A STUDY ON REMOTE MASKING

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A Dessertation Submitted in part fulfilment for the
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DEDICATED TO

MY

ELDER SISTER

WHO IS UNABLE T0 C0MMUJICATE

WITH OTHERS.

C E R T I F I C A T E

This is to certify that the dissertation ' A Study on Remote Masking " is the bonafide work in part fulfilment for the Degree of M.Sc, Speech and Hearing, carrying 100 marks, of the student with Register No. 7

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C E R T I F I C A T E

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

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D E C L A R A T I O N

This dissertation is the result of my own study undertaken under the guidance of M.N. Vyasa Murthy, 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.

Mysore
Dated:15 may 1981

Reg. No. 7

A C K N 0 W_L_E_D G E M E N T

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CHAPTER - I

INTRODUCTION

The values of puretene and speech audiometry is greatly enhanced by the skilled use of masking with a sound of suitable intensity and quality. Masking is the name given to the Psychoacoustic phenomenon where by the threshold of audibility of a sound is raised by the presence of another sound. In clinical audiometry the term usually denotes the blocking of one ear by a masking sound which raises its hearing threshold for a test sound applied to the other ear.

Remote masking consists of a threshold rise for low-frequency tones when the ear is exposed to a high frequency noise band delivered, at over all noise levels of 80-100 db Spl.

The Phenomenon of remote masking was first described by Bilger and Hirsh (1956), this pnenomenon has been the object of numerous Physiological investigations (Bilger and Hirsh, 1956; Deatherage et al 1957_a; Bilger, 1958, Burgeat mid Hirsh, 1951) and has been attributed to mechanical non-linear distortion of the cochlear partition as an effect of the envelope of a non-uniform signal(Karlovich and Osier, 1977).

Another possible contributing factor to remote masking given by ward, 1963 is the attenuation of low-frequency stimuli by elicitation of acoustic reflex by the hign frequency masker. But this idea was opposed by Biiger (1966) who reported the occurrence of contralateral remote masking in subjects with surgically excised middle ear muscles.

This conflict has been there since long time i.e. whether the remote masking phenomenon is due to nonlinear distortion of the cochlear partition or this is due to action of middle ear muscles.

A group of experiments was done by warn (1967) to elucidate the nature of contralateral remote masking. His results demonstrate that contralateral remote masking is nearly as great.

1. in ears with paralyzed middle ear muscles as in normal ears,
2. for bone conducted as for air conducted tones.

Ward (1967) found low negative correlation between contralateral remore masking and auditory fatigue. Such a negative correlation indicated that the middle ear muscles play only a minor role in contralateral remote masking. It appeared, that contralateral remote masking represents primarily central mask arising at one or more centers receiving afferent innervation from both right ana left ears, and that the change in time of contralateral remote masking can be ascribed to adaptation processes either in the noise channel or, is a the efferent system, in the contralateral channel.

In recent years EM has been studied in patients with auditory impairments in the hope that it could serve as a test for topographic diagnosis of deafness.

Clinical studies using remote masking (Jerger et ai, 1960; Rittmanic, 1962; Bilger, 1966; Keith and Anderson, 1969; Quaranta and Cervellera 1970, Cervellera, et a±, 1971) Rave revealed that the value of remote masking is normal; for conductive hearing loss subjects, is variable in sensori neural hearing loss cases, and is reduced in subjects with Meniere'a disease.

They proposed this remote masking threshold shift can be used as a test of cochlear partition stiffness.

PURPOSE OF THE STUDY:-

As there was no study on Indian population on remote masking, this study was undertaken to determine the norms i.e. the amount of threshold shift owing to the phenomenon of remote masking in normal hearing adult subjects.

This study was therefore designed to answer the following questions,

(1) Will tnere be any significance difference in remote masking between right and left ears in normal hearing subjects?

(2) Will tnere be any significance difference in remote masking between Male and Female subjects?

(3) Will there be any significant correlation between the degree of hearing loss and remote masking in SN loss subjects?

BRIEF PLAN OF THE STUDY:-

A group of 3b normal hearing subjects, comprising both males and females, within the age range of 17-36 years were selected for the study. Tne testing procedure can be summerized as follows;

The threshold of sensitivity for pulsed tones was determined for frequencies; 250,500 and 1000 HZ for each ear separately. The narrow bang noise centered around 3 KHZ was presented at 98 dbspl(72 dbHl) in one ear and the marked threshold (Ipsilateral masking) for each frequencies were determined. The difference between the masked threshold and unmasked threshold was considered to be the remote masking value for that particular frequency.

Finally, the remote masking values were determined for the other ear also.

Remote masking value was taken for 16 SN hearing loss cases, varying in degree of hearing loss, to verify whether degree of hearing loss rented to remote masking or not in SH hearing loss cases.

IMPLICATION OF THE STUDY:-

The "Norms" established by tnis study would be useful to use "Remote masking test" for diagnostic purposes in tnis Institute.

DEFINITIONS

THRESHOLD:-

Threshold is the least audible sound pressure level often defined as the level of a sound at which it can be heared by an individual 50% of the time.

NARROW BAND NOISE:

Is a sound in which energy is concentrated within a small frequency interval.

REMOTE MASKING (RM):-

Remote masking consists of a threshold rise for low frequency tones when tne ear is exposed to a nigh frequency noise and band delivered at over all SPL of 98 db.

THRESHOLD SHIFT:-

It refers to the difference in threshold in terms of db between the masked threshold and unmasked threshold.

REVIEW OF LITERATURE:-

Remote masking is a low frequency phenomenon. (Bilger and Hirsh, 1956). Remote masking was first sescribed by Bilger and Hirsh in 1956. Remote masking consists of a thresnold rise for low frequency tones when the ear is exposed to a high frequency niose band delivered at over-all noise levels of 80-100 dbSpl.

This Remote masking pnenomenon has been studied by numerous investigators (Bilger and Hirsh, 1956; Deatherage et al 1957-; Biiger 1958; Burgeat and Hirsh, 1961). These author described Remote masking as results from unsyummetricai mechanical action of is said to permit detection of the envelope of a sound that varies in auplitude at audiofrequency and effectively generates broad band noise with in the Inner ear.

Psychoacoustic (Deatherage et al, 1957_b; Biiger, 1966) and physiologic (Deatnerage et al 1957 ;) studies attributed remote masking to nonlinear distortion process witnin the waveform envelope of a band limited high frequency masker.

Karlovich, R.S and Osier, H.A (1977) studied auditory marking generaten by two-tone complexes centered around 7 KHZ in 10 yound adults with normal hearing as a function of the frequency separation (Δf) and Spl of the masker's components. The purpose of their study was to provide data on aural distortion by statistically assessing the remote masking effects generated by aural difference tones ($f_2 - f_1$). The results were given as follows:-

EFFECTS OF MASKER Δ f:-

The data implied that remote masking usually occurs when the masker spl is 90 db or geater; for same maskers Δf_s, the effects, although small in magnitude, were significant when the masker Spl is 85 db.

The data of Deatherage et al (1957_b)evidenced the presence of remote masking at the harmonics of the modulation frequency or interruption rate for their high frequency tonal marker.

EFFECTS OF MASKER Spl :-

Remote masking generated by high frequency noise band generally is evident when the masker is about 80 db Spl (Bilger and Hirsh, 1956).

According to Karlovich, et al study, significant remote masking effects become more apparent when the masker Spl was 85 db or higher.

Bilger (1958) observed that remote masking deviated from predicted values when the masker band included frequencies above 4 KHZ, and ne suggested that frequencies above 4 KHZ may not be effective for remote masking as those below 4 KHZ.

Wenner (1968_a) found that remote masking decreases as the center frequency of his two-tone masker complex increased.

According to Kariovich, R.S. et al study, Remote masking,

(1) was evident for test signals in the frequency region corresponding to the master's Δf;

(2) Increased with masker Spl, but at a rate less than that usually observed when lower frequency bands of noise are used as masters, and

(3) Was relatively constant in magnitude for a given Spl as a function of the master's Δf.

The masking produced in low frequency regions by high frequency two tone complexes supported the hypothesis that Remote masking is primarily a result aural distortion.

Another possible contributing factor to remote masking is the attenuation of low-frequency stimuli by elicitation of acoustic reflex by the high frequency masker (Ward, 1963).

Studies done by Ward, 1961; Gjaevenes and Vigran, 1967 have pointed that the reflex contraction of the middle ear muscles an important factor in contraiateral remote masking.

Contralateral remote masking might represents any one or a combination of,

(1) an attenuation of the test signal caused by reflex contraction of the middle ear muscles,

(2) Direct masking by physiological noise from there muscles, or

(3) Some form of central masking, interaction between neural events originating at the respective cochklea.

Burgeat and Hirsh, 1961; Wara, 1961_a disclosed the ioiiowing characteristics of contraiateral remote masking.

(1) CRM causea by a steady noise decreases witn time, generally reaching an asymptote after 3 to 5 min, at least for noise above 1200 HZ.

A later study done by ward, 1962. showed that contralateral remote masking at 250 HZ induced by 600-1200HZ noise continued to decrease for at least 20 min.

Fletcher and Loeb (1962) found no change in contalateral remote masking with time when a series of clicks was the master.

(2) contralateral remote masking (in nb) decrease witn time is equal to the decrease with time of the ipsilateral remote masking caused by the same high frequency noise,

(3) Contralateral remote masking grows linearly with Spl for Spl's above 90 do, though at a rate less than unity.

(4) This growth with Spl depends on the frequency of the arousal noise, the higner the frequency the slower the rate of growth of contralateral remote masking.

(5) Extrapolation of such linear growth curves implies that contralateral remote masking begins at above 85 db Spl regardless of arousal frequency.

(6) Contralateral remote masking is greater at 500 HZ than at 250 or 1 KHZ.

(7) A high irequency puretone, even at 130db Spl produces only 1 to 2 db CRM.

(8) A brief interraption in the masker does not restore contralateral remote masking to its original

level. Although the contralateral remote masking induced by repeated 1-min exposures to 2400-4800 HZ noise at 115 db Spl was constant when 90 seconds of rest was inseted between tne exposures, a 15 second interval resulted in progressively less CRM on successive tests.

(9) The CRM is sligntly greater when the test ear has just been exposed to high frequency noise (Ward 1961a)

There are certain studies which say that middle ear muscle do not play any role in contralateral remote masking. They are given below:-

Observation done by Fletcher and King (1963) and Bilger (1966) showed that contralateral remote masking can be observed in persons whose stapedius muscles had been excised; although the amount of contralateral remote masking produced by a given noise is not as great as in normals, this may be due to the presence of a slight conductive deficit in the non-stapedec--tamized ears, which reduces the sound reaching the cochlea and so decrease tne central masking.

Bilger (1966) compared normal control subjects with subjects who had cut stapedius muscles. He demonstrated no difference in eigher ipsilateral or contralateral remote masking between 2 groups. Hence he concluded that the acoustic refix do not play a role in remote masking of either type.

Similar results were observed in persons with Belli's palsy, a disease whose symptam include paralysis of the middle ear muscle.

Gunn, W.J.(1973) conducted 2 experiments to explote the possible involvement of the acoustic reflex in a supra-threshold loudnen shift resulting from masking tone sufficiently intense to elicit a middle ear reflex. 10 normal hearing adults were asked to adjust the level of a 400 cps supra threshold tone in the homolateral ears in an attempt to keep the perceived sound source subjectively centered when presented binaurally simultaneously with the 3 KHZ manaural masker 15 110 db Spl. The durations of simultaneously presented masker and supra threshold masker was varied from durations shorter than the latency of the acoustic reflex to durations sufficiently long to insure complete contraction of the middle ear muscles. The result showed the possible involvement of the acoustic reflex as well as other more central factor in remote masking shifts.

In 1967 ward conducted 6 experiments in order to elucidate the nature of contralateral remote masking, results of the experiments were as follows:-

BONE CONDUCTION:-

The first experiment demonstrated that the threshold of a BC tone is elevated by a contralateral noise to the same extent as an AC tone. Ward (1967) did not observe any significance difference between AC and BC.

EFFECTS OF CHANGES IN FREQUENCY AND LEVEL:-

His study Showed that switching from one frequency of masker to another does not restore the contralateral remote masking to the value it would have had, in the fresh ear, with the 2nd noise.

Two experiments were conducted for this. The outcome of this experiments were quite different from what would be expected if the middle ear muscle were responsible for the contralateral remote masking. After continued exposure to a sustained stimulus, the muscle relax, but again contract when tae exposure frequency is shifted by more than an octave (Luscher,1930; Wersall, 1958) or when the intensity is raised by as little as 3 db (Gjaevenes and Sohoel, 1966).

After one or two min of exposure, 1 to 2 db residual contralateral threshold shift was persist in all subject. This residual shifts was small, although Loeb and Fletcher (1961) report values of

7-8db at 500 HZ following a Znin exposure to 2000-2200 HZ noise at 100 db Sl in the other ear.

THE CRM AND TTS:-

4th experiment was conducted to find out the relationship between contralateral remote masking and temporary threshold shift.

Two conclusions were drawn from this experiment are:-

(1) The correlation between contralateral remote masking produced in the 2 ears of a given listener was only about 0.50, although the test-retest correlation on a given ear for identical test given 6 months apart was about 0.75.

(2) Negative correlations were obtained between contralateral remote masking in a given ear and the temporary threshold shift later produced by low-frequency tones and noises in the same ear. This was statistically significant. But Loeb and Fletcher(1961) have reported no significant correlation.

CRM IN SHORT NOISE BURST:-

Experiments done by Perlman and Care 1939, showed that, although stapedius muscle begins to contract a few mili second after onset of a loud sound, the attainment of full reflex strength takes much larger (Metz, 1951). If an intense tone is to be effective in reducing the temporary thresnold shift produced by high intensity clicks, its onset must precede the click by as much as 150 mili second in same ears

(Ward-1962$_b$). Furthermore, impedance measurements indicate that as much as a full sound may be required far relaxation of the muscles.

Therefore, it seemed reasonable to assume that if one presents a low-frequency tone pip to one ear and high frequency noise burst to the other, the amount of contralateral threshold shift should depend on the exact temporal relations between the stimuli. It was predicted that if the consensual aural reflex were able to produce a shift in thresnold by reducing the amount of low-frequency energy reaching the cochlea, such an effect should require somewhere near 100 mili second to build up to a maximum. A somewhat longer time should be needed for the shift to disappear.

CONTRALATERAL REMOTE MASKING AND PERSTIMMULATORY FATIGUE:-

Ward (1961$_a$) noted that the change of contralateral remote masking witn time bears at leasT a superficial resemblance to the course of "perstimulatory fatigue"- the gradual loss of ability of a stimulus sustained in one ear, to influence the latenalization of a diotic test tone.

In 1967, Gjaevenes and Vigran concluded that the contralateral remote masking is " most probably caused by the middle ear muscle reflex. However, they felt they could not decide whether other mechanisms were involved.

Then, in a follow-up work Gjaevenes et al 1969 calculated the expected threshold shift due to the acoustic reflex on the basis of eardrum impedance measurements made with and without the contralateral noise. These calculations indicated that the observed contralateral remote masking was substantially bigger than could not accounted for by eardrum impedance changes. Therefore they concluded with Bilger(1965) and Ward (1967) that the central factors are predominant in the contralateral remote masking and that the middle ear muscles are responsible for a small part of the masking only.

TEMPORAL EFFECTS IN MASKING:-

CHANGES IN MASKING AS A FUNCTION OF TIME:-

Burgear and Hirsh (1961) concluded that remote masking decrease over an exposure priod of 5 minutes using a 2 KHZ - 4 KHZ octave band masker and a 700 or a 800 HZ test tone, they demonstrated threshold improvement as a function of exposure time for both ipsilateral and contralateral remote masking, but direct masking was stable over time at least up to 25 minutes or probably much longer.

Bilger and Melnick (1968) believed that the findings of Burgeat and Hirsh might have resulted from the change in the frequency of the test tone.

Zwislocki et al (1958) have demonstrated that threshold tracking behavior is influenced by criterial variables when the listener bracks threshold for low-frequency signals in quit. According to them one of the criterial effect is threshold improvement as a function of time after onset of tracking.

Bilger and Melnick's result for a 500 HZ tone masked by a 2-4 KHZ (remote) and a 200-4 KHZ noise(direct) showed that both the directly masked and the remotely masked threshold improved over time. The shift in direct masking was influenced by the onset of tracking and the method of centrol, while the shift in remote masking was "independant of these factors."

' . In recent years remote masking has been studied in patients with auditory impairments in the hope that is could serve as a test for topographic diagnosis of deafness.

Clinical studies using remote masking (Jerger et al, 1960; Rithmanic, 1962; Bilger, 1966; Keith and Anderson, 1969; Quaranta and Cervellera, 1970) revealed that the value of remote masking,

(a) a is normal,for equal overall band levels in the cochlear partition, in subjects with conductive hearing losses;

(b) is variable, and not related to the severity of the hearing loss, in subjects with SN hearing losses.

If remote masking is due to nonlinear mechanical action of inner ear, then results of masking experiments should be similar for listeners with normal hearing and those with SN hearing loss. But masking experiments done using Narrow noise bands have failed to show similar results for those two groups.

Data presented by Jerger, Tillman and Peterson (1960) and by Rittmanic(1962) indicate that remote masking threshold of listeners witn cochlear impairments were at a higher Spl than those of normal hearing listeners under similar masking conditions. Although these elevated remote masked threshold were interpreted as indicating a spread of masking the low-frequency quiet threshold of the listeners with cocnlear impairment were 20 - 30 db higher than threshold of normal hearing listeners. The result was that the amount of remote masking observed for listeners with impaired hearing was much less than observed for listeners with normal hearing.

Bilger (1965) argued that the mechanical action of the cochlear is not impaired by a SN deficit, so that remote masking should be same for normal ears and ears with cochlear damage with masked under identical conditions. He reports data on two listeners with SN nearing loss and audiological signs of cocnlear impairment. He treats the data of the two listeners as failing on the lower limit of the control normal data, even though results of one of them appears to fall more than 10 db below chat of the lower limit.

Ke ith ana Anderson (1968) investigated the remote masking in-ears with cochlear impairment. They investigated the level of noise at which remote masking appears, the remote masked thresholds, and the amount of remote masking resulting from two narrow bands of noise at three Spls. They defined remote masking as the elevation of threshold that occurs at frequencies lower than one octave below the low cut off frequency of anoise band. They compared the results of listeners with normal hearing and to those with presumed cochlear impairment. Their, SN hearing loss cases were divided into two equal groups, Group A having threshold at no greater than 15 db HTL from 250 to 2 KHZ and no greater than 45 db HTL at 4 KHZ, and Group B having threshold at no greater than 15 db HTL at 250 and 500 HZ and greater than 45 db HTL at 3 Kilo and 4 Kilo HZ. They have used 2 narrow band of noise, 1300-1990 HZ, and 3090-3920 HZ at 70,80 and 90db Spl. Results of their study were as follows:-

Bilger and Hirsh (1956) reported the presence of remote masking for noise bands at level greater than 80 db Spl. In Keith and Anderson study, remote masking appeared for the normal hearing group with the 1300-1990 HZ noise band at 70 db Spl. Remote masking was first observed with this noise band at 80 db Spl for the other two groups.

Somewhat different results were obtained with the 3090-3920 HZ noise band. Remote masking was never observed with the 3090-3920 HZ noise band at 70 db Spl. Although the amount of remote masking resulting from this noise band at 80 db Spl was at 5 to 8 db for the normal hearing group, it was only 1.5 to 3.5 db for listeners in Group A. Remote masking for listeners in Group B using the 3090-3920 HZ noise band was first observed with the noise at 90 db Spl. Remote masking for these listeners with presumed cochlear impairment did not appear with the noise band at lower Spls than for the normal hearing listeners. It appeared that when the noise band is centered at frequancies of hearing impairment, the Ievel of noise at which remote masking first appears far listeners with cochlear impairment is at a higher Spl than for listeners with normal hearing.

When data of the three groups were compared, the amount of remote masking was approximately the same for all groups with the 1)00-1990 HZ noise band at 80, and 90 db Spl. But witn the 3090-3920 HZ noise band, the masked thresholds were at a lower Spl and there was substantially less remote masking for Group A and B than for the normal hearing group.

A conclusion of earlier studies was that "the impaired ear is excessively marked at frequencies below the noise band"(Jerger, Tillman, and Peterson,1960) and that the ear witn the SN impairment revealed a greater spread of masking than the normal ear at frequencies below the noise band(Rittmanic,1962). In both studies, the quiet thresholds reported for listeners with impaired ear appeared to be equal to or higher than the masked threshold of the normal heading listeners. Even a slight amount of remote masking for listeners with SN hearing loss would result in a masked threshold that was at a higher Spl than the masked threshold of normal hearing listeners.

Keith and Anderson's (1968) interpretention of the data is that remote masking can be observed on listeners with SN hearing impairment, but that a noise band centerea at frequencies of hearing impairment must be at a higher Spl than for normal hearing listeners before the phenomenon occurs. The amount of remote masking resulting from a noise of a given level is less for listeners with cochlear hearing impairment than that observed for normal hearing listeners. From this, they predicted that, the amount of remote masking is dependent upon the hearing level for frequencies within the noise bund, but not upon the hearing levels for frequencies at waicn remote masking occurs.

Unlike the results of previous investigators (Bilger and Hirsh, 1956, Deatherage, Bilger, and Eldredge, 1957), the remote masking observed in this

study was not aba constant SL. The remote masking resulting from the 1300-1990 HZ noise band increased gradually from 200 to 600 HZ, and the remote masking resulting from the 3090-3920 HZ noise band increased with frequency from an amount at 200 HZ to a maximum at 600 to 800 HZ ana then decreased to a minimum at 1500 HZ. A similar thresnold contour was observed in all experimental groups. The difference in patterns of remote masking observed in the Keith and. Anderson 1968 experiment and previous studies may be attributed to differences in the slope of the noise bands. Results of the 1300-1990 HZ noise band at 80 db Spl in the present study can be comparer to Bilger and Hirsh's(1956) 54-db/Oct 1420-1900 HZ noise band at 80 db Spl-
The unreshold in noise for both stuaies were within the 1 db at 200, 250 and 300 HZ. At frequencies within the noise band, thresholds were within 3 db from 300-1000 HZ, the thresholds obtained in the Keith and Anderson study were below the threshold obtained by Bilger and Hirsh, apparently because the skirts of the noise band in the Keith and Anderson study were much steeper than 54 db/Oct. A similar phenomenon was noted for every noise band used by Bilger and Hirsh when a comparisan was made between masked thresholds for their 36 and 54 db/Oct conditions. Because of the ear's remarkable ability to follow the filtered noise on the low-frequency side, noise with a more gradual slope may effectively hide the result of decreasing remote masking from 800-1500HZ.

The similarities between results of this investigation and known parameters of the acoustic reflex lead Keith and Anderson(1968) to the conclusion that a dual mechanism of middle ear plus inner ear activity is a more suitable explanation of remote masking.

Cervellera et al (1978) studies the remote masking in patients with Meniere's disease during hearing loss fluctuations produced either by the disorder or by glycerol administration (Klock hoff and Lindblom, 1967). They recorded the remote masking for pulsed tones of 250, 500 and 1 KHZ; the masker was a continuous narrow band noise centered at 3 KHZ with 305 HZ band width, delivered at an overall Spl of 98 db. They showed that the value of remote masking decreased during the acute phase that is when the hearing loss increased, and on the contrary, it increased if the glycerol produced an improvement in hearing. Negative glycerol did not significantly modify the remote masking value.

Clinical studies using remote masking have revealed remote masking is normal only when both the endolabyrinthine pressure and the cochlear hydrodynamics are normal. Increasing the stiffness of the cochlear partition affects adversely the mechanism of motion of the cochlear duct and reduces the remote masking valves.

Cervellera, et al suggested the possibility of using remote masking to study the transmissionmechanism of the cochlear.

Quaranta et al (197S) studied Remote masking in normal young subjects and in patients with presbycusis in order to determine whether aging of the inner ear also induces stiffness of the cochlear partition. Their results demonstrate that with the aging ear remote masking values were reduced. symmetrically in both ears and progressively as a result of aging. This finding suggests the hypothesis that the cochlear partition grows shift thus losing the possibility of incurring the mechanical nonlinear distortions responsibilty for remote masking. They hypothesis that the basilar membrane is the structure of the cochlear partition most seriously affected by loss of elasticity.

Quaranta et al (1978)'s result demonstrated the existence of "cochlear conductive presbycusis" (Schuknecht, 1974) and showed that shiftness of the cochlear partion, produced by aging, is a condition common to all older subject independent of the clinical type of presbycusis and remote masking can be considered a useful test of stiffness of the cochlear partition.

Cervellero,G.et al (1980) studied remote masking in patients suffering from unilateral Meniere's disease, acoustic neuromater, other SN lesions and presbycusis.

The result of their researcn demonstrate that remote masking values are consistently reduced both in presbycusic subjects and in the ears of patients with Meniere's disorder; the remote masking value is normal in acoustic neuramata; it is variable and not related to the severity of the hearing loss in SN hearing losses. The normal remote masking in acoustic neuroma-confirmed the hypothesis that remote masking is a phenomenon arising in cochlear partition (Deatherage et al, 1967; Karlovich and Osier, 1977).

As to the lesion site causing the remote masking reduction, they hypotherized that remote masking reduction is not related to lesions of the hair cells but rather to a failure of the cochlear conductive hydrodynamic system. The remote masking behaviour in experimental groups snowed chat remote masking is independant of the audiometric configuration, of the sensation level of the tonal tests and of the sensation level of the masking narrow band. They observed asymmetrical remote masking performance when the hearing losses were botn symmetrical and asymmetrical. These findings led them to believe that the remote masking redaction depends upon inner ear extrasensorial structure lesions. They consider that a cochlear conductive impairment may sometimes contribute to the patnogenesis of SN hearing losses, ana suggested the possibility of using the remote masking as a test of end-organ rigidity.

Though there are only few studies have been devoted on remote masking so far no attempt has been made to Measure the remote masking value on our Indian population. So this study will be the first attempt to establish the norms of remote masking an Indian population.

METHODOLOGY

This study on remote masking comprises of the following steps;

1. To obtain the puretone threshold; for pulsed tone; of 250 HZ, 500HZ and 1000 HZ for both normal hearing subjects and for hearing loss subjects.

2. To obtain puretene ipsilateral masked thresholds for pulsed tones of 250 HZ, 500 HZ and 1000 HZ in the presence of narrow band noise centered around 3 KHZ at 98 db Spl. (72 db HL).

3. To measure the threshold shifts for normal hearing subject and for hearing loss subjects.

SUBJECTS:-

36 normal hearing subjects (students and staff of AIISH) were selected randomly. The criteria for selecting normal hearing subjects were as follows:-

1. They should have normal hearing within 20 db HL at all audiometric frequencies. (ISO 1964).

2. They should not have any complaint of earache, eardischarge or any kind of ear problems.

3. They should be able to understand the

the instruction and carry out
the test without any difficulty.

Remote masking in 16 SN hearing loss subjects, varying in degree of hearing loss, was determined at 250, 500 and 1000 HZ, to study whether remote masking is related to degree of hearing loss in SN loss cases or not.

To classify the degree of hearing loss in SN loss cases, Good-man's (1965) classification of hearing loss system was used.
(Classification given in Appendix).

APPARATUS AND TEST ENVIRONMENT:-

The apparatus for measuring the remote masking value consisted of a two-channel audiameter(Madson 0B70). A TDE-39 earphone mounted in an M_X 41/AR cushion was used to obtain audiometric threshold in quiet as well as in presence of noise. The masker was a continuous narrow band noise centered at 3 KHZ delivered at an overall Spl of 98 db (72 db HL). Additional noise generator (Madson circuit board No. ME 013318) and a narrow band filter centered at 3 KHZ (Madson Circuit Board No.ME 013325 was used to obtain the 3 KHZ noise.

The calibration of the instrument was done using B and K equipments. The Air condition calibration was carried out by using a Audio Frequency analyzer(B &K

type 2107), an artificial ear (B & K type 4152) and a condensor Microphone (B & K type 4144). The audiameter was calibrated in terms of frequency, intensity, linearity, frequency response of the ear phone.

The noise level in the room was measured using a Spl meter type 2209 couplea with 1/2an inch condensor Microphone (type 4165).

The details of the equipment are given in the appendix.

The experiments were carried out in a sound treated room at the All India Institute of Speach and Hearing, Mysore.

PROCEDURE:-

- All the subjects were first tested to obtain puretene thresnolds at 250, 500 and 1000 HZ for pulsed tones. A vernier scale of 1 db steps was used to obtain exact threshold for each subject and for each ear separately. For obtaining puretene tnresnolds following Instructions were given:-

" You are going to hear pulsed tones your ear. Wherever you hear the tone, raise your finger, keep the finger raised as long as you hear the tone. When you don't hear the pulsed tone, put down your finger. Donot raise your finger until you hear the tone once again. Continue the same whenever you hear the tone. Listen carefully".

The Hughson-Westlake (1944) procedures was used to obtain thresholds for pulsed tone using a 50% criteria.

ESTABLISHMENT OF MASKED THRESHOLD:-

After obtaining the thresholds for pulsea puretenes, masked thresholds were determined separately for each subject. Subjects were instructed as follows:

> " You are going to hear noise in your right ear continuously. Donot respond to the noise. In the same ear you will hear pulsed tone. Whenever you hear the pulsed tone in tne presence of noise, respond to the tone by raising your finger. Donot respond when you don't hear the pulsed tone. Respond to the tone when you think it is just heard".

To obtain the masked threshold, additional noise generator and a narrow band filter centered around 3 KHZ was used, to mask the low frequency tones of 250, 500 and 1000 HZ. Before obtaining the thresholds, the noise generator was adjusted to produce constant overall Spl of 9S db. Noise and pulsed tones were presented to the right ear first. After determining masked threshold for right ear, masked thresholds of left ear were determined.

ESTABLISHMENT OF REMOTE MASKING VALUE:-

After obtaining the masked threshold, remote masking values were determined. The difference between masked threshold, and unmarked threshold, was considered as the remote masking value for that frequency. The remote masking value was found out for both ears.

The data, thus obtained, were analyzed statistically.

RESULTS AND DISCUSSION

The present study was undertaken to collect the normative data on remote masking and also to collect remote masking data on SN hearing loss cases.

The sample selected in the present study consisted of 36 normal hearing subjets. (15 Males and 21 Females). In this experiment threshold shift due to remote masking was recorded at 250 HZ, 500 HZ, and 1000 HZ for each ear separately.

Remote masking in 16 SN loss subjects, varying in degree of hearing loss was determined at 250 HZ, 500 HZ, and 1000 HZ to study whether remote masking is related to the degree of hearing loss in SN hearing loss cases or not.

Results of this investigation have been given in two parts:-

1. Establishment of norms for remote masking at 3 audiometric frequencies. (250 HZ, 500HZ, and 1000 HZ).
2. To study whether remote masking value is related to the degree of hearing loss in SN hearing loss cases or not.

Measures of central tendency significance of difference between means were used toanalyze tne results statistically.

ESTABLISHMENT OF NORMS:-

Table 1 in the appendix gives the remote masking value far both right and left ears of 36 normal hearing subjects at frequencies of, 250 HZ, 500 HZ, 1000 HZ.

The statistical mean (M) value of remote marking at 3 test frequencies for both left and right ear were computed.

The values are given in table II.

TABLE - II

Frequency	Right ear	Left ear
250	20.55	21.25
500	31.77	33.75
1000	46.19	47.97

There was no significant difference between the mean remote masking values of right ear and left ear at the test frequencies (250, 500, 1000 HZ) at both .05 and .01 probability levels.

Table III shows the remote masking values for both Male and Female subjects (given in appendix).

Table IV shows the mean value of remote masking for both right ear and left ear in Male and Female groups.

TABLE - IV

Frequency	MALES		FEMAI<ES	
	Right	Left	Right	Left
250	21.06	22.33	20.19	19.04
500	32.66	34.8	31.14	33.0
1000	49.73	48.33	44.09	

Significance of difference between means of Male group and Female Group was computed. It was observer that there was no significant difference between the means at both 0.05 and 0.01 level of confidence.

Totally 72 ears were tested, combined mean which was computed for 72 ears is snown in table V. Table V represents combined mean values of remote masking at 3 audiometric frequencies.

TABLE - V

Frequency	Average remote mas0king(db)
250	20.9
500	32.79
1000	47.08

The normal hearing subjects yielded mean Remote Masking values of 20.9, 32.79 & 47.08 db for the frequencies, 250, 500 and 1000 HZ respectively.

The data established, in this study are compared with the data established by cervellera et al (1980). Table VI shows the comparison of data.

TABLE - VI

Average Remote Masking (db)

Fre-quency.	Present study - data -	Cerveiiera et al 1980 Study - data -
250	20.9 (11-31)	26.4 (21-34)
500	32.79(21-41)	17.5 (12-29)
1000	47.08(29-57)	25 (18-32)

(Paranthesis shows range of remote masking value).

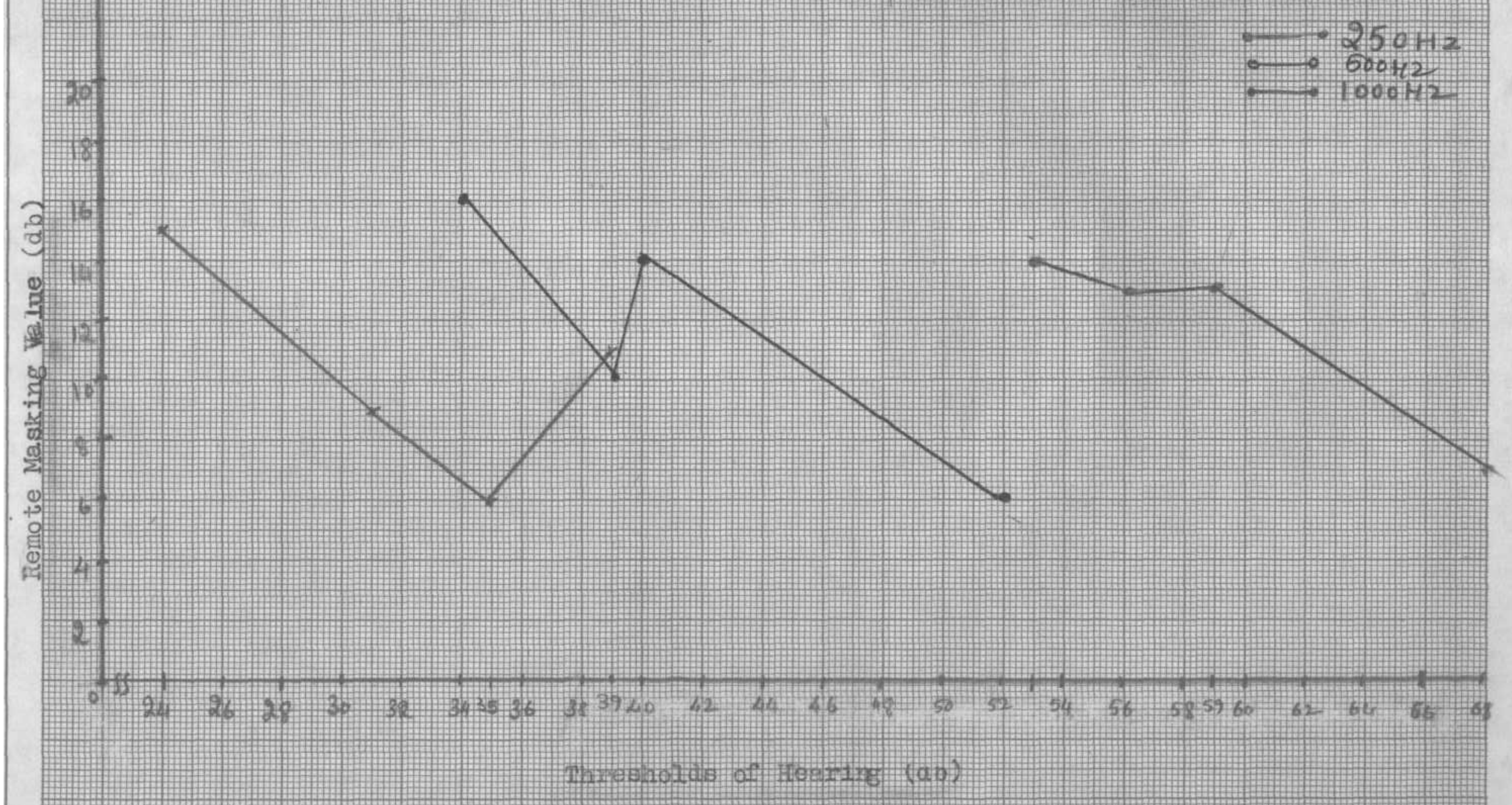
CLINICAL GROUPS:-

Remote Masking values in 4 subjects having Moderate hearing loss are given in Table VII.

TABLE - VII

Nb. of subjects.	250 HZ		300 HZ		1000 HZ	
	Thres-hold.	RM values	Thres-hold	RM values	Thres-hold	RM values
1	39	11	40	14	59	13
2	24	15	34	16	68	7
3	35	6	52	6	56	13
4	31	9	39	10	53	14

GRAPH-I : Showing the relationship between thresholds of hearing and Remote masking value in Moderate hearing loss cases, at frequencies of 250, 500, 1000 HZ.



Graph I shows the thresholds and Remote Masking values, at 3 test frequencies. It is clear from the graph that there is no relationship between Remote Masking values and thresholds of hearing at all the test frequencies. The same data were subjected to statistical analysis. It was found that there was no correlation between the threshold of hearing and remote masking at 0.05 and 0.01 level of probability.

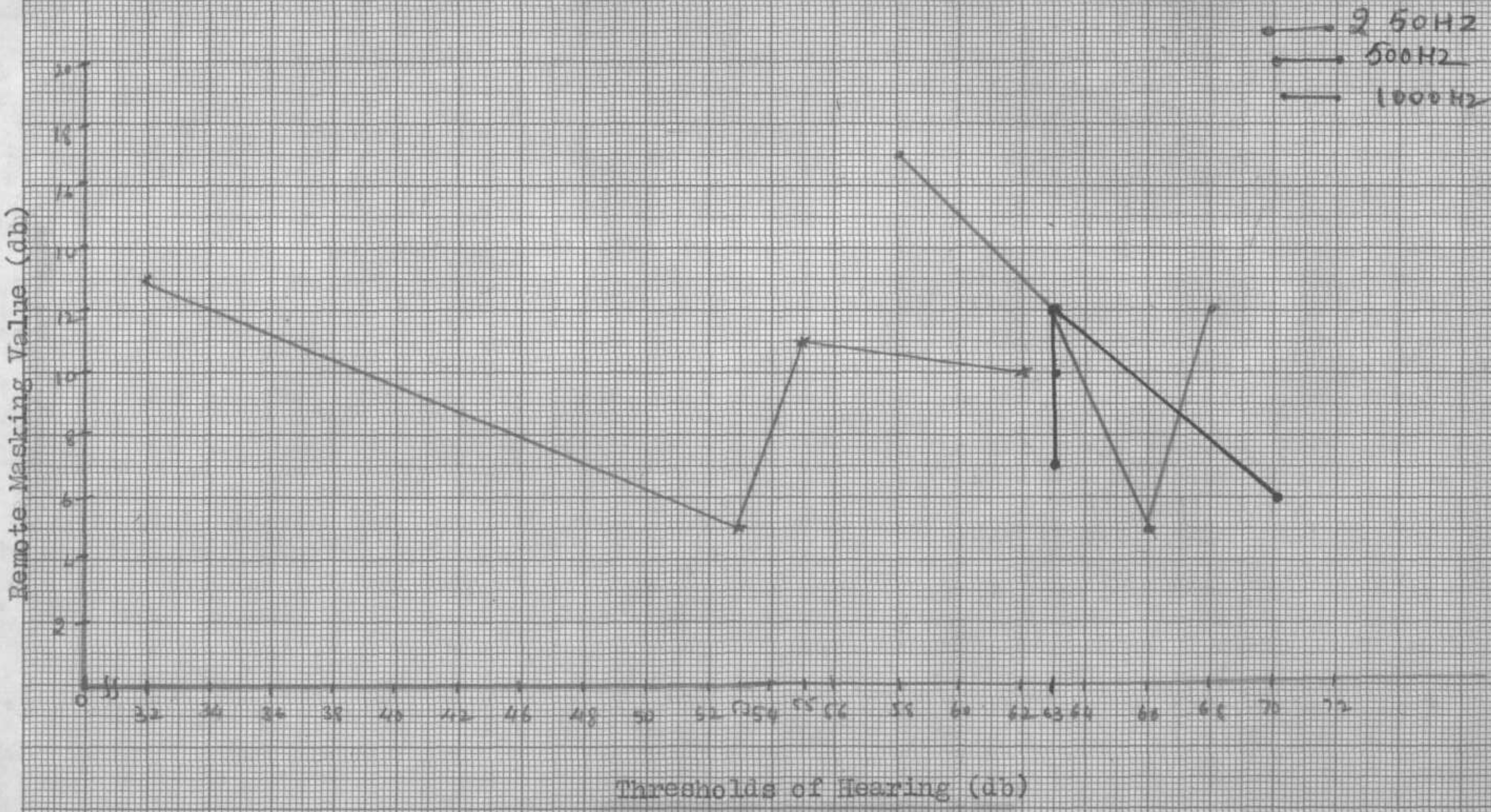
Table VIII and Graph II indicate the relationship between thresholds of hearing and remote masking values in 4 Moderately severe hearing loss cases.

TABLE - VIII

subjects	250 HZ		500 HZ		1000 HZ	
	Thres-	RM values	Thres-hold	RM values	Thres-hold	RM values
1	32	13	63	12	63	12
2	62	10	63	10	58	17
3	55	11	70	6	68	12
4	53	5	63	7	66	5

Graph 2 reveales nonlinear relationship between thresholds of hearing and Remote Masking values in moderately severe hearing loss ears. This was verified statistically by computing co-efficient of correlation which indicated no correlation between thresholds of hearing and Remote Masking values at both 0.05 and 0.01 levels of confidance.

GRAPH II : Showing the relationship between Thresholds of Hearing and Remote masking value in 4 Moderately severe hearing loss cases, at frequencies of 250, 500, 1000 HZ.



5 severe hearing loss ears were tested to findout the relationship between the thresholds of hearing and Remote Masking values. The data are given in Table IX and graph III. This graphical representation shows no relationship between thresholds of hearing and Remote Masking value.

TABLE - IX

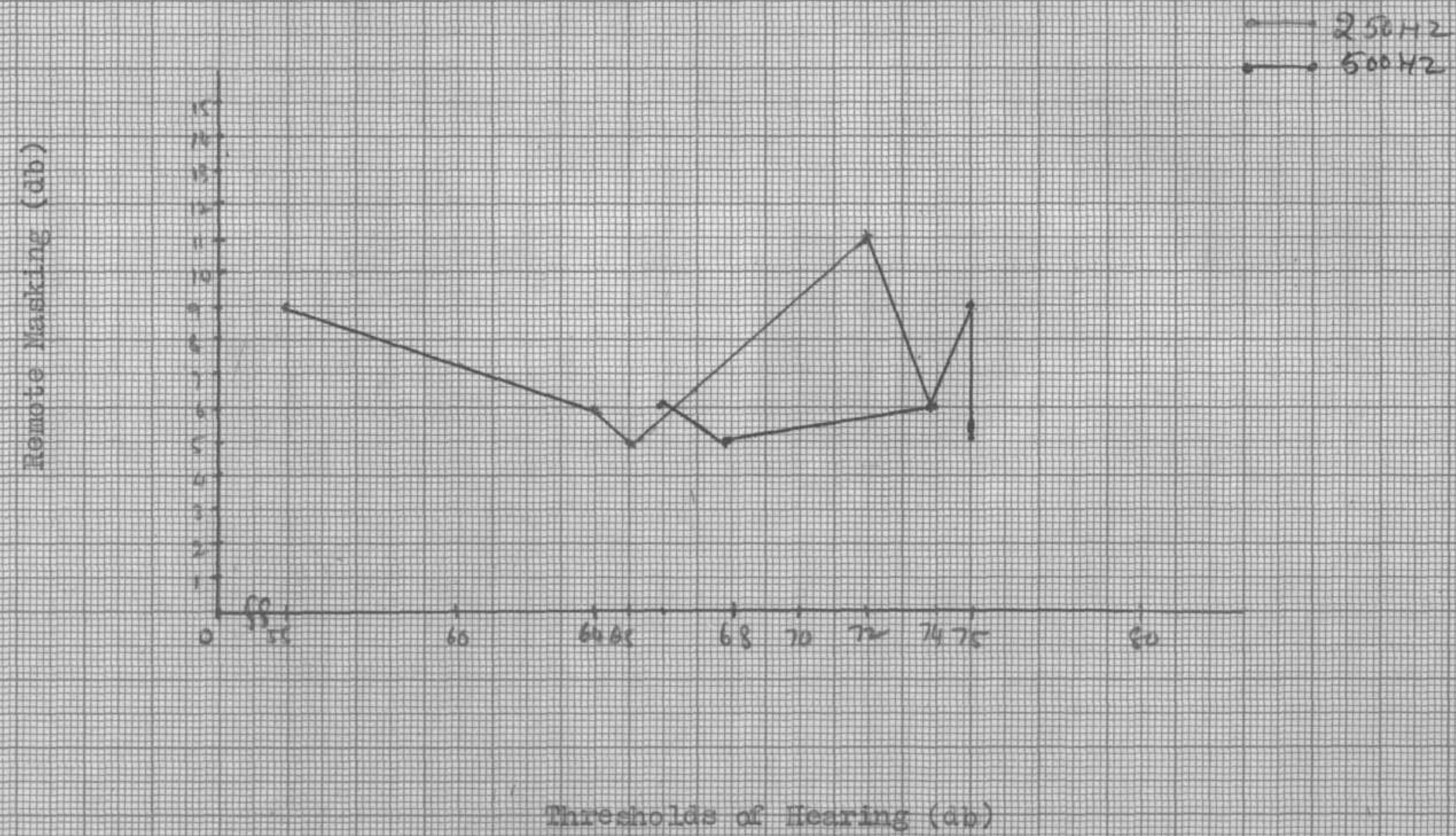
No. of subjects	250 HZ Thres-hold	250 HZ RM values	500 HZ Thres-hold	500 HZ RM values	1000 HZ Thres-hold	1000 HZ RM values
1	72	11	66	6	72	22
2	74	6	74	6	72	4
3	64	6	68	5	102	6
4	65	5	75	5	72	8
5	55		75	9	85	5

Three subjects with high frequency hearing loss were tested. Threshold values and Remote Masking value, are given in table 10(X) and Graph 4. Statistical analysis revealed that there was no correlation between the degree of hearing loss and remote masking values in the high frequency hearing loss cases.

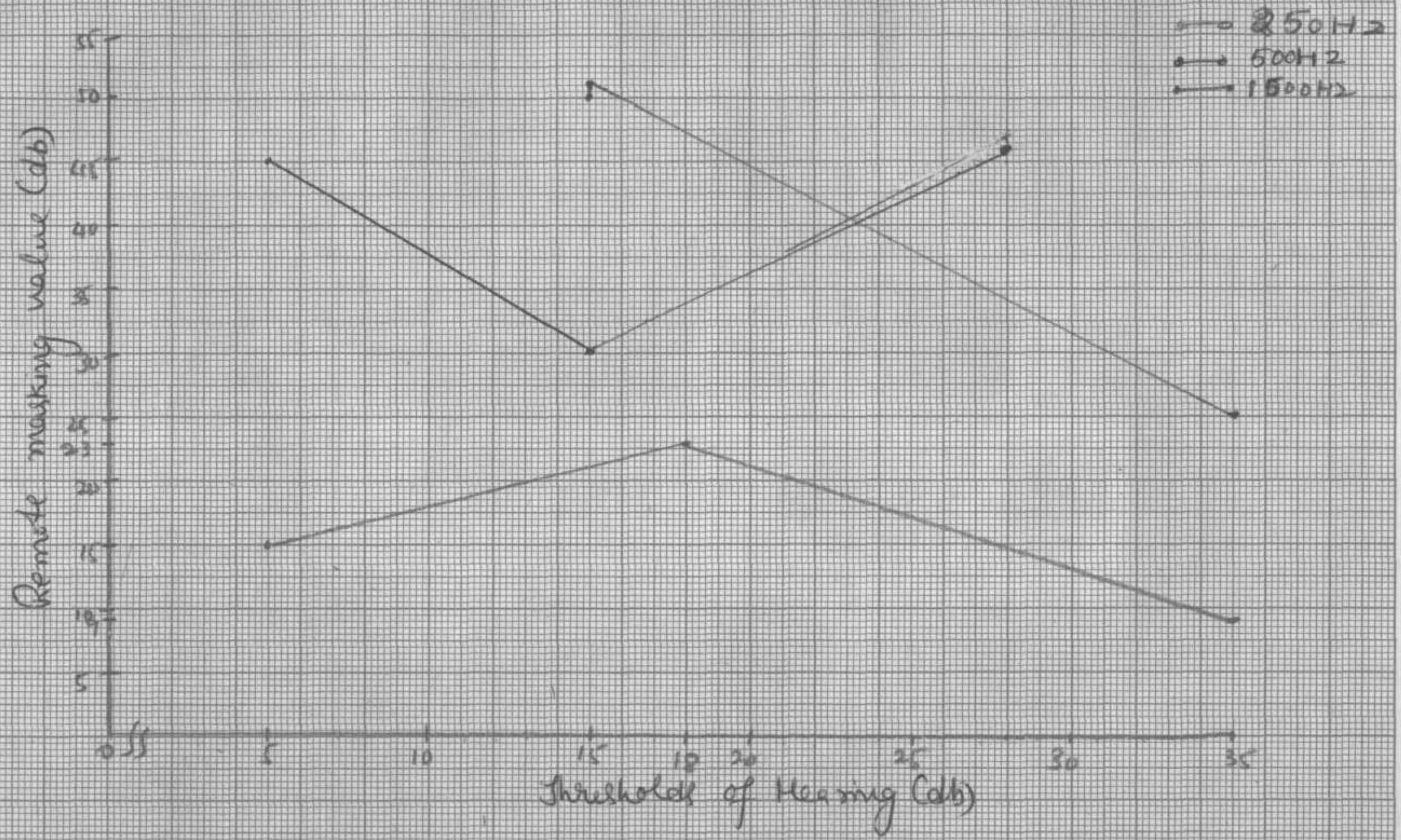
TABLE - X

No. of subjects	250 HZ Tnres-hold	250 HZ RM values	500 HZ Thres-hold	500 HZ RM values	1000 HZ Tnres-hold	1000 HZ RM values
1	18	23	5	45	15	50
2	35	19	28	46	15	51
3	5	15	15	30	30	25

GRAPH III: Showing the relationship between Thresholds of Hearing and Remote Masking values in 5 severe hearing loss ears, at frequencies of 250, 500 HZ



GRAPH III : Showing the relationship between Thresholds of Hearing and Remote Masking values in 5 severe hearing loss ear, at 1000 HZ.



GRAPH IV : Showing the relationship between Thresholds of Hearing and Remote Masking value in 3 high frequency hearing loss cases at 250, 500, 1000 HZ

DISCUSSION :-

Study done by Cervellera et al (1980) showed, no significance of difference between ears with regard to Remote Masking value. The present study agrees with the results of tne Cervellera et al (1980) study.

Further, the results of the present study showed that there is no significant difference in Remote masking values between Males & Females.

The Remote masking value obtained in the present study at 500 HZ and 1000 HZ are greater than the values reported by Cervellera et al (1980). At 250 HZ this study shows a lower value than the value reported by Cervellera et al (1980). This discrepancy may be due to the frequency composition of the masking noise used for remote masking. In the present study the narrow band noise centered around 3 KHZ at 98 db Spl (72 db HL) was used. The bandwidth of the masking noise as per the manufacturer of Madson 0B70 audiometer is 300 HZ (2850-3150 HZ). The band width of noise used by Cervellera et al (1980) was 305 HZ (2875-3180 HZ) and it was presented at 98 db Spl. Although there is not much difference between the noise used. in tnis study and the noise used in Cervellera et al (1980) study, interns of overall Spl and band width, however it is important to note that the band rejection rate is also an important characteristic while we describe narrow band noises. It is possible that the noise used by Cervellera et al (1980) and the noise used. in this study probably differed significantly with regard to band rejection race. Unfortunately the charactristics of the noise used in this study could not be determined in the Institute. The equipment required for noise analysis was not functioning.

Normative data collected in this study may be used in the clinic if we want to use "Remote Masking" for diagnostic purposes. This data along with the data to be collected an Meniere's disease cases would be useful in deciding whether "Remote Masking" can be used as a test to detect Meniere's disease cases. Earlier studies (Cervellera et al, 1978) show that in Meniere's disease cases reduced Remote Masking values are observed.

The present study has also revealed that the remote masking is not dependant on the degree of hearing loss in SN hearing loss cases. These results are in agreement with the results of the study reporter by Cervellera et al (1980). .

SUMMARY AND CONCLUSION :-

The phenomenon of Remote Masking was first described by Bilger and Hirsh (1956). Remote Masking is a low frequency phenomenon. It consists of a threshold rise for low-frequency tones when the ear is exposed to a high frequency noise band delievered at over all Spl of 80-100 db.

There are two possible contributing factors to explain remote masking phenomenon studies done by Bilger and Hirsh, 1956; Deatherage et al, 1957_a; Bilger, 1958; Burgear and Hirsh, 1961; attributed this phenomenon to mechanical nonlinear distortion of the cochlear partition as an effect of the envelope of a non-uniform signal.

Another possible contributing factor to Remote masking given by Ward 1963, is the attenuation of low frequency stimuli by elicitation of acoustic reflex by the high frequency masker.

In recent years Remote Masking has been studied in patients with auditory impairments in the hope that it could serve as a test for topographic diagnosis of deafness.

Clinical studies using Remote Masking (Jerger et al, 1960; Rittmanic, 1962; Bilger, 1956; Cervellera et al 197 have revealed, reduced Remote Masking value in conductiv hearing loss subjects and variable in SN hearing loss cases. They proposed this remote masking value can be used as test of cocnlear partition stiffness.

As there was no study on Indian Population on Remote masking, this study was undertaken to determine the norms in normal hearing adult subjects.

A sample of 35 subjects with an age range of 17-36 years was selected for the present study.

The test frequencies selected for the study were 250 HZ, 500 HZ am 1000 HZ. Narrow band noise centered around 3 KHZ at 98 db Spl (72 db HL) (300 HZ band width, as per the specification given by the 0B70 Madson audiometer manufacturer) was used to mark the pulsed tone of 250 HZ, 500 HZ and 1000 HZ.

To establish the nearing threshold and remote masking threshold for pulsed tone, vernier scale of 1 db step was used. After establishing the hearing threshold for pulsed tone, the noise was presented 98 db Spl in the same ear (Ipsilateral marking) and the masked thresholds for each frequency were determined. The Remote masking value was computed by finding out the difference b tween the masked tnreshold and unmasked threshold. Remote masking values were determined in the same manner for the other ear also.

Remote marking value was obtained for 16 SN hearing cases, to verify whether remote masking value is related to degree of hearing loss or not in SN hearing loss cases.

The data obtained were analyzed statistically.

The following are the conclusions of the present study;

(1) Regarding "remote masking", there is no significance difference between right ear and left ear values in normal hearing subjects.

(2) Males and Females do not significantly differ with respect to "Remote Marking".

(3) As per the present study "Remote Masking" values of normal hearing subjects, are as follows; 20.9 db at 250 HZ, 32.79 db at 500 HZ and 47.08 db 1000 HZ.

(4) The present study revealed that the Remote Masking value is not related to degree of hearing loss in SN loss subjects.

This is in agreement with the results reported by Cervellera et al (1980).

RECOMMENDATIONS FOR FURTHER STUDY:-

1. "Remote Masking" values are to be determined in Meniere's disease cases.

2. As the "Normative data" established in the present study differ at 1000 HZ from the data reported by other investigators, further studies are needed.

LIMITATIONS;-

Bandwidth of the narrow band noise used in this study was not actuually verified due to nonfunctioning of the noise analyzing equipment. The specification given by the manufacturer of 0B70 audiometer r garding band width of narrow band noise is assumed as the band width of the noise used in this study.

APPENDICES

AUDIOMETRIC CALIBRATION:

Standards : ISO (1964)

Audiometer: Madson 0B70-2 Channel audiometer.

INSTRUMENTS USED TO CALIBRATE AUDIOMETER

1. Audio frequency analyzer (B&K type 2107)
2. Pre-amplifier (B&K type 2616)
3. Condensor Microphone (type 4144)
4. Artificial ear (B&K type 4152)
5. Frequency counter of Roder make - type 203
6. Level recorder (type 2305)
7. Spl. meter (type 2209) with 1/2an inch condensor Microphone (type 4165)
8. Beat frequency Oscillator type (1022)

INTENSITY CALIBRATION

Frequency in HZ	Input level	Reference in db Spl	Expected output in db Spl	Obtained output in db Spl.
250	60 db	24.5	84.5	83.0
500	60 db	11.5	71.5	71.0
1000	60 db	6.5	66.5	66.0
2000	60 db	8.5	68.5	69.0
4000	60 db	9.0	69.0	67.0
6000	60 db	8.0	68.0	74.5
8000	60 db	9.5	69.5	73.0

B3NCY CALIBRATION

Frequency in Hz.	Measured output in Hz.
250	250
500	498
1000	1001
2000	1994
4000	3996
6 000	5997
8000	8002

NOISE LEVELS IN THE AUDIOMETRIC ROOMS MEASURED IN OCTAVE

Sl. No.	Octave banus in Hz.	Maximum allowable noise level in db Spl.	Noise level in the room in db Spl.
1.	75-150	31	14
2.	150-300	25	18
3.	300-600	26	10
4.	600-1200	30	12
5.	1200-2400	38	10
6.	2400-4800	51	11
7.	4800-9600	51	11

Weighting Network	Noise level in db Spl
A	18 db A
B	22 db
C	32 db

Goodmmanss(1965) classification of hearing loss.

db	Classification of Hearing loss.
-10 to 26	Normal limits
27 to 40	Mild hearing loss
41 to 55	Moderate hearing loss
56 to 70	Moderately severe hearing los
71 to 90	Severe hearing loss
91 +	Profound hearing loss.

T A B L E - I

Table I Showing the remote masking value at 3 audiometric frequencies for both right and left ear in 36 Normal hearing subjects.

Subject	Right ear			Left ear		
	250	500	1000	250	500	1000
1	2	3	4	5	6	7
1	12	22	46	10	32	40
2	16	32	43	15	30	40
3	16	25	47	14	36	35
4	22	30	56	25	32	47
5	16	25	44	13	28	42
6	15	26	50	17	29	50
7	19	29	41	20	39	49
8	23	38	45	23	39	51
9	14	29	49	11	21	29
10	19	32	38	26	32	45
11	22	32	40	20	37	52
12	15	39	37	23	42	52
13	16	32	52	17	38	40
14	22	32	53	39	31	51

Continued — I

1	2	3	4	5	6	7
15	21	30	46	19	38	51
16	22	38	45	13	38	52
17	24	36	56	22	37	56
18	20	36	48	30	38	54
19	24	26	48	28	32	46
20	26	33	51	21	37	52
21	19	33	50	17	32	41
22	22	33	40	19	35	46
23	19	36	50	17	24	36
24	15	39	47	20	42	50
25	21	35	51	23	34	50
26	26	36	52	21	35	50
27	22	40	45	21	31	56
28	19	25	55	16	26	52
29	17	36	57	21	39	56
30	26	40	56	31	33	52
31	29	32	51	24	40	53
32	31	30	46	16	35	57
33	27	31	51	26	29	53
34	19	28	51	20	31	44
35	22	27	54	25	29	41
36	22	31	52	32	34	54

T A B L E - III - FEMALE

No. of subjects	Right ear 250	500	1000	Left ear 250	500	1000
1	12	22	46	10	32	40
2	16	32	43	15	30	40
3	16	25	47	14	36	35
4	16	25	44	13	28	42
5	15	25	50	17	29	50
6	14	29	49	11	21	29
7	19	32	48	26	32	45
8	22	32	40	20	3?	52
9	22	32	53	19	31	51
10	19	33	50	17	32	41
11	22	33	46	19	35	48
12	21	30	46	19	38	51
13	22	38	35	13	38	52
14	20	36	48	30	38	54
15	24	26	48	28	32	46
16	22	40	45	21	31	56
17	19	25	55	16	26	52
18	37	36	57	21	39	56
19	26	40		31	33	52
20	29	32		24	40	53
21	31	30	46	16	35	57

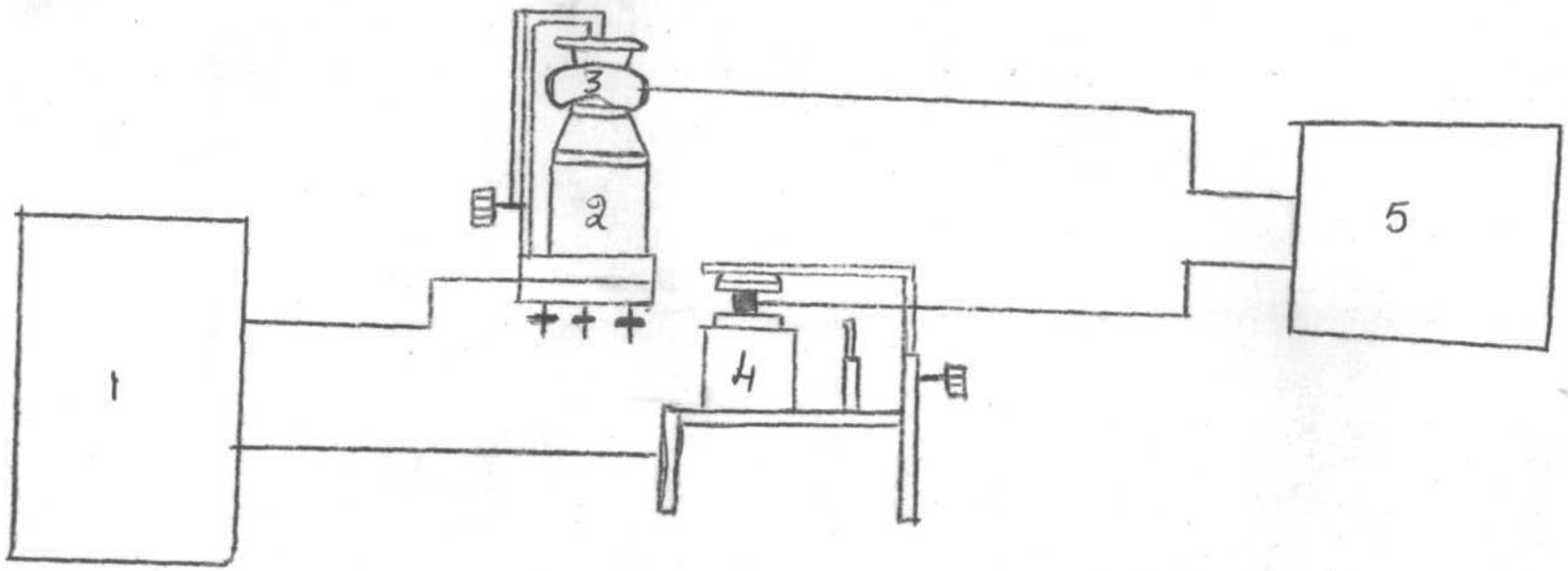
Contd. Table III

MALE

1	2	3	4	5	6	7
1	22	30	56	25	32	47
2	19	29	41	20	39	49
	23	38	45	23	39	51
4	16	32	52	17	38	40
5	15	39	37	23	42	52
6	15	39	47	20	42	50
7	21	35	51	23	34	50
8	19	26	50	17	24	36
9	24	36	56	22	37	56
10	26	33	51	21	37	52
11	26	36	52	21	35	50
12	27	31	51	26	29	53
13	19	28	51	20	31	44
14	22	27	54	25	29	41
15	22	31	52	32	34	54

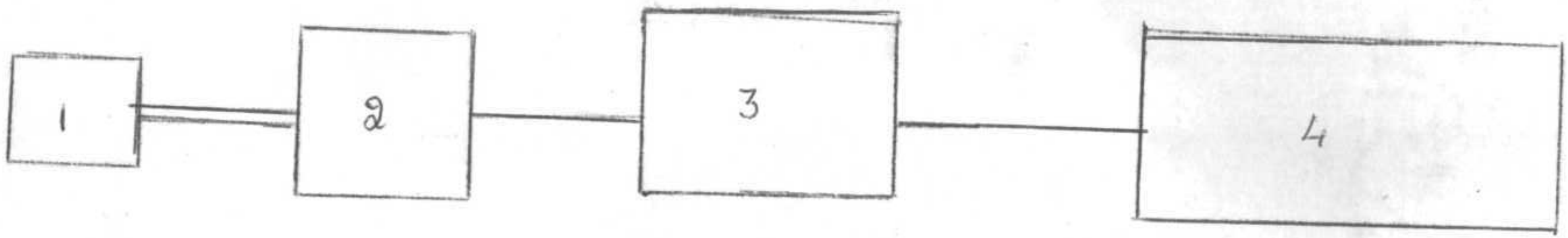
FIG. A

BLOCK DIAGRAM SHOWING THE EXPERIMENTAL SET UP FOR CALIBRATION.



1. Audio Frequency Analyser: B & K type 2107.
2. Artificial:ear:type B & K 4152
3. Ear Phone : TDH 39
4. Artificial Mastoid : B & K type 4930
5. Audiometer : Madson OB 70

Block diagram of the set up.



1. Power Supply.
2. Noise Generator: Madson Circuit Board No. ME 013318.
3. Narrow Band Filter (3 KHZ): Madson Circuit Board No. ME 013325
4. Audiometer : Madson OB 70

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