UTILITY OF HORNS GAIN

Reg. No.M9114

AN INDEPENDENT PROJECT IN PART FULFILMENT FOR THE FIRST YEAR M.SC.(SPEECH & HEARING) SUBMITTED TO UNIVERSITY OF MYSORE-6.

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

1992

To my Dadu, Baba and Ma
who are the light of my life

CERTIFICATE

This is to certify that the Independent Project entitled: **UTILITY OF HORNS GAIN** is the bonafide work in part fulfilment for M.Sc. in Speech and Hearing of the student with

Director
All India Institute
Speech and Hearing, Mysore.

Mysore
1992

CERTIFICATE

This is to certify that the Independent Project entitled: **UTILITY OF HORNS GAIN** has been prepared under my supervision and guidance.

Mysore
1992

Dr.(Miss)S.Nikam,
GUIDE

DECLARATION

This Independent Project entitled: **UTILITY OF HORNS GAIN** is the result of my own study undertaken under the guidance of Dr.(Miss) s.Nikam, Prof. and Head of the Department of 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
1992 **Reg. No. 9114**

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INTRODUCTION

Hearing is a vital link of man to the communicating world, and the hearing-impaired is robbed of this vital experience. Those who have a hearing loss great enough to interfere with communication need to learn about the nature and magnitude of their loss, whether it can be corrected or further progression can be arrested. Following which if the hearing aid is required one should learn how helpful a hearing aid would be, and to learn to use the hearing aid effectively. In this quest for a more efficient sound the field of earmolds has seen a proliferation of the fitting option within a span of time between 1949 to 1991.

From 1949 to 1985, the dispensing community has given a number of earmold fitting option is the area of physical shape, acoustical options, tubing options and earmold fabrication material increase from a simple few choices to now more than 90 options. The result of this growth at the dispenser level has been confusion.

Mynders, 1986.

The currently available option can be broadly categorised into:

1. Physical style options
2. Modular hearing aid models

3. Non-occluding options
4. Antifeedback options
5. Acoustical style options.

Acoustic Modifications.ofEarmolds:

Technological advancement in the field of amplification system has been dramatic improvements in responses and sound quality of hearing aids over recent years, and further improvements can still be made by modifying the sound channel from the hearing aid to the tympanic membrane. These techniques involving the principle of acoustic have been known to science for over a century and to the industry for decades. but have only recently been pat to use.

For the researcher and dispenser, as reported by Gerling (1981), the new earmold technology has some basic philosophic consideration. They are

1. To preserve the balance acoustically between the high frequencies and low frequencies in the normal speech spectrum.
2. To extend the high frequencies in wearable hearing aids.
3. To gradually slant the frequency response of an aid.
4. To keep the output of an aid within the client's dynamic range.

These are accomplished by adjusting the frequency response of the hearing aid with special attention to the earmold and associated planning. Individual adjustments to low, middle and high frequencies with the use of venting damping and horn effects respectively. Can be made (Fig.l). Though, this ought to be interpreted with CAUTION AS THE EFFECTS ARE NOT AS CLEAR CUT AS IS OFTEN IMPLIED.

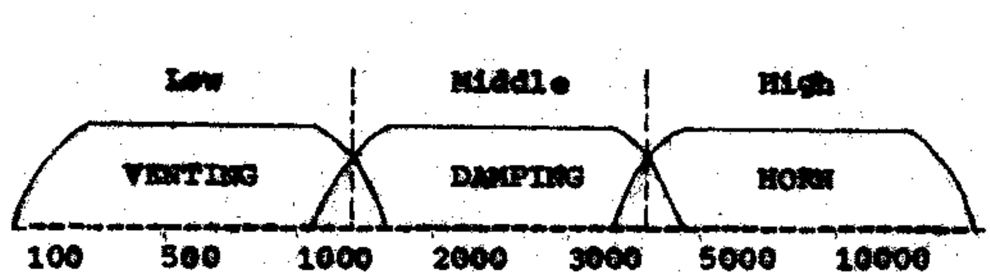


Fig-1 Earmold modification and frequency of influence.

The acoustical style options listed:

by Mynders (1986) include -

I) Parallel vent; (2) Diagonal vent; (3) External vent
4) SAV; (5) PVV: (6) Custom vent; (7) Short canal/wide bore
8) Killion 6R12; (9) Killion 6AM; (10) Killion 8CR
11) Killion 6B0; (12) Killion 6B5 (13) Killion 6B10
14) Killion 6CR; (15) Killion C1O; (16) Knowles dampers
17) Killion 6EF (18) LH 6EFA; (19) LH 6EFB: (20) LH 8CR
21) LH 8CR Freefield: 22)CFA-2: (23) CFA-3: (24) CFA-4

25) CFA MC, (26) OFA 5, (27) Wide range mold: (28) FGM 29) Tubing sizes (30) Tube fitting? (31) Macrae-molds (32) Belled bore (33) Dual bore (34) Advanced design free field mold.

In the present study, an attempt has been made to evaluate the relation between the frequency response of the hearing aid with respect to usage of different types of horns.

Acoustic horn: Killion and Knowles (1978), Killion (1981); Brunved (1985) report of the use of acoustic horn principle in hearing aid response modification. Acoustic horn, as defined by Brunved (1985) is "a tube of varying cross section having different terminal areas that provide a change of acoustic impedance". In hearing aids, the horn provides a better acoustic impedance of hearing aid tubing and the relative low impedance of the ear canal. The result is a reclamation of high frequency energy which would otherwise be lost due to poor impedance match. In other words, the use of horns increase the higher frequencies of the hearing aid response. The effectiveness of a horn is governed by specific acoustic laws with regard to the physical dimension of the horn. Typically a plumbing system having a total length of 00 mm. and terminating with 4 mm. inside diameter at the earmold will start increasing the high frequencies at about 2 KHz and may show upto 5 dB - 8 dB increment at 4 KHz.

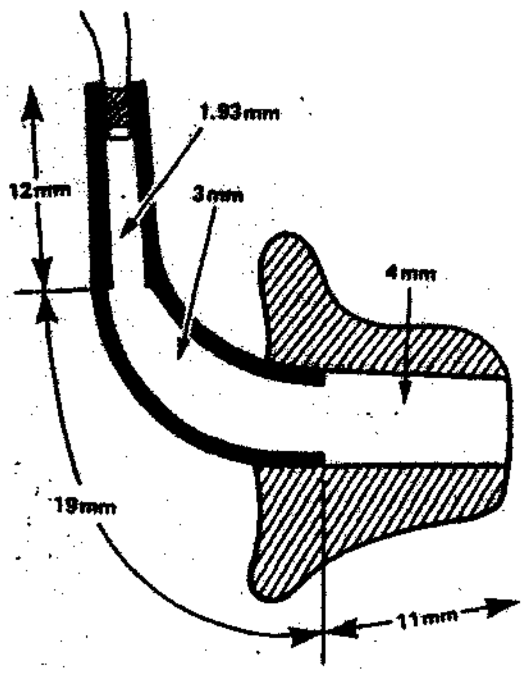


Fig.2: 4 mm Libby Horn.

Libby Horn; The Libby modification of the 8 CR earmold has labelled the 4 mm Libby Horn. The tube is used without internal dampers. The smoothening of response being accomplished by a damper, typically 1500 ohms placed at the end of the earhook for OTE aids.

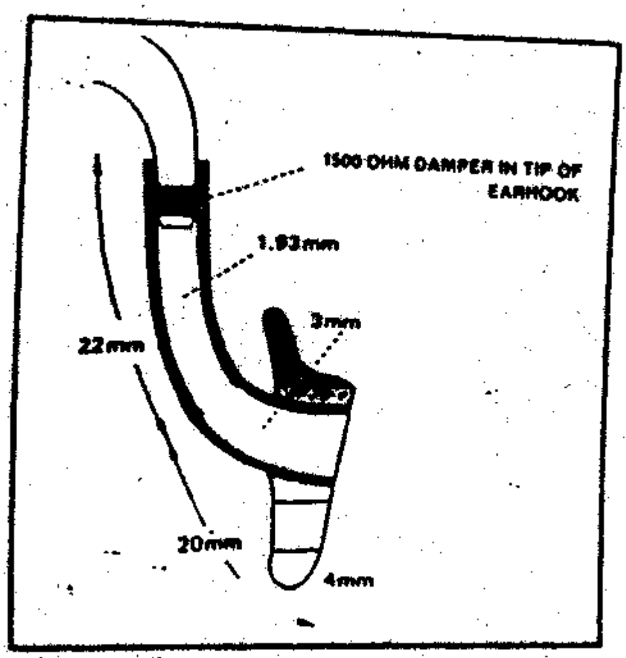


Fig.3: 3 mm Libby Horn

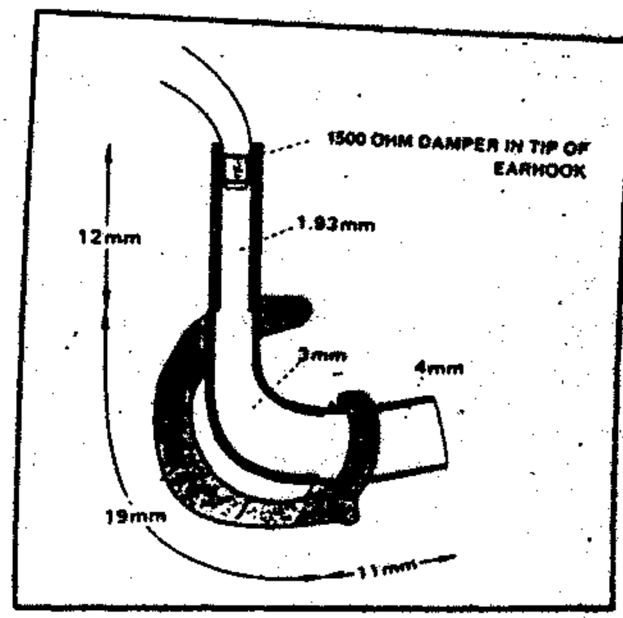


Fig.4: Libby Horn tube with free-field or CROS earmold.

3 mm Libby Horn: It is a modification of the Killion 6 EF dual tubing earmold. He modified it as a single molded piece labelled the 3 mm Libby Horn.

Bakke Horn: An earmold with a Bakke Horn gives practically the same acoustical performance as an earmold with a Libby Horn. In this, the tube is easier to exchange and the mold relatively easier to manufacture. This made up of rigid plastic and can be glued directly into a hard acrylic earmold.

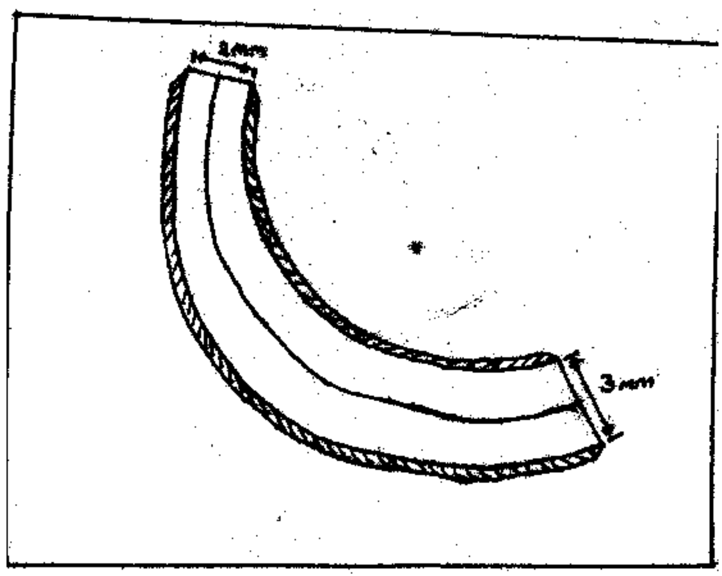


Fig. 5. Bakke Horn

The other devices include -

1. Exponential Horn (Brunved, 1985) which is a horn with cross-sectional area increasing exponentially with axial distance.
2. Killion Horn - This incorporates acoustic horn usually with dumping plug (filters).
3. Reverse Horn - This is a tubing or earmold combination that terminates at the earmold with a smaller internal diameter

than that of the tubing, thus rolling off the higher frequencies (opposite of acoustic horn). In other words, it can be used to reduce high frequencies in a prescribed controlled and reversible manner. This was reported toy ELY (1981).

Need for the study:

1. To know the frequency characteristics of different Behind-the-ear hearing aid as the canal diameter of eanmold is varied ie 3 mm, 4 mm, Libby Horn, Bakke Horn.
2. To find out among these three horns which one is most effective interms of frequency response.

REVIEW OF LITERATURE

The field of audiology and audiological rehabilitation is recent. It started only at the time of second world war. And the field of earmold is more recent than that. The concept of usage of horns is even more recent than that of earmold. "Use of horn", this concept was started at around nineteen seventies, by Lyberger (1970) and Knowles and Killlon (1978).

The acoustic horn, as defined by Brunved (1985) is "a tube of varying cross-section having different terminal areas that provide a change of acoustic impedance" .

The earmold with horns give a narked improvement in reproduction of high frequency sounds especially in connection with wide-range hearing aids. This is accomplished gradually or in steps increasing the internal diameter of the hearing aid's plumbing, consisting of sound hook, tubing and earmold. The tubing diameters are commonly on the order of 1 mm internal diameter (ID) tubing at the receiver, 1.3 to 1.4 mm(ID) through the earhook, 1.9 to 2 mm (ID) in the coupling tubing which extends from the hook to (and generally through) the earmold.

Advantage/Use of Horns:

- It gives a marked improvement in reproduction of the high frequency sounds especially in connection with wide range of hearing aids.

- Users have reported that the sound is more pleasing, natural and less tiring.
- The intelligibility of speech is much better especially in noisy environment (Pascoe et a1. 1973: Triantos and McCandles, 1974) cited by ELY (1981).

There are several horns and their modif ications are reported in the literature. A renaissance earmold tech-. nology has resulted from the contribution of Killion whose objective was to produce wide band and flat or smooth insertion response curves.

The major Killion series of earmolds reported by Killion, 1981; include the following -
1) The 6R12 earmold; (2) The 8 CR earmold (3) The 6 AM earmold (4) The 6 BC series of earmold (5) The 16 KLT earmold 6) The Bakke horn (7) Modification of the 8 CR earmolds by Libby, called Libby modification of the 8 CR.

<u>The 6R12 Earmold</u>: (Ref.Fig.6 Page No.12)

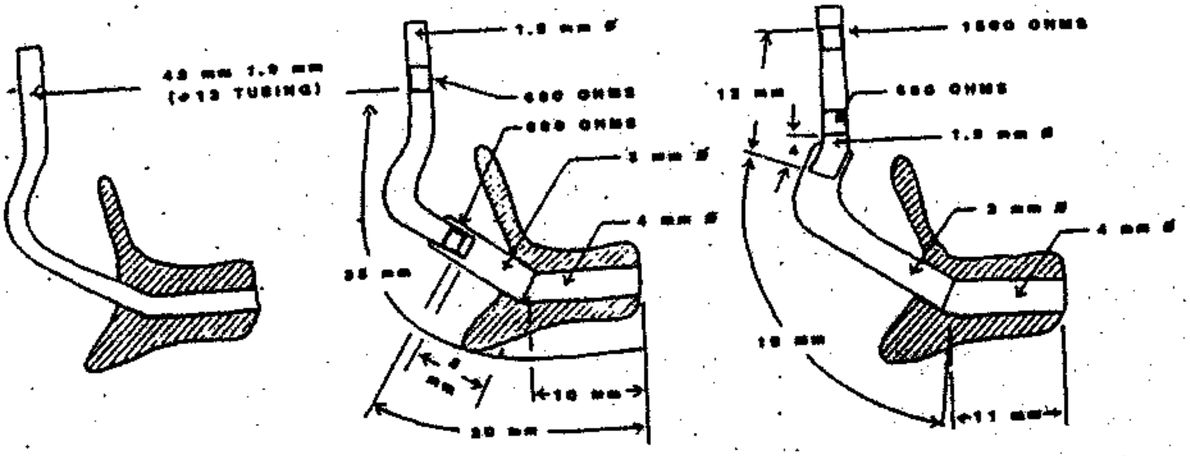
It has a high frequency cut-off at approximately 6 KHz, and the frequency response curve rises approximately 12 dB between 1000 and 6000 Hz when measured in Zwislocki coupler, The 'R' stands for "Rising response". The construction of this earmold is such that changing from a standard earmold with No.13 tubing to a 6R12 earmold generally reduces the resonance peak around 100 Hz by approximately 10-15 dB, and increases the output in the 4000 to 6000 Hz region by about 5 dB. The work of Pascoe (1975); Harford and Fox (1978) and Schwartz et al. (1979) indicates this increased high frequency gain may substantially improve auditory discrimination ability. Additionally, Lawton and Cafurelli (1973) showed that the smoother response and increased high frequency gain provided by the 6R12 earmold also results in improved quality judgments.

<u>The 8CR earmold</u> (Ref.Fig.7 Page No.12)

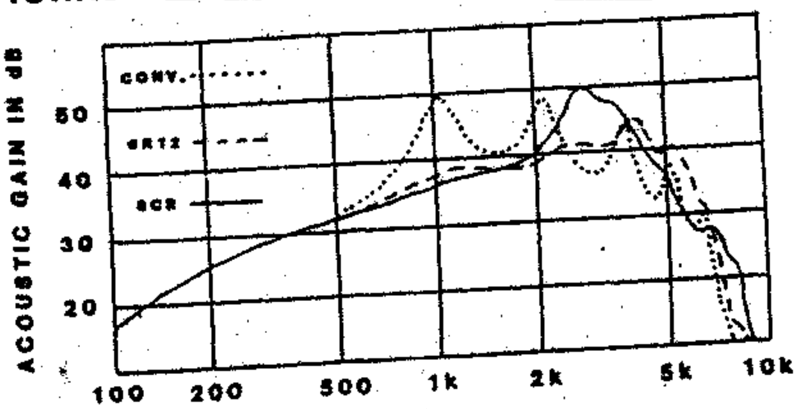
It has a high frequency cut-off at approximately 8 KHz The designation "CR" refers to "Canal Resonance" compensation. According to Killion (1980), this earmold is constructed so that a wave length resonance occurs at about 2700 Hz to compensate for the loss of external ear resonance that occurs when the earmold is placed in the ear canal. Kallion (1980) has suggested that a morenatural sound quality is obtained with this earmold. However, if loudness tolearance is a problem then more acoustic damping is required to smooth the large resonant peaks at 2700 Hz and 8 KHz to acceptable levels.

<u>The 6 AM earmold:</u>

It has an approximate cut-off frequency at 6 KHz. This earmold is vented to achieve a low frequency roll-off effect in addition to the improved acoustic transformation of high frequency energy. The vent in this earmold is short with

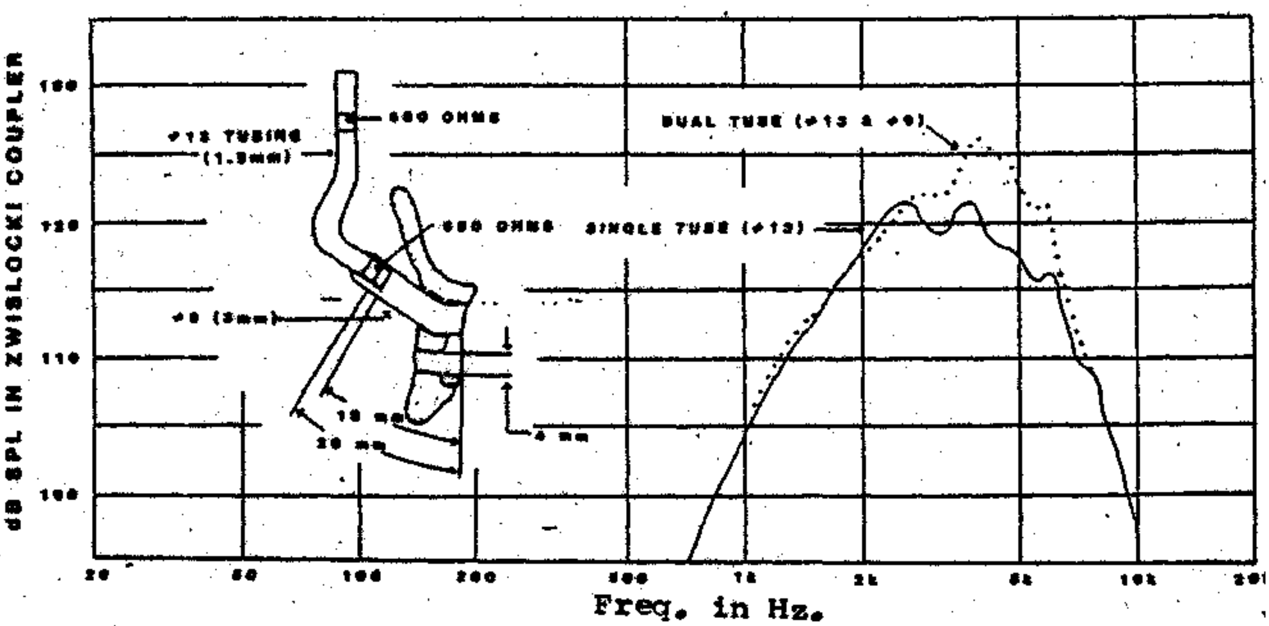


CONVENTIONAL Fig.6 6R12 Fig.7 8CR



Freq. in Hz

A 2 cm^3 coupler response of a wide band aid with conventional(dotten line),6R12 (broken line) and 8 CR (solid line) earmolds.



Zwislocki coupler response of a wide band reciver with a 6 AM

Acoustic modifier" earmold.

a wide diameter to ensure adequate low-frequency attenuation. Killion (1977,1980) has noted that a parallel vent in a high frequency earmold produces the desired low-frequency trans mission loss yet has little effect on high-frequency output since the parallel vent functions primarily as an acoustic mass, allowing only low frequency energy to escape out the vent. It is a dual diameter tubing having vented type with a damper in the tube to smooth the response. The vent in this mold consists of a single 5 mm long hole of 4 mm diameter.

The 6 BC series earmolds:

It uses the 'horn effect' and the 'reverse horn effect' to produce upto a 10 dB high-frequency boost (thus, the designation 'B') or a 10 dB high-frequency cut ('C') below the 6 KHz cut-off point. When the internal diameter of the tubing is constant throughout the length of the ear mold (such as in the case with a conventional standard ear mold) the term 6 BC is used to indicate 'no boost' is response.

The 16 KLT earmolds:

It is constructed to allow a smoothly rising response up to the 16 KHz cut-off point. According to Killion (1980) the ‘LT’ designation indicates this earmold is a 'long tube' version of an in-the-ear aid that has been developed by

Halperin et al. (1977) for patients with profound sensori-neural hearing losses below 8 KHz and nearly normal hearing above 8 KHz. At present, to commerically available ear level aid provides gain in this frequency range. It is seen an ear hook with a specific internal diameter is required for this simulated aid to achieve the desired acoustic effect.

The 6 EF earmold(Killion. 1981) :

This earmold was designed to work especially well with the Knowles E.F. receiver, but has found to be effective with nearly all Knowles receivers. It utilizes a dual tubing system, employing 21 mm of No.13 tubing from the ear hook to a terminal section 3 mm in diameter and 2 mm long. In addition to the benefits of the basic dual tubing arrangement, the 3 mm final section allows the insertion of lengths of smaller ID tubing to control the high-frequency response. The 6 EP takes advantage the fact that the outside diameter (OD) of several standard sizes of tubings is 0.116" and that they fit well into the 3 mm final diameter. For smoothening of the response, a 680 ohm damper is used at the end of the earhook on an OTE aid. It's location is far enough from the ear canal to avoid clogging by wax. This was designed to meet two requirements.

1. There should be no damper in the earmold (all. the damping had to be in the hearing aid or ear hook).
2. She earmold should hare a maximum 3 mm sound channel.

Libby modification of the 8 CR earmold:

Libby (1981) found that while excellent acoustical results were obtained using the Killion 8 CR earmold, some practical problems arose including -

1. Accumulation of moisture in the tubing (possibly because of the damper's presence).
2. Cosmetic objections to the multiple tubings required.
3. The difficult in joing the tubings with accurate dimension and
4. the difficulty of replacing the tubing assembly.

To overcome these difficulties Libby has an earmold tube molded in one piece that was generally similar to the 8 CR.

This was invented for meeting three requirements which included -

1. to produce a smooth wide band transparent frequency response,
2. for improved, natural sound quality for speech and music,
3. for better fidelity ratings.

Different sizes of Libby Horn are resorted.

1. The 4 mm Libby Horn - This is a modification of Killion' s 8 CR earmold.

Here the tube is used without internal dampers. The damper is placed at the end of the ear hook, typically it is of 1500 ohms. This was designed to provide a smooth response extended to 8 KHz and a maximum response at 2.7 KHz to compensate for the loss of canal resonance caused by occluding the ear with an earmold. The last 11 mm of the horn was cut to permit the remaining 11 mm of the sound channel of the earmold to serve as the last section of the horn.

Advantages:

- The 4 mm damped horn can produce 10-15 dB greater high frequency response than a standard 2 mm bore earmold above 2 KHz.
- It is useful in obtaining maximum undistorted high-frequency response.

Disadvantage/Limitation:

Though 4 mm Libby horns provide maximum high-frequency response, it has some limitation especially for children where the size of the ear canal is small. The 4 mm horn is larger than 1.93 mm and does not hold the 2 mm dampers. To overcome this problem Killion (1982) designed the 3 mm horn.

3 mm Libby Horn - This horn construction entitled the 6 EF which consists of a 21 mm section of 2 an internal diameter (ID) tubing and a 22 an section of 3 mm (ID) tubing. The 6 EF ear mold .now has been incorporated in the one piece, tapered unit of a 3 mm Libby Horn. This 3 mm bore can easily be enlarged to 4mm when solid portion of the mold is reached so that the final portion ef the 3mm horn can be centered into the eanmold to provide the initial portion of the 3 mm sound channel. It produces peak at about 6 KHz. This is exactly 1.93 mm and holds the 2 mm dampers securely.

Advantage over 4 mm Libby Horn:

- It can be used for smaller ear canal especially for children.
- it is used in cases where less than maximum high frequency response is necessary.
- It can produce 8-10 dB greater high-frequency response than a standard 2 mm bore earmold above 2 KHz.

Diadvantages of Libby Horn:

Although Libby horn provides considerable acoustical improvement, however, some difficulties in practical use have been reported.

- As the tube, horn and earmold are an integrated unit, the tube is difficult to exchange.
- It is noted that the earmold is difficult to manufacture, because it is hard to find room for the horn in the tip of the earmold, unless the tip of the horn is cut away.
- If the internal diameter of the tubing is reduced or blocked in any way, it will lessen the high freqaency response.

Apart from these two Libby horns (4 mm and 3 an) several other modifications are also reported la the literature.

1) <u>2 KHz Earmold design</u>:

Designed molds utilize horn effects to control the high frequency component and damping to control the middle frequencies, made for mild to moderate hearing losses la adults, constituting *the* bulk of the demands for hearing aids. However, these molds required to modification for other population. Eg. Children having canal bore and pinna dimensions too small to accommodate 8 CR and 6R12. Efforts are now being made to respecify current mold design for the smallest ear. Also, those with severe or profound losses may need to have filters removed from their 8 CR or 6R12 molds since the middle frequencies damping may be deleterious. with a patient with severe to profound loss with a mass till it is presumed that maximum gain is needed in the 2 KHz area, perhaps ranging from 1.5 KHz - 3 KHz, Using the quarter wave resonance principles that adds resonance to the 2 KHz area and shifts the primary resonance resulting an improvement in the gain characteristics. Since the wave length is about 16 cm, 2 KHz resonance peak requires an abrupt jump or step tubing diameter at quarter wave length ie 4 mm from bone opening.

2) <u>Bakke Horn</u> (Knowles and Killion, 1983)

In Scandinavia, a relatively simple method of manufacturing earmolds with horns have been developed. A relatively wide channel is drilled or milled in the earmold. The Bakke horn is used, simultaneously functioning as attachment for the tube to the earmold. An earmold with Bakke horn is shown schamatically in Fig.5. It appears that the horn execusion covers the top 30 mm of the sound path to the tip of the ear-mold and that tube is exchangeable. The real ear insertion gain of a normal BTE hearing aid with an earmold with a Bakke horn shows that the frequency range is extended by almost two octaves aad the level of the high-frequency is increased by 10-15 dB, while the masking resonance in the middle frequency range is redxtced by approximately 4 dB. It gives practically the same acoustical performance as an earmold with the Libby horn with the Bakke horn.

Advantages:

- the tube is reportedly easier to exchange.
- it is relatively easy to manufacture
- the Bakke horn is made of rigid plastic and can be glued directly into a hard acrylic earmold.
- for use ia connection with soft earmolds, another version of the Bakke horn the Bakke horn 'S' with a large flange and fastening area is available.

In case of narrow earcanals, difficulty could be encountered in obtaining a round opening of 4 mm in diameter in the tip of the eanmold. A 4 mm round opening is not essential, however. Therefore, in the area of the opening, it is possible to benefit from the fact that the ear canal often has an oval cross section and make the top part of the opening oval or partly without wall, as proposed fey Knowles and Killion.

The folded horn:

N.U - *E*ar electronics engineers have developed folded horns. When incorporated into as in-the-ear or in-the-canal hearing aid produces following measurable characteristics.

1. Extended useful frequency range to 9000 Hz.
2. Significant smoothening of high frequency peaks.
3. Acoustical resonance developed at 2700 Hz to offset the loss of canal resonance and sensitivity created by hearing aid insertion.
4. It produces an acoustical resonance of 2700 Ha to compensate for loss of canal resonance and if effectively flattens all other peaks, providing a smooth insertion gain response. Dampening title resonant peaks also means more useful gain without feedback serendipity that would not go unnoticed by the hearing aid filter.

The Libby horn with CROS earmold:

The Libby horn in CROS *m*old configuration with damper in tip of ear hook was designed to be a stepped here version of the typical cross eermold fitting. It can also be used as a tube only.

Research ON smooth wide band frequency responses:

The achievement of the optimal fitting hearing aid/ coupling system has been a goal for persons with impaired hearing. The search for important electroacoustic parameters is apparent in hearing aid literature. Considerable interest has been generated during the previous ten years regarding two major issues. The width and the smoothness of a frequency response. Recent developments in hearing aid receiver and earmold designs have generated this interest because they propose extending the high frequency range of aids as well as smoothing possibly deleterious resonant peaks.

The most widely known developments have been referred to as the "earmold plumbing" approaches described by Killlon and Libby horn. These approaches vary in the high frequency range provided, slope of frequency response and the characteristics of frequency response smoothness either completely or with a peak around 2.7 KHz. The propose of the 2.7 KHz peak is to compensate for the loss of ear canal resonance due to earmold occlusion. Libby suggested that the goal of hearing and fitting should be eo enable listeners to achieve maximum speech intelligibility and "natural" sound quality, so that they are not aware of wearing the aid until it is removed.

Rezon (1980) compared speech intelligibility perford-inance of 11 people with hearing-impairment wearing an experimental, extended high frequency range hearing aid and a 6R12 earmold with each persons individual hearing aid and conventional earmold. She found better performance with the experimental aid.

Mueller, Schwartz and surr (1981) examined the performance of subjects with sensori+neural hearing loss/wearing a conventional CROS mold and a CROS mold with a tapered horn. Results showed improved functional gain for the tapered horn in the 4000 Hz to 6000 Hz range, indications of better quality with the standard CROS mold, but it is not clear that whether the tapered horn actually smoothed the response or the difference between the responses was only in the high frequency range gain.

Grave and Metzinger's (1981) reported increased functional gain at 2000 Hz and 4000 Hz with an undamped Libby horn compared with a conventional earmold for 15 children with serveto profound hearing-impairment.

Regarding clinical experience, Libby (1980) found that 70% of a clinical ease load preferred a hearing aid with an 8 CR earmold and 20% could not tell the difference. The 8 CR earmold reportedly provides a smooth wide band response through

8000 Hz. Killion (1980) reported that significantly higher fidelity ratings were obtained with a smooth response obtained via a damped 'earmold (80%) versus a peaked response via as undamped earmold (63%).

Soeholt and Hoffman (1982) studied the usage of diffe-rent horn bores (ie Libby horn, Bakke horn, horn with ring and adapter open mold with Bakke horn) in patients with a hearing loss of less than 80 dB HL. Results showed improved speech discrimination scores in background noise. Many patients who suffer from tinnitus were relieved of their condition when fitted with a hearing aid with smooth frequency characteristics and an earmold with horn bores.

Dalsgaard and Jensen (1983) studied the real ear insertion gain of a normal behind-the-ear hearing aid with earmold with a Libby horn. The frequency range is extended by almost one octave, and the level of the high frequencies is increased by 10-15 dB, while the masking resonance in the middle frequency range is reduced by approximately 4 dB.

Bakke horn gives the same results as Libby horn.

F ernades and Cooper (1983) reported improved sound quality, and sound clarity, an increased word intelligibility and open feeling on nine college students aged 18 years to 24 years.

fitted with hearing aid with Libby horns as compared to conventional earmold. The degree of hearing was serve to profound high frequency loss.

Muller, ischwartz and Surr (1981) compared the Libby horn, open ear mold with c-hooked carrier, to the traditional CROS mold with standard 13 tubing and demonstrated that the Libby horn provided more functional gain in the frequencies (in 4-6 KHz) But discomfort reported due to width of the 4mm tubing so Libby developed a 3mm horn earmold for use in smaller ear canals.

Mueller et al (1981) reported that 3 mm Libby horns were used more favourably than 4 mm Libby horn due to greater comfort. Study by Pas Loe (1975), Jerger and Krelin (1968) and Harford and Fox (1978) have suggested that in general the best hearing aids for speech identification are those with extended high frequency amplification and a smooth gently rising frequency response.

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Lavton and Caferrelll (1978) said that smoothing the response and extending the band width of a low powered National Health Service hearing aid would improve both discrimination and sound quality for a group of experienced hearing aid users. They utilized the 6R10 design (Killion, 1976).

Pederson (1984) reported that venting of earmolds with a narrow borewould ventilate the earmold with minimal effect on the frequency response. The use of a "Libby Horn" instead of She 8 CR design might offer similar acoustical advantage without the need for filters with their attendant condensation and cosmetic problems.

Gabrielsson (1965) have shown the sound quality is the most important factor in subjects acceptance of hearing aids.

Robinson and Cane and Lutman (1939) compared and stepped earroold of the 8 CR design with a standard constant bore ear-mold on subjects of steeply falling type of hearing loss. And it was found that stepped earmold was preferred by subjects.

Burgess and Brooks (1991) took 22 subjects with predo-minantly high frequency hearing loss. The compared the perfo-mance of earmolds having conventional 1.9 mm through tubing with earmolds fitted with a smooth horn with a final internal diameter of 4 mm.

It is found that subjectively the horn filling was rated as clearer, more natural, undistorted and acoustically comfortable objectively by both Bekesy audiometry and in the ear pressure measurement, the horn gave more gain in the higher frequencies. With the horn there was improved recognition of phonemes, especially fricatives/and affricates.

METHODOLOGY

Selection of the hearing aid :

A total of 10 (ten) behind- the -ear hearing aids were taken-up for the study. Out of these 10 hearing aids, six hearing aids belonged to the used group.

Selection of horns (earmold):

Horns of different sizes (3 mm Libby, 4 mm Libby and Bakke horns) were selected randomly.

Selection of battery:

1.5 volts standard pen torch batteries were used.

Test environment:

Test was carried-out in an air-conditioned and partially sound treated room. The ambient noise levels inside the room was within permissible levels (ISI 0776-1984)).

Instrumentation:

The following instruments were used for study are -1. Hearing Aid Test System (Fonix 6500) 2. FONIX M1.550 instrumentation microphone 3. HA-1 2cc coupler 4. Different sizes of horns ie. 3 mm Libby,4 mm Libby and Bakke horns.

5. Standard HA-2, 2 cc coupler

6. Ear level (BTE) hearing aid adaptor.

Calibration check and leveling:

At the outset hearing aid testing calibration check and leveling was carried-out. After that test was carrier-out according to instruction given in the manual ( ).

Procedure:

The,hearing aid test system (FINOX 6500) was set up as specified by the manufacturers. Leveling was performed each time the instrument was turned on.

1. The microphone (M1550) was inserted into the HA-2 2 cc coupler and the earphone (receiver) of the behind-the-ear hearing aid was connected with the hearing aid adapter. Using a start length of plastic tubing. The tube which is used is. a ? 13 thick wall tubing, and 0.6" long.

2. The aid was placed in the sound chamber. The location of the microphone of the hearing aid was at the reference test point in the chamber.

3. The hearing aid was switched on and the volume/was selected at full on position.

4. The sound chamber was closed firmly.

5. START button was pressed to begin the test.

6. The full-on gain was noted and the volume of the hearing aid was adjusted by lifting the lid of the sound chamber to get the reference test gain.
7. Again by closing the lid continue button was pressed to complete the test. Readings were noted down from the screen.
8. For the same hearing aid, the receiver was then attached to the reference mold. The mold was firmly attached by fun take to a HA-2 2 CC coupler inserted with the microphone (FONIX M1550) to prevent any leakage of sound.
9. Again the electroacoustic characteristics were measured.
10. Similarly using different types of horn molds (4 mm Libby horn, 3 mm Libby horn, and Bakke horn) the electroacoustics characteristics were recorded.

The electroacoustic characteristics measured were -

1) Maximum output sound pressure level at 90 dB input (OSPL 90).
2) High frequency average output sound pressure level at 90 dB input (HFA OSPL 90).
3) High frequency average full-on gain (HFA FOG)
4) Reference test gain (RTG)
5) Total harmonic distortion at 500 Hz (THD at 500 Hz)
6) Total harmonic distortion at 1 KHz (THD at 1 KHz)
7) Total harmonic distortion at 1.6 KHz (THD at 1.6 KHz)
8) Intemodulation distortion at 1 KHz (DP at 1 KHz)
9) Equivalent input noise (SIN)
10) Low frequency limit of the frequency range Fl.
11) High frequency limit of the frequency range F2.

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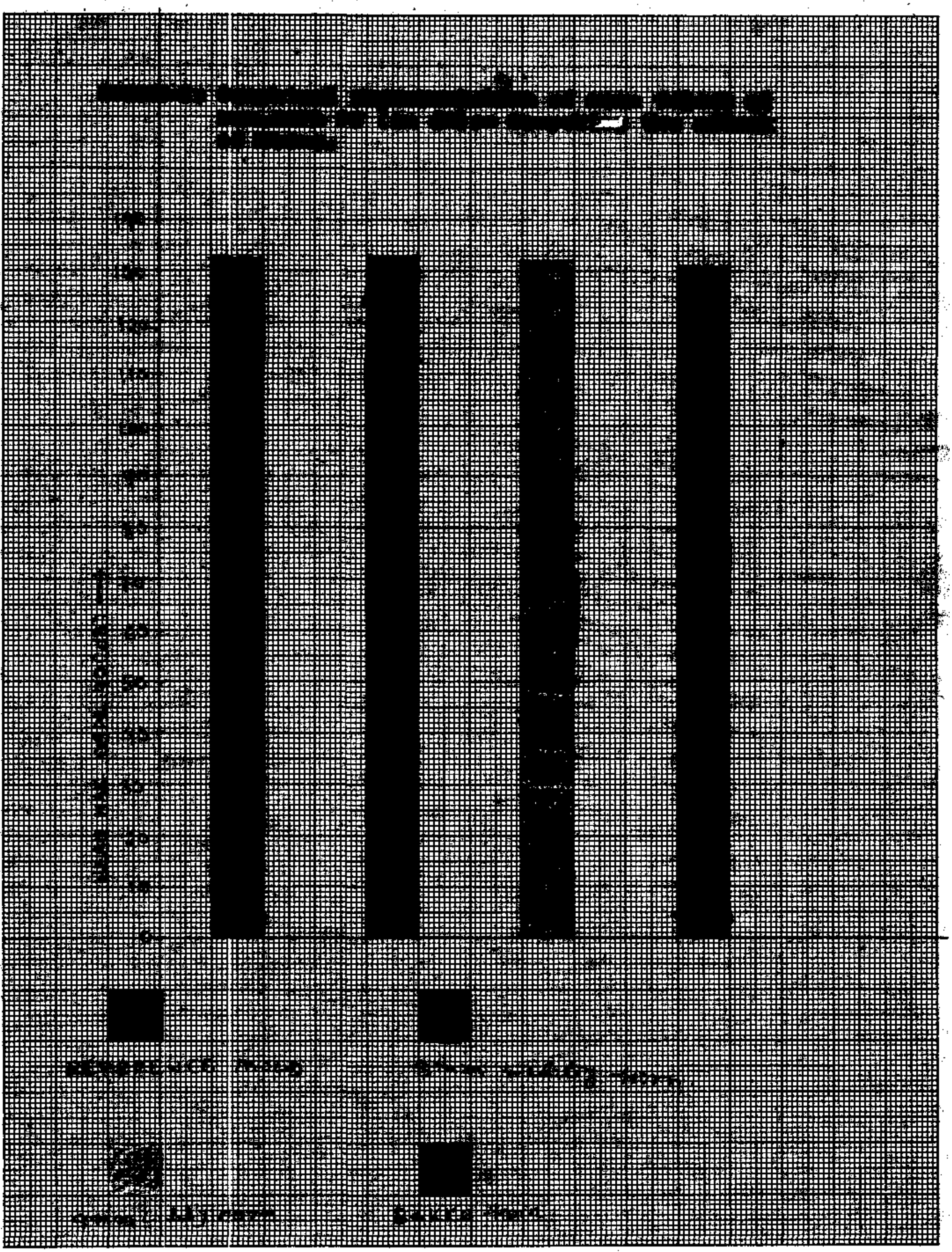

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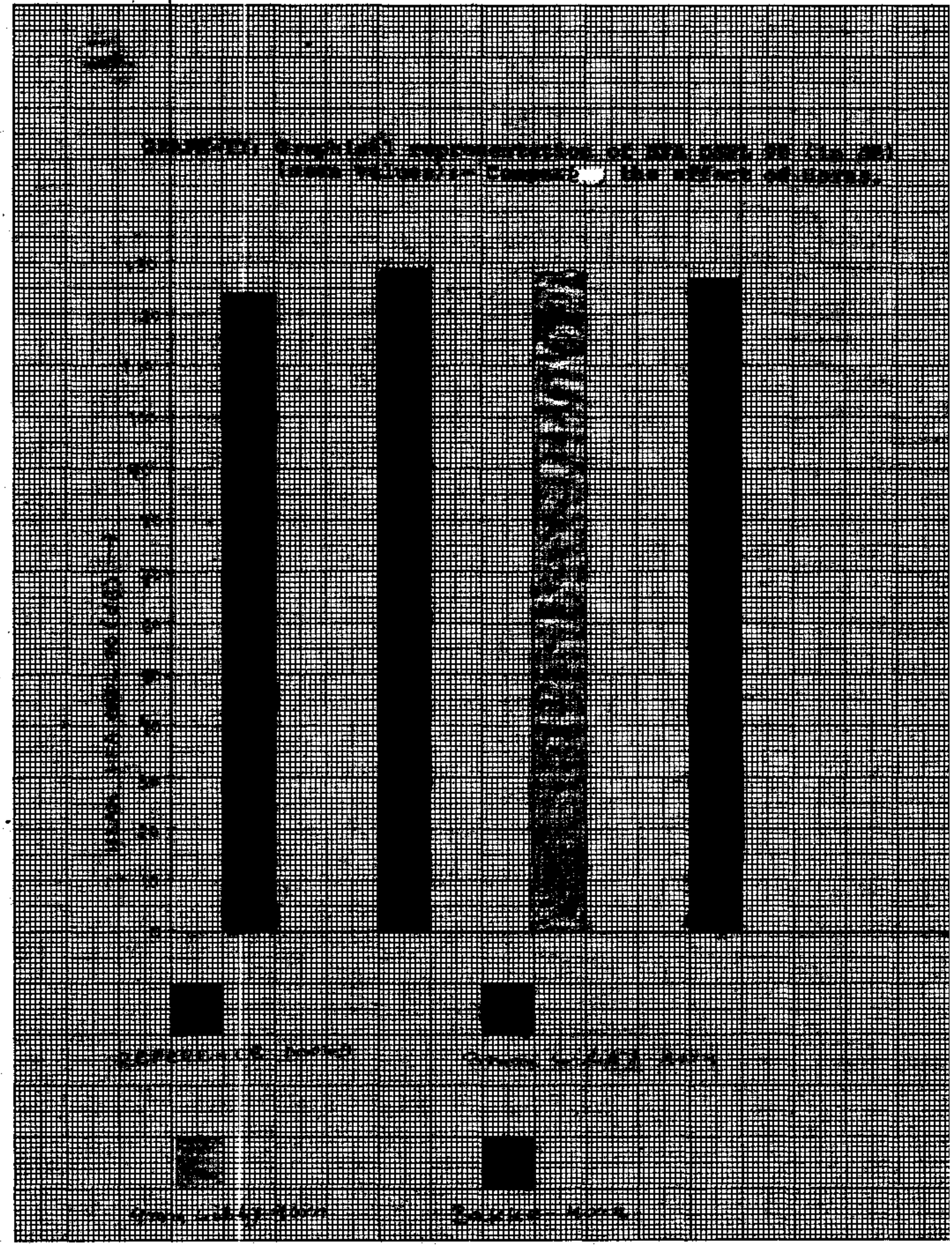

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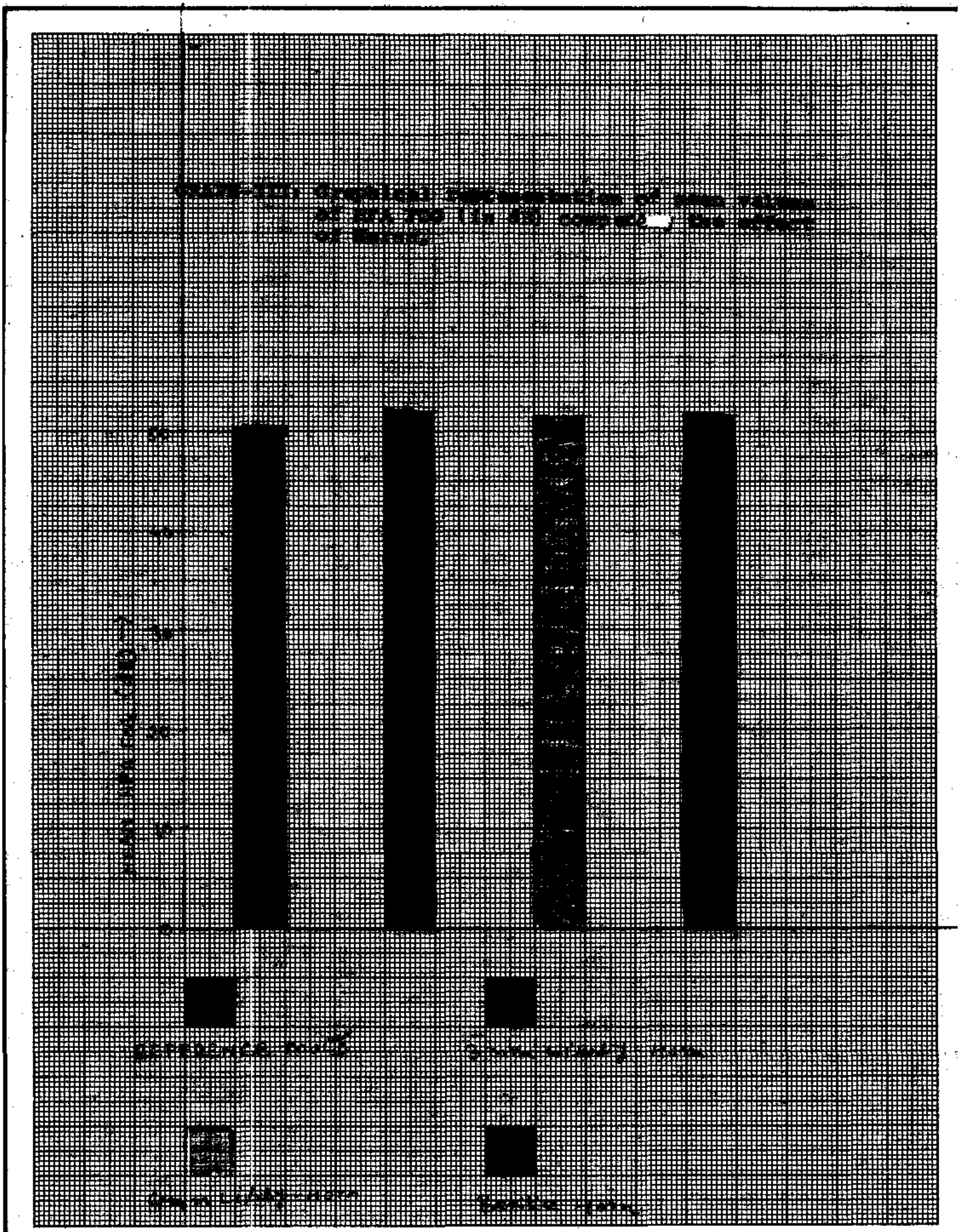

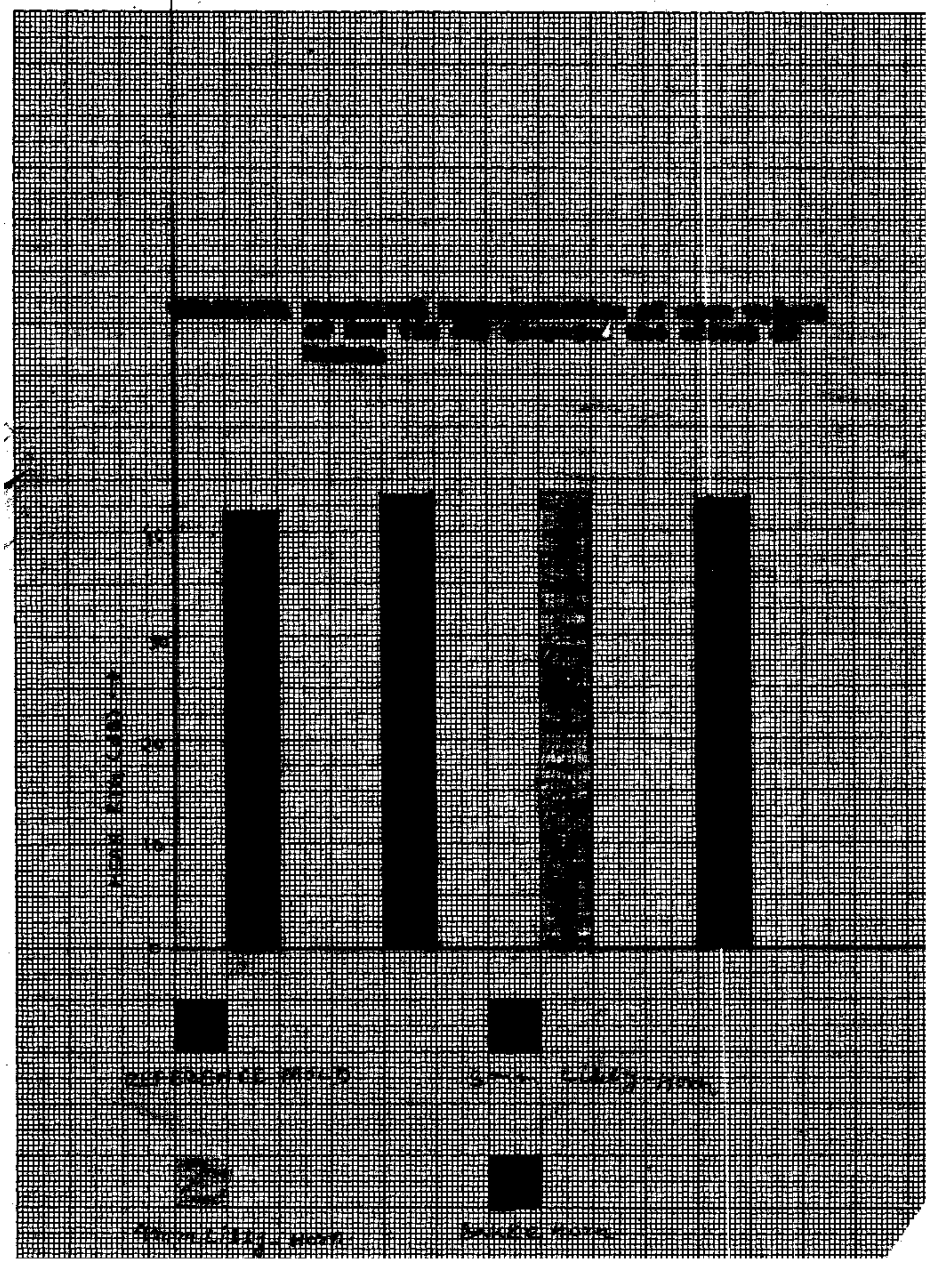

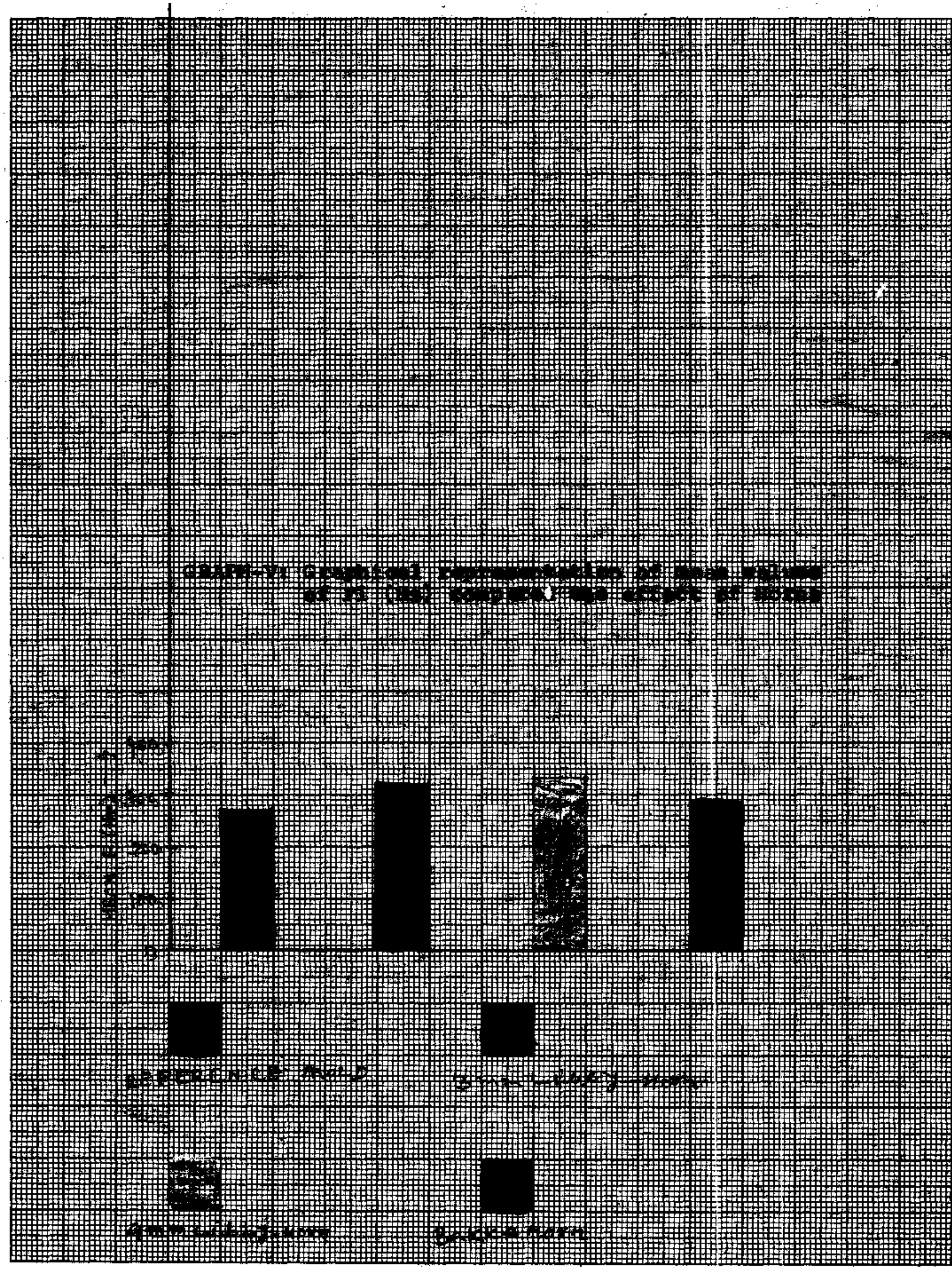

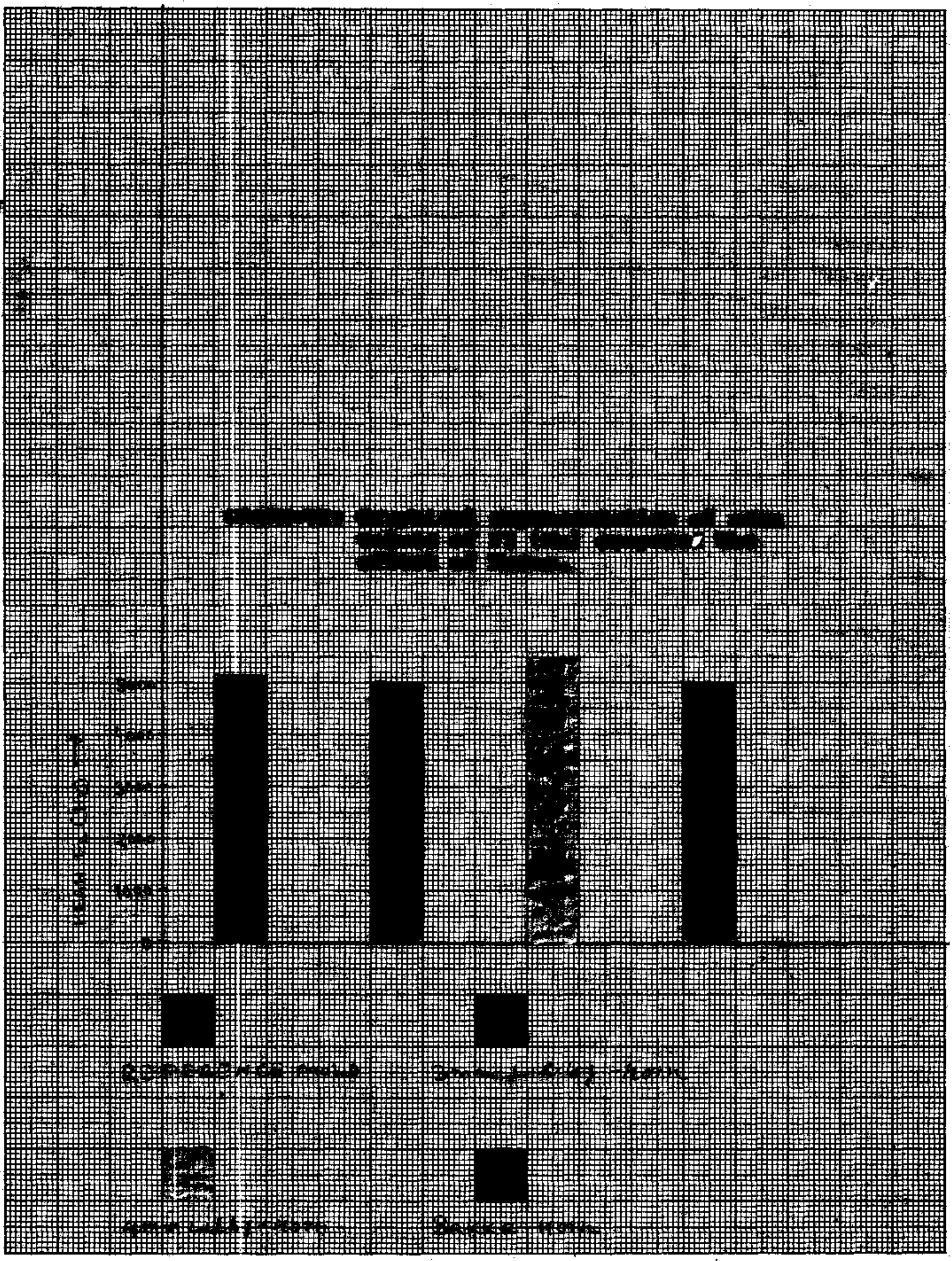

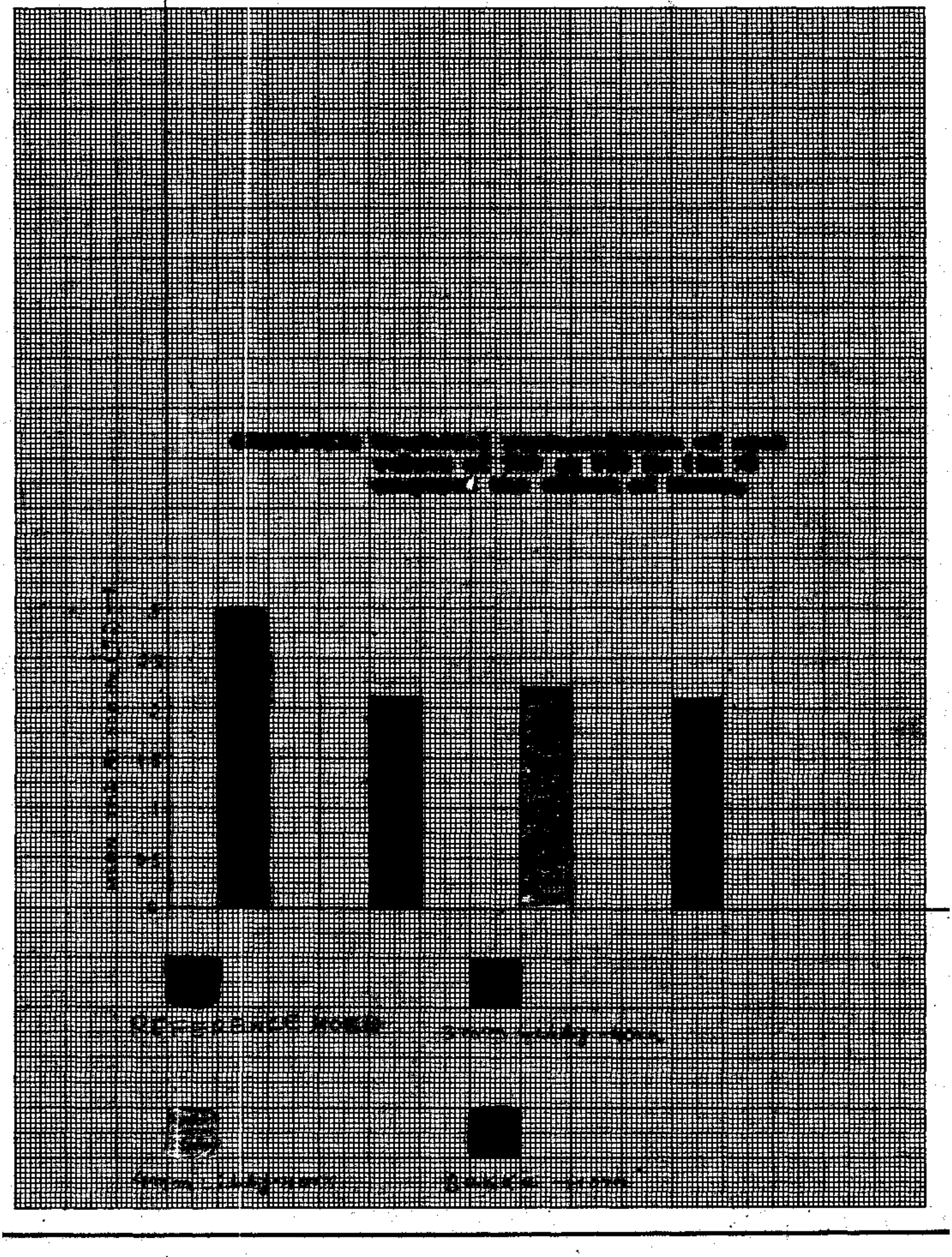

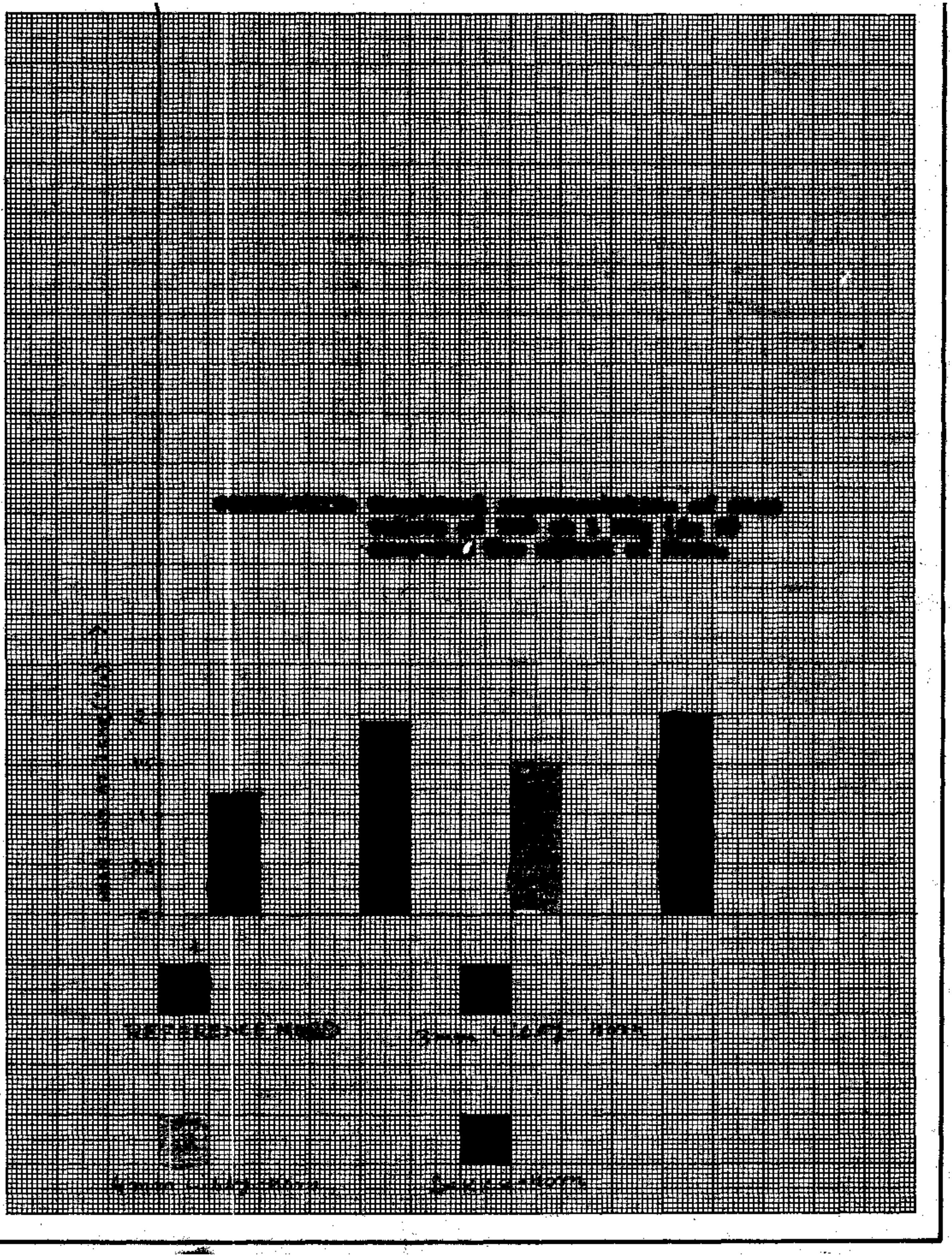

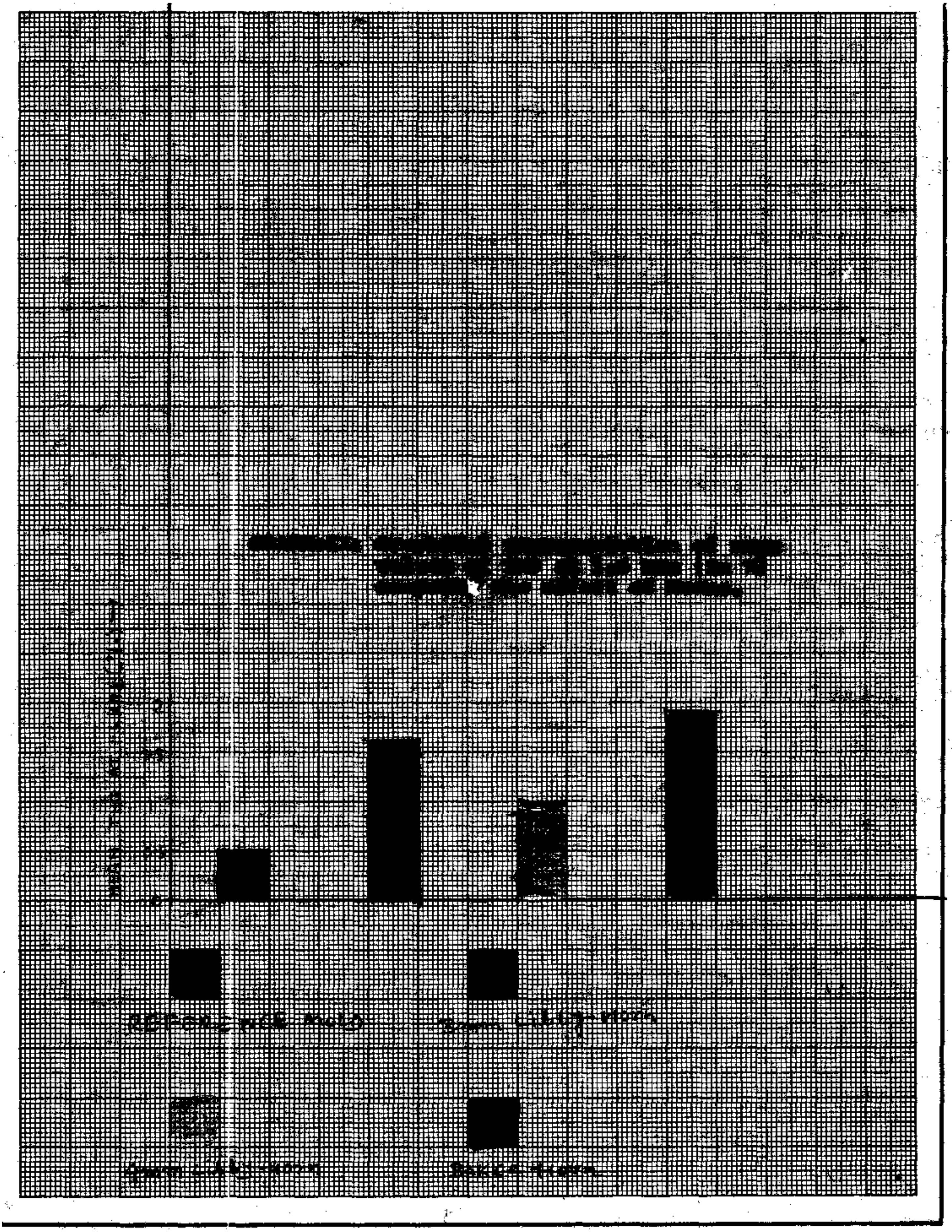

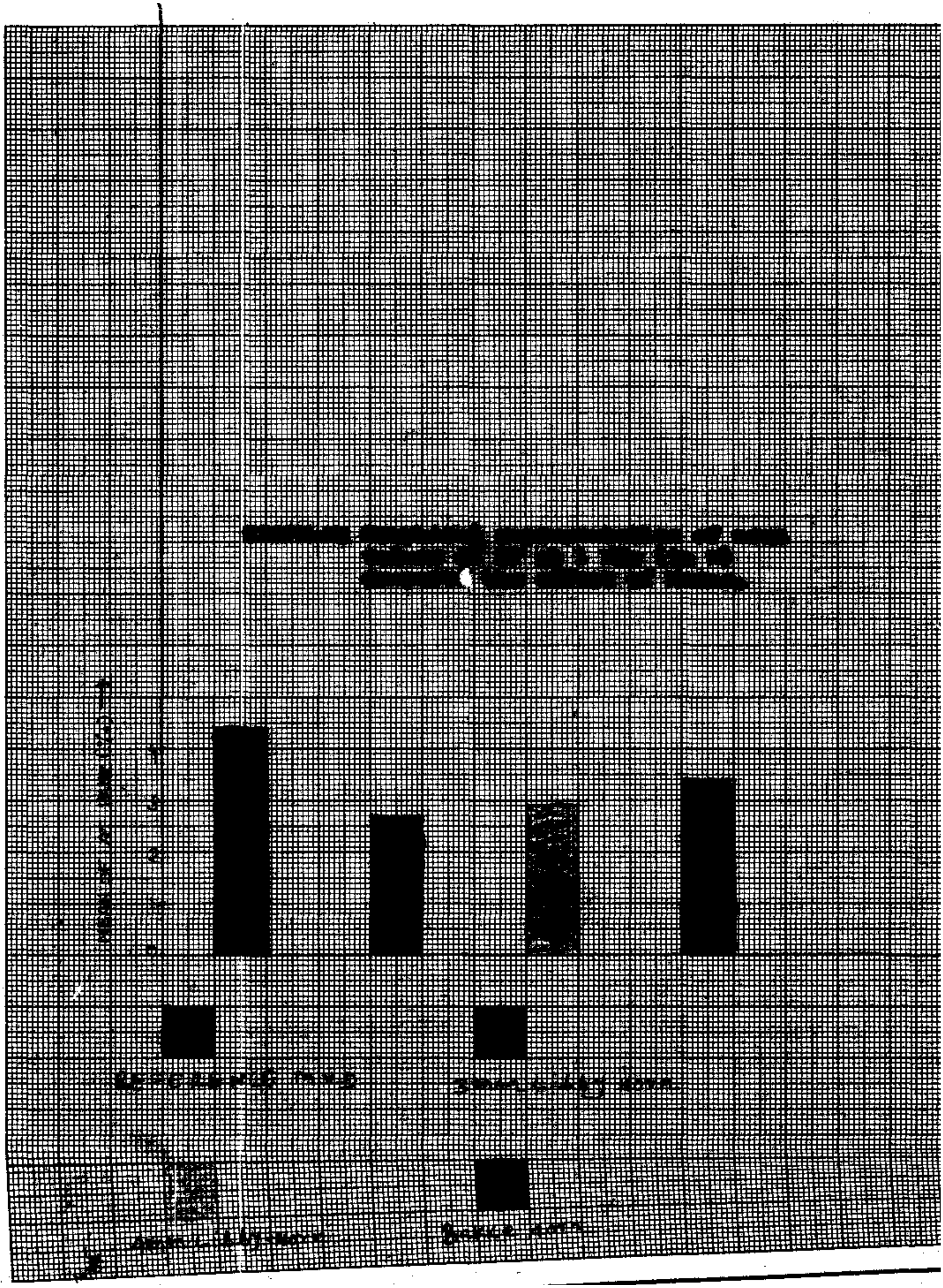

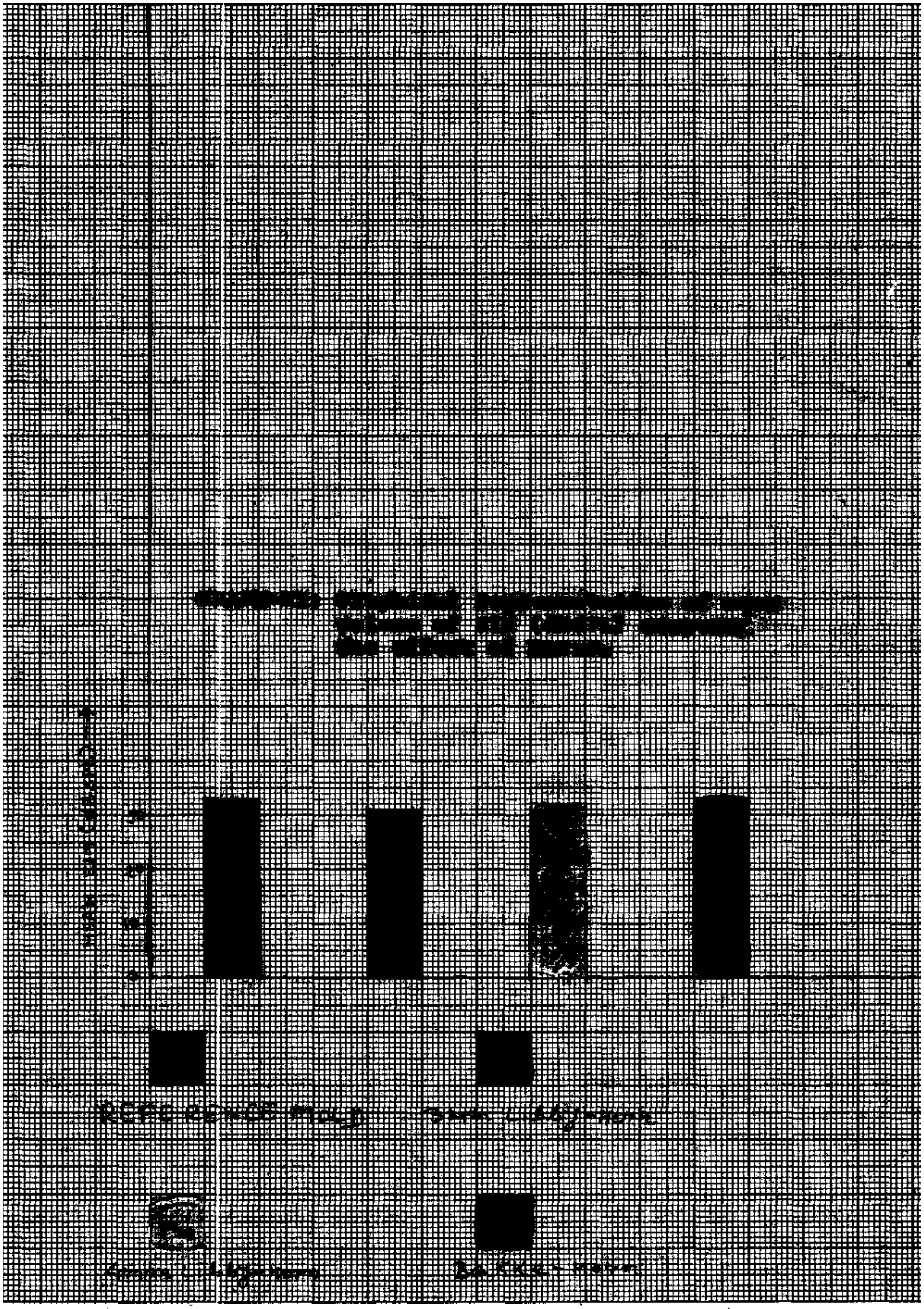

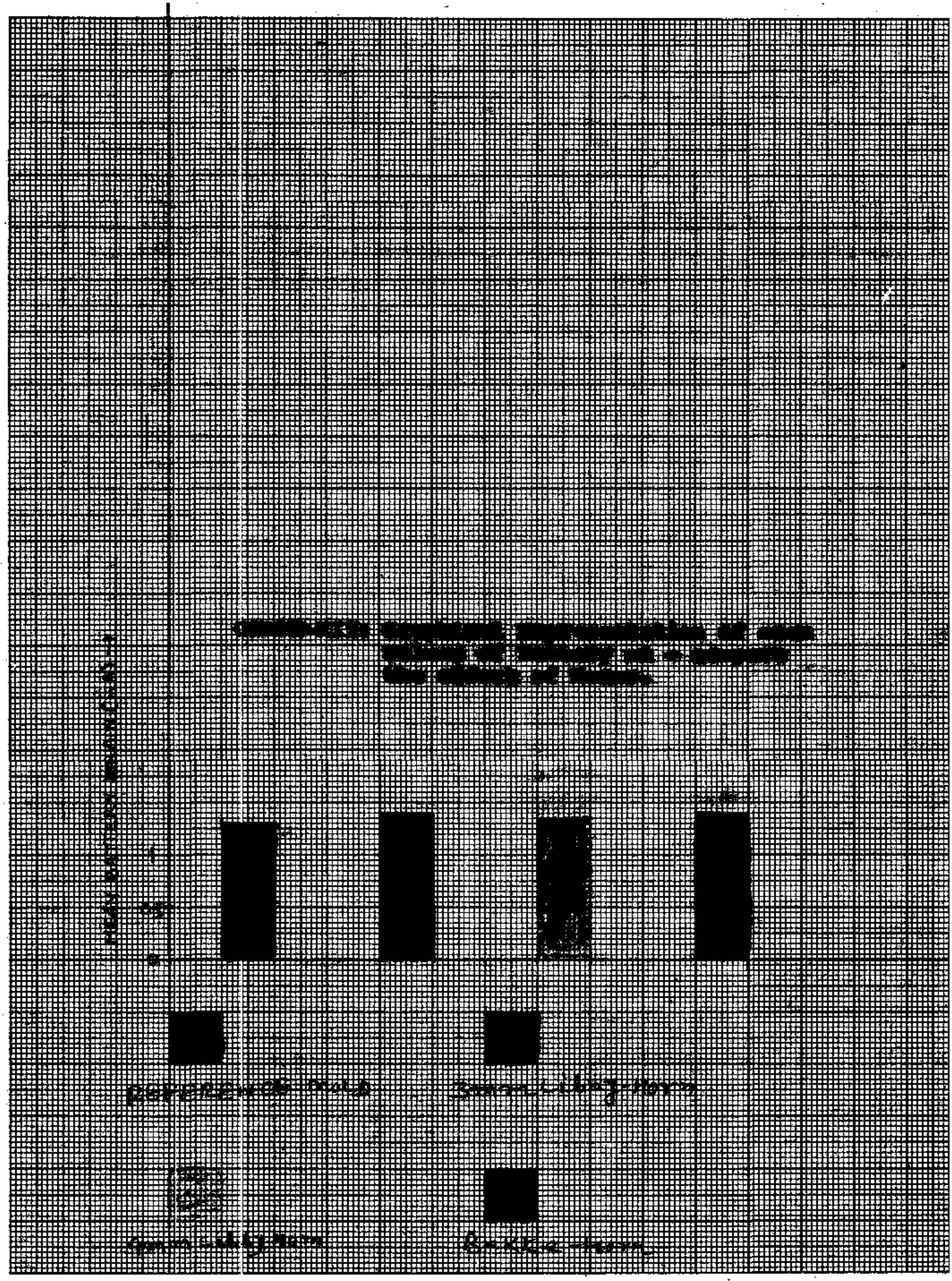

RESULTS AND DISCUSSION

The data was collected based on the methodology described earlier.. Table-1(Appendix-II) shows the number and the different models of hearing aids used. The data was tabulated and the mean and standard deviation values were computed. These are shown in Table-2. Data was also represented graphically.

Statistical analysis was carried out using the 2 way analysis of variance to check for any significant difference for electroacoustic characteristics of hearing aids for the 10 hearing aids. Although the graphical representation of mean values using bar diagram showed differences on several electroacoustic characteristics but they were not found/significant statistically,at 0.05 level(F-0.05).

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SUMMARY AND CONCLUSION

A total of ten BTE hearing aids were taken Up for the study. Electroacoustic characterises of each hearing aid was tested using different types of horns. Statistical analysis was done using 2 way analysis of variance. Data were tabulated and showed graphically.

Results indicated that there was no significant different on the electroacoustic parameters using the three types of horns.

. **Conclusion**

Studies by many investigators have shown that there is an improvement of gain at high frequencies with horn mold as compared to ordinary type of earmolds. But the present study showed contradictory results. This caa be accounted for, by the limited number of sample size utilised.

Recommendation:

- Test should be done on the hearing-impaired persons to check their opinion.

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APPENDIX A

Parameters which are tested were as follows:

1. Maximum OSPL 90 (Output Sound Pressure Level at 90 dB)

It is defines as the highest possible sound pressure level obtained in the acoustic coupler from the hearing aid at any frequency at 90 dB input level.

2. Reference point

It is a point on the hearing aid chosen for the purpose of defining its position, normally the centre of the main sound entry to the hearing aid ie. centre point where microphone is kept while carrying-out electroacoustic measurement.

3. Reference test frequency

1600 Hz is used as a standard frequency for /electro-acoustic measurements.

It is defined as the frequency at which the setting of the gain control is made is relation to the average output OSPL 90.

4HFA OSPL (High Frequency average OSPL)

It is the average output at 3 frequencies like 1 KHz, 1.6 KHz and 2.5 KHz.

.5. Reference Test Gain (RTG)

It ia the acoustic gain of the hearing aid with the gain control at RTG position,

6. HFA FOG (High Frequency average full on gain)

It is the average gain at 1 *KHz,* 1.6 KHz and 2.5 KHz when the volume control is set on full-on position.

7. EIN (Equivalent input noise) Level

It is the hearing aid's ambient noise level even without any input.

8. Total harmonic distortion (THD)

Harmonic distortion is nothing but the ratio between the output sound pressure of the total harmonic distortion products with reference to sound pressure level of fundamental frequency

9. Battery life/battery current

Battery life depends on consumption of current by amplifier. Battery life interns of hours is

$$- \frac{\text{Battery capacity}}{\text{Battery current consumption.}}$$

It is expressed ia terns of microampere.

10. DF at 1 KHz (Intermodulation distortion)

Intermodulation occurs when the output signal certains frequencies that are arithmetic stems and differences of two or more Input frequencies. When two or more signal frequencies (as in Speech) are applied simultaneously at the input it is the result of amplifier routinearity.

11. Frequency response curvet

The basic frequency response curve describes the relative amount of gain as a function of frequency. For this measure, the gain control is set at reference test position and with a constant Input of 60 dB, the signal frequency is varied. The output curve is reconded automatically or manually.

The frequency range of am hearing aid refers to the useful range of the frequency response. It is expressed fey two numbers F1 representing me low frequency limit of amplification and F2 representing the high frequency limit of amplification.

APPENDIX B

Hearing aid test system (FONIX 6500^{R}), showing its various connections.