TO

MY PARENTS

ESTABLISHMENT OF TOM VALUES IN NORMAL HEARING ADULTS

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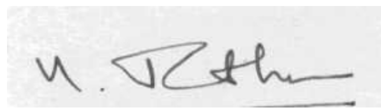
INDEPENDENT PROJECT

C E R T I F I C A T E

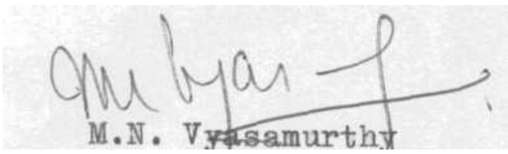
This is to certify that the Independent Project entitled "Establishment of TOM Values in Normal Hearing Adults" is the bonafide work in part fulfilment for the I Year Degree of M.Sc. (Speech and Hearing) of the Student with Register No.5.



Director
All India Institute of Speech
and Hearing
Mysore - 6

CERTIFICATE

This is to certify that this Independent Project has been prepared under my supervision and guidance.



GUIDE

D E C L A R A T I O N

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 & Hearing, Mysore, and had not been submitted earlier at any University for any other degree or diploma.

Register No.5

Mysore:
Dated : Signature

ACKNOWLEDGEMENTS

I am very grateful to Mr. M.N. Vyasamurthy, Lecturer in Audiology, All India Institute of Speech & Hearing, Mysore, for his guidance and suggestions.

Myssincere thanks to:

Dr. N. Rathna	:	Director All India Institute of Speech & Hearing Mysore
Dr. S.D. Isloor	:	ENT Surgeon Sahyadri Hospital Shimoga
Dr. S. Nikam	:	Professor & Head of the Department of Audiology All India Institute of Speech & Hearing Mysore
Dr. J. Bharath Raj	:	Professor & Head of the Department of Psychology All India Institute of Speech & Hearing Mysore
Mr. S.S. Murthy	:	Lecturer in Electronics All India Institute of Speech & Hearing Mysore
Mrs. S. Menon	:	Reader and Head of the Department of Speech Pathology All India Institute of Speech & Hearing Mysore

I express my deepest gratitude to the subjects and to all the other students and staff for their help in the study.

C O N T E N T S

CHAPTER I

INTRODUCTION

A threshold of octave masking test (TOM) has been suggested as a substitute for measuring aural harmonic thresholds (Grimm and Bess 1973). The test consists of measuring the monaural masked threshold of a pulsed tone (f_2 one octave above a steady-state pure tone masker (f_1) in a threshold tracking paradigm. "The threshold of octave masking is that masker sensation level (SL) in dB where the initial threshold shift in f_2 occurs as established by a slope extrapolation procedure" (Olsen and Berry 1979).

Clack by a series of experiments (1967, 1968a, 1968b) suggests that the threshold of aural overload; as by best beat technique (Wegel and Lane 1924) is comparable to the masked threshold measured in the frequency region where harmonic distortion occurs. Agreement between TOM and threshold of aural overload test has been established by Clack and Bess 1969, Grimm and Bess 1973 and Nelson and Bilger 1974. Further it is also established that the aural overload threshold and TOM values occur at considerably reduced sensation levels in sensorineural ear when compared to the values obtained in normals.

Grimm and Bess (1973) mention the following advantages of TOM teat:

1. differentiation between cochlear and normal hearing subjects;
2. excellent test-retest reliability;
3. appropriate for both unilateral and bilateral hearing loss; and
4. minimal instrumentation along with ease of administration.

Lawrence and Blanchard (1954) suggest that aural overload threshold can be used to predict susceptibility to noise induced hearing loss. As many investigations have found agreement between TOM values and threshold of aural overload. It may be inferred that TOM values may also be useful to predict susceptibility to noise induced hearing loss.

Thus it appears that TOM test has wide clinical applications.

Statement of the Problem:

The present study is aimed at collecting norms for TOM test, and to compare the norms with previous studies.

Brief Plan of the Study:

Beltone 200-C clinical audiometer calibrated to ANSI (1969) specification was used in this study.

Threshold shifts were measured for 15 normal subjects, using f_1= 500 Hz, f_2 = 1000 Hz tones at threshold level, 10 dBSL, 20 dBSL and 30 dBSL. TOM values were determined by slope-extrapolation method.

Limitations of the Study:

1. Frequencies other than 500 Hz and 1000 Hz could not be tested because the subjects could not differentiate the masker and the maskee when higher frequencies were used.

2. A small sample was used due to limited time allotted for collecting data.

DEFINITIONS OF THE TERMS:

TOM: Threshold of Octave Masking is defined as "the threshold of octave masking is that masker sensation level (SL) in dB where the initial threshold shift in f_2 occurs as established by a slope extrapolation procedure"! (Olsen and Berry 1979).

Masker: A steady-state pure tone of 500 Hz was considered as the masker in this study.

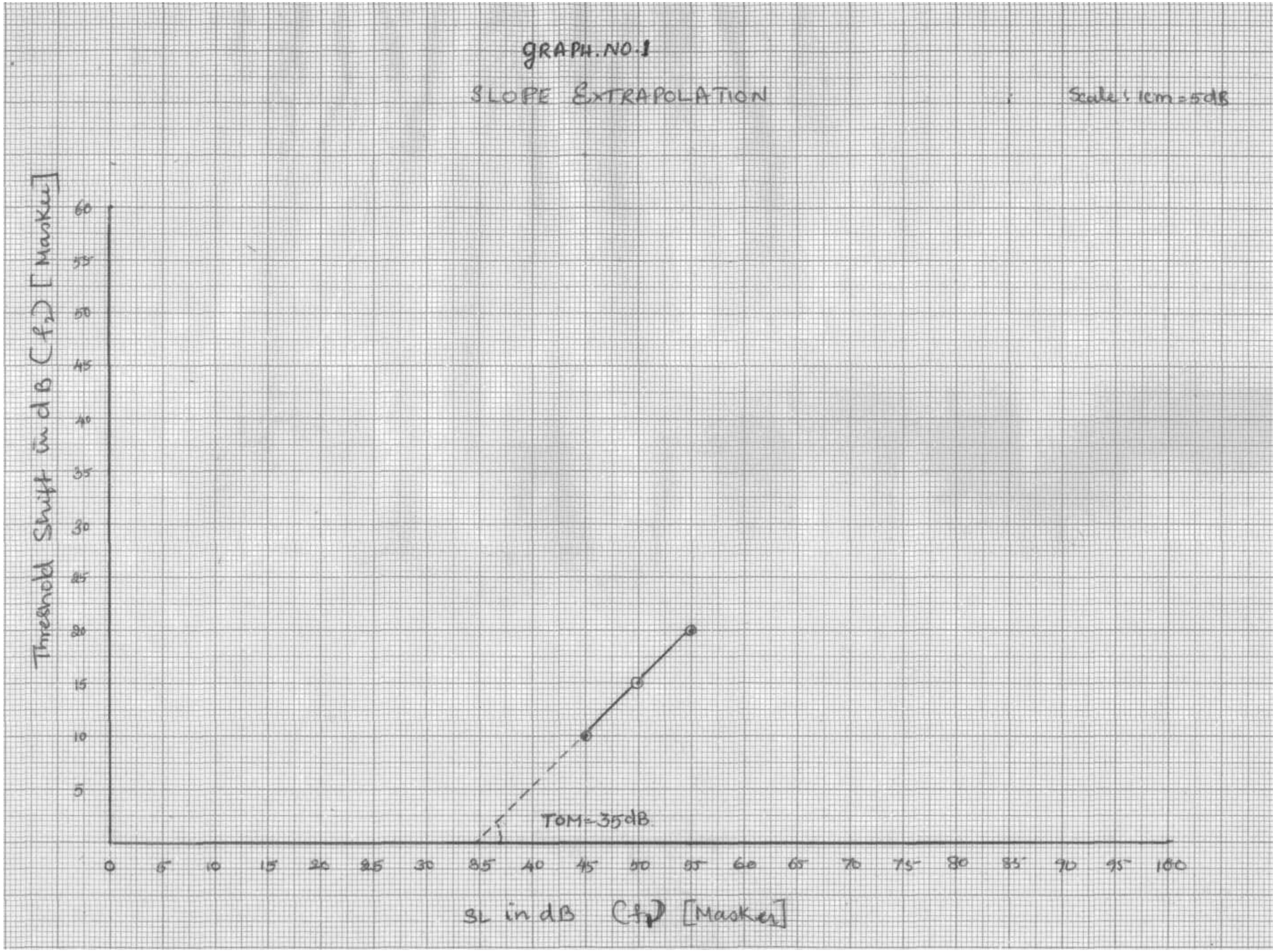
Maskee: A pulsed 1000 Hz tone was considered as (f_2) the maskee in this study.

Slope Extrapolation

Slope extrapolation is a graphical method of finding TOM. Masker values are plotted in X-axis and maskee values are plotted on Y-axis. The line joining the points are extended to cut the X-axis. The point of intercept is taken as TOM value (see the graph), (No.1).

Aural Harmonic-s:

"The ear generates overtones, called aural harmonics (AHs), when the mechanisms within the cochlea are forced to vibrate beyond their capacity for simple proportionate response." (Wever and Lawrenee 1954).


GRAPH. NO. 1
SLOPE EXTRAPOLATION
Scale: 1cm = 5dB
TOM = 35dB
Threshold Shift in dB (f_2) [Masker]
SL in dB (f_1) [Masker]
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
5 10 15 20 25 30 35 40 45 50 55 60

CHAPTER II

REVIEW OF LITERATURE

Threshold of octave masking test is of recent origin. This test has been suggested as a substitute for measuring aural harmonic thresholds (Grimm and Bess 1973).

Wegel and Lane (1924) have studied the threshold of aural overload using best-beat techniques.

Clack (1967) studied aural harmonie distortion in normals with a constant 1000 Hz fundamental (f_1) while the listener traces his threshold for an interrupted 2000 Hz (f_2) objective tone. Both tones are presented simultaneously to the same ear with the consequent variations in the masked thresholds recorded during manipulations of the time relation between f_1 and fg. He found that the threshold shift (TS), produced with an f_1 of 60 or 65 dB sensation level (SL).

Clack and Bess (1969) have done a study on "Aural Harmonics: the tone-on-tone masking Vs the best beat method in normal and abnormal". Their detailed study runs as follows:

Pure tone stimulation at sufficient intensities produces perception of the signal's pitch, loudness and two less directly observable events - harmonic distortion and masking. The ear generates over tones, called aural harmonics (AHs), when the mechanisms within the cochlea (Wever and Lawrence 1954) are forced to vibrate beyond their capacity for simple proportionate response. At the same time the fundamental signal also causes the ear to lose sensitivity for the higher frequencies. This spread of masking is presumably the reason aural harmonics are not heard as separate perceptual entities at moderate signal intensities even though their presence is detectable using special psychophysical procedure.

The most common of these procedures is the method of best-beats, based upon a suggestion by Wegel and Lane (1924). With this method, clinical investigators have measured the lowest intensity (in dBSL) of the pure tone fundamental (f_1) required fo make the second aural harmonic (fAH) just detectable. This threshold of distortion has been related to inner ear pathology (Lawrence and Yantis 1956) to the estimation of cochlear reserve in otosclerotic ears (Yantis and Magielski 1958) to the intelligibility of speech in patients with sensori-neural impairmen-ts (Yantis et al, 1966) and possibly even to the determination of susceptibility to acoustic trauma (Lawrence and Blanchard 1954, Capano, 1962). In spite of its potential significance in hearing conservation and the diagnostic evaluation of hearing disorders, otologist and audiologist do not utilize the best-beat method as a regular clinical tool. The neglect may be due to certain practical as well as theoretical difficulties. One aspect of the latter is the problem of masking at the octave interval and its complicating effect upon resultant measurements.

The confounding effects of sensitivity upon the aural harmonic measurements was first demonstrated and explained by Egan and Humpp (1951). They suggested that a rather large, somewhat idiooyncratic, bias may be introduced as f_1 intensity is lowered to obtain the aural harmonic threshold. Some more recent work using a different procedure has indicated that the amplitude of F_{AH} is below th-e perceptual threshold when the ear's distortion begins and grows at a rate equal to or less than the masked threshold for intensities below 70 dBSL (Clack, 1967). Such reasoning suggests that the aural harmonic levels, by the best-beat method, might be essentially equivalent to the masked threshold measured in the immediate frequency vicinity of

To test this hypothesis, two separate experiments are discribed here. In the first, the threshold of masking and th-e aural harmonic threshold levels were obtained from the sample of normal ears. The second experiment compares the masking thresholds from a group of sensori-neural impaired listeners to the aural harmonic thresholds obtained by previous clinical investigators using the best-beat method.

Clack and Bess (1969) have compared the tone-on-tone masking and best-beat threshold in normals in their first experiment. They took 5 college students (3 male and 2 female) ranging in age from 22 to 33 with a mean age of 26 years. Their hearing level were below 25 dB (Ref. I.S.O. 1964 norms) for frequencies between 125 and 8000 Hz.

Beat-beats: The listeners hear a loud, low pitched fundamental with a softer, higher pitched, background tone which waxes and wanes in loudness, i.e., beats at a rate determined by the frequency difference between the aural harmonic and the exploring tone. Then intensity of the exploring frequency (f_e), in this case approximately a 2004 Hz tone, is adjusted to maximize the prominance of the beating, obtained initially with a 70 dBSL 1000 Hz fundamental. When the perceptual range of the beat is maximized, as reported by the observer, the criterion of 'best' is met and the exploring tone is thought to be at the same intensity as the aural harmonic. Both tones were the-n attenuated together by the experimenter until the beating background could no longer be heard and adjustments of the relative intensity and/or changes in beating rate, due to varying the frequency of the exploring tone, could no longer produce reliable responses. This SL of the fundamental was recorded as the threshold of the aural harmonic.

A maico aural overload tester, MA-3, was used for making measurements by the best-beats method.

Tone-on-Tone Masking:

This procedure simply involves measuring the monaural masking at one octave above the fundamental masker. In these experiments a continuous 1000 $\pm$ 1 Hz signal was the masker and the listener traced his threshold for an interrupted 2000 $\pm$1 test-tone. They have used Hewlett-Packard 203 A to generate the (f_1) while the test-tone was generated by the Bekesy audiometer.

The mean threshold of the aural harmonic, 59 dBSL is within the range, 52 to 65 dBSL, reported by previous investigators (Lawrence and Yantis, 1956, Lawrence and Blanchard, 1954). This sample of normal ears, therefore, seems fairly typical of the population. The mean tone-on-tone masking threshold (TOM), 50 dBSL is slightly lower than the 59 dB harmonic threshold. Apparently, masking at the harmonic frequency becomes effective slightly before there is any evidence of amplitude distortion. This finding is consistent with the bias inherent in the best-beat measurements (Wegal and Lane, 1924; Egan and Klumpp, 1951; Clack, 1967). The absolute magnitude of the difference, 6 dB, is not, however, directly comparable to the results of previous investigators for two reasons. First, differe nt instructions or testing details, such as attenuating f_1 and the exploring tone (f_e) in steps less than 5 dB, might have resulted in harmonic thresholds differing some what from those obtained here. Second, an error is involved in determining the threshold of masking from linear extrapolation. It is well known, for instance, that the growth of masking is S-shaped - not linear (Wegel and Lane, 1924). Thus, it is quite likely that masking actually begins at lower levels than indicated by TOM values reported here. Although both sources of error affect each of the numerical threshold values to some degree, two facts are clear - (l) masking and harmonic distor-tion appear at almost the same f_1 - levels, and (2) both kind of threshold measurements tend to rank ears in the same way. This evidence is consistent with the contention that both psyehophysieal procedures, tone-on-tone masking and the best-beat method, produce essentially equivalent results in ears with normal absolute hearing thresholds. What happens when the absolute threshold is affected by sensori-neural disease processes is investigated next.

In their second experiment, they have compared tone-on-tone masking thresholds in normals and abnormals.

Eight normal hearing college students and 8 sensori-neural i-mpaired patients were tested as mentioned above (The mean TOM value for sensori-neural loss group was 26 dBSL). The mean aural harmonic thresholds, reported for groups of abnormals were f_1 = 1000 Hz are 13 dBSL (Yantis and Magielski, 1958) and 30 dBSL (Yantis et al, 1966). The mean TOM, 26 dBSL, obtained with the group of abnormals sampled here falls within this range. This lowering of TOMs suggests their interchangeability with aural harmonic thresholds.

There is a distinct practical advantage in substituting the TOM procedure for the best-beat method. Often the initial best-beat determinations have taken as long as 30-45 minutes, depending upon the experience, motivation, and intelligence of the listener as well as the experience of the tester. The listener's task is psychophysically quite complex in attempting to maximize the perceptual loudness range of a soft beating tone. In the tone-on-tone masking situation, on the other hand, listeners only determine whether or not a tone is present. Although extrapolation of results takes a few minutes, the single sets of threshold shifts needed usually requires less than 5 minutes of patient time. Consequently, more patients c-an be tested more quickly than is possible with the best-beat method. They conclude as follows. In the first experiment, the threshold of octave masking (TOM) was shown to be equivalent of the aural harmonic threshold level in normal ears. The second experiment reveals that even when the ear is impaired by sensorineural disease pro-cesses, the TOM is affected in the same way as the aural harmonics threshold. It appears that the results of both experiments provide support for the contention that the best-beat method and the tone-on-tone masking procedure measure essentially the same phenomenon. Further studies employing larger samples with a wider variety of hearing disorders, however, will be needed before a co-nfident judgement can be made about the clinical value of the tone-on-tone masking procedure.

Conclusion:

Clack and Bess (1969) have concluded their study as follows:

In the first experiment, the threshold of masking (TOM) was shown to be equivalent to the aural harmonic threshold level in normal ears. The second experiment reveals that even when the ear is impaired by sensori-neural disease processes, the TOM is affected in the same way as the aural harmonics threshold. It appears that the results of both experiments provide support for the content ion that the best-beat method and the tone-on-tone masking procedure measure essentially the same phenomenon. Furthermore, in at least one case, it was demonstrated that the TOM is mere sensitive to super-threshold disfunctioning than the usual speech discri-mination test. The tone-on-tone masking procedure, therefore appears to have all the essential diagnostic properties which have made measurement of the aural harmonic threshold desirable. Further studies employing larger samples with a wider variety of hearing disorders, how ever, will be needed before a confident judgement can be made about the clinical value of the tone-on-tone masking procedure. Grimm and Bess (1975) suggested a threshold of octave masking test (TOM) as a substitute for measuring aural harmonic thresholds. The excerpts of the above study are given here:

The measurement of aural harmonic thresholds has demonstrated excellent potential as a diagnostic tool in audiology. Such measurements provide information as to the functioning of ears about midway between absolute and discomfort thresholds. A number of investigators have demonstrated that the subjects with cochlear involvement yield lower harmonic thresholds than normal hearing persons (Opheim and Flottorp, 1955, Lawrence and Yantis, 1956; Lawrence, 1958, Yantis et al., 1966). Two studies have reported that aural harmonic threshold measurements can be used as a substitute for recruitment tests (Sokolowski 1951; Ophein and Flottorp 1955). Aural overload testing has also been used to predict susceptibility to acoustic trauma (Lawrence and Blanchard, 1954) to estimate the amount of cochlear reserve in otosclerosis (Yantis and Magielski, 1958) and to determine whether amplitude distortion is a contributing factor to discrimination b-reakdown at intensity levels above the PB maximum (Yantis et. al., 1966).

Though harmonic threshold measurements appear to have value, few audiologists include this test among their clinical battery. The probable reason for this neglect seems to be the difficulty involved with obtaining accurate harmonic threshold determinations.

The psychophysical technique most commonly used to measure harmonic thresholds is the explorating tone method. Very simply this technique involves introducing a fundamental tone to the ear at an intensity sufficient to pr-duce a second aural harmonic. To assist in the detection of this harmonic, an exploring tone, varying in frequency from the aural harmonic by only a few cycles, is introduced to the same ear. This exploring tone then beats with the aural harmonic and is heard in the background of the fundamental. The use of this method for detecting harmonics, however, has been subjected to considerable criticism. For example, Bekesy (1957) concluded.

Recently, Clack and Bess (1969) proposed a simpler alternative tone-to-tone masking technique which was found to produce results essentially equivalent to the exploring tone method. The rationale for this technique was based on a series of earlier experiments by Clack (1967, 1968a, 196-8b). He revealed that harmonic distortion begins and grows at a rate equal to or less than masked threshold (below 70 dBSL). Based on these data, Clack and Bess (1969) reasoned that harmonic thresholds and masking thresholds may be equivalent if the masking was measured in the frequency vicinity of the aural harmonic. According ly, this test involved measuring the manaural masking at one octave above the fundamental masker (Mr) using 1000 Hz as the Mr, Clack and Bess (1969) found that the intensity level first needed to cause a threshold shift in the maskee (Me, 2000 Hz) was greater for normals than it was for a sensorineural impaired group. Thus less Mr intensity in sensation level (SL) was needed with abnormal hearing listeners to produce a small threshold shift in the Me. The intensity level first needed to cause a shift in the Me was referred as the threshold of octave masking (TOM).

The purpose of this research was to further evaluate the usefulness of the TOM for differential diagnosis. The present study endevored to eliminate certain limitations found in the initial investigation by incorporating a layer N; more Mr and Me frequencies, and choosing subjects with clearly defined lesions of the cochlea.

METHODS:

Subjects: 10 Normal Hearing Subjects and 12 sensorineural involvement subjects were selected for the study.

They discuss as follows:

The results of this investigation have shown that the TOM test will differentiate subjects with cochlear involvement from normal hearing subjects at all three Mr frequencies (500 Hz, 1000 Hz and 2000 Hz). In addition, the test has demonstrated excellent test-retest reliability.

The tone-on-tone masking technique seems to have cert ain clinical advantages. TOM can be administered in cases with both unilateral and bilateral hearing losses.

In the initial TOM investigation, Clack and Bess (1969) hypothesized that thresholds of octave masking and harmonic distortion appear at the same Mr levels. To further examine this hypothesis it is interesting to compare the aural harmonic threshold data obtained by previous investigators to the TOM values obtained in the present study.

It is apparent from the foregoing table that the harmonic thresholds and TOM values are very similar in the normal group for all three frequencies. Moreover, the TOM values are fairly compatible with the harmonic thr esholds seen in the sensori-neural impaired listeners; although there is more variability. Thus, these data lend further support to the contention that TOM values

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and aural harmonic levels, as measured by the exploring tone method, yield essentially the same data.

TABLE

Mean aural harmonic thresholds reported by three previous investigators and mean threshold of octave masking values obtained in the present study

		500 Hz	1000 Hz	2000 Hz
Harmonic Thresholds				
Lawrence and Yantis (1956)	Normal	—	52 dB	57 dB
	SN		17 dB	23 dB
Yantis, Millin and Shapiro (1966)	Normal	47 dB	53 dB	50 dB
	SN	28 dB	30 dB	28 dB
Ophein and Flottorp (1955)	Normal	42 dB	—	—
	SN	10 dB		
TOM values				
Grimm and Bess (1973)	Normal	44 dB	53 dB	56 dB
	SN	16 dB	28 dB	16 dB

Before this test can be used in a clinical setting with any degree of confidence additional study is needed using larger samples with a variety of hearing disorders. In particular, data are needed in subjects with purely conductive & VIII nerve lesions. The effects of hearing loss at the Mr and Me also warrant investigation.

Finally, there needs to be additional research cond-ucted on the number of masked data points required to obtain an accurate TOM value. A basic assumption of the TOM is that masking grows linearly once an initial shift in the Me occurs.

If the intensity levels of the Mr are not sufficient to produce a linear function, then the extrapolation procedure will cause an underestimation of the TOM value. Hence, it seems important to investigate how greater Mr intensityty levels can affect the TOM.

In conclusion, this study further examined the usefulness of the TOM test in differential diagnosis. The results indicated that the test was capable of differentiating between normal hearing persons and subjects with cochlear involvement. The test was found to be quick and easy to administer. The results of the study were in agreement with the initial investigation by Clack and Bess (1969) and also with the harmonic thresholds reported by previous investigators (Ophein and Flottorp, 1955; Lawrence and Yantis, 1956; Yantis et al., 1966).

Olsen and Berry (1979) administered TOM test to normal hearing and sensori-neural impaired listeners at four test frequencies; 500, 1000, 2000 and 4000 Hz. The TOM value was found to be inversely proportional to the degree of hearing loss at the masker frequency. Results indicate that the TOM is capable of distinguishing subjects with sensori-neural involvement from those with normal hearing and of providing a measure of the degree of sensory disfunction. Examination of the slope of octave masking revealed that once the influence of hearing loss is overcome at higher intensities the sensorineural ear performs essentially the same as the normal ear in a tone-on-tone masking test.

Grimm and Bess (1973) conducted a study to investigate further value of TOM test in differential diagnosis. A group of normal and sensori-neural impaired listeners were administered the TOM test. They tested 3 frequencies 500, 1000 and 2000 Hz. The results showed significance (0.05) difference between the normal and abnormal hearing groups. Test-retest reliability was also proved to be excellent. They also compared the TOM values with the aural harmonic thresholds reported by previous researchers, They found close agreement between them. They also suggested that TOM is easy to administer, data can be obtained in a very short period of time. This test may appear to have a potential as a special test in audiometric diagnosis.

Methodology they have followed were:

They have taken 22 normal hearing and 24 sensori-neural ears from a total of 29 persons (16 female and 13 male). Hearing sensitivity of these cases ranged from audiometric normal (with 10 dBHL, ANSI 1969) to a marked hearing loss of 55-70 dB based on pure tone average of 500, 1000 and 2000 Hz. Audiometer used by them was Grason Stadler Bekesy Model E 800.

They established pure tone threshold for f_1 (250, 500, 1000 and 2000 Hz) and f_2 (500, 1000, 2000 and 4000 Hz). The TOM values were traced as follows. Threshold for a pulsed f_2 signal in quiet was taken; next f_1 was introduced into the same ear phone with increasing intensity until a 10 dB threshold shift in f_2 was noted. Two subsequent 5 dB increments were introduced and corresponding shifts were noted. TOM was calculated as follows (as shown i-n the graph, in Appendix-1).

A line of best fit is drawn through the three data points representi ng the 10 dB, 15 dB and 20 dB threshold shifts. The function is extended to intercept the f_1 SL axis. The point of intercept is considered the threshold of octave masking.

They have compared the results with that of Grimm and Bess (1973). Tom values were almost same for normals whereas sensori-neural loss group displayed less agreement. There was discrepancy in the results of Grimm and Bess (1973) and Olsen and Berry (1979) in sensori-neural loss group. This discrepancy was probably due to less homogenity of the sensori-neural loss group in the study of Olsen and Berry (1979). They further point out that a TOM value of A 20 dB is indicative of a greater degree of unspecified sensori-neural pathology.

They conclude that TOM values are inversely related to threshold sensitivity at f_1 As such, the TOM value reflects the severity of sensori-neural loss. Humes (1978) has rev-iewed the application of the aural overload test to temporary threshold shift, susceptibility to noise-induced hearing loss, speech discrimination, site of lesi on testing and auditory recruitment. It is rather tempting to infer that since aural overload and TOM values occur at approximately equivalent sensation levels, the tests have mutual applicability to the areas discussed by Humes. This notion must be put to experimental test, however, as the physiological relationship between octave masking and the aural overload threshold remains speculative,

CHAPTER III

METHODOLOGY

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Subjects: 15 normal hearing subjects in the age range of 19-29 years (Male : 8 and Female: 7) were selected for this study. The subjects were selected on the following criteria.

1. They should not have had any history of eardischarge, tinnitus, giddiness or any other otologic complaints.

Heari ng sensitivity should be within normal limits, i.e. within 20 dBHL (ISO 1964) in the frequencies from 250 Hz to 8 K Hz.

Equipment: Beltone 200-C clinical audiometer was used. It is a two channel audiometer. Channel one provides eleven test frequencies and channel two provides six frequencies.

Channel one has (125 Hz, 250 Hz, 500 Hz, 1500 Hz, 2000 Hz, 3000 Hz, 4000 Hz, 6000 Hz).

Channel two has (500 Hz, 1000 Hz, 2000 Hz, 3000 Hz, 4000 Hz, 6000 Hz).

Frequency accuracy of the audiometer was ± 3% and SPL accuracy of ± 3 dB at all frequencies. TDH-49, Z-10 ohms telephonics type of head set was used. The audiometer was calibrated in accordance with the speeifications given by ANSI 1969. Calibration was excercised using an artificial ear B&K 4152, a condenser microphone B&K 4132 and a sound level meter B&K 2203 with an octave filter set B&K 1613. The output values of the earphones at 70 dB HTL are given in the appendix.

Test Environment: The experiment was carried out in an aeoustically treated room at All India Institute of Speech and Hearing. The ambient noise levels were below the proposed maximum allowable noise levels (Hirschorn, M. 1971) for audiometer calibrated to ISO 1964 (see Appendix).

Procedure: Pure tone Ac thresholds for all subjects were determined by using Hughson-Westake procedure. The ear which has better sensitivity for 500 Hz and 1000 Hz was selected for TOM test. In a subject, if the ears are equally sensitive at 500 Hz and 1000 Hz right ear was selected for TOM test. The subjects were instructed for TOM test as follows.

First you hear a pused tone of 1000 Hz (fg) in quiet. Whenever you hear the pulsed tone, you are required to indicate b-y flickering your finger. Later, you will be hearing two tones or wobbulating tones in the same ear. When you hear two tones or wobbulating tones, you are required to indicate by showing two fingers. The moment you fail to hear the wobbulation i.e. the moment you hear the wobbulation changing into a continuous tone, indicate it by raising only one finger.

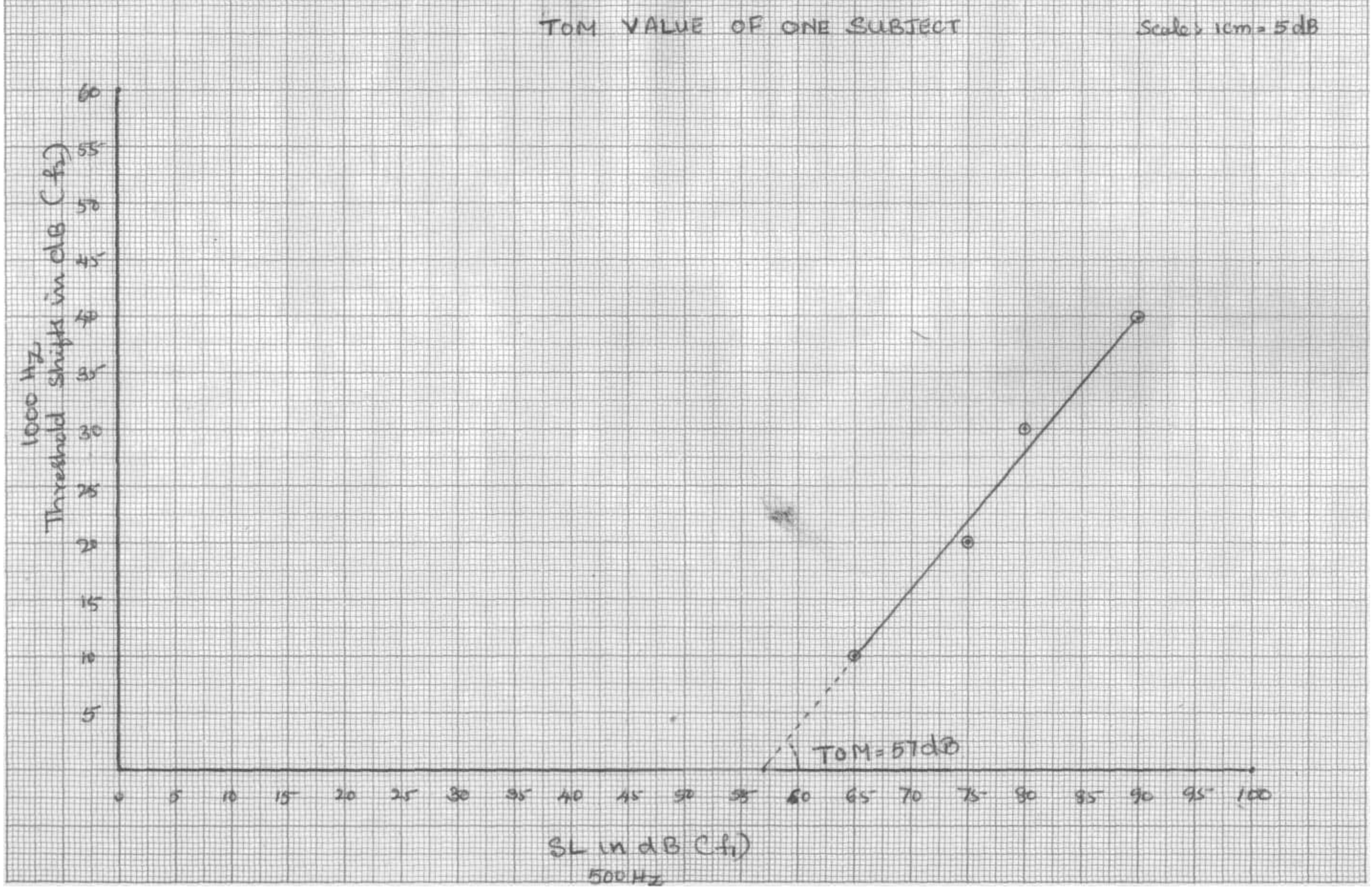
Before collecting the data for TOM test the subjects were given some practice events so as to make them familiar with pulsed tone and wobbulation.

Threshold for pulsed to 1000 Hz (fg) tone in quiet was obtained. Later 500 Hz (f_1) tone was introduced into the same ear at 0 dB HL. Intensity of f_1 (500 Hz) was increased in 5 dB steps, until the pulsed tone was masked. Later, intensities of f_1 (500 Hz) tone required to mask the pulsed tone presented at 10 dB SL, 20 dBSL, 30 dBSL were determined and corresponding shifts were noted.

The threshold of octave masking (TOM) was calculated by plotting the threshold shifts in fg (1000 Hz) as a function of intensity level of f_1 (500 Hz) as shown in the graph (see next page no2),A line of best fit was drawn through the data points representing the 10 dB, 20 dB, 30 dB threshold shifts. The function was extended to intercept the f_1 intensity level axis. The point of intercept is considered the threshold of octave masking (TOM). Slope extrapolation procedure was used.

GRAPH. NO. 2

TOM VALUE OF ONE SUBJECT



Intra-subject Reliability:

A sample of 5 subjects was retested in the similar way using the procedures as described earlier for intra subject reliability. A minimum gap of 50 days was given between test retest sessions.

The data were analysed statistically.

CHAPTER IV

RESULTS AND DISCUSSIONS

Previous studies by Lawrence and Yantis (1956), Yantis, Million and Shapiro (1966) revealed mean aural harmonic thresholds of 52 dB and 53 dB respectively. Grimm and Bess (1973) reported mean TOM value of 53 dB at 1000 Hz. According to Olsen and Berry (1979) TOM values for MOO Hz is 55 dB.

In the present study mean TOM value is 57 dB for 1000 Hz which closely agrees with previous studies. Table 1 gives the TOM values at 1000 Hz obtained from 15 subjects and Table 2 gives the mean TOM values and standard deviation values.

Grimm and Bess (1973), Olsen and Berry (1979) have done studies on normal subjects as well as sensori-neural loss cases and they have found that TOM value was inversely proportional to the degree of hearing loss at the masker frequency.

Grimm and Bess (1973) report mean TOM value of 28 dB for sensori-neural loss group, whereas Olsen and Berry (1979) report mean TOM value of 23 dB for sensori-neural loss group.

Table 1 showing the TOM values for all the subjects

Subjects	TOM values for 1000 Hz tone
1	60 dB
2	66 dB
5	52 dB
4	67 dB
5	53 dB
6	64 dB
7	58 dB
8	59 dB
9	40 dB
10	56 dB
11	57 dB
12	58 dB
13	59 dB
14	57 dB
15	58 dB

MEAN TOM Value is 57.4 dB

Standard Deviation 5.4

Table 2 : Comparison of TOM means and standard deviations (in dBSL) found by Grimm and Bess and Olsen and Berry and present study

Subjects	Masker frequency (Hz) 1000 Hz
Normal Hearing	
Grimm & Bess (1973)	
Mean TOM	53
Standard Deviation	6.0
Olsen & Berry (1979)	
Mean TOM	55
Standard Deviation	4.3
Present study	
Mean TOM	57
Standard Deviation	5.4

CHAPTER V

SUMMARY AND CONCLUSIONS

Normative data on TOM test have been determined. The results showed that the mean TOM value for 1000 Hz tone was 57 dB. This value closely agrees with the values reported by Grimm and Bess (1973) and Olsen and Berry (1979).

Beltone 200-C dual channel clinical audiometer calibrated to ANSI (1969) specification was used in this study. 15 normal subjects were tested and TOM values were obtained.

Conclusions! It is obvious from the results of the present study that the TOM values obtained in this study agree with the TOM values reported by earlier investigators. As mentioned earlier, TOM values for higher frequencies could not be determined as the subjects failed to make out 'masking' of maskee.

Recommendations!

- To test large number of normal subjects and establish TOM values.
- To establish TOM values for frequencies 2000 Hz and 4000 Hz.

- To establish the usefulness of TOM values in detecting subjects who are susceptible to noise induced hearing loss.

  To establish the relationship between TOM values and acoustic reflex thresholds.

- To establish the relationship between TOM values and TTS.

  To establish the relationship between TOM values and "Fatigability of reflet".

A study may be undertaken to verify whether low acoustic reflex threshold, greater 'Fatigability of reflex', lower TOM value and greater TTS go together in a subject or not.

Comments! While collecting data, the present investigator observed that the subjects could not make out 'masking' of maskee when higher frequencies were used. It is not known how the other investigatorscould collect data at higher frequencies. Further attempts are to be made to establish TOM values for higher frequencies.

CHAPTER VI

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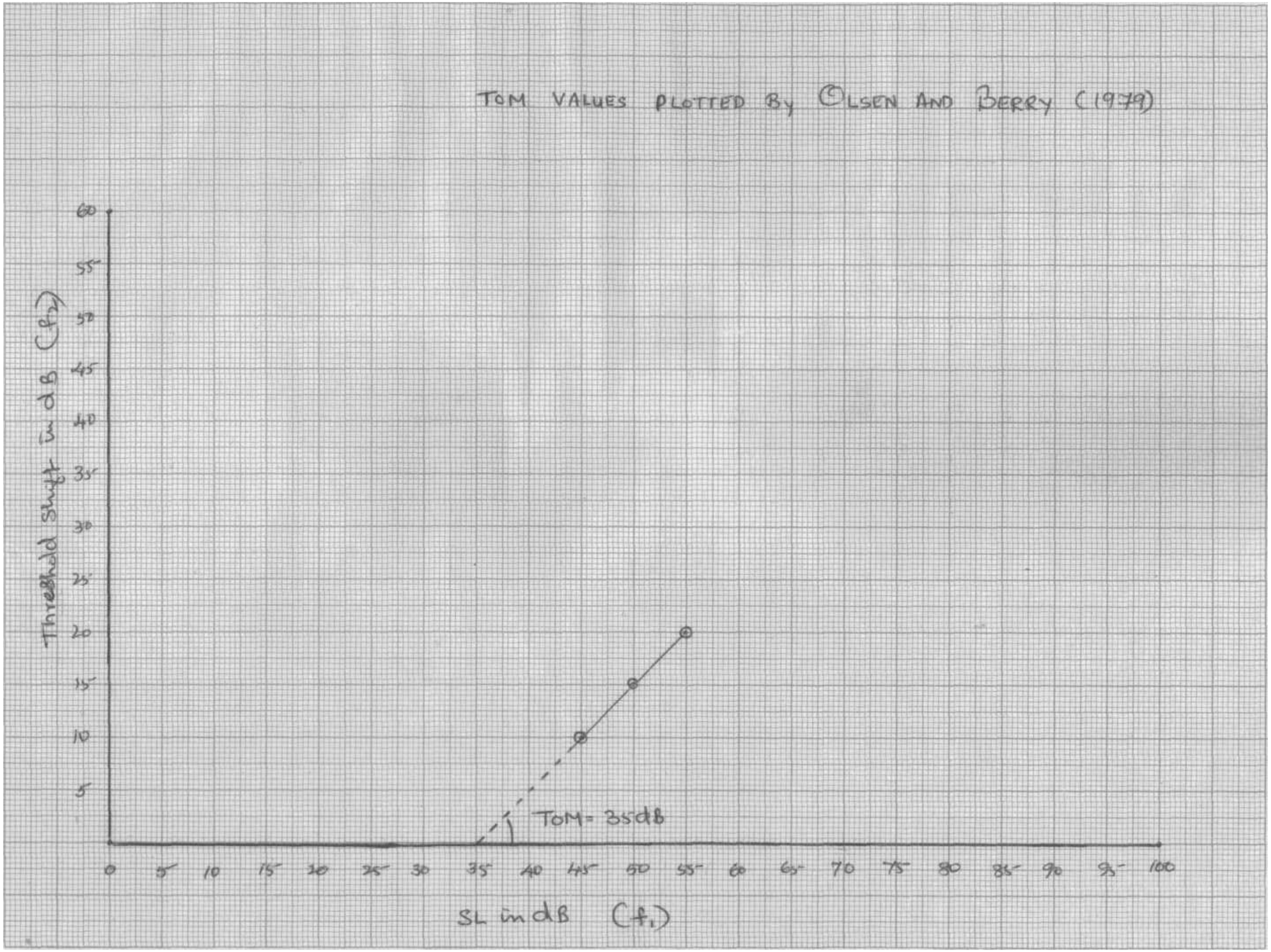
* * *


TOM VALUES PLOTTED BY OLSEN AND BERRY (1979)
Threshold shift in dB (f_2)
60
55
50
45
40
35
30
25
20
15
10
5
TOM = 35dB
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
SL in dB (f_1)

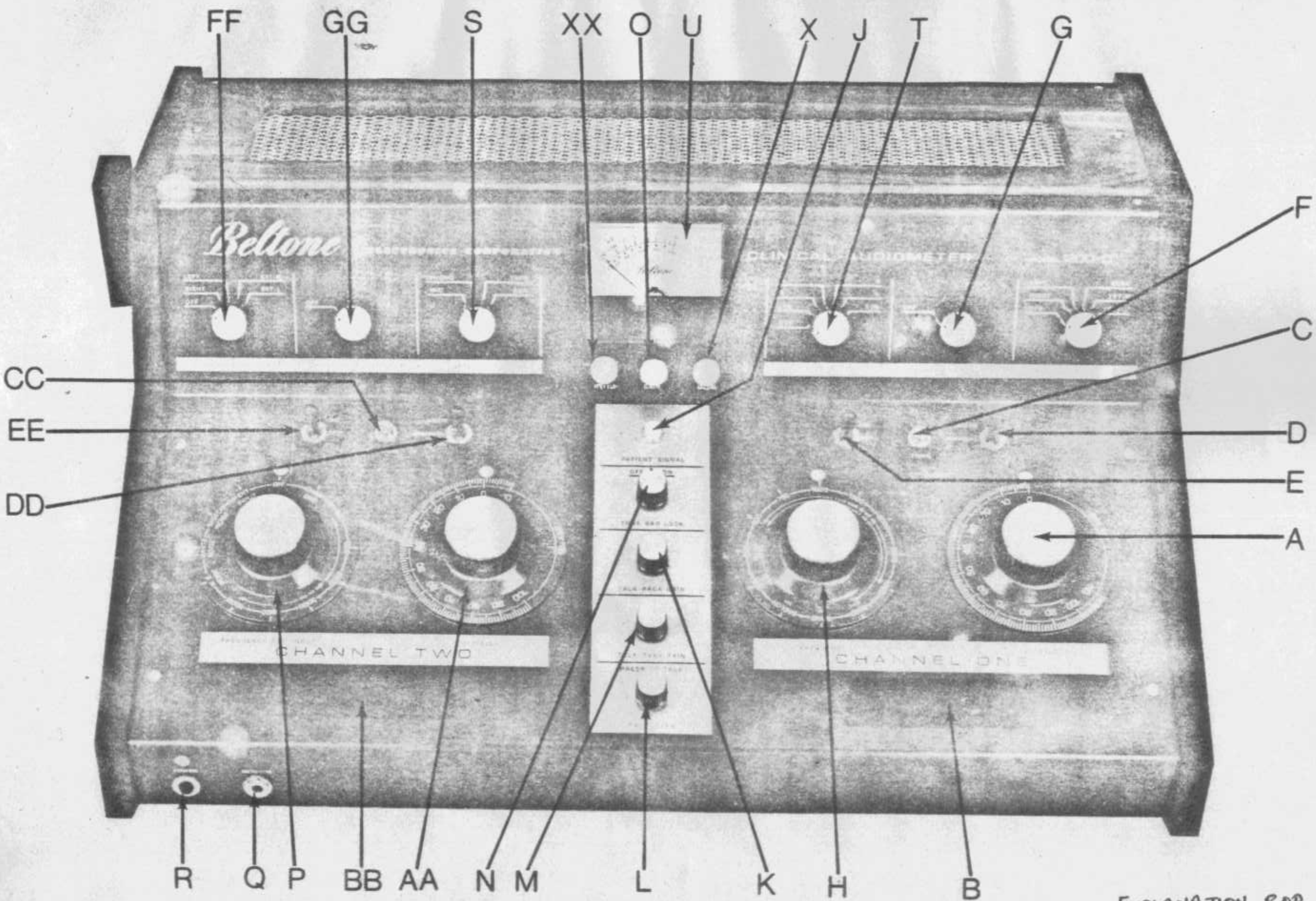


FIGURE 2.1 ILLUSTRATION, OPERATING CONTROLS

EXPLANATION FOR A, AA, B, BB, c.

SEE NEXT PAGE

AUDIOMETER USED FOR FINDING TOM VALUES

(A), (A-A)	=	Output Attenuators
(B), (B-B)	=	Tone Interrupter
(C), (C-C)	=	Tone 'on' lamp
(F), (F-F)	=	Output Selector
(J)	=	Patient signal lamp
(E), (E-E)	=	Tone Reversing Switch
(D), (D-D)	=	Automatic/Manual Switch
(G), (G-G)	=	Monitor Control
(T)	-	SISI (Short Increment Sensitivity Index)
(S)	=	Speech Unit
(U)	=	VU meter
(N)	=	Tone Bar Lock
(L)	=	Talk-over switch
(M)	=	Talk-over gain
(0)	=	VU meter selector switch
(X)	=	Channel one VU meter gain control
(XX)	=	Channel Two VU meter gain control
	=	Talk-Back gain.

APPENDIX-II

Beltone 200-0 Audiometer: (Used for TOM Test)

It is a dual channel clinical audiometer used in general diagnostic tests.

Audio Frequency Analyser B&K Type 2107 (Used for Ac Calibration)

Type 2107 is an Ac operated Audio-frequency analyzer of the constant percentage band width type.

It has been designed especially as a narrow-band sound and vibration analyzer, but may be used for any kind of frequency analysis and distortion measurement within the specified frequency range.

A built in mechanical device enables automatic tuning from an external motor supplied with weighing net works of sound level measurements, A, B, & C and a 7 point input socket for connection of a B&K condensor microphone or preamplifier as required. The instrument is supplied with an output switch, by means of which the rectifier and meter circuit can be switched to measure either the peak or the RMS values of input signal. To enable easy and accurate meter reading for both high and low frequency signals, two different standardized meter damping characteristics can be selected. A means is provided for connection of external filter, band pass filter set Type 1612 between the amplifier stage. This instrument is used with artificial ear type 4152 K for AC calibration.

Artificial Ear Type 4152:

An artificial Ear Type 4152 is designed to enable acoustical measurement on ear phones to be carried out under well defined acoustical conditions. It consists basically of a replacable acoustical coupler, and two sockets for the mounting of a condensor microphone cartridge Type 4132 and a cathode follower Type 2613 or the sound level meter Type 2613.

A spring arrangement is provided to fulfil certain standard requirement regarding the force applied to the object under measurement. This can be adjusted to apply and desired force on the ear phones.

The artificial ear satisfies the I.S.O. specifications (I.S.0./T.C.43).

A P P E N D I X III

Output values for R & L Settings at 70 dB HTL

Channel One											
Frequency required	125	250	500	750	1000	1500	2000	3000	4000	6000	8000
Frequency Actual Hz	126	250	498	747	998	1491	1989	2985	3983	5971	7954
dBSPL Red Phone 70 HTL (R)	116.5	96.2	83.0	78.0	77.0	77.0	81.0	80.0	81.0	84.0	80.7
dBSPL Blue Phone 70 HTL (L)	116.8	96.5	83.0	78.1	77.2	77.1	81.0	80.9	80.5	85.2	81.4
Channel Two											
Frequency Actual H z			502		1002		2003	3008	4010	6009	
dBSPL Red Phone 70 HTL (R)			83.0		77.0		81.0	80.0	81.0	84.0	
dBSPL Blue Phone 70 HTL (L)			83.0		77.1		81.0	81.0	81.2	85.0	

Sound Pressure level in dB Ref.20. micro Pa

ANSI-69 Threshold values for TDH - 49

Earphones in Mx-41 / AC Cushions.

Obtained Values

Frequency in Hz	250	500	750	1000	2000	3000	4000	6000	8000
dBSPL	26.5	13.5	8.5	7.5	11.0	9.5	10.5	13.5	13.0

APPENDIX IV

Maximum allowable background Sound Pressure Levels in dB for no masking above the zero hearing loss setting on a standard audiometer (Decibles re 0.0002 Microbar). The proposed standard data were developed by subtracting the difference between ASA and ISO reference threshold values from the ASA background noise.

Audiometric Test Frequency (Hz)	Octave Band Octaves	Sound-Pressure level (dB) Proposed Standard
125	75/150	31
250	150/300	25
500	300/600	26
1000	600/1200	30
2000	1200/2400	38
4000	2400/4800	51
6000	4800/9600	51
8000	4800/9600	56