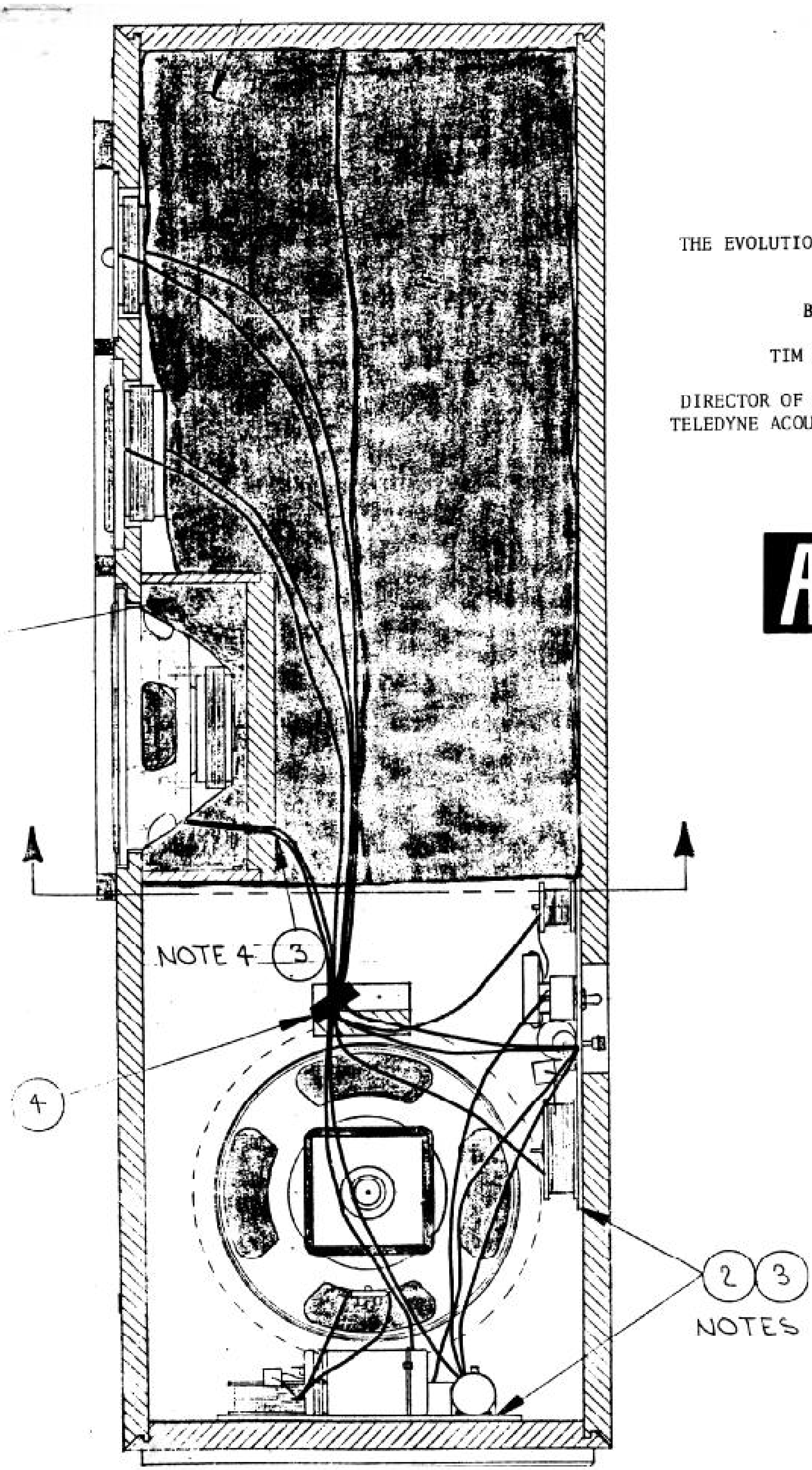


# THE EVOLUTION OF THE AR90

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# INTRODUCTION

For many years Acoustic Research has been one of the world's leaders in the design of bookshelf loudspeakers, pioneering the way with the first acoustic suspension system 25 years ago. However, in recent years we have come to realize that more and more of the larger bookshelf systems we make are being used, not on bookshelves, but as floor standing systems, either with or without a stand. It is, however, an unfortunate fact that a system optimised for use on a bookshelf cannot also be optimised for use on the floor, particularly if that floor standing position is back against a wall (as it invariably is). It was with this in mind that we set out to produce a system that would be truely optimised in every respect for use in such a position - the result was the AR-9, a system unusual in the way attention was spent in so many areas to produce a system that actually achieved its best performance in real listening rooms and not in some idealised test chamber or environment.

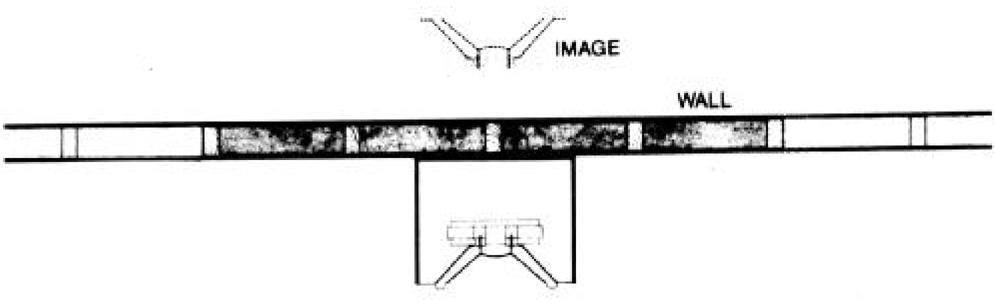
The AR-9, in fact, since its introduction has been perceived as achieving this goal admirably, and as being far superior to the "bookshelf-speaker-on-a-stand". However, in order to achieve the finest performance possible in all respects, the AR-9 is of necessity large and expensive to build. If size and price are considerations, the bookshelf speaker on its stand had to be reluctantly chosen over the large AR-9. With these thoughts in mind, we set out to produce a realistic alternative to this speaker-stand combination (or even to the speaker on the floor minus stand), a speaker that was similar in size and price,but that also had most of the attributes and performance of the AR-9. The result is the AR-90.

## DUAL SIDE-FIRING WOOFERS

The first and most obvious feature of the AR-90 is that, like the AR-9, it has two woofers, placed at floor level on either side of the cabinet. The reason for this is the same as that in the AR-9 - to produce a smooth middle to low frequency response in a real listening environment. When a loudspeaker is positioned against a wall, that wall acts as an excellent mirror for low frequency sound waves and produces images in that wall, the floor, the ceiling, etc.

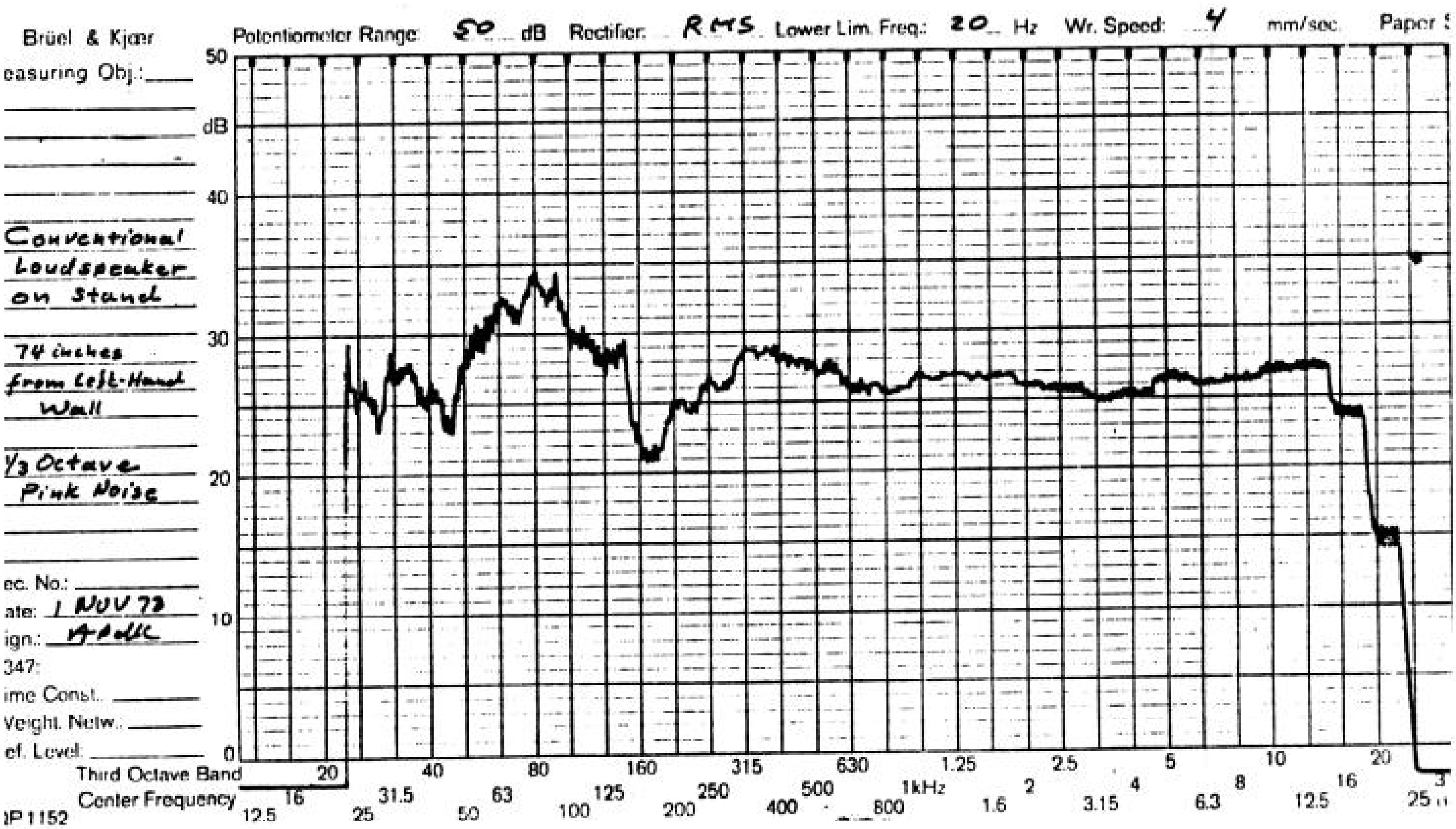
These images of the loudspeaker behave just like real loudspeakers. The sound they radiate, when combined with the sound coming directly from the loudspeaker itself, either adds to that direct sound or subtracts from it, depending on the frequency. The major such effects are caused by the wall behind the speaker system and by the floor, as these are the closest to the speaker and thus have the "loudest" images.

If we look at the drawing below, we can see the situation for the wall behind the speaker.



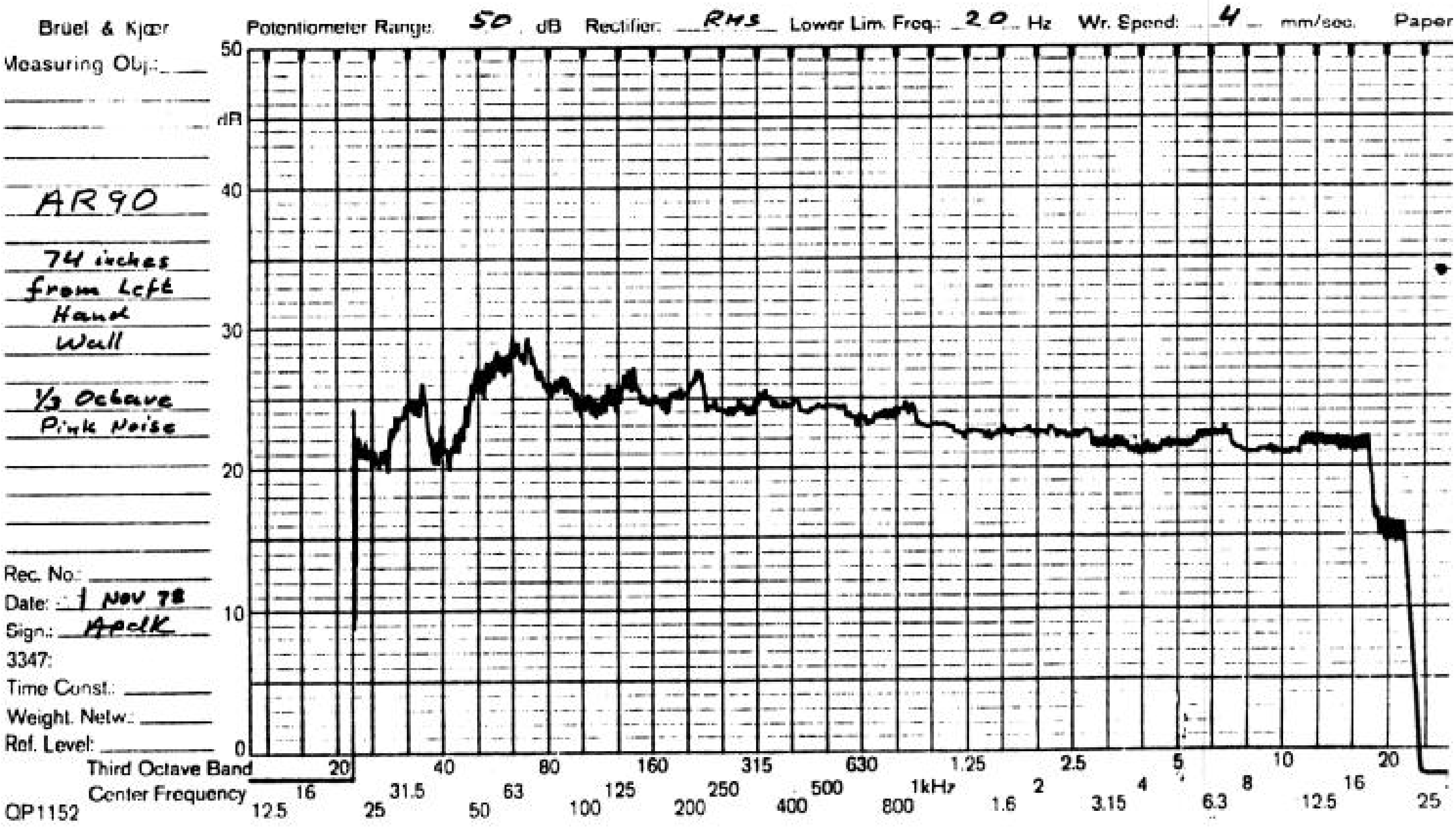
It can be seen that sound waves, moving across the front and then toward the back of the speaker cabinet, will bounce off the wall and go out toward the listener a short time after the direct sound from the loudspeaker. Because of this time difference, the peaks and dips of sound pressure in the wave--like the peaks and dips in a wave on the surface of water--will coincide at some frequencies and cancel at others.

If the distance from the speaker, around the cabinet to the wall, and back to the front of the cabinet again, is exactly one-half the distance beteen wave peaks (one-half wave length), there will be severe cancellation. This means a substantial drop in bass output at that frequency. The result can be measured, and is visible in the frequency response curve below, measured in a relatively typical listening room. Although the dip in response varies somewhat with system placement and exact cabinet dimensions, it is never absent.



How do side-firing woofers remove this effect? When the distance between the loudspeaker drive unit and the wall is reduced, the frequency of the dip is raised. In the AR-9 and the AR-90, the close proximity of the woofers to rear wall and floor makes the distance between the woofers and their images about one foot, which raises the dip frequency to about 500 Hz. However, the woofers only operate up to about 200 Hz, at which frequency the front mounted lower midrange unit begins to take over. The woofers are thus not providing a significant output around 500 Hz where the images would produce a dip and the system output is smooth in this region.

The 8 inch lower midrange unit which provides the system's output in this range is, as mentioned, front mounted. This means that the distance from this unit to its image in the wall is just over 3 feet in the AR-9 and just under 3 feet in the AR-90. Thus for the 8 inch drive unit, the wall dip drops to just below its range of operation and once again does not appear in the system response as this is now where the woofers are operating. We can see a typical room response curve for the AR-90 (Page 5) which clearly shows the absence of the wide dip around 200 Hz which was in evidence on the earlier curve of a conventional speaker system in the same room position.


Brüel & Kjær
Potentiometer Range: 50 dB
Rectifier: RMS
Lower Lim. Freq.: 20 Hz
Wr. Speed: 4 mm/sec.
Paper
Measuring Obj.:
AR90
74 inches from Left Hand Wall
1/3 Octave Pink Noise
Rec. No.:
Date: 1 Nov 78
Sign.: Apdk
3347:
Time Const.:
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dB
50
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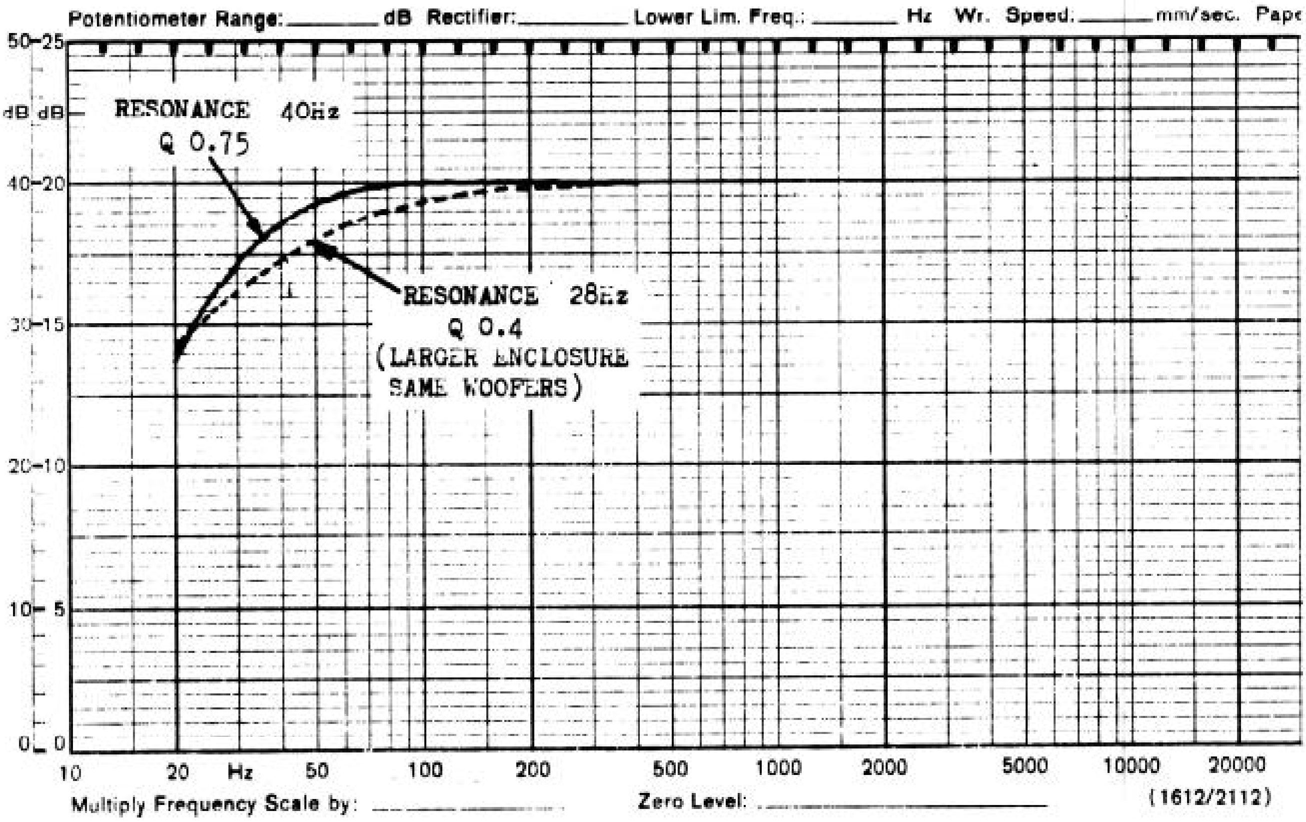
Third Octave Band Center Frequency
12.5 16 20 25 31.5 40 50 63 80 100 125 160 200 250 315 400 500 630 800 1kHz 1.25 1.6 2 2.5 3.15 4 5 6.3 8 10 12.5 16 20 25
QP1152

## LOW FREQUENCY RESPONSE

We have seen how woofer placement is critical to reproduction of a smooth frequency response in the lower midrange, but what about the bass response itself? In the AR-9 we use two massive 12 inch woofers in a cabinet of three times the volume of cabinet that a single such woofer would be used in. The resulting extremely low Q bass response is then modified by special circuitry to achieve an extremely well damped, well extended bass response that is only 3 dB down at 28Hz.

The techniques used in the AR-90 are somewhat different and provide a low end that is only a few Hz removed from that of the AR-9 and that has a slightly higher Q than that of the AR-9, these ends being reached by manipulation of the mechanical and acoustical parameters involved.

Let us consider what happens when we take two woofers and place them in parallel. In order to achieve the same resonant frequency from the two woofers that we get from one of them alone, the cabinet for the two woofers will have to be twice as large as that for the single woofer. If we increase the cabinet size further, although the system resonance will drop, we may end up with less output at low frequencies as the Q will drop also. This can be clearly seen in the illustration on Page 7.




EFFECT ON LOW FREQUENCY RESPONSE OF INCREASING CABINET

SIZE ABOVE THE OPTIMUM VALUE FOR A GIVEN PAIR OF WOOFERS.

What, then, is to be gained from two woofers over one used in a smaller cabinet? If the two units are spaced closely together compared with the wave-length of sound over the whole frequency range in which they operate, then for the same voltage input the two units will give 6 dB more output than the single unit in a smaller cabinet (they will, of course, take twice the power from the amplifier to do this, as they will be presenting it with half the impedance). Each ten inch woofer in the AR-90 has an impendance of 8 ohms so that their combined impendance matches the 4 ohms of the other drive units. The boost in output caused by the close coupling enables us to mass load these woofers to lower their resonance in the system while giving a combined acoustic output that matches that of the rest of the system; the result is an extended bass response down to within a few Hz of that in the AR-9.

However, the resonant frequency is, as we have seen, only half the story when we consider the reproduction of low frequencies. In order to optimise this extended bass response, one other parameter has to be carefully controlled. This is the type and positioning of internal damping material within the enclosure. Conventional techniques such as filling the cabinet with loose fibreglass,or similar materials, do not work in a tall cabinet like that of the AR-90 with the woofers placed at one end. This is because strong standing waves can easily be generated from end to end in such an enclosure and these cannot be damped out by such arrangements. The internal damping is thus confined to 4 rolls of absorbent material carefully aligned in the upper two-thirds of the cabinet only, the lower third being empty of any such material; the rolls are fairly densely packed and thus prevent sound waves reaching the cabinet top and being reflected, while the empty lower portion of the cabinet ensures that the Q is not lowered drastically as it would be if the whole interior were densely wadded. The undamped lower portion of the cabinet is not a problem, as the woofers only operate up to 200 Hz and thus never produce sound with a short enough wavelength to set up internal standing waves between the cabinet walls.

## LOWER MIDRANGE UNIT

This is an 8 inch driver mounted in its own acoustic suspension enclosure, attached to the front panel of the AR-90 from behind. The crossover frequency used is 200 Hz at the lower end of the range, 1200 Hz at the high end. The choice of low frequency crossover has an added advantage in addition to the wall-dip elimination already described - it means that the woofers do not simultaneously have to reproduce relatively high frequencies and very low frequencies with consequent large cone movements. This reduces the production of Doppler or intermodulation distortion by the woofers.

## UPPER MIDRANGE UNIT

This is a fully sealed 1-1/2 inch diameter dome unit with special energy-absorbent diaphragm. The frequency range covered is from 1200 to 7000 Hz; the upper portion of the frequency range is maintained in level by use of a "semi-horn" surrounding the dome, providing better acoustic loading. Below 3000 Hz the semi-horn has no effect, and the unit is essentially a simple dome radiator.

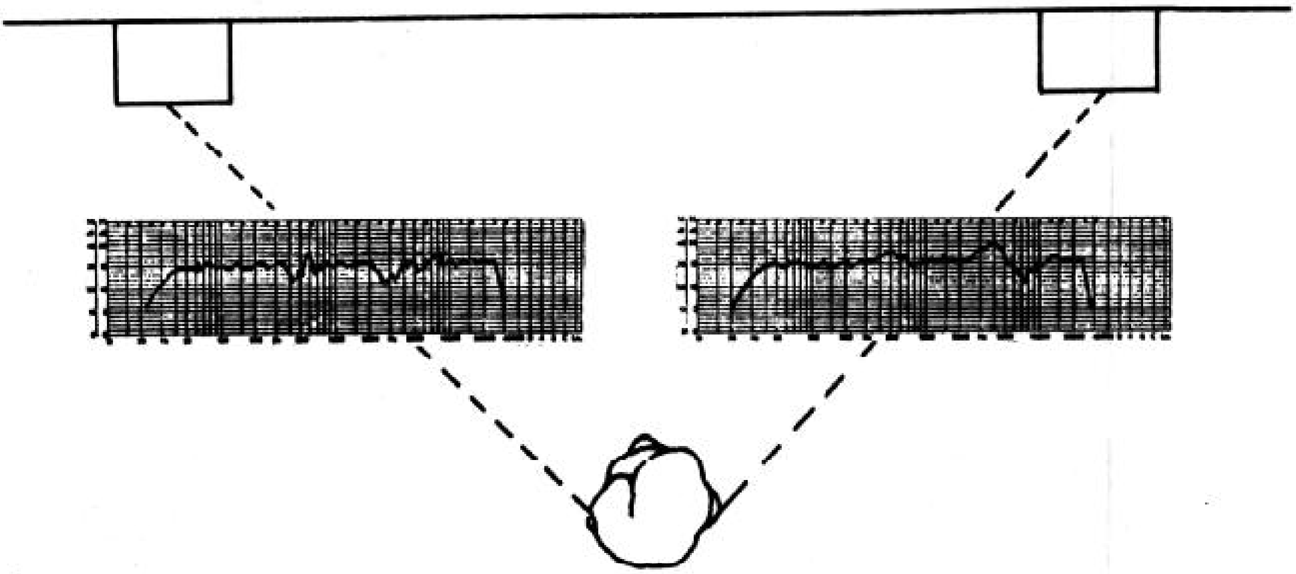
To increase its power-handling capacity, the coil is surrounded by (and completely immersed in) a specially-developed high-temperature magnetic fluid. This was made necessary because conventional magnetic fluid, as used in units designed to operate at lower power levels, literally boiled away at the levels at which the AR-9 and AR-90 are designed to work. In addition, heavy tinsel lead-out wire and high-temperature adhesive are used in this unit.

## THE TWEETER

This unit is a fully-sealed 3/4 inch unit with energy-absorbent dome. It covers the frequency range from 7000 to beyond 20,000 Hz. Like the upper midrange, the voice coil of the tweeter is surrounded by magnetic fluid. It is constructed with cyano-methacrylate adhesives for high-temperature, high power handling operation.

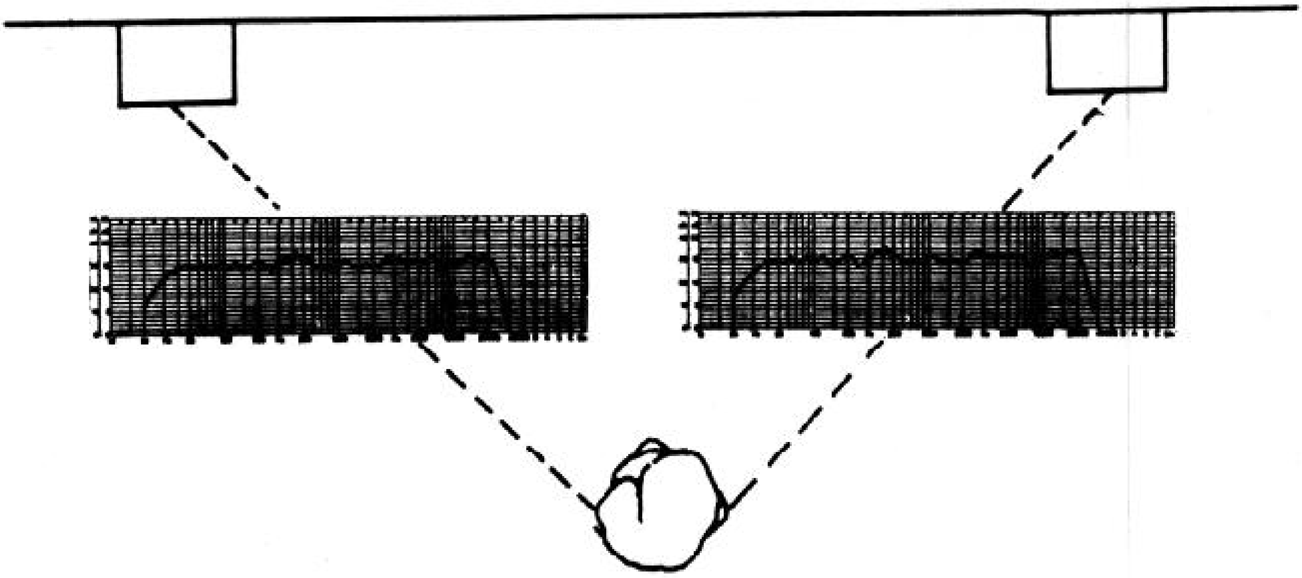
## DRIVE UNIT PLACEMENT - THE VERTICAL ARRAY

Whenever two driver units operate in the same frequency range, as is the case just above and below the crossover frequencies of a system, there is danger of interference patterns affecting frequency response and stereo placement at the listener's position. If the drivers are mounted side by side, the usual result is that the sound in the crossover region is radiated as a series of beams spread out horizontally. If the listener changes his listening position, he will receive a changed frequency response from the loudspeaker system. The result of this is that in a stereo pair, the listener will perceive a different frequency response from EACH loudspeaker system, as he will never be in an identical position relative to each, just as is shown diagrammatically below. Unfortunately, regardless of how much effort has gone into designing midrange and highrange units with perfect dispersion, if these units are mounted incorrectly, complete blurring of the stereo image will be the result.



HORIZONTAL OR NON-VERTICAL ARRAY OF MID AND HIGH FREQUENCY DRIVERS AND CONSEQUENT LOBES AND INTERFERENCE EFFECTS CAUSE TWO DIFFERENT FREQUENCY RESPONSES TO ARRIVE AT THE LEFT AND RIGHT EARS OF A LISTENER.

The solution chosen in the AR-90, as in the AR-9, is to mount the mid-range and high frequency drive units in a single vertical array. As each drive unit used exhibits excellent dispersion over its frequency range, this ensures uniform horizontal distribution of sound throughout the frequency range of the system. This is because the unavoidable interference patterns between drive units in the crossover regions have now been moved into the vertical plane where they are identical for each speaker system at the listening position. The result is that the listener now perceives the SAME frequency response from each speaker system in the stereo pair, as shown below, the stereo image in consequence being extremely precise and stable.



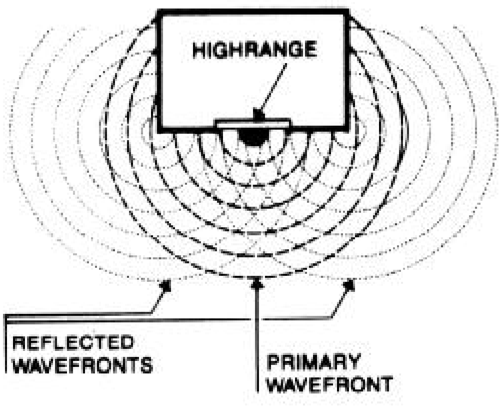
VERTICAL ARRAY OF MID AND HIGH FREQUENCY DRIVERS PLUS ABSORPTION OF ACOUSTIC BLANKET™ MINIMIZE INTERFERENCE EFFECTS AND INSURE THAT IDENTICAL FREQUENCY RESPONSES ARRIVE AT THE LEFT AND RIGHT EARS OF A LISTENER.

# THE "ACOUSTIC BLANKET"™

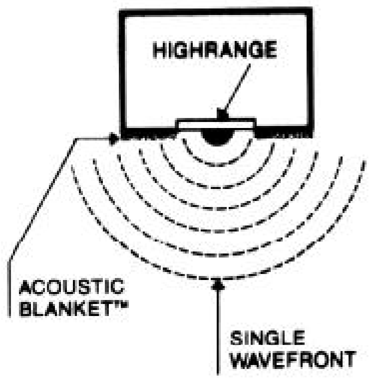
On a conventional loudspeaker cabinet, sound waves from the tweeter and midrange units move across the front panel and are reflected from obstructions such as mounting screws, moldings, decorative parts, and even from the cavities formed by other driver units. When the sound waves reach the cabinet edges and grille frame, they are reflected again.

The direct and reflected sound waves interfere with each other in a way that varies with frequency, blurring the stereo image and making frequency response uneven.

These effects are suppressed in the AR-90, as in the AR-9, by an acoustic "blanket", a layer of absorbent material on the front panel surrounding the mid and high frequency drivers (patent applied for).




*Conventional loudspeaker system showing reflected waves from enclosure edges.*




*Loudspeaker system with Acoustic Blanket™ showing absence of reflected waves.*