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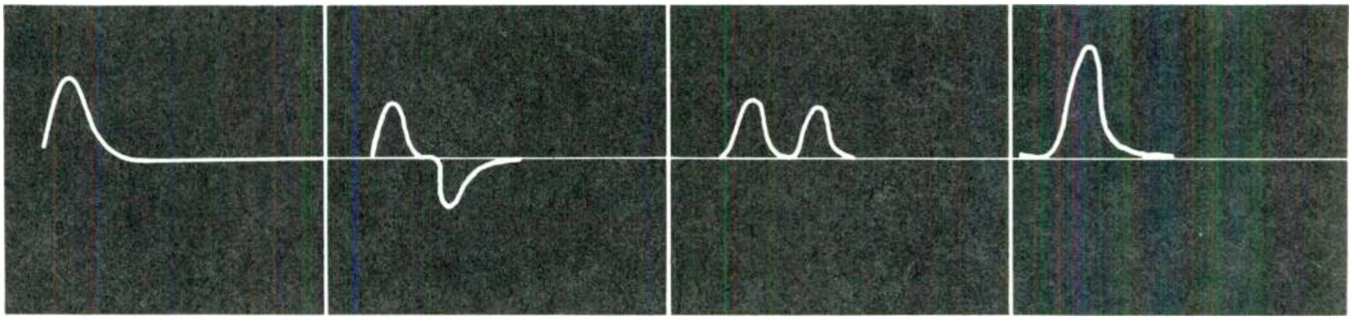
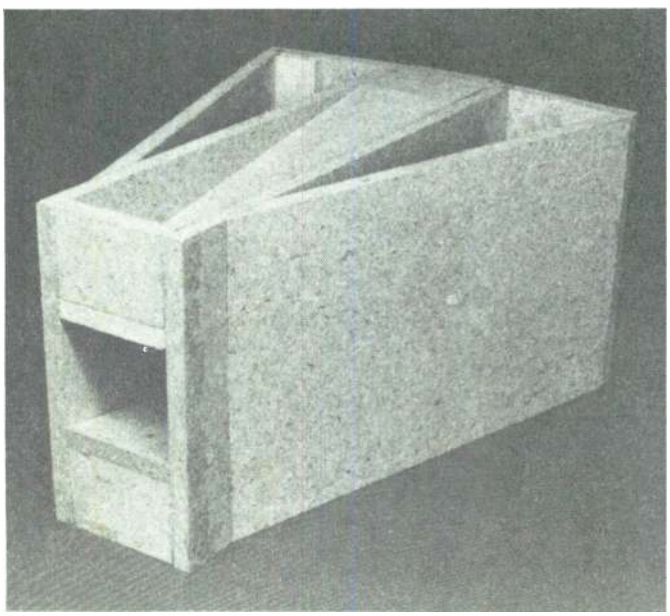
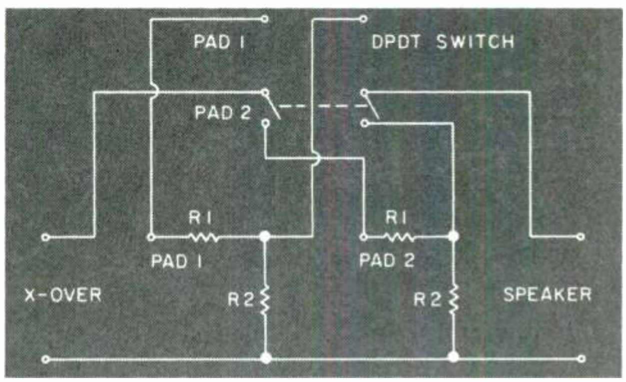


PULSES FOR TIME ALIGNMENT

BUILDING A TINY 70 HERTZ HORN





LEVEL SWITCHING

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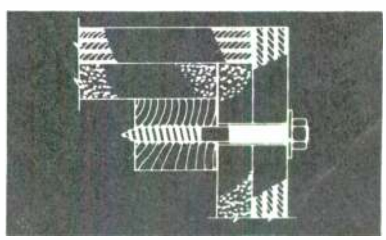
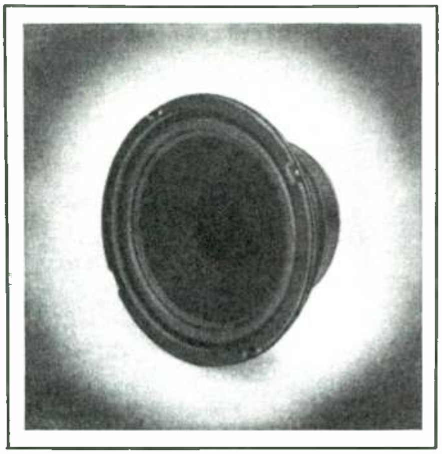


Good News

The IQS Series 401 FFT Spectrum Analyzer is an Apple II-based system that allows complete analysis using the Fast Fourier Transform method. This laboratory-grade instrumentation system provides the hardware and software to perform inpulse analysis of physical systems or analyze arbitrary signals for power spectrum, phase or group delay characteristics. System facilities allow test signal generation and the acquisition, analysis, storage and plotting of real-time waveforms and spectra. System software features versatility and ease-of-use, while high-resolution graphics provide clear presentation of data. Contact **IQS INC.,** 5719 Corso di Napoli, Long Beach, CA 90803.

At the top of **ACOUSTIC RESEARCH's** new three-way bookshelf speaker system line is the AR78LS, which uses AR's Dual-Dome mid-highrange drive unit. The Dual-Dome's design enables the tweeter and midrange to be physically less than a wavelength apart at crossover frequencies. The unit is housed in a compact monitor-sized walnut veneer cabinet and costs $399.99.

AR's other offerings—the AR58B, AR48B and AR38B—are more conventional in design, but feature the new Twin Drive Unit, which allows for more precise driver alignment. Prices for these systems range from $199.99 to $349.99. For additional information, contact Acoustic Research, 10 American Dr., Norwood, MA 02026.

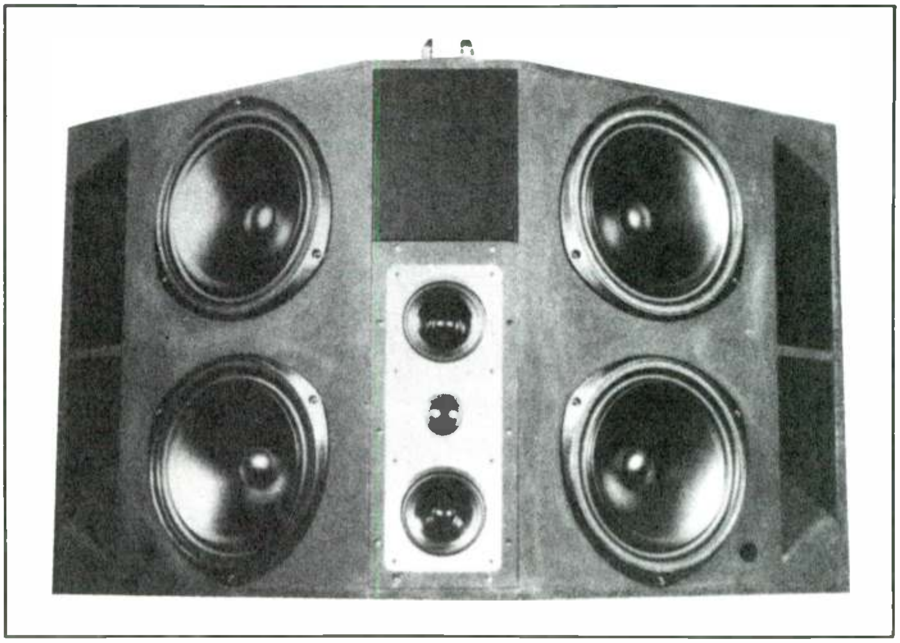


The new **KEF** KM-1 Monitor Loudspeaker features an integral power amplifier with a maximum output exceeding 1,200W. The amplifier is comprised of two power supplies and eight separate output sections to feed seven drive units. Other features include an active three-way dividing/equalizing network, a hybrid floating input circuit and an S-type soft-clipping limiter that is automatically activated under near-continuous peak-overloading conditions.

Its sound pressure level is 120dB on program peaks under typical listening conditions, while its frequency response measures 30Hz to 20kHz, ±2dB. It has a signal-to-noise ratio of more than 100dB.

Write to KEF, 425 Sherman Ave., Palo Alto, CA 94306.

PYLE INDUSTRIES INC. has added an 8-inch, high-compliance woofer (model number W8C200-F4S) to its automotive speaker separates. The woofer has a chemically treated polyurethane foam surround for longer life and smoother response. It also features a high-temperature, 1½-inch, four-layer voice coil and is designed for sealed enclosures as small as .25 ft³ when used with an electronic crossover and .50 ft³ when driven with a moderate power amplifier and used with a passive crossover. The rated power is 100W RMS with a frequency response of 20Hz to 3kHz. The suggested retail price is $39.95. Write to Pyle Industries at 501 Center St., Huntington, IN 46750.



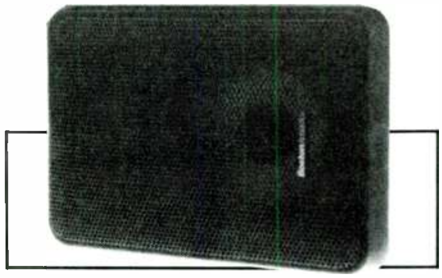
The **NAKAMICHI** SP-400 Mobile Speaker System is the last link in the company's complete Mobile Sound System. The three-way speaker's most impressive feature is a separate housing for the crossover networks, which minimizes distortion due to magnetic leakage. The speaker spans a broad frequency range—50Hz to 22kHz—and has a maximum power rating of 80W (40W nominal). Crossovers occur at 2.5kHz and 8.5kHz. Contact Nakamichi USA, 1101 Colorado Ave., Santa Monica, CA 90401.

ACOUSTICAL PHYSICS LABORATORIES has announced the Acoustic Image Model III loudspeaker system. This floor-standing, three-way system incorporates a long-excursion, rubber-suspended, 10-inch woofer and features a gradual deep bass roll-off from 35 to 21Hz. A separate, time domain corrected, 5-inch driver handles the 200Hz to 3.5kHz midrange section, while a 1-inch soft dome tweeter produces the treble response from 3.5 to 20.1kHz. Its frequency response range is ±1dB. The Model III handles a maximum of 200W/channel into 8 ohms. Its nonresonant, high-density enclosure is finished in walnut veneer. The price is $850 a pair.

Acoustical Physics has also introduced its Acoustic Image Model I, a two-way loudspeaker system that has a frequency response from 36Hz to 22kHz ±3dB and can handle 125W into 8 ohms. The Model I costs $450 a pair. The Acoustic Image subwoofer is also available for frequency response of 21 to 500Hz.

For more information about these products, contact Acoustical Physics at 151 6th St. NW, Atlanta, GA 30313.

BOSTON ACOUSTICS has released two new speaker systems—the A150 Series II three-way system and the C700 two-way automotive system. The A150 Series II combines a 10-inch acoustic suspension woofer, a 1-inch CFT/1 dome tweeter—both newly designed—and a 3½-inch midrange. It requires no stand and is supplied with a built-in pedestal base. Its enclosure, which is taller, wider and thinner than its predecessors, is made of



¾-inch particle board and is heavily braced to resist vibration. Frequency response is 38Hz to 25kHz ±3dB. Crossover frequencies are at 650Hz and 3kHz. Prices range from $250 to $295.

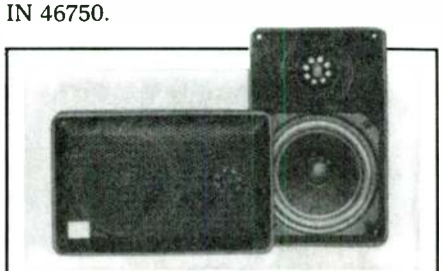
The C700 system combines a 5¼-inch, high-compliance, long-throw woofer and the new CFT/1 dome tweeter. The woofer and tweeter diaphragms are equipped with weather-resistant organic foil for long service, and the speaker's thinline housing requires only one circular cutout for mounting. Frequency response is 58Hz to 20kHz ±3dB, with the crossover at 3kHz. The C700 costs $198 a pair.

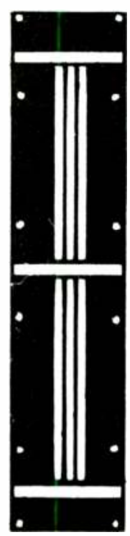
For additional information, contact Boston Acoustics, 130 Condor St., Boston, MA 02128.

PYLE INDUSTRIES INC. has introduced a new speaker system to its Horizon Series, the Horizon HP43A. This flush-mount midrange/tweeter system is equipped with a 4-inch midrange, a 1-inch compression-loaded dome and a 12dB high-resolution crossover network. The midrange has a chemically treated polyurethane foam surround, while the Power-Proof® voice coil features special heat-dissipation and power-handling capabilities.

The Horizon HP43A is rated at 55W RMS maximum and has a frequency response of 100Hz to 20kHz, with a sound pressure level of 101dB. Suggested retail price is $155.95 a pair.

For information, contact Pyle Industries Inc., PO Box 620, Huntington, IN 46750.





About This Issue

Contributing Editor **G.R. Koonce** begins our issue with some opinions on article philosophy, which I trust will generate some discussion. By the way, I'm glad to announce that author Koonce's six-part construction series on a speaker builder's instruments will begin in our next issue. The prolific **Bruce Edgar** gives us another of his nifty horn designs starting on page 7. This small version draws on some older classics for its design and benefits from Edgar's unusual capacity to simplify the construction techniques. For those who want to time-align drivers, **Ernest Wittenbreder** has an excellent pulse generator beginning on page 14. Add a mike and a triggered scope, and your drivers are easily time-aligned either by positioning or delays in electronic crossovers. If matching your driver outputs is a problem, Glenn Phillips tells you all you need to know (p. 20) about devising fixed pads or using adjustable ones.

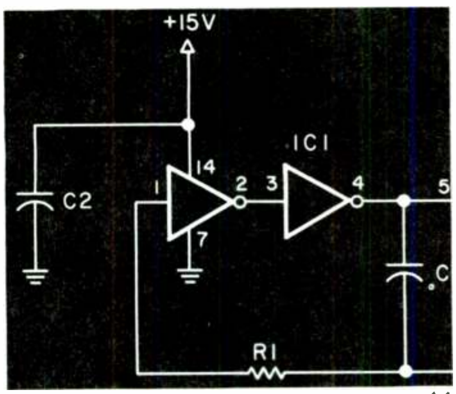
Bob Carlberg's fourth speaker building adventure starts on page 24. **Tom Nousaine, Doug Cabaniss** and **Ken Rauen** each spell out some valuable tips for your system on pages 26–27. For information on bass box construction, don't miss **Steve Ball's** guidance on pages 28–29. Neat drawings, Steve. A new stuffing guide for **Bob Ballard's** active crossover board (*SB* 4/82, p. 26) appears on page 34.

While we are still a bit behind schedule, we thank you all for your patience and expect to be back on track before year's end.

SPEAKER BUILDER

VOLUME 4 NUMBER 2 AUGUST 1983

FEATURES



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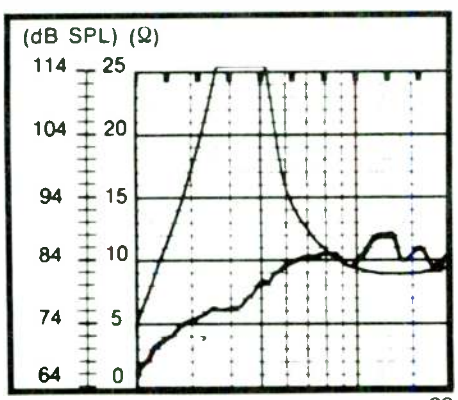

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Editorial

A Case for Custom

by G. R. Koonce

Several *SB* letter writers have said, in effect, that they want "more plans of great speaker systems and less of that math stuff." I have always been troubled by people who want cookbook instructions to follow rather than learning to think for themselves.

I have had some bad experiences with duplication of designs. The closest to a real disaster was a small one-way system using a 5-inch driver with diffuser port. Several friends built successful copies over a two-year period, then one decided to produce the box, even planning to mold the small cabinet. He purchased a couple dozen pairs of drivers, but four of the hand-built units did not work properly. I checked several of the new drivers, and on the average, total Q (Q_{TS}) was up 70%, while efficiency (n_o) was down 3dB, indicating magnet or air gap changes.

My friend told the vendor that the units were defective, and the vendor directed him to the manufacturer. The manufacturer said the seller requested numerous changes, but if my friend returned the "good" and "bad" units, the manufacturer could build what he needed. The manufacturer's efforts resulted in repaired units with resonance (f_s) that was 20Hz too high. You can't give up 20Hz on a 5-inch driver. My friend decided not to invest in the dies needed for molding, which turned out to be a smart decision because we never did get more of the proper drivers.

Anyone with the knowledge and equipment to identify such curveballs from manufacturers (in this case, all the drivers looked the same and had the same model number) could handle the initial box design. Sticking some novice builder with a mess like this, however, prevents me from publishing past designs. What is *SB's* or the author's responsibility in such a case?

Klipsch literature indicates that after the introduction of the Klipschorn they intended to provide copies of the plans. Home constructors did such a poor job that the unit was getting a bad reputation, so they stopped supplying plans. I believe *SB* should stick to articles helping readers learn to do it themselves even if cookbook projects are more popular.

Sorry for the tirade, but only a handful of driver manufacturers hold their production tolerances tight enough that published box and crossover designs will work exactly as expected. Cookbook articles too often fail to warn of any potential problem. It would be too bad if a novice lost interest in construction because of a bad first experience. □

Telephonitis

We occasionally receive a phone call or letter full of distress, frustration and sometimes anger because an advertiser or some special supplier has no telephone, or if they do, they don't answer it.

We usually check things out and almost always discover that the owner is alive and well, often working at a full-time, daytime job and running the special, part-time business out of his or her home.

The problem is usually the telephone. Some of us do all our com-

Continued on page 32

A 70Hz MINI HORN

BY BRUCE EDGAR
Contributing Editor

When most constructors think of horns, they envision large structures such as the Klipsch designs or the concrete monsters that decorated the audio magazines in the Fifties. However, if you do not need the very low bass response *(i.e.,* below 50Hz) that the large bass horns give, you can achieve satisfactory results with a small horn having a cutoff between 60 and 100Hz. A horn with a cutoff of 70Hz would be about half the size of a 40Hz horn and fit into most people's living rooms.

With this philosophy in mind, I designed and constructed the corner horn shown in *Fig. 1*. Approximately a cube 20″ on a side, the 6″ driver fits onto the back *(Fig. 2)*. If made of particle board, the entire unit, including driver, will cost less than $40. Although this may look like a complicated project at first, it is well within the capabilities of the average woodworker. When you are finished, you will be rewarded with a speaker that optimizes cost, efficiency, performance, and size.

PROPER DRIVER. Horn enclosures are like any other enclosures: they need to be designed for a specific driver to obtain the best results. The usual figure of merit for bass horn drivers is the moving mass rolloff frequency, f_{hm}, as given by Keele:[1]

$$f_{hm} = 2f_s/Q_{es}$$

where f_s is the free air resonant frequency, and Q_{es} is the familiar Thiele/Small electrical resonance parameter.

If you assume a 50Hz resonance and a Q_{es} of 0.5 for a particular woofer, you get a 200Hz mass rolloff frequency, which is not satisfactory. A Q_{es} of 0.2 will bring the f_{hm} up to 500Hz, but woofers with those characteristics are not available on today's market. A few musical instrument speakers meet the low Q criterion for horn drivers, but their price ($150 and up) puts them out of consideration for a low cost system. Some other low Q drivers exist, but their resonance frequencies are close to 20Hz, which yields an f_{hm} of 200Hz again.

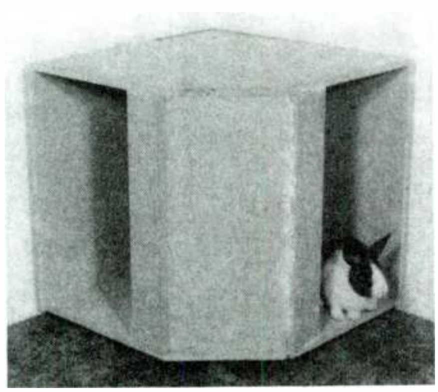

FIGURE 1: The completely assembled corner horn occupies a relatively small amount of room space. The rabbit is optional, but shows the scale.

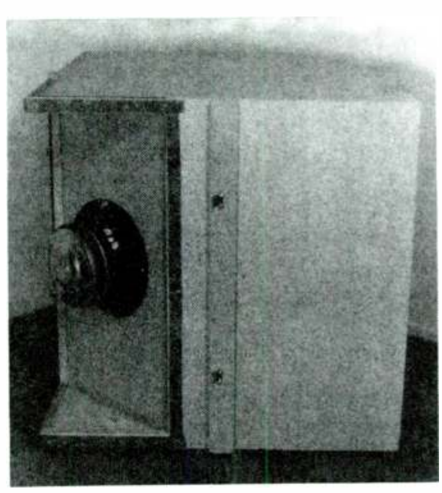

FIGURE 2: This view with the back chamber removed, shows the 6″ Pyle woofer in place at the rear of the horn.

The following formula gives the definition of Q_{es}:

$$Q_{es} = \frac{R_e}{(B\ell)^2}\sqrt{\frac{M_{ms}}{C_{ms}}}$$

where R_e = voice coil DC resistance, $B\ell$ = magnetic flux density-voice coil length product, M_{ms} = driver compliance. According to this formula, a low Q driver must have a big, efficient magnet, a low voice coil resistance, low cone mass, and a high compliance.

Of the many drivers for which I have measured the Thiele/Small Q parameters, I have found one that will work well in a horn. The Pyle W6C200F is a 6″ driver with advertised parameters of f_s = 49Hz, Q_{ts} = 0.29, and V_{as} = 0.5ft³. They cost under $30 apiece from dealers such as Universal Sound (2253 Ringling Blvd., Sarasota, FL 33577), and Circle Sound (2772 W. Olympic Blvd., Los Angeles, CA 90006). Although the calculated f_{hm} is 330Hz, its slow rolloff gives useful response up to 500Hz.

After I had selected the 6″ Pyle driver, I realized I was following the lead of PGAH Voigt[2] who used a 6″driver in his successful horn speakers. However, since Voigt was attempting to reproduce the entire audio spectrum with one driver in one horn, he developed a 6″ twin cone driver with an unbelievably large magnet, a low mass cone and voice coil, and a high compliance suspension. From his notebooks and spectrum tests, I have estimated that the Q_{es} was 0.05 or lower. Today, we can use tweeter and midrange horns with crossovers to reproduce the upper ranges and can achieve good results with driver Q's of 0.2-0.3.

HORN DESIGN. We start our design by specifying the throat area. Keele gives

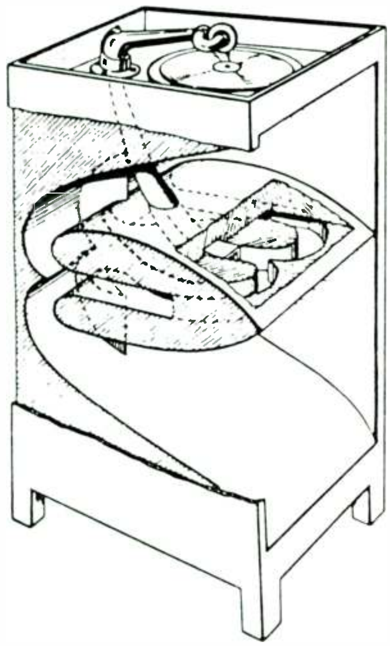

FIGURE 3: RCA's Orthophonic phonograph of 1926 used a folded horn and inspired Edgar's design.

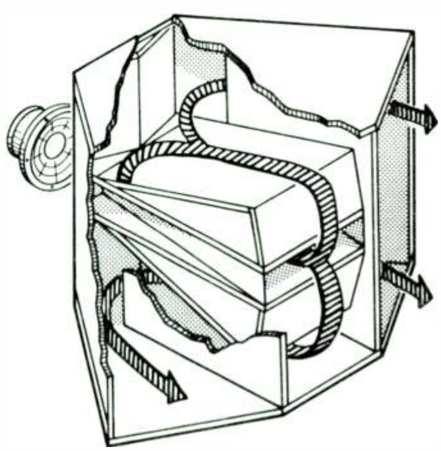

FIGURE 4: The air passages in the 70Hz folded corner horn are similar to the 1926 Orthophonic design.

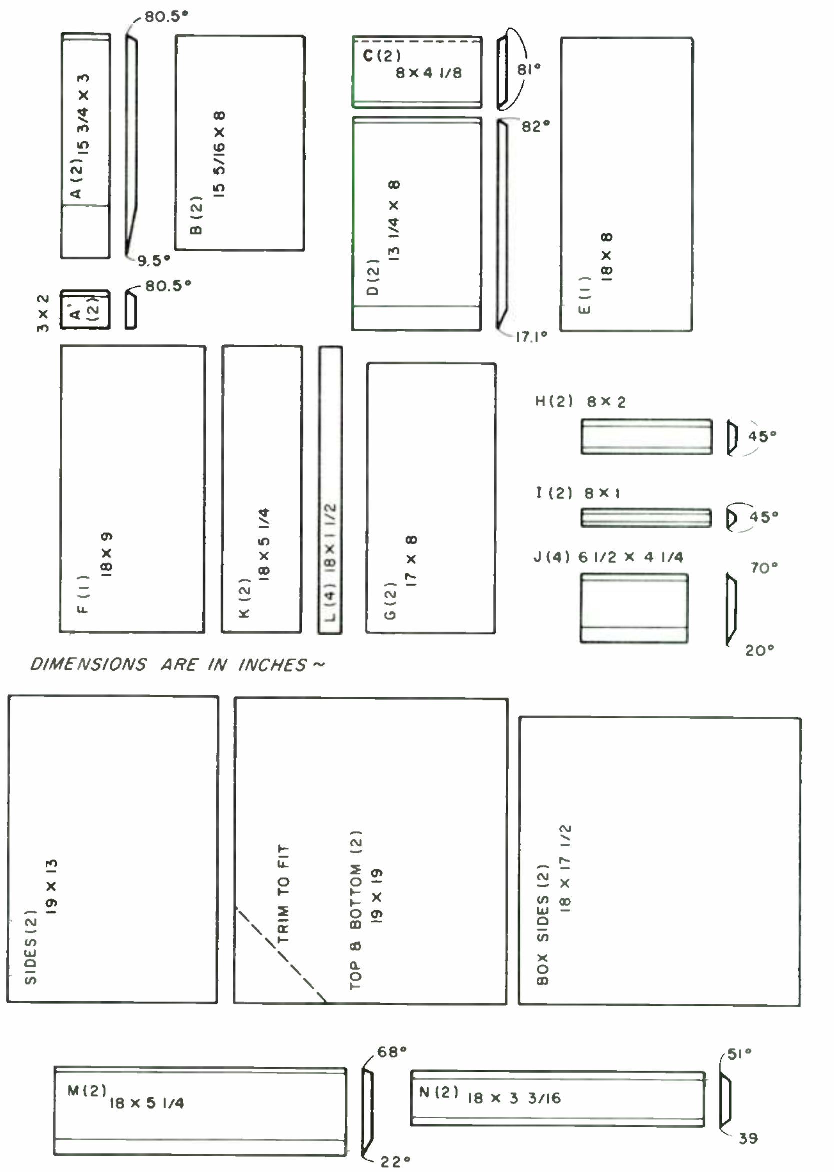

FIGURE 5: The dimensions for all of the particle board parts are as shown. The number needed for one complete horn is circled inside each part.

the following throat area formula, which maximizes efficiency:

$$S_{to} = \frac{2\pi f_s Q_{es} V_{as}}{c}$$

where V_{as} is the volume of air with the same acoustic compliance as the woofer, and c is the speed of sound (13,500in/sec). From three samples I have measured parameters for the Pyle (see *Table 1*).

As you can see, the parameter values can vary considerably, but the throat area changes within only a small range. Samples One and Three were close to the manufacturer's specifications, but Sample Two's compliance is higher, resulting in a lower f_s. The three factors balance out, allowing us to specify a throat area without too much regard for differences from sample to sample.

The optimum throat size is a goal, but not an absolutely fixed figure. The optimum S_{to} in this case is about 25-30% of the driver area. However, the horn's folding geometry sometimes forces you to use a slightly larger throat to shorten the length. Some penalties occur, and I will discuss them later.

This design is based on the tractrix horn contour[3] I made the low frequency cutoff 70Hz. The mouth size is determined by the equation:

$$a = c/2\pi f_c$$

where f_c is the cutoff frequency and a is the mouth radius for a round horn. For

TABLE 1

Sample	F_s(Hz)	Q_{es}	(V_{as}) (cu.in)	S_{to} (sq.in.)
# 1	49.6	0.29	956	6.4
# 2	45.1	0.27	1300	7.4
# 3	49.5	0.31	864	6.2

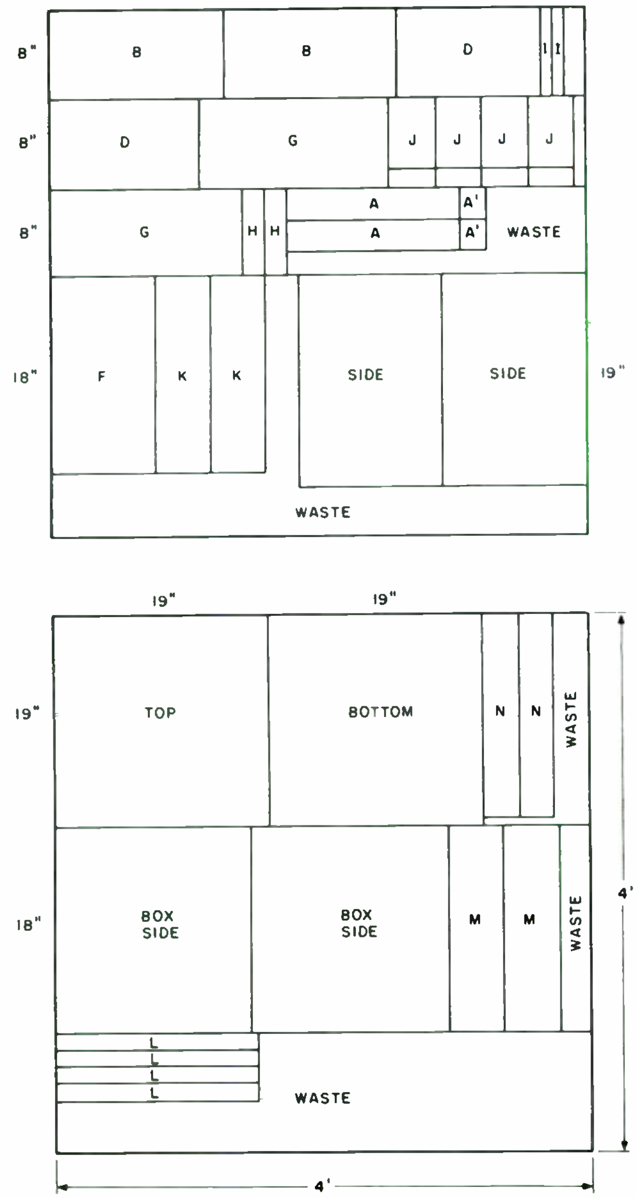

FIGURE 6: For efficient use of the ½" plywood or particle board, cut the parts with this pattern.

70Hz, the mouth area is 2960in² or 20.5ft² Obviously a full size horn won't fit in most living rooms, but by placing the horn in a corner, you can reduce the mouth area by one-eighth, to 370in² With a throat of 6.2in² this tractrix horn will have a 53" length. Increasing the throat area to 8.3in² shortens the length to 49". For my particular folding geometry, an 8.3in² throat was more convenient. *Table 2* shows the tractrix expansion.

Near the cutoff frequency, the reactance of the air mass will reduce the acoustic output, and the horn will not achieve its intended low frequency response. The technique of reactance nulling cancels out this factor by means of a sealed chamber behind the speaker, which stiffens the system compliance to counteract the throat reactance. Keele gives a formula[1] for the back chamber volume in an infinite exponential horn:

$$V_b = \frac{V_{as}}{\frac{f_c}{Q_{es} f_s} - 1}$$

I realize we actually are designing a finite tractrix horn, but this formula gives an approximate idea of the size required. Since the formula assumes an optimum throat area, a better formula is:

$$V_b = \frac{V_{as}}{\frac{S_{to} f_c}{S_t Q_{es} f_s} - 1}$$

where S_{to} is the optimum and S_t the actual throat area. In our case, the back volume for an optimum throat is 250in³ and for the larger throat, 350in³ Thus the penalty for a larger throat is a larger back volume. To permit adjustment of the back volume, I decided the design should allow easy access to the back chamber and driver.

If these equations can give you only approximations, then how do you determine the back chamber volume experimentally? Plach and Williams[5] and Feeser[4] suggest that you start by measuring the system resonance with a trial back chamber. If the resonance is above the cutoff frequency, decrease the chamber's size; if the resonance is below the f_s, increase its size. Continue this process until the back chamber's volume correctly loads the speaker to annul the throat reactance.

FOLDING GEOMETRY. I have examined practically every horn design published in this century to discover how previous horn builders practiced their art. One successful design was the acoustic phonograph developed by Maxfield and Harrison[6] using wave impedance matching techniques. The Orthophonic Phonograph, as Victor dubbed it, is shown in *Fig. 3*. I thought if the horn were laid on its side, it could fit into a corner. If the throat tube were terminated at the back instead of continuing up to the tonearm, I could mount the driver on the back, where space is wasted on most corner horns. This location also provides easy access to the driver's back chamber to alter the loading.

HORN CONSTRUCTION. The horn geometry, although seemingly complicated, permits modular construction. I don't like to cut compound angles, so I designed the joints as simple angle or butt joints. The project uses ½" particle board throughout, although plywood could be used also. *Figure 5* shows the part sizes and their angles. You can cut all the panels for one horn from one 4'×8' sheet or two 4'×4' sheets (which may be easier to bring home from the lumber yard). In the cutting diagram *(Fig. 6)* cut the large top and bottom pieces last. Small errors usually occur in construction, and cutting these two pieces to the exact size required makes the job's final stages easier.

Cutting the acute angles is a problem for most builders, but I have found a good solution *(Fig. 7)*. A cabinet maker's tenon jig (Sears #9GT3235) holds the

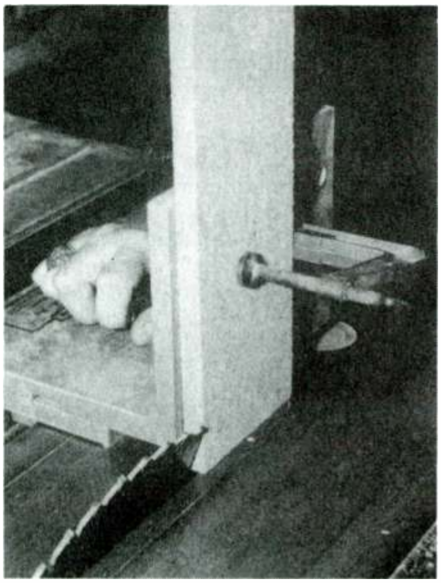

FIGURE 7: Use a table saw with a tenon jig to cut the angles easily and safely.

piece upright as you push the piece past the saw blade. The jig also makes the task safer since the saw blade is highly exposed.

Begin with the manifold section of the throat. Set Part A on Part A′ to form a wedge shape *(Fig. 8a)*. You will need two of these wedges for each horn. A′ is just an aid to keep A at the correct angle. Check to see that the two assembled pieces lie flat on a table, as shown in *Fig. 8a*. If not, check your saw blade angle. An error of 1° will be noticeable. Glue and nail the two pairs of parts, making sure the sides of A and A′ join smoothly.

Take one of the B pieces and set the two flare assemblies on it *(Fig. 8b)*. Draw a pencil line on B along each A piece. Repeat for the other B piece. The line allows you to blind nail part B to the flare pieces. After checking the positioning (slippage leads to a trapezoidal shape, which causes difficulties later), glue and nail the B pieces to each side of the flares *(Fig. 8c)*.

Set flare pieces C and D on B and check your angles. Glue and clamp one of the 8 × 1″ scrap pieces to part C to provide a support for part D. After the glue has set, spread glue along pieces C and D where they join each other and part B. I use ½″ brads to tack down the acute angle end where B and D join. A strap clamp holds C and D together while the glue sets *(Fig. 9)*. When the glue begins to set, you can toenail C, D and B together with brads. After the glue is completely set, repeat the same operation for the C and D pieces on the other side. Now your throat manifold should resemble *Fig. 10*.

THE BOX MODULE. The next step is to construct the box that encloses the throat manifold. Join E and G and a side piece with glue and 1″ brads to form a U-shaped box *(Fig. 11)*. Glue and clamp into place the divider pieces (I) and the corner pieces (H). Set the throat assembly into the box and align it according to *Fig. 12*. Draw lines along the throat assembly so that when you glue it later, you will have an alignment guide. Take the speaker mounting board (F), match it up with the throat assembly while it is still in the box, and draw a line along F where it joins the throat assembly. Now push all this out, maintaining the alignment lines on F. Reach in on the opposite end with a long pencil (or a pencil attached to a long dowel) and make an outline of the throat opening on F. Those with large hands might ask a wife, child or friend with smaller hands to help with this. Cut the throat opening out by drilling a ¼″ hole in each corner and cutting the waste out with a saber saw.

Spread a liberal amount of glue along the edges of the throat assembly where it contacts the box side. Place it back in the box and align it with the pencil marks. I used several long reach clamps and weights to fix the throat assembly while the glue sets. Use a Q-tip to remove the excess glue from the joints and caulk

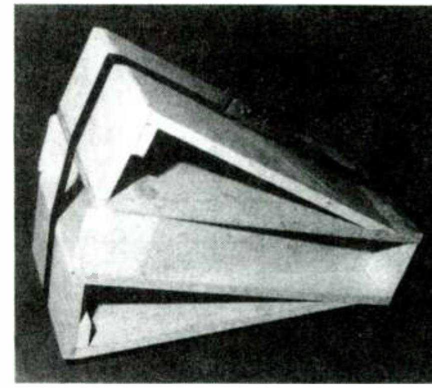

FIGURE 9: Attach the outer flare parts to the throat manifold assembly and use a strap clamp to hold them together while the glue sets.

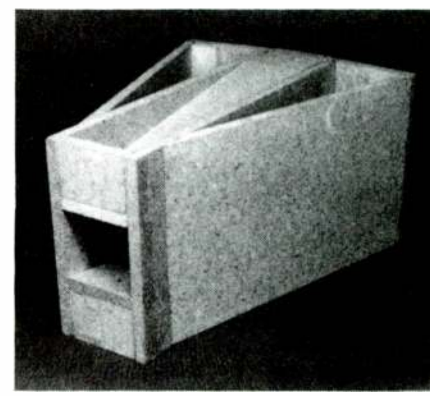

FIGURE 10: The folded structure becomes clear at this stage. The throat opening is at the rear.

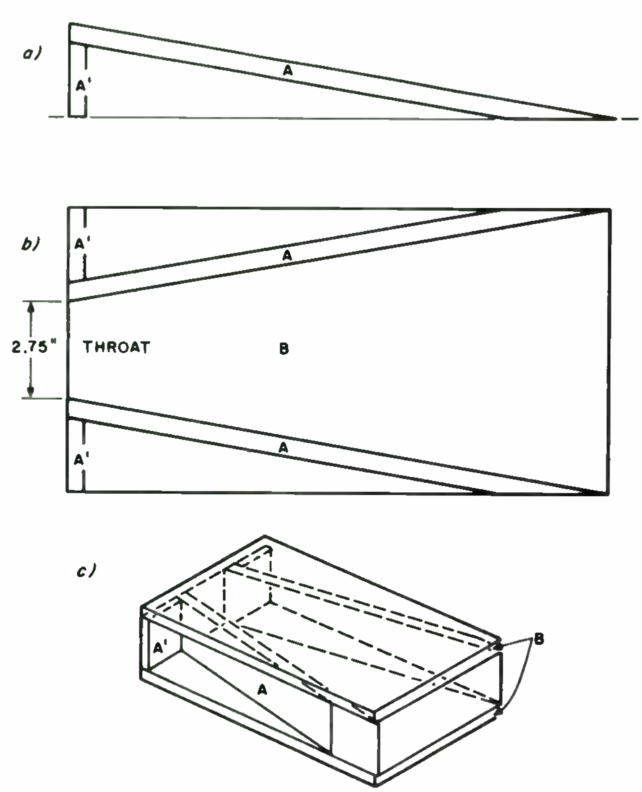

FIGURE 8: Begin construction with the throat manifold. The three steps in its assembly are illustrated above.

TABLE 2

Tractrix expansion for a one-eighth size corner horn, 70Hz cutoff

L (inches)	Area (sq. in)
0	8.3
4	10.8
8	14.1
12	18.4
16	24.1
20	31.6
24	42.0
28	55.0
32	73.0
36	99.0
40	135.0
44	192.0
48	297.0
49	370.0

them with it to minimize any gaps or air leaks.

After this assembly sets, draw out the exit ports on the inside of the side piece for the box. As before, drill holes in the corners, flip the board over and cut out the opening with a saber saw. Now spread glue on the exposed edges of the throat assembly and the box. Fit the other side piece on and nail along the outside of the box. Use clamps and weights to hold it all in place. After the glue sets, draw out the other exit ports and cut out with a saber saw. You can do this from the inside by using the previously cut set of exit ports and drilled holes in the corners. The holes provide guide points so you can cut from the blind side.

Now fit the speaker board F on with nails and glue. I used a wood rasp to smooth out the throat opening and the exit ports. Fit the divider parts J to the speaker board with glue and small brads *(Fig. 14)*. The box should resemble *Fig. 15*. Now is the time to caulk any voids that appear along the exposed joints. As you can see, some joints had small gaps, which I filled with cheap butyl caulk. I am not sure if this did any good since I used plenty of glue on the inside joints, but it gave me peace of mind.

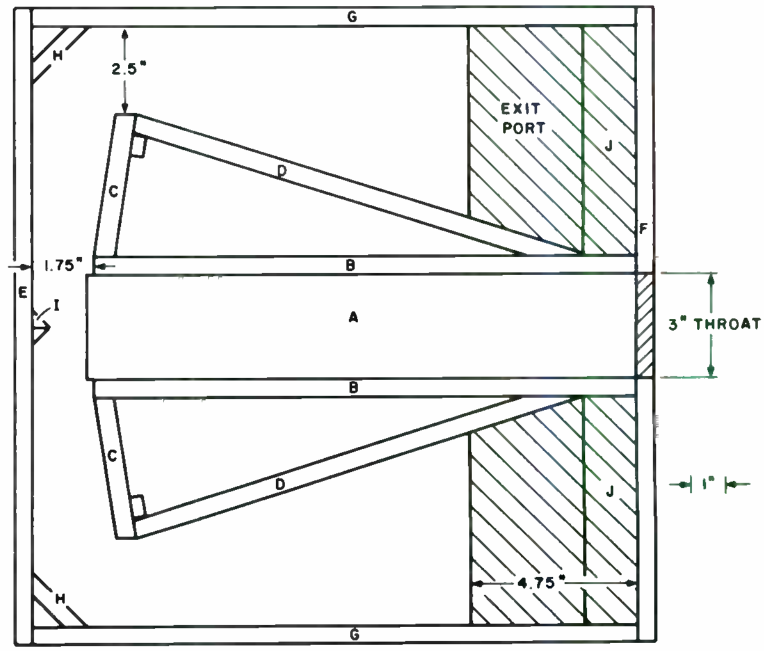

FIGURE 12: This side view shows the placement of parts and the critical dimensions.

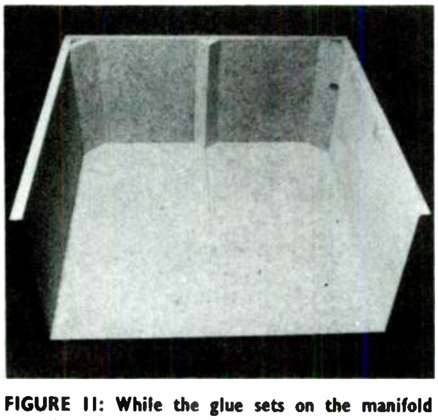

FIGURE 11: While the glue sets on the manifold assembly, make the outer box module. Note the corner reflectors.

FINAL STEPS. Once the box module is complete, you can attach the outer flare pieces. First nail and glue the "legs" (part L) to part K. After the glue has set, place the K/L assembly and the beveled parts M and N on the side of the box module *(Fig. 14)*. Once the outer flare is properly aligned and you have checked the angles, remove M and N and draw lines along the legs of the K/L assembly on the box module's side. Take K/L off and spread glue along the legs where they contact the box module. Place K/L back on the box, aligning it along the previously drawn lines. Use a strap or a frame clamp. After the glue has dried, glue and toenail the beveled pieces M and N into place. Repeat the sequence for the flare assembly on the opposite side.

If you do not have a spare corner, build yourself a corner jig *(Fig. 16)* to do the alignment of the top and bottom pieces. I built mine out of scrap pieces of ¾" plywood about 2ft.[2] Place the box module and the top and bottom pieces into the corner jig and adjust for the best alignment. Draw lines along the box module on the top and bottom pieces for future reference and for the trim line in front. Cut off the excess piece in the front of the top and bottom pieces, and glue and nail the top and bottom pieces to the box using the previously drawn lines as reference.

Now glue and nail the outside flare pieces to the top and bottom. As a final step set your saw at 45° and ripcut a corner off a ¼" thick pine board. Cut the triangular strips into two 18" sections and glue them into the crevice between the outside flare pieces you just finished attaching and the box module. Do not nail these filler pieces, except from the outside; the outer flare piece might bow out. This happened to me, and I had to disassemble the side to shave down the filler piece and reassemble the part—all very unnecessary.

Originally I thought I could extend the side pieces to provide a back volume for the driver, but the magnet stuck out so far as to make such extensions impractical. I devised a 90° angle section of two boards to clamp on the back, but I could not get a good air seal with this. Finally I

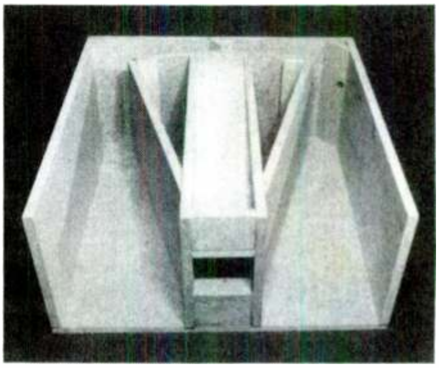

FIGURE 13: Position the manifold assembly in the box module and check all the angles before gluing in place.

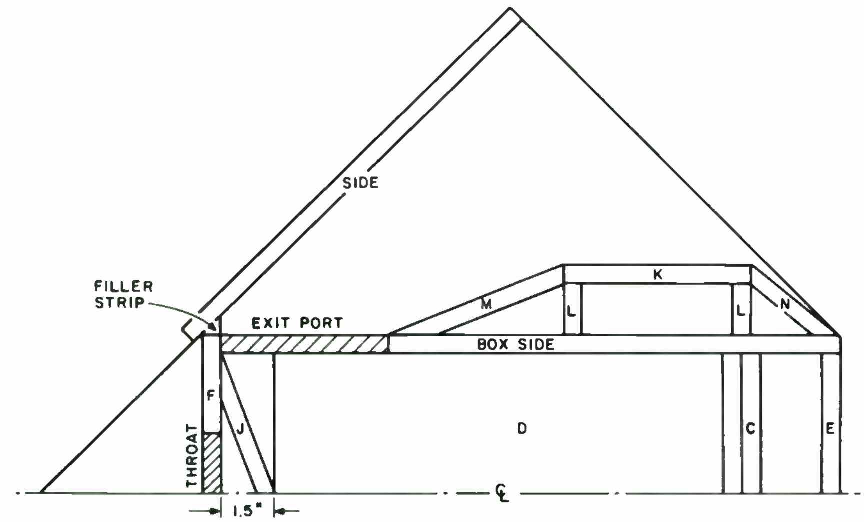

FIGURE 14: This top view of one half of the box module shows the location of the outer flare pieces.

constructed a series of boxes to clamp on for resonance tests before selecting the final back chamber volume.

TESTING THE HORN. With each of the various back chambers strapped on and sealed with foam tape *(Fig. 17)*, I measured the impedance, the Q parameters, and the frequency response, as summarized in *Table 3*. If you make the system resonance near the flare cutoff of 70Hz, the mid-size box is the logical choice for a back volume. It also produces an acceptable value for the system's total Q (Q_T). From *Table 3*, you can see that the back volume controls the system Q.

TABLE 3

	Volume (cu. in.)	f_s	Q_e	Q_t
Small Box	196	80 Hz	1.07	0.87
Mid Box	304	67	0.93	0.79
Large Box	439	56	0.71	0.62

For the frequency response curves, I used a Sennheiser MD421 poked into the horn's mouth as advocated by Keele[7] for a near field test. I excited the speaker with white noise (FM interstation hiss). The mike's output went to a Shure mike preamp and then to a Fast Fourier Transform spectrum analyzer. The FFT averaged the signal for 20 seconds to minimize transient glitches. This method produces repeatable results with little variation using different noise sources. *Figure 19* shows the frequency response using the mid-size box.

I had believed that reactance nulling with a back volume would boost bass response near the flare's cutoff frequency. The measured response turned out to be the same for all three back chambers. Above 100Hz, the mid-size box created the smoothest response, indicating that some nulling occurs in the midband also. Rereading Plach and Williams[5] revealed that the improved bass response I expected from reactance annulling occurs only when the horn shape is a special hyperbolic contour, and the driver resonance is above the cutoff frequency. Leach found in some horn simulations[8] that the concept did not apply to exponential horns. To acquire nulling in our speaker would require a hyperbolic horn (T=0.5) with a length of 120," rather excessive for the side benefit of the added bass response.

To make the back chamber, use scraps from the horn to make an open face box with internal dimensions of 7"W×4"D×12"H. Set your saw blade at 45° and cut the corners off the box on the long side so the corners do not stick out beyond the outer flare pieces. I used ⅛" masonite to cover the corners. Caulk the joints well from the outside and put foam strips along the edges where it meets the back of the horn. After you have found the enclosure volume you want to use, attach it with corner brackets and screws.

The response plotted in *Fig. 19* gives a 6dB bandwidth from 90 to 330Hz. At first I was somewhat disappointed with the bass response, but the tractrix horn is basically an exponential shape near the throat, and the exponential horn starts to achieve full acoustical loading only at 1.2 to 1.3 times the f_c. You could improve the bass response with an equalizer. The calculated mass rolloff frequency of

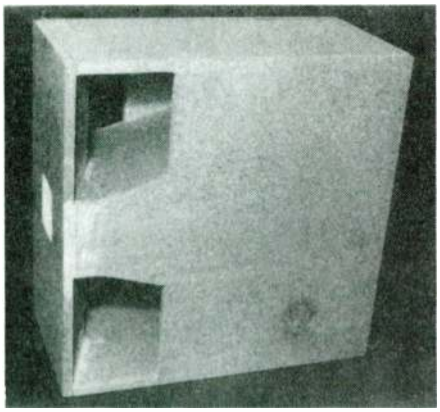

FIGURE 15: The completed box module should have this appearance before you attach the outer flare pieces. Note the throat opening and the exit ports.

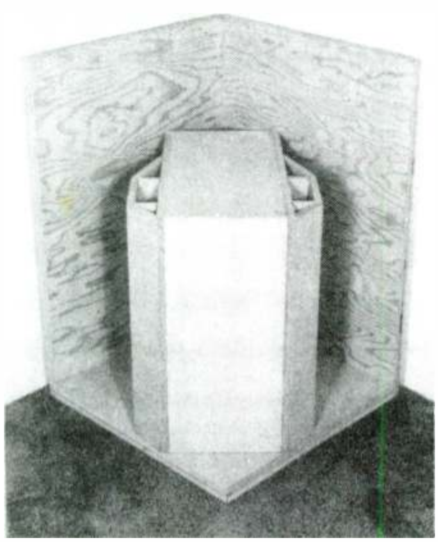

FIGURE 16: Use a temporary corner jig of plywood to align the top and bottom pieces.

FIGURE 17: Clamp on one of the back chambers to test for system response.

330Hz agrees well with the observed response. I have found that a single pole 6dB/octave crossover at 400Hz works well, giving a higher system rolloff rate.

Note the difference between the calculated and the experimentally derived back volume. The calculated value, 350in³ was based on the assumption of an infinite exponential horn because the throat impedance terms are simpler. The tractrix horn in this speaker is a one-eighth scale horn and the tractrix contour is shorter than the equivalent exponential[3] so the resultant air column load on the throat is less than for an infinite horn. Thus the actual volume of 300in³ (with the driver displacement thrown in) is an expected result. The back volume formula is useful because it shows the upper limit on the chamber's size.

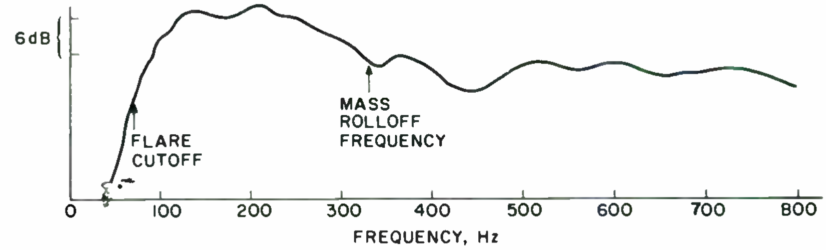

FIGURE 19: System response with the mid-size box extends down to 70Hz.

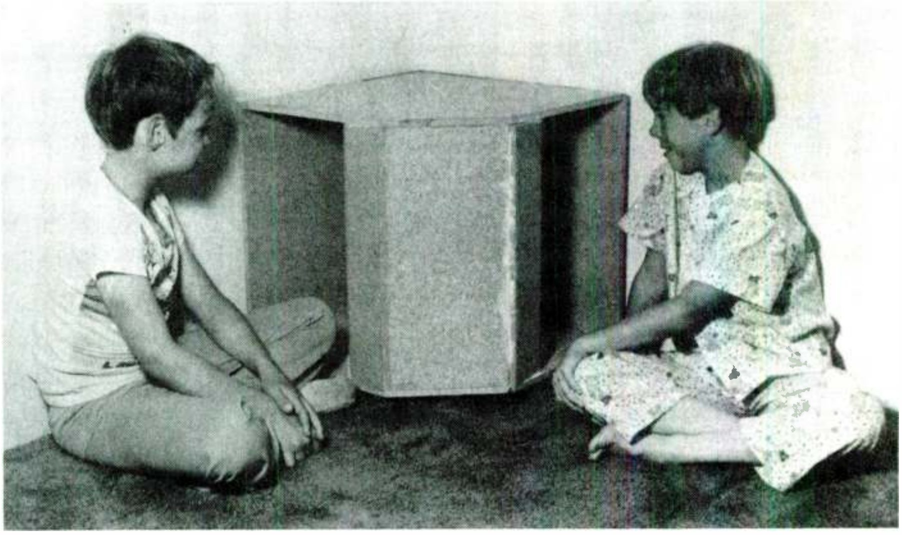

FIGURE 20: Is the rabbit still inside the speaker? The author's sons wait patiently for her reappearance.

LOOKING BACK. How does my horn compare with Dinsdale's[9]? First, his is front and back horn loaded, which may or may not be successful depending on the driver used. However, he does not present any supporting data such as Q measurements or response curves to justify his design. Second, although his is a tractrix horn, he introduces a 20% safety factor into the flare rate computation. The result is a 58Hz flare rate, but with a mouth cutoff of 70Hz, which gives better bass response at the cost of greater length (63"). I found that longer horns became unwieldy with my folding configuration.

Could you use a different driver in this speaker? The answer is probably no. The design is optimized specifically for the 6" Pyle driver. A larger driver won't fit in the back, and almost all of the small (5-6") drivers I have tested have Q's in the 0.4 to 0.6 range. This gives them a lower mass rolloff frequency when used in a horn. The thing to look for is a driver with an abnormally large magnet structure for its frame. Push in the cone; if you experience little resistance, you have a likely candidate. If you find moderate resistance to your push, the driver probably is damped mechanically in the suspension and spider. After these preliminary eliminations, test them for Q parameters.

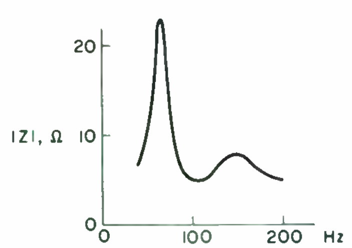

FIGURE 18: With the mid-size box, the resonance is at the right place for smoothest overall response.

I thought I had developed an original design, but as the saying goes, "there is nothing new under the sun." As I was searching through some old issues of *Wireless World*, I found a 1927 article by an A. Dinsdale[10] (an interesting coincidence) that borrowed the same folding configuration from Maxfield and Harrison (1926) and that I used in *Fig. 3*. However, his horn used a ¾" diameter compression driver to drive a 5' full size exponential horn with a 128Hz cutoff. Of course, in 1927 only one horn was used in sound reproduction crossovers and multiple drivers were not used generally for home equipment. Unfortunately, in this same period, Rice and Kellogg introduced the dynamic driver, which displaced horns in the domestic market until Voigt and Klipsch brought out their designs in the Thirties and Forties.

How does it sound in the listening room? I quickly noticed its ability to create high sound pressure levels in the room without distortion. Loud brass selections sound very realistic; even organ recordings have that convincing reality that makes me want to believe an organ is in the next room. I use a 15W receiver in my system and rarely turn the volume control beyond the first notch. With this efficiency, even digital and direct to disk recordings display their sonic virtues to the fullest.

The missing element in this discussion is what to do about reproducing the rest of the audio spectrum. A bass horn requires a midrange and a tweeter horn to complement it. Direct radiator midranges are usually dominated by the bass horn, and I don't recommend them. In a future article, I will show how to build the midrange horn with cone driver that complements this bass horn.

Most of us speaker enthusiasts do not design and build our equipment in a vacuum. We also have job and family responsibilities that influence our projects in unexpected ways. While I was building the corner horns, my sons, eight and nine years old, received a rabbit for Easter. She turned out to be pregnant, and I had to drop my corner horn project to build larger and larger cages to keep up with the exponentially growing rabbit population. *Figure 20* shows the size of the horns from the human perspective, and *Fig. 1* shows them on the rabbit scale. □

Continued on page 36

AN AUDIO PULSE GENERATOR

BY ERNEST H. WITTENBREDER JR.

At the Audio Engineering Society meeting in New York in the Fall of 1980 a paper was presented on a pulse generator useful for speaker design and testing and for sound reinforcement. I was impressed by the paper and demonstration, but when I found the price was $295 (read unaffordable), I decided to design and build my own pulse generator. In this article I will describe it, how it can be used, and how to construct it.

In a two-way speaker system, the tweeter diaphragm is usually closer to the listener than the woofer cone. Suppose that a transient with a large frequency content in the crossover region is applied to the speaker system. Because of the tweeter's proximity, the listener will hear the tweeter transient slightly earlier. Other factors such as the larger mass and inductance of the woofer and crossover network tend to increase this delay. All these factors move the acoustic position of the woofer further behind the tweeter, confusing imaging and distorting transients in the crossover region.

PULSE MAKER. The audio pulse generator described in this article generates pulses of a single polarity (either entirely positive or entirely negative with respect to ground). The repetition rate of the pulses is variable, polarity is switchable, and the frequency content of the pulse is also variable. A block diagram of the system is shown in *Fig. 1.* Positive polarity pulses are shown in *Fig. 2.* Note that the shape of the high frequency pulse is the same as the shape of the low frequency pulse. Note also the time scale for each pulse.

In the test setup shown in *Fig. 3.*, pulses from the generator go to the crossover and to the amplifiers, which drive a two-way powered speaker system. The acoustic pulses received by the microphone are fed to an oscilloscope. The clock of the pulse generator triggers the scope's trace and the pulse to the speaker at the same time.

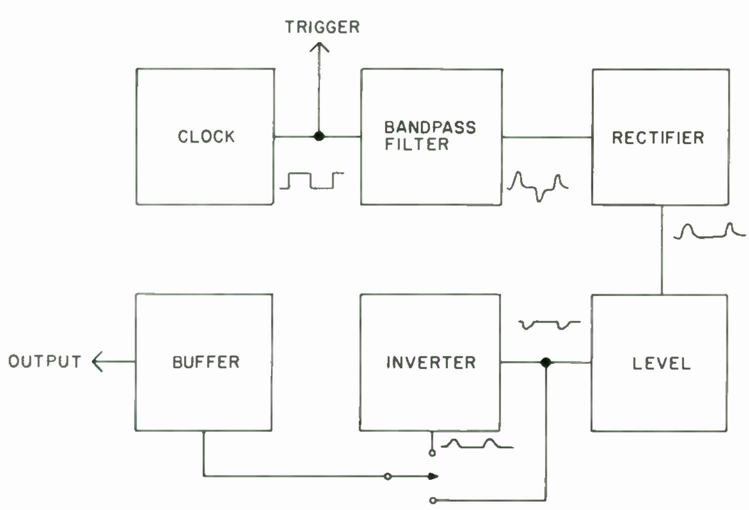

FIGURE 1: The clock generates a simple square wave, which is the trigger for the scope. At the same time, the square wave is shaped by the filter and rectifier into a series of positive-only pulses. At the inverter, a switch enables you to select positive or negative pulse trains.

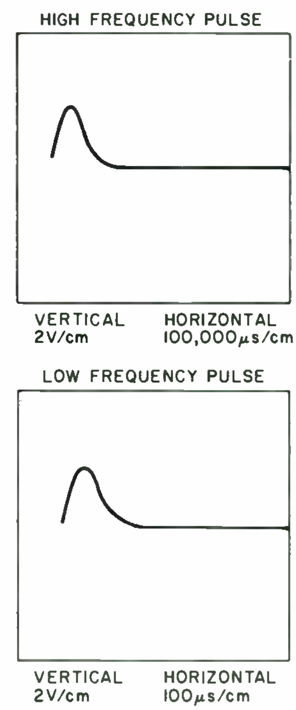

FIGURE 2: Both the HF and LF pulses have the same shape and polarity (positive shown above).

After traveling through the crossover and drivers, the pulses from the woofer and tweeter arrive at the microphone at different times and with different polarities, as shown in *Fig. 4.* The pulse frequency should be adjusted so the two pulses have the same amplitude. Frequently, speaker manufacturers wire the woofer and tweeter out of phase to approximate proper time alignment, which sounds better than doing nothing at all. Usually the leads on the tweeter should be reversed so the pulses from each driver have the same polarity, as shown in *Fig. 5.*

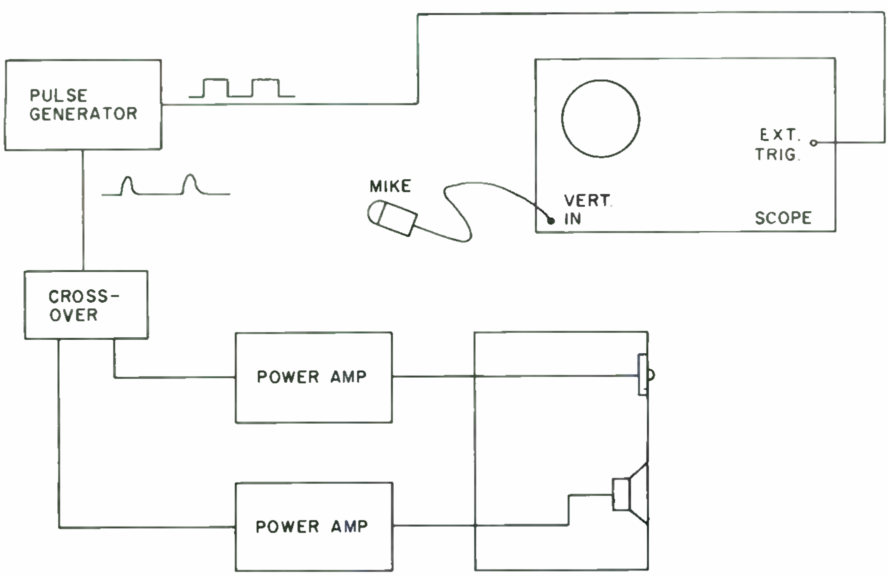

FIGURE 3: After passing through the crossover and the drivers, the pulse as picked up by the mike has two time components. The pulse from the woofer is behind the one from the tweeter.

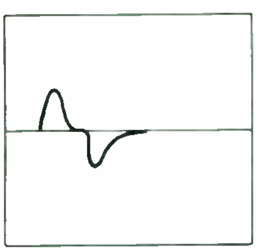

FIGURE 4: If the manufacturer has reversed the polarity between the two drivers, the pattern on the scope looks like this.

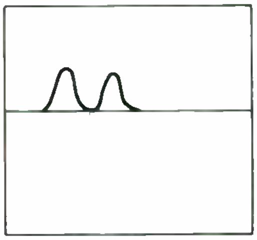

FIGURE 5: After rewiring the drivers for the same polarity, adjust the pulse frequency so the amplitudes are equal.

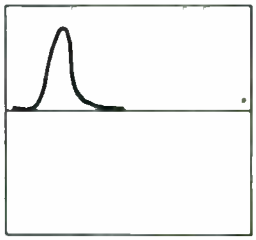

FIGURE 6: When the drivers' outputs are in phase acoustically, the pulses in the scope overlap and have maximum amplitude.

To time align the two drivers move the tweeter away from the microphone without moving the woofer or add a time delay network at the input of the tweeter amplifier. When the pulses overlap and the composite peak is at a maximum, the drivers are properly time aligned and polarized *(Fig. 6)*. I time aligned my Fried H satellites (similar to LS3/5A's) by building a special pair of speaker stands to tilt the speakers, moving the woofers forward and the tweeters back. Proper placement of the stands ensures time alignment between woofers and satellites.

In commercial speaker systems time alignment is accomplished by stepped driver placement, tilting the enclosure, or with delay lines in the crossover networks. For powered speakers electronic delay networks are preferable because they yield better amplitude response on axis. (Moving the tweeter back reduces the tweeter's output relative to the woofer.) Time alignment off axis is also better with electronic time delays.

PULSER CIRCUIT. The clock is a variable frequency CMOS oscillator made from three inverting buffers (one half of a 74C04). Its square-wave output serves as a trigger signal and the input pulse to the bandpass filter. The clock schematic is shown in *Fig. 7*. The bandpass filter *(Fig. 8)* is a state variable filter. The LM13600N is a dual operational transconductance amplifier (OTA), which has a current controlled output impedance, or current controlled transconductance. If this were a state variable filter, with fixed center frequency, the OTA's would be replaced by resistors. The output of the summing inverting amplifier, OA1, is the highpass output. Together, OTA1 and OA2 form an integrator with the desired bandpass output. OA4 is a damping amplifier. The gain of this amplifier determines the Q and gain of the bandpass filter. Formed by OTA2 and OA3, the second integrator is the lowpass output, and the setting of the 50Ω pot determines the center frequency of the bandpass filter.

The rectifier *(Fig. 9)* is a precision half wave rectifier (OA5), which inverts and passes only positive pulses so the output is always positive pulses. It is the input to the level amplifier *(Fig. 10)*, OA6, which is an inverting amplifier with variable gain. OA6's output feeds a unity gain inverting amplifier, which always outputs negative pulses (the output of the inverting amplifier is always positive pulses). The output buffer OA8 is switchable to either the negative pulses of the level amplifier or the positive pulses of the inverting amplifier. The output buffer has a 620Ω resistor in series with its output for short circuit protection.

The power supply circuit is shown in *Fig. 11*. The circuit employs a full wave bridge rectifier and three-terminal IC voltage regulators to obtain ±15V DC. Additional filtering is employed near

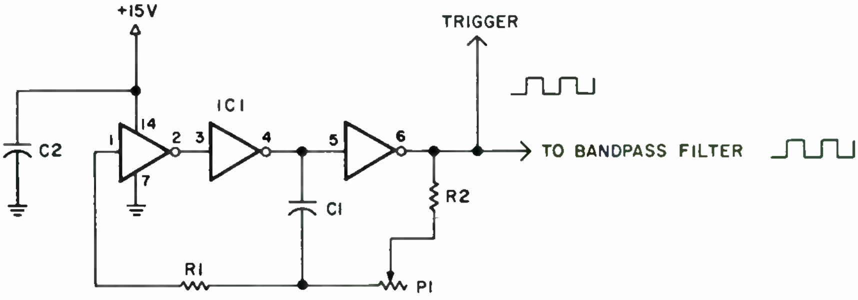

FIGURE 7: The schematic for the clock is a square-wave oscillator built from three inverting buffers.

each IC using 1μF tantalum capacitors for decoupling.

CONSTRUCTION. I mounted the switches, the pots, and the lamp on the front panel of my enclosure and the jacks and linecord on the rear panel. See *Photos 1 and 2*. The circuit pattern and parts placement diagrams are shown in *Figs. 12 and 13,* respectively. When stuffing the board, be careful to orient the diodes, integrated circuits, transformer, and electrolytic capacitors properly, as indicated on the parts placement diagram. Mount the circuit to the chassis using standoffs attached near the four corners of the circuit board. Connect the pots so that CW represents maximum frequency, maximum clock rate, and maximum level, to avoid confusion. Part values generally are not critical. I used 5% carbon film resistors. To save money you could substitute .1μF ceramic capacitors for the 1μF tantalums for decoupling. I recommend ceramic, silvered mica, or low dissipation film capacitors for the bandpass filter, and a mylar (polyester) capacitor in the clock.

ALIGNING SPEAKERS. You will need the following equipment: oscilloscope, microphone, and microphone preamplifier. Connect the trigger output of the pulse generator to the external trigger input of the oscilloscope. Connect the pulse output to the vertical amplifier. Turn the clock rate pot so the rate is low. You can look at the clock independently if you look at the trigger output of the pulse generator.

Now set the clock rate at maximum. After setting the bandpass filter at the highest frequency, observe the pulse output and gradually lower the bandpass frequency. The pulses will get longer and finally disappear as the bandpass frequency approaches and then goes below the clock rate. If you lower the clock rate, the pulses will reappear, but they will be longer than before. Keep this

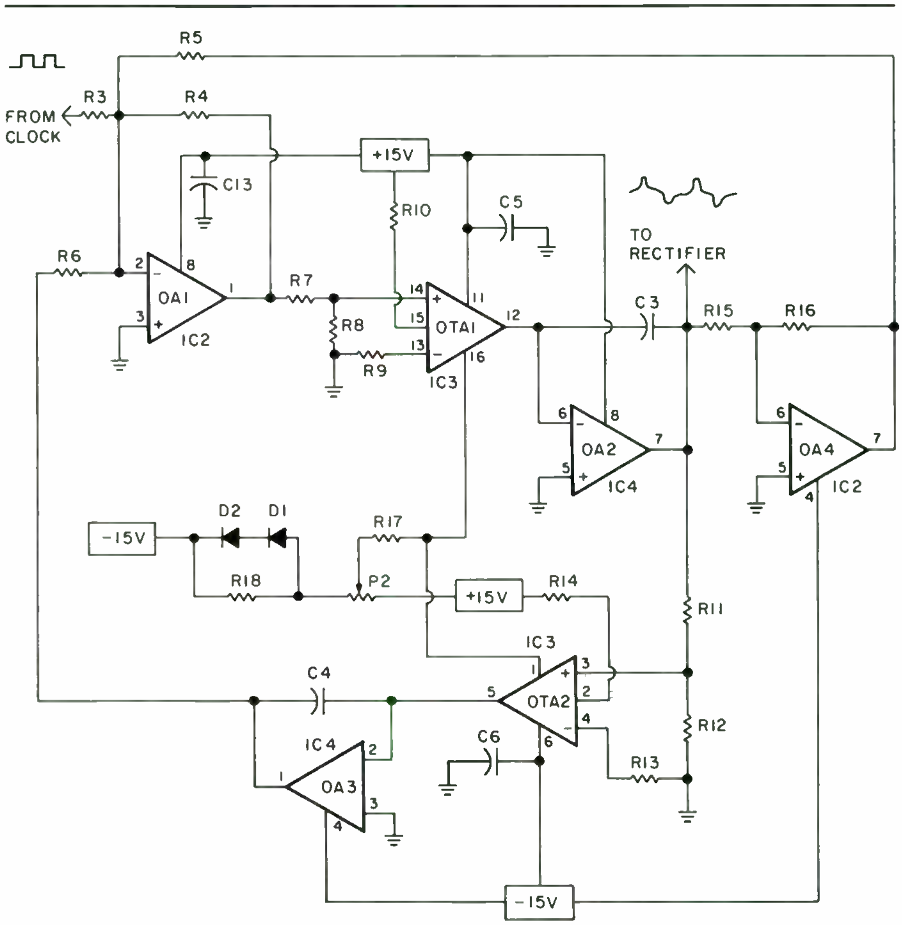

FIGURE 8: The schematic for the bandpass filter shows how OTA's instead of resistors provide variable center frequency.

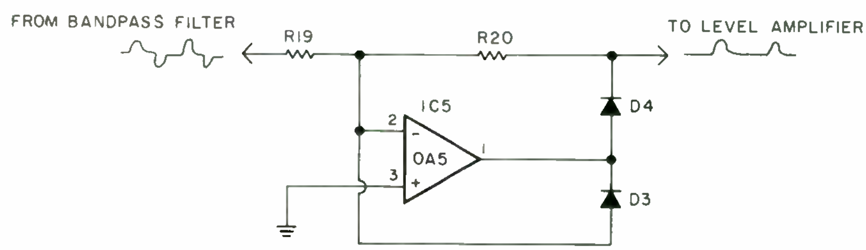

FIGURE 9: The rectifier passes only positive pulses.

PARTS LIST

C1	1.5μF 100V Met. Polyester	IC8	7915UC/LM340T-15	R10	15k ¼W 1% MF
C2	.1μF 50V Cer. Disk	BR1	W02M 1.5A 200V Bridge Rect., or 4	R11	10k ¼W 1% MF
C3, 4	1000pF Silver Mica		1N4001 Diodes	R12, 13	1k ¼W 1% MF
C5, 6	.1μF 50V Cer. Disk	L1	Neon Ind.	R14	15k ¼W 1% MF
C7, 8	.1μF 50V Cer. Disk	D1, 2, 3, 4	1N4148	R15, 16	10k ¼W 1% MF
C9, 10	1000μF 25V Elect.			R17	15k ¼W 1% MF
C11, 12	25μF 25V Elect.	T1	Signal PC34-125 (34V CT, 125μA)	R18	1k ¼W 1% MF
C13	.1μF 50V Cer. Disk	S1	SPDT Toggle	R19, 20	10k ¼W 1% MF
		S2	SPST Toggle	R21, 22, 23	10k ¼W 1% MF
IC1	74C04			R24	619E ¼W 1%MF
IC2	LF412N	R1	1.5M ¼W 5% CF		
IC3	13 600N	R2	2.74k ¼W 1% MF	P1	1Meg Pot
IC4, 5, 6	LF412N	R3, 4, 5, 6, 7	10k ¼W 1% MF	P2	50k 10 Turn
IC7	7815UC/LM340T-15	R8, 9	1k ¼W 1% MF	P3	10k Log Pot

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A few years ago, when Audio Control's C-22 Octave Equalizer was beginning to really take off, the engineering department said, "Why don't we make a version with even better specs and add a laboratory-grade pink noise generator for the experimenter?" Sounded ike a great idea: .009% THD, 102dB signal-to noise, pink noise generator ±.5dB 20-20kHz. So they did it.

C-25 Specifications:

DISTORTION (at 1 volt from 20Hz to 20kHz): less then .009%. **FREQUENCY RESPONSE:** From 3Hz to 100kHz, plus or minus 1dB. **HUM AND NOISE:** (10kHz band-width): minus 96dB re 1 volt, minus 102dB re 2 volts. **MAXIMUM INPUT:** 7 volts. **MAXIMUM OUTPUT:** 7 volts. **INPUT IMPEDANCE:** 100K ohms. **OUTPUT IMPEDANCE:** 680 ohms. **CONTROL CENTERS:** 32, 60, 120, 480, 960, 1920, 3840, 7680, 15.5kHz. **CONTROL BANDWITH:** "Q": 2.5 **CONTROL RANGE:** Plus or minus 15dB. **SUBSONIC FILTER:** 18dB per octave Tchebychev alignment. **SUBSONIC ROLLOFF:** Minus 1dB at 25Hz, minus 3dB at 20Hz, minus 21dB at 10Hz. **SIZE:** 19" (48.2cm) W, 3.5" (8.9cm) H, 6.5" (16.5cm) D, (standard EIA rack mount). **WEIGHT:** 6.75 pounds (3.2kg). **PINK NOISE GENERATORS:** ± 1dB 20-20kHz. **BACK ELECTRET MICROPHONE:** ±.1.5 dB 20-20kHz **WARRANTY:** 2 years.

Unfortunately, the vast majority of dealers just didn't understand the whole point and Audio Control ended up with a pile of superb equalizers. They languished until we noticed them on the back shelf and made Audio Control a deal they couldn't refuse.

THEIR LOSS IS YOUR GAIN.

We're not talking about a cheapo imported knock-off here. Audio Control lavished the best components and design into the C-25.

Fiberglass boards. Precision resistors and capacitors. Silky-smooth pots and superb specs. Frankly, there's probably $129 worth of materials in each C-25.

LAB-GRADE PINK NOISE GENERATOR.

Anybody who reads this publication knows how useful pink noise is in evaluating and adjusting speakers. Even if you don't have a measurement instrument, pink noise lets you do considerable adjustment by ear. In conjuction with a handheld spectrum analyzer it opens up a whole world of interactive EQ testing.

When we got the shipment of C-25's from Audio Control, Accessoterica benchtested it's pink noise generator against a B & K Model 1405 Noise Generator. The Audio Control C-25 was more accurate.

So even if you just use the C-25 as a pink noise generator, it's a great buy.

TWO SPECIAL CIRCUITS FOR HOME HI-FI.

Audio Control is a great believer in solving real-world audio problems. So they added an 18dB/octave Tchebychev subsonic filter circuit and a Rumble Reduction circuit to the C-25.

Subsonic filter is down 1dB at 25 Hz, down 3dB at 20 Hz and down 21dB at 10 Hz. If you bought or built vented or transmission line speakers, you know how important a circuit like this is, especially if you like a healthy 40Hz boost in your program material the way we do.

The Rumble Reduction circuit mono's bass below 200Hz to combat rumble, mechanical feedback, warped records and resonances. Vertical groove components are effectively cancelled without losing stereo spearation. If you don't agree with this approach, the circuit comes out with the touch of a button.

THE $549 C-101 FOR $299!

We also grabbed up a few packaged C-101 Octave Equalizers with 101-LED Realtime Spectrum Analyzer, measurement microphone pink noise generator. All units are 100% guaranteed, electronically and cosmetically. They're not repairs, but demo units returned by dealers. Some manufacturer's would just sell them back as new, but Audio Control made a deal with Accessoterica to clear them out at cost. You couldn't do better if you bought a brand new C-101 at retail. Same features and specs as the C-25 with 10-band Spectrum Analyzer with 2 & 4dB range, slow and fast decay, SPL mode and microphone on 20-ft cord with ± .1.5dB 20-20K specs. A steal, while they last at $299. Full 2-year warranty from the factory.

PAIRED SLIDERS FOR EASY ADJUSTMENT.

Audio Control is the only company that puts left and right channels next to each other. Doesn't seem like much until you start adjusting an equalizer frequently. As you probably know, a difference of as little as 3dB in the midrange bands can smear sound imaging. (A lot of bias against equalizers stems from this adjustment problem which is solved simply by putting left and right controls near each other so you don't have to build two curves.)

THE RIGHT STUFF.

Of course, the C-25 has an extra tape monitor loop, a program switch for comparison (especially useful in conjuction with the pink noise generator and your trusty ear for quick speakers EQ's), and an EQ-tape circuit which lets you equalize tapes without repatching C-25. It's packaged in a standard 19" rackmount chassis with RCA-type inputs and outputs on the back--including two for the pink noise generator. We even talked a pile of C-22 manuals out of Audio Control, although you're on your own concerning the pink noise generator. But then you wouldn't be reading this page if we didn't think you'll know what to do with pink noise.

VERY LIMITED SUPPLY.

Order your C-25 right now since we have a very finite supply. Order it toll-free with a bankcard and get it within seven days. Mail us a money order for two-week service or a personal check (which we have to let clear) for three to four week delivery. WE PAY FREIGHT via U.P.S. on all orders! Whether you need a pink noise generator, a great octave EQ or just a sharp subsonic filter, $129 is a superb deal on a great unit.

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Accessoterica

12902 Hwy 99 Everett, WA 98204 (206) 625-9041 Toll-free order 1-800-328-5757 ext. 175 observation in mind. You must operate at a lower clock rate for lower frequency pulses. In other words, *the clock rate must be lower than the bandpass frequency.*

Attach the output of the pulse generator to an auxiliary input on your preamplifier. Compare one pair of drivers in a cabinet at a time. Place the microphone about a meter or so from the speakers on axis, and look at the pulse output of each driver. If the bandpass frequency is set too low, the output of the upper frequency driver will be attenuated and will not look much like a pulse. Adjust the bandpass frequency so the pulses have the same maximum amplitudes. If they do not have the same polarity, reverse the leads to one of the drivers. (This may cause frequency response problems, and you may have to choose between time alignment and amplitude response.) After reversing the leads connect both drivers and change their relative positions as you watch the microphone output on the oscilloscope. When the two drivers are time aligned, their pulse peaks will overlap, the optimum position appearing as the largest peak on the oscilloscope display.

BETTER SOUND. The difference I noticed between aligned and nonaligned was subtle but unmistakable. Voice articulation showed the greatest improvements, and the words of singers became easier to understand, perhaps due to the 3kHz crossover in the Fried H satellite. Imaging seemed a little better with the system time aligned, but not remarkably so. How much improvement you will get depends on how badly your speakers are aligned to begin with and the amount of phase information presented in the program material. □

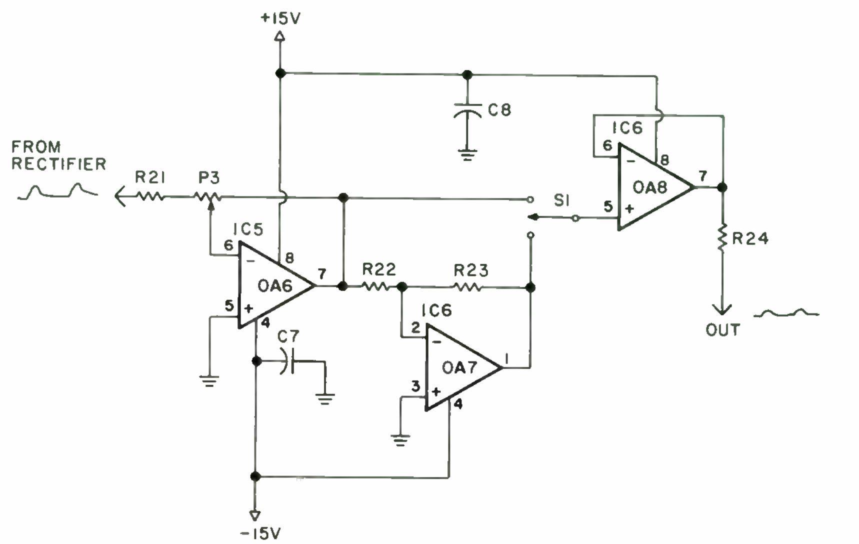


FIGURE 10: The level amplifier uses an inverting op amp (OA6) with variable gain. OA7 is another inverter, and the switch selects positive or negative pulses.

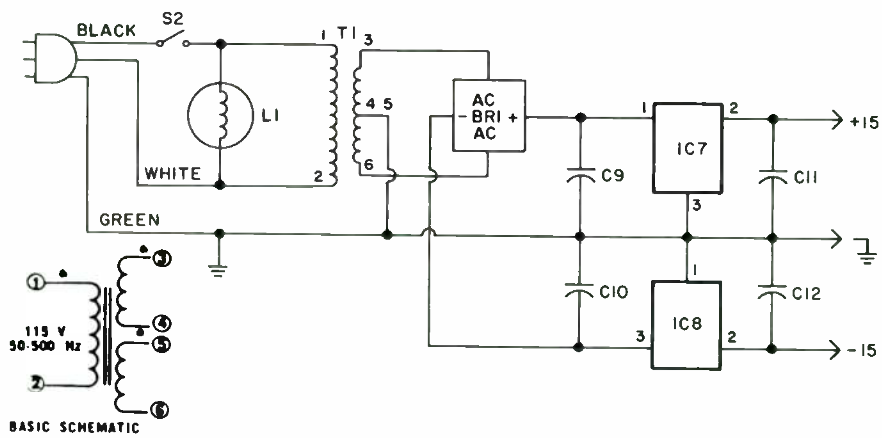


FIGURE 11: The power supply is a full wave bridge rectifier.

PHOTO 1: The front panel has few controls. The frequency pot is a 10 turn type.

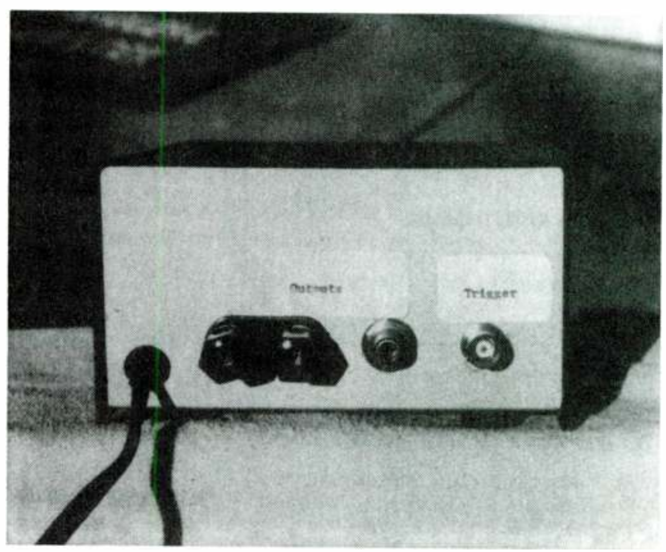


PHOTO 2: Rear panel view of the prototype generator.

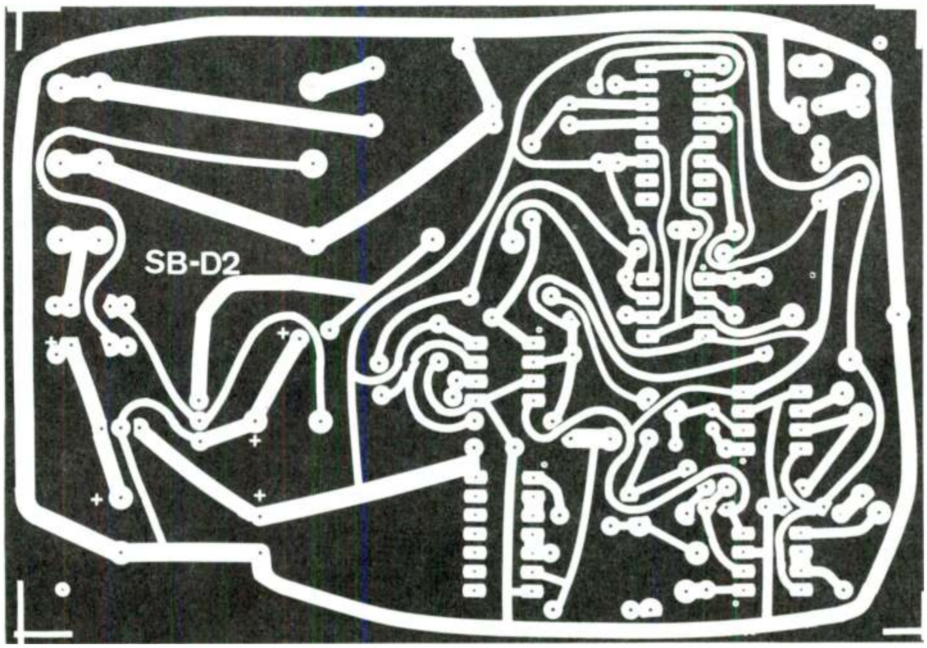


FIGURE 12: Circuit board pattern for the pulse generator.

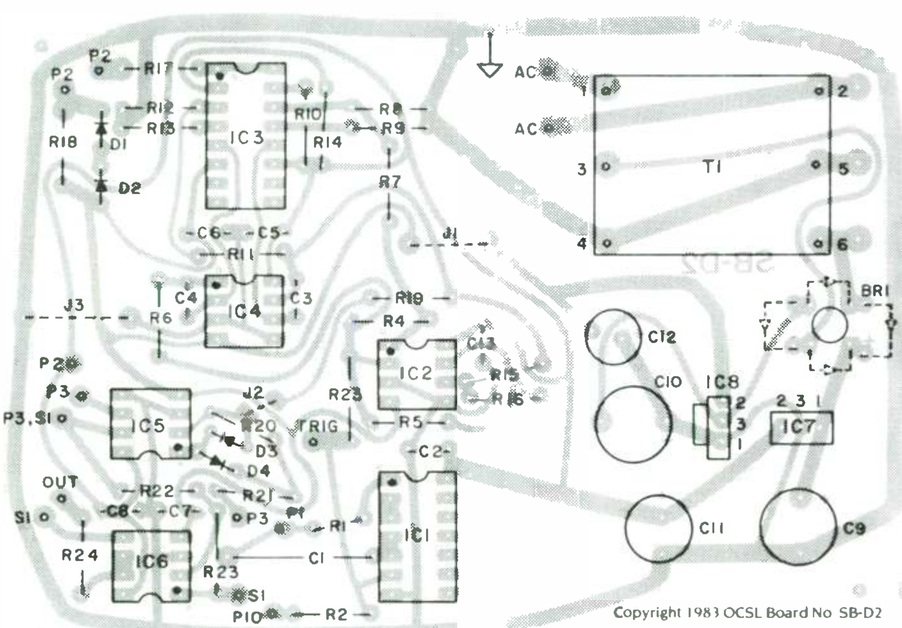


FIGURE 13: This is the stuffing guide for the SB-D2 circuit board. Note that the transformer T1 has a spare set of holes near the board's edge for a slightly larger board mounted transformer. The author's Signal PC 34-125 fits the closer holes. Signal's PC 34-300 fits the wider ones. BR-1 is a standard full wave bridge, which fits the inner four holes. Extra holes are provided if you prefer to use less expensive 1N4001 diodes.

$3.79 is what replacing a lost magazine costs us. It will cost you $2.00 if you don't notify us of your change of address in time. If we update our files early, it saves us the bother of having to re-mail the magazine, charge you the $2.00 fee and lose money on the deal. We'll all be much happier if you tell us promptly when you're moving and where you're moving to and from. Thanks for your cooperation.

LEVEL CONTROLS AND BALANCING PADS

BY GLENN PHILLIPS

Padding devices are resistive network circuits, fixed or adjustable, which convert usually more efficient tweeters and midranges to a level relative to a woofer. The devices are inserted between crossover and driver and are usually considered to be a driver subsystem. For this article's purposes, we'll assume the crossover is of the passive type.

Some beginners think padding networks are frequency-discriminating, akin to equalizers. They aren't; they affect the entire pass-band section of the associated driver and adjust the relative acoustical balance between drivers. They also, within certain limits, can adjust balances in the acoustical environment.

Many loudspeaker system designers try to avoid padding devices by using drivers with equal acoustical outputs. This subject has been much debated.

ADJUSTABLE CONTROLS. Loudspeaker systems can have two main types of adjustable level controls: the "T" type and the "L." The latter is the most commonly available and is therefore the one I'll discuss here.

An L-pad is like a volume control, but has the extra duty of maintaining a proper impedance load on the crossover whenever the control setting is changed. It is not the same as a potentiometer, whose impedance varies as the control setting changes and which therefore will interact with and vary the driver's crossover frequency. *Figure 1* shows an adjustable L-pad schematic.

The adjustable L-pad is a convenient device and easy to operate: just turn the knob as desired. But it has some subdued gremlins. If it can be adjusted, it can be maladjusted. This is okay if a little response imbalance is to your taste.

But when the fool at the party decides your sound system needs some expert adjustment via his (or her) calibrated senses—and you just spent all that afternoon going nuts, listening to pink noise and test tones for the perfect system balance.... In seven years you'll be paroled and can try again, unless your lawyer can convince the court it was justifiable homicide.

The adjustable control's inherent minor problems are that poor internal wiper tracking on the two wire-wound resistors can produce slight impedance upset and small frequency shifts in the related crossover network. These wipers and resistors also oxidize with time and begin to sound scratchy.

Adjustable L-pads are customarily placed so the control knobs are accessible from the rear of the enclosure or from the baffle board, behind the speaker grille. Just put yours any place that seems suitable.

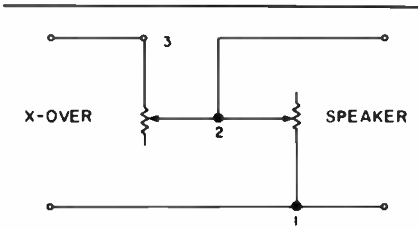
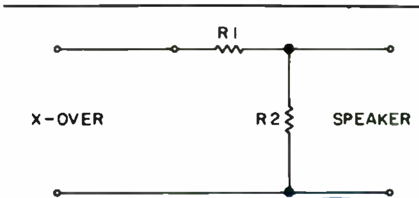


FIGURE 1: Schematic for adjustable L-pad.



$$R_1 = \left(\frac{10^{(0.5\times A)} - 1}{10^{(0.5\times A)}}\right)Z$$

0.05

$$R_2 = \left(\frac{1}{10^{(0.5\times A)} - 1}\right)Z$$

A = The amount of loss needed in dB.
Z = The driver's DC resistance, R_e.
Use the nearest value of standard resistors that is approximate in value to the one needed.

FIGURE 2: Schematic for fixed L-pad.

Before you buy one, ask about its power handling capability. Midrange drivers require a beefier control than a tweeter. You'll also need to consider the crossover point and whether the loudspeaker system will be two- or three-way. (Midrange units are considered from the lower crossover frequency.) Keep in mind how much power you intend to subject it to. These devices are usually rated as low, medium or high power, and are also described as having 4, 8 or 16Ω nominal impedances.

FIXED PADS. These devices serve the same function, but are permanently set: they have no controls to twiddle. Fixed L-pads are usually mounted on the crossover board inside the system.

Some users like loudspeaker systems without externally adjustable controls: they tend to rationalize that the entire speaker unit is pre-balanced for accuracy. The manufacturer would like you, too, to believe this age-old myth. These systems were balanced in various types of chambers, outdoors in free-air, on graph machines and by computer; the only missing factors were those the manufacturer cannot control—your listening environment and related system components. This is not to say that some manufacturers are better guessers than others. Some get lucky.

L-pad components can be determined from formulas when you know the working impedances and amount of loss needed, in decibels. Most writers suggest you use the driver's nominal impedance, whatever that is, to compute the L-pads. I prefer to use the driver's DC resistance, R_e, as this value is realistic rather than arbitrary.

Tweeter unit resistors should have power ratings of 5-10W depending on the crossover frequency and the amount of power to which the unit will be subjected. Midrange units need 10-20W power capability in the resistors. I give the calculations in *Fig. 2*. See the sidebar for a BASIC program that determines these values.

OLD COLONY PRESENTS
FALL SPECIALS

SBK-C1A JUNG ELECTRONIC CROSSOVER *Only $24.75 per card!*

This versatile circuit began as a two channel 30Hz, 18dB/octave infrasonic filter. But you can adapt two of them for use as a single channel two-way electronic crossover simply by changing the values of a few resistors and capacitors. For three-way operation, add another pair of cards and change the parts values to move the crossover points to the appropriate frequencies. For further information on sub-woofer and 3-way crossovers, see *SB* 3/82, or *TAA* 4/75. Please specify one crossover point for each two-way crossover from the following frequencies: 60, 120, 250, 500, 1k, 2k, 5k or 10k.

Based on a simple op amp design, the crossovers typically have a frequency response of ±0.2dB 30Hz-160kHz. Output impedance is 10Ω non-inverted, input impedance is 50kΩ. Power supply needed should provide ±15V DC @ 10mA per card.

NEGLEX 2477 SPEAKER CABLE *Only $2.00 per foot!*

For less than the price differential between standard and fancy finishes on a pair of speakers, you can make a significant improvement in the *actual sound* of your system. This high definition Neglex cable is a coaxial configuration using Mogami OFHC wire and copolymer insulation. Termination kits provide two short lengths of OFHC wire, two spade lugs and an insulating sleeve (one kit required for each end of cable).

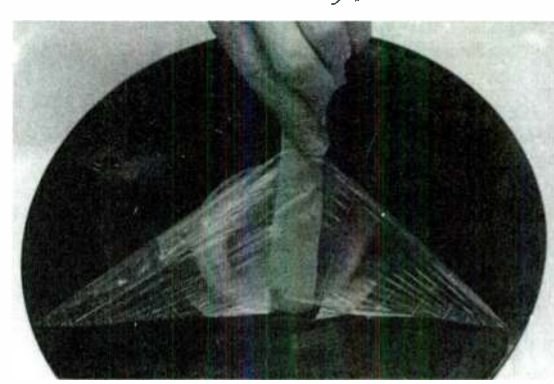
The cable has extremely low capacitance, impedance, inductance, and eddy current effects. In the audio frequency range, impedance is virtually flat (see Nelson Pass' article on speaker cables in *SB* 2/80 for a discussion of these effects). Small improvements in low bass, extreme highs, imaging, depth, distortion, and amplifier damping all add up to audibly better sound and greater listening enjoyment—just one more way to remove some of the haze which prevents your system from sounding as clear as it should.

ULTRAMINIATURE EARPHONES *Only $19.50!*

Actual size

If you have a personal stereo tape player or FM tuner, you will appreciate the sound quality and comfort of these earphones. So small and light they fit into the outer ear *without* a bulky headband, they sound considerably better than the headphones usually supplied with personal stereos. The bass is deep and strong, highs clear, and midrange smooth, with crisp, clean detail. Samarium cobalt magnets provide light weight—**just 18 grams**—and high efficiency. An extra pair of foam earpads is included. Because of their good sound and extreme comfort (they seem to melt away after a few seconds, leaving just the music), many people like to use them with their home systems as well (you'll need a mini to standard phone plug adaptor).

KM-9 WILLIAMSON RECORD CLEANING SYSTEM *Only $8.50!*



Developed by Reg Williamson, this two step system removes static charges from records virtually forever, and removes deep-down dirt thoroughly and safely. Static charges (as high as several *kilovolts)* lock dirt on the record and create annoying pops as the stylus traces over charged areas. The surfactant neutralizes those charges by supplying molecules with cationic ends to capture the negative ions.

The cleaning solution dissolves the dirt and holds it in a clear film when it dries. Simply peel the film away and the record is cleaner than when it left the pressing plant.

You supply distilled water, glycerin, isopropyl alcohol, an applicator and buffer pad. We supply ½ oz of de-static liquid (1000 treatments), and 4 oz of deep cleaner (80 disks). Regrettably, due to Postal Regulations, this cannot be shipped outside the US.

ORDER FORM Old Colony Sound Lab, PO Box 243, Peterborough, NH 03458 USA

Qty.		Price
______	Jung Crossover Cards $24.75 each	______
______	Ft. Neglex Speaker Cable $2.00/ft.	______
______	Termination Kits $.75 each (Available August, 1983)	______
______	Ultramicro Earphones $19.50 each	______
______	Williamson Record Care Kit $8.50 each	______
______	Destatic Refill (½ oz) $4.50 each	______
______	Deep Cleaner Refill (4 oz) $4.00 each	______
	Total amount enclosed:	______

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Phone Orders: (603) 924-6371 (MC or Visa only) 9-4 EST M-F

For full kit listing, send stamped, self-addressed envelope to: Old Colony Sound, PO Box 243, Peterborough, NH 03458.

```
1Ø REM THIS PROGRAM COMPUTES THE VALUE OF
2Ø REM THE TWO RESISTANCES REQUIRED FOR A
3Ø REM FIXED L-PAD WHEN A DB LOSS IS NEEDED
4Ø REM THE SPEAKER CLINIC/GLENN PHILLIPS 198Ø
5Ø CLS
6Ø PRINT "WHAT IS THE DRIVERS DC RESISTANCE ?"
7Ø INPUT Z
8Ø PRINT "WHAT IS THE DB LOSS NEEDED ?"
9Ø INPUT A
1ØØ LET L = .Ø5*A
11Ø LET K = 1Ø↑L
12Ø LET R1 = Z*((K-1)/K)
13Ø LET R2 = Z*(1/(K-1))
14Ø PRINT "THE VALUE OF R1 SERIES RESISTOR =";R1;"OHMS"
15Ø PRINT "THE VALUE OF R2 PARALLEL RESISTOR =";R2;"OHMS"
16Ø PRINT
17Ø PRINT "WOULD YOU LIKE ANOTHER ? TYPE 1"
18Ø INPUT X
19Ø IF X = 1 THEN 21Ø
2ØØ STOP
21Ø GOTO 5Ø
22Ø END
```

This simple BASIC program written on the TRS-80 Model II computes the value of the two resistances required for a fixed L-pad when you need a dB loss.

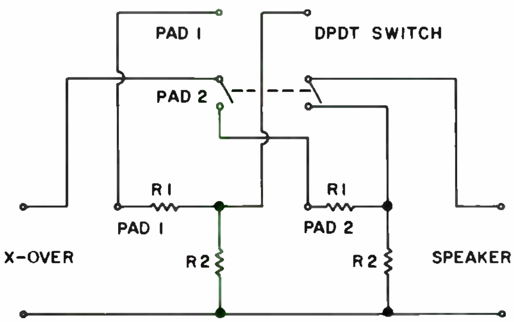

FIGURE 3: Simple switchable L-pad.

SWITCHED PADS. We can take the fixed pad one step further into a form known as the "switched" type. This uses equations identical to the fixed pad, but with sections ganged together on a single DPDT switch or similar type of rotary switch. This device can be as flexible as the variable type and can effectively satisfy most requirements; you can also add attenuation steps as desired.

You can always readjust a switchable pad if someone tampers with it, and it can become as elaborate as you need. If it resembles a stepped volume control, you'll always have a beautifully tracking device with almost unlimited adjustment possibilities. But don't get carried away. In designating a complex pad you'll do best for fine-tuning if you remove small decibel chunks rather than large ones. A simple diagram appears in *Fig. 3*.

I hope these notes have stimulated some thoughts and questions. Consider the type of balance control you would like for your particular system. No one type is actually the best: some better suit certain applications. When designing, it's your decision. □

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4. AARL, *Electronics Data Book*, The American Radio Relay League, Newington, CT., 1976.

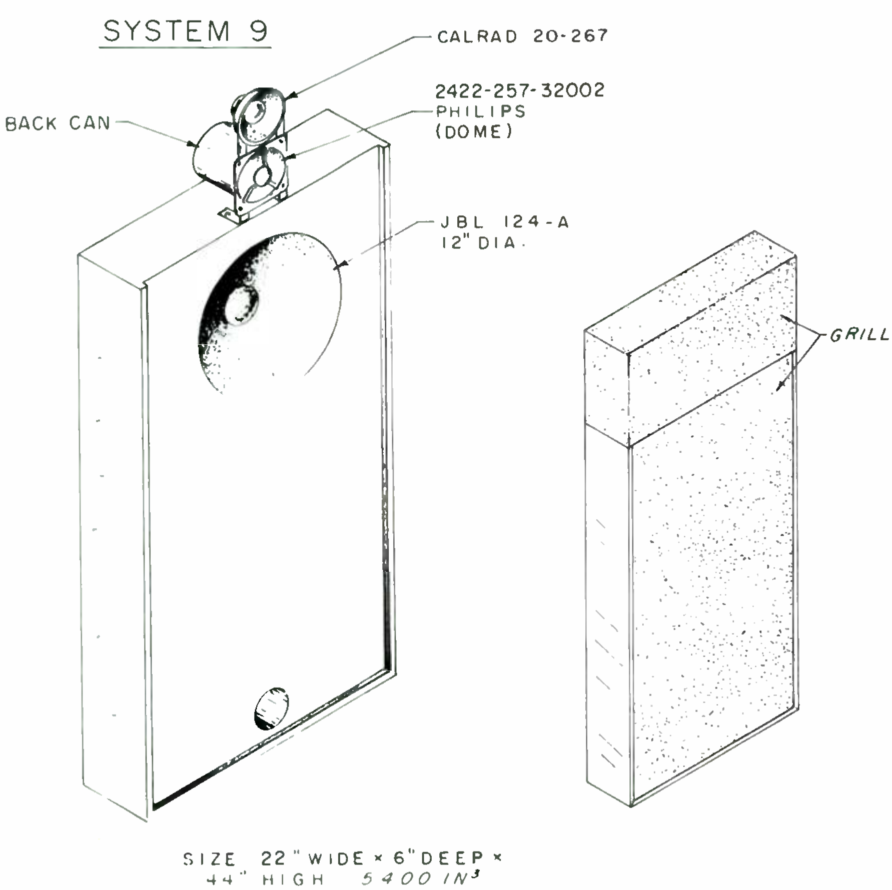
A strongly opinionated cautionary tale of one man's fifteen-year search for the ultimate home built speaker system

A SPEAKER BUILDER'S ODYSSEY: PART IV

BY ROBERT CARLBERG

SYSTEM 9: FULL-RANGE PANELS. I was so pleased with my speakers' performance that when the money came up (income tax '78, I think), I ordered a second JBL woofer to complement the first. It had to be specially ordered because in the intervening two years the maker had taken it off the separate component market. I knew it was still available, however, because JBL uses the 124A in the 4315 Studio Monitors, in a cabinet that is simply terrific for them.

I decided I wanted two woofers because I was having some difficulty deciding how to supply signal to a center-channel subwoofer. Do you filter out the lows from just one channel, try to combine both, or take a line-level output from the preamp to a subwoofer amp? This last option would have been the best, but I had difficulty finding an active crossover circuit that would matrix the two channels while still maintaining stereo separation. I was using a passive crossover for the first method, which soaked up a lot of power and occasionally created some odd imaging problems (as in old stereo demonstration disks with 100% stereo separation). My solution was one subwoofer per channel.



I briefly considered building one double subwoofer cabinet for center-channel, but decided against it on the basis of discoveries in another experiment with the Three Panels. The ears are supremely sensitive to phase relationships; this is how sources of noise are placed for depth and location. If you don't believe me, put your favorite stereo record on in mono and try to determine the kind of room in which it was recorded.

I discovered this when first aligning the high-frequency elements. At first I mounted the midrange and the tweeter side-by-side, but they proved to be nearly impossible to time align in this configuration. Even my slightest movement —for instance, walking in front of them— profoundly changed their relative alignment to my ears. I'm not talking a mere 15 degrees as in vertical movement, but up to 90 degrees in horizontal movement. The only possible conclusion was that I had to mount the tweeter above the midrange, in a vertical line. In this configuration, I could walk anywhere in front of the speakers, even between them, with no image instability.

Since I had already learned that the alignment of the subwoofers was almost equally critical, I had to rule out placing them at some horizontal distance from the rest of the drivers. They would have to be aligned vertically. So, using the former subwoofer cabinet and its newly built twin, I free-mounted the midranges and tweeters to make Full-Range Panels.

The old Lafayette 8" woofers were again returned to the bookshelf cabinets, with Calrad tweeters, for a second system.

I was surprised to find the Full-Range Panels were an excellent system, with quite satisfactory low-end imaging (after all, high frequencies are extrapolated from the wings). It was like getting an entire new record library, as each record revealed previously unnoticed details and basslines. I was at last approaching my goals in sound reproduction.

I spent months listening to them and comparing them with the other available high-quality systems—Dahlquists (anemic low end), Snells (woofer faces downward, for some odd reason), Acoustat electrostatics (good highs, but low power capability), Magneplanar Timpanis (again good in the highs, but perhaps over-forward in the mids). I was convinced my own system was, on the whole at least, as good as anything commercially available, especially taking the $500-a-pair price into account.

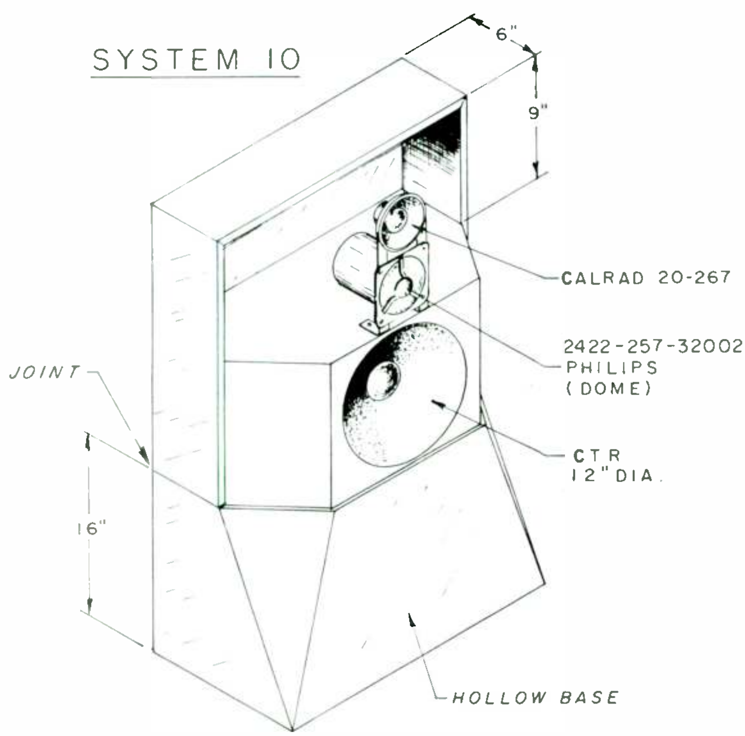
SYSTEM 10: MARC'S TENS. The next move came in response to another commission, this from a friend (Marc) who liked my Full-Range Panels, but wanted something with a bit more finish. The Panels had been worked over several times, and they weren't very dressy-looking.

For him I returned to an earlier concept—the minimal baffleboard idea of the Omni Towers. I designed a cabinet that provided visual interest by its transition from a square base to a truncated-pyramid front, finished again in easy-care rosewood laminate, and set off by sculptured black grillecloth.

For drivers we used the new Philips dome mids and Calrad tweeters, with an inexpensive CTS 12" woofer. The Lafayettes by now were strictly special-order and priced beyond what my commissioner was willing to pay. They turned out to be serviceable units, not nearly as good as the JBL's (and $100 more), but much better than the Speakerlabs (at about $20 more). They responded well to my established cabinet geometries, and the system as a whole was sonically, as well as visually, a modest success.

NEXT TIME: MARK ELEVENS

SYSTEM 10



APPROX. SIZE: 24" WIDE × 40" HIGH ×
12" DEEP 3780 IN³

Tools, Tips & Techniques

Acoustical Sums

Nelson Pass' crossover article in *SB* 2/82 addresses the phase issue with practical completeness not seen even in the *Journal* of the Audio Engineering Society. Several landmark articles come close.[1-6] All are in the JAES *Speaker Anthology.* The JAES articles and some experimentation led me to most of Pass' conclusions. I found a summing crossover electrically accurate and acoustically deviant. Perfect drivers still will not sum because they are non-coincident and energy in the room will not cancel the low pass response bump completely.

To build on the Pass article my solution to poor acoustic summing and the 6dB per octave rolloff *(Fig. 1,* Curve A) from the summing half is a hybrid crossover with attributes of summing and independent filters. The 0.033μF cap in the feedback loop rolls off the low pass to 12dB per octave and smoothes out the bump *(Fig. 1,* Curve B). The 0.033μF cap on the noninverting leg compensates for the shelving effect he speaks of *(Fig. 1,* Curve C). The crossover fills in the dip at the crossover point and blends well between my horn loaded AMT's and woofer enclosures. Not a perfect solution, but the best I've heard yet.

Ken Rauen
Detroit, MI 48221

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DQ10 Fix

After two years of use, I discovered that one of the tweeter controls on my Dahlquist DQ10 speakers had become scratchy. A voltmeter across the tweeter terminals confirmed that it had become erratic as well. I removed the controls from both speakers and found that both were horribly burned.

Dahlquist said that burned or scratchy level controls were evidence of speaker abuse, but my 200W amplifier was within the specified power rating of the speaker, and I had always used the recommended fuses. Still, Dahlquist was happy to sell me replacements at $3.35 each. This is not terribly expensive, but I would recommend that you replace the stock 3W, 25Ω pot with one that has higher power-handling capability.

The moral of this story is that DQ10 owners should be prepared to replace the level controls after a couple of years. I wonder if burned level controls are at the root of the problems with the often-maligned Dahlquist top end and if they

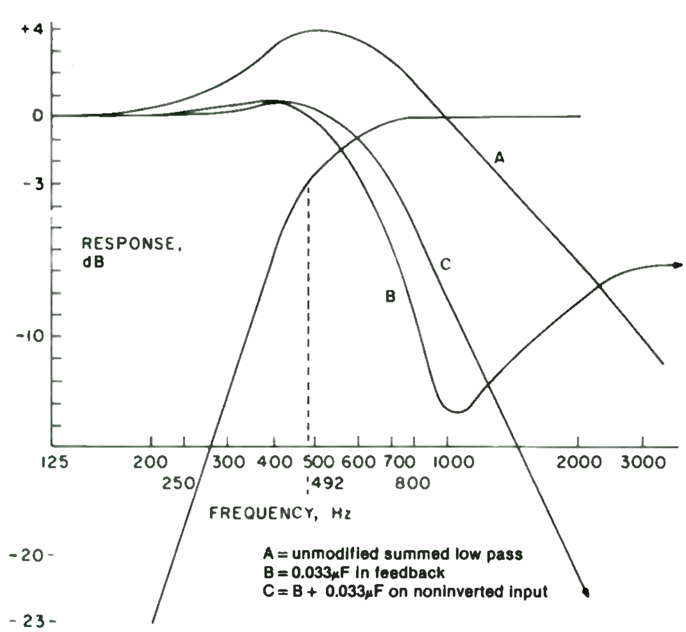


FIGURE 1: Rauen's crossover produces these effects.

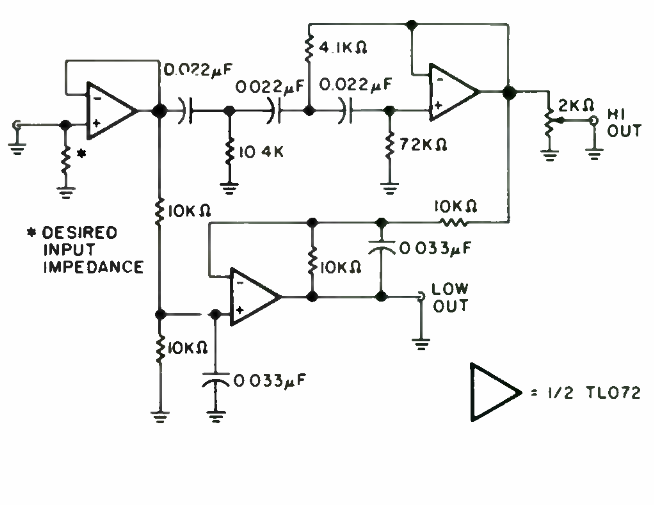


FIGURE 2: This active crossover solves some of the problems Rauen encountered with other designs.

have inspired the tweeter modifications that have been flooding the market.

Tom Nousaine
Wixom, MI 48096

Room Boom

Here's a message for all you out there in rear/floor firing subwoofer land. Are your concerts held in a room with wooden floors and rattling paneled walls? Do you get reverberation and unnatural response peaks? I hear you—loud, but not clear.

Next to a remodeling job, the best solution I can suggest is an 18″×18″ foam rubber cushion that you would normally use to make wheelchair seats more comfortable. What is different about this cushion is its "acoustic" shape. It has 75 3″-high ridges and dips, which are responsible for its designation as an "egg-crate cushion." You can buy such a cushion at a medical supply store.

I have two vented subwoofer units, one 10″ and one 12″, that fire indirectly. Placing one or more "egg crates" 6″ to 10″ from the woofer on the reflecting surface helped tone down much of the room boom I was getting.

Doug Cabaniss
Sullivan, IN 47882

Bigger by Stuffing

I recently read an article that said an increase of up to 40% in apparent speaker box size is possible by stuffing the enclosure with fibrous material. The author did not recommend exact stuffing quantities, however, so I did my own simple experiment to determine how much you could expect the effective size to increase with various stuffing densities. I experimented with long-fiber wool and Poly Fiber-fil, a product normally used for stuffing toys. The latter is 100% polyester.

I used a driver of known free-air resonance and V_{AS}, then compared the system resonance of this driver in a 1 ft³ test box at various levels of filling to the free-air resonance. I then solved Small's sealed-box design equation for box volume (Vb). *Table 1* shows my results. I had only a small amount of the long-haired wool, so I did not include densities of more than one-half pound per cubic foot.

Not surprisingly, I confirmed the 40% increase, but found it occurs only at a given density. More interestingly, perhaps, is that the polyester material seems to be more efficient at increasing volume than the wool.

Tom Nousaine
Wixom, MI 48096

Test Results

Density (lb./ft³)	% Increase Vb Wool	% Increase Vb Poly	System Resonance Wool	System Resonance Poly
0	0	0	57.5	57.5
.25	+9%	+13%	55.5	54.6
.50	+27%	+28%	52.1	51.8
.75	-	+35%	-	50.8
1.0	-	+40%	-	50.0
1.25	-	+37%	-	50.5
1.50	-	+14%	-	54.4

Test Equipment

- Test box—1 ft³ internal volume
- Heath IG18 signal generator
- Heath IM4100 frequency counter
- Heath IM5225 FET multimeter
- KEF B200—SP1039 8″ woofer
  —Fs 22.4, V_{AS} 9660 in³

Sealed-Box Design Equation

$$Vb = V_{AS} / [(Fb/Fs)^2 - 1]$$

TABLE 1: As you can see, stuffing the enclosure can increase the apparent box size. Note especially the bigger increase with polyester stuffing.

Craftsman's Corner

Brute Force Bass P.A. Enclosure

I drew the accompanying plans to use as a low-end reinforcement to an existing Bozak P.A. column. The 250-pound column needed the optional 2×4 support, but you can eliminate it if you use the enclosure alone.

I designed the enclosure specifically for a 15-inch Altec driver (421-8H) to be driven by a 300W/channel McIntosh, which requires the extra thick wood and additional bracing. This driver has about a dozen stiffening members on the back of the mounting lip (where a front-mounted woofer would normally be placed), so you must rear-mount the driver, which requires a removable front baffle. Three 5-inch-long and 18 4-inch-long hanger bolts hold this in place. Install these bolts by locking two nuts onto the machine-thread end of the bolt and then screwing the wood-thread end (which you cover with glue) into the 2×2 or 2×4 pilot hole. For maximum strength, I did not countersink the bolts to keep the hex nuts flush, but you have that option. I have used these bolts on four water-bed frames (three per corner), and they are quite strong, certainly stronger than T-nuts. The finished speaker should weigh well over 100 pounds.

Nothing is fancy about this enclosure design. It is merely an 8 to 9 ft³ sealed box with the emphasis on rigidity (and ugliness), but it does have a specific purpose.

By the way, I'd like to congratulate Techart Associates on their outstanding illustrations in *SB*. As a professional draftsman, I enjoy seeing good work, and their drawings really look sharp.

Steve Ball
Austin, TX 78745

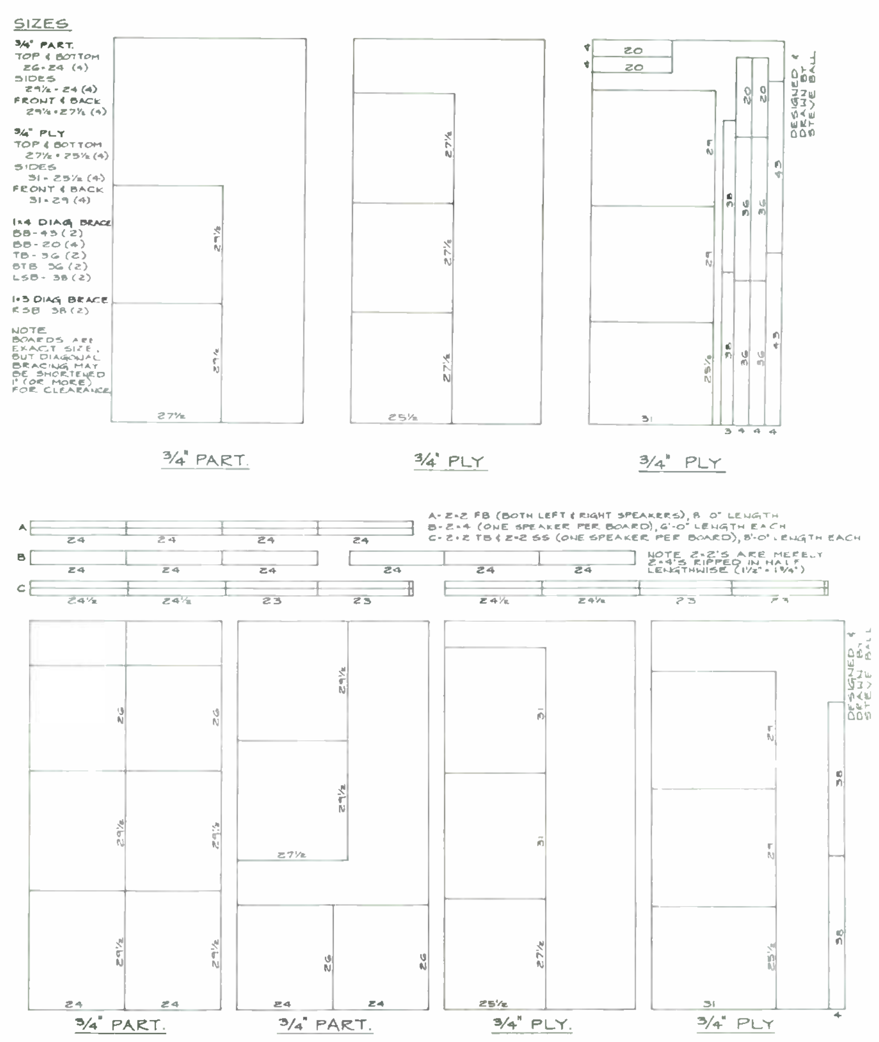


Figure 1: Cutting guide for bass enclosure.

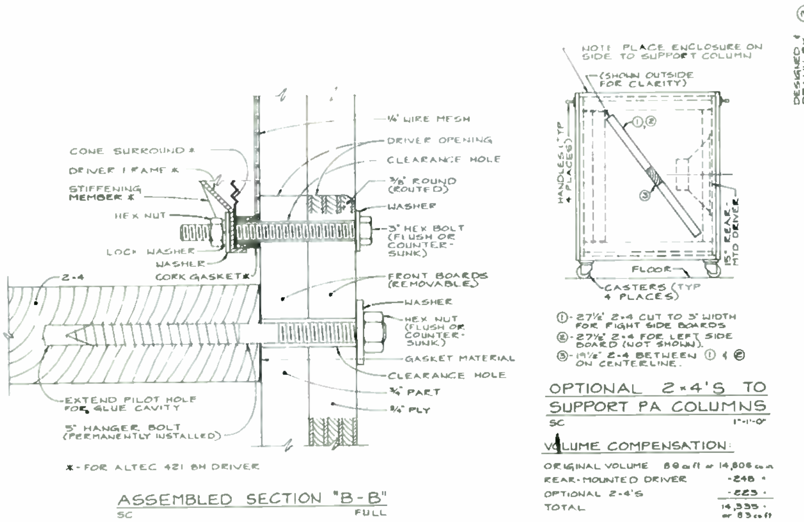


Figure 2: The author designed this enclosure for a 15-inch Altec driver to be driven by a 300W/channel McIntosh. This accounts for the extra-thick wood and additional bracing.

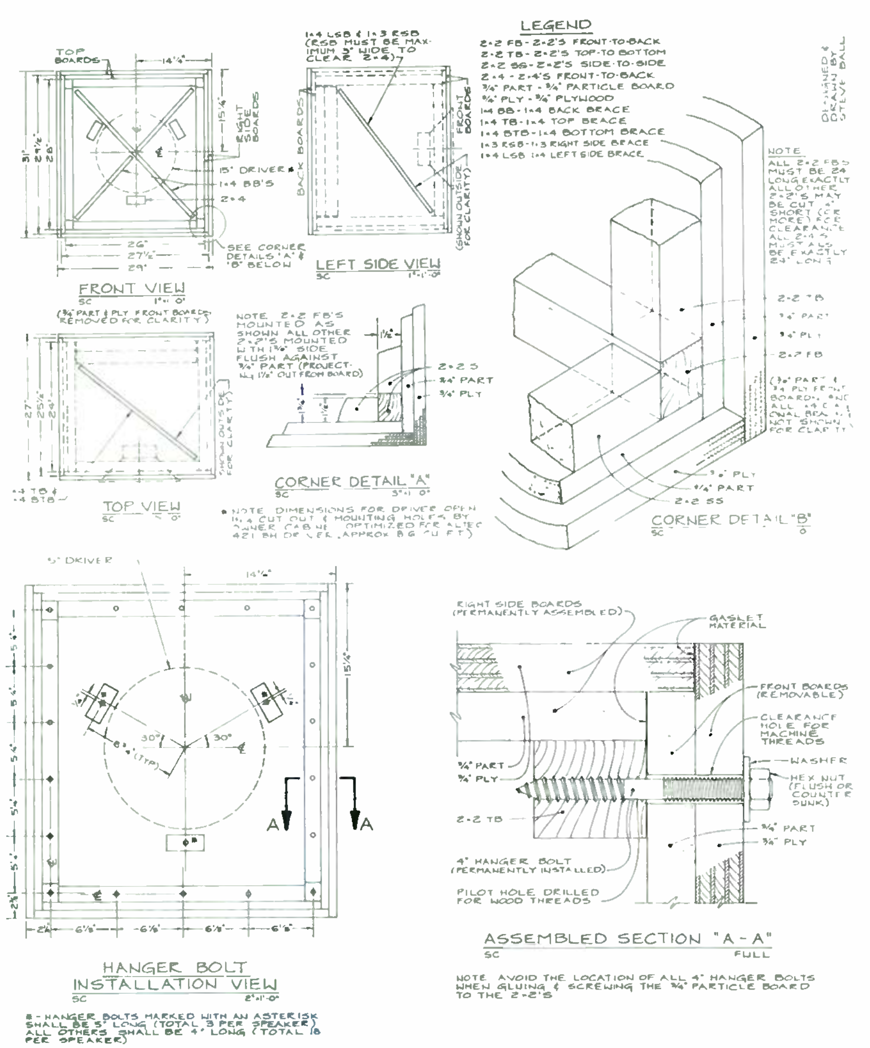


Figure 3: The driver and removable front baffle are held into place by three 5-inch and 18 4-inch bolts. On the basis of his experience in building water beds, the author chose these bolts for maximum strength. For additional support, add the optional 2 × 4's to the P.A. columns.

Kit Report

The Timbrels

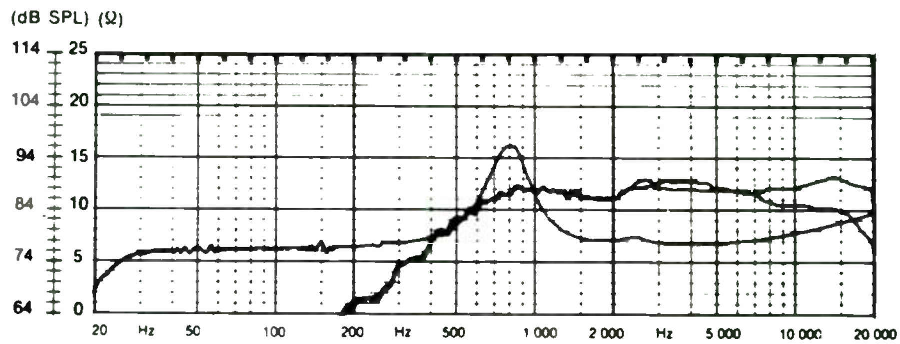


FIGURE 1: The Audax 1-inch tweeter response curves on axis and 30° off axis, as well as its impedance curve.

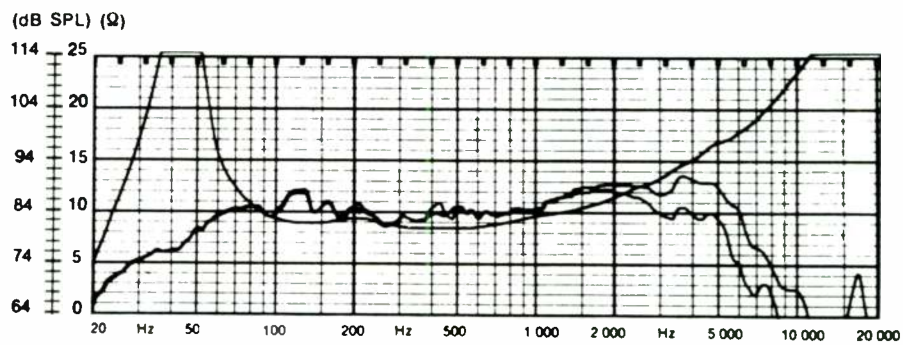


FIGURE 2: The Audax 6½-inch bass/midrange driver (HD17B25H) curves on axis and 30° off axis, plus its impedance curve.

A longer while ago than I care to admit in print, Bill Nye of The Speaker Works, which is located in the wilds of northern New Hampshire (Box 303, Canaan, NH 03741) supplied me with a nice set of Audax drivers and a reprint of a construction article from England's *Hi-Fi Answers* on how to build the Timbrel loudspeaker. This bookshelf design has a fine pedigree, and I am sorry I did not get around to building it with more dispatch. Bill has since decided to leave the speaker business, but he *is* having a closeout sale. (See *SB* 1/83, p. 37.)

Malcolm Jones, technical director of Falcon Acoustics of Norwich, England, designed the Timbrel. Mr. Jones also, in case you didn't know, left KEF a few years ago to form his own business, specializing in crossover networks. He designed some justly famous devices for KEF before his departure and is considered by many as something of a wizard in crossover technology. The Timbrels are small, closed-box units, each measuring a mere 10 by 17 by 8 inches and having a volume of slightly more than 0.5 cubic feet. Drivers, crossovers and construction materials should not cost much more than $150 a pair, depending on shipping costs and the box material you choose.

The tweeter for this two-way design is the Audax 1-inch HD12x9D25 soft-dome driver. *Figure 1* shows the manufacturer's response/impedance measurements. The bass/midrange is the Audax HD17B25H with a 25-ounce, 15k gauss magnet and a smooth response below 5kHz *(Fig. 2)*. Its cone is bextrene with a plasticized PVC (polyvinyl chloride) surround (the cone's hinge) and is alleged to be better at cone damping than neoprene units. Audax makes a similar unit with a much smaller magnet, the HD17B25J, which does not give the same performance in this unit and should not be used.

The crossover is an assembled, passive design by Malcolm Jones, crossing at approximately 2.4kHz. He carefully selected the elements to deal with speaker impedances at the crossover point and other factors involved in designing a practical and effective crossover.

The dimensional details of the enclosure appear in *Fig. 3*. You can recess the bass/midrange for flush mounting by first routing a ½-inch or wider circular groove 3/16 inch deep and 6⅝ inches in diameter in the front panel. A jigsaw on a circle cutting rod is best for cutting the 5⅞-inch speaker hole. See *Fig. 4* for the cutout details for the tweeter mounting.

The two panels are laid out to mount the drivers ¼ inch off center, mirror image for left and right, to minimize diffraction effects. Both drivers are front mounted for easy replacement and access to the interior. Neither the back nor the front panels are removable. A small cutout on the rear panel allows you to mount a pair of five-way or some other binding posts on a stiff metal or hard masonite subpanel attached to the inside wall of the box. Be sure to caulk it thoroughly to prevent air leaks.

All the joints are simple butt types glued with liberal amounts of carpenter's water-based adhesive. They are screwed together with 1½-inch No. 6 flat-head wood screws. You should also reinforce all joints with ¾-by-¾-inch battens glued and screwed together. Avoid solvent-based adhesives whose vapors can damage the drivers' cones. If you must use such a glue, allow plenty of time for thorough drying and for vapors to leave the enclosure. *Figure 5* is a cutting guide for the simple parts for two enclosures.

Preferred enclosure material is ¾-inch chipboard, although high-grade plywood is also acceptable. Paint the speaker panel matte black before assembly. *Figure 6* details two methods of constructing a frame for an acoustically neutral grille cloth. To lessen diffraction effects, either bevel the inner edge to 45° or affix a strip of jute rug pad to the inner edge.

The designer of this enclosure strongly recommends using a special 8½-by-10½-by-½-inch bituminous felt pad affixed to the back panel as a minimum means to absorb wall resonances. Several manufacturers, including KEF and Spendor, reportedly use this type of material in their commercial products. The material, widely available in England, is imported into the US by several suppliers, two of which are listed at the end of this report.

The panels look like laminated layers of roofing or builder's felt that has been soaked in diluted roofing cement. They have a damp feel and are slightly flexible. Bill Nye suggests installing additional half sheets on side walls and quarter sheets on top and bottom panels if you want to ensure that panel resonances are damped. This adds up to two and one-half sheets per enclosure, or five for the pair. These retail from speaker supply houses for about $4 each, but the results are worth the extra investment.

Your local lumberyard or builder's supply may sell a similar product called *Greylite Sheathing*. It is available in 4-by-8-foot, ½-inch-thick sheets, which you can cut with a sharp knife. The price locally is $5.50 per sheet. If you cannot locate that product, ask for sidewalk and driveway expansion joint filler, which usually comes in 4 or 5-inch-wide strips that are 5 to 10 feet long.

Use an organic or water-based roofing adhesive to mount the panel. Larry Hitch at Madisound suggests using a tile cement made for installing ceramic floor or wall tiles. This cement is available from a tile shop or building supply store. He advises you to wear gloves, smear the cement liberally over the inside walls, wait 20 minutes and then press the bituminous panels in place. You can also hold them in place with a small finishing brad in each corner while slower adhesives set.

To absorb back wave in the closed chamber further, roll a 24-by-1-by-72-inch piece of cotton batting (the English refer to is as BAF wadding) into a fat sausage shape and insert it through the larger speaker hole. Arrange it inside so that it does not constrict the bass driver cone. An equivalent amount of fiberglass will accomplish the same result, although is is difficult to handle without gloves and can contaminate driver voice coil/magnet gaps. Alternatively, use the

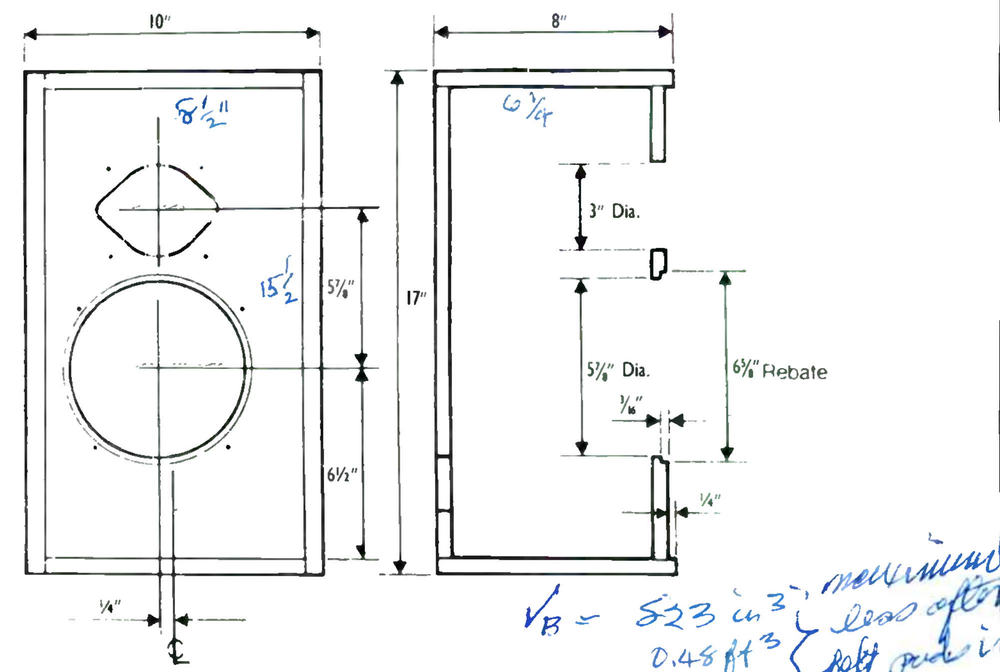


FIGURE 3: Enclosure dimensions for the Timbrel speakers.

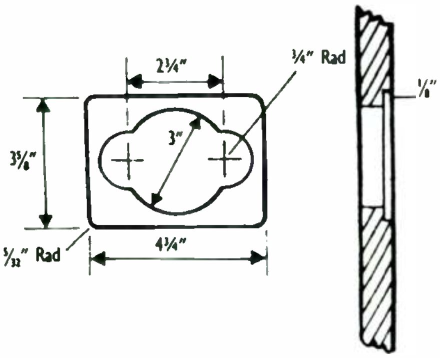


FIGURE 4: Cutout details for the tweeter mounting. Note the ⅛-inch recess, which allows you to flush mount the unit's steel plate.

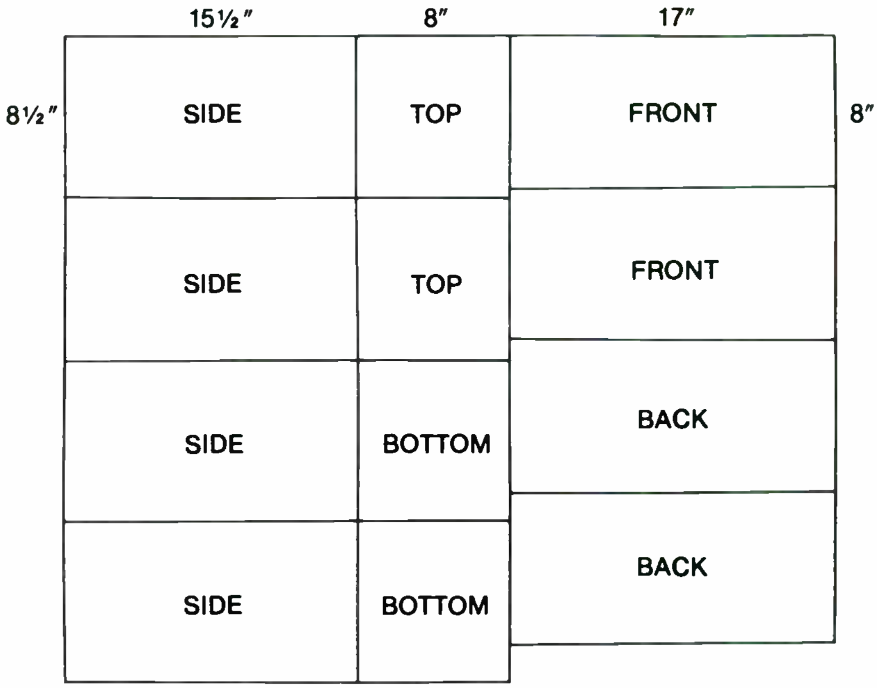


FIGURE 5: Cutting guide for ¾-inch (18mm) chipboard or plywood.

Kit Report

same quantity of polyester or dacron fiberfill (available from fabric shops) to get the same effect more neatly.

Mount the crossover on ½-inch standoffs inside, near the bottom of the rear wall, close to your terminals and away from the bass/mid magnet. Solder the wires from the crossover to the terminals and bring out the driver leads through their respective holes. I used Neglex/Mogami speaker wire to make all internal connections. The Falcon 21b crossover supplied with the kit I assembled was not marked for output connections. In case you get one in which the little guide for proper connections is not supplied, the 21b's connections are as follows, from left to right looking at the *solder side* of the board and counting from one through six:

Woofer 1+, 2−; Tweeter 3+, 4−; Input 5−, 6+.

Use a length of thin weather stripping or Mortite® to make an airtight joint between driver frames and cabinet cutouts. Make pilot holes for wood mounting screws and install the drivers, carefully protecting the cones by placing one hand around the screwdriver blade while driving the screw. Even better, use No. 6 Tee nuts behind the panel, with appropriately larger mounting holes. After soldering the crossover leads to the speakers, use No. 6 machine screws to mount the drivers. Be sure to observe the red dot mark on the drivers indicating the positive terminal.

Power handling of these units is a rated maximum of 30W, although normal music signals through a 50W-per-channel amplifier should be safe, particularly if the amplifier has overload protection. These are not rock-and-roll monitors, however. About 15W is minimum. The speakers are remarkably smooth in the bass region, giving much more apparent response below 100Hz than would seem possible in so small a pair of enclosures and drivers. Avoid sustained sine-wave testing for response. Tone-burst tests, however, showed a speaker under very good control. Some English reviewers of the unit have noted a minor lack of smoothness and integration in the upper midrange and find the speakers do not perform quite as well as the LS3/5A, for example. You should be able to assemble a pair of Timbrels for less than $150, however, and for that sort of investment, you can't do much better.

Edward T. Dell
Editor/Publisher

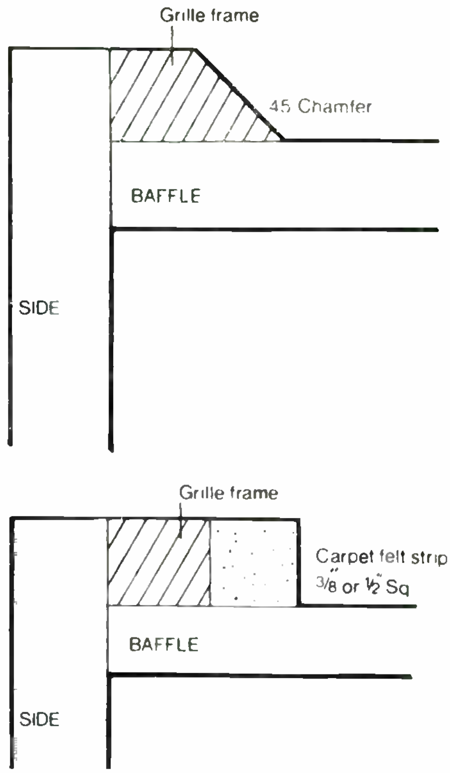


FIGURE 6: Grille frame construction details show methods of either beveling the inner edge or adding jute rug pad material to diminish diffraction problems.

Materials List Per Pair of Speakers

3/4-inch (18mm) chipboard
- Front/back—15½ × 8½ inches, 4 pieces
- Sides—17 × 8 inches, 4 pieces
- Top/bottom—8½ × 8 inches, 4 pieces

Battening—¾ × ¾ inch, 21 feet
Screws—1¼-inch × No. 6 flat head, one gross
Fiberglass or equivalent—24 × 1 inch, 2 yards
Bituminous Panels (see text), 2
Audax HD17B25H drive units, 2
Audax HD12x9D25 tweeters, 2
Crossover Networks—Falcon 21b, 2
Recessed input panels & connectors, 2

Materials Sources

Speaker Works
PO Box 303
Canaan, NH 03741
(603) 523-7792

Madisound
8982 Table Bluff Road
PO Box 4283
Madison, WI 53711
(608) 767-2673

Editorial

Continued from page 6

municating orally. In this age of the WATS line many people would prefer to telephone than to write. If a business doesn't have a telephone or doesn't answer it from 9 to 5, then the business doesn't exist for such callers.

Several readers have called to ask about one particular vendor in the last month or so—Atlas Circuits (PO Box 892, Lincolnton, NC 28092). I wrote to the owner, Richard Allran, and he assured me that the company is alive and well, making single-sided circuit cards, one off, at 38 cents per square inch plus one cent per hole for drilling holes (all must be No. 60 size). Atlas has an information sheet on all its services for interested readers. But don't call the office—you may or may not find someone at home.

Telephone addiction leads to other problems, too. We get lots of phone calls asking questions such as "What does Old Colony's Williamson amplifier sound like—compared to XYZ's Model 23?" and "How can I modify my Kresge X01 speakers to sound better?"

Obviously, we can't answer such questions by phone—or even by mail. Other questions such as "May I have author Jones' telephone number?" are, for other reasons, unanswerable. We ask any of you who want to communicate with an author or fellow reader to write to him or her in care of the magazine, including a stamped envelope with your name and address on it. We will forward it to the person. That way the author's privacy is preserved.

The telephone is a great device. We like and use it a lot and urge you to use it for credit card charge orders of subscriptions, back issues or whatever. (Our subscription service desk is open from 9 a.m. to 4 p.m. daily, Monday through Friday.) But, please, use our phone—and your own—in moderation. □

SB Mailbox

CD SUPPORTER

"The Digital Decision" editorial in 1/83 (p. 6) brought my attention front and center immediately, as I am currently manufacturing laser optical reflective video disks at Technidisc, a subsidiary of Producers Color Service.

The compact disk (CD) holds more promise for acceptable manufacture than the press and record and audio equipment manufacturers would have us believe. Although Technidisc is the only American producer of laser video disks—since IBM and MCA merged, and DiscoVision Associates (DVA) and 3M went out of the business—the technology is not as overwhelming as it seems.

The compact disk is made by the *identical* process as the laser video disk, differing only in its format (digital vs. FM), playing speed (several hundred RPM vs. 1,800 RPM) and size (4.7 inches vs. 11.8 inches). In addition, the CD is one-sided, while the laser disk is two-sided. The last two differences are to the CD's advantage, but the first two are inconsequential. Actually, the digital mastering electronics are considered "duck soup," and the CD should be easier to produce. It also has a more elaborate error-correction scheme to suppress defects (which are as difficult to control as those in semiconductors) of microns in size and on a larger substrate.

There has been too much hype that "Americans can't do it," as Sony insinuated in a Los Angeles press release last fall. DVA's failure last year and hasty business community analysis have seemingly supported this conclusion.

Americans *can* do it, and the world *can* have CD. We must create that consciousness.

Kenneth M. Rauen
Detroit, MI 48221

ESL EXPERIENCE

In response to Ronald Wagner's response to Roger Sanders' articles on Electrostatic Speakers (*SB* 4/80, p. 32), I have had several telephone conversations and letters from Roger Sanders in the last two years because I liked his *TAA* articles and became convinced that ESLs would be worth trying.

I built four ES panels of Roger's design using welding rods and mylar film purchased from him. The effort in time and dedication is great, but the task was completed, and the panels tested full range on an H.H. Scott tube amplifier.

I have never heard such purity of sound from any system, including Frank Van Alstine's reference system (Magneplanar's). Mr. Wagner appears to have an engineering background and speaks with mathematics. I, too, have an engineering education in electricity. Mr. Sanders, to my knowledge, has no strong math background, but he does have much knowledge gained from experimentation and listening. This kind of knowledge is as important as engineering because it is our ears that have control of our checkbook and know what is good and bad acoustically, no matter how good the math answers look.

My decision to try ESLs was based in large part on Roger's statements that the builder would be satisfied beyond his expectations—or words to that effect. In amateur publications such as *TAA* (and *SB*) these kinds of articles that stress what people wanted to try, how they did it and what their results were are all important. Perhaps they are more important than all that math?

I hope more persons like Sanders will tell us their stories. I hope, also, that the Wagners will report their math, but be more understanding when attempting to correct another author's work.

Kent A. Doeling
Minot, ND 58701

PHASE QUESTIONS

After reading your article on phase correcting crossovers (3/82, p. 14; 4/82, p. 26), I am looking forward to building the Old Colony kit. I have some questions, however.

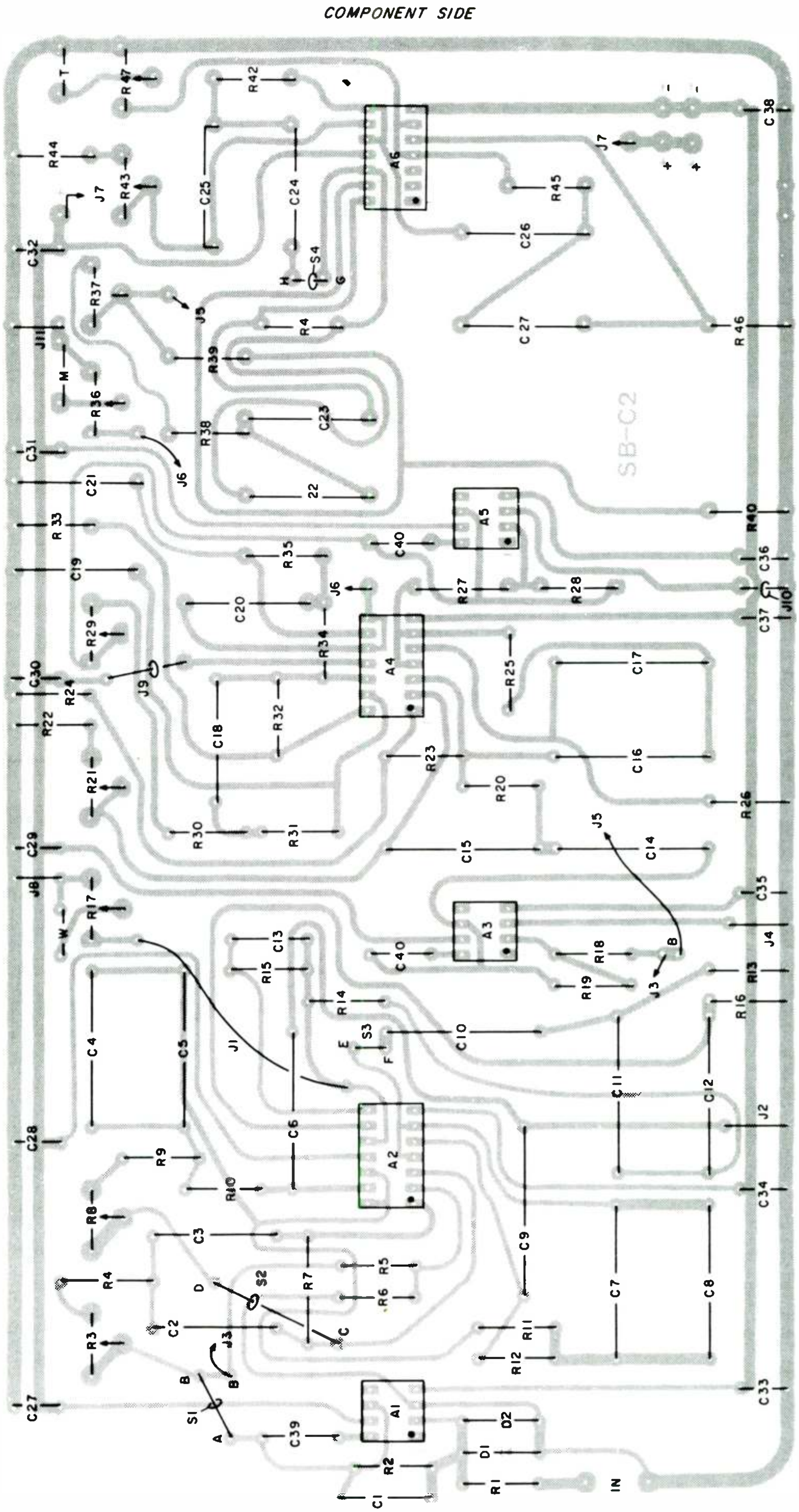
Continued on page 35

CORRECTION: BALLARD BOARD

Bob Ballard has made some additional corrections to his two-part article on active crossovers (*SB* 3/82, p. 14; 4/82, p. 26). In Part II, the power supply connection area of the schematic on page 28 has two symbols, △ and *. The △ refers to the 531 IC, while the * refers to the 4136 IC. In addition, pin 7 should go to positive VCC and pin 4 to negative VCC, which is opposite what appears in the drawing.

Also in Part II on page 28, in the Parts List R44 should be 8.2k ohms and R46 9.1k ohms.

Finally, we are printing a revised stuffing guide, which replaces the incorrect version that appeared in Part II.



Revised stuffing guide for Ballard's active crossover board.

SB *Mailbox*

In regard to the actual phase output of the high and low pass sections, I can see why they are in phase; but would one of them be delayed 360° in relation to the other, since one leads 180° and the other lags 180°?

With reversed phase, should the drivers be connected with reverse polarity, so that compression (kick drum) is not perceived as rarefaction?

A letter by Arthur Josselyn (4/82) on high quality speakers for musical instruments prompted some thoughts I would like to share. Ideal sound systems, for whatever purpose, always involve tradeoffs. You can build a speaker to have a smooth, clean, wide-range spectrum, but usually at the cost of efficiency, or you can reverse the priorities. If you have ever seen a full-size 30Hz bass horn, you realize why most groups don't have them: they are too large, heavy and costly to transport.

My suggestion depends on whether your group uses a mixer and a reinforcement system or simply uses mikes on the instruments' speakers. For the latter case, you could use small, high quality monitors, providing you don't push them too far (just enough to hear on stage). If you don't mike the stage monitors, each speaker system should match the frequency spectrum of the particular instrument used.

The industry is striving to bring sound reinforcement speakers up to the level of home high fidelity. I've personally heard several systems that would do a creditable job in the home as well. More than one company (Pyle and Oaktron for example) offers a line of high performance drivers suitable for the demands of sound reinforcement systems.

Clifford L. Dunning
Portsmouth, NH 03801

PASSIVE CROSSOVER HUNT

I read with interest Nelson Pass's article about phase coherent crossover networks *(SB* 2/82, p. 12) and was especially impressed by his passive 6dB/octave network *(Fig. 4)* using a capacitor/inductor system.

My speaker system consists of a pair of SMGs and a Polk LF14 subwoofer. I would like to triamp this system using a passive crossover network. I assume that the Polk subwoofer has the wide bandwidth required for accurate total system response, as the drivers appear to be the same ones Polk uses in its full-range systems.

Can anyone suggest a circuit topology and crossover frequencies for such a system? Also, where can I obtain the large-value inductors suitable for such a system?

Thanks in advance for any help.

Bill Norris
Pewaukee, WI 53072

WHAT'S THE DOPE?

Thank goodness for a magazine with ideas more advanced than "build a box and cut a vent hole to size until it sounds good." Your articles are becoming complicated, but are lucid for the most part.

My question is this: does anyone know whether you can dope or impregnate paper or fiber drivers with a solution to lengthen speaker life, reduce humidity differences and help control breakup (distortion)? What specifically would this solution contain? Has anyone tried this, and what was the result?

Steve Williamson
Wayne, MI 48184

See "The AR-1 Rejuvenated," SB *2/82, p. 7.—Ed.*

ON THE Q_T

I have only one comment about *Speaker Builder*—excellent. I do, however, miss articles on reducing the Q_T of a speaker

SB Mailbox

system. I am experimenting with Small's recommendations about damping the speaker with resistive loading on the chassis holes or directly around the chassis. I have found that neither a bass system nor a mid system should have a Q_{TS} greater than 0.7. If you want super sound, it is better to have a Q_{TS} of 0.5. For mid frequencies, the procedure is rather complex. You can lower the Q_{TS} with damping, but I suspect that the higher frequencies can give you problems because of excessive reflection.

James Wattstraat
Groninsen, Netherlands

70Hz MINI HORN

Continued from page 13

ACKNOWLEDGEMENTS

I thank Mike Schulz for commissioning the design and building of the corner horns, Mark Baca of Circle Sound for loaning drivers to aid in the search for the most appropriate one, and Manfred Buechler for the photographs.

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SAINT LOUIS AUDIO SOCIETY meets monthly for discussion and equipment audition. For information sheet send a stamped, self-addressed envelope to SLAS, 7435 Cornell, Saint Louis, MO 63130.

SERIOUS AUDIOPHILES interested in a central Colorado group (Denver, Boulder, Ft. Collins, Greeley area) contact James S. Upton, 2631 17th Ave., Greeley, CO 80631.

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SAN FRANCISCO BAY AREA AUDIOPHILES. Audio Constructors society for the active, serious music lover. We are dedicated, inventive and competent. Join us in sharing energy, interest, expertise and resources. Send self-addressed stamped envelope to S. Marovich, 300 E. O'Keefe St., Palo Alto, CA 94303 for newsletter.

THE AUDIO SOCIETY OF HONOLULU cordially invites you to attend one of our monthly meetings and meet others like yourself who are interested in the how's and why's of audio. Each meeting consists of a lively discussion topic and equipment demonstrations. For information on meeting dates and location contact Bob Keaulani at 1902 South King Street, Honolulu, HI 96826, (808) 941-1060.

CONNECTICUT AUDIO SOCIETY WANTED. Serious audiophiles in Conn., or Putnam or Dutchess Co., NY, contact John J. McBride, 33 Perry Dr., New Milford, CT 06776, (203) 355-2032.

THE COLORADO AUDIO SOCIETY is a group of audio enthusiasts dedicated to the pursuit of music and audiophile arts in the Rocky Mountain region. We offer a comprehensive quarterly journal plus participation in meetings and lectures. Membership fee is $10 per year. For more information, send SASE to: CAS, 6225 Snowbird Dr., Colorado Springs, CO 80918.

THE NEW YORK AUDIO SOCIETY meets monthly with prominent guest speakers, discussions and demonstrations of the latest equipment. Its $20 annual membership dues include a subscription to S/N, the society's quarterly publication. For a free invitation to our next meeting, call (212) 544-1222, (212) 289-2788 or (201) 647-2788 or write us at PO Box 125, Whitestone, NY 11357.

SARASOTA AUDIOPHILES interested in forming a club—write: Mark Woodruff, 5700 N. Tamiami, Box 539, Sarasota, FL 33580.

AUDIOPHILES INTERESTED IN FORMING an audio club in the Washington, D.C. area please contact: Joseph Kmetz, 9861 Goodluck Rd., Apt. #10, Lanham, Maryland 20706 or call days (301) 794-7296, eves. (301) 585-3186.

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A CLUB FOR FM AND TV DXers, offering antenna, equipment and technique discussions, plus updates from FCC on new station data. Monthly publication "VHF—UHF Digest." Annual convention in August. For more info: Worldwide TV-FM DX Association, PO Box 97, Calumet City, IL 60409.

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Advertising Index

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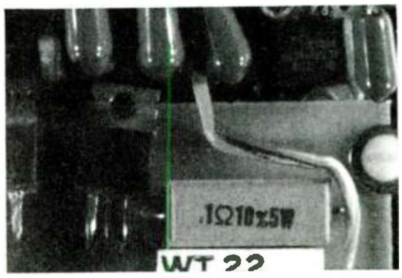

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