THE EFFEGT OF POSITIVE VENTING VALVE *ON* THE ELECTROACOUSTIC CHARAGTERISTICS OF DIFFERENT GATEGORIES OF BODY LEVEL HEARING AIDS

REG, No. M 9208

An independent project submitted as part fulfilment for the

first year M.Sc. CSpeech and Hearing) to the

University of Mysore

All India Institute of Speech and Hearing

MYSORE - 570 006

May 1993

DEDICATED TO : MY DEAR AMMA AND APPA

CERTIFICATE

This is to certify that project entitled : "THE EFFECT OF POSITIVE VENTING VALVE ON THE ELECTROACOUSTIC CHARACTERISTICS OF DIFFERENT CATEGORIES OF BODY LEVEL HEARING AIDS" is a bonafide work, done in part fulfilment for the first year Degree of Master of Science (Speech and Hearing), of the student with Reg.No M 9208.

MYSORE
MAY 1993

DIRECTOR
ALL NDIA INSTITUTE
OF SPEECH AND HEARING
MYSORE - 6.

CERTIFICATE

This is to certify that this Independent project entitled : **"THE EFFECT OF POSITIVE VENTING VALVE ON THE DIFFERENT CATEGORIES OF BODY LEVEL HEARING AIDS"** has been prepared under my supervision and guidance.

MYSORE
MAY 1993

Dr.(Miss) S.NIKAM
GUIDE

DECLARATION

I hereby declare that this independent project entitled : "THE EFFECT OF POSITIVE VENTING VALVE ON THE ELECTROACOUSTIC CHARACTERISTIC OF DIFFERENT CATEGORIES OF BODY LEVEL HEARING AIDS" is the result of my own study under the guidance of Dr(Miss) S.NIKAM, Professor and Head of the Department of Audiology, All India Institute of Speech and Hearing Mysore, has not been submitted earlier at any university for any other Diploma or Degree.

MYSORE
MAY 1993

REG. NO M. 9208

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CHAPTER 1: PROLOGUE

"Hearing Loss" is an handicap only when the listener is kept away from perceiving sounds of importance to him.

With modern techniques of amplification, it is possible to combat most such handicaps. So development of a good wearable hearing aid that is well suited for individual users is of great importance.

Many technological advances in improving the response and sound quality of hearing aids over recent years have taken place. Further, improvements can still be made by modifying the sound channel from the hearing aid to the tympanic membrane. These modifications are usually done on the earmould.

Earmould, sometimes called the earpiece, is an insert designed to conduct the amplified sound from the hearing aid receiver to the canal as effectively as possible.

Uses of Earmould:-

1.Holds receiver or hearing aid in the ear.

2.Channels the sound from the receiver to the earmould

3.Acoustic modifications of the earmould affects the response of the hearing aid (to suit individual wearers).

The new earmould technology has some basic philosophical considerations. They are:-

a) To preserve the balance acoustically between the high and the low frequency in normal speech spectrum.

b) To preserve the normal eardrum - freefield transfer function.

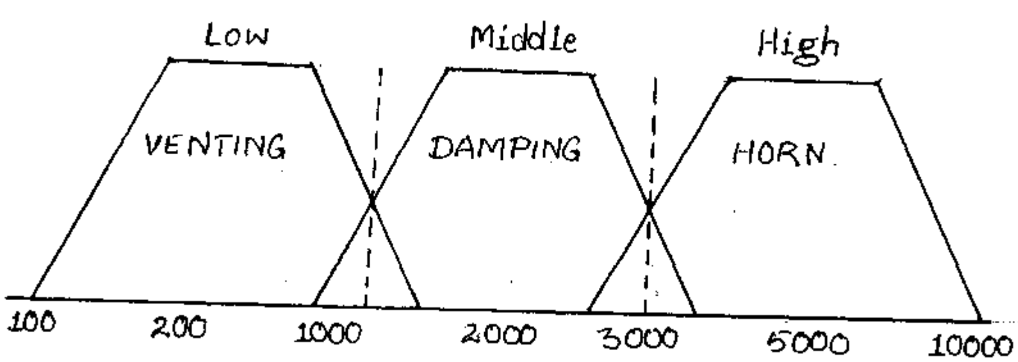
c) To extend the high frequency in wearable hearing aids.

d) To minimize and or elevate the standard peak in hearing aid response at 1 KHz - 5 KHz for many mild and moderate losses.

e) To gradually slant upward the frequency response of hearing aid.

f) To keep the output of an aid within the clients dynamic range.

These are accomplished by adjusting the frequency response of the hearing aid with special attenuation to the earmould and associated plumbing.Individual adjustments to low-middle and high frequency use of venting, damping and horn affects can be made respectively.



EARMOULD MODIFICATION AND FREQUENCY OF INFLUENCE.

I) HORN EFFECTS - ACOUSTIC HORNS :-

Killion and Knowles (1978), Killion (1981), Brunved (1985) report the use of acoustic horn principle in hearing aid response modification. It is defined by Brunved (1985) as a tube of varying cross-section having different terminal areas that provide a change of acoustic impedance.

Types of acoustic horn are - Libby Horn, Bakke Horn, Exponential Horn, Killion Horn and Reverse Horn.

II.ACOUSTIC DAMPING:-

Tubing response and Helmholtz response (produced by the acoustic compliance of the air cavity in front of the hearing aid receiver causes sharp peak in the output of the hearing aid. Skinner (1988). These can be excited by sharp transient sounds, causing a "ringing" sound as "echoing" sound, Various acoustic resistance/damping elements have been used to smoothen the frequency response of the hearing aid—earmould system and to control gain and saturation output. This in turn reduces the feedback problem Killion,(1980).

TYPES OF DAMPERS:-

a) Lambs Wool

b) Sintered Filters

VENTING:-

Vent is defined as the opening from the surface of an ear mould to its sound input channel which is an intentionally produced leak. Langford,(1975) cited by Pollack (1975). Earmould venting appears to have been used first by Grossman, (1943), in combination with button receiver system as reported by Lybarger et al. (1985).

A vent depending upon its length and diameter can alter the response of the hearing aid:-

1. It increases the user's comfort by releasing pressure built up in the external auditory canal.

2. Eliminates blocked up feeling in the ear for subjects using occluded earmould.

3. It improves the quality of sound heard by the user.

4. It can alter the frequncy response of the signal from
A
the hearing aid primarily by reducing low frequency amplification thus enhancing speech discrimination both in quiet and in noise situations.

5. Ventilates ear canal, alleviates discomfort, heat and humidity.

6. To allow direct access to unamplified sounds.

7. For medical reasons.

8. It prevents the earmould from acting as an ear-plug at low frequency, and allows very low frequency of persons own voice to enter the ear at given normal level.

Briskey et al (1966) Lybarger (1967,1958), McDonald and Studebaker (1969), all of them studied and found venting of ear moulds resulted in a reduction of SPL for low frequencies.

Lybarger (1968, 1967), Major (1969), found that the frequencies which are reduced by venting are those below 300 Hz.

Pollack (1975) found that there was a reduction in low frequency amplification with an increase in vent diameter.

Weatherton and Goetzinger (1971) suggested that venting is best suited for fitting subjects with high frequency losses.

TYPES OF VENTS:-

Vents can be divided into -

I. Non-Adjustable vents _ which includes

a) Parallel vent

b) Diagonal Vent

II. Adjustable vents -which includes

a) P.V.V - Positive venting valve

b) S.A.V - Select - a - Vent

c) V.V.V - Variable Venting Valve

I.NON-ADJUSTABLE VENTS:-

Here, the dimensions of the vent cannot be varied,

a) PARALLEL VENT:- A channel parallel to the sound bore. It reduces the low frequency gain without reducing the high frequency gain.

b. DIAGONAL VENT:- When the earmould tip is too small to take two channels, the vent may have to be introduced as a side branch. It reduces the low frequency gain along with irregularities in the high frequency response and reduction in the high frequency gain. This can result in an increased acoustic feedback. This can be rectified by using an expansion chamber in the vent or introducing acoustic filters into the vent tubes. This reduces the leakage of higher frequency signals.

There is increased reduction of low frequency gain when the length of the vent is shortened and diameter is increased.

Venting may produce a higher gain in the frequency region just above that where low frequency gain has been reduced. It is caused by resonance effects in the vent tube and meatal cavity. The effect may lead to a lower quality of fit of the hearing aid rather than a higher one when compared with non-vented ear mould. This is particularly the case when the emphasized frequency is centered around 400 Hz, the point at which speech has high intensity components. If this occurs, it is advisable to expand the diameter of the vent or shorten its length, either of which should increase the frequency of the emphasized region.

II) ADJUSTABLE VENTS:-

In recent years several adjustable venting systems have come into widespread use. These systems provide the hearing aid filter with a means of varying the dimensions of the vent bore, presumably altering its acoustic effect, until the optimal vent is found. The most popular adjustable systems are those which includes a set of inserts each of which is a push-fit into a precisely bored hole with a seating ring on the lateral face of the earmould.

There are 2 types of Adjustable Vents -

a) S.A.V(SELECT-A-VENT)& b) P.V.V-(POSITIVE VENTING VALVE)

SELECT A VENT-(S.A.V):- As reported by Lybarger (1985), this system has inserts with 5 hole size and one without a hole. It is a solid cylinder of 4.7 mm long and 3.6mm in outer diameter with a hole which extends its full length. Inserts with a hole which have diameter of 0.79 m, 1.57 mm, 1.98 mm and 2.36 mm will be provided. The inserts fit precisely into sockets on the outer face of the earmould. Sound reaches the vent inserts via a sound channel that starts at the earmould tip. If this channel is too long or too small in diameter, the insesrts may have little effect. They work best when the channel is short and atleast 3 mm in diameter Lybarger (1985).

VARIABLE VENTING VALVE-(V.V.V):- Was first described by Feingold (1972). Griffing and Shields (1972). It is an air valve which is inserted permanently and securely into the earmould to preclude leakage. The valve is controlled by a small plastic knob that can readily be adjusted by the user to any degree of open or closed valve position. The threaded valve may be turned over 540 of rotation from fully closed to fully open position, i.e., the frequency response of hearing aid can be altered by the user.

POSITIVE VENTING VALVE-(P.V.V) It has a small cup-shaped insert with a thin bottom in which there is a small hole. Each system of P.V.V., includes six inserts one of which is simply a plug. The remaining five opening incorporate an opening of different diameter like 0.51 mm, 0.79 mm, 1.57 mm, 2.39 mm or 3.17 mm. The insert is 2.5 mm deep, 4 mm in outer diameter and the thickness of the floor of the insert is approximately 0.5mm. The channel between earmould tip and vent insert should not be too long or too small in diameter but, it should atleast be short and 3 mm diameter for good transmission.

The acoustic effects of adjustable vents are same as that of uniform bore vents, except that P.V.V. with parallel vent configuration results in no effective change in high frequency characteristics compared to an unvented earmould.

Use of P.V.V with a side branch (diagonal vent) configuration results in high frequency transmission loss.

In assessing the effects of adjustable venting system the following factors should be considered.

a) EFFECT OF VENT BORE:- The magnitude of the low frequency transmission loss which occurs when a vent is incorporated into the coupling system is determined by the impedance of the vent bore beyond the insert as well as the impedance of the insert itself. Hence, if the impedance of the insert is to be the dominating factor, impedance of the vent bore beyond the insert, must be kept as small as possible. To acomplish this, the vent bore should be as short and wide as possible.

b) EFFECT OF THE INSERT:- Two findings about the insert are:-

1. (i) With 15 mm length and 2.4 mm diameter of vent bore, the five inserts did not result functionally in five different vents. The five inserts actually produced only two different vents since the two smaller diameter inserts produced effects which are functionally indistinguishable from each other as did the three larger diameter inserts.

(ii) Lybarger, (1978) reported data obtained using P.V.V. inserts with a bore beyond the insert 4.6 mm in length and 3 mm in diameter. With this short, wide vent bore, the two smaller diameter inserts produced results which were different from each other but the three large diameter inserts still gave essentially indistinguishable results.

2. The range of effects obtainable from the smallest to the largest diameter insert is not very great, the frequency of the vent asociated resonance changed from about 5A0 Hz with the two smaller diameter insert. The low frequency transmission loss for a given frequency is about 7.9 dB greater for the large diameter insert than for small diameter inserts. Studies show that the diameter of the vent bore beyond the insert is potentially much greater than the effect of changing the hole size in the insert itself.

PREDICTING THE ACOUSTIC EFFECTS OF VENTING:-

Lybarger (1978 b) provides data on the effects of P.V.V. in parallel vent configurations in which the vent bore beyond the insert is varied in length and diameter. Reference to these tables should make it possible either to predict with reasonable acuracy, the acoustic effect of a vent which is in hand or to specify with some precision the values desired on variable vent parameter in a yet to be fabricated earmould.

CHAPTER II. METHODOLOGY

SELECTION OF HEARING AIDS:-

A total of 30 new body-level-hearing aids (10 -strong category, 10- moderate category and 10 - mild category) were taken for the study. All these hearing aids are manufactured in India.

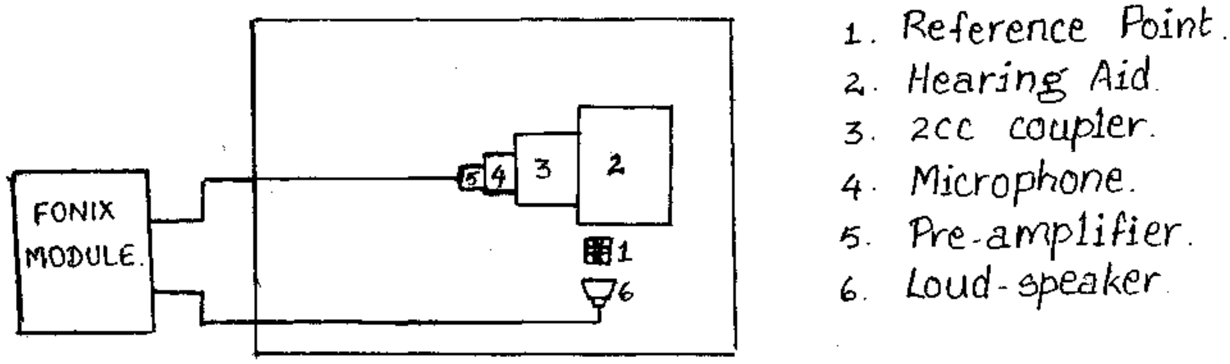
Test Environment

The test was carried out in an air-conditioned sound treated room. The ambient noise levels inside the room were within the permissible levels (53.1 - 1977.)

Instrumentation:-

The instruments used for the study were as follows:

1. Hearing Aid Test System (Fonix 6500) with a built-in computerized program for testing of the hearing aids.
2. Microphone (M1550).
3. Standard HA-2, 2CC Coupler.
A. Body level hearing aids.
5. Earmould without vent and earmould with positive venting valve (all the six diameters).



BLOCK DIAGRAM OF

HEARING AID TEST CHAMBER SYSTEM.

PROCEDURE:- At the outset, the instrument for making electroacoustic measurement was got ready.

1. Leveling was done as soon as the instrument was switched on, as per the instructions in the manual.

2. After leveling, the body level hearing aid was placed in position with its microphone opening facing the loudspeaker at the test point and with proper acoustic connection to the 2CC coupler i.e., the receiver was connected to the coupler and the coupler inturn was connected to a pick up microphone of Fonix.

3. The correct battery voltage was provided for the hearing aid.

A. The volume control was set to the full-on position.

5. ISI button was pressed to carry-out the electro acoustic characteristics of the body level hearing aid.

6. The device was made to run through the entire program, the results were displayed on the video monitor.

The screen displayed the values of Max. OSPL9O, HFASSPL90 and HFAFOG. Then the volume control was adjusted to match the gain displayed on the screen. Thus, the RTG was measured. Then by pressing the continue button, the values of F1, F2, harmonic distortion at 500 Hz, 1 KHz and 1.6 KHz were obtained.

7. The following parameters were considered-

a) OSPL90
b) HFAOSPL90
c) FOG (Max)
d) F0G (HFA)
e) RTG
f) Response limit
g) Fl(low Frequency cut-off)

h) F2(high frequency cut-off)

i) Harmonic distortion at 500 Hz: 1KHz: ;1.6 KHz

j) D.F., distortion at 1 KHz

k) Equivalent input noise level (EIN)

8) The same procedure was repeated with the

a) Hearing aid with earmould.

b) Hearing aid with earmould vent (all 6 diameters) separately.

9) Similarly, the electro-acoustic characteristics of all the other body-level-hearing aids were measured.

CHAPTER III. RESULTS AND DISCUSSION

The purpose of the study was to find whether there was any significant difference between earmould without positive venting valve (P.V.V hence forth) and earmould with positives venting valve on the electro acoustic charactesristics of different categories (mild, moderate & strong) of body level hearing aids.

The data was collected based on the methodology given in the previous chapter. The data was tabulated and mean and standard deviation values were computed.

Appendix II and III shows the graphical representation of the Mean Values.

Statistical analysis was carried out using unpaired t-Test to check for any significant difference among the earmould without positive venting valve and earmould with positive venting valve on the electroacoustic characteristics of diferent categories of body level hearing aids at 0.05 level.

Results show significant difference for a few electro acoustic charactseristics between earmould without positive venting valve and earmould with positive venting valve in strong and moderate category hearing aids which is given below in tabular form.

There was no significant difference between earmoulds without vent and earmould with positive venting valve in mild category hearing aids.

STRONG CATEGORY HEARING AID.

Characteristic	Condition in which significant difference is seen.
1) HFAOSPL 90	Between earmould without P.V.V and earmould with P.V.V (0.79 mm, 1.57 mm & 3.17 mm.)
2) FOG (MAX)	Between earmould without P.V.V and earmould with P.V.V (0.79mm, 2.39 mm, 3.17mm and plug)
3) FOG(HFA)	Between earmould without P.V.V and earmould with P.V.V (0.79mm, 1.57mm,2.39mm) and plug
4) RTG	Between earmold without P.V.V and earmold with P.V.V (0.79, 1.57mm, 2.39mm) and plug.

MODERATE CATEGORY HEARING AID

1) HFAOSPL90	Between earmould without P.V.V and earmould with P.V.V (0.79 mm, 1.57 mm, 2.39 mm, 3.17mm) and plug.
2) FOG(MAX)	Between earmold without P.V.V and earmold with P.V.V (0.51 mm).
3) RIG	Between earmold without P.V.V and earmold with P.V.V (0.51mm, 0.79mm, 1.57mm, 2.39mm, 3.17mm) and plug.

The significant differences seen in the results for the parameter like HFA0SPL90, FOG(MAX),. FOG(HFA) RTG in strong and moderate category hearing aids is because of the incorporation of the vents in the earmoulds as the earmould sound bore, vent length etc was kept constant.

Thus,the incorporation of vents in earmoulds does affect the electroacoustic characteristics HFAOSPL90, FOG(MAX), FOG(HFA) RTG of the hearing aid.

From the results it is evident that the P.V.V can provide an optimum fit, altering the frequency response of the signal from the hearing aid primarily by reducing low frequency amplification thus enhancing speech discrimination both in quiet and in noisy situations.

CHAPTER IV. SUMMARY AND CONCLUSION

The aim of the present study is to determine the effect of positive venting valve on the electroacoustic characteristics of different categories (Mild, Moderate & Strong) of body Level hearing aids.

The electroacoustic characaterestics were measured for thirty Body Level hearing aids (10 in each category) for eight different conditions.

These comprised of the following:

1) First condition where the electroacoustic characteristics measurement were made for the hearing aid only.

2. Second condition where the electroacoustic characteristics measurements were made for the hearing aid with the earmold attached to it.

3) The next condition where the electroacoustic characteristics measurements were made for the hearing aid which was attached to earmold with P.V.V inserted in them.

In this conditilon, there are six different vents and therefore six different measurements were made.

Conclusion:

As is evident from the study, the effect of P.V.V is highest in strong category hearing aids followed by moderate category, and least or no difference in mild category hearing aids. Significant difference was seen for the following electroacoustic characteristics of hearing aids:-HFA0SPL90, FOG(MAX), FOG(HFA), RTG. Thus, P.V.V affects a few of the electroacoustic characteristics of hearing aids.

SUGGESTIONS FOR FURTHER STUDY:-

1) A study could be carried out using these P.V.V using subjects by making use of insertion gain optimizer (IGO) hearing aid trial system.

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Appendix-I

SATURATION SPL (OSPL-90) It is important to know at what level a hearing aid limits its output when it receives a high level input signal. It is defined as the SPL developed in a 2-cc earphone coupler when the input SPL is 9OdB and the gain control of the hearing aid is full-on.

HIGH FREQUENCY AVERAGE SSPL-9O(HFA-SSPL9O) IS defined as the average of lOOOHz, 1600Hz and 2500Hz SSPL9O values.

HIGH FREQUENCY AVERAGE FULL-ON-GAIN (HFA-FOG): is defined as the average of 1000 Hz,1600 Hz and 2500 HZ SPL values when the input SPL is 60DB and the gain control of the hearing aid is full on.

SPL is 60dB and the gain control of the hearing aid is full on.

REFERENCE TEST GAIN (RTG): This gain setting is established, , using an input SPL of 60dB by adjusting the gain control so that the average of the lOOOHz, 1600Hz and 2500Hz gain value are equal to the HF-average, SSPL-90 minus 15 ± IdB.

USE GAIN (UG): This is the gain of the hearing aid measured by setting the volume control at 1/3 of the maximum volume setting available for that aid.

FREQUENCY RANGE: The frequency range of an aid refers to the useful range of the frequency response. It is expressed by two numbers, one representing the low-frequency limit of amplification (Fl) and other high frequency limit (F2) with both numbers expressed in Hz.

TOTAL HARMONIC DISTORTION: Harmonic distortion is a result, primarily, of over loading the hearing aid amplifier or earphone. It ocurs when the instantaneous output sound pressure of the hearing aid earphone is not directly proportional to the instantaneous sound pressure at the microphone. Measured at 500Hz, lOOOHz and 1600Hz.

DF. DISTORTION AT IKHZ (INTERMODULATION) DISTORTION: This occurs when the output signal contains frequencies that are arithmetic sums and differences of two or more input frequencies. When two or more frequencies (as in speech) are applied simultaneously at the input, it is the result of amplifier non-linearity.

EQUIVALENT INPUT NOISE LEVEL(EIN): This particular characteristic relates to the magnitude of internal noise generated by the hearing aid.

CURRENT DRAIN: With the gain control in the reference test position, measure the battery current with a pure tone lOOOHz input signal at a sound pressure level of 65dB.

APPENDIX-II

(Strong Category Hearing-Aids).

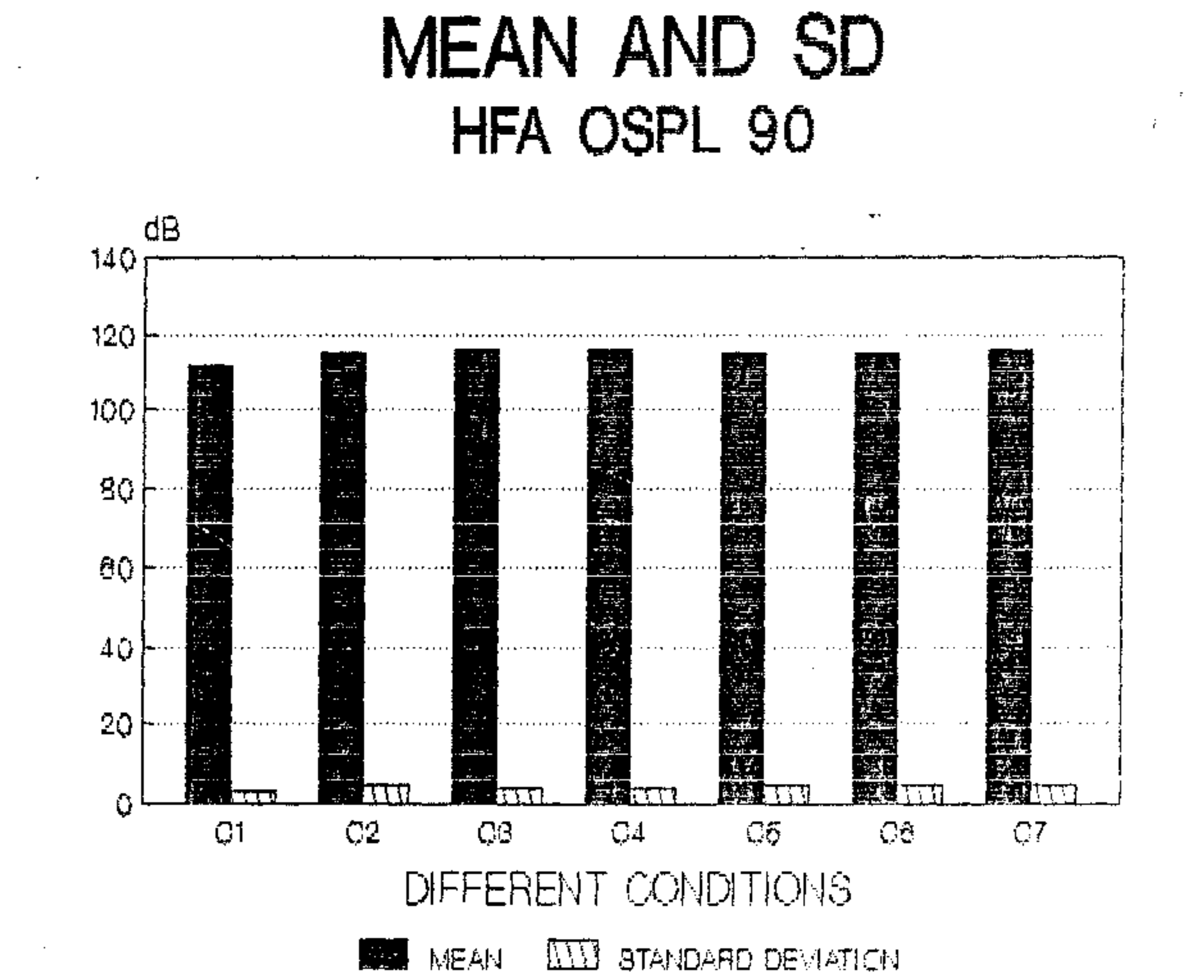
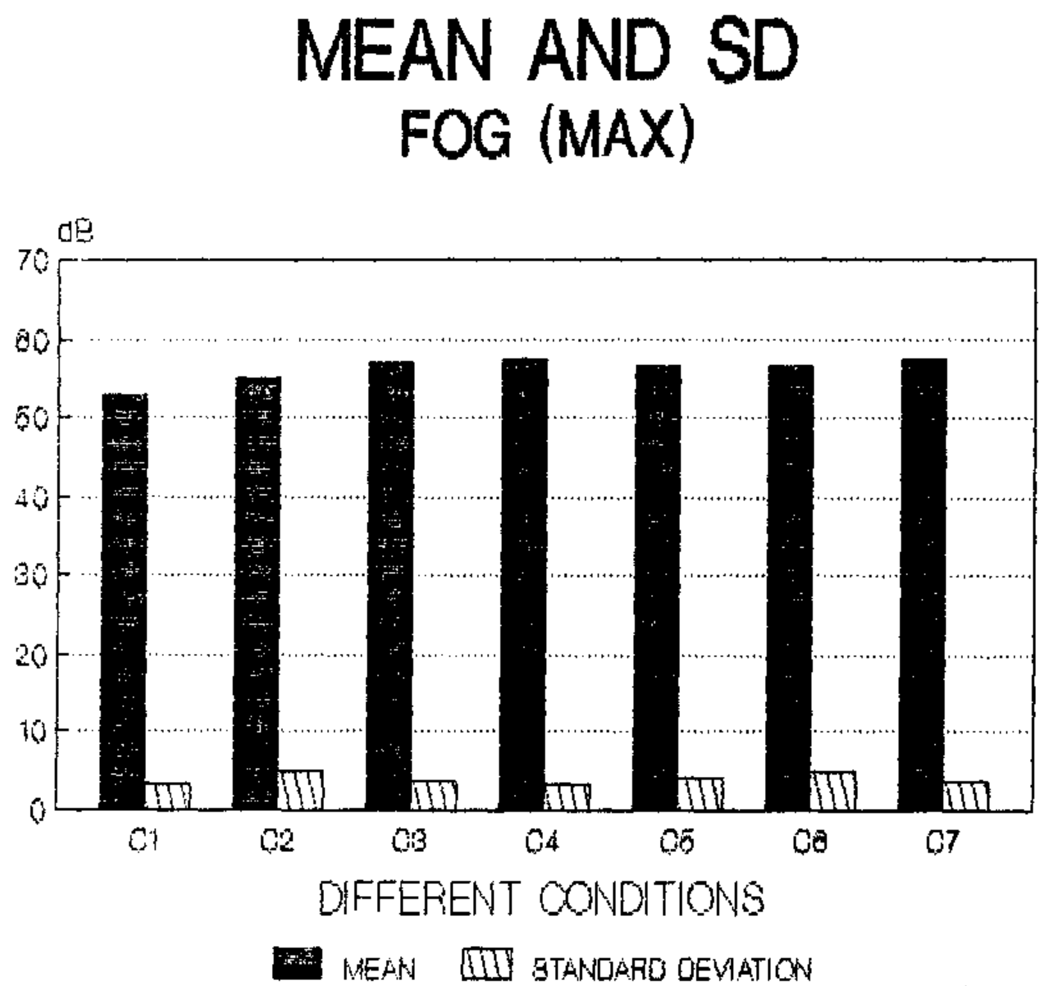


FIG. NO. 1



MEAN AND SD
FOG (MAX)
dB
70
60
50
40
30
20
10
0
C1
C2
C3
C4
C5
C6
C7
DIFFERENT CONDITIONS
MEAN
STANDARD DEVIATION

FIG NO. 2

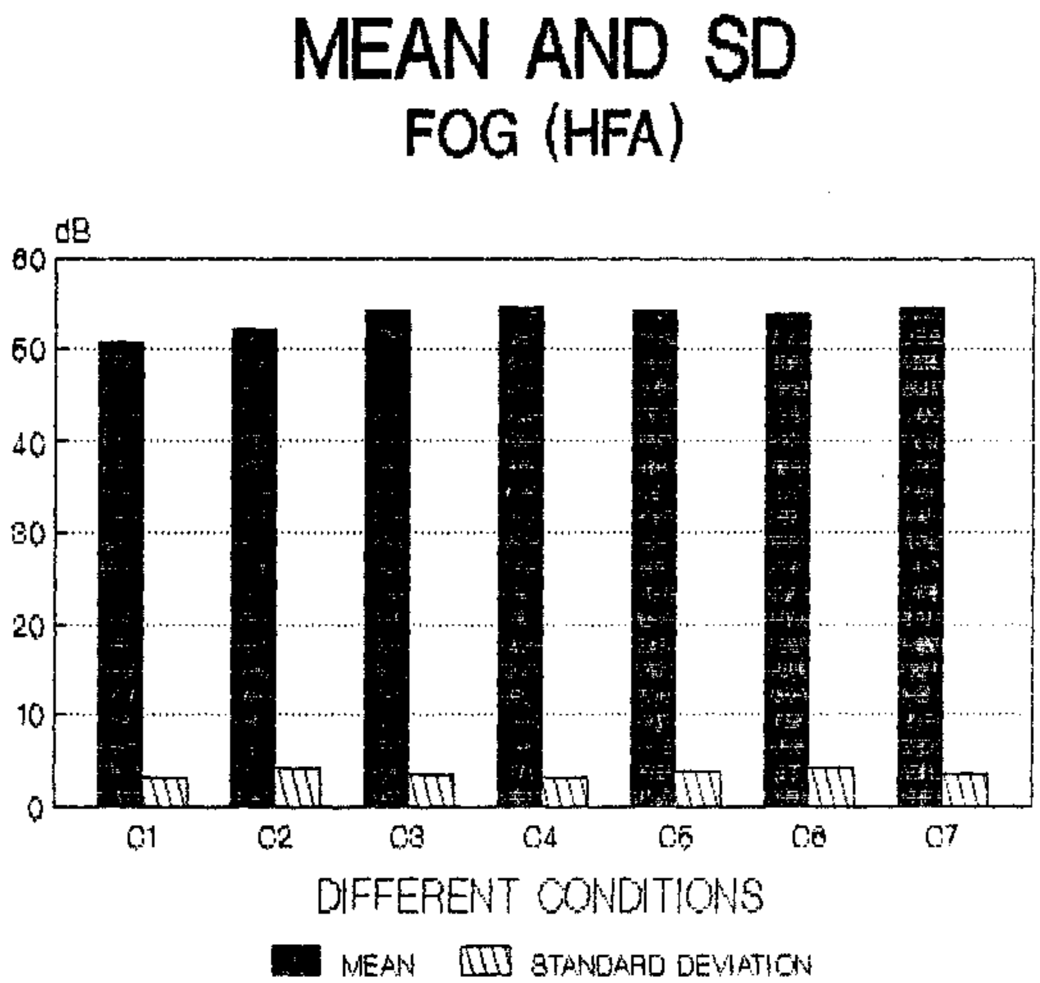

MEAN AND SD
FOG (HFA)
dB
60
50
40
30
20
10
0
C1
C2
C3
C4
C5
C6
C7
DIFFERENT CONDITIONS
MEAN
STANDARD DEVIATION

FIG. NO. 3

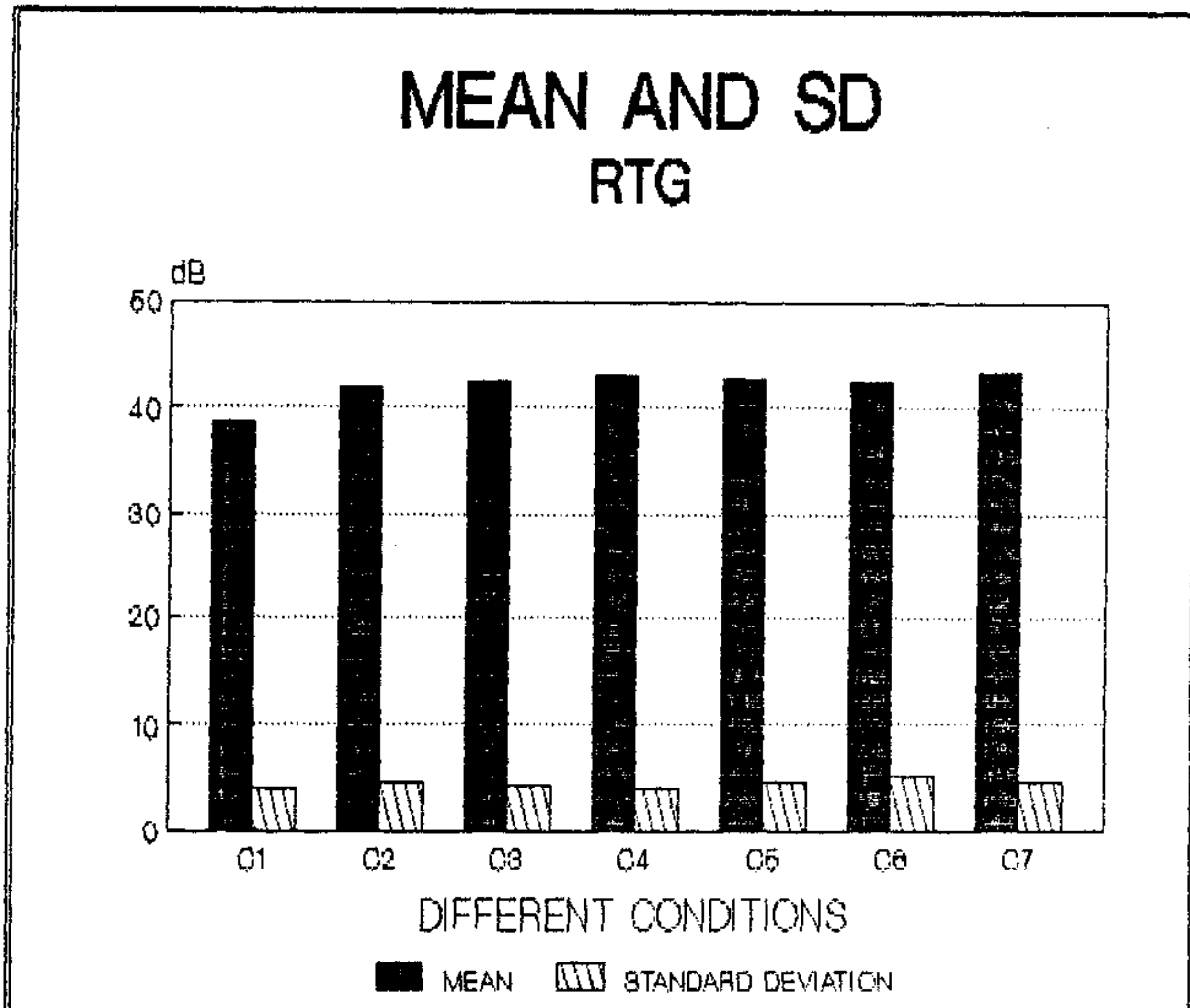
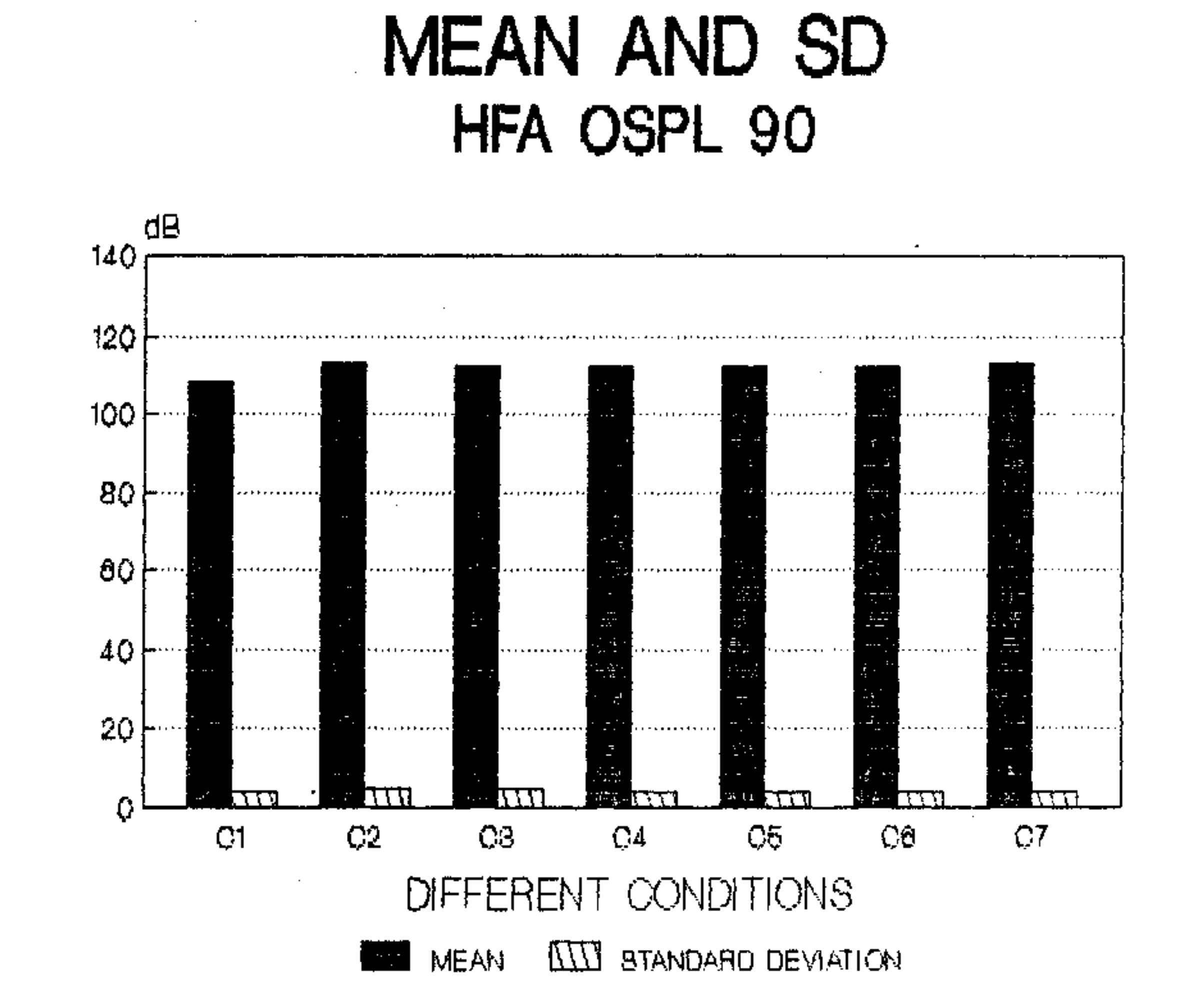

MEAN AND SD
RTG
dB
60
40
30
20
10
0
C1
C2
C3
C4
C5
C6
C7
DIFFERENT CONDITIONS
MEAN
STANDARD DEVIATION

FIG. NO. 4

APPENDIX- III

(Moderate Category Hearing Aids).



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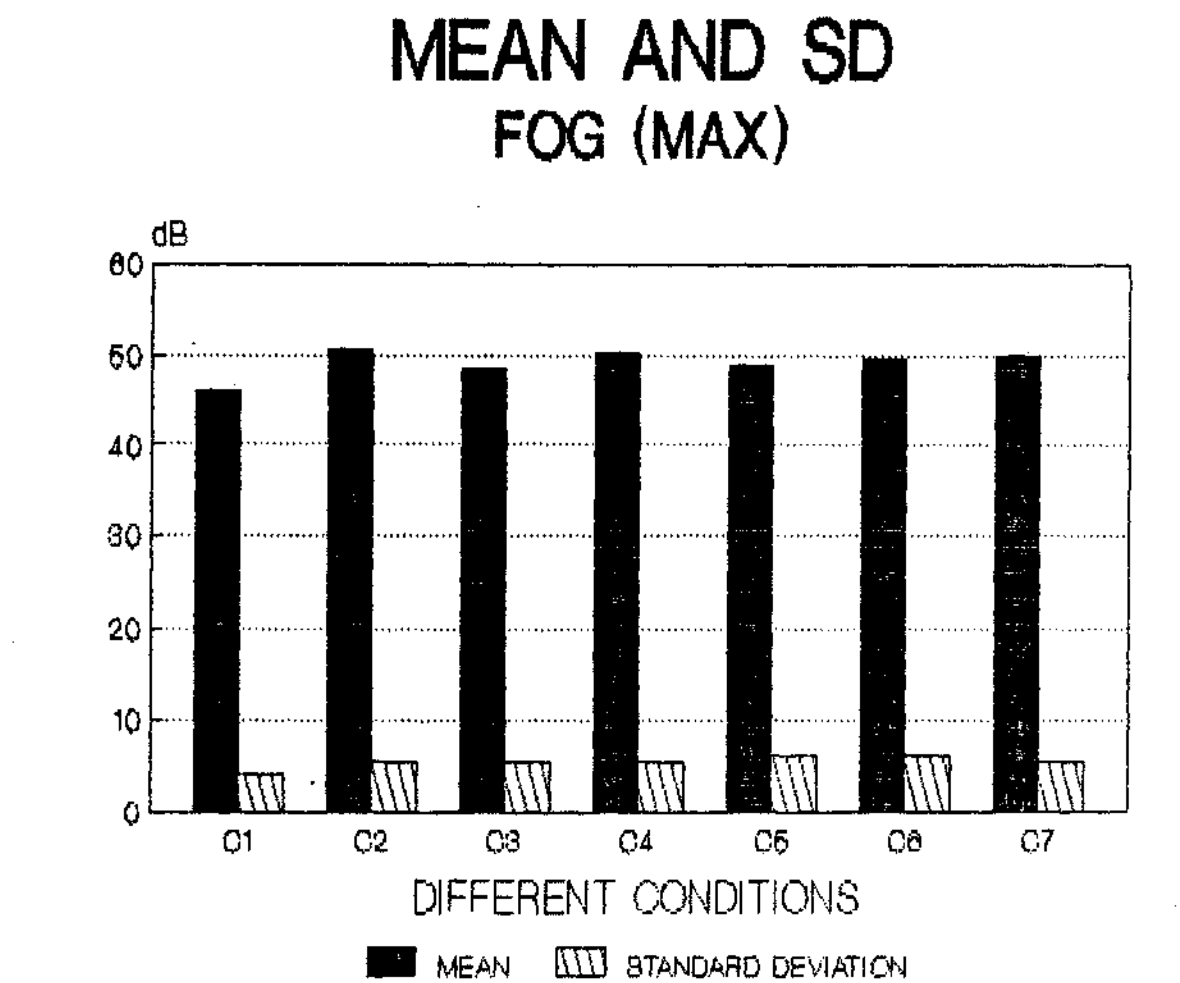
MEAN AND SD
FOG (MAX)
dB
60
50
40
30
20
10
0
C1
C2
C3
C4
C5
C6
C7
DIFFERENT CONDITIONS
MEAN
STANDARD DEVIATION

FIG. NO. 6

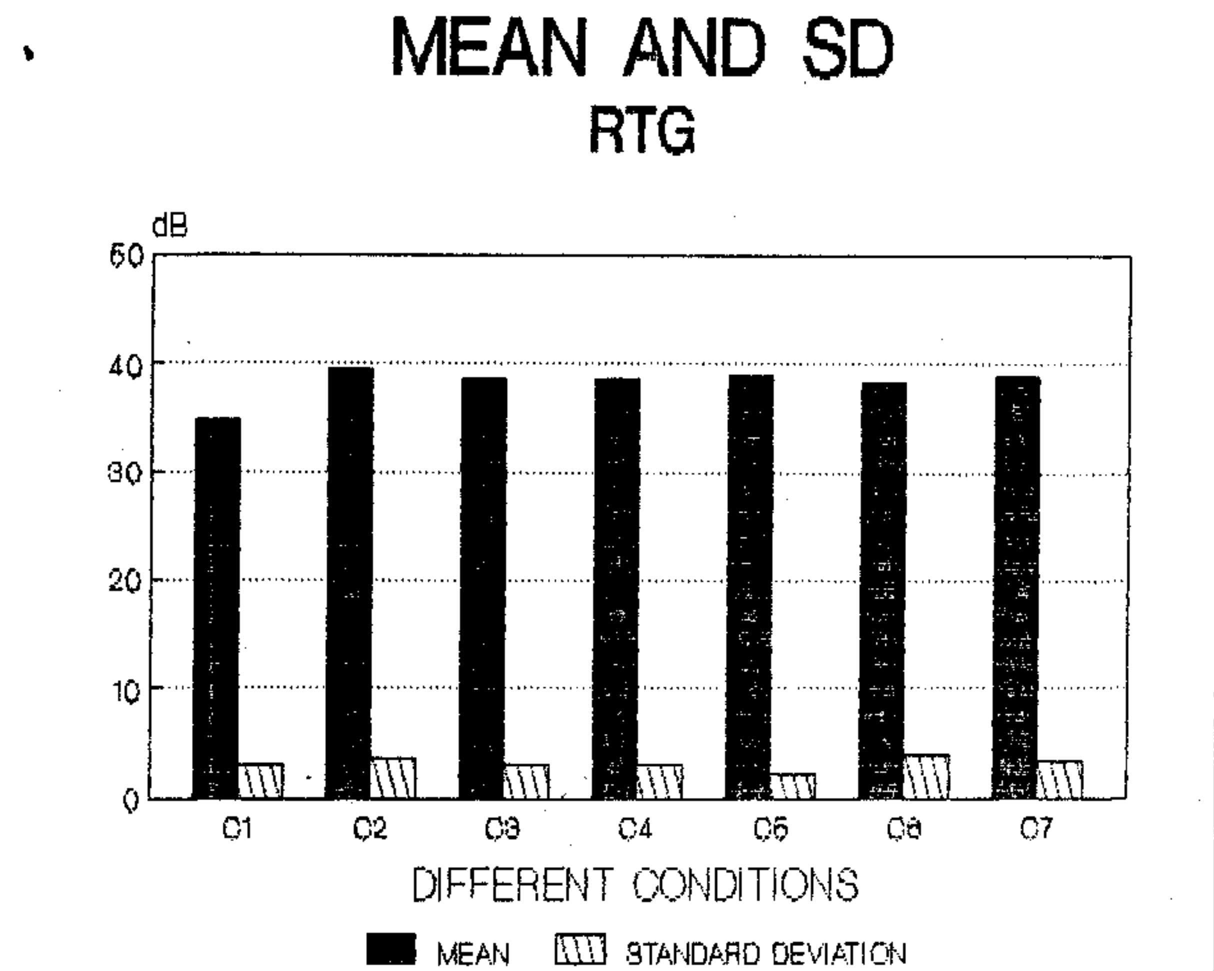
MEAN AND SD
RTG
dB
60
40
30
20
10
0
C1
C2
C3
C4
C5
C6
C7
DIFFERENT CONDITIONS
MEAN
STANDARD DEVIATION

FIG. NO. 7