THE AR91 AND THE AR92

BY

TIMOTHY HOLL

VICE PRESIDENT ENGINEERING

TELEDYNE ACOUSTIC RESEARCH

AR91 WITH ACOUSTIC BLANKET™

AR92 WITH ACOUSTIC BLANKET™

TELEDYNE
ACOUSTIC RESEARCH
10 AMERICAN DRIVE, NORWOOD, MA 02062 U.S.A

INTRODUCTION

Why floor standing? Why the vertical array? To find the answers we have to go back two years. Acoustic Research had by then been a leader in bookshelf loudspeakers for 23 years, starting with the invention of acoustic suspension by the company's founder. But AR also realized in latter years that more and more of its speakers were being used not on shelves but on the floor, a position for which they were not optimized. A speaker stand would improve matters somewhat, but many problems still existed with such placement of a system designed for shelf mounting. We thus decided to make a loudspeaker specifically designed to be floor standing.

The result was the now famous AR9. With this system, we knew it would be placed on the floor, and we knew it would be stood upright when in its final listening environment. This enabled us to design a system that not only had remarkable bass but, because of the above mentioned knowledge of final positioning, also a system with excellent stereo imaging and a system that gave a smooth, flat response when placed in real rooms.

The AR9 was designed as, and has since been perceived as, a reference speaker in all respects. However, it is big and it is expensive. With this in mind we introduced the AR90 in January 1979. The AR90 was a smaller, less expensive system with all of the features of the AR9, but for slightly less bass which is also slightly less well damped.

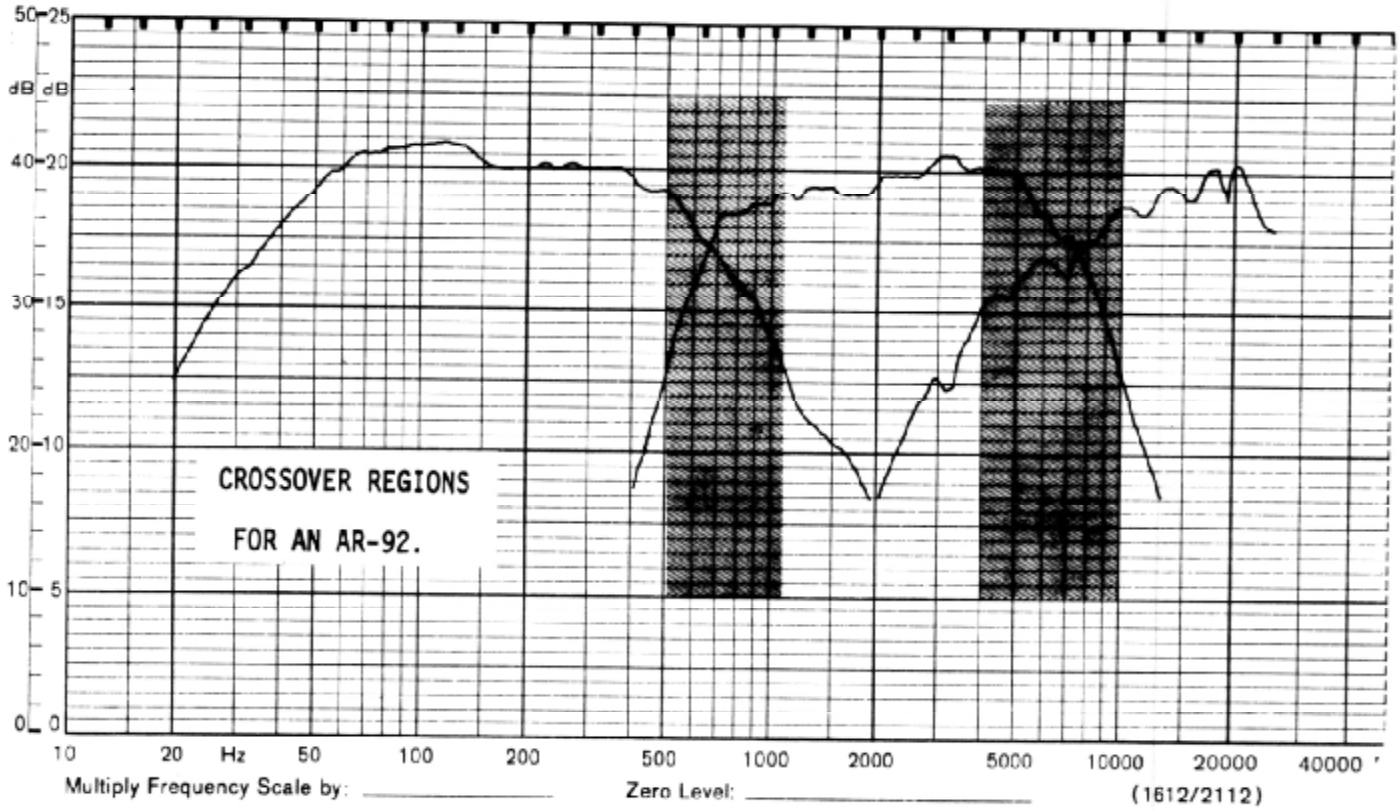
It was during the design of these two systems that we began to re-think our concept even more. Should smaller, more moderately sized speakers

be made such that they could be shelf mounted? If they are, we have no control over whether the speaker will be used upright or lying down, and thus no control over final drive unit alignment. All the evidence was against this approach and pointed to the achievements in performance made with the AR9 and AR90, many of which could be incorporated in smaller systems by designing these also specifically as floor standing systems. Enter the AR91 and AR92.

STEREO IMAGERY

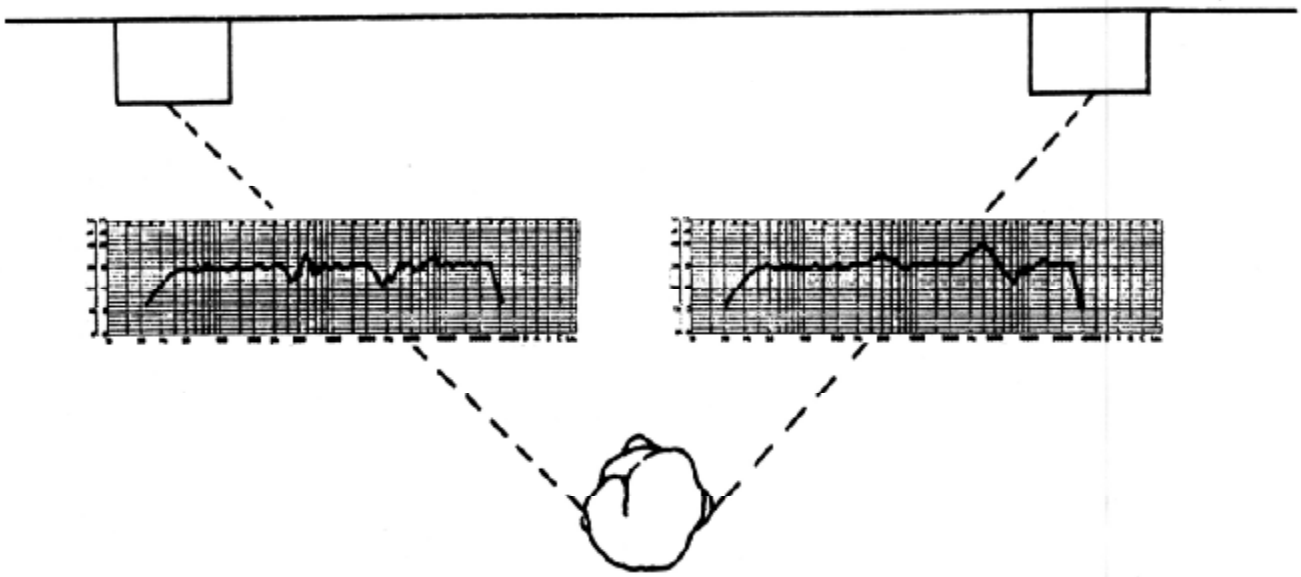
One immediate advantage in designing a floor standing speaker is that we know which way up the speaker will be placed. This means that we know which orientation each drive unit in the system will have with respect to the other drive units and with respect to the listener. In a book-shelf system, which may be placed on end or on its side, this is not a predictable factor. Why is this important?

In a multi-drive unit system, there will be portions of the frequency range where more than one unit is operating. This will be in the "cross-over regions" where the output of one unit rolls off and the output of a second unit comes into play. This can be seen in the response curves below. In this overlap region, the output of the one unit will either add to or subtract from the output of the other, depending on the relative phase of the signal from each unit. If the spacing between the two units is small compared to the wavelength of any frequency in the crossover region, this addition or subtraction will depend only on the electrical connection to the units and will be the same anywhere in the listening room.



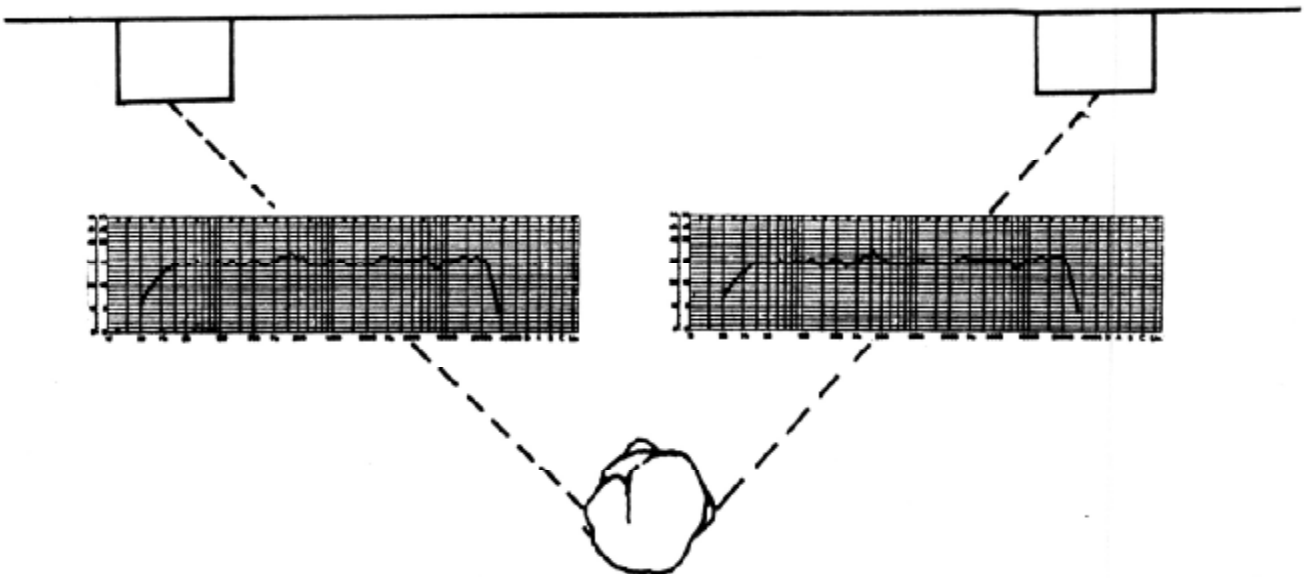
However, if the distance between the units is comparable to or larger than the wavelength, then whether the units add or subtract depends not only on electrical connection but also on listening position in the room and also on frequency. This is because the relative phase of the signal from each unit at the listening position depends also on the relative distance from each unit to the ear. If we are dealing with a midrange unit and a tweeter placed side by side, then the difference between the distance from the midrange unit to the ear and the distance from the tweeter to the ear will vary as we move around in front of the speaker.

This will cause the frequencies at which the additions or cancellations occur to vary and, as a result, the frequency response of the system as a whole to vary with listening position. This means that the left speaker in a stereo pair would give a different response to that of the right speaker as shown below.



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 final effect of all this is that a stable, well defined stereo image cannot be created - the image is imprecise and unclear. The obvious answer is to ensure that the difference between the midrange unit - ear distance and the tweeter - ear distance will remain constant no matter where we sit in front of the speaker. This can be done by mounting one unit directly above the other - in effect we throw the interference patterns into a vertical plane. If this is done for all drive units in a system that would cause such problems, that is, if we use a vertical array for such units, then the listener will hear the same frequency response from each system as shown below.



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 result is a stable and well defined stereo image. In the AR9 and the AR90, we put the midrange units and tweeter in such a vertical array. The woofers did not have to be part of this array due to the low frequency (200 Hz) at which they crossover to the 8 inch lower midrange unit. The wavelengths here are long enough compared to the distance between drive units that the problem does not exist.

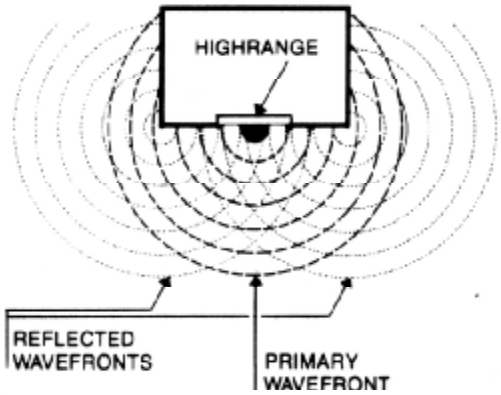
When it came to designing the new systems, we did not have such flexibility. With a three way system we are limited to a crossover from woofer to midrange in a frequency region where the interunit distance becomes significant. To obtain the sort of stereo imagery we achieved with the AR9 and AR90, all three drive units (woofer, tweeter and midrange) in the AR91 and AR92 have to be in a single vertical array.

THE ACOUSTIC BLANKET

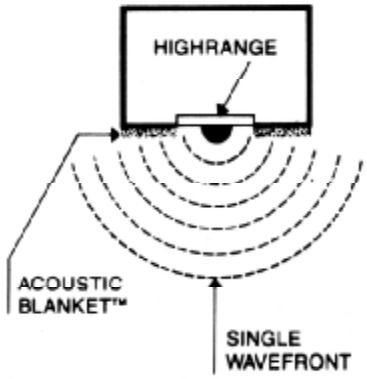
We have seen above how interference between soundwaves from different drive units can cause frequency response to vary with listening position and thus "muddy up" the stereo image. Unfortunately another cause can give a similar effect. If the wavelength of soundwaves emitted by a drive units is small compared to cabinet dimensions, these soundwaves can be diffracted by the cabinet edge or reflected by protrusions such as the grille frame or the edge of another driver. These reflected soundwaves will in turn interfere with the direct sound waves and cause similar position sensitive frequency response aberrations to those described in the previous section. If we are to enjoy a truly stable stereo image, then these reflected waves must be reduced as much as possible.

This was achieved on the AR9 and AR90 by the Acoustic Blanket™, a layer

of absorbent material surrounding the mid and highrange drivers. This has been continued on the AR91 and AR92.



Conventional loudspeaker system showing reflected waves from enclosure edges.



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

This "blanket" progressively attenuates sound waves traveling through it across the cabinet surface so that they are either completely absorbed or reduced (depending on the length of "blanket" they travel through) by the time they reach obstructions. When this "blanket" is coupled with the vertical array already described, the result is one of exceptional stereo localization with a very stable stereo sound stage.

MIDRANGE AND HIGHRANGE UNITS

The AR9 and the AR90 both utilized new tweeters and midrange units built with high temperature adhesives and with magnetic fluid in the voice coil gaps. By such means we were able to achieve better power handling capability than ever before.

The AR91 and AR92 use the same tweeter as the AR9 and AR90, but the midrange has to be a modification of that in those systems. The 1-1/2 inch dome used is, in both cases, a sealed unit and thus its resonance frequency is determined by the air cavity under the dome. This resonance determines the low frequency limit of the unit.

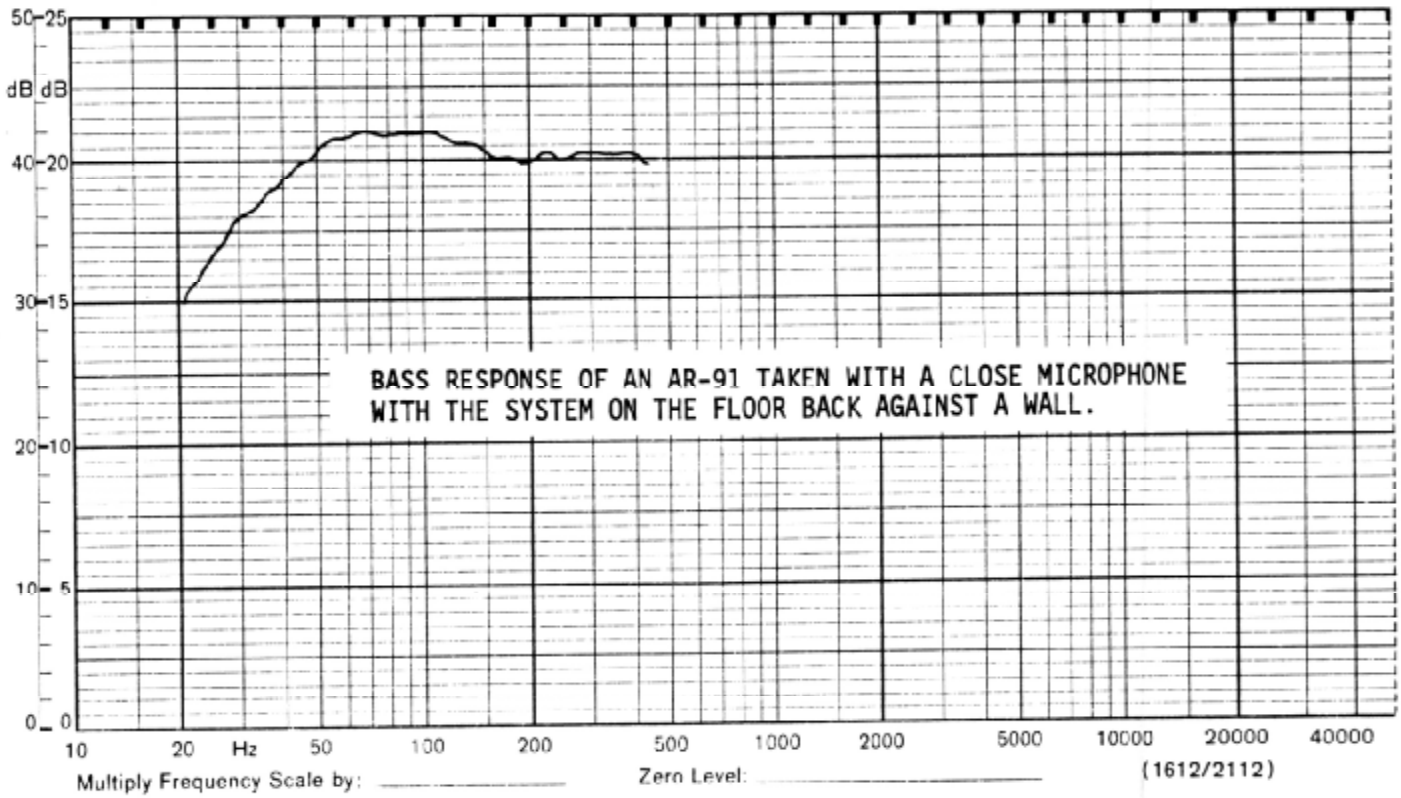
In the AR9 and AR90 unit the entire voice coil gap is filled with magnetic fluid to achieve their exceptional power handling ability. This means that the air cavity under the dome is relatively small, as the magnet air cavity is sealed off by the fluid, and thus the resonance is at a relatively high frequency. This does not matter in a four way system such as the AR9 or AR90 where the 1-1/2 inch unit is only used above 1200 Hz, but in three way systems such as the AR91 and AR92, we needed a unit that went down lower if we were to avoid taking the woofer up to frequencies where it becomes directional. The answer is simple - only the inside of the voice coil has magnetic fluid between it and the metalwork. The dome now "sees" a larger volume behind it as the outside of the voice coil gap is no longer sealed, the unit goes down to 700 Hz and, because we have not removed magnetic fluid completely, we still have significantly better power handling than in our earlier dome midrange units.

We thus have a midrange unit and tweeter that maintain the smoothness of response of the units in the AR9 and AR90 and that cover the range above 700 Hz. Below that frequency we have to look at the woofers.

THE BASS RESPONSE

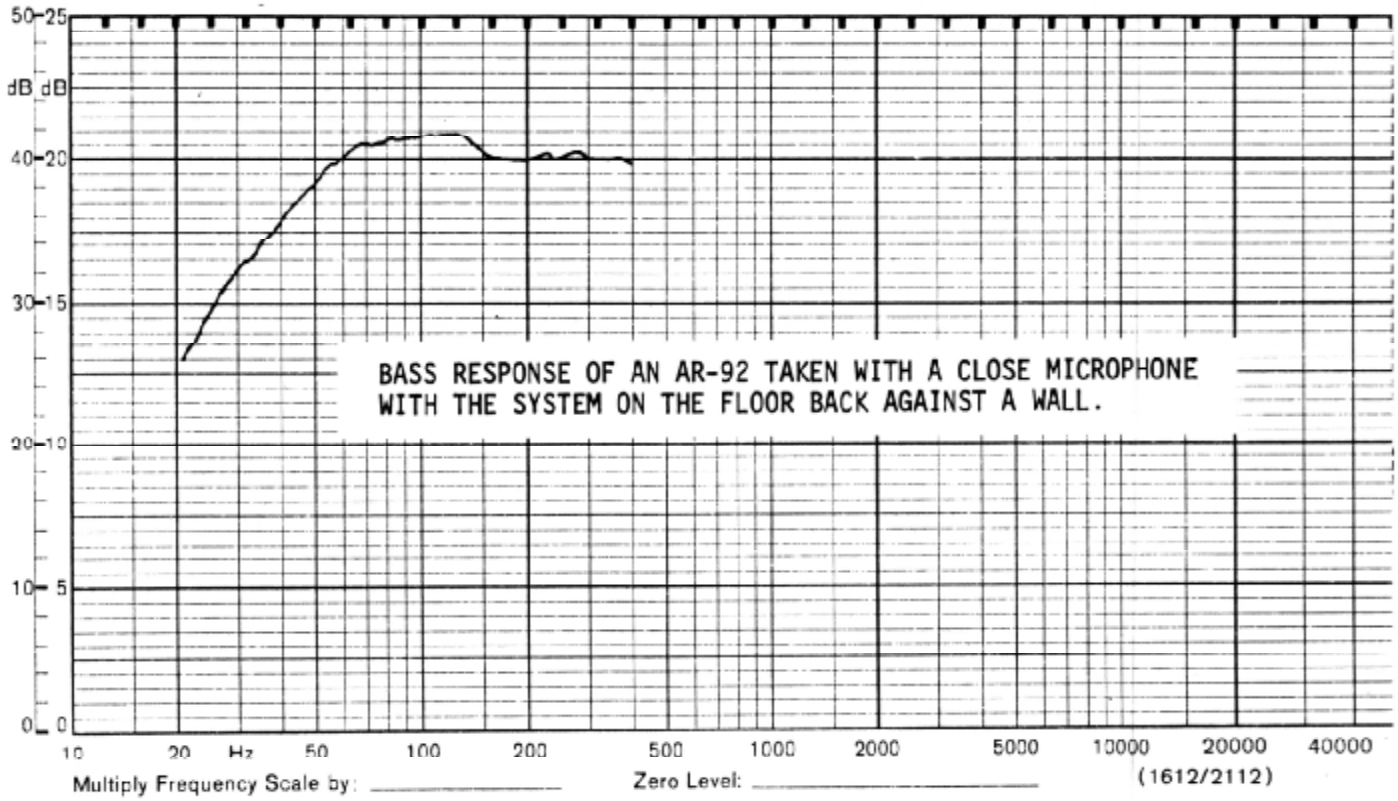
The AR9 used twin 12 inch 4 ohm woofers in parallel, together with special equalization circuitry, to achieve a critically damped bass that was only 3 dB down at 28 Hz. The AR90 came close to this, using two 10 inch 8 ohm mass loaded woofers in parallel.

The AR91 uses a single 12 inch woofer identical to those used in the AR9 in a volume of 46.8 litres. Dense packing of internal damping material gives a resonance of 40 Hz with a Q of .56. When this is combined with the crossover network, the result is a well damped bass end that is 3 dB down from average system level at 35 Hz (see curve below)



BASS RESPONSE OF AN AR-91 TAKEN WITH A CLOSE MICROPHONE WITH THE SYSTEM ON THE FLOOR BACK AGAINST A WALL.

The AR92 utilizes a completely new 10" woofer in the same size enclosure as the AR91. The unit was specifically designed for this system so that the same type of well damped low end could be achieved. To this end the unit employs a new large 8900 gauss magnet structure to give the same degree of electro-magnetic damping as that of the AR 12 inch woofer. The resultant system has a Q of .7 and is 3 dB down at 44 Hz (see curve below).



BASS RESPONSE OF AN AR-92 TAKEN WITH A CLOSE MICROPHONE WITH THE SYSTEM ON THE FLOOR BACK AGAINST A WALL.

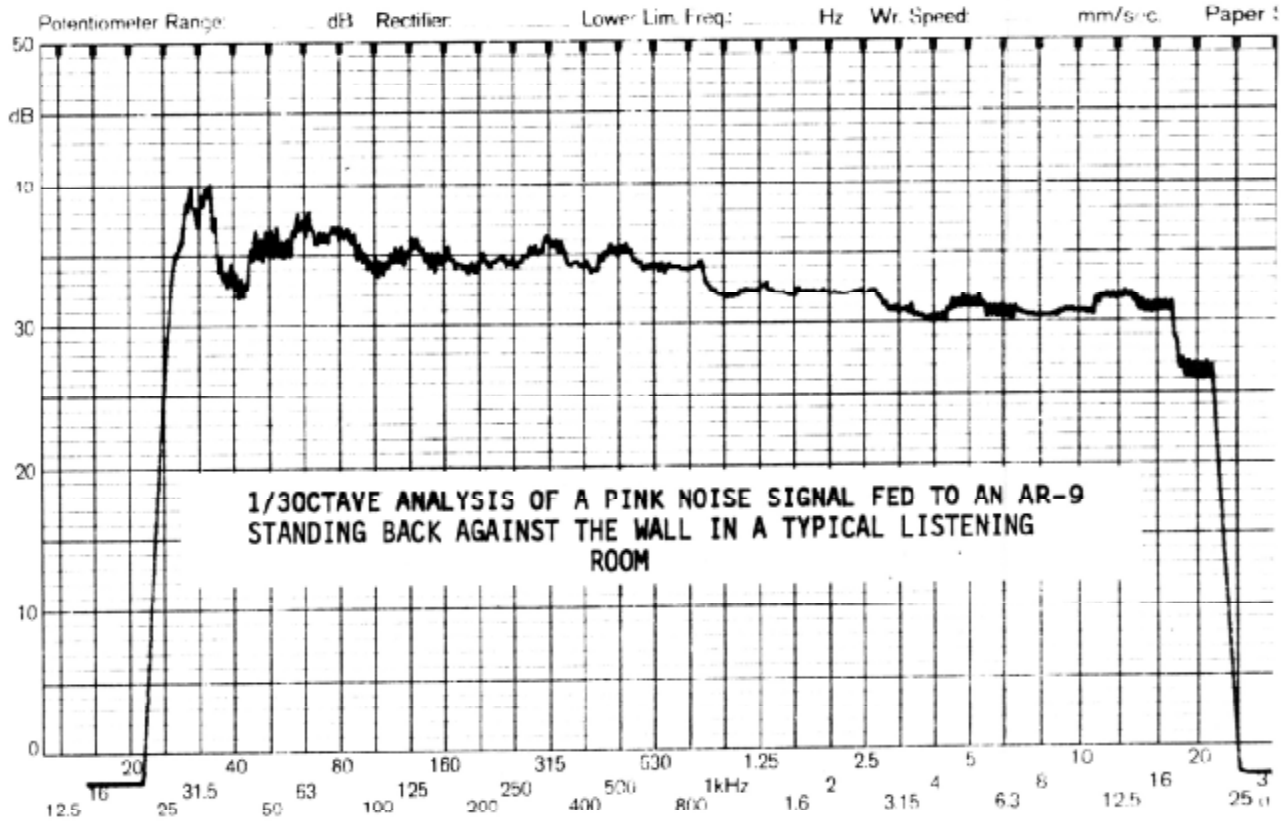
THE WALL DIP

3 dB down point and Q do not, unfortunately, tell the whole story on bass performance. One drawback of most loudspeakers back against a wall on or near the floor is an upper-bass phenomenon known as "wall dip". This can be seen on a 1/3 octave pink noise plot of a typical bookshelf speaker in a listening room back against a wall. The curve, shown below, was taken using a rotating microphone which averaged the output in each 1/3 octave over a generalized listening area in the room.

1/3 OCTAVE ANALYSIS OF A PINK NOISE SIGNAL FED TO A BOOKSHELF LOUDSPEAKER MOUNTED ON A STAND BACK AGAINST THE WALL IN A TYPICAL LISTENING ROOM.

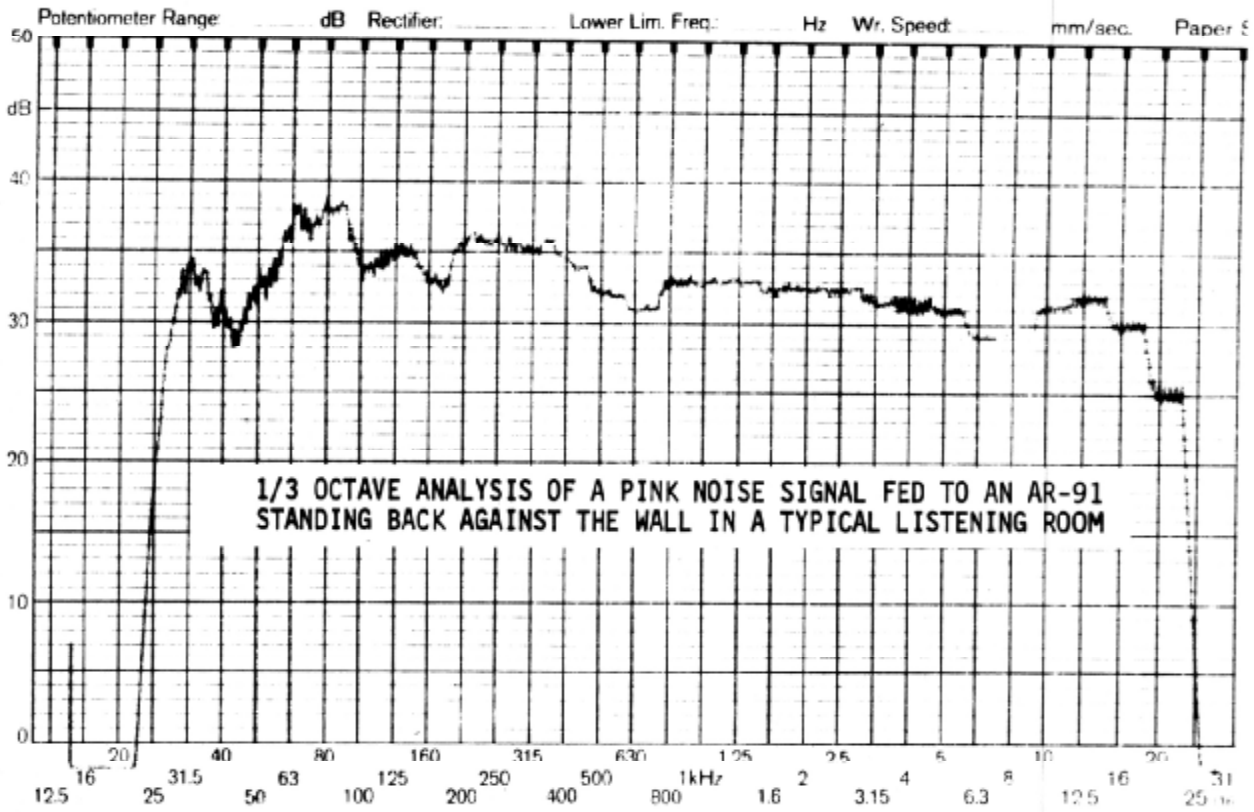
The reason for the dip around 200 Hz is that sound from the front mounted woofer is reflected from the wall behind the speaker and the floor beneath it and, at some range of frequencies, this sound will be out of phase with the direct sound. A dip is the result.

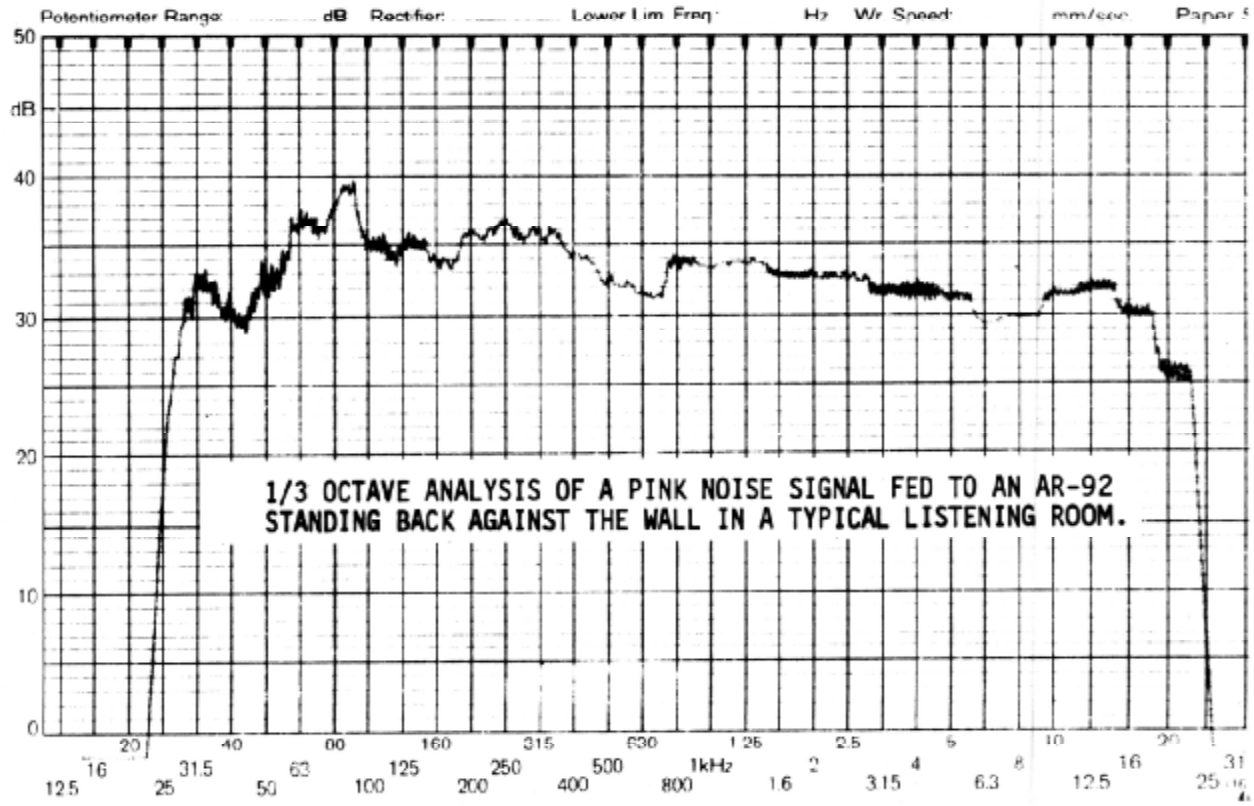
In the AR9 and AR90,side mounted woofers are so close to the wall behind the system and to the floor that the frequency of this dip is pushed well above the relatively low crossover frequency of 200 Hz. The result is that system response does not exhibit the "wall dip" as can be seen below.



1/3OCTAVE ANALYSIS OF A PINK NOISE SIGNAL FED TO AN AR-9 STANDING BACK AGAINST THE WALL IN A TYPICAL LISTENING ROOM

The AR91 and AR92 have conventionally front mounted woofers, a necessity in order to maintain a vertical array and thus good stereo imagery as seen earlier. The woofers are deliberately relatively close to the floor so that the floor reflection only becomes out of phase with the direct sound as we approach the crossover region. The front mounted woofer in each system does, however, also cause reflections in the wall behind the system if it is placed back against a wall. As this is the most likely position for a floor standing speaker to be placed in, this cannot be ignored. The cabinet used is fairly slim, but the interference frequencies still occur in the pass band of the woofer on the two 3-way systems. As this effect is unavoidable, albeit reduced as we have removed the floor contribution, we took account of it throughout the crossover development. Much of the crossover design work was done with the system placed back against the wall in actual calibrated listening rooms and also in an outdoors pi environment (on the ground against a long wall). In this fashion the network was tailored for real life listening situations and a room plot taken under the same conditions as the previous two curves does not exhibit the dramatic "wall dip" effect of the earlier bookshelf speaker on a stand in the same room position. The plots for the two systems may be seen overleaf.


Potentiometer Range: dB Rectifier: Lower Lim. Freq.: Hz Wr. Speed: mm/sec. Paper
50
dB
40
30
20
10
0
1/3 OCTAVE ANALYSIS OF A PINK NOISE SIGNAL FED TO AN AR-91
STANDING BACK AGAINST THE WALL IN A TYPICAL LISTENING ROOM
20
40
80
160
315
630
1.25
2.5
5
10
20
16
31.5
63
125
250
500
1kHz
2
4
8
16
31
12.5
25
50
100
200
400
800
1.6
3.15
6.3
12.5
25


Potentiometer Range: dB Rectifier: Lower Lim. Freq: Hz Wr. Speed: mm/sec Paper
50
dB
40
30
20
10
0
1/3 OCTAVE ANALYSIS OF A PINK NOISE SIGNAL FED TO AN AR-92
STANDING BACK AGAINST THE WALL IN A TYPICAL LISTENING ROOM.
20
40
80
160
315
630
1.25
2.5
5
10
20
16
31.5
63
125
250
500
1kHz
2
4
8
16
31
12.5
25
50
100
200
400
800
1.6
3.15
6.3
12.5
25