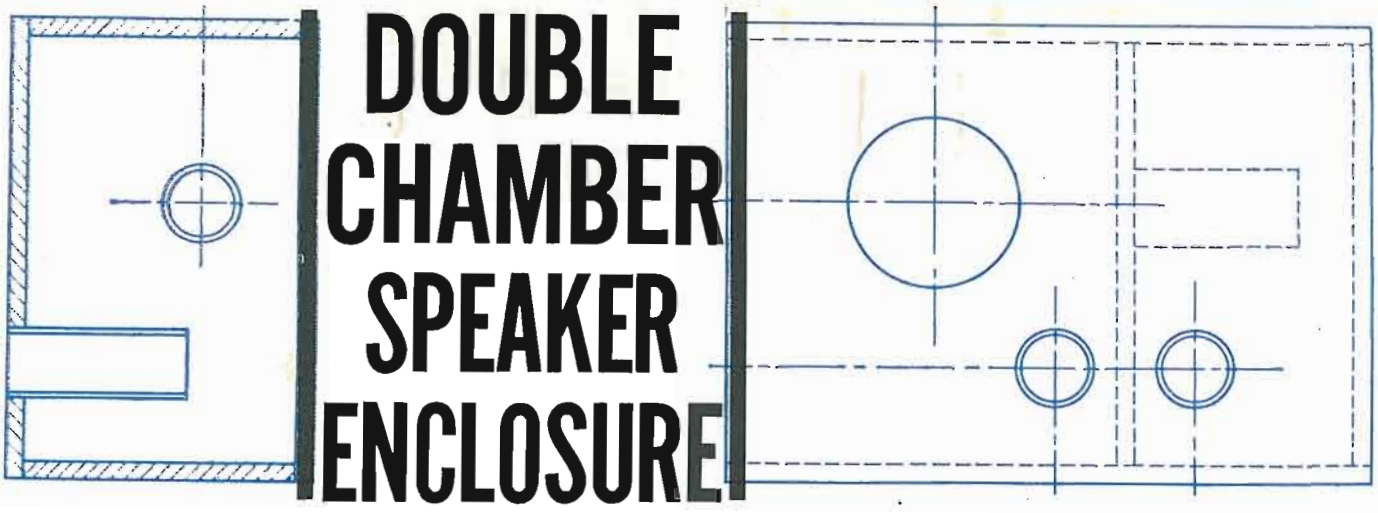


DOUBLE CHAMBER SPEAKER ENCLOSURE

By *GEORGE L. AUGSPURGER*

Construction details on an experimental enclosure that will extend the bass response of almost any good 8-inch loudspeaker down to a usable 35 cps.

THIS enclosure will extend the bass of almost any good 8-inch loudspeaker to a usable 35 cps. With a good, high-efficiency speaker installed, performance in the very low bass region is excellent. The design is easy to build and dimensions are reasonable. The proportions lend themselves to a variety of styling treatments. It is, to put it briefly, a pretty interesting little box.

What Is It?

Basically, a double-chamber (or double-tuned) enclosure differs from the usual reflex configuration by having two tuned chambers instead of one. The idea is not new. Variations of the double-tuned reflex have been used by the *BBC* and *Quad*, among others. Considerable freedom in design is possible and results can also vary, depending on just what you are trying to do.

The configuration shown in the photographs is different from any other I've seen. It was worked out to allow maximum flexibility in experimentation while trying to find out just how far the bass response of a standard 8-inch speaker could be extended.

How It Works

A normal reflex enclosure is matched to the characteristics of a specific loudspeaker or group of loudspeakers. It is essentially a Helmholtz resonator tuned to a suitable low frequency (35-70 cps) where the speaker, without help, can't move enough air to maintain uniform bass response.

At its resonant frequency, the reflex enclosure inverts the phase of the sound from the rear of the loudspeaker, adding it to that produced by the front of the cone. The enclosure also loads the speaker acoustically, reducing cone movement and distortion.

But above and below this resonant frequency, the reflex enclosure unloads its driver. As a consequence, if the resonant frequency is set too low, mid-bass response is weak and the speaker can be overloaded in this range. If the resonant frequency is set too high, deep fundamental tones are lost and the speaker is easily overloaded by low-frequency signals.

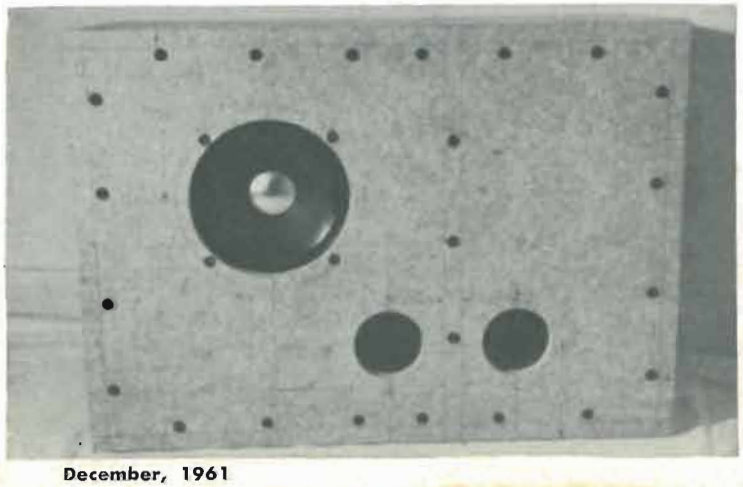
In contrast, the double-chamber enclosure is tuned to *two* frequencies about an octave apart. The higher frequency gives acoustic loading in the mid-bass region, and the lower frequency maintains loading down to a suitable low-frequency limit.

The photos show the experimental enclosure built to house an 8-inch loudspeaker. The interior design and dimensions are shown in Fig. 1.

In this design, the larger chamber (in which the loudspeaker is mounted) is tuned to 70 cps. Its volume is about 1.8 cubic feet. The combined effect of two ducted ports is used to tune the chamber. One port is placed in the partition between the two chambers and the other exhausts outside.

Below 70 cps, the first chamber starts to unload the speaker and air moves freely through the port in the partition.

Front panel of the unfinished double-chamber enclosure.



Finished version of enclosure constructed by the author.

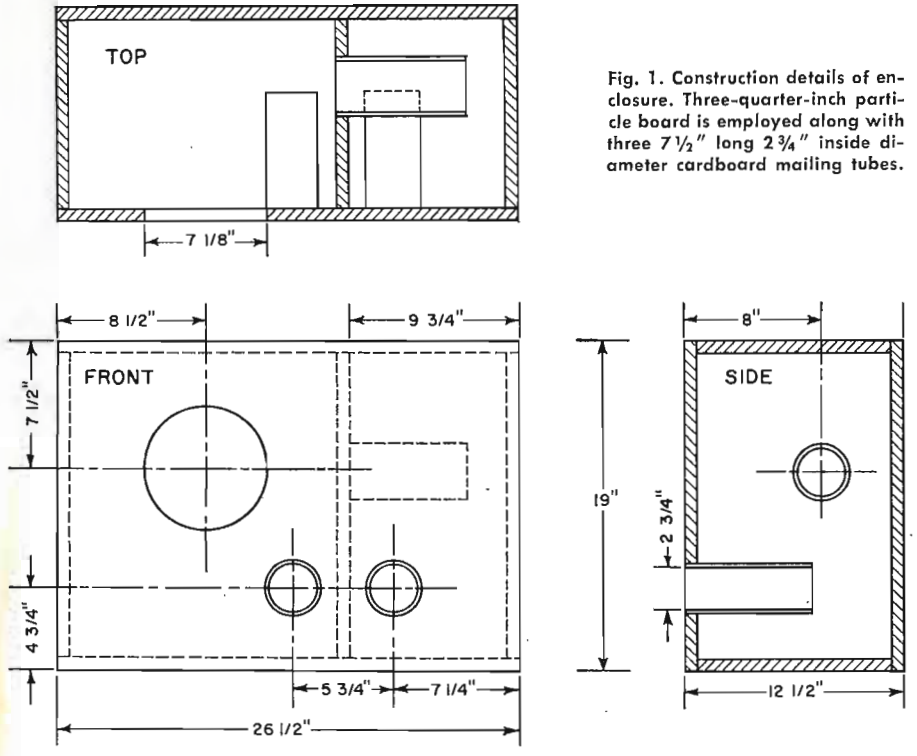


Fig. 1. Construction details of enclosure. Three-quarter-inch particle board is employed along with three 7½" long 2¾" inside diameter cardboard mailing tubes.

As far as the speaker is concerned, the partition ceases to exist. Then, near 35 cps the combined volume of both chambers reacts with the two outside ports to establish the lower system resonance.

Effect on Impedance

By spreading reflex action over a band of about two octaves, the double-tuned enclosure eliminates the need for close matching to a particular loudspeaker.

To verify this, the experimental enclosure was tried with three 8-inch loudspeakers having free-air cone resonances of 39, 56, and 70 cps respectively. Impedance curves were run in each instance and these are shown in Fig. 2. Instead of the double-peaked impedance curve of a reflex system, there are three peaks and two dips. The dips at 35 and 70 cps indicate the two system resonances and they show up quite clearly on all three curves.

It's important to remember that impedance curves are useful only if you know what they are related to. A smooth impedance curve does not necessarily have any connection at all with smooth response. There have been a number of recent articles pointing with pride to smooth impedance curves achieved by stuffing a reflex port with an old Angora sweater or gluing a layer of thick felt to the speaker cone suspension.

This approach is a little like trying to improve the performance of a car by keeping your foot on the brake. It runs smoothly no doubt, but you've thrown away most of the power in the process.

The nice feature about a good reflex system is that the levelling-out of impedance is a result of acoustic loading on the speaker cone. This acoustic loading increases efficiency while lowering distortion—a most worthwhile combination.

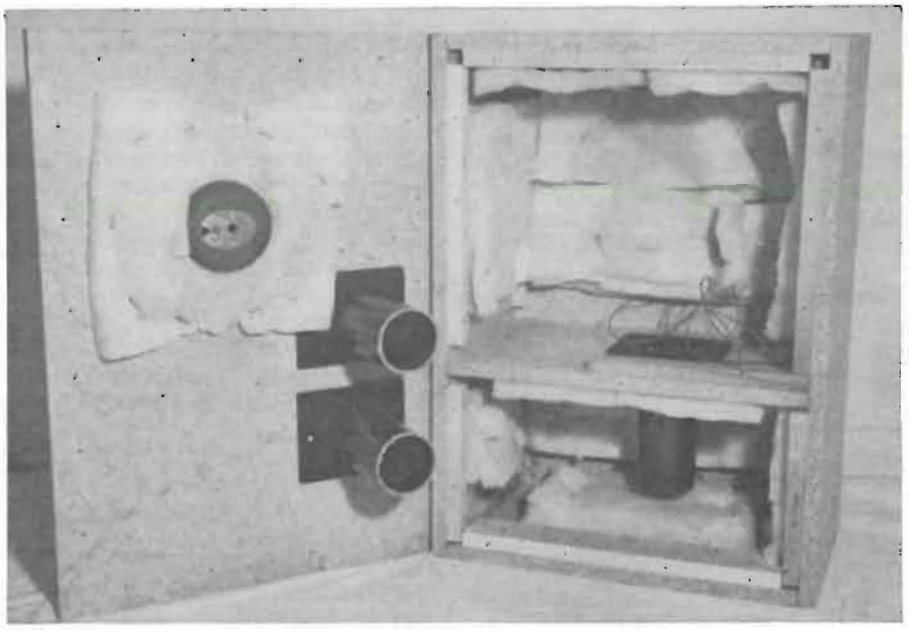
In the case of the experimental double-tuned enclosure, there is only one frequency at which some additional resistive damping might be desirable. Note the upper impedance peak which lies between 85 and 105 cps, depending on the speaker installed. In some cases, this peak will correspond to a slight boominess in reproduction. Fortunately, the cure is simple—tack a layer of damping material immediately behind the speaker. A single thickness of one-inch glass wool or a couple of layers of burlap will do nicely.

This bit of resistive damping is a good precaution against mid-bass boom and it goes directly to the fundamental problem without noticeably affecting the efficiency of the system below 70 cps. The damping layer is clearly shown in one of the photographs.

Bass Performance

Fig. 4 shows free-field response curves of the experimental enclosure with a *JBL* LE8 and a *JBL* D216 installed. This leads us to issue a word of caution: I have a distrust of published "response curves" because no little squiggly line can possibly delineate the listening quality of a loudspeaker system. Consequently, if you must look at curves, please try to find out as much as possible about how they were made before comparing them. And then don't believe everything you see until you have a chance to hear the systems in question. Enough said!

The curves in Fig. 4 were run with the experimental enclosure lying on its back on a 12-foot-square platform on top of a building. A calibrated microphone was suspended 6 feet from the speaker 45 degrees off-axis.



Interior of the enclosure, shown here in a vertical position. Three ducts are used.

The system was driven by 8 volts of pure sine-wave signal from a standard *McIntosh* 60-watt amplifier. There was no attempt to change the damping factor of the amplifier to get a better curve.

Now the *JBL* D216 is an extremely efficient 8-inch speaker with a very light cone assembly. The LE8 is a less efficient unit featuring a rather elaborate long-throw cone suspension. It is designed to deliver full-range response in small bookshelf enclosures.

Yet, although these are two quite different units, the curves of Figs. 2A and 2B are almost identical below 200 cps. This is further indication that the heavy acoustic loading and reflex action of the double-tuned enclosure are primary con-

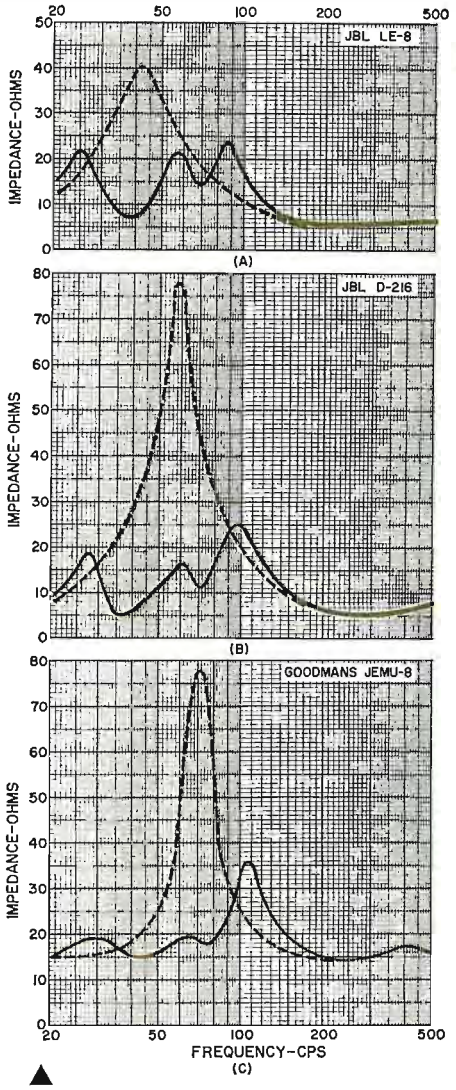


Fig. 2. Impedance curves of three of the loudspeakers used in the enclosure. The dashed curves are the impedances measured in free air, while the solid curves show the impedances of the three speakers when they were mounted in enclosure described. Two Jim Lansing and one Goodmans 8" loudpeakers were employed for these tests.

trolling factors in the bass response of the system.

Also note that even though the system is radiating into a 180-degree solid angle, both speakers maintain substantial output to about 32 cps. This is particularly impressive considering that we are talking about 8-inch speakers.

The main difference between the two speakers' performance lies above 200 cps. The LE8 is flat within about 5 db from 32 to 1000 cps. The D216, being the more efficient speaker, climbs gradually about 6 db up to its midrange level. This, incidentally, points up a common misconception about long-throw loudspeakers. Other things being equal, the less efficient speaker does *not* have more bass—it has *less* midrange.

Since the bass response of a speaker system in a room generally extends lower and is more efficient than outdoors, it is a toss-up as to which of the two speakers tested will have the smoothest bass under normal listening conditions.

In the double-tuned enclosure, the D216 has a crisp, firm bass characteristic. Bass is not particularly prominent until a really low fundamental comes along.

The LE8 in this enclosure has a more robust, rich bass which some people will prefer. In all honesty, however, this is really a case of gilding the lily since it will deliver comparable performance in smaller, less complicated enclosures.

Bass Distortion

Trying to coax 35 cps out of an 8-inch speaker doesn't accomplish much unless it is an *honest* 35 cycles. If the output turns out to be mostly frequency doubling, far better to restrict the bass range to a more orthodox limit.

Fortunately, in the experimental system the lack of distortion at very low frequencies is even more surprising than the extension of frequency response.

Fig. 3 is a graph of response and distortion of the two systems below 200 cps. Fig. 3A is the D216 in the double-tuned enclosure while Fig. 3B is the LE8 in the same enclosure.

Again the tests were made outdoors. This time the speaker system was placed vertically against the wall of a building and the microphone was placed three feet away on-axis. The signal was a pure sine-wave and the speaker was driven by a standard 60-watt *Dynaco* amplifier. Again, there was no adjustment of the amplifier's normal damping factor.

For the distortion measurements, the speakers were deliberately overdriven. Eleven volts were fed to the D216. This represents 15 watts into 8 ohms. Why 8 ohms when the D216 is rated at 16 ohms? You must understand that the rated impedance of any loudspeaker is just a convenient figure to use when hooking it up to an amplifier. Its measured impedance will wander all over the place at various frequencies. *JBL*, like many other speaker manufacturers, uses an average impedance rating, that is, the measured impedance of a 16-ohm unit can be expected to vary from, say, 6 to 60 ohms at different frequencies.

So far so good. But the heavy acoustic

(*Continued on page* 72)

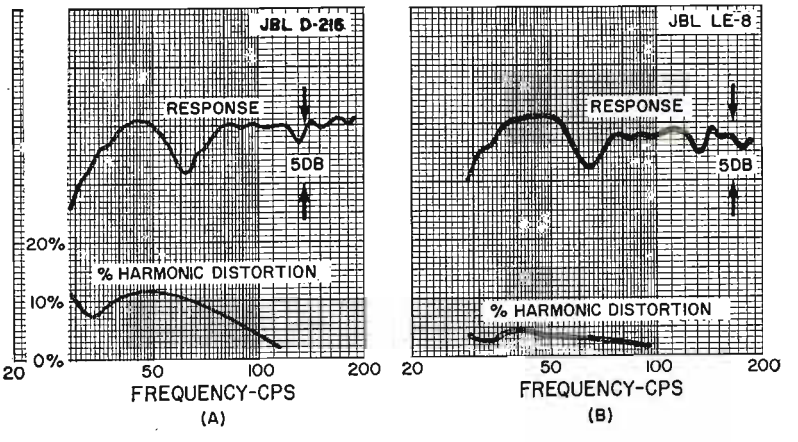
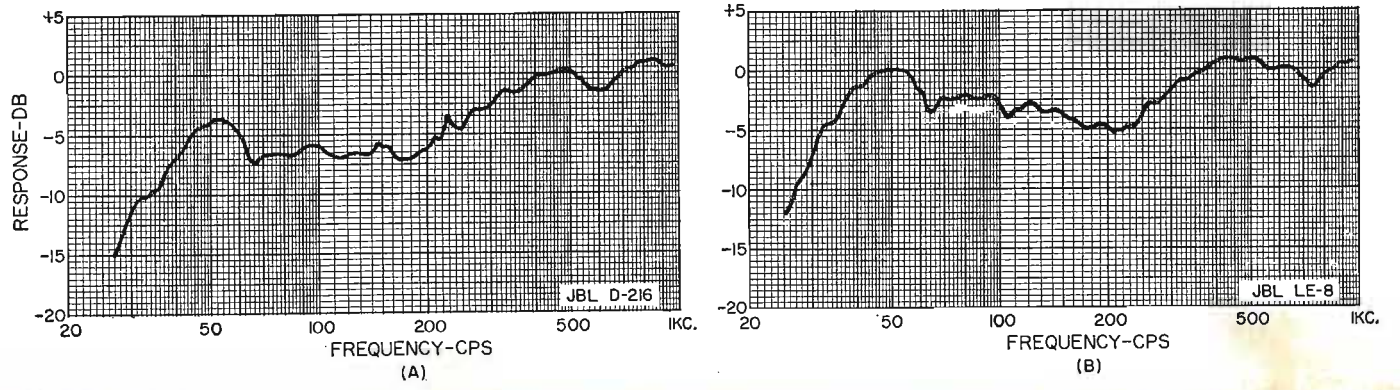


Fig. 3. Response and harmonic distortion of (A) JBL D-216 and (B) JBL LE-8 loudspeakers in the double-chamber enclosure. Power input was 15 watts in both cases.

Fig. 4. Free-field response of two of the 8" loudspeakers used in the experimental enclosure. The loudspeaker whose acoustic response is shown in part (B) of the figure is about twice as expensive as the speaker whose response is shown at (A).



(*Continued from page* 43)

loading of the double-chamber enclosure keeps the impedance of the speaker so low through the bass range that it really seems fairer in this case to call it an 8-ohm system for purposes of calculating rated power.

Now 11 volts (whether you agree that this represents about 15 watts or not) into a D216 produces an *awfully* loud noise. At 35 cps, even though the speaker was outside, all the windows in the building were rattling and the floor was vibrating perceptibly.

Yet, at this intensity the total harmonic distortion did not exceed 11% at any frequency above 30 cps. At 35 cps, the distortion actually dropped to 7% because this is the frequency at which the reflex action of the enclosure is most effective.

But if the low distortion of the D216 is impressive, take a look at the graph for the LE8 in the double-tuned enclosure, Fig. 3B. Again, 11 volts were required to produce the same intensity at 200 cps. Again, it seems legitimate to call this 15 watts of sine-wave power.

Notice that the distortion of the LE8 under these conditions is less than 5% at any frequency above 30 cps. At 35 cps, the total harmonic distortion is only 2%!

Once more, I want to point out that in this test the speaker was making a *very* loud noise. At any normal listening level, the performance of the LE8 is at least this good in a simple small vented enclosure. But for special applications such as electronic organ or string bass reproduction, the LE8 in a double-chamber enclosure makes an efficient, yet compact, system of truly outstanding bass performance.

What About Highs?

High-frequency reproduction is not affected by the enclosure, of course. But the exceptional bass possible from the double-chamber enclosure prompts the use of a high-quality 8-inch speaker having clean highs as well. A good high-efficiency speaker, such as the *JBL* D216, *Electro-Voice* SP8-B, or *Altec* 755C, will have good response up to 3000 cps or so before serious peaks and dips appear.

A good high-efficiency tweeter is therefore recommended to balance the full bass brought out by the enclosure. The finished system shown in one of the photographs uses a D216 crossing over to a *JBL* 075 ring radiator at 2500 cps. Considering size and money invested, the performance of the system is superb.

Construction

The exact dimensions of the double-chamber enclosure are not critical. The

main chamber should be 1.8 to 2 cubic feet in volume and the smaller chamber should be between .9 and 1 cubic foot. The dimensions shown in Fig. 1 are convenient and can be used for either a horizontal or vertical unit.

The two outside ports can be located on any surface. In the finished enclosure shown in the photograph, the ports are located on the bottom rather than the front of the cabinet.

The enclosure must be solidly put together of ¾" stock. Particle board ("Novaply," "Timblend," etc.) is recommended because of its comparatively high density. Whichever panel you make removable for installation of the speaker, use plenty of screws to hold it in place. Note the "bank vault" appearance of the unit in the photos.

The interior surfaces of the main chamber should be liberally lined with glass wool or similar absorptive material. It is not necessary to line the second chamber, but it won't hurt to use the remaining scraps of padding here.

The drawings show three port tubes of circular cross-section. These are actually heavy cardboard mailing tubes with inside diameters of 2¾" and lengths of 7½". If it is easier to build wooden tubes of rectangular cross-section, they will work just as well. The cross-sectional area of each tube is 6 square inches. Inside dimensions could thus be 2"x 3", 1½"x 4", etc.

Any Questions?

Q. Can I install a 12-inch speaker?

A. Not in the enclosure shown. Why would you want to?

Q. What causes the "hole" at 65 cps?

A. Interaction between the two chambers which I was not able to foresee when I made the original design. The hole is only about 3 db deep and unnoticeable in listening tests, but it can probably be smoothed out by making the second chamber a little smaller in relation to the first, and then re-adjusting the lengths of the three port tubes.

Q. How good is the performance of a cheap 8-inch speaker in this enclosure?

A. A husky speaker in the $8.00 to $15.00 class can be expected to perform quite well down to about 40 cps in the double-chamber enclosure. But you naturally won't be able to get powerful bass with the low distortion afforded by better speakers.

Q. Will this design be made available commercially?

A. As far as I know—no. The general public is willing to accept an 8-inch speaker in a bookshelf enclosure, but once the cabinet grows to 3 or 4 cubic feet, people install a 12- or 15-inch speaker no matter what the experts say.

Q. Some of your statements sound pretty far-fetched for an 8-inch speaker. Aren't you really exaggerating a little?

A. No. ▲