# Upgrading a Unique Stereo Column System

*Revising his column speaker design, this author adds more, higher-quality drivers for an improved response.*

**By Roger Russell**

In a previous article[1], I described a single long column of wide-range drivers and equalizer. I have now improved this version using even smaller drivers that are of much higher quality and also more expensive. The response is smoother and more extended with lower distortion. The appearance has been revised and, to me, is much more pleasing to look at. I have added protection circuitry and a grille to complete the system (**Photo 1**).

PHOTO 1: The finished system in author's living room.

## THE DRIVERS

The new drivers, made by Vifa in Denmark, cost $68 each, making a total of $3400 for 50 of them. They are not available from the usual Vifa suppliers. However, they are available from Haig Audio in Michigan.

The drivers in my first article were 4″, The new ones are 3½″, with a copper shorting cylinder around the pole piece (**Photo 2**). Unlike some shorting ring designs, this ring extends through the entire height of the gap and beyond. This is known to reduce distortion—particularly in the voice range—by a factor of 10 or more. The ring also greatly reduces any impedance rise at the higher frequencies.

In addition, the cone is made of a woven fiberglass material, which has been used in various dome midranges and tweeters for many years and has proven to furnish smoother response without the peaks sometimes found in rigid materials such as those having metal cone or dome construction. The magnet structure is not only reverse-polarized but also has an external steel cover, which reduces stray magnetic fields that could affect the picture of a television set if placed in close proximity.

Each driver diaphragm assembly is very light, weighing only 2.5 grams, or 0.088 ounces. Use of a flat spider, which is the major centering device for the voice coil, assures the same linear cone travel in each direction while keeping the coil exactly centered in the magnetic gap. A thin rubber surround eliminates the possibility of deterioration often found with foam surrounds. The square basket allows closer spacing between the drivers.

## MULTIPLE DRIVERS AND POWER HANDLING

Although the cone area of the new drivers is smaller, I have used 25 instead of 20 of them in each system, and each driver has more than twice the cone excursion capability. They are arranged in a column 87¼″ high. The effective cone diameter is only $2^{11}/_{16}$″. The area is 5.7 in$^2$.

So how can such tiny drivers shake the room? First, if you add up the area of all the cones, the total effective area comes to 142 in$^2$. In comparison, a 15″ woofer has an effective area of 120 in$^2$, making the 25 driver area just slightly more than a 16″ woofer—impressive! Because the total cone area is very large, very little excursion is needed at the lower frequencies.

Each driver can handle at least 12W, so 25 drivers can handle 25 × 12, or 300W. Twenty-five voice coils can dissipate more heat than one 2″ or 3″ voice coil. When used with the equalizer, the system can be thought of as having reduced efficiency as the frequency is decreased below 150Hz. This is because more power is required to maintain a constant sound level output. It is most inefficient at 30Hz, where it requires the most power. Despite this special power requirement, each driver handles only 1/25 of that.

## SYSTEM SENSITIVITY

At a distance of 2m, I measure an average of 10dB higher output from the column compared to a single driver in the test box. The sensitivity of a single driver is rated at 82.5dB. This means that the sensitivity of the column is effectively 92.5dB at that distance.

But wait, this increase in sensitivity is not for the whole frequency range. It only goes from 25Hz to about 1500Hz. As frequency increases beyond 1500Hz, the output gradually becomes the same as the output of the single driver. It is even less than the single driver above

PHOTO 2: The 3½″ driver used in this system.

5kHz by a few dB, all the way to 20kHz.

This behavior is typical of columns composed of individual drivers with wide overall dispersion. The effect is related to driver size, directionality, and driver spacing[2]. The change in output for my system is compensated with equalization at the higher frequencies to maintain a constant output.

The 10dB gain advantage over much of the frequency range is why the system requires very little power most of the time. In fact, it is only ⅒ of the power compared to a single driver for the same listening level. The reduced column gain at the higher frequencies is not where most energy in music is. The fundamental portion of the spectrum for most musical instruments occurs below 1kHz, and you can take full advantage of the higher sensitivity in this area. The extra power needed to maintain good response at the higher frequencies is not a problem for 25 drivers.

Of course, for a single driver, the sound level decreases by 6dB for every doubling of distance. In the long column, sound level decreases only 3dB for every doubling of distance. So, within limits, there can be a further advantage in effective sensitivity at distances greater than 2m.

In addition, sensitivity today is often referenced to a driving voltage of 2.83V instead of 1W, which means a 4Ω system will play 3dB louder than an 8Ω system for the same voltage. However, the 4Ω system is actually drawing 2W of power from the amplifier to accomplish this while the 8Ω system draws only 1W. This is confusing for the buyer and allows the manufacturer of the 4Ω system to advertise a figure that could be mistaken for higher sensitivity.

## SYSTEM PROTECTION

The completed terminal board is shown in **Photo 3**. I use a bi-stable resistor, which looks like a small ceramic disc capacitor, in series with the system. This normally has a very low resistance, but when excessive current passes through it, it switches to a high resistance and effectively prevents the system from playing. You can easily reset the resistor by turning down the volume for about 10 seconds to restore normal performance. Because the systems will handle very high power, it is unlikely that the resistors will ever trip, but if they do, you will be suddenly plunged into a very low sound level.

To overcome this sudden change, I have added two high current incandescent lamps in series and connected the series pair across the resistor. This way, if the resistor trips, the current is then directed through the lamps. The speakers will still play, but the higher resistance of the glowing lamps will limit the power to the speakers. The higher the power to the system, the brighter the lamps will glow and the higher the resistance in series with the system will be. Although this protection circuit will reduce the chance of overdriving the system, it is only an approximation and will not protect under all circumstances.

I attached the lamps with clear silicone RTV sealer, which holds the lamps firmly and will withstand vibration and reasonably high temperatures as well. Attach the two solder lugs with pop rivets in a place where they will not

show later when you install the board in the cabinet.

I made the terminal board out of a piece of ¼″ tempered Masonite and sprayed it black on the visible side. Be sure the board is no higher than the diagonal of the terminal hole; otherwise, you will not be able to fit the terminal board assembly through the terminal hole of the finished cabinet. The board in **Fig. 1** is 5″ × 3¾″.

The dashed lines in **Fig. 2** show the outline of the hole in the cabinet. I used a five-way binding post that accepts a dual banana plug (**Photo 4**).

Drill the eight 3/32″ diameter mounting holes for the terminal board inside the back of the cabinet before assembling the cabinet; otherwise, you will need to drill the holes inside the finished cabinet with a drill that will need to fit through one of the driver holes. Use foam tape to seal between the terminal board and the cabinet.

## THE CABINET

I decided to have a local cabinet shop make the cabinets for me at a cost of $750 per pair, including painting and the base. In **Fig. 3**, I have shown decimals as well as fractions for the driver holes in case you use computer-controlled machinery to make the front panel. The location of the braces is indicated by the arrows on the left side.

This pair of cabinets was made out of Baltic birch multi-plywood. However, you could also use ¾″ kitchen counter underlayment, which is less expensive and is a very dense and fine grain particleboard. All the pieces can be glued and nailed together with finishing nails, which are countersunk.

The center-to-center distance of the driver holes is 3⁷⁄₁₆″, including the space between the drivers. The distance from the bottom of the cabinet to the center of the bottom driver hole is 2⅜″. I used the same distance from the top of the cabinet to the center of the top driver hole. The terminal hole is 2½″ high and 3½″ wide and is located directly behind the second driver from the bottom. It is centered 5¹³⁄₁₆″ up from the bottom of the cabinet.

**Figure 4** shows a cross-section of the column including a driver hole, the terminal hole, and a brace. I used 11 internal braces—½″ thick with two 2½″ circular holes—in the system to break up internal resonances and strengthen the walls of the cabinet. I have indicated that the front dimension of the brace is 4³⁄₁₆″ and the rear dimension is 5¹³⁄₁₆″, but you may need to adjust this slightly to fit exactly in the cabinet.

The left and right front edges of the cabinet are beveled at 45°, which could help reduce edge diffraction effects and provide a more interesting appearance. The edges of the terminal hole are also beveled the same way.

When you mount a driver in the ¾″ front board, the terminals will hit the side of the hole. I used an undercut at the inside of each driver hole to allow space for the terminals and the hookup wire that is soldered to the terminal (**Fig. 5**). Be sure the undercut is located at the lower portion of the circle as indicated. Rout at each location with ¼″ radius. The total width is 1⁷⁄₁₆″.

You must make the undercut before the cabinet is assembled. To do this, you must accurately locate the centers of all the driver holes and then drill a hole size that will fit the pin for the router attachment. Drill straight through the front board. You can then use the router to make the cuts on the underside of the board.

To preserve the strength of the narrow mounting board, cut the actual driver holes after the cabinet is completely assembled, using the same pinhole that

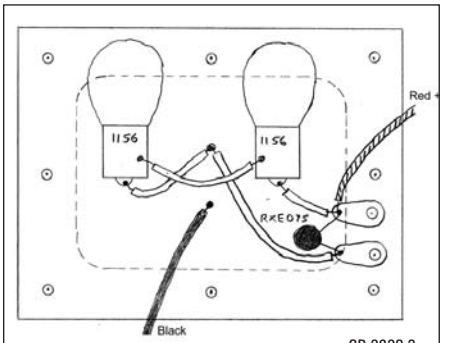


**FIGURE 2: Terminal board pictorial.**

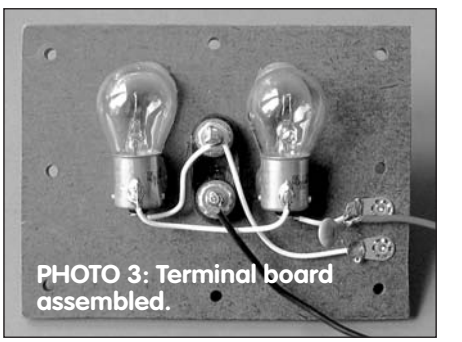

**PHOTO 3: Terminal board assembled.**

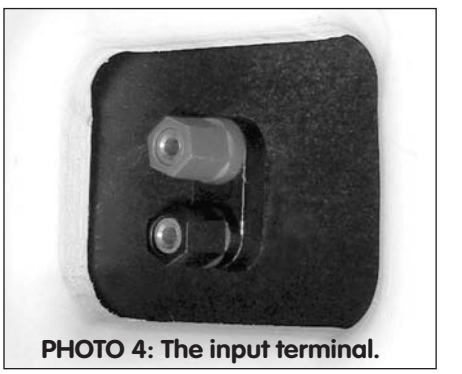

**PHOTO 4: The input terminal.**

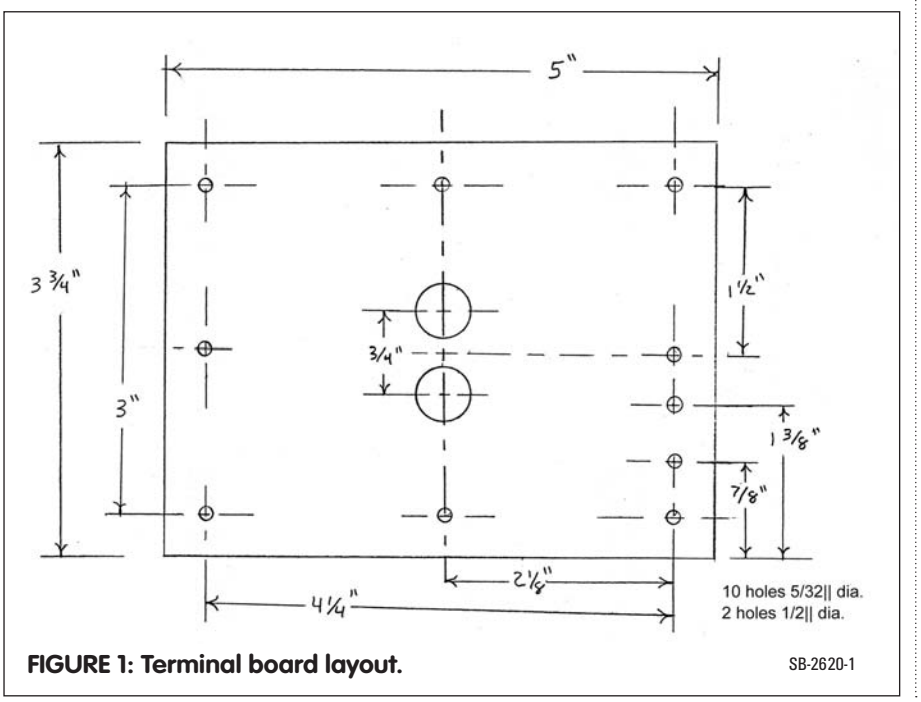


**FIGURE 1: Terminal board layout.**

was used for the undercut. Be sure the size of the driver holes is exactly 3 1/16″ in diameter, as there is not much space between the cabinet edge and the basket of the driver for the foam tape to provide a good seal. If the hole is smaller, the driver will not fit, and if it is larger, the foam will not have enough surface to seal.

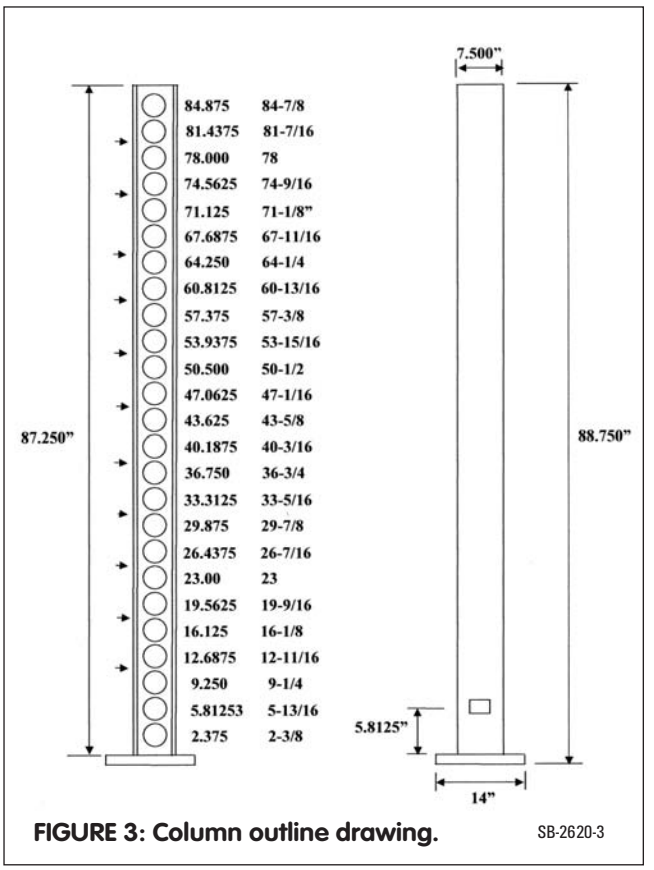


**FIGURE 3: Column outline drawing.** SB-2620-3

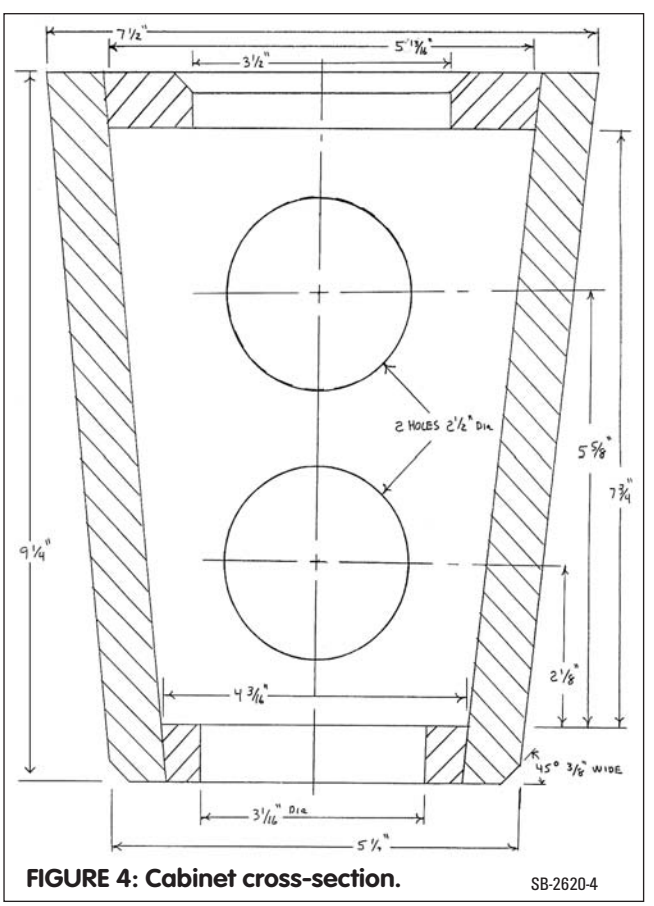


**FIGURE 4: Cabinet cross-section.** SB-2620-4

**Figure 6** shows front and side cross-sections of the bottom of the cabinet, with two pieces of wood used at the top and bottom for strength, and two ⅜″ holes at the bottom for bolts that hold the base to the cabinet. A 2½″ wide cutout just behind the bottom driver allows room for the magnet structure, and the same cutout is made at the top of the cabinet for the top driver.

The construction of the base (**Fig. 7**) includes two ¾″ thick pieces of particleboard glued together and bolt heads countersunk in the bottom of the stand so they don't stick out below the bottom. The front and both sides are beveled at 45°. **Figure 7** shows the position of the cabinet where it is attached to the stand and the location of the holes for the bolts for the stand. These correspond to the same location in the bottom of the cabinet.

After filling and sanding, you can spray the cabinet with primer and several coats of white

semi-gloss lacquer. I like white because I think the cabinets look less imposing, since they are so tall.

If the column is too tall for your ceiling height, you can make the cabinet one or two drivers shorter. Substitute an 8Ω 15W resistor for each driver that you remove from the system. Removing one or two drivers will not make a big difference, but bear in mind that the fewer drivers you use, the lower the power handling and the less bass capability there will be. In any case, the column must run from floor to ceiling in your room to be effective[3]. If your ceiling is higher than this column, you could use additional drivers, but these are not required, at least not for this design.

## THE GRILLE

My first system did not include a grille. A grille frame 87¼″ long and 6″ wide could be easily bent or broken. I thought of a better solution by making the frame part of the cabinet and then adding a perforated plastic grille to it. I used my unfinished test box (**Photo 5**) to try out my idea. Some 12′-length extruded aluminum tile floor edging at Home Depot was perfect for this application. It even has holes for screws. I cut two short pieces and attached them to the test box ⅛″ from the edge of the drivers.

I also found some perforated vinyl gutter guards that come in 36″ lengths. You'll need three for each system. The vinyl fits inside the edging on either side and bows out in the center by about ½″. The bow will allow room for the driver cone excursion. I cut off the rigid edges on both sides using a small bandsaw, being careful to keep the width at 4⅞″; otherwise, the guard will not bow out far enough or match the bow in the next section. I cut the width of each section so the holes lined up.

Although the vinyl looks very open, I calculated it to be only 58% open. Fortunately, measurements and listening show that the response is not affected. For the finished system, I sprayed the edging white to match the white cabinet, but, of course, you can choose any color to match the finish of your cabinet.

When installing the edging, I used a piece of ⅛″ Masonite about 1′ long to gauge the spacing between the edge of the driver basket and the inside edge of the extrusion. I then marked the location of the screw holes, punched and drilled with a 3⁄16″ drill. There are alternate oval and round holes in the edging. I used the round holes most of the time, but at the top and bottom of the column it might be necessary to drill an extra hole to keep the strip straight when you install the grille pieces.

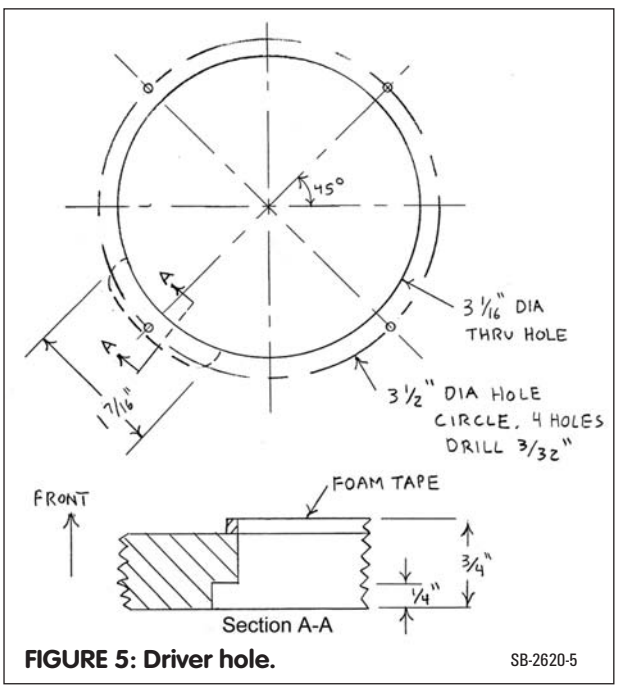


**FIGURE 5: Driver hole.** SB-2620-5

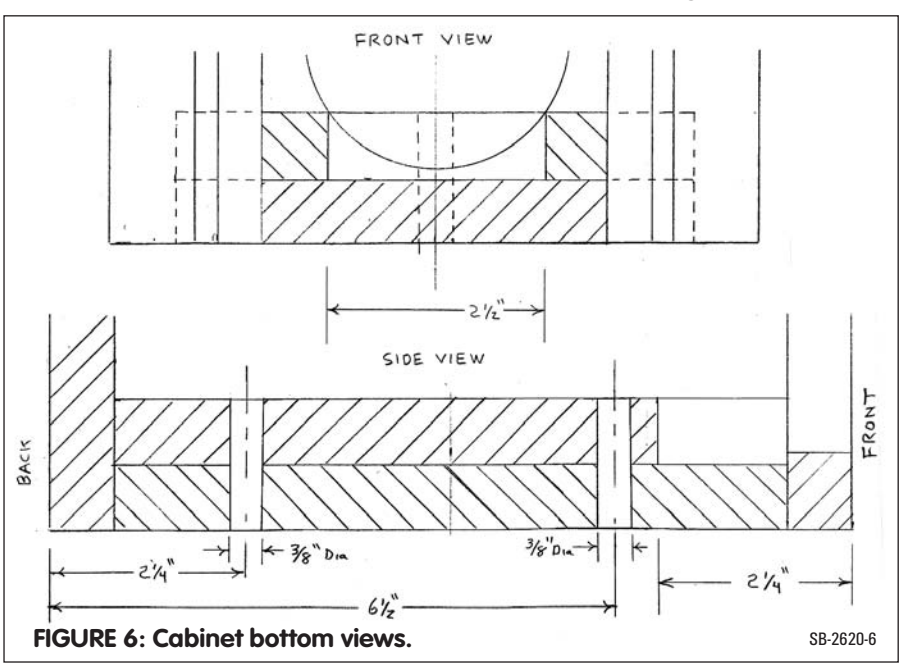


**FIGURE 6: Cabinet bottom views.** SB-2620-6

## FINAL ASSEMBLY

With the 3½″ R13 fiberglass left over from my first design, I made a template out of cardboard in a trapezoidal shape to match the inside dimensions of the cabinet. I then easily compressed the fiberglass and cut it with a utility knife (**Photo 6**). The dimensions are 7″ high—4¼″ at the top and 5¾″ at the bottom. I used a total of 38 pieces, with the paper backing removed, placing three pieces between each brace section and five pieces in the bottom section.

Although you can drill the driver screw holes ahead of time, I prefer to set the cabinet on its back and equally space all the drivers. Then, I mark the holes with a pencil and punch and drill them with a 3⁄32″ drill.

The preferred screws are #6 × ¾″ deep thread, pan and black. Be sure all the mounting screws are in place before testing the system. Initially, I used only two screws on opposite sides for testing and it caused the voice coil to rub. The basket is plastic and will bend a little with only two screws holding it, so I added the two remaining screws, and it worked fine.

## WIRING

I wired the drivers in series-parallel (**Fig. 8**). There are five groups with five in se-

**PHOTO 5: The grille construction.**

**PHOTO 6: Fiberglass template.**

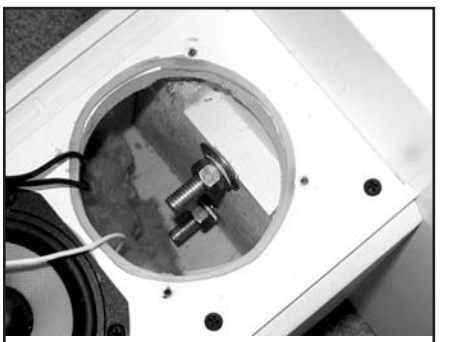

**PHOTO 7: Lowest driver cutout showing bolts.**

ries in each group. This comes out to the same 8Ω impedance as a single driver and is satisfactory for most amplifiers.

All the drivers are in the same electrical phase. I prefer 8Ω instead of 4Ω. The connecting wires from the amplifier to the speaker can be lighter gauge and, therefore, less costly. Terminal connections at the amplifier and speaker are less critical for contact resistance.

The wiring is shown in **Fig. 9**. I used #18 stranded hookup wires to connect all the drivers. You could use heavier wire, but the resistance of this wire is negligible compared to the speaker resistance. Wires from the positive input are red, the black are negative, and 8″ white wires connect the drivers in series. All connections are soldered.

For a single wire to a driver, I twisted ½″ length strands together and tinned with solder. Then, I bent ¼″ of this 180° with thin nose pliers, allowing me to fit the U-shape around the driver terminal, crimp it in place, and then solder. When connecting two wires to the same terminal, you can twist the pair together, tin, bend, crimp, and solder in the same way.

I used two ⅜″ × 3½″ plated bolts—along with a ⅜″ lock washer and ⅞″ washer under each bolt head and nut—(**Photo 7**) to attach the base to the cabinet. To seal between the drivers and the cabinet, I used ⅛″ thick foam with adhesive on one side, cut into strips ⅛″ wide and attached to the edge of each driver hole. The foam compresses very easily and forms a good seal.

After wiring the system, you can make

**TABLE 1: DRIVER PARAMETERS.**

| | |
|---|---|
| Nominal impedance: | 8Ω |
| Voice coil resistance: | 6.3Ω |
| Operating power: | 22.5W |
| Sensitivity: | 82.5dB re: 1W at 1m |
| Frequency range: | 200Hz to 15kHz |
| Free air resonance: | 87Hz |
| Voice coil diameter: | 20mm |
| Voice coil height: | 8.7mm |
| Air gap height: | 4mm |
| Voice coil inductance: | 0.12mH |
| Effective diaphragm area: | 38cm$^2$ |
| Moving mass: | 2.2g |
| Magnet weight: | 105g |
| Force factor (BL): | 2.95 |
| Vas: | 3.1 ltr |
| Qms: | 3.08 |
| Qes: | 0.87 |
| Qts: | 0.68 |
| Net weight: | 420g or about 14.8 ounces |

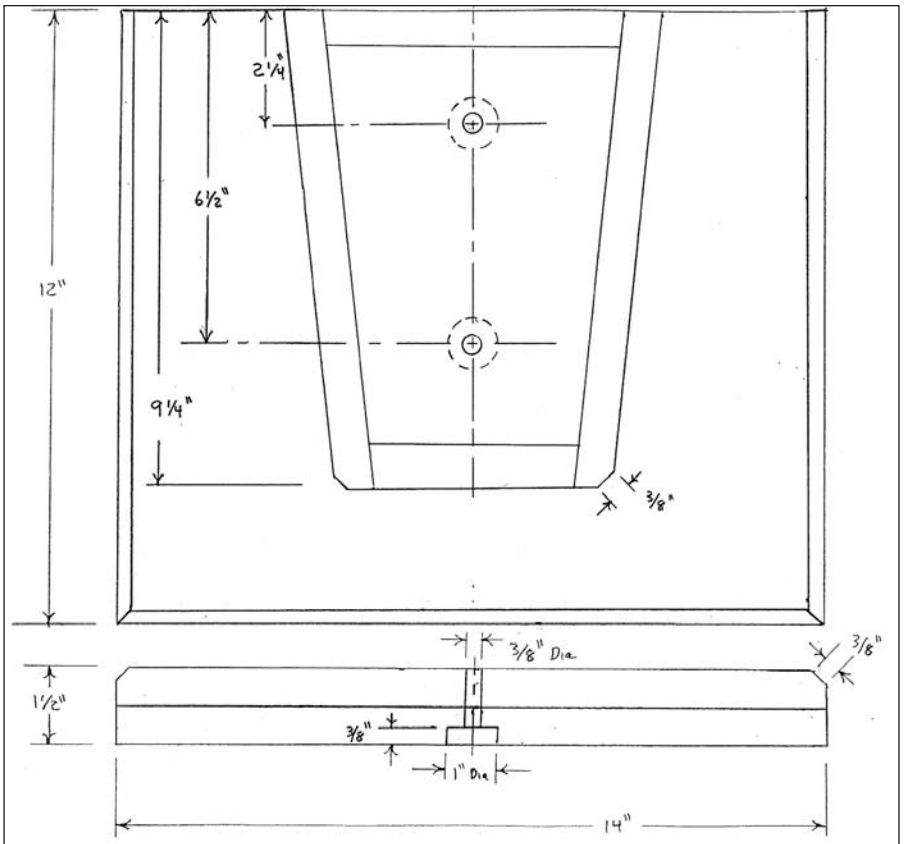


**FIGURE 7: The stand construction.** SB-2620-7

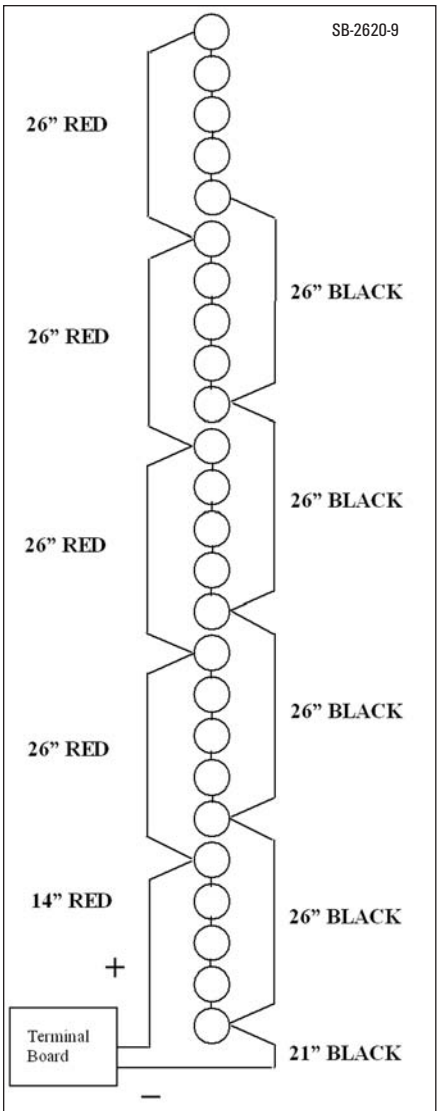


**FIGURE 9: Wiring diagram.**

a final polarity check by connecting a 6V battery to the input terminals. With the positive lead connected to the red terminal and touching the black to the negative, all of the cones should move outward.

## EQUALIZATION

Equalization is used to compensate for the response at low frequencies[4]. The equalization curve is significantly different from the first system and must be changed to match the new drivers. In the cabinet, the drivers go down to about 150Hz and then output decreases, reaching a slope of 12dB/octave. I initially made the bass equalization curve to be close to the opposite of this rolloff, but later modified this slightly for a listening correction. Compensation up to 20dB is used.

I again used a McIntosh MQ107 equalizer (**Photo 8**) for the response adjustments. The equalizer was made from 1981 to 1993 and is often available through eBay or other sales places. It has low-frequency and high-frequency compensation controls plus seven adjustable filters, which can be ⅓ octave or 1 octave width and each boost or cut 12dB in the ⅓ octave mode or 15dB in the octave mode.

You can select the center frequen-

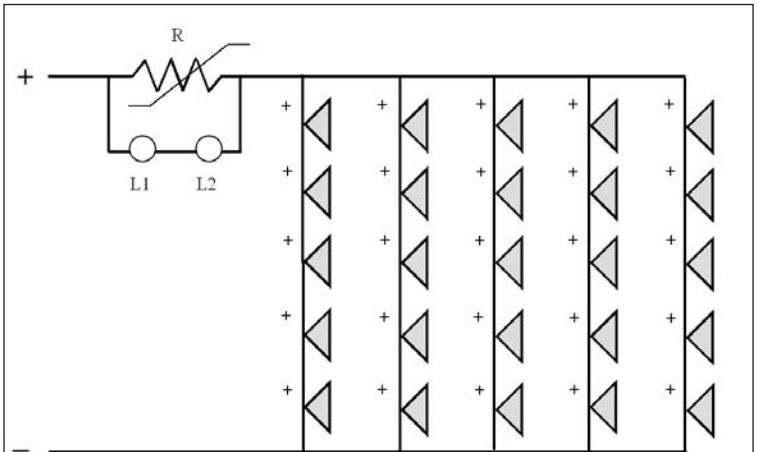


**FIGURE 8: Schematic.** SB-2620-8

**TABLE 2 CAPACITOR VALUES.**

| | Narrow Filter | | Wide Filter | |
|---|---|---|---|---|
| Frequency | Capacitor A | Cap. B | Capacitor A | Cap. B |
| 20 | 1.0 | .39 | – | – |
| 25 | 1.0 | .27 | 4.7 | .056 |
| 31.5 | .82 | .22 | – | – |
| 40 | .56 | .18 | – | – |
| 50 | .56 | .12 | 2.2 | .022 |
| 63 | .39 | .12 | – | – |
| 80 | .22 | .12 | – | – |
| 100 | .22 | .082 | 1.0 | .012 |
| 125 | .18 | .056 | – | – |
| 160 | .12 | .056 | – | – |
| 200 | .12 | .039 | .56 | .0082 |
| 250 | .12 | .022 | – | – |
| 315 | .082 | .022 | – | – |
| 400 | .056 | .018 | – | – |
| 500 | .056 | .012 | – | |
| 630 | .039 | .012 | – | – |
| 800 | .022 | .012 | – | – |
| 1000 | .022 | .0082 | – | – |

cy and filter width by plugging in two small capacitors for each filter. **Table 2** shows capacitor values (in microfarads) for center frequencies and width from 20Hz to 1kHz.

You can insert capacitors in the corresponding A and B slots in the equalizer. Three holes are available for each capacitor, but only two holes are actually used, depending on the lead spacing of the capacitors. Each filter has a control with a center detent that can adjust the amplitude to boost or cut. The center position is electrically flat.

A compartment box with capacitors originally came with my equalizer but may not be included with yours. Recommended capacitors, which you can purchase from Mouser Electronics, are metallized polyester or equivalent for values up to 0.56µF. Use non-polar electrolytic capacitors for higher values. Capacitors must have a voltage rating of 50V or higher.

Six of the seven filters are used for each channel. **Figure 10** shows the frequencies, capacitors, and control settings that I used. The low-frequency compensation controls are not used and are set to one. The high-frequency compensation controls are set at maximum. The same equalizer settings are used in both channels.

You can use additional frequencies by calculating new capacitor values in **Table 3**. Note that "stock" values are normally the only ones available. If, for example, you calculate a capacitor value of 0.095µF, the closest value available will be 0.1µF.

You can use other equalizers as long as the initial adjustments can accurately follow the response curve in **Fig. 13**. The closer the initial equalization matches the opposite of the driver rolloff, the better the low frequencies will sound. However, you may decide to go a step further and compensate for other influences, such as room resonances. High-frequency equalization is also needed to produce a smooth and very flat response out to 15kHz and beyond where the response gradually decreases. You can adjust the highs to suit your preference with these controls at the right side of the equalizer.

**TABLE 3: CAPACITOR CALCULATION.**

| Capacitor | Narrow Filter | Wide Filter |
|---|---|---|
| Capacitor A | 23.5 divided by frequency in Hz | 118 divided by frequency in Hz |
| Capacitor B | 7.2 divided by frequency in Hz | 1.44 divided by frequency in Hz |

## MEASUREMENTS

I have driven both speakers with random-phased pink noise for the response curve in **Fig. 11**. I used a Bruel & Kjaer 4133 condenser microphone that has very flat response out to 40kHz. The output goes to a General Radio ⅓ octave analyzer and chart recorder

PHOTO 8: The McIntosh MQ107 equalizer, with cover removed.

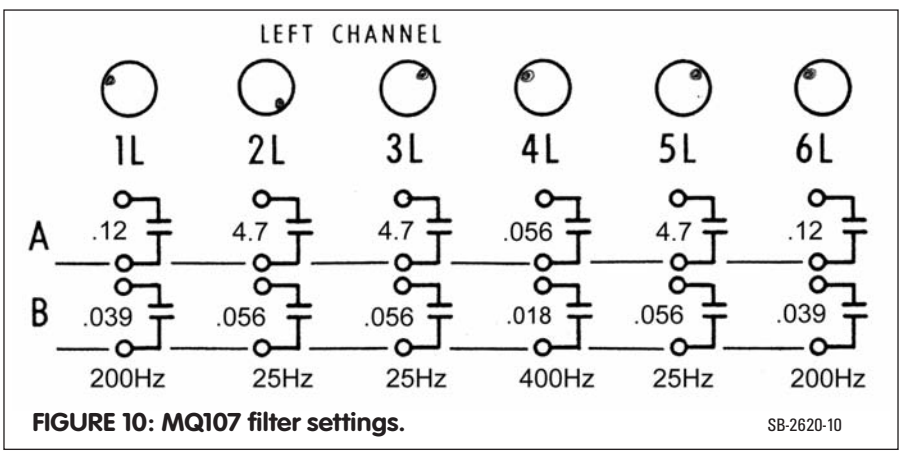

**FIGURE 10: MQ107 filter settings.** SB-2620-10

**FIGURE 11: Combined system response. Each major division on the graph is 10dB. The first section at the left is 25–250Hz, the center section is 250–2500Hz, and the right section is 2500–25kHz.** SB-2620-11

that automatically sweeps from 25Hz to 25kHz.

I located the microphone at the listening area about 9′ from each speaker and 4′ from the floor. The response in my room is very smooth and extends beyond 15kHz. The low-frequency response is slightly higher than the rest of the range, which many people seem to prefer[5], including me. You can always adjust this to suit your own preference.

When multiple drivers are used to cover the same frequency range, you can sometimes observe an effect called "comb filtering," which is caused by reinforcement and cancellation of the sound from drivers that are different distances from the microphone. It is most easily shown with a response curve using a sine wave sweep for the measurement. However, you hear music differently than what is indicated by a pure tone graph. This is due to the masking effect and is more like listening with multiple ⅓ octave filters or perhaps wider[6,7]. When making a listening test, a constant wideband sound source, such as the pink noise that I have used, makes any changes easier to hear.

One of the major factors is driver spacing. So when does driver spacing in a long column become noticeable compared to one, long, continuous column such as a ribbon? The closer the drivers are, the less perceptible any variation in sound is. A spacing of 1′ between drivers is obviously too large, and if you put your ear 6″ from such a column and move up and down, you will be able to clearly hear individual sources, even far back from the column.

However, the closely spaced drivers used in this column perform far better. By the time you move back 3 to 4′ or more, the sound from the column appears to be uniform. In addition, with music, you can come as close as 1′ and the sound still appears to be continuous.

The response of a single driver in a small test box is shown by the curve in **Fig. 12**. The single driver response does not account for other factors when all of the drivers are working together in a column, near a wall, or for room resonances.

Mutual coupling between closely spaced drivers at low frequencies can increase bass output by several dB. Although the effect is most noticeable when the drivers are all located in close proximity to each other, such as a square or circle, some gain may also be realized by orienting the drivers in a column. In addition, with the system near the wall, it is essentially radiating into a solid angle of 180° instead of 360°, giving 3dB of gain.

Room resonances certainly have an important influence on the response as well, particularly back at the listening position. In making the final adjustments, I needed to make some minor corrections, mostly in the voice area. It was only a couple of dB, but it made a dramatic improvement. Also, my expertise in adjusting the filters in the equalizer has improved. Altogether, the sum total of these factors influenced the final equalization curve (**Fig. 13**), which is noticeably different for the new drivers.

Equalization below 30Hz is reduced to prevent excessive infrasonic power from being delivered to the system. However, the acoustic response in the room is still going strong at 25Hz.

The impedance curve for the entire system is shown in **Fig. 14**. The impedance for the new drivers, having the copper shorting cylinder, increases very little at the higher frequencies compared to drivers without the copper cylinder.

## SAFETY FIRST

Each system weighs 81 lbs. If you place the system on a soft carpet with thick padding underneath, you should add a set of four floor spikes (available from Parts Express) to make it more stable. You can drill holes in the bottom of the thick base near the corners for the spikes, which are thin and go through

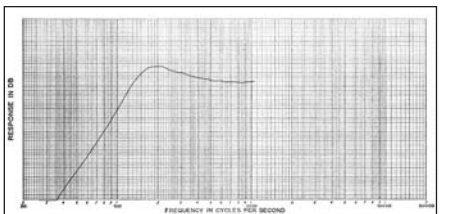

**FIGURE 12: Response of a single driver. Each major division is 5dB.** SB-2620-12

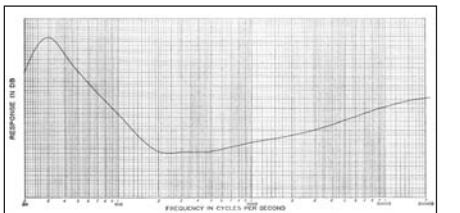

**FIGURE 13: Equalizer response. Each major division is 5dB. The measurement is from 20Hz to 20kHz.** SB-2620-13

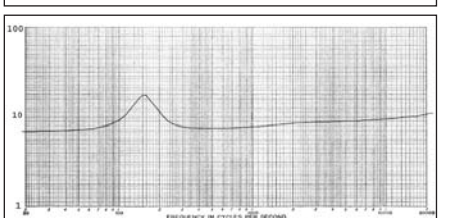

**FIGURE 14: Impedance curve. The vertical scale is in ohms and is shown on a dB scale of 5dB per major division. The measurement is from 20Hz to 20kHz. System resonance is 155Hz.** SB-2620-14

the carpet without damaging it. You could also make a larger base.

You can achieve further stabilization by anchoring the top of the cabinet firmly to the wall using one of two different friction lid supports available from Home Depot. The first is made by Ives-Schlage, H. B. Ives, New Haven, CT 06511 (www.schlagelock.com). Two screws anchor the support to the wall and two more screws anchor the support to the top of the cabinet. The support is adjustable for the angle and distance of the cabinet to the wall.

The second is a lid support made by The Stanley Works, New Britain, CT 06053 (www.stanleyworks.com). Two screws anchor the bracket to the wall and one screw anchors the bracket to the top of the cabinet. Again, the support is adjustable.

## USING THE SYSTEM

A typical listening arrangement forms an equilateral triangle between the listener and each speaker. In my living room (**Photo 1**) the speakers are about 8´ apart, so my best listening spot, although not critical, is around 8 or 9´ from each speaker. The systems are about 3˝ from the wall. High-frequency dispersion is wider with these drivers, and I prefer listening without having the systems toed in toward the listening area.

Typically, only 2 or 3W are all that is needed for a good listening level and most program material. However, it is always good to have a power reserve for program peaks. More important, deep bass will require more power because of the equalization requirements. I have been using a power amplifier that can deliver 260W per channel into 8Ω. It is probably much more than is needed, but I like to have a reserve of power available, just in case.

You will notice that as you approach the columns, they do not become as loud as an ordinary system. You can listen as close as 3´ from the wall and still get excellent stereo sound, including spaciousness. So you can also use these systems in a fairly small room, where you can't avoid being close to them.

## CONCLUSION

The new system was a financial risk for me because I was unsure whether the finished product would justify the cost. As it turned out, in my quest for better sound, the improvement was very significant and well worth the expense.

After adjusting for what you see versus the excellent bass that you hear, you'll discover more benefits. The response of the system is very smooth, and is free from any resonances, peaks, or dips. I found the coherence—when an entire orchestra is playing—to be amazing. You may realize, perhaps for the first time, that the stereo image, depth, and spaciousness provided by this system is totally mesmerizing, and you are aware only of what the artist has produced.

The superior imaging of the system lets you locate the entire characteristic sound of each instrument more accurately in space. When all the instruments are playing, you experience their complete sound at their individual locations, as opposed to becoming all muddied up with each other. This is true whether you are listening to the softest or loudest passages. Details are incredibly realistic and the impact of bass drums is surprising.

The column is very directional vertically, so floor and ceiling reflections that would normally interfere with the direct radiation are effectively eliminated. Because this long column runs from floor to ceiling, the sound will always be the same whether you are standing, sitting, or at any other height. This is a significant advantage over traditional systems that not only radiate sound as much vertically as horizontally but also exhibit response changes with listening height. At the same time, the horizontal dispersion provided by the smaller drivers in the column ensures a wide radiation angle over most of the frequency range.

You will also experience a completely effortless sound throughout the entire frequency range, due to the large, effective cone area that couples so well to the air. Normally, the area available for mids and highs in most systems is very small, and single drivers are easily driven into distortion at higher levels. Not only is the sound from this column system effortless, but it also fills the room from top to bottom and appears to play louder than a typical point-source system. When you combine all of these impressions, it goes beyond overwhelming. *aX*

***Roger Russell*** *has a degree in electrical engineering from Rensselaer Polytechnic Institute, Troy, NY. He has written several articles about loudspeaker design, testing, and other audio devices. Several patents have been awarded for some of his designs. Retired now, he was a member of the Audio Engineering Society and the International Society for General Semantics for many years. Besides his love of stereo sound and music, his other interests range from photography to mystery clocks and science fiction. He has a web page at* **www.roger-russell.com.**

### REFERENCES

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2. "Performance of Series-Parallel Speaker Arrays," James F. Novak, *Audio*, 9/61, p. 23.

3. Patent number 4,267,405 Stereo Speaker System for Creating Stereo Images awarded to Roger Russell, May 12, 1981. This patent describes closely spaced drivers arranged in a long column.

4. Patent number 3,715,501 Loudspeaker System awarded to Roger Russell, February 6, 1973. This patent describes the use of equalization to compensate for the low-frequency rolloff of a loudspeaker system.

5. "Speaker Evaluation: Ear or Machine? Part 2," Roger Russell, *The Audio Amateur*, 1/75.

6. *Acoustical Engineering*, Harry F. Olson, Ph.D., Van Nostrand Company, Inc. 1957, pp. 572–573.

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### PARTS LIST AND SUPPLIERS

R: Polyswitch RXE-075, 60V and 40A maximum
L1, L2: Incandescent automotive lamps GE 1156
D1 to D25: Vifa model TG9FSD10-08 wide range driver

**Parts Express**
725 Pleasant Valley Drive
Springboro, OH 45066-1158
1-800-338-0531 *www.partsexpress.com*

**Mouser Electronics**
1000 N. Main Street
Mansfield, TX 76063
1-800-346-6873 *www.mouser.com*

Vifa drivers
**Haig Audio**
1-248-425-1027 *kenhaig@earthlink.net*