# EFFECTS OF VARIATION IN LENGTH AND DIAMETER OF ACOUSTIC COUPLERS ON THE FREQUENCY RESPONSE CHARACTERISTICS OF HEARING AIDS

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## Introduction

The acoustic coupler is a device, made out of plastic, that links the hearing aid receiver to the ear. It serves the dual function of chanellising the sound into the ear canal and supporting the receiver to fit snugly on the ear. Thus, it is essential for all types of air conduction hearing aids.

To derive maximum benefit from a hearing aid, a custom acoustic coupler-made from the user's ear impression–becomes a necessity.

The acoustic coupler assumes critical importance in the individual fitting of a hearing aid, because of its increasing use as an acoustic modifier (Ling, 1971). Studies on modification clearly indicate that the hearing aid response can be significantly altered by changing or modifying the structure of the coupler. The major modifications that effect the hearing aid response characteristics are venting, variation in length and diameter of the sound bore of the coupler.

The primary purpose of venting is to attenuate low frequency signals. Vents creates a damping action which effects the low frequencies and enables the amplified high frequency signals to reach the ear (Dadd & Harford, 1968).

According to both American and international standards, the standard length of the sound bore in the acoustic coupler is 18mm and the diameter 3mm. If the bore length is longer or the diameter smaller than the standard, the primary peak will be lower in frequency and the high frequency cut-off is lowered. On the other hand, if the length is shortened or diameter increased, the primary peak will be higher in frequency and the high frequency cut-off is extended (Lybarger, 1972).

## Need for the Study

In actual practice it is difficult to maintain the standard length and the diameter of the sound bore of the acoustic coupler. Individual differences in the size and shape of the ear canal and the type of material used for making the couplers are two of the factors that bring about variations in length and diameter of the sound bore of the acoustic coupler. It is important to know whether these variations have any effect on the response characteristics of a hearing aid and if so, to what extent. It is also essential to know how far variation in length and diameter can be made without affecting the hearing aid response. This study is also of

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importance, keeping in view the subjects with severe hearing loss. Use of open and vented couplers by these subjects limits the hearing aid usuage due to acoustic feed back. This necessitates the study of variation in length and diameter in an effort to help them use the hearing to the maximum possible extent.

**Purpose**

The study was undertaken to study the effect of modification of the standard length and diameter on the response characteristics of the hearing aid and to study the interaction of length the diameter of the sound bore due to modification.

**Experimental Procedure**

Twentyfive acrylic substitute couplers, with varying diameter and length, were used in the experiment and the response with each coupler was recorded in SPL values at each frequency employed. Data was manually recorded and analysed.

The following instruments were used :

Hearing Aid Test Box ( B & K 4217 )

Frequency Analyser ( B & K 2107 )
Condenser Microphone ( B & K 4144 )

2 Cm³ Coupler ( DB 0138 ) and

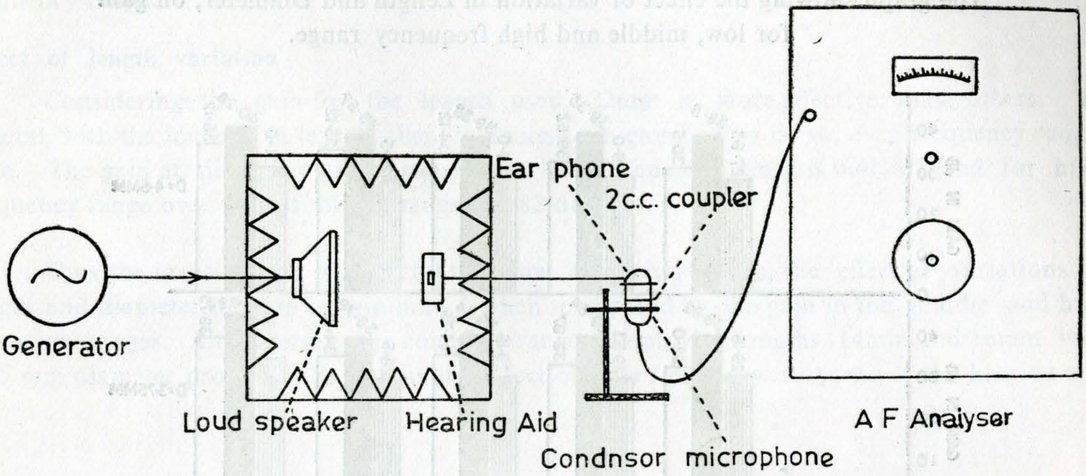
Danaid I Hearing Aid with one Danavox Sub Minor Receiver

Five variations in length (14, 16, 18, 20, and 22mm) and five variations in diameter (1.50, 2.25, 3.0, 3.75 and 4.5mm ) of the sound bore in the acoustic couplers were chosen. Thus for each length there were five variations in diameter and for each diameter five variations in length.

The substitute acoustic couplers made of acrylic were similar in shape and size to the metal substitute acoustic coupler used with the 2 Cm³ couplers.

The procedure followed in this study is the same as the one used in the evaluation of response characteristics of hearing aids. The input level in the Hearing Aid Test Box was 60 dB for all the test frequencies. When the hearing aid was kept in the Test Box, the volume control of the hearing aid was adjusted until the output at 1000 Hz was 100 dB. Following this, other substitute acrylic couplers were used in the place of standard metal substitute keeping volume control at the same position and the output recorded.

Given below is the block diagram of the experimental set up :




The Condenser Microphone was kept inside the Test Box and connected to the Frequency Analyser. The sensitivity of the amplifier input and that of Condenser Microphone in the Frequency Analyser were adjusted and 'K' factor of the Microphone was added. The attenuator knob of the front panel of the Test Box was set to give an input of 60 dB.

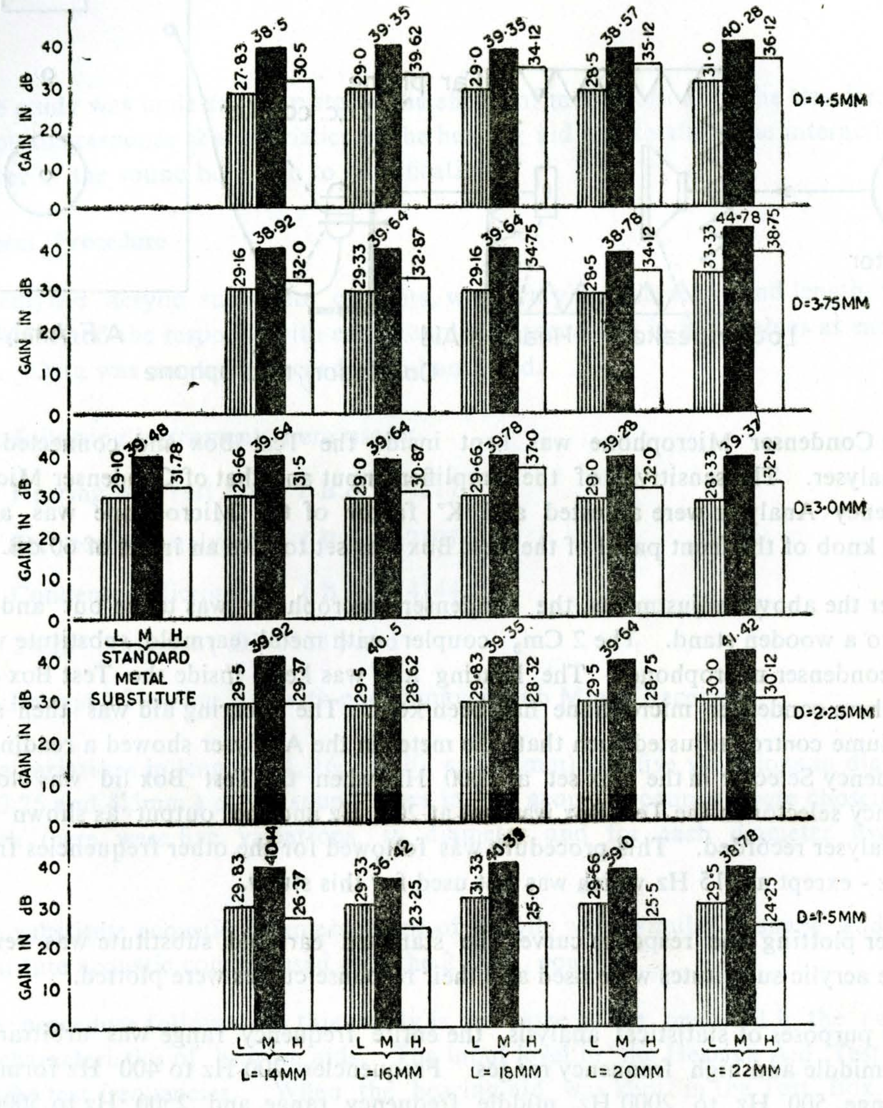
After the above adjustments, the condenser microphone was taken out and was fixed vertically to a wooden stand. The 2 $Cm_3$ coupler with metal earmold substitute was screwed on to the condenser microphone. The hearing aid was kept inside the Test Box in the same position where condenser microphone had been kept. The Hearing aid was then switched on and its volume control adjusted such that the meter in the Analyser showed a reading of 100 dB with Frequency Selector in the Box set at 1000 Hz, when the Test Box lid was closed. Then the frequency selector in the Test Box was set at 200 Hz and the output as shown on the Frequency Analyser recorded. This procedure was followed for the other frequencies from 200 Hz to 5000 Hz - except at 315 Hz which was not used for this study.

After plotting the response curve, the standard earmold substitute was removed and each of the acrylic substitutes were used and their response curves were plotted.

For purposes of statistical analysis, the entire frequency range was arbitrarily divided into low, middle and high frequency ranges. Frequencies 200 Hz to 400 Hz formed low frequency range, 500 Hz to 2000 Hz middle frequency range and 2500 Hz to 5000 Hz high frequency range. The actual SPL output at each frequency with each of the acrylic substitute couplers was noted. The difference in the SPL values from those of the input level were treated as gain in dB.

## Results

The graph showing the effect of variation in Length and Diameter, on gain for low, middle and high frequency range.




**Effect of diameter variation**

On the whole, compared to other diameters, 1.5mm seems to bring an increase in gain at low frequency range, though not to a significant degree and 3.75 mm is effective for middle and high frequency ranges in terms of gain. Another significant point is that while the amount of gain for low frequency range is 0.87 dB for the diameters used, it is 9.63 dB for high frequency range.

**Effect of length variation**

Considering the gain for the length used, 22mm is more effective than others. In general, with the increase in length, there is increase in gain. This is so, even frequency range-wise. The gain at middle frequency range, over low frequency range is 0.41 dB and for high frequency range over that of middle range is 0.82 dB.

Thus the investigation shows that at low frequency range, the effect of variations in length and diameter on gain is minimum, when compared to the gain in the middle and high frequency ranges. Considering the complete range, employing lengths 14mm and 16mm with 2.25 mm diameter produces the minimum effect on the frequency response of the heariug aid.

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वाक्यदोषो नाम यथा स्वल्पस्मिन्नर्थे न्यूनं, अधिकं,
अनर्थकं, अपार्थकं, विरुद्धं चेति ।।

*Speech is said to be defective where there is insufficiency redundancy or want of meaning a misjoinder in sayings.*

(Charaka Samhita 3-8.55)