ALTEC LANSING ENGINEERING NOTES

TECHNICAL LETTER NO. 262

Coverage of Multiple Mantaray Horns

by Mark Ureda and Ted Uzzle

Introduction

Mantaray™ horns may be stacked and splayed in pairs, as indicated in Altec Lansing Tech Letter 241[1]. They may also be combined in other ways—dissimilar horns, for example—to achieve an unprecedented variety of dependable and predictable coverage angles and patterns. The physical assembly of the horns turns out to be easier for Mantarays than for most other horns, and nearly impossible for some.

The Meaning and Importance of Apparent Apices

The concept of the apparent apex of a horn was developed at Altec during 1977 and 1978 as part of an on-going research program in loudspeaker directivity and coverage. Other aspects of this wide-ranging research have included auto-Q, stacked and splayed acoustical devices, solid angle measurements of acoustic radiation, quantization of coverage shape and discrimination, asymmetrical radiation patterns, off-axis performance of multiple loudspeakers, sound field behavior underneath infinite patterns of ceiling loudspeakers, and the like.

It was hypothesized that the measured coverage of a loudspeaker depended very much on its placement relative to the center of rotation of the turntable in the anechoic chamber. In 1978 one of the authors (Ureda) published a paper[2] describing the apparent apex method of measuring, and defining, coverage. This method was based on mathematicl analysis and verified by experiment.

In December of 1977 the Altec acoustical department was verifying its own in-house measurements of the then-new Mantaray horn family. These tests were being conducted in the anechoic chamber at the California State University at Sacramento, California. This chamber, built commercially by Eckel Corporation, is larger than 6,000 ft^3, wedgetip to wedgetip, and is usable to about 100 Hz. Bruel & Kjaer test instrumentation was used.

Although the weeks of testing were intended to include single horns only, an opportunity was found to investigate the apparent apex theory and its effect on stacked and splayed Mantarays.

Defined most simply, the apparent apex of a horn is that point around which you can rotate the horn and measure the same polar pattern at any distance. Were you to use any other point of rotation, you would get different coverage patterns at different distances from the horn. This can be as much as 10% of the true coverage angle when the center of rotation is displaced by only a moderate distance from the true apex. This has highly distressing implications for those who use polar patterns to design their sound systems, especially when the polar patterns used were created with an arbitrary, unspecified center of rotation (which includes practically all polar patterns published before 1978, and those published since by most loudspeaker manufacturers other than Altec Lansing). The coverage pattern of the contemplated horn loudspeaker may be quite different at one hundred or two hundred feet away than at the close proximity measurement distance.

We associate the apparent apex of a horn with the point in the horn at which the wavefront starts to curve and expand. Figures one through seven show horizontal and vertical apparent apices of Mantaray horns. The throat geometry of Mantaray horns allows the horizontal and vertical expansions to start at different points, and this is the technique largely responsible for their unexcelled uniformity of directivity.

Do not confuse apparent apex with the acoustic center of the horn and driver combination, which is a quite different concept[3]. Imagine, if you will, the use of a garden hose as a throat for a horn. If the hose were twenty-five feet long, the effective acoustic source would be twenty-five feet farther behind the horn than if the hose were not interposed, although in fact the hose might be coiled up and the driver physically immediately next to the horn. The sound radiation pattern coming out of the horn, however, would be the same regardless of the length of the hose, and therefore, by the definition above, the apparent apex would not move.

Why is the apparent apex concept important? Here's an example. Rotate a true 90° horn around a point one foot away from its apparent apex, and note the −6 dB angles. At a two-foot measurement distance it's a 45° horn; at a four-foot measurement distance it's a 68° horn (this is the "coverage angle" most manufacturers would quote); at one hundred feet it's an 89° horn. The ordinary way of measuring polar patterns, and using them to match a given horn to a given room, is wrong, and always has been.

Mathematical techniques have been developed at Altec to compute the real coverage angles of a horn given an incorrectly measured polar pattern, and knowing also the apparent apex and the actual point of rotation used.

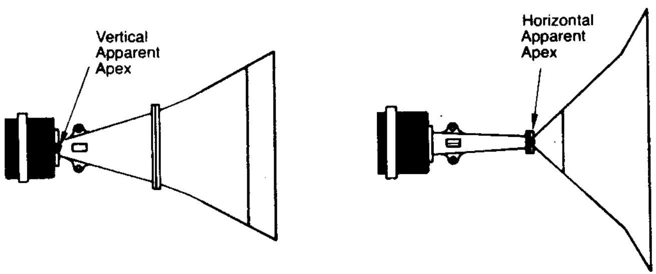

Figure 1. Horizontal and vertical apparent apices of MR94A Mantaray horn.

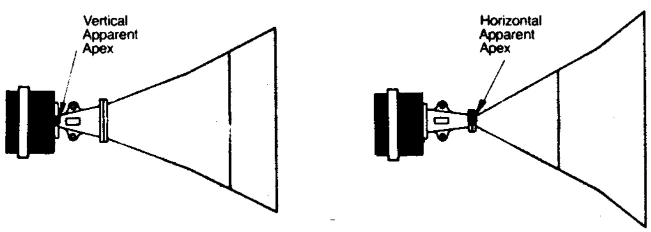

Figure 2. Horizontal and vertical apparent apices of MR64A Mantaray horn.

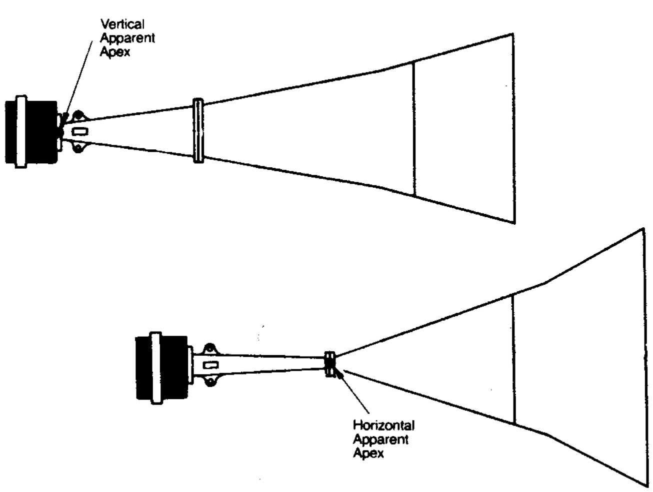

Figure 3. Horizontal and vertical apparent apices of MR42A Mantaray horn.

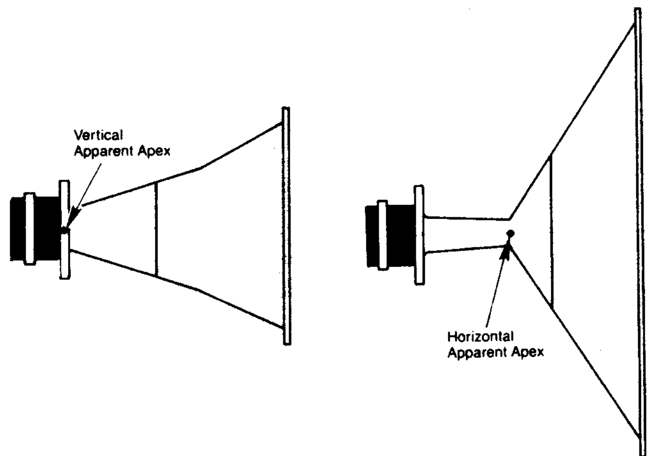

Figure 4. Horizontal and vertical apparent apices of MRII5124 Mantaray horn.

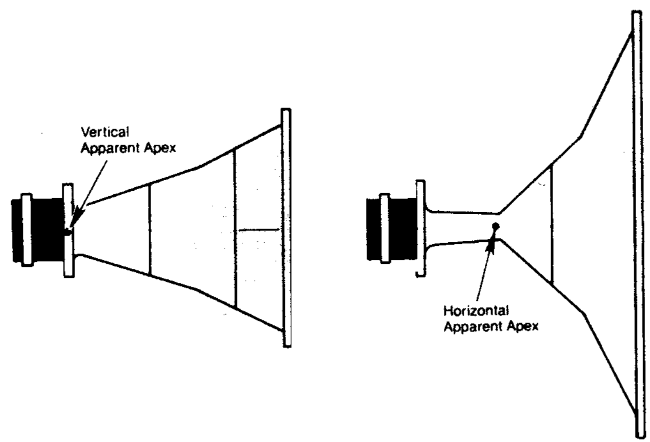

Figure 5. Horizontal and vertical apparent apices of MRII594 Mantaray horn.

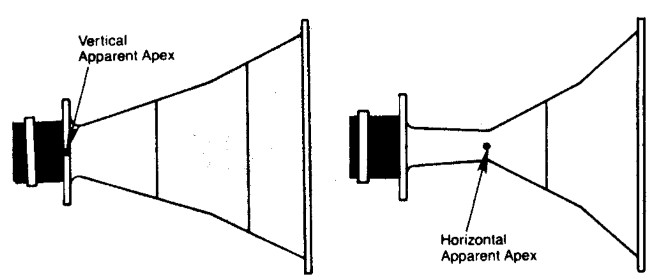

Figure 6. Horizontal and vertical apparent apices of MRII564 Mantaray horn.

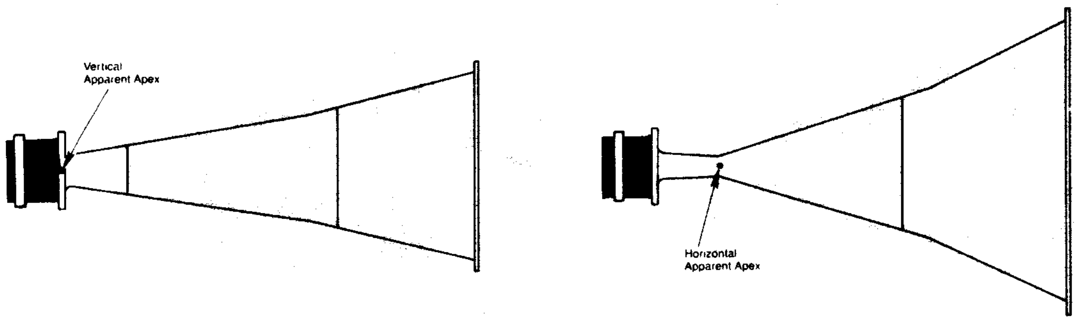

Figure 7. Horizontal and vertical apparent apices of MRII542 Mantaray horn.

Assembly of the Horns

Two Mantarays may be splayed horizontally so that their −6 dB angles cover adjacent areas with a minimum of interference and unwanted interaction, and the resulting coverage pattern will be sum of the two individual horizontal angles. Here's how it's done. Put the vertical sides of the two horn mouths together. They can be connected with stout hinges. Swing one horn back so that its driver crosses the driver on the other horn, and the two horizontal apparent apices are as nearly as possible in a vertical line, one above the other. This is shown in plan view in Figure 8. It will be necessary for one horn to be vertically displaced so the drivers and throats will clear each other, as shown in the rear view in Figure 9. The two vertical slots at the rears of the bells thus should be very nearly in a vertical line, one above the other.

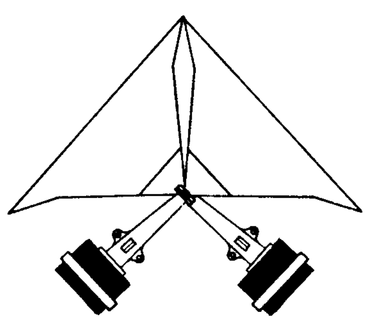

Figure 8. Plan view of two Mantarays splayed horizontally.

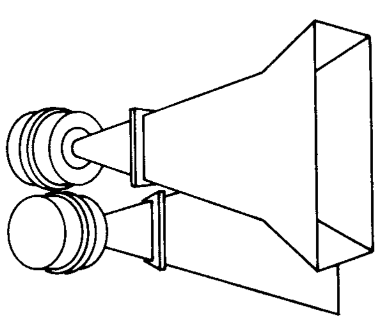

Figure 9. Rear view of the drivers and throats offset from each other.

In the case of the larger Mantarays with metal throats, the MR94A, MR64A, and MR42A, the existing bolts holding the throats on the bells can be removed and replaced with longer bolts, which then can be put through slotted angle or especially drilled pipe or conduit. Dissimilar horns may be combined in this same way, in spite of the difference in lengths of the bells. The key is to bring the apices together and then keep the horn mouths as close as possible.

Our approach to vertical splaying is essentially the same. The vertical apparent apices (located this time at the driver mounting flange) must be brought together as close as possible, with one Mantaray offset sideways so the drivers will clear. Figure 10 shows a side elevation of two Mantarays splayed thus. Again, if dissimilar Mantarays are used this way, bring the apparent apices as close together as they will go, and then arrange the horn bells as close together as they will fit.

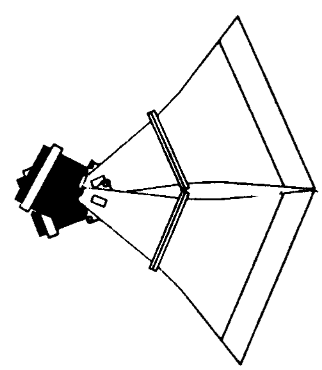

Figure 10. Side elevation of two Mantarays splayed vertically.

What effect will this offset have on horn coverage? A simple geometric analysis shows that the axes of the horns will indeed no longer be coplanar, but the offset of eight inches or so will not widen with distance from the horn array, and the coverage patterns in the audience area will be offset themselves by only eight inches.

Mantarays are easy to assemble in this manner, and the resulting horn cluster no more difficult to construct and hang than any other arrangement of multiply oriented horns.

Results

Figure 11 shows the horizontal coverage angles possible using only the three large Mantarays. Based on actual measurements, it shows combinations available in 30° increments, from 60° to 240°. Patterns all the way to 360° are possible. Notice that all combinations deliver the desired angle within a 10° envelope.

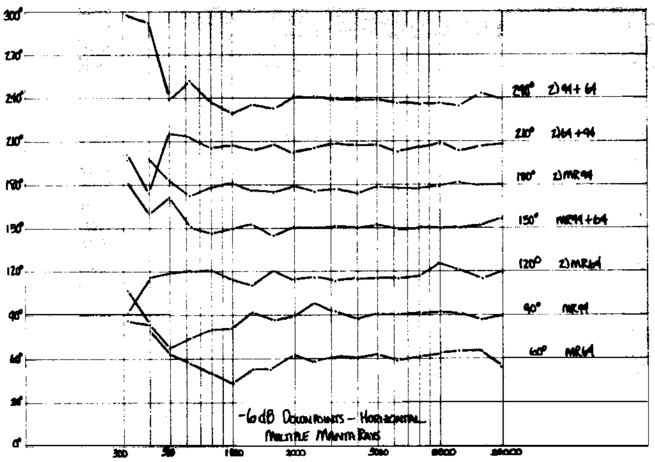

Figure 11. Coverage Angles of various combined Mantarays.

Figure 12 shows the horizontal polar pattern for two MR64As properly splayed. Figures 13 through 16 show polar patterns for other combinations of Mantarays. These illustrate in general:

- well-kept −6 dB angles;
- excellent front to back discrimination;
- a minimum of interference lobing through a broad frequency range (500 Hz−16 kHz).

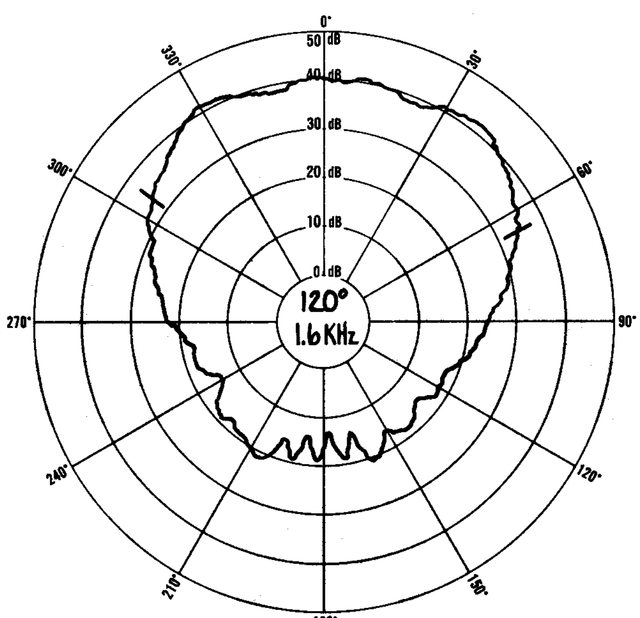

Figure 12. Polar pattern of two splayed MR64As at 1.6 kHz.

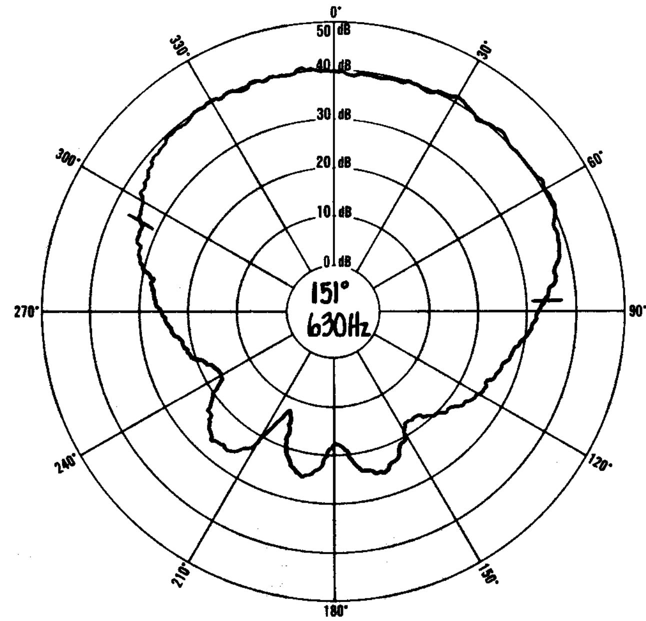

Figure 13. Polar pattern of splayed MR94A and MR64A at 630 Hz.

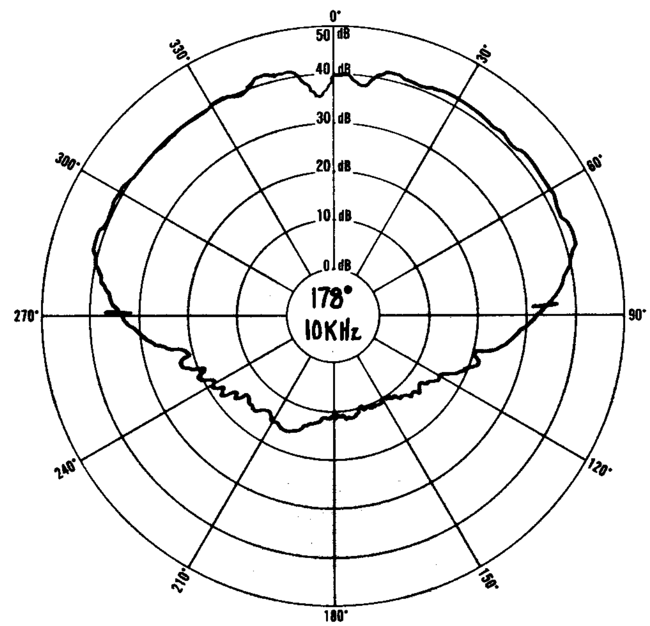

Figure 14. Polar pattern of two splayed MR94As at 10 kHz.

What about the overlap zone? We devoted particular attention to this concern. We mounted two MR94As together, equalized the drivers for flat response, and ran overlaid polars of the combination in 1/3 octave increments from 500 Hz to 16 kHz. The result is shown in Figure 17, a remarkable demonstration of constant directivity control. We see the frequency-domain behaviors in Figure 18. The off-axis response in 30° increments is shown, as well as behind the horn. As you can see, the response is uniform all the way across the combination of horns. Figure 19 shows the response exactly in the center of the overlap zone, showing no (six x)/x interference effects.

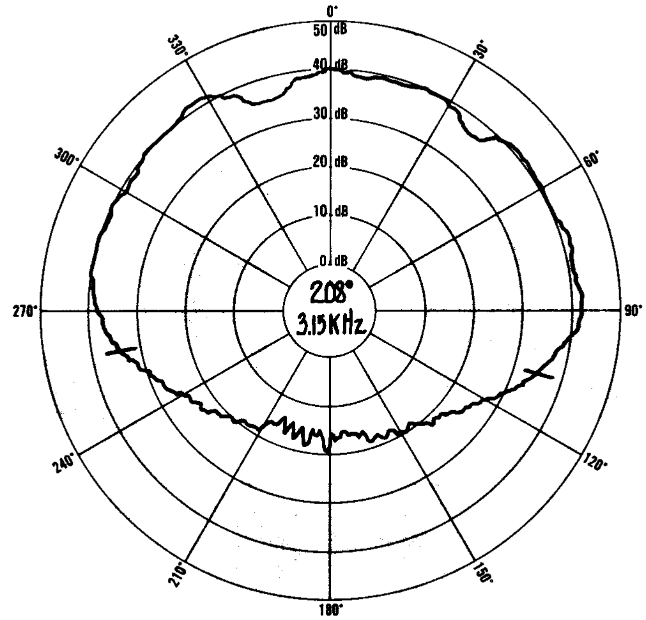

Figure 15. Polar pattern of two splayed MR64As and a MR94A at 3.15 kHz (three horns total).

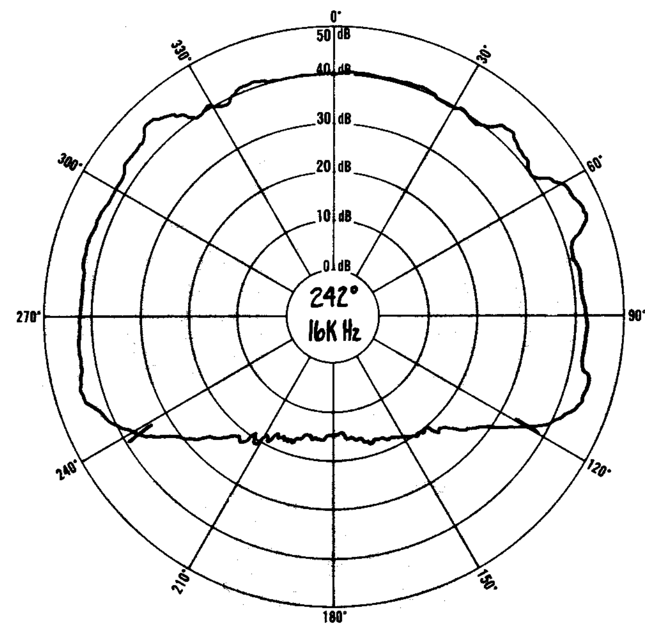

Figure 16. Polar pattern of two splayed MR94As and a MR64A at 16 kHz (three horns total).

In Conclusion

Mantaray horns array easily to provide uniquely well-behaved directional coverage at wide angles requiring multiple horns. Their throat/bell slots are at the horizontal apparent apices, which facilitates accurate splaying. Their planar surfaces allow the mouths to be put together without any gap in the middle, reducing the hazard of interference effects in the overlap zone. Their polar patterns are sharp wedges of sound without the "waistbanding" characteristic of horns with curved surfaces.

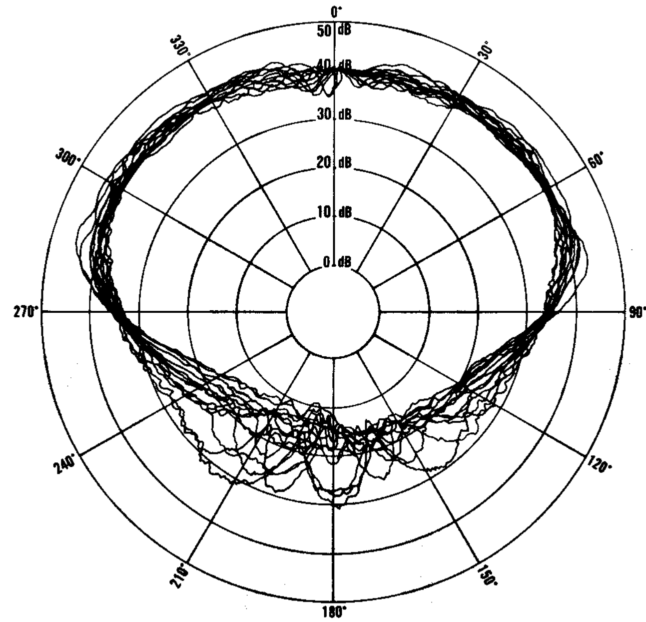

Figure 17. Two splayed MR94As measured at 1/3 octave intervals.

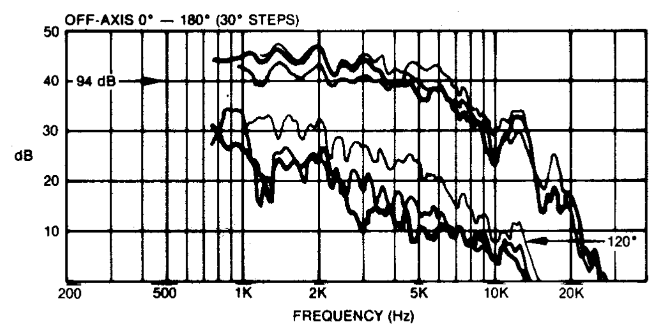

Figure 18. Unequalized response across a combination of two MR94As.

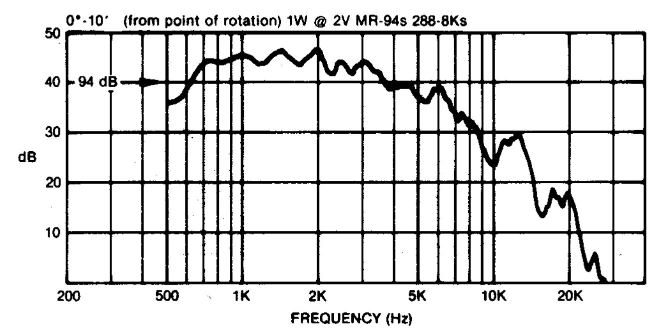

Figure 19. Response directly in the overlap zone.

We have shown that the Altec Lansing Mantaray constant directivity horn can dependably deliver specialized wide-angle coverage within a tight tolerance and over a broad range of frequencies.

References

1. Foreman, C., "Applications for the Altec Lansing Mantaray Constant Directivity Horns", Technical Letter 241, Altec Corporation, 1979, pp. 5-6.

2. Ureda, M., "Apparent Apeax Theory", presented at the 61st Convention of the Audio Engineering Society, November 1978, preprint no. 1403, *passim*.

3. Trott, W.J., "Effective acoustic center redefined", *J. Acoust. Soc. Am.*, v. 62 n. 2 p. 468 (August 1977). See also, Uzzle, T., "Polarity and Phase", Applications Note 9, Altec Corporation, 1981, *passim*.