 | 6000 | 8000 |
|---|---|---|---|---|---|---|---|---|
| Air Conduction | Right | | | | | | | |
| | Left | | | | | | | |
| Bone conduction | | | | | | | | |

Fig 1 correction sheet for audiometer.

Audiometer: Earphone: Channel: Place:

Calibrated by: Date: Equipment:

| FREQUENCY | 125 | 250 | 500 | 750 | 1000 | 1500 | 2000 | 3000 | 4000 | 6000 | 8000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| l.SPL* | | | | | | | | | | | |
| 2•Audiometer Dial Reading. | | | | | | | | | | | |
| 3.Line 1 Minus Line 2 | | | | | | | | | | | |
| 4.Equipment & Mike correct | | | | | | | | | | | |
| 5. Line 3 minus Line 4 | | | | | | | | | | | |
| 6. ANSI -TDh-39 ** | 45.0 | 25.5 | 11.5 | 8.0 | 7.0 | 6.5 | 9.0 | 9.5 | 10.0 | 15.5 | 13.0 |
| ANSI -TEH-49 *** | 47.5 | 26.5 | 13.5 | 8.5 | 7.5 | 7.5 | 11.0 | 9.5 | 10.5 | 13.5 | 13.0 |
| 7.Line 5 minus Line 6 | | | | | | | | | | | |
| 8. CORRECTION | | | | | | | | | | | |

F13- 2

Calibration worksheet for audiometer earphones (*) SPL = Sound Pressure level in dB re 20 Pa. (**) ANSI-TEH-39 proposed ANS1-69 threshold values for TEK-39 earphones in MX-41/AR cushions.(***} ANSI-TDH-49 proposed ANSI-69 threshold values for TDH-49 earphones in 7X-41/AR cushions (''''} Correction-rounded to the nearest 5 dB: - = audiometer weak, make threshold better. + = audiometer strong, make threshold poorer, (Wiber L.A. 1978).

Audiometer: Channel: Vibrators

Place: Calibrated by: Date:

Equipment used: . + B & K Mastoid.

| FREQUENCY | 250 | 500 | 750 | 1000 | 1500 | 2000 | 3000 | 4000 |
|---|---|---|---|---|---|---|---|---|
| Voltage reading: | | | | | | - | | |
| 1. dB re 1 dyne | | | | | | | | |
| 2. HAECOM B&K Mast.Correct* | | | | | | | +1.0 | +9.5 |
| 3. Line 1 minus/ plus -Line 2 | | | | | | | | |
| 4. Audiometer Dial | | | | | | | | |
| 5. Line 3 minus Line 4 | | | | | | | | |
| 6a.MASTOID Bone | 41.4 | 30.7 | 19.3 | 16.9 | 15.4 | 8.1 | 6.6 | 11.2 |
| 6b.FRONTAL Bone | 54.9 | 45.7 | 31.8 | 26.9 | 24.4 | 16.6 | 14.1 | 17.7 |
| 7. Line 5 Minus Line 6 | | | | | | | | |
| 8. CORRECTIONS** | | | | | | | | |

Fig. 3
Calibration sheet for bone vibrators (*) Corrections specific to HEACOM B & K mastoid (B&K Model 4930 S.N. 331268} (') Threshold for MASTOID placement of RE B 70-A re ANSI S3,13-1972 norm incorporating Wilber B&K corrections (Journal of the Acoustical Society of America, 52, 1265,1972) ('') Threshold for FOREHEAD placement of RE B-70-A re ANSI S3.13-1972 Norm incorporating B & K corrections (Journal of the Acoustical Society of America, 52,1265,1972)(**) corrections rounded to nearest 5 dB: += strong ,make threshold

Audiometer: Place: Date:

| TRANSDUCER | EARPHONES | | | | BONE VIBRATOR | | LOUDSPEAKER | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| CHANNEL | I | | II | | I | II | I | | II | |
| EAR | Rt. | Lt. | Rt. | Lft. | | | Rt. | Lft. | Rt. | Lft. |
| 125 | 47.5 | | | | | | | | | |
| 250 | 26.5 | | | | 41.4 | | 15.0 | | | |
| 500 | 13.5 | | | | 30.7 | | 9.0 | | | |
| 750 | 8.5 | | | | 19.3 | | | | | |
| 1000 | 7.5 | | | | 16.9 | | 3.0 | | | |
| 1500 | 7.5 | | | | 15.4 | | | | | |
| 2000 | 11.0 | | | | 8.1 | | -3.0 | | | |
| 3000 | 9.5 | | | | 6.6 | | | | | |
| 4000 | 10.5 | | | | 11.2 | -4.0 | | | | |
| 6000 | 13.5 | x | | | | | | | | |
| 8000 | 13.0 | | | | | | | | | |
| Spee- | 20.0 | | | | 29.4 | | 13.0 | | | |
| White Noise | 20.0 | | | | | | 13.0 | | | |
| Speech Spec-trum | 20.0 | | | | | | 13.0 | | | |

*Warble tone

| | ANSI - '69 TDH -49's | | | | ANSI - '72 RE B 70-A | | EXPECTED OUTPUT | | | |

Fig-4 Monthly calibration check summary
(Wilber L.A., 1978)

Check list for daily and weekly examination of Audiometers.

1. Clear the equipment and examine for damage.

*2. Switch on, allow warm-up, adjust according to manual.

*3. Earphone serial numbers tally with equipment.

*4. Switch knobs are secure ; Switches operate smoothly.

*5. Lamps and indicators (For eg. SISI Pulse Indicator, V.V. meter, digital read-outs) function correctly.

*6. Patient's signal system operate correctly.

*7. Check battery state whether sufficient to run the audiometer.

*8. Threshold levels are subjectively correct for :

   (a) Air conduction

   (b) Bone conduction

*9. High level listening test satisfactory on :

   (a) Air conduction

   (b) Bone conduction

   (c) Masking (including insert)

   (d) Loudness balance

   (e) SISI

   (f) Other function

10. Attenuators are silent and attenuate over proper range.

11. Noise or hum and unwanted (entraneous) sound levels are adequately low.

12. Radiated noise from instrument is inaudible at the patient's position.

13. Speech circuits (if provided) operate correctly.

14. Head bands are in good condition and tension are correct.

15. (Automatic audiometers) Mechanical operations, including limit switches and frequency switches are satisfactory. Noise from instrument is inaudible at the patient's position.

*16. Reset all controls to normal operating positions for commencement of patient testing.

The tests marked with an astrick are recommendation for daily check procedures. Other checks may be performed at weekly intervals.

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