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SOME EFFECTS OF HUMAN VOICE DIRECTIVITY AND THE LOCAL ACOUSTICAL ENVIRONMENT ON MICROPHONE PERFORMANCE

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1. INTRODUCTION

Microphones often need to be placed in far from ideal positions for both recording and live sound reinforcement purposes. In musical shows and theatrical performance it is often desirable to conceal a miniature radio microphone on the actor or performer but this often results in loss of sound quality and clarity. There would appear to be no published information concerning the effects of miniature microphone positioning and corresponding performance. Even the standard tie-clip microphone position is far from ideal, yet again there is little or no published information. This paper sets out to redress the balance and presents some results from a recent study concerning microphone positioning and also a number of other deleterious effects on microphone performance caused by the local acoustic environment.

2. BODY AND HEAD WORN MICROPHONES

The basic test set up used for the investigation is shown in figure 1. A miniature reference microphone is used to measure the speech signal directly in front of the mouth of the test subject. A second, test microphone is simultaneously used to measure the acoustic speech output signal of the 'talker' at various test positions. Each microphone signal is analysed by a dual channel FFT analyser and the transfer function obtained. The difference between the magnitude of the two signals is plotted as the desired result. The test microphone was calibrated to the reference mic to within better than 0.5 dB, having been first measured to ensure that it had a flat response (within + / - 0.5 dB) over the range of interest.

One of the most common locations for a miniature radio microphone capsule is a jacket lapel or equivalent position. Figure 2 shows the acoustic effect of this mounting position both in terms of signal level reduction and spectral changes. As can be seen the level reduces significantly (equivalent to a loss of 4 dBA). Up to 1.6 kHz or so, the spectrum of the speech picked up is effectively just reduced in level. At high frequencies however (greater than 1.6 kHz) the signal frequency response drops off rapidly, leading to a dull sound with lack of clarity and reduced intelligibility.

Figure 3 shows the effect of the other main, general purpose, mounting position - the tie. As perhaps might be expected, this is very similar in character to the Lapel position, again exhibiting a 4 dBA loss of signal level. However a peak at around 500 to 800 Hz also occurs. This is a well known effect and is caused by chest resonances of the talker. The need for corrective equalisation can be clearly seen, but also the for the first time the exact nature of the problem is highlighted. The high frequency roll off is essentially as per the lapel position albeit slightly steeper.

One of the most popular positions for a microphone in musical productions is to conceal the capsule on the forehead, or within the hair at the front of the head. Figure 4 shows the effect of this mounting position. Apart from an overall loss of signal level amounting to -3dBA, the overall response is not too bad but with peaks introduced at 160 Hz, 1 KHz and 2.5 KHz. A general loss of high frequencies [> 2.5 kHZ] is also exhibited.

An alternative position is to mount the microphone on the ear, at the front. (see figure 5 for illustration of microphone test positions). Figure 6 shows the response graph for this location. An overall level reduction of 5 dBA occurs with a reasonably flat response out to 1.6 kHz, thereafter followed by the familiar HF roll off.

If spectacles are being worn, these can offer a very useful and concealed mounting position. Figure 7 shows the effect of this location. As can be seen a much better overall response is obtained with only 1 dBA loss of signal and much reduced high frequency losses.

Recently, specially developed, miniature flat microphones have been developed for mounting directly on the face. Figure 8 illustrates why this is a good choice from an acoustical point of view. With this mounting position, the high frequency roll off, typical of the other mounting positions, is very much diminished and the overall signal loss is reduced to 0 dBA.

Some further experiments were carried out to look at the way human acoustic (speech) output is affected by microphone positioning below the plane of the mouth but away from the body. Figure 9 compares the spectra and output levels at 100, 200 and 300 mm below the mouth, with that experienced directly in front. The evenness (or otherwise) of the responses is clearly shown as are the relative signal strength losses. Overall reductions of -3 dBA, -7 dBA and -9 dBA were measured corresponding to the 100, 200 and 300 mm positions. The figure also clearly shows how a dip in the spectrum moves up in frequency with increasing distance. It is interesting to note how the high frequency content is not attenuated in the same manner as for the body worn microphones at similar distances / relative positions.

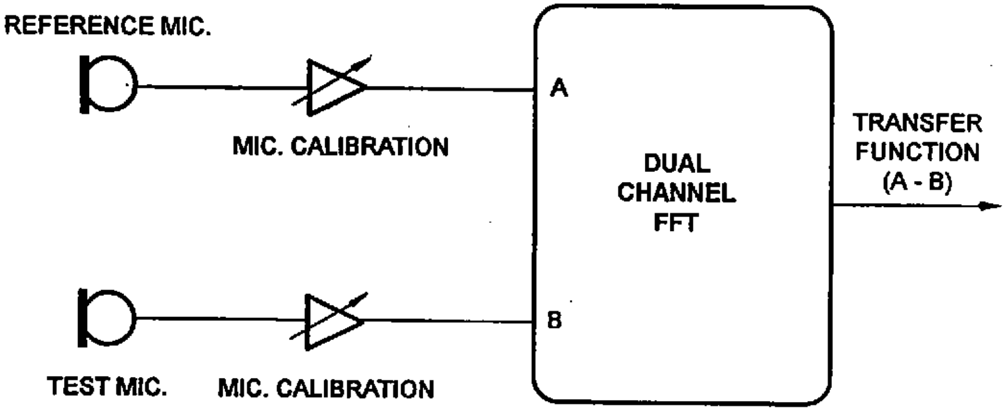
Figure 10 throws some useful light on the question of sound radiation from a human talker and is taken from the work of Dunn and Farnsworth.

3. LOCALLY REFLECTING SURFACES

The effect of locally reflecting surfaces also further complicates the situation eg lecterns. Here, reflections from the lectern surface can strongly interact and interfere with the direct sound from the talker and produce highly audible, comb filtering, peaks and dips in the response. (see figure 11). The presence of a person at a lectern can also seriously affect the local soundfield. For example new reflections can be caused and directed straight into the face of the microphone. It is common (or just Murphy's law ?) for a reflection from the main loudspeaker system to be picked up and directed straight into the open microphone. Figure 12 shows how strong this acoustic effect can be. Here narrow band peaks of up to 12 to 14 dB have been caused by the introduction of the talker at the lectern.

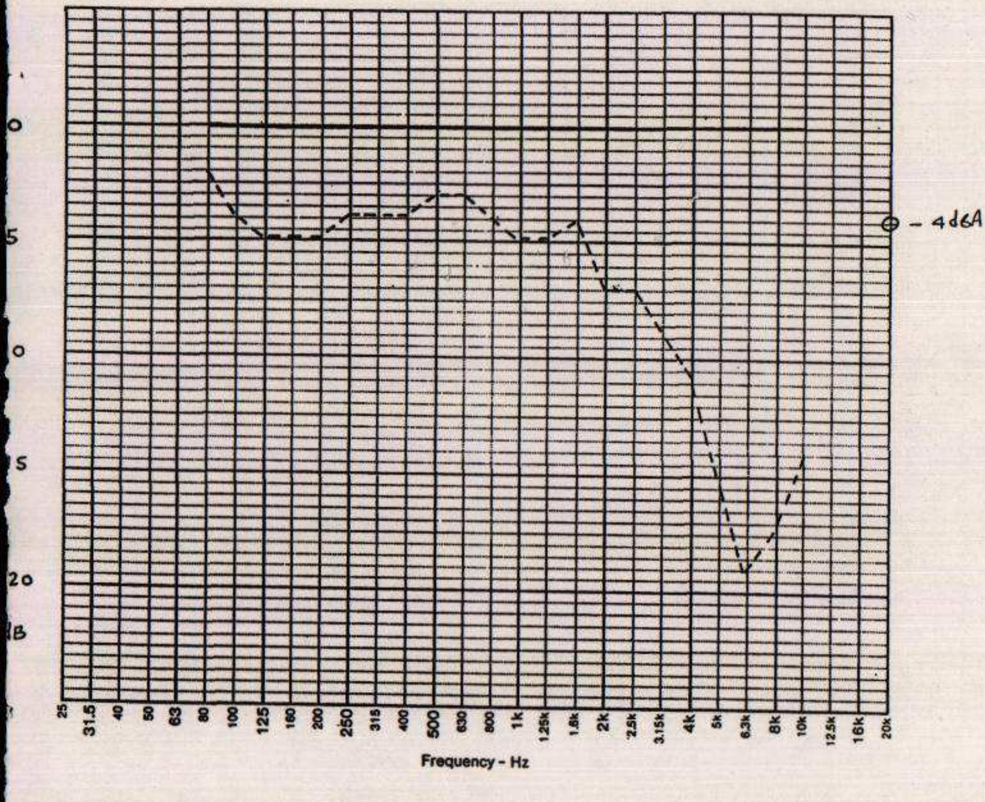
Directional microphones can be used to help overcome such problems but the downside is that it becomes very easy for the talker to 'go off axis' and voice pickup is lost. A common method of apparently overcoming this, is to employ two highly directional microphones, one on either side of the lectern. Whilst this can work, a talker who tends to move about can cause phase shifts to occur between the arriving signals. This causes large interference dips to appear within the resultant reinforcement spectrum as shown in figure 13. Clearly, this is not the optimum solution to the problem. Alternative approaches will be discussed during the lecture.

The author would like to acknowledge the help and assistance of Audio Technica in supplying the test microphones and encouraging this work.



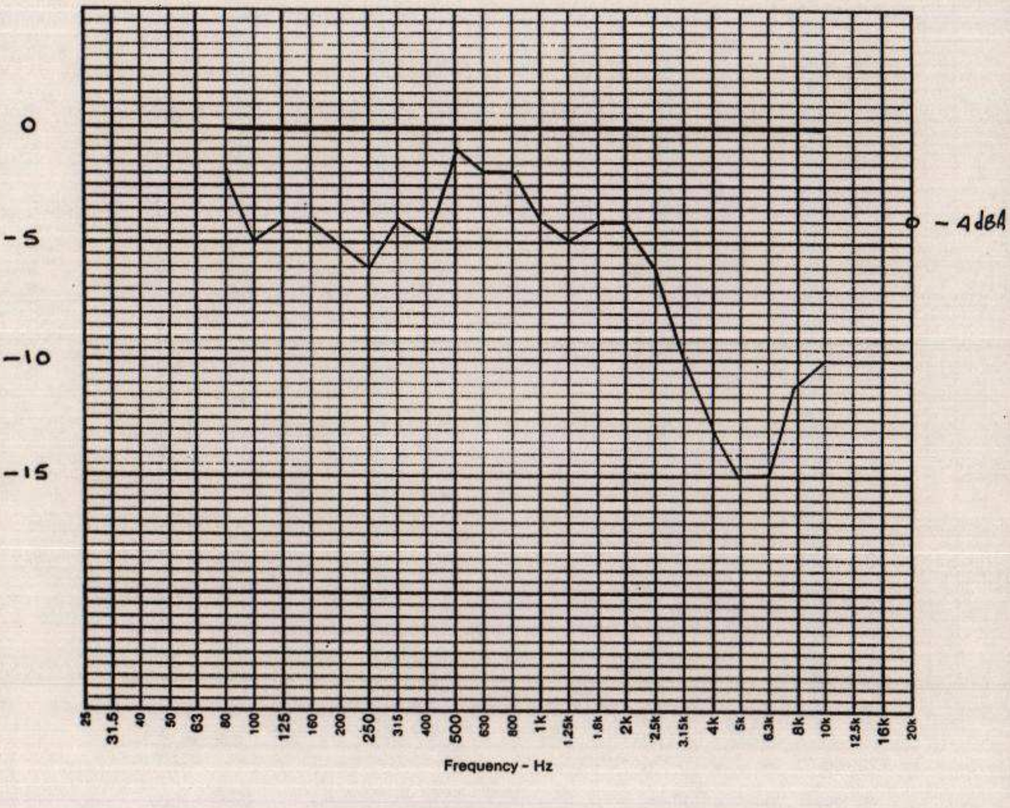
BASIC TEST SET UP

FIGURE 1



TYPICAL LAPEL POSITION

FIGURE 2



TYPICAL TIE POSITION

FIGURE 3

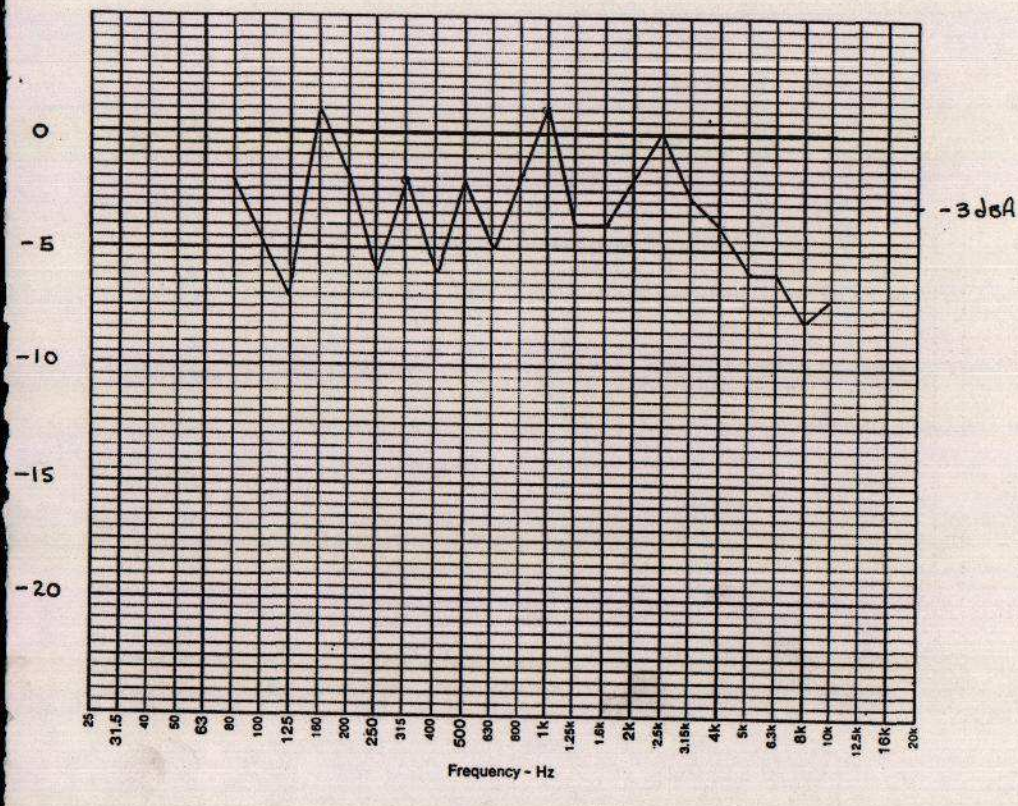


FIGURE 4 FOREHEAD POSITION

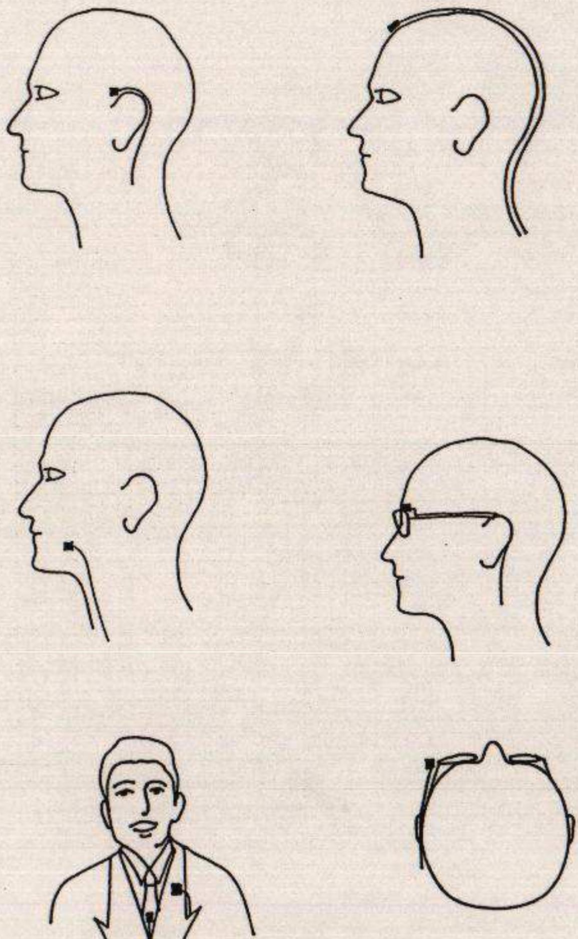


FIGURE 5 MICHROPHONE POSITIONS

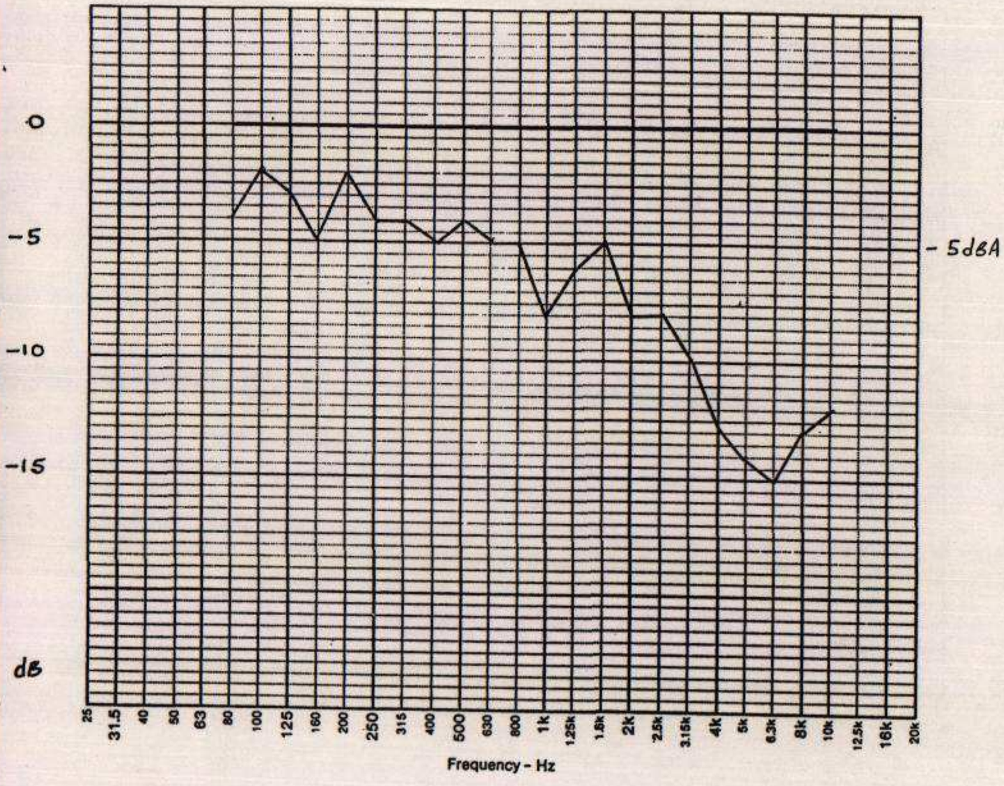


FIGURE 6 MICROPHONE AT FRONT OF EAR

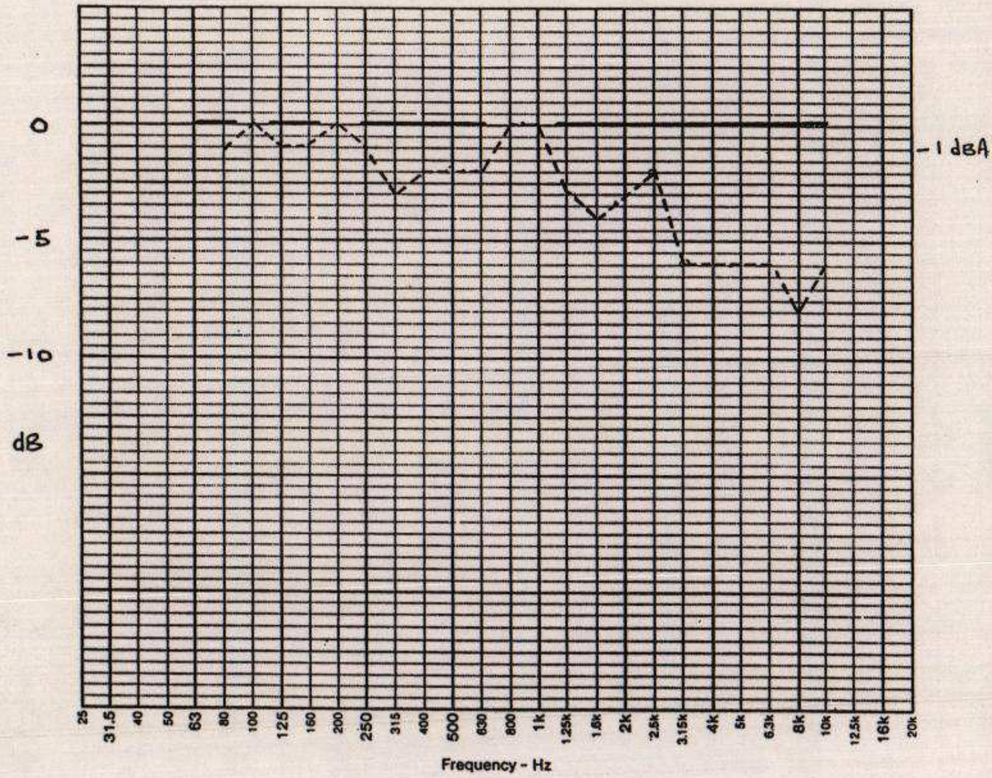


FIGURE 7 MIC MOUNTED ON SPECTACLES FRAME

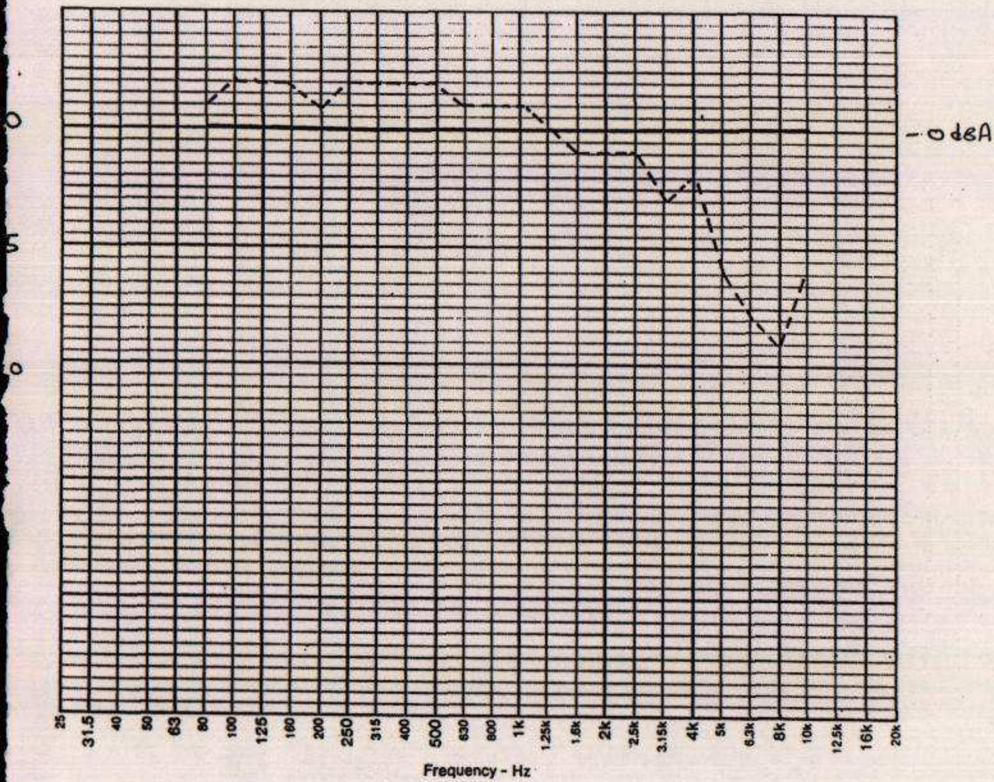
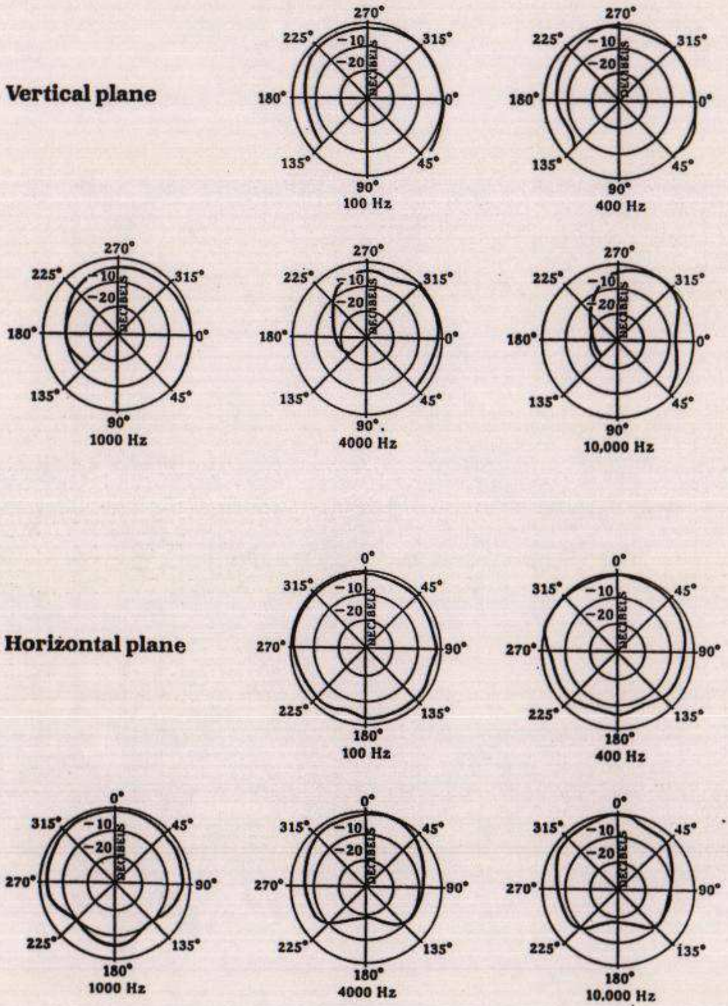


FIGURE 8 TYPICAL FACE (CHEEK) POSITION

FIGURE 9 **Directional characteristics of human voice**
After Dunn and Farnsworth



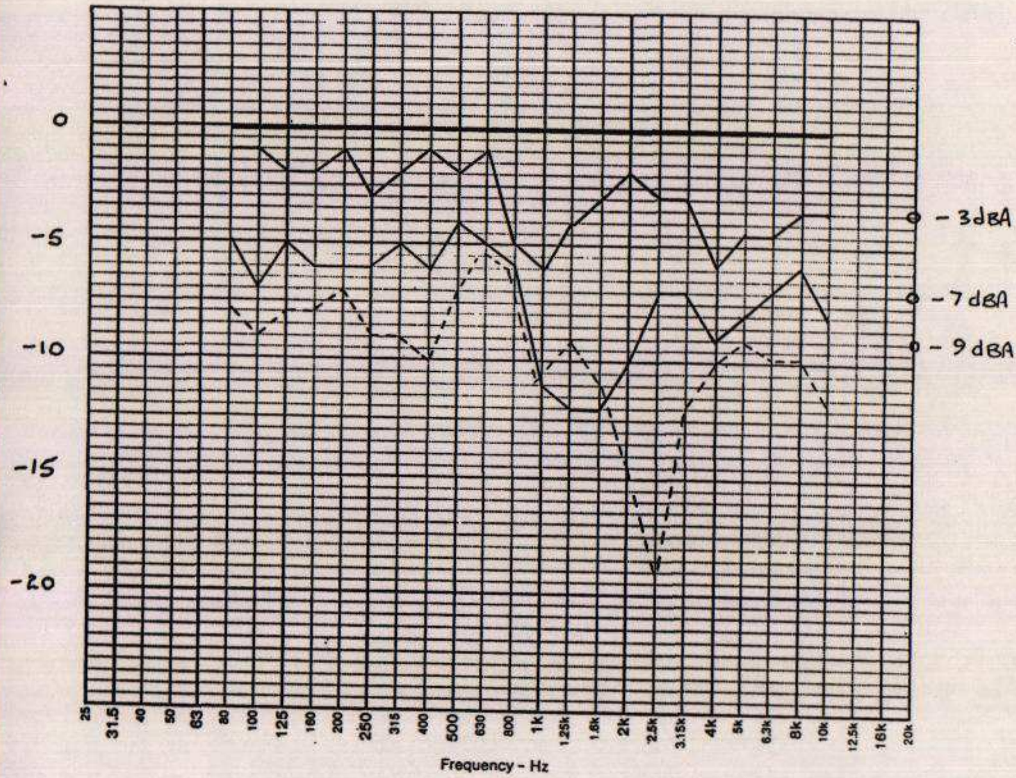


FIGURE 10

VOICE SPECTRA BELOW MOUTH

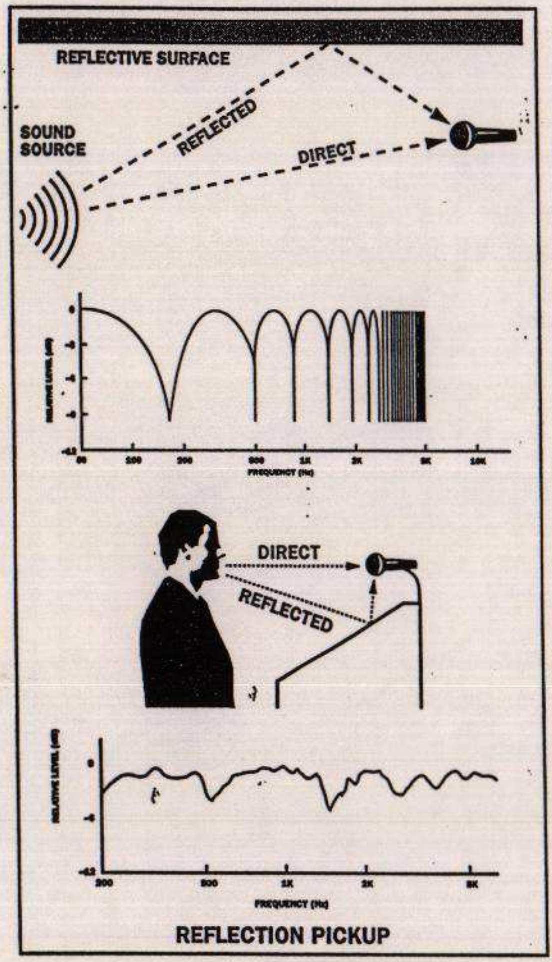

REFLECTIVE SURFACE
SOUND SOURCE
REFLECTED
DIRECT
DIRECT
REFLECTED
REFLECTION PICKUP

FIGURE 11

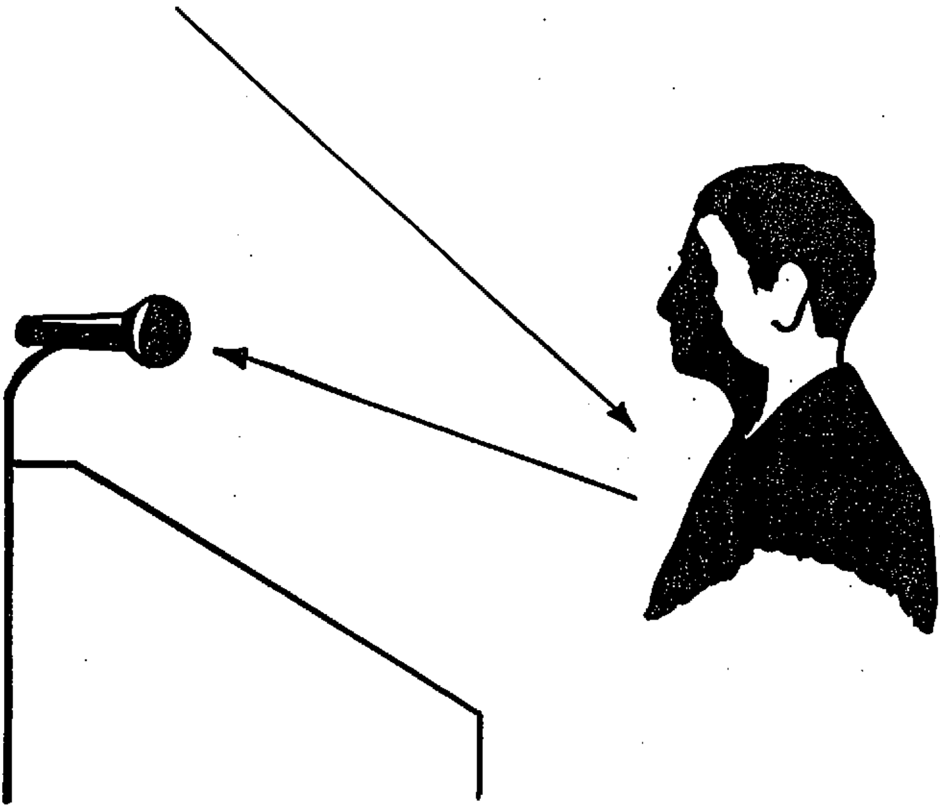
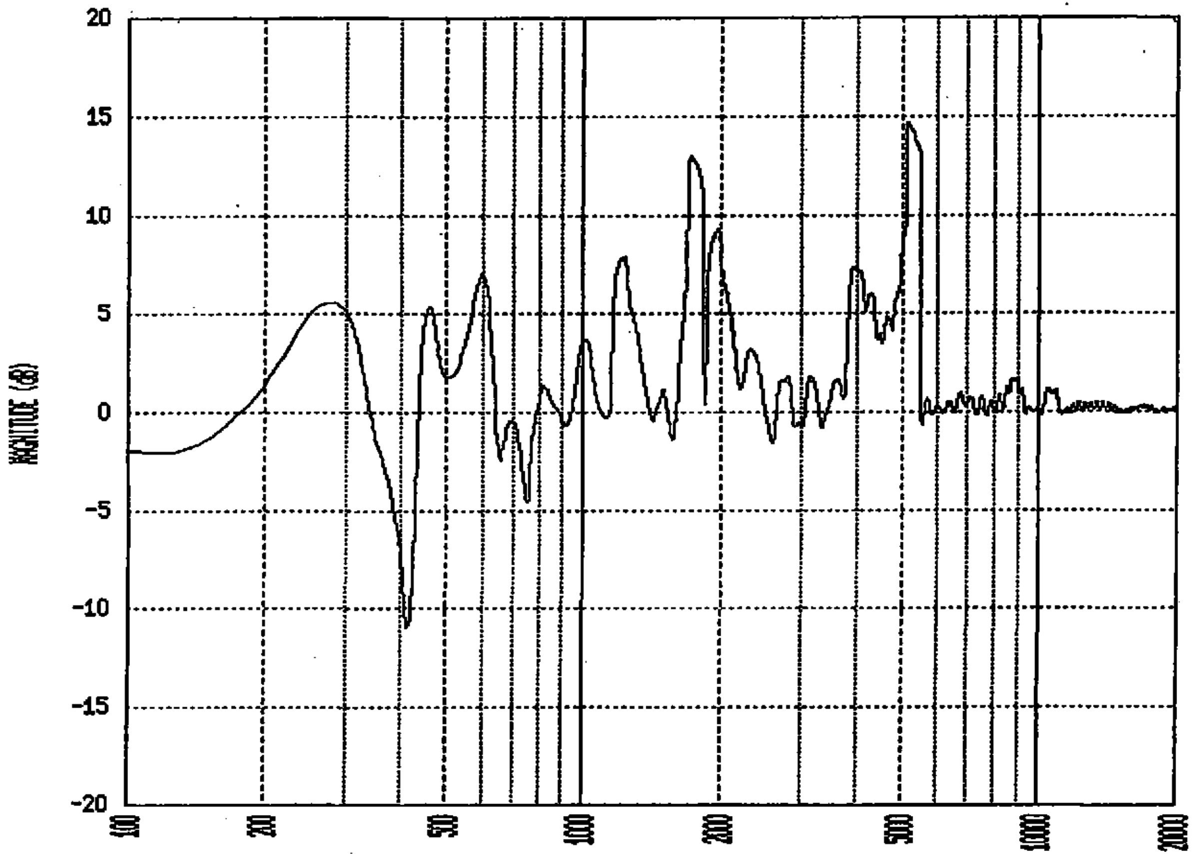


FIGURE 12 REFLECTIONS FROM TALKER BACK INTO MICROPHONE



FILE: LECTERN4.

FIGURE 13 RESULTANT FREQUENCY PLOT OF TWO OUT OF PHASE LECTERN MICROPHONES

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