Bose 901 loudspeaker

By J. Gordon Holt • Posted: Nov 7, 1995

Specification
Description: Moving-coil loudspeaker housing 9 full-range 4"-cone drivers arranged for 11% direct-radiated and 89% reflected sound. Supplied with variable active equalizer consolette. Nominal impedance: 8 ohms.
Price: $476/pair.
Manufacturer: Bose Corporation, 1 Strathmore Rd., Natick, MA 01760 (1971). Bose Corporation, Mountain Road, Framingham, MA. Tel: (800) WWW-BOSE (999-2673). Fax: (508) 820-3465. Web: www.bose.com (2001).

Manufacturer's Comments
Our technical analysis of the theory behind the 901 differs from *Stereophile*'s in a number of respects. Since the final test of a speaker is in its sound with actual program material, we urge *Stereophile* readers to audition the Bose 901 and then judge for themselves whether *Stereophile* or the 15 other US and foreign reviews, which draw completely different conclusions, is correct.—**Bose**

The Bose 901 has created more of a stir in audio circles than any other loudspeaker we can think of, with the possible exception of the original Acoustic Research system. Much of the 901's popularity is attributable to Julian Hirsch's rave report in *Stereo Review*, and there is no doubt but that Amar Bose's compellingly convincing ads had their effect, too. But these things alone could hardly account for the 901's popularity. Perhaps the most important single factor in the 901's sales is its awesomely spacious sound, which makes other systems in a showroom sound a bit trivial, as if the Bose is the Truth and the Light, and the others are just playing around. The 901 sounds fantastically open and spacious, with a big, fat low end and a socko you-are-there presence that seems to put the performers right in the room, surrounded by the original auditorium.

We were duly impressed by these qualities, too, and reported this in our preliminary report in the last issue. But we were less impressed by some other qualities of the 901, one of which was not altogether the fault of the system.

We have observed in the past that some loudspeakers seem to be more critical than others of placement in the room, and while we have never definitely established what it is about a speaker that affects its room sensitivity, we do have some ideas on the subject.

Standing waves, which determine to a major extent a small (in comparison with a concert hail) room's acoustical coloration, are most effectively set into resonance by soundwaves originating from the room corners. The fact that, in a living room of typical size, the strongest standing-wave resonances usually occur at low frequencies, is the main reason why putting a speaker in a corner will produce the most bass-heavy sound. Once we get out of the corner, though, the efficiency with which each standing wave is stimulated will depend on the speaker's precise location relative to the room corner. Two feet out from the corner, and it may only "tickle" the major resonance in the room. That peak then will be less severe than with the speaker cornered. Three feet out, and that particular resonant mode may not be excited at all—the response may be perfectly smooth there but another resonance, which may have been completely suppressed two feet from the corner, may now be fully excited, producing a peak at another frequency.

The larger the room, the less critical the speaker placement is likely to be, but in many typical listening rooms, a change in speaker placement of as little as a foot can make the difference between a sodden, suffocatingly heavy low end and a tight, well-defined one.

The crucial factor seems to be the location in the room from which the woofer(s) are feeding energy into it. Thus, it is often (usually, in fact) possible to obtain flatter overall response with a single relatively small woofer, which radiates from a small area, than from a multi-woofer system whose low end radiates from a general area that may be several feet wide.

By the same token, loudspeakers which radiate their lows in one direction (they are nondirectional *after* they leave the speaker) seem less prone to excite all the room resonances than ones which radiate from front and rear or front and sides. True omnidirectional (360-degree) bass radiators make it harder still to control standing waves, and that appears to be one of the problems with the Bose 901.

The 901 is neither an omnidirectional radiator nor a true doublet (front-and-rear) radiator. Most of its energy comes from a broad angle at the rear; a single driver in front delivers but a small fraction of the total radiated energy. The entire audio spectrum is radiated from both front and back, with back output predominating. The back wave is then supposed to be reflected from the wall behind the speakers, and these reflections "spray" the sound all over the listening room. The effect, as far as bass frequencies are concerned, is that the room is being stimulated, not by a pair of small surfaces, but by a pair of very broad areas. And the result is that, if there are any standing waves possible in that room, they will all be stimulated to the fullest. And although the 901 speakers are less critical of room placement insofar as stereo imaging is concerned than are most other systems, their approximate locations are nonetheless circumscribed by the requirements of a nearby rear wall and the usual dictates of symmetrical placement in the room, so their bass performance ends up being more dependent on the vagaries of the room than on the inherent capabilities of the speakers.

Thus, some 901 installations will have deep, tight, and quite well-defined bass, while others (in the majority) will exhibit uncontrolled bass resonances at frequencies which are entirely a function of the room dimensions. This no doubt explains the very widely conflicting reactions of different listeners who auditioned the Bose 901 in stores or purchased them for use at home.

The 901 equalizer (which connects between preamp and power amp) does have a switch position that attenuates the range below about 50Hz (for reducing "turntable rumble and other low-frequency disturbances") and this can help to alleviate the situation in many cases, if used. But since bass attenuation is a dirty word to most audiophiles, fewer people use it than don't, which is hardly the fault of the speaker. The filter cannot, however, cope with resonances above 50Hz.

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Now, let's consider for a moment some of the basic premises on which Dr. Bose based the design of the 901.

The major departure from conventional design here is the system's unique directional characteristics, with most of the sound coming from eight rear-facing speakers and the rest from a single front-facing speaker. According to Dr. Bose's literature, this was done to simulate the conditions in a concert hall, where measurements have shown that only about 11% of the sound reaching a listener is direct sound, coming straight from the instruments, while the rest is reverberant energy, due to reflections from the boundaries of the hall (walls, ceiling, etc.). The implication here is that the 901 turns your listening room into a mini-auditorium, and that the spaciousness of the 901's sound is due to reverberations in the listening room. It is our feeling, though, that Dr. Bose is either oversimplifying his explanation of what the 901 does or has drawn some dubious conclusions from his basic premise, because as far as we can see, the "reverberant" aspect of the listening room is not really pertinent to the operation of the system at all.

Reverberation is a slow decay of sound in a hall, due to reflections bouncing back and. forth between the hall boundaries (walls, ceiling, etc.) until they are absorbed. In a listening room of typical size, reverberation as such is too short in duration to contribute anything to the sound except some smearing of detail and the excitation of resonances within the audio range, so they are undesirable. And it is not reverberation that the 901 depends on anyway, it is reflection. And what the reflection does, we believe, is to produce the acoustical equivalent of an electrical comb filter (fig.1).

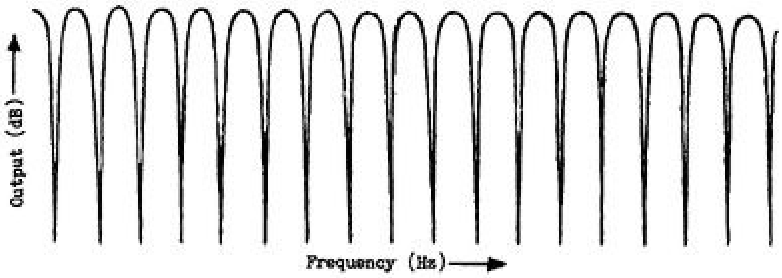

Fig.1 Frequency response (bandpass characteristic) of a comb filter.

We think of the spatial aspect in sound as being a function of the directions from which sounds are reaching our ears. This is only half of the story, though. With one ear stopped up, the other is virtually oblivious to the directions of incoming sounds. In a concert hall, the unblocked ear can readily hear the hall reverberations arriving from all directions, but the spatial sense is entirely absent, just as it is from a monophonic recording. With both ears functioning, neither is any more aware of direction than it is working alone, but now the two ears are hearing *differences* between the impinging reverberations, and it is the comparisons between each ear's "input" which our brain interprets as spatial information.

The sounds reaching us directly from the instruments are relatively simple in structure, consisting of a series of wavefronts like the walls of rapidly expanding balloons spreading out from each instrument. If we face an instrument head-on, its wavefronts pass each ear at the same instant and at the same angle—both ears hear exactly the same thing, and we localize the soundsource as dead ahead. Instruments located to one side reach the ears at slightly different moments, and the "shadow" of the head causes the more distant ear to hear a slight loss of volume and overtone content, and our brain tells us the sound is over *there*, to one side.

The reflected sounds which we hear as reverberation, though, are exceedingly complex. Since they reach us from different directions, it is obvious that they will have travelled different distances (from the source) before they reach us. The infinite number of distances involved means that many soundwaves reaching us will be out of phase with one another at certain frequencies from certain directions and at other frequencies from other directions, and the patterns of cancellation will be different from one side of the hall than from the other (footnote 1).

The effect, as far each ear is concerned, is a series of sharp dips in the frequency response of the reverberant sound, with one ear hearing the dips at one set of frequencies and the other hearing them at another set of frequencies. And, of course, the location of each instrument on the stage will cause it to produce dips at different frequencies in its reverberant sound.

The same principle has been used to produce pseudo-stereo recordings from monophonic ones, by means of a comb filter. This is a device which gives a frequency response that looks like a comb, and when two such devices are used, with the dips at different frequencies, the result is a pair of signals which simulate the spatial cues of reflective reverberation. Feed one to each speaker, and the mono sound will appear to spread across the space between them instead of appearing midway between them. (Other tricks are used in pseudo-stereo production to give the illusion of left-right positioning for certain instruments, but the main source of "spread" in these recordings comes from the comb filters.)

Footnote 1: You may argue that this would not be so if you sat *exactly* in the middle of the hall and listened to an instrument *exactly* on the middle of the stage, and we suppose it shouldn't, but it is anyway, which is probably one reason acoustical experts can't predict how a new hall is going to behave.—**J. Gordon Holt**

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This is what the Bose 901 does, on a small scale. Fig.2 shows the paths of sound waves coming from a left-channel 901. A listener hears not only the front-facing speaker **A**, but also the right-rear reflection **B** and the left-rear reflection **C** which, bouncing from the side wall, effectively spreads the source of reflections beyond the limit of the rear wall and partway around the side wall. The reduced output from the front speaker (11% of the total) prevents it from dominating the entire sound "stage" and thus contracting the apparent radiating area to a small point. And since the distance between the front speaker and the listener is shorter than any other path, sounds from there reach him first, and his ear responds by localizing the unified wavefronts of direct sounds at about the center of the speaker. (This is known as the Precedence Effect.)

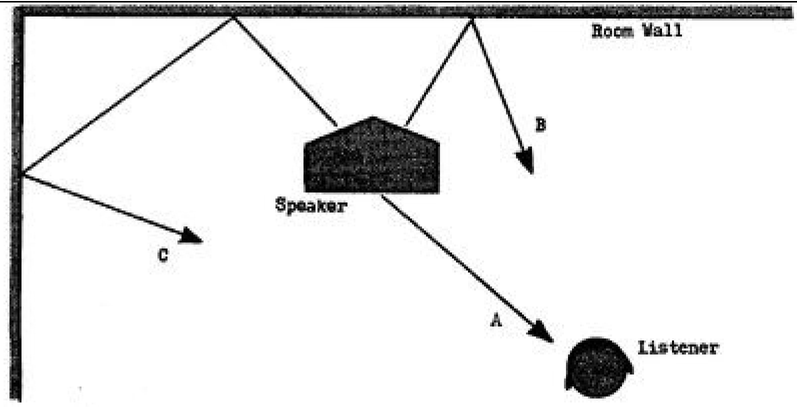

Fig.2 How reflections from the rear of a Bose 901 broaden the apparent source.

As for the rear-radiated sounds, these behave as do the reflected ones in a concert hall. Their time of arrival at the listener varies according to the distance they travel, phase interference takes place, and the comb filter effect chops holes in the response of the reflected sounds.

This broadens the apparent soundsource, and in that sense it does add spaciousness to the sound, but this alone can't account for the 901's remarkably spacious sound. What is needed to do this is the reverberant information from the second channel. It gets the same reflective treatment as that from the first channel, but now, along with the phase interference in each set of reflected signals, there is additional interference between them. Since this causes combing of similarities in the two reverberant fields more than it affects their differences, the effect is to increase the differences between the two reverberant signals, and our ears perceive the increased difference as enhanced spaciousness.

It is probably fair to say that the 901 actually exaggerates spaciousness from recordings, rather than reproducing it as it is contained in the recording. But since two-channel stereo reproduction is inherently deficient in spatial qualities anyway, it must also be said that the net result is an improvement in realism. The 901 does not synthesize the added spaciousness, though; it merely enhances what is already on the recording. Thus, a recording made outdoors will not be imbued with concert-hall spaciousness, but is instead made to sound even more convincingly outdoorsy. And a recording with no spatial information on it at all, like a mono one, will sound somewhat diffuse but will have virtually no more spaciousness than it would through any other speaker system.

This tremendous gain in spatial effect is not, however, achieved without some sacrifices. Even though Precedence Effect helps to localize the discrete wavefronts from direct sounds in their proper places across the stereo stage, there is enough repetitive (cyclical) signal content in even the direct sounds for them to be subject to some combing as a result of the multiple reflections, and this causes some loss of imaging specificity. There is no increase in "wandering" tendency—indeed, the 901 yields as stable a stereo image as any speaker we have tested. But there *is* a perceptible widening of the apparent source of any given sound, making it possible (by spacing the speakers too far apart) to create such monstrosities as 2'-wide singers and 8' guitars.

Even with optimal spacing, some purists will cavil at this loss of specificity, even though we point out that instrumental localization is not all that pinpointed under live listening conditions. On the other hand, at a live concert, our aural localization is abetted by visual localization, so there *is* something to be said for having more-specific aural localization when we must depend entirely on our ears, as when listening at home.

What *is*, we feel, a more serious shortcoming of the 901 principle is that it subjects the direct sounds in a recording to the same reflective process that enhances the recorded spatial material. The first of the rear-reflected waves reaches us a relatively long time after the front-radiated wave has passed, and while this is of no consequence as far as spatial information is concerned—and may actually enhance it—it cannot help but impair the detail of those signals which represent direct sound in the recording. Precedence effect can retain the localization of the direct sounds, but it cannot prevent the rear-reflected sounds from being audible a fraction of a second later. And since each rear-radiated wave reaches us from an infinite number of distances, it arrives not as a single delayed impulse, but as a smear. There is no perceptible echo—the delay is too short for the ear to perceive as a gap. Instead, there is what appears to be a marked softening of detail, as though every sound is being followed by a rapid decay rather than a sharp cessation of sound. It sounds, in fact, like short-lived hangover, which is just what it is. The only difference between this and the hangover we associate with resonating loudspeakers is that this involves a wider range of frequencies and is acoustically rather than mechanically induced.

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There are two other things about the design of the 901 that we question, too. One of these is the use of electrical equalization to compensate for deficiencies in the speakers at the high and low ends of the audio range. Equalization of this kind is fine, of course, if only a small amount is needed to add the last *n*th degree of perfection (?) to a system, and if the loudspeakers can take it without swapping extended range for increased distortion. What bothers us about the 901, though, is the *amount*of compensatory boost that has been used, rather than the fact that it is used at all.

The equalizer that is part of the 901 system offers a selection of response curves via several front-panel switches (fig.3), but even in the operating mode that is identified as having the flattest response, the speakers themselves are being fed rather substantial amounts of bass and treble boost. And we are not convinced that this can yield as good performance as is obtainable from a system that needs little correctional boost or none at all.

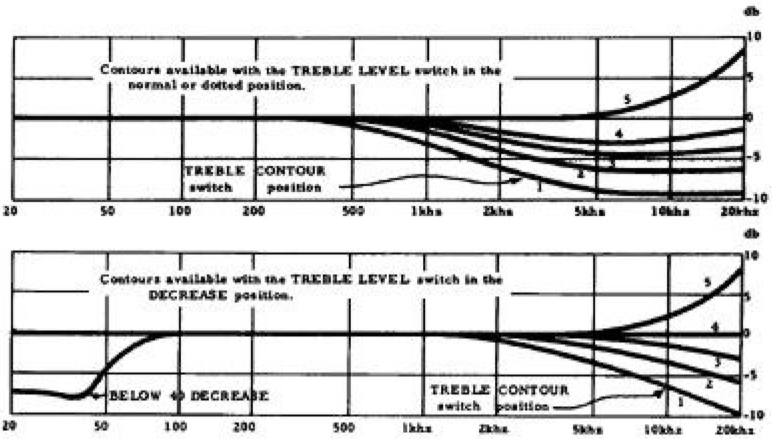

Fig.3 Response curves (from one of Bose's blurbs for the 901) show the wide range of equalization contours available from the speaker's active equalizer.

Dr. Bose approached the problem of the inescapable bass resonance in speakers by moving this up in frequency (to around 200Hz) and applying equalization to offset the normal 6dB/octave rolloff below resonance. The result is unusually smooth response down through the range where all other speakers exhibit some sort of resonance, but the amount of bass boost necessary to carry the speakers below 40Hz is quite substantial, and puts rather extreme demands on the output capabilities of the amplifier, as well as on the capacities of the speakers.

The speakers themselves produce audible distortion below 40Hz at what we would judge to be only moderate listening levels, yet on musical program material, the only subjective effect of this is to make deep lows sound a little less deep, and, in fact, the 901 is able to put out really respectable levels (even on bassy program material) without offensive distortion when driven by a modest 35Wpc with the equalizer unit set for bass cut (*ie*, with equalization ceasing at 40Hz), or with a brute-force power amplifier like the Crown DC-300, the 901 will deliver more than enough acceptably clean volume to satisfy anyone but a decibel fanatic.

But what about that 200Hz resonance? Dr. Bose contends that, if you use for the nine speakers ones whose resonances all occur at slightly different frequencies, the resonance of any one becomes "inaudible." We are not convinced of this, for a resonance causes a transducer to continue vibrating for a time after the signal that started it going. has ceased, and adding more resonances can only cause the system to "hang over" at more different frequencies. Thus, we do not feel it was purely coincidental that the 901 we tested seemed to have a tend toward upper-bass heaviness in the four rooms we set it up in.

The effectiveness of highÄfrequency boost is open to some question, too. Theoretically, any device that has had its high end boosted, to yield the same treble response as an unequalized device, should have the same treble performance on musical signals, but we have not always found this to be the case. Equalization can cause a speaker cone to react more promptly to a transient signal, but it cannot reduce the inertia of the cone, and thus cannot increase the cone's ability to *stop* moving once the transient has passed.

Instead, improving its start-up speed is more likely to make its stopping ability worse by causing it to overshoot the mark We could not determine just how much of the Bose 901's high-end performance was the result of this and how much was the result of smearing due to the prolonged room reflections, but the fact remains that all of our listening panelists gave the 901 rather poor marks for detail and definition. (Try this yourself: Play some sound-effects recordings of clinking or clanking metal, adjust any controls on hand for the most natural sound from these, and then see if you can stand listening to music with the same control settings.)

Of course, the apparent high end from the 901 is profoundly affected by the surface texture of the walls behind and beside the speakers, for the more absorptive these are, the less treble will be reflected into the room. The worst possible condition is with draperies behind them (or an open entrance way), and the best is with glass.

The 901's veiling tendency will not appeal much to audio perfectionists with amplifiers that don't add hardness to the sound, and who can feed these clean, quiet program material. But it will be a definite boon to most hi-fi buffs, for it makes the speakers unusually tolerant of the hardness of typical solid-state electronica and the distortion from imperfectly tracked discs. And we mean no insult when we add that the 901 made our few treasured 78-rpm discs sound as listenable as we have ever heard them, and managed to do this without deadening their high end (as do all filters we've tried).

We don't wish to give the impression, though, that the 901 is a dull-sounding system. You can, of course, make it sound that way via the treble-cut settings on the equalizer, or you can make it sound hard and zippy at the top, but with the equalizer set for flattest response (according to Bose's curves, and our ears), the 901 has much of the brilliance of a typical horn system, but without the "horny" midrange coloration.

If we were to judge the 901 in terms of the best sound available, then, we would say that it produces a more realistic semblance of natural ambience than any other speaker system, but we would characterize it as unexceptional in all other respects. It is ideal for rock enthusiasts to whom sheer sonic impact is of paramount importance, and for classical listeners who want the next best thing to ambient stereo without the cost and the bother of rear-channel add-ons. However, we doubt that the 901 will appeal to perfectionists who have developed a taste for subtleties of detail and timbre.