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SPEAKER BUILDER

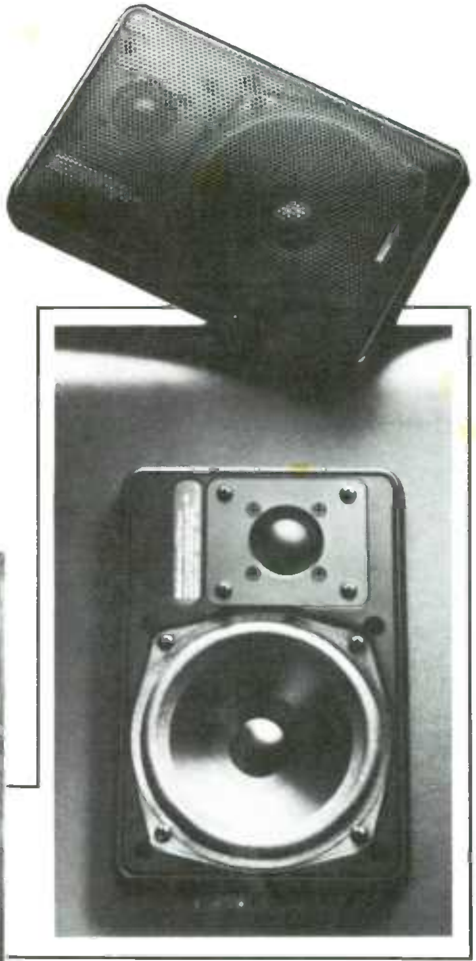
Good News

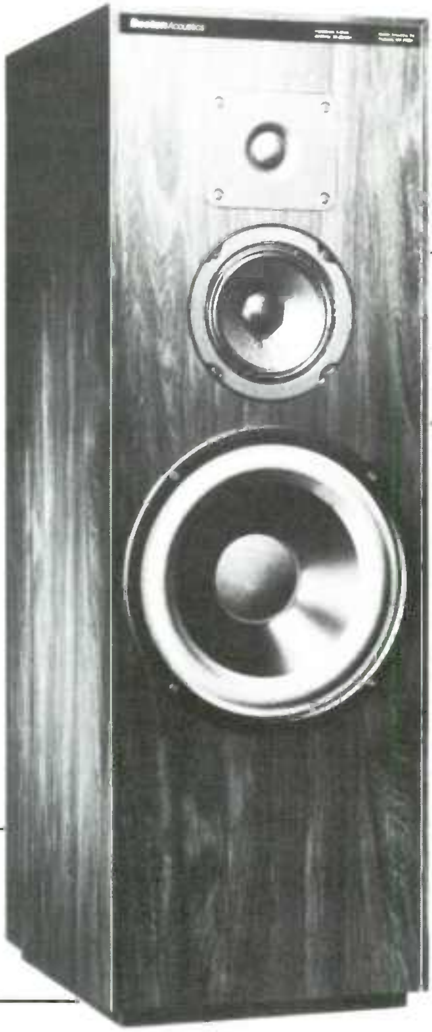
Four new products have been released by **BOSTON ACOUSTICS**. The T830 and T1000 tower speakers feature tall, slender enclosures that require minimum floor space.

The T830 is a three-way floor standing system featuring an 8″ woofer, 3½″ midrange, and 1″ CFT dome tweeter. Frequency response is 45Hz–25kHz ±3dB. Power handling is 75W.

At the top of the new speaker line is the T1000, a three-way, four-driver system incorporating dual 8″ woofers, a 6½″ midrange, and a 1″ CFT dome tweeter. Frequency response is 38Hz–25kHz ±3dB. Power handling is 150W. Both speakers have an efficiency of 90dB/1W/1m (2.83V).

Suggested retail price: $450/pair (T830); $1200/pair (T1000).





Joining the extensive line of automotive speakers is the 797 three-way 6x9 system. It was designed for those who want home loudspeaker sound quality in their car or van, but who want the convenience of an all-in-one system that fits existing speaker cutouts.

The 797 features a 6x9-inch long throw woofer, based on the same design used in the top-of-the-line 793 component series. It also includes a 2″ midrange and a ¾″ wide dispersion tweeter. Frequency response extends from 36Hz–20kHz ±4dB. Power handling is 40W normal, 80W peak.

Suggested retail price: $199.95/pair.

Boston Acoustics has also released an improved version of the C3700, their first car speaker system. The C3700 Series II is a two-way plate style system that combines a 5¼″ long throw woofer and new CFT4 1″ dome tweeter.

Both drivers and full crossover network are mounted in a stronger thinline housing which has a refined black finish and perforated steel grille. The CFT4 tweeter is based on the same design used in BA's most expensive home loudspeaker systems. The new generation tweeter provides smoother treble response than the original.

Frequency response is 58Hz–20kHz ±3dB. This 4Ω system has a power handling capability of 40W nominal, 80W peak. It requires a mounting depth of only 1½″, and can be mounted in a single cutout between 3½ and 5″ in diameter.

Suggested retail price: $179/pair.

For complete details on these products, contact Boston Acoustics, 247 Lynnfield St., Peabody, MA 01960, (617) 532-2111.

Fast Reply #HK336

Software for the speaker builder has been introduced by *SB* author Max Knittel through **MAXIMUM EFFORT SOFTWARE**.

LoudSpeaker is an interactive audio loudspeaker design computer program for the IBM PC. Program features include:

- Closed, vented, and passive-radiator box designs.
- Instantaneous calculation of box volume, frequency response, vented and passive-radiator tuning frequencies, maximum input power, maximum sound pressure level, vent dimensions, and crossover inductor design.
- Storage of up to ten different designs.
- Production of printed designs.
- Production of graphs of up to six frequency response curves on the same display screen.
- Library of up to 100 drivers on disk.
- Automatic units conversion of centimeters, meters, liters, inches, and feet.
- Pull down menus, windows, and dialogue boxes.
- Context-sensitive help. Call at any time if you are unsure about what to do next.
- Installable for black and white or color graphics displays.
- 20-page indexed user guide.

Hardware requirements include: IBM PC, PC-XT, PC-AT, or compatible running DOS 2.0 or higher; IBM-compatible graphics adapter; 256K of RAM; single disk drive.

Suggested retail price: $29.95.

To order, or for more information, write Maximum Effort Software, 2701 Cedarwood Ave., Bellingham, WA 98225.

Fast Reply #HK765

Two new products are being introduced this summer by **SIGNET**: the SL-100 Definitive Image® three-way floor standing loudspeaker system, and Music-Line®, a new OFC speaker cable.

Utilizing the patented Ferralipse® high-frequency lens, the SL-100 system was designed to achieve an unusually wide (120°) dispersion pattern, which provides balanced, phase-coherent, and frequency-invarient sound over its entire range.

The Ferrallipse is an acoustic lens consisting of a double-ellipsoid reflector, each cavity of which has a high-frequency driver positioned at one of its focal points, and firing into it. The reflected sound energy from the two elliptical surfaces converges in phase, and is reradiated in a single, broad, symmetrical pattern. This technology, the makers claim, eliminates the high-frequency beaming and combing effects typical of most speaker designs.

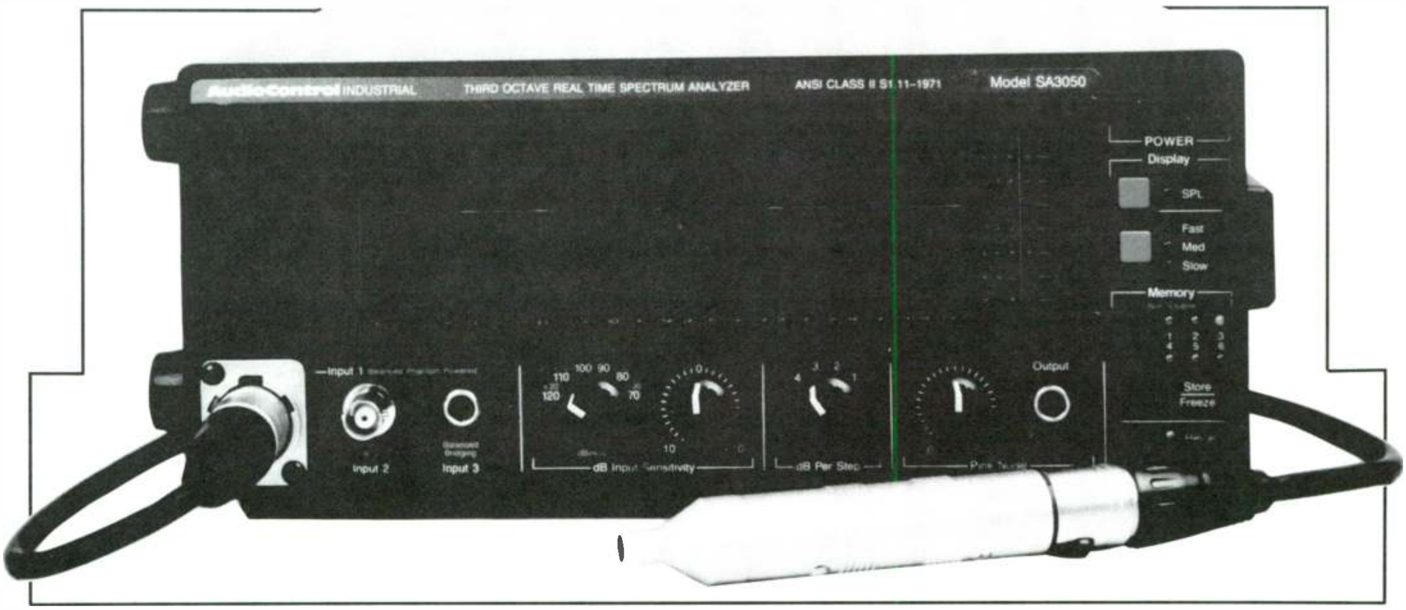
Bass and midrange sections of the SL-100 consist of a 10″, long throw, low-frequency driver with a vented aluminum voice coil form and a polymer-impregnated cone, plus a 3″ soft-dome midrange driver with a 3″ voice coil.

Complementing the SL-100 is the Music-Line speaker cable and three associated cable terminators. The new oxygen-free copper cable utilizes a somewhat tighter wind than other cables, and therefore has more surface area per unit length to handle a greater dynamic range.

Signet also offers three types of gold-plated cable terminators which permit easy installation and maximum transfer between virtually any amplifier and loudspeaker.

For more information, contact Signet, 4701 Hudson Dr., Stow, OH 44224.

Fast Reply #HK23



AUDIO CONTROL INDUSTRIAL's SA-3050 is a measurement-grade, one-third octave, real-time analyzer designed for audio signal analysis. It combines a state-of-the-art microprocessor-based design with modern electronic manufacturing techniques.

Features include: 30 one-third octave bandwidth filters; fourth-order filters which conform to ANSI S1.11-1971 Class II, type E standards; internal pink noise source; 9 by 30 large-format LED display with 1dB resolution; six internal memories with battery backup; SPL scale; 92dB display range; signal input from balanced microphone input, balanced phone jack, or unbalanced BNC connector; optional battery operation; optional printer and expansion ports.

To learn more, contact Audio Control Industrial, 6520 212th SW, Lynnwood, WA 98036, (206) 775-8461.

Fast Reply #HK123

INFINITY SYSTEMS, INC. has introduced the RS5000, the top-of-the-line addition to the company's recently-introduced RS Series of compact, high performance home speakers.

A 10″, three-way model, the RS5000 was designed to deliver accurate, full-range sound reproduction with extended deep bass response. The system features a specially developed smaller aperture EMIT® tweeter, and an auto-reset protection circuit which virtually eliminates the possibility of tweeter overload. In addition, the system's minimum diffraction design technology provides optimum recreation of the natural spatial relationships between voices and instruments.

Suggested retail price: $279.

Infinity has also released the VRS-2, VRS-3, and VRS-4, a new line of two-way stereo television loudspeakers. The Video Reference Standard Series loudspeakers were created to supply superior sound reproduction from stereo television, Beta and VHS Hi-Fi, and laser disc systems. The top model VRS-2 is self-powered and utilizes a long throw 8″ polypropylene woofer, and a 1″ Polycell® polypropylene dome tweeter. The VRS-2 features a 25W per-channel amplifier, equalized for extremely linear and extended low frequency response.

Suggested retail price: $499/pair (VRS-2); $299/pair (VRS-3); $199/pair (VRS-4).

For more information, contact Nina Stern, Infinity Systems, Inc., 9409 Owensmouth Ave., Chatsworth, CA 91311.

Fast Reply #HK354

SPEAKER BUILDER
MAGAZINE

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About This Issue

John Cockcroft offers another dual driver system (p. 6) he has dubbed the "Mini-Dancer" since the low-end drivers function as partners, with the remarkable advantage of excellent response in a surprisingly small box. How much power do your passive crossover components dissipate? Contributing Editor **G.R. Koonce** has researched the question fully and Part One of his helpful findings begins on page 14.

The egg shape as a cabinet enclosure is attracting more interest. **Clay Allison** shows us how to construct one (p. 19) in a different manner from Rion Dudley's earlier technique (*SB* 2/84). Complementing Allison's work is **Dave Davenport's** review of Focal's Egg enclosure and systems (p. 30).

If you own one of Speakerlab's S-6 systems, you may be surprised, as **Ben Poehland** was, that it can be dramatically improved by modifying its crossover network. Ben gives us full instructions starting on p. 22. **Greg Szekeres**, **Matt Honnert**, and **Pete Crosby** share very helpful facts about stuffing materials, flush mount techniques and transmission line lengths, all beginning on page 26. Elegance is the keynote in **Mike Shea's** system incorporating Gold Ribbon and Dynaudio drivers. The *Letters* section this time, beginning on page 38, is a treasure trove of opinion, response, and field reports.

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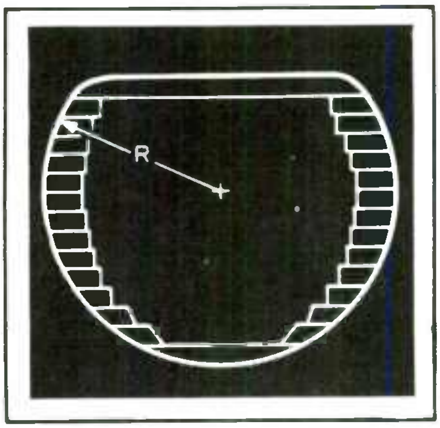

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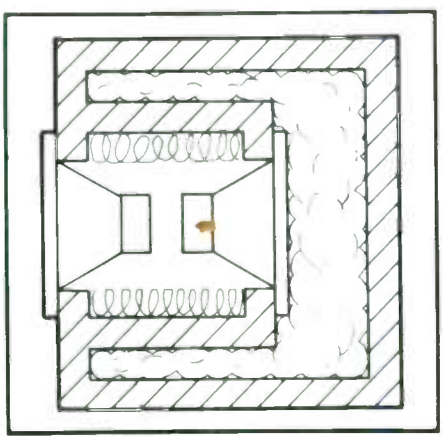

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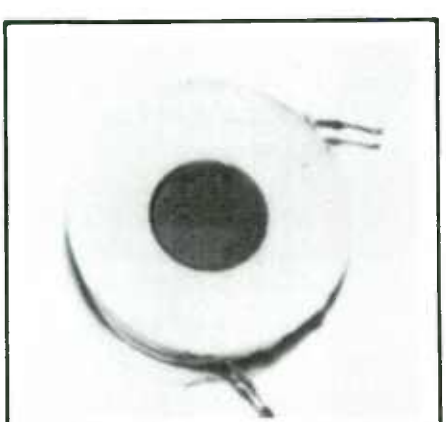

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FEATURES

DEPARTMENTS

Editorial

Growth Pattern

Can we talk?

This is just between us, OK?

Publisher to reader and, I hope, reader to publisher. This magazine is a winner. Nice news, that is, and I enjoy it because I don't think I had much to do with the success. Not with the important reasons for *Speaker Builder* being a winner, that is.

As I see it, two important things have happened: First, our talented, technically educated and very hard working editors began, about three years ago, to invest a lot of time in speaker building theory and construction.

Second, readers like yourself have been equally busy building, experimenting, questioning, writing letters and beating down the doors of our advertisers.

The publisher, during that time, has just been getting up every morning and coming to work, trying to help our staff to manage and produce the publication.

We have a winner: not merely a magazine that is a winner, but an engrossing, challenging and rewarding avocation that is a winner. And I think it is time for that avocation to grow in a strong and significant way. I want it to grow because it is a valuable human endeavor and because I get a kick out of running something successful.

When I say this hobby (and this journal) need to grow, I think you should have some idea of what scale I'm talking about. I am not talking Time, Inc., here. Not even CBS styles of *Stereo Review* or *Audio*. I'm talking about *larger*. At present, *Speaker Builder* is not small, it is tiny. Worldwide, we are reaching fewer than 6,000 homes each 90 days. Our compatriots at *Absolute Sound* and *Stereophile* (God bless 'em) are edging up to 30,000 every other month or so for those whose only upgrading tool seems to be the pocketbook or credit card.

I think we can do better than 6,000 quarterly. And I think you think we can do better than that. Am I right? Something that is this much fun should be much more widely talked about, shared, and spread to those poor souls out there in the outer darkness of mere ready-made, pre-packaged commercialism.

So, I have laid major plans for a major expansion campaign. Direct mail, ads of all sorts and lots of money spent.

I will be asking every tenth one of you for some idea of what you like or don't like about *SB*, about your preferences in speakers, audio gear, and possibly about how you like to live.

But at the same time we are doing all that, I have an alternative I wish you'd consider. Before we spend a lot of dollars on mailing list fees, printing costs and ad space charges, I thought you'd like the chance to do something for the hobby of speaker building and earn some of that promotional money yourself.

It will cost us about \$4—\$5 to find each new speaker builder prospect and convince him or her to sign up. I'd like to add 10,000 new ones to *SB*'s subscriber roster. Rather than spend \$40,000 or so with our postmaster, printers, and media salespeople, I'd rather give you the money.

So, we are making you an offer in a new **Sharefare Program**. Sign up three new *Speaker Builder* subscribers and your next year's subscription is free. Sign up two and we'll credit you with two-thirds of next year's subscription. Sign up one and you've earned one-third off. We have a field all set up in your computer record for your credits.

Rules. There are, of course, rules. Subscribers must be newcomers to *SB*, must mention your name and Magic Number to credit your account. Rates are full price. **Sharefare** is experimental, so we are setting a December 31, 1986 termination date on this first offer.

If you like it—and if we like it—**Sharefare** may become a regular offering. I welcome your comments, opinions, and your participation.

One further way you can help. Would you like to see *Speaker Builder*, or our other two magazines *Audio Amateur* or *Computer Smyth* on your favorite newsstand or in your audio dealer's store? If you would, and they would, send us names, addresses and telephone numbers. We will do the rest.

—E.T.D.

THE MINI-DANCER:
A PUSH/PULL CONSTANT PRESSURE SPEAKER SYSTEM

BY JOHN COCKROFT

Briefly stated, the constant pressure principle* involves placing two speakers in tandem in a single box, connected acoustically and electrically, to function as a single speaker, with the same characteristics as a single one of the speakers, with the single exception that the stiffness of the suspension is approximately doubled. This means that the combined pair of speakers sees a larger box than a single speaker, for any given enclosure size, thus exhibiting a lower F_c and Q_{tc}.

In my first article (*SB* (3/85), I discussed the merits of constant pressure loading as a means of achieving a small box speaker system with smooth, extended bass and excellent transient response. Using this principle, I constructed two speakers which I subsequently stacked into one system of singular sonic beauty.

Having proven to myself the principle was indeed a sound one (no pun intended), I was curious about how much design freedom I would have in order to create a superior system. My main concern was developing a very small system—I live in a small apartment and have little space to place speakers, much less to build them.

I read a paper by Karl Erik Stahl of Audio Pro[1], and became interested in his statements regarding lowered harmonic distortion through the use of a push/pull configuration in his Amplifier-Controlled-Euphonic (ACE) bass systems. I considered that, since constant pressure loading required two woofers, they could operate in push/pull. I was also thinking of methods of stiffening and damping enclosures to eliminate spurious resonances and to allow cleaner sound. I decided to put all of my eggs in one enclosure (so to speak), to see what I could do with these thoughts.

*Ivor Tiefenbrun of Linn Products, Scotland has filed for world patents on the design. He also owns the trademark "Isobarik", which denotes the constant pressure principle. For this reason, constant pressure systems may be constructed for personal use only. None may be made commercially without license from Linn Products.—Author

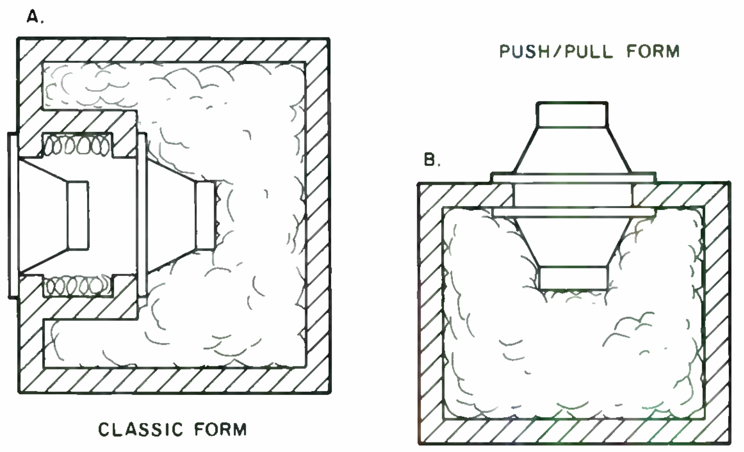

FIGURE 1: Two constant pressure systems, the classic form (a) and the push/pull form (b).

SMALL SPEAKER SOUND. Smallness was the first problem I dealt with. I had designed and constructed many small speakers which performed well in all areas but the bass. Many small speakers on the market, some cheap and some extremely expensive, suffer from the same problem. All of the bass, it seems, is in the hyped-up advertising and not in the speakers. I didn't want to build another one of those.

My Project One, described in the previous *SB* article was a relatively small speaker (about 450 cubic inches net volume). It was based on a cutaway photograph of the Linn S.A.R.A. speaker system. It performed quite well. I decided to try a 4″ version, which turned out to be less than half the net volume of my first project.

Next, I considered the push/pull arrangement. I felt the constant pressure loading presented an excellent opportunity to use push/pull. It actually simplified the enclosure construction by elminating the loading tunnel *(Fig. 1a)*, required to couple the speakers in a normal constant pressure system.

To utilize push/pull, I placed the two speakers face-to-face on opposite sides of the baffle opening *(Fig. 1b)*. I used the same machine screws to seal and bolt the two units together. The only critical requirements are making the hole in the baffle large enough to clear the suspension surrounds of the speakers, and making sure the sealant material doesn't interfere in the same area.

Next, I connected the speakers electrically in a series, with the external unit in reverse phase (the positive post of the internal speaker connected to the positive input, and the positive terminal of the external speaker connected to the negative input). Then I connected the two speakers' negative posts.

DANCERS IN MOTION. The name I have coined for this push/pull constant pressure configuration is "Dancer." It is as though two dancers, one taking the lead and the other following, are going through the motions as the speaker performs its functions. When one dancer steps forward, the other steps backward. (That's because one speaker is turned around. Both speakers move in the same linear

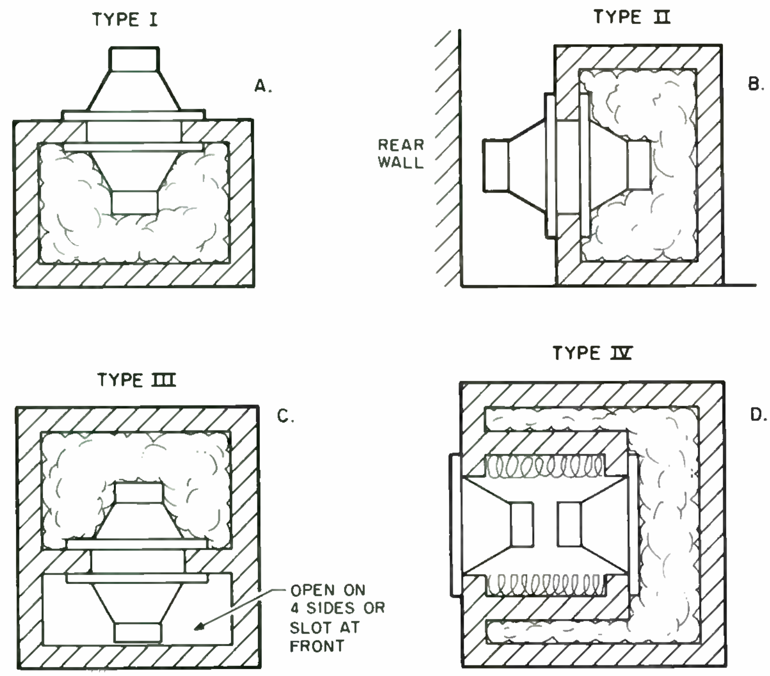

FIGURE 2: Four types of push/pull configurations.

direction. Don't let my analogy confuse you on this point.) I call this little speaker the "Mini-Dancer."

I decided to use a saturated mixture of sand and white glue (Elmer's, Wilhold, and so on) as a stiffening and damping compound. The results have been excellent. My enclosure seems as inert as any I have thumped.

I found a pair of speakers at Radio Shack, #40-1022 (don't substitute), which cost $9.95 each. Their stated specs were: F_{sa} 55Hz, Q_{ts} .35, V_{as} .23 cubic feet. Since I no longer have equipment for measuring speakers easily, I took Radio Shack's word for it.

Of course, if possible, measure the speakers individually. The gods were kind to me, because my fudging had no apparent bad effects.

THEY CAN HANDLE IT. These speakers are rated at 10W each, which seems conservative to me, considering their rather hefty-looking construction. A re-reading of the Radio Shack catalog ad revealed the speakers were also suited for auto use. Since most auto speakers are used unbaffled, or are poorly baffled, they handle less power. Baffled correctly, they can undoubtedly handle more. At any rate, I've had no trouble with my 35W amplifiers.

I planned to have a Q_{tc} of about .7 for my system, but it came out to about .645. This was based on a single speaker in the box. I didn't understand the relationship between single and compound speakers when I designed the box. It was only after receiving feedback from *SB* readers, in response to my first article, that I began to see what was going on. The actual Q_{ts} is probably a little below .6, which would account for the fine transient response.

Because of the small size of the 4″ woofer and its fairly hard cone, the high-end of the woofer holds up quite well, even though the speaker is mounted inverted and the sound comes from the rear of the cone. The sound is very open because it radiates in a full circle. In some locations, such as a very live room, you might wish to attenuate the sound to the rear. Do this by using felt, fiberglass, tufflex, BAF, or similar material *(Fig. 3)*. Even a small pillow behind the speaker might do the job. At one point in my experiments, I just used a couple of blackboard erasers. At another point (and currently), I sandwiched a 2″ thick piece of dense foam between the speaker and the rear wall. This omnidirectional configuration sounds fine coming from a single speaker, but the imaging might be a bit on the diffuse side in a stereo situation.

SOUND OPTIONS. If you like that type of sound, all is well and good. If you don't, you will need to cut off the rear and possibly some of the side radiations. The OHM F2 speaker uses this method with great success. I believe they use tufflex padding. If you prefer a more sharply-focused image, perhaps your box should be redesigned along the lines of *Fig. 2d*, with the speaker radiating forward in a normal manner. If you go this route, be sure to add the extra volume of the loading tunnel between the two speakers to the main enclosure.

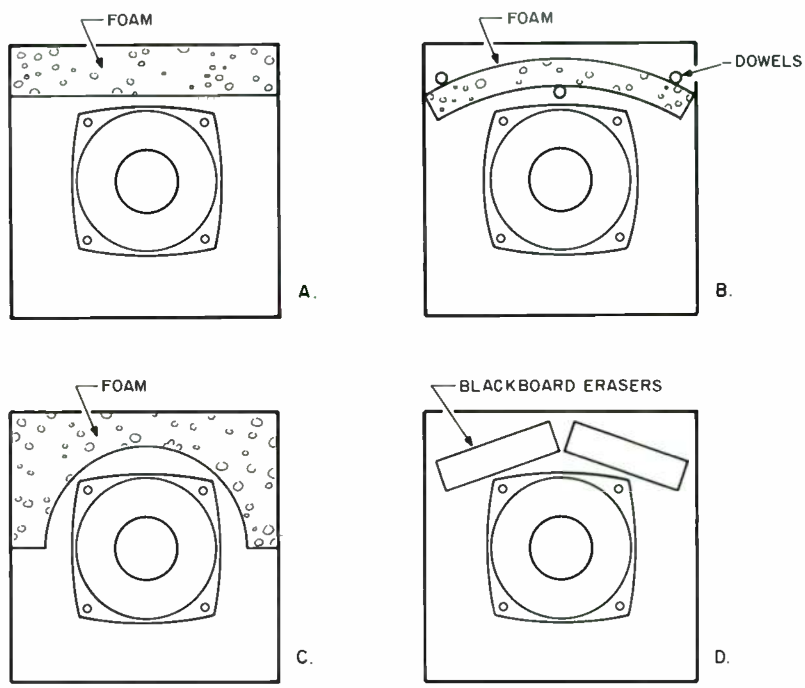

FIGURE 3: Author Cockroft suggests four methods of obtaining rear wave attenuation.

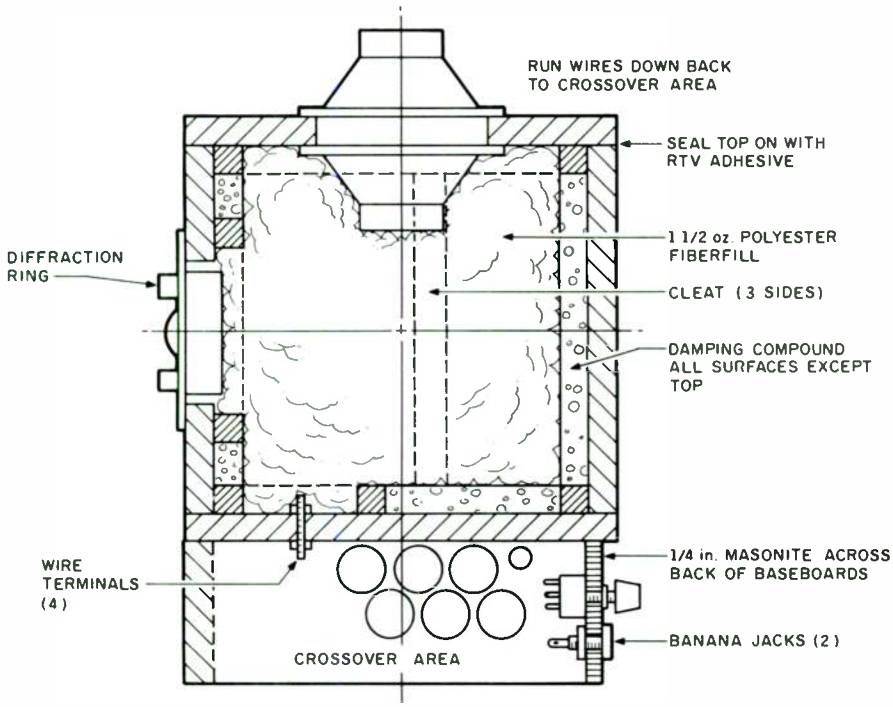

FIGURE 4: Construction details for the Mini-Dancer.

PARTS LIST

½" plywood or particle board:

2	7 ⅝" x 7⅝" (top and bottom)
2	7⅝" x 6⅝" (front and rear)
2	6⅝" x 6⅝" (sides)
1	7⅝" x 2½" (base front)
2	6⅝" x 2½" (base sides)
1	7⅝" x 2½ x ¼" masonite or plywood (terminal and pot board)

The ½" x ½" cleats may be cut from the above. About 9 feet will be required. Cut to fit during assembly to assure a good fit.

4	each 8-32 x 1" pan head or round head machine screws
1½	oz. polyester fiberfill pillow stuffing
1	tube RTV silicone rubber adhesive (bathtub sealant)
2	input line terminals (I used banana jacks)
4	feedthrough terminals (simplest would be brass machine screws or threaded rod and nuts with solder lugs)
2	banana plugs (for line hook-up)
1	4Ω, 10W resistor
1	50Ω pot
1	6μF capacitor (see article)
2	Radio Shack #40-1022 4" woofers
1	Peerless K010DT 1" dome tweeter
1	diffraction ring

Misc.

White glue
Sand

Optional

4	additional feedthrough terminals (if you decide to run the upper woofer wires inside the box)
4	sheet metal or wood screws (#6 x ¾") for mounting tweeter.

The net internal volume is 160 cubic inches. I assumed the speaker to be about 15 cubic inches. In this case, you might have to raise the treble crossover point because Radio Shack claims a 5kHz top end for these particular woofers. Try 4 or 4½μF for starters. Please keep in mind that this is an experimental speaker. I have just one unit, so other than theoretically, I can't be sure about the stereo imaging.

I used a Peerless K010DT8 dome tweeter, with a diffraction ring mounted on its face. The crossover is simplicity in itself. The woofers run free at the top, and the tweeter has a 6μF capacitor (six 1μF mylar units in parallel).

Tweeter attenuation consists of a 4Ω 10W resistor in series with the tweeter, and a 50Ω pot in parallel with the tweeter. The tweeter should be adjusted so that it is just barely heard above the woofer. Most people have the tweeter turned up too high. While this can be thrilling, it sacrifices a great deal of realism.

LEND AN EAR. I usually set my tweeter by using the interstation hiss of an FM station. With my ear halfway between the tweeter and the woofer (on this little system, that's quite a feat), and with the tweeter turned all the way off, I gradually turn up the tweeter until I can just notice it as a slight edge on the woofer noise. I then turn the volume up (on the amp, not the tweeter) and listen. It should sound full, rich, and even. If it sounds somewhat hollow, I raise the tweeter slightly. If it sounds too hissy on the high end, I lower the tweeter a bit. Your final sound should be solid, even, and sort of monolithic.

Try reversing the tweeter leads to see which arrangement gives the smoothest response. Then, play the best quality music signal you can find and listen for a while. If you aren't satisfied, make a mark on the tweeter knob so you know where you began, and make a minute adjustment. This should be done, preferably, over a period of days, with much listening and a minimum of tweaking.

Make your decisions based on the best music material. Use your tone controls to handle the others, otherwise you'll never finish adjusting. When you find your spot, make sure you mark it.

MAKING THE BOX. I constructed the box with ½" plywood, because that was what was available. I would have preferred particle board. After it was assembled (if you aren't familiar with construction techniques, refer to my first article), I glued in ½" by ½" cleats around the corners, vertically near the centers (but not *on* the centers) of the back and sides, and one on the bottom about 2" from the front panel and parallel to it. Forward of this cleat, I mounted the terminals for the internal woofer and tweeter.

If you plan to run the wires from the external woofer through the box to the crossover, mount these terminals here as well. In addition, mount a set on the top plate of the speaker. The terminals can be any air-tight method of electrical connection. I find that lengths of

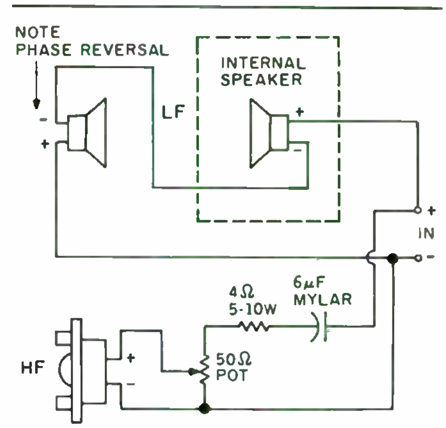

FIGURE 5: The author's Mini-Dancer wiring diagram.

Setting tweeter level

10–32 brass threaded rod and brass nuts make excellent terminations, for lugs and for direct soldering. On my box, I just ran the wires from the external tweeter down the back on the outside to the crossover, but it really is neater to run them inside and then out the bottom.

The crossover network (such as it is) is merely fastened to the bottom of the box, or to the base which consists of three boards (front and sides) glued to the bottom to create a space for an accessible crossover and attenuation network. But, I'm getting ahead of myself.

Next, glue cleats (the same size) around the tweeter hole, about a ½″ away from the opening. There is no need to follow the contour of the hole. A simple square, diamond, or what-have-you shape will do. The cleats form dams for casting the damping compound.

At this point, it might be a good idea to randomly drive some carpet tacks or small staples about halfway into the areas to be cast. These will serve as additional anchors for the cast material. I didn't do this (I just thought of it), but it wouldn't hurt.

A THICK COMPOUND. The damping compound is white glue (Elmer's, Wilhold, and so on), combined with beach or bag sand. The compound works better when you pour the sand into the glue rather than the other way around. The mixture should be stirred thoroughly and have the consistency of concrete. I mixed up small quantities in a plastic coffee cup.

Just before pouring (that's a misnomer, as it is too stiff to pour) the material, paint the areas to be covered with white glue. Add the material on top of the wet glue. Then, move and press the compound around with a spatula, spoon, or wooden coffee stick to make sure all areas are filled and tamped.

For best results, pour the compound about ¼″ deep and wait a day or so before pouring in the remainder. This gives the center a better chance to dry. Make sure your poured panel lays flat for several days, or else the compound will gradually flow and bulge toward the bottom of the panel. Wait at least a week before sealing up the box.

It might be possible for you to add the damping material to the panels individually before assembly. This will save a great deal of time. The way I did it, however, practically guarantees the enclosure will be totally tight. The cleats cover all joints (except the top, of course), and the damping material seals the other side of the cleats. The box becomes almost monolithic.

I don't think fumes are as troublesome as with the asphalt/felt type of damping, but it wouldn't hurt to wait a few days for the material to completely dry before you seal up the box.

BUILDING THE BASE. The base of the enclosure consists of three pieces of ½″ plywood (front and sides) glued to the bottom of the box, and a strip of ¼″ masonite (to hold jacks and pot) screwed or glued to the rear edges of the sides. As a refinement, you could make a removable bottom panel.

Before mounting the speakers, paint a layer of white glue around the edges of the holes and let dry, so that the sealant will adhere to the surface. Now is a good time to paint the speaker panels (usually black), because it will be harder to do later on.

After you wire the tweeter and seal it with RTV silicon rubber, screws, duxseal, or what-have-you, mount it to the box. Make sure the sealant doesn't get on the speaker surrounds. Next, mount both Radio Shack speakers on the same screws. I used 8–32 pan head 1″ machine screws with double nuts (placed on the outside).

Use a flashlight battery to test the speakers, making sure they move as a single unit and move in the proper direction. If the phase is wrong on one of the speakers, they will push together, bowing their cones out slightly. They will then try to pull apart, sucking the sides of the cones slightly inward. This could damage the speakers if continued.

FINAL PREPARATIONS. Don't forget to solder the woofer connections inside the box, and put in about 1½ ounces of polyester fiberfill. Then, after waiting for the damping material to harden, secure the top to the box. Make sure the wires and stuffing are well away from the top edge. Run a ¼″ bead of RTV silicone rubber adhesive around the top edges of the box and cleats. Press the cover in place, forcing the rubber to squish out, and make sure the lid lines up with the sides. The best way to handle the excess rubber goop (so I'm told) is to let it harden, and then trim it off with a wet razor blade the next day. I generally don't do it that way. Instead, I wipe it off so I can make sure the edges and corners really line up. A good engineering practice, maybe, but cosmetically it is very poor. Most paint won't stick to the smeared residue, but then I remind myself that it's only an experiment.

After drying for five to six hours, the speaker can be listened to at low to moderate levels. For full performance, wait 12–24 hours.

Recalling the success I had using a bass boost filter with my first project, I decided to listen to the Mini-Dancer with the filter plugged in. In this case, I changed the capacitors marked "C" (there are two) to .33μF (.22μF + .1μF + .01μF)). In this mode, the speaker sound reminded me of a transmisson line speaker, and with only a tiny fraction of the size. It plays loud enough for a bedroom or small apartment, but if you like *loud*, I didn't design this speaker with you in mind.

NO COMPARISON. There are very few commercial speakers I would prefer to listen to. I haven't heard another small system come close to the Mini-Dancer (even without a filter) in terms of tone depth and realistic balance, especially when you consider the $40 construction cost. I assume you could construct a bass boost filter, if you don't make it fancy, for under $25. To put it mildly, the price is a rather small sacrifice for a speaker that is very close to the best available.

I hope this article has proven interesting, and has created a desire within you to construct one of these fascinating constant pressure systems. Note: Since this article was written, I have constructed a system similar to the Mini-Dancer with a net internal volume of only 80 cubic inches [Micro Mini Dancer?]. Though it features a leaf tweeter instead of a dome tweeter, the sound is virtually the same.)

REFERENCES

1. "Synthesis of Loudspeaker Mechanical Parameters by Electrical Means: a New Method for Controlling Low-Frequency Loudspeaker Behavior," Karl Erik Stahl, *Journal* Audio Engineering Society; Vol. 29, No. 9, September 1981.

WOOFERS

PEERLESS K050WGX................$14.00
5¼″ paper cone woofer with rubber surround, 50-4,000Hz frequency range, 1″ voice coil, 4 and 8Ω, SPL = 88dB, Fs = 50Hz, Qts = .34, Vas = 12 liters.

PRECISION TP165R................$22.00
6½″ polypropylene woofer with rubber surround, 35-4,000Hz frequency range, 1¼″ voice coil, 8Ω, SPL = 88dB, Fs = 33Hz, QTS = .32, Vas = 40 liters.

SEAS P17RCY.....................$25.00
6½″ polypropylene woofer with rubber surround, 40-4,000Hz frequency range, 1″ voice coil, 8Ω, SPL = 91dB, Fs = 37Hz, Qts = .23, Vas = 36 liters.

SIARE 18VR......................$30.00
7″ fiberglass woofer with rubber surround, 35-5,000Hz frequency range, 1″ voice coil, 8Ω, SPL = 91dB, Fs = 37Hz, Qts = .18, Vas = 30 liters.

FOCAL 8N401DBE..................$35.00
8″ neoflex woofer with neoprene surround, 33-3,000Hz frequency range, 1″ voice coil, 8Ω, SPL = 91dB, Fs = 31Hz, Qts = .33, Vas = 84 liters.

PRECISION TD205R................$27.00
8″ polypropylene woofer with rubber surround, 32-3,000Hz frequency range, 1½″ voice coil, 8Ω, SPL = 90dB, Fs = 32Hz, Qts = .33, Vas = 60 liters.

SEAS P21REX.....................$30.00
8″ polypropylene woofer with rubber surround, 35-3,000Hz frequency range, 1½″ voice coil, 8Ω, SPL = 91dB, Fs = 33Hz, Qts = .37, Vas = 69 liters.

POLYDAX TX2025RSN (revised).......$35.00
8″ TPX cone woofer with rubber surround, 50-5,000Hz frequency range, 1″ voice coil, 8Ω, SPL = 90dB, Fs = 49Hz, Qts = .61, Vas = 47 liters.

SIARE 22FC......................$50.00
8″ carbon fiber woofer with rubber surround, 38-5,000Hz frequency range, 1¼″ voice coil, 8Ω, SPL = 91dB, Fs = 37Hz, QTS = .40, Vas = 30 liters.

FOCAL 10N501....................$52.00
10″ neoflex woofer with neoprene surround, 25-5,000Hz frequency range, 1½″ voice coil, 8Ω, SPL = 92dB, Fs = 22Hz, Qts = .23, Vas = 212 liters.

PRECISION LOUDSPEAKER DATA BOOK..................$ 2.00
POLYDAX LOUDSPEAKER DATA BOOK....................$ 2.00
SIARE LOUDSPEAKER DATA BOOK......................$ 3.00
FOCAL LOUDSPEAKER DATA BOOK......................$ 3.00
PEERLESS LOUDSPEAKER DATA SHEETS.................$ 3.00
SEAS LOUDSPEAKER DATA BINDERS....................$10.00

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PART I

CROSSOVER COMPONENT CAPABILITIES AND REQUIREMENTS

CURRENT LIMIT TESTING AND POWER DIVISION

BY G.R. KOONCE
Contributing Editor

When we use passive crossovers (COs), we must establish the stress requirements and capabilities of the CO components. Capacitor voltage ratings and resistor power ratings can usually be established, but the following information is more difficult to obtain:

1. The current capability of the coils (inductors).
2. The average and peak power requirement for each CO section.
3. The maximum voltage and current stress for each CO component at a given power.

This first of two articles will address the first two items. I will show you a method of measuring the peak coil current, along with results for typical available units. We will then look at how the power to a speaker system splits up among the various drivers, both peak and average.

In Part II, we will examine the third matter, the voltage and current requirements for components in common parallel first-order through third-order COs for two-way and three-way systems. To allow direct comparison and application, we will use the same component numbering appearing in R. M. Bullock's articles (*SB* 1, 2/85).

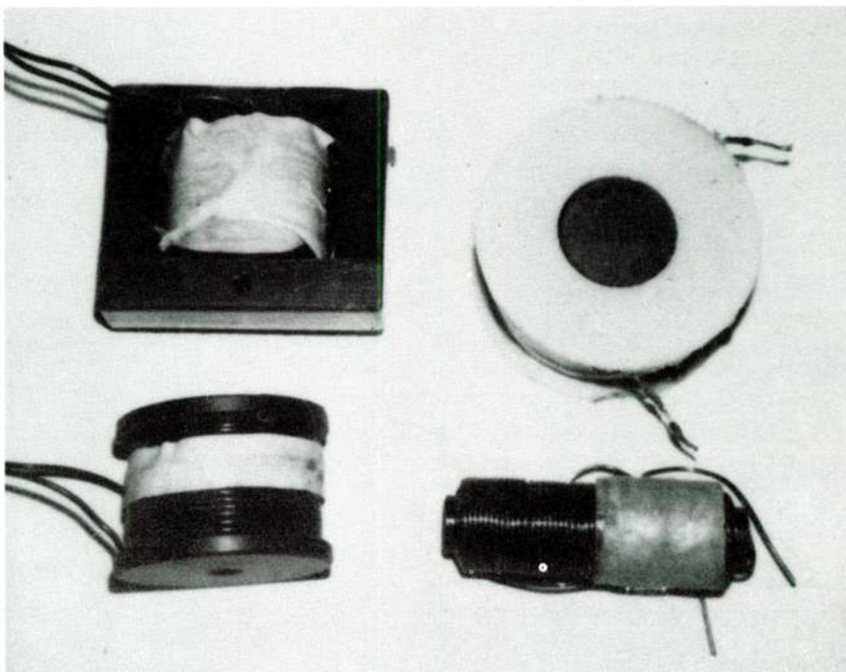


PHOTO 1: Various types of cored crossover coils.

TABLE 1
CHARACTERISTICS OF COILS SHOWN IN PHOTOGRAPHS

Picture Ident.	Core Type	L mHy	Rdc ohms	Ipk Amps	Core Area sq. in.	Core Length in.	Winding Length in.	Winding OAD in.
PHOTO 1:								
Top Lft	Iron	0.50	0.08	>16	0.33	*	0.9	1.1
Top Rht	Slug	3.0	0.8	8	0.44	0.9	0.8	1.75
Bot Rht	Solen.	1.5	0.29	2.8	0.11	1.95	1.7	0.7
Bot Lft	Bobbin	0.7	0.13	13	0.51	0.96	0.7	1.25
PHOTO 2:								
Top Lft	Solen.	2.5	0.38	2.4	0.11	1.95	1.8	0.8
Top Rht	Solen.	2.0	0.56	2.4	0.10	1.35	1.0	0.7
Bot Rht	Solen.	0.92	0.28	7.6	0.20	1.0	1.0	1.0
Bot Lft	Same coil as **PHOTO 1:** bottom right							
PHOTO 3:								
Top Lft	Bobbin	2.5	0.25	7.2	0.63	1.18	0.85	1.4
Top Rht	Same coil as **PHOTO 1:** bottom left							
Bot Rht	Bobbin	0.86	0.21	10	0.33	0.96	0.65	0.9
Bot Lft	Bobbin	0.5	0.25	6.5	0.15	0.55	0.3	0.75

* Iron core has 0.06 in. air gap. Total path length = 3.8 in.

CURRENT LIMITS OF TYPICAL COILS. If you use air core coils, you have no problem with linearity. For small size and minimum resistance, cored coils are the answer. *Photo 1* shows four of the popular types of cored coils found in COs. Starting top left and moving clockwise, we have an iron core coil, slug ferrite core coil, solenoid wound ferrite core coil and a ferrite bobbin core coil. *Table I* shows the peak current capabilities of the four coils, ranging from 2.8A to over

16A. Neglecting CO effects, these coils could deliver to an 8Ω woofer peak powers ranging from 63W to 2048W without saturating. While 2048W peak would keep most of us happy, the 63W peak probably would not.

Photo 2 shows four solenoid-type coils. *Table I* again shows peak current limit, ranging from 2.4–7.6A. I have seen the 2.5mHy coil used in several systems with nominal 8Ω woofers. Distortion was quite noticeable at system input powers in the 20–25W average range. These long solenoid coils wound on small diameter cores are power-limited, and should be either avoided or tested carefully before use. In general, you are safer when the core diameter is larger and the inductance is lower.

Photo 3 shows four ferrite/bobbin core coils; Table I indicates the current limits range from 6.5–13A. That little coil in the lower left corner, which I have always restricted to tweeter application, can take 6.5A or 338W peak at 8Ω. These bobbin core coils are the best choice for building. They are small, have low resistance, good Q and a wide frequency band. I have had no trouble with these coils in any CO application.

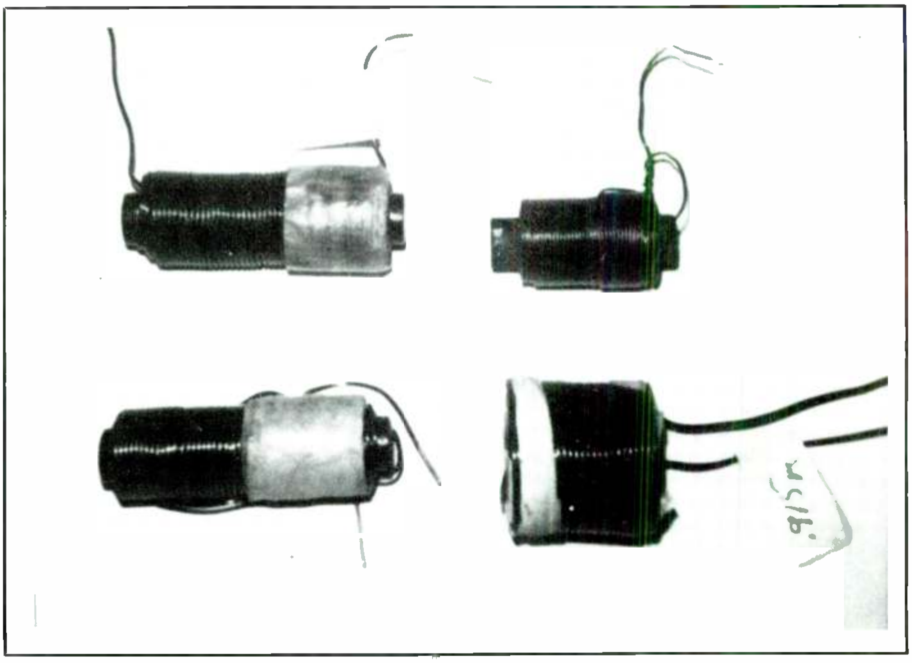


PHOTO 2: Various solenoid wound ferrite core coils.

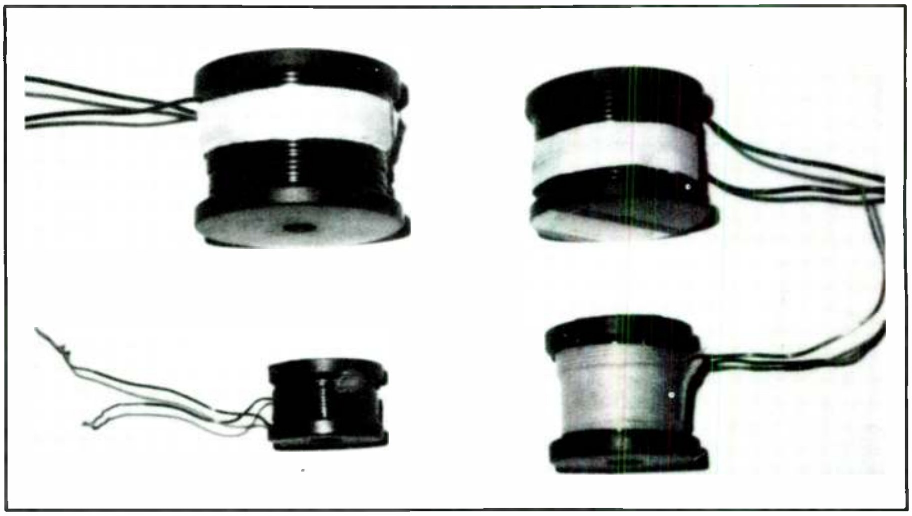


PHOTO 3: Various ferrite bobbin core coils.

MEASURING COIL PEAK CURRENT LIMIT. Given a large amplifier, you could load your coil with 8Ω and apply more and more power until the resistor showed non-sinusoidal voltage. Aside from problems of what test frequency to use, the test is unfair (and probably inaccurate) since the coil and load are being overheated by making an average measurement. I decided to look for a better way.

Figure 1 shows a technique for measuring coil current while maintaining a low average coil dissipation. For 15A peak, average coil current has always been under two amperes. Iron core coils have a slow rounding into saturation, but the knee produced by ferrite cores is fairly sharp, making measurement quite easy. This technique also allows coil inductance measurement via the equations in *Fig. 1*.

Is the peak current limit of a ramp a valid indication of the performance everywhere in the audio band? If the core permeability stays constant over the audio band, then the measurement is valid. With ferrite cores, this should not be a problem, however, with iron cores you must carefully consider the results. Unless you have excellent iron you do not want to use it on anything but the woofer.

Figure 2 shows the actual schematic and parts ratings for the coil current limit test circuit I use. It is important to keep on time a very small portion of the total period to allow the coil current to decay to zero. If the scope trace does not start at zero current, increase the ratio of total period to "on" time. I have a pulse generator which produces the required drive waveform; *Fig. 3* shows a drive circuit for those who do not. It runs at about 24Hz and produces "on" times at the coil of 40υS to 10mS in three overlapping ranges. For testing small coils (less than 0.3mHy), you may wish to increase operating frequency for a better scope display. For coils larger than 5mHy, the "on" time may become a large part of the period and you may want to lower the operating frequency. The values shown are the best compromise for the typical range of CO coils.

The two TO-3 power transistors in *Fig. 2* have wide performance tolerances at the levels of current being used. You may have to lower R2 to produce enough base drive at Q1 for approaching 15A. Do not increase this drive, unless it is necessary, since it provides a safety limit in case you accidentally short circuit the output. Note that by 15A, a voltage drop is developing across Q1, R3 and the coil resistance to the point where the ramp is degenerating into an exponential rise. This is not a problem with the coil, just a limit in the test set. Coil saturation is an up-break in the curve, not a downward rounding. Always

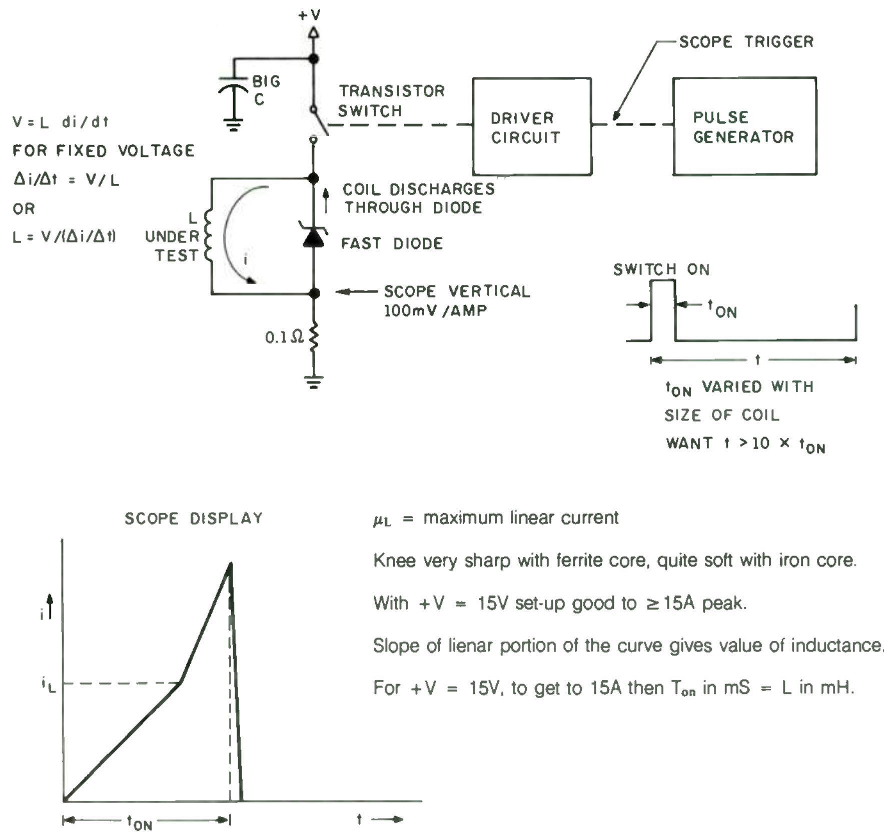
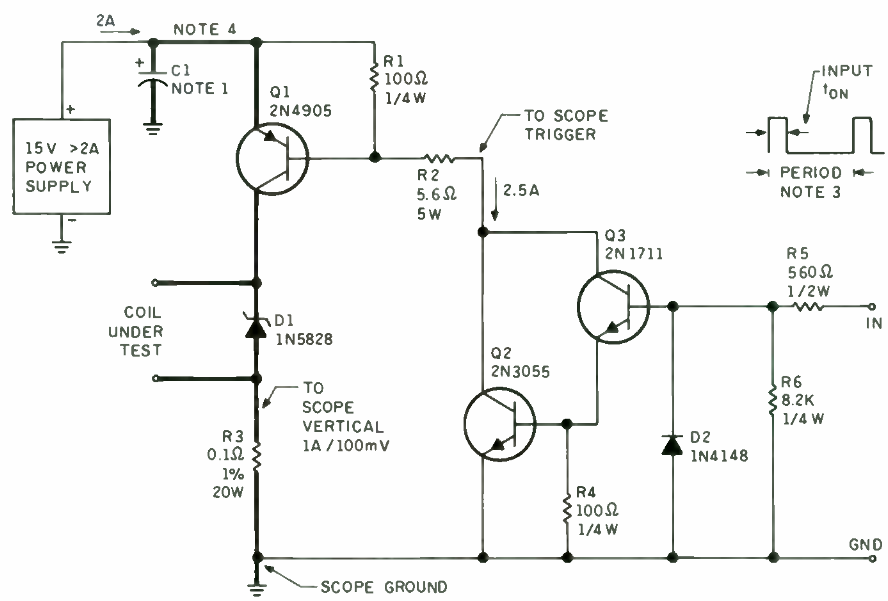


FIGURE 1: Method of measuring coil linearity limit.



NOTES: 1. C1 should be at least 60,000μF at ⌈15V. I use 143,000μF.
2. Q1, D1 & Q2 should be heatsinked.
3. T_{on} should be less than 10% of total period. T_{on} should be +10–+15V. Off time can be 0––15V.
4. Heavy line wiring handles 15A.

FIGURE 2: Schematics and parts ratings for coil current test circuit.

start testing at the low end of the "on" time and increase it gradually while watching the current on the scope.

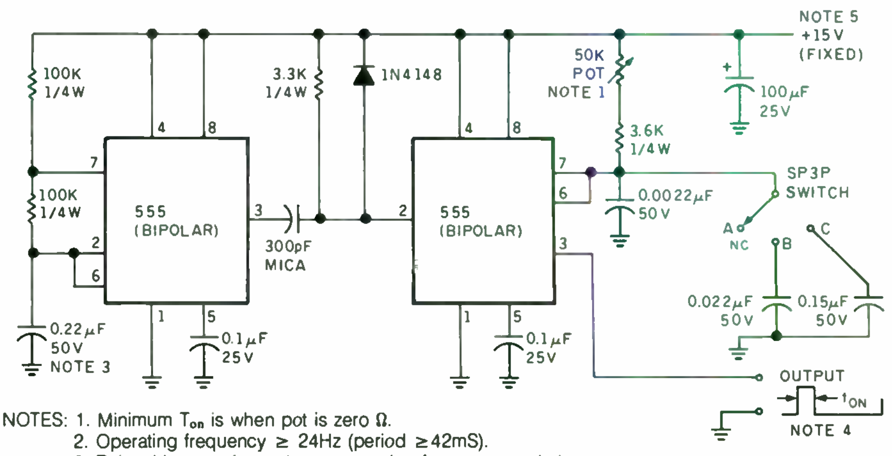
POWER DIVISION AMONG DRIVERS. I have examined the average power division with second-order Butterworth COs many times. In general, I find the high-pass (HP) and low-pass (LP) average power outputs for a two-way system are equal for a CO frequency in the 800–1000Hz range. In a three-way system, if you add a tweeter in the 5kHz range, it will see only about 10% of the total average input power.

Fortunately, additional data are available for third-order Butterworth (BW) COs in a work by Penkov[1]. Penkov took a sample composed of seven types of program material (six of music, one of speech), and examined peak (actually 50μS average) and average (10S ave.) output from various CO sections. The reader should consult the reference for specific details. I prepared *Figures 4* through *6* using this data. *Figure 4* shows average power through the HP, and LP relative total input power versus CO frequency. The curves are wide because of the probabilities involved in such measurements. The top of each curve is near certainty; the percentage of power should almost never exceed these values. Equal HP and LP power occurs at a CO frequency around 700Hz, not far from my experience with second-order BW COs.

Figure 5 shows the same data for peak power. The probability range shown is 0.5 to 0.997. According to Penkov, a probability of 0.5 indicates this percent power will be exceeded on the average once every four minutes, for 0.997 once every 11 hours. Thus 0.5 is probably an acceptable design value, with equal LP and HP power occuring at a CO frequency around 800Hz. Note that the HP section has a much greater range of percent power between the two given probabilities.

Figure 6 shows the ratio between peak power and average power through various COs. The HP sections show a wider range between the two probabilities, an expected result with transients basically composed of high frequency content. For design purposes, we note for third-order BW sections peak power is about 10 times average power. If you want to be really conservative for LP sections, use 30 times average power, and for HP sections, use 50 times average power.

Continued on page 18



NOTES: 1. Minimum T_{on} is when pot is zero Ω.
2. Operating frequency ≥ 24Hz (period ≥42mS).
3. Raise this capacitor to lower operating frequency and vice versa.
4. On voltage ≥14 into test circuit, off voltage = 0.
5. Current drain ≥ 22nA maximum.

Switch Position	Approximate T_{on} at Coil Minimum μS	Maximum μS
A	44	160
B	108	1600
C	580	10,600

FIGURE 3: Schematic and parts ratings for driver circuit.

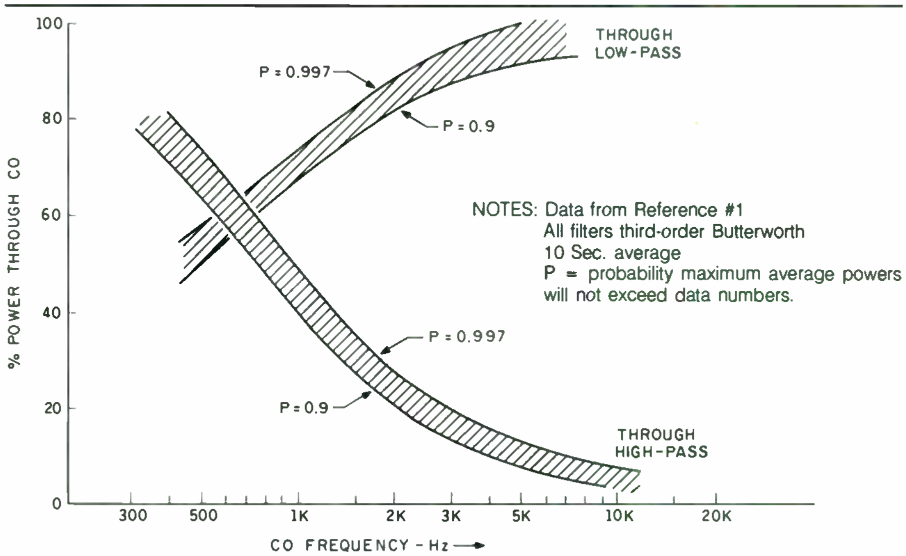


FIGURE 4: Percent of average power getting through CO versus CO frequency.

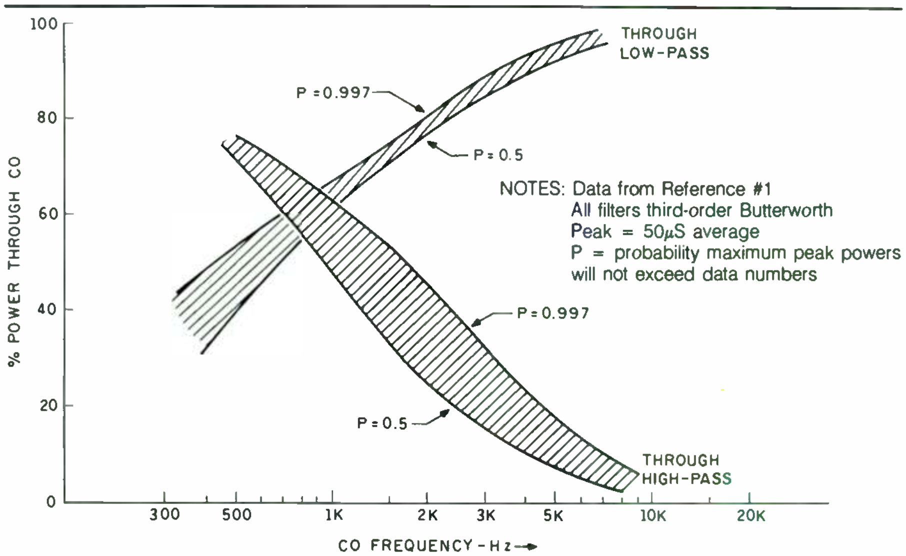


FIGURE 5: Percent of peak power getting through CO versus CO frequency.

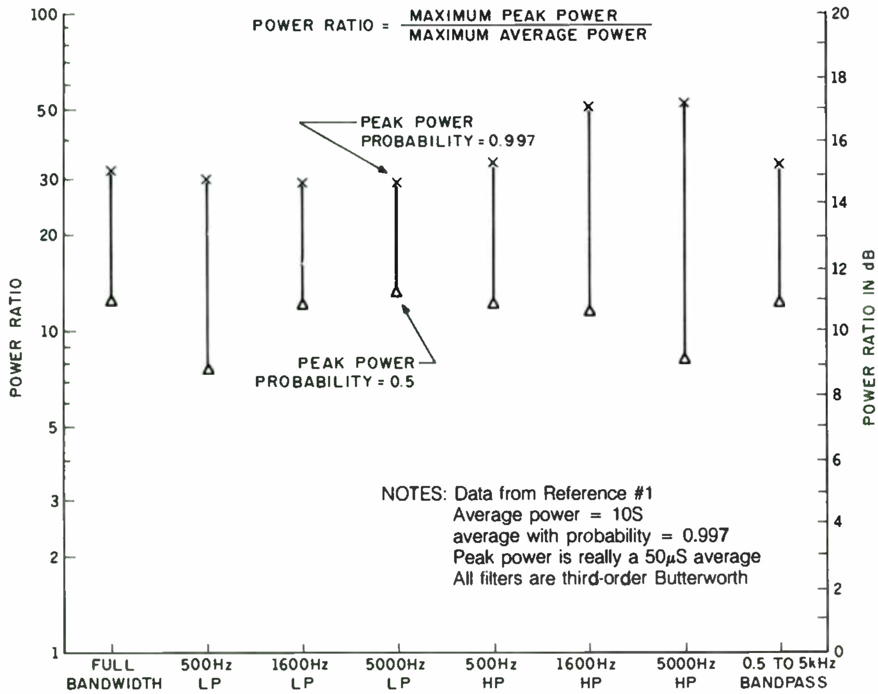


FIGURE 6: Peak to average power ratio in music.

Continued from page 16

CONCLUSION. The peak linear current for a variety of coil types has been presented, along with a test technique to evaluate other coil samples. How power in the music spectrum divides for BW COs has been shown, along with an indication of the peak power excess above average power. In Part II, we will examine the stresses placed on components for a variety of common COs as a function of input voltage and current delivered to each driver.

ABOUT THE AUTHOR

G.R. Koonce is an electrical engineer with twenty-seven years experience in design of audio frequency circuitry for military applications; the last eighteen years, he has been involved primarily with PCM encoded digital formats. Since the mid-1950s, he has constructed his own home audio gear and test equipment from kits or scratch. After many years in racing, he now devotes spare time to the design and construction of speaker systems and speaker-oriented computer programming. He is a member of the Audio Engineering Society.

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THE UNBOX ENCLOSURE

BY CLAY ALLISON

After reading Rion Dudley's "The Egg and I" (*SB 2/84*), I decided to share the methods I used to build a similar egg enclosure in 1983.

While reading his article, I noticed that, in some ways, our designs were similar. For example, our drivers were nearly identical. Mr. Dudley used a 6½" polypropylene Madisound woofer and Audax tweeter, while I chose a 5¼" Audax bextrene woofer (HD13B25H2C12) and a 1" Audax cloth dome tweeter (HD100D25). In addition, we both cut out rough shapes from layers of particle board and plywood, and then sanded them.

But our designs also had differences, the most important being the way we layered the wood to form the egg shape. While Rion's eggs were layered similar to orange sections, I layered my eggs as shown in *Figs. 1a* and *1b*.

Mr. Dudley's egg design may be less time-consuming, but I believe my construction methods offer several important advantages. These include: a large, flat baffle for increased driver placement flexibility, an accurate method for determining design stage internal volume, thick walls for high density, a low resonance enclosure, and an edgeless baffle which results in low diffraction. In addition, my design has no problems with internal standing waves, and you don't need a bandsaw for the construction.

DESCRIPTION. I built my eggs by stacking and gluing together oval-shaped wooden rings of progressive

PHOTO 1: Due to little output at his egg's bottom end, the author added a subwoofer.

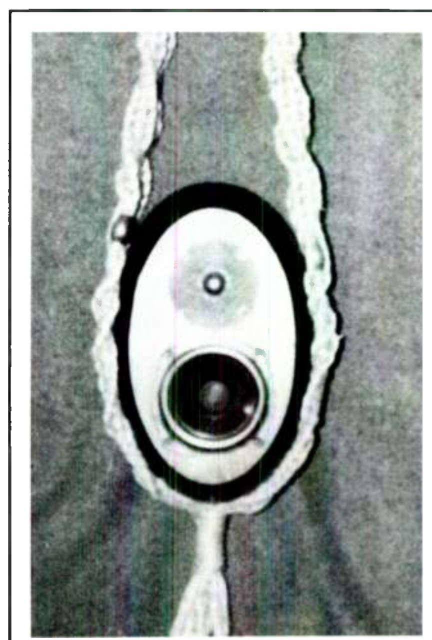

PHOTO 2: The author's egg enclosures rest in macrame plant hangers, four feet from the floor.

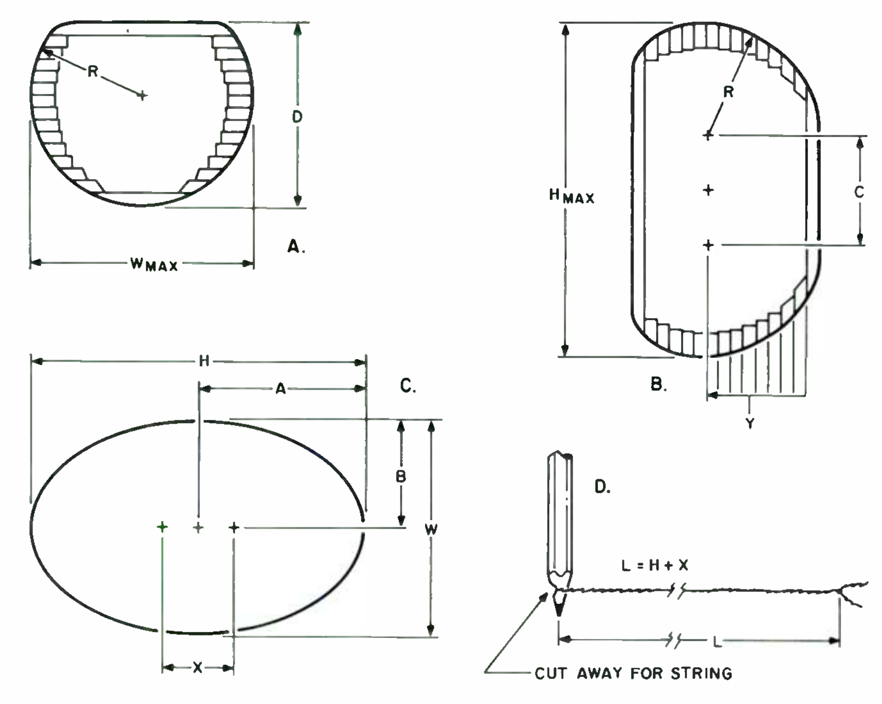

FIGURE 1: The egg's top cross-section (A), side view (B), and ellipse (C). Guide for drawing the ellipse (D).

sizes. Because the enclosure will be side-stepped, you will need a power sander to smooth the outer surface.

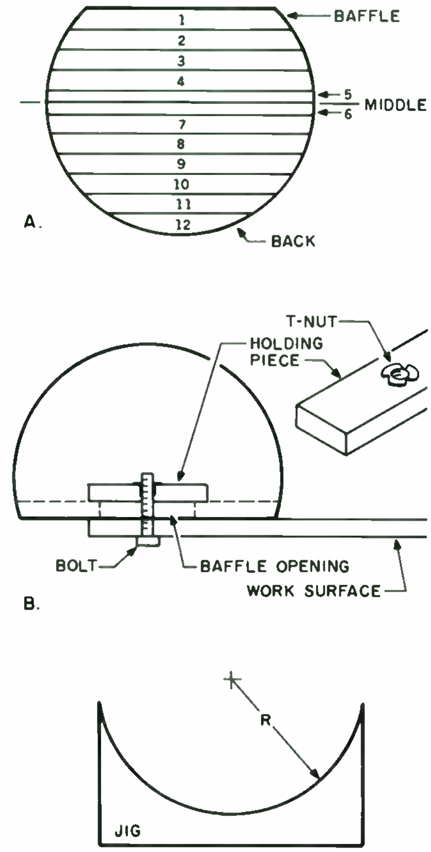

FIGURE 2: Draw and label layers (A), and use a wooden jig to get a uniform-shaped curve while sanding (B).

Other than a jigsaw to cut the oval rings, however, you won't need to use any other power tool.

Figure 1a shows a top cross-section view of a 15-layer egg, its sides already smoothed. From this view, it is circular, with a radius equal to one-half the maximum width. *Figure 1b* shows a side view. The radius is the same, and the distance (C) is the difference between the height and width. *Figure 1c* is an ellipse, and it shows how the egg would look from the front.

When I designed my eggs, I was able to accurately calculate the volume (using a method discussed later). I simply changed dimensions and recalculated until I achieved the proper volume. So that you can skip this plug-and-chug stage, I decided to derive a few simple formulas. To do so, I had to first set the dimension ratios to approximately equal that of my eggs: 1.5 to 1 to .86 (height/width/depth).

When you stick with the given design procedures, the formulas will be within 5% accurate for 3–15 liter enclosures. Enclosures much larger than this are impractical because of many layers and wasted wood. If your egg is smaller, the 1½″ wall thickness is unnecessary. If your baffle becomes too small, you will need to change your ratios, and the formulas in *Table 1* will not apply (you must calculate volume using the method I will describe later).

DESIGNING. Your first step in designing an egg enclosure is to choose a volume. For this demonstration, I chose 6½ liters. The first formula in *Table 1* solves for W_{max}, or external width max. Your answer will be in inches. The 3 in this formula is for my egg's 1½″ wall thickness. You can reduce the thickness for small eggs, but beware that the oval rings will become fragile, especially if you use particle board. If, however, you decide to increase your egg's wall thickness, simply change the 3 in the formula to twice your wall's thickness.

The formula gives me: W_{max} = 10″, H_{max} = 15″, D = 8.6″, and r = 5″. An egg that is 8.5″ deep will require 10 layers of ¾″ material, plus two layers of ½″ material. It will be helpful if you make a drawing similar to *Fig. 2a*, and number the layers as shown. Note that the middle of the egg lies between layers 5 and 6. Because these will be the largest layers, their dimensions will be H_{max} by W_{max}. If the center of your enclosure lies near the middle of a layer, you will have one middle layer.

With the exception of two back layers, you will have two of each size layer per enclosure. To find the layer sizes, draw the enclosure out to scale and measure, or use the formulas in *Table 2*. Solving for layers 4 and 7, Y = .5 and R = 5 (see *Fig. 1b*). The answer shows the eggs can also be cut 5″ by 10″. Since the four center layers are the same size, I will need only six different sized layers. After calculating for all the layers, it is best to make a list of the layers and their dimensions, as illustrated in *Table 3*.

VOLUME CALCULATION. After you determine the dimensions for all layers, you can now find the volume by calculating the volume inside each layer and adding the results. The formula to find the volume of a single layer is $V = T\pi AB$ (*see Fig. 1c*). T represents the material thickness, A is the long radius, and B is the short radius. *Table 3* shows that the actual volume is very close to the desired volume. If you wish to increase the volume by some small amount, you could cut one of the mid-area layers' diameter a bit larger inside. The same procedure, reversed, applies if you want a small volume decrease.

DRAWING THE PATTERNS. Begin by taping thin cardboard or heavy paper to a drawing board. Refer to *Fig. 3* and draw a rectangle with the same dimensions as your layer pattern. Divide the rectangle into four equal parts. Set a compass for a radius of H/2. Pivot at point C and cross line D at two places as shown (or use the formula for the distance X). Place thumb tacks into your drawing board at points A and B. Get some heavy thread that won't stretch while drawing, and cut and knot as shown in *Fig. 1d*. Loop the string over the thumb tacks and into the pencil notch. Adjust the knot, if necessary. Draw the ellipse, keeping the thread tight, the pencil vertical, and the string in the notch. Now, draw another ellipse inside the one you've just drawn with dimensions of H-3 by W-3 for 1½″ wall thickness.

TABLE 1

V = Volume in liters
$W_{max} = (0.96\sqrt[3]{61V}) + 3$
$H_{max} = 1.5W_{max}$
$D = 0.86W_{max}$

TABLE 2

Y = Distance of layer from center
$R = W_{max}/2$
$C = H_{max} - W_{max}$
$W = 2\sqrt{R^2 - Y^2}$
$H = W + C$

TABLE 3

Layer #	External W	External H	Internal W	Internal H	Volume inches³
1	8⅜	13⅜	—	—	
10	8⅜	13⅜	5⅜	10⅜	32.85
2	9¼	14¼	6¼	11¼	41.42
9	9¼	14¼	6¼	11¼	41.42
3	9 11/16	14 11/16	6 11/16	11 11/16	46.04
8	9 11/16	14 11/16	6 11/16	11 11/16	46.04
4	10	15	7	12	49.48
7	10	15	7	12	49.48
5	10	15	7	12	32.99
6	10	15	7	12	32.99
11	7⅛	12⅛	4⅛	9⅛	22.17
12	5¼	10¼	—	—	
				Total Volume	394.88
				.229 ft³	6.47 ltr

CONSTRUCTION. Once you have cut the patterns, trace them onto your wood. To align the ovals during assembly, put two or four alignment marks on each layer. Simply draw a mark directly below the center lines you drew previously on your patterns. Before you cut the wood, notice how the two back layers are cut inside at an angle *(Figs. 1c* and *1d)*. This is done to eliminate thin spots. It will have very little effect on the volume, but if you want to make sure, you can easily recalculate. You can also reduce the amount of sanding by cutting the outer edge of some front and rear layers at inward angles.

ASSEMBLY. Assembly is simple and requires no nails or screws. All you need is your favorite wood glue, and clamps or heavy weights to hold it in place during drying time. Once the glue dries, you can cut the holes in the baffle. Use the method shown in *Fig. 2b* to hold the enclosure during sanding. To obtain a uniformly-curved shape while sanding, use a wooden jig with a radius of R. After sanding, fill the cracks with wood putty and paint the enclosure. Your baffle can be veneered or covered with a variety of materials. Since low diffraction is of concern, flush-mounted drivers are ideal.

My crossover *(Fig. 4)* is a slightly-modified Audax design (FK 2-30), featuring increased tweeter attenuation and small bypass capacitors across the high-pass caps. With a calculated F3 between 85–90Hz, the eggs alone have very little output at the bottom end, so I found that a subwoofer was absolutely necessary *(Photo 1)*.

My eggs hang from the ceiling, about 4′ from the floor, in macrame plant hangers *(Photo 2)*. They are passively crossed over at 120Hz to a pair of Dynaudio 30W 54s. The overall sound is smooth and pleasing, with no noticeable colorations. The image is open, with lots of depth, completely filling the 10′ wall in my listening room.

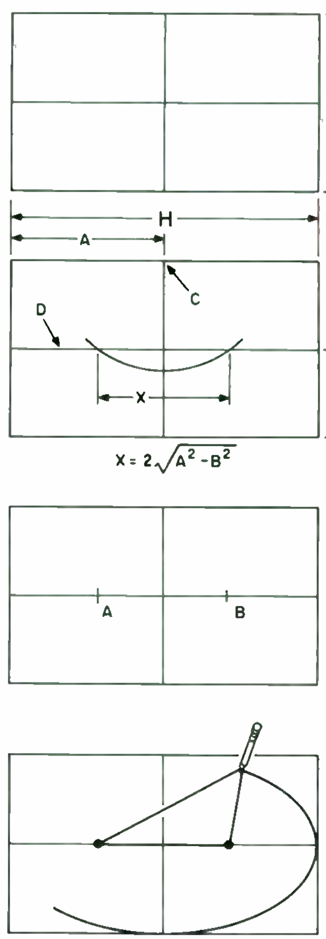

FIGURE 3: The author's guide to drawing layer patterns.

ABOUT THE AUTHOR

A resident of Indiana for twenty-two years, Clay Allison has a degree in electronics. In addition to building speakers, he also enjoys woodworking, furniture refinishing and carpentry.

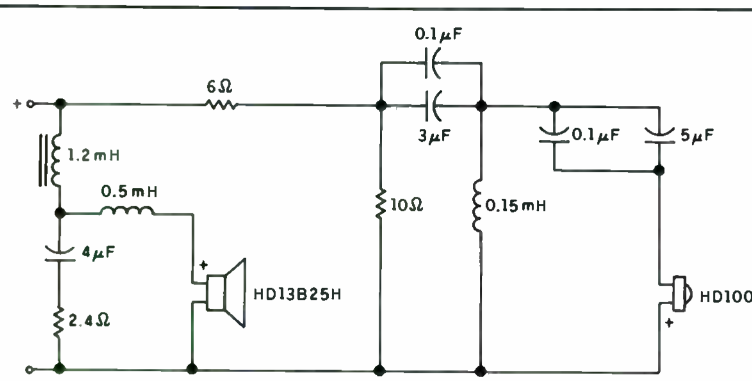

FIGURE 4: The slightly-modified Audax FK 2-30 crossover design.

UPGRADING SPEAKERLAB'S S-6 CROSSOVER

BY BENJAMIN L. POEHLAND

Seven years ago, I purchased my first and only loudspeaker kit, a pair of Speakerlab "Super-Six" S- 6s. The Super-Six name refers to their extra heavy-duty horn tweeters and midrange horn oversized compression drivers. These were used on the Super-Sevens also. The tweeter is a dead ringer for the Electro-Voice T-350. The midrange resembles the Atlas PD-4V coupled to an Electro-Voice 8HD diffraction horn, also used in the Speakerlab K. My modifications (*Photo 1*) should be applicable to any version of the S-6, and probably to the S-7 versions as well since they have similar components and specifications. The S-6 crossover schematic appears in *Fig. 1*.

My Sixes replace a pair of JBL Century 100s. I grew tired of the JBLs and was itching to try some "horn sound." I assembled the Sixes without difficulty by strictly adhering to Speakerlab's instructions. The high end on my JBLs was always a disappointment to me, and for the first year or two I reveled in the Sixes' ultrasensitive high end. As more years went by, I am not sure whether my listening matured or my taste changed, but the day came when I tired of the Sixes and was ready to replace them with something else.

The Sixes' faults had become apparent: a total lack of stereo image and soundstage depth, a "hot" high end, an overly honky midrange (L-pad adjustments and equalizers notwithstanding), a harsh indistinct quality in the upper bass/lower midrange, and a low bass that lacked punch. However, something in my soul makes it almost

PHOTO 1: The Super-Sixes after modification with grille covers removed. I reversed the baffle board in the unit on the right.

impossible for me to cast aside something made with my own hands unless I'm absolutely certain that its usefulness has ended. Stifling mental images of what the Sixes would look like surrounded by refuse in the municipal dump, I cast a cold analytical eye at them and wondered whether they could be salvaged. They could, and I did.

CROSSOVER MODS. After designing a set of bookshelf extension loudspeakers for a friend, I came to the conclusion that just about any woofer could be combined with just about any midrange/tweeter with the right crossover. In other words, I regard the crossover as the heart and brains of a speaker system. After poring over the S-6's driver specifications I felt satisfied that the drivers were high quality and, in terms of frequency response, should be suitable in a system such as this one. However, a crossover analysis revealed several problem areas.

The midrange and tweeter are extremely efficient drivers, which have been combined with a terribly inefficient woofer design. The stock crossover does not contain sufficient attenuation components to lower the efficiencies of the horns to that of the woofer. The presence of R1 raises the midrange input impedance to 16Ω, an undesirable situation leading to uneven frequency response and image instability. Finally, the midrange crossover slopes are too shallow for a horn.

Speakerlab's literature recommends 12dB slopes for horns (P. Snyder, *Guide to Crossover Design*, Speakerlab 1972, p. 8), and in commercially available horn systems the steeper cutoff slopes are most often used. I had a hunch the crossover frequencies were too high, and I was curious whether lowering them would improve anything. After a great deal of listening, patience, and nasty mathematical calculations, I designed a new crossover for the S-6. Its schematic is shown in *Fig. 2*.

Although I consulted several publications on crossover design, I mostly used the procedures and formulas given in the Philips handbook (M.D. Hull, *Building Hi-Fi Speaker Systems*, N.V. Philips Gloeilampenfabrieken Eindhoven, The Netherlands, 1978, pp. 78–99. Unfortunately out of print). Lowering the bass/midrange crossover point by 300Hz removed the indistinctness in the lower midrange and added punch to the low bass. The ad-

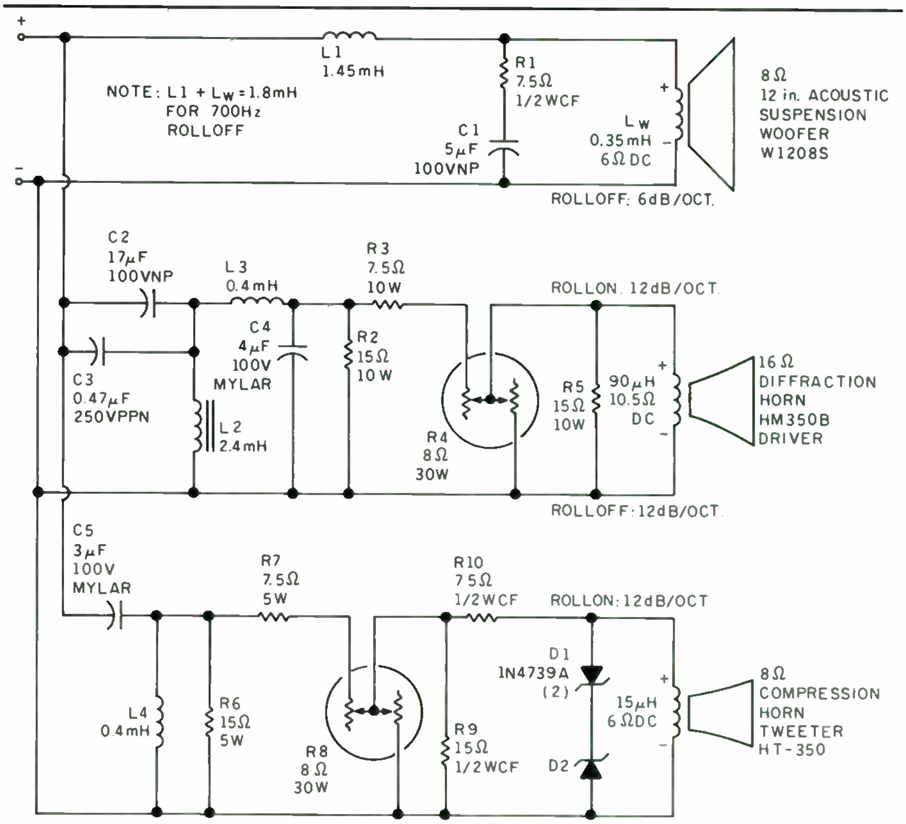

FIGURE 1: The Speakerlab S-6 stock L-pad crossover schematic diagram. Nominal crossover frequencies: 1kHz, 6kHz.

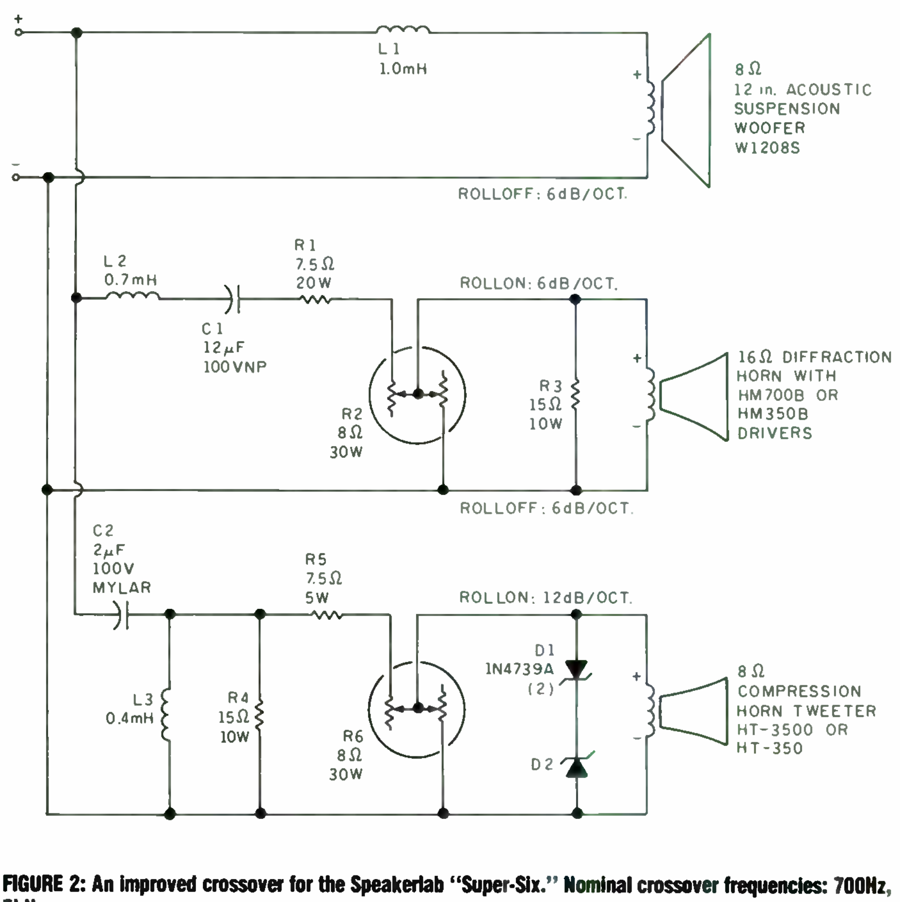

FIGURE 2: An improved crossover for the Speakerlab "Super-Six." Nominal crossover frequencies: 700Hz, 5kHz.

dition of compensation network R1–C1 visually stabilized the woofers during reproduction of first-octave program material, and curiously contributed a sense of improved depth to the upper bass that seemed to extend well into the midrange.

I cured the midrange honk by doing two things. I added R2, which simultaneously attenuates all the midrange passband frequencies and restores the midrange impedance to about 8Ω, and I changed the response slopes to 12dB/octave to give cleaner midrange separation from the higher and lower passbands. I increased C4's value slightly above the nominal 12dB in an attempt to smooth out a slight peak in the eighth octave, which I discovered during many listening tests.

I also made a few changes in the high end. Increasing C5's value to 3μF lowered the roll-on point (the top-end of the passband slope) by about 1kHz, and adding a second attenuation circuit R9–R10 shaved an additional 6dB off the high-pass response and permitted precise adjustment of the associated L-pad. *Photo 2* shows the rebuilt crossover board. The Sixes' response is now much smoother than the stock version, and they also begin to exhibit something that resembles a real stereo image.

To make all these changes, you must relocate the crossover boards outside the speaker boxes. I covered the crossover hole with a piece of ¼-inch plywood fitted with banana jacks to connect the crossover outputs to the individual drivers inside the box. Of course, this meant opening up the speaker enclosures by removing the woofers. As long as I was ripping things apart, I decided to make some other improvements.

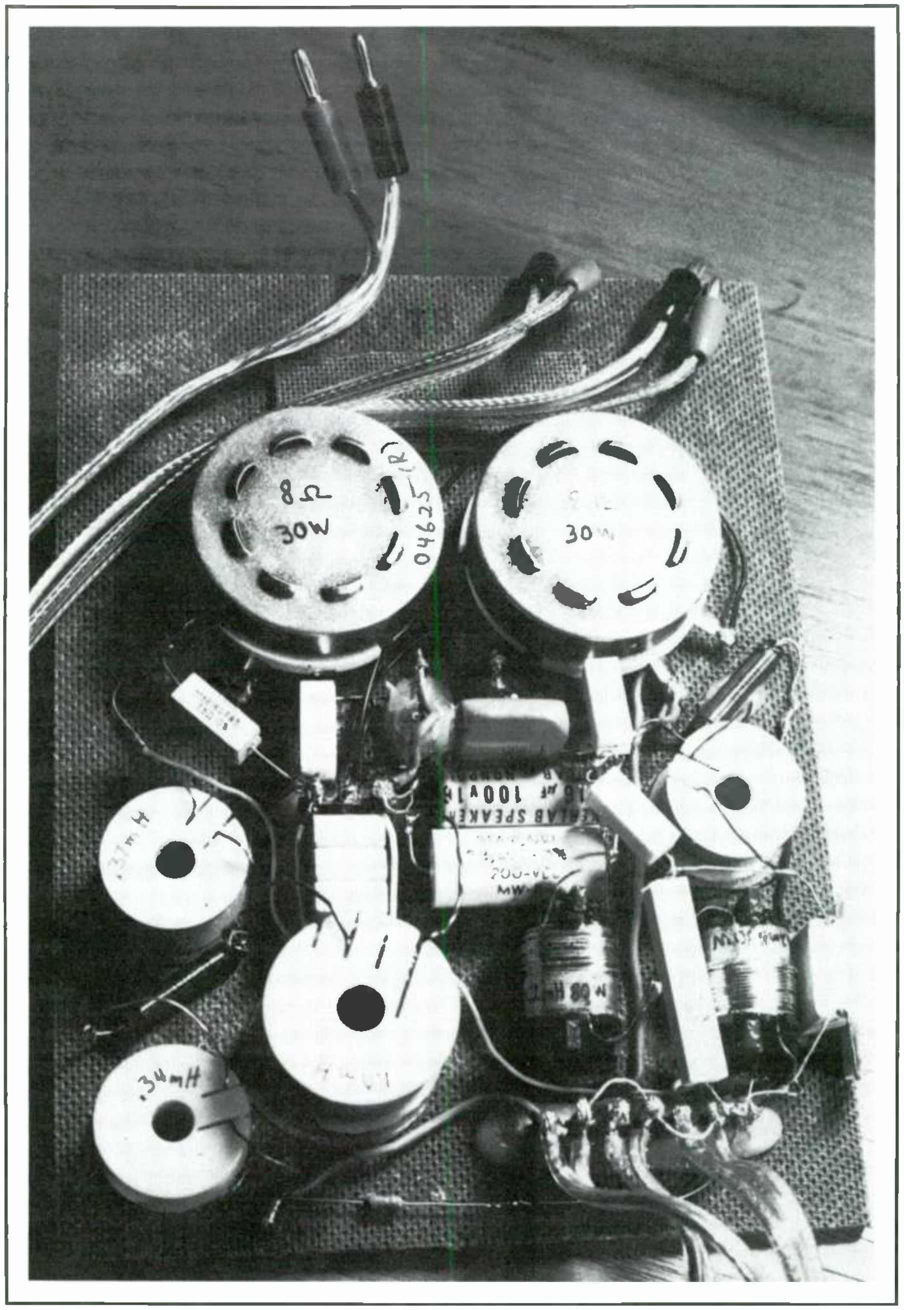

PHOTO 2: My modified crossover for the Speakerlab S-6. Some components are composite values. R5 and D1–D2 are mounted on the terminal board inside the enclosure. I mounted components with RTV silicone.

MORE UPGRADES. I removed the midrange horns and coated their exterior surfaces with a ½-inch layer of RTV-type silicone rubber compound. This completely damped all the metal diffraction horn's resonant vibrations. When I reconnected the compression driver to the horn, I wrapped the threads with teflon pipethread tape for a snug fit.

I ripped out all the original internal wiring and replaced the relatively thin Speakerlab wire with some nice 14-gauge stranded zipcord. I am not a wire freak, but it probably would not hurt to use Monster Cable for these internal connections. I soldered all the internal connection between the drivers and the banana jacks, on the theory that soldered connections conduct better than any mere mechanical connection.

Finally, I made what was probably the most significant physical modification by reversing one of the baffle boards 180 degrees and remounting the drivers. In a stock S-6 stereo pair, both loudspeakers are configured so that the midrange transducer is on the right-hand side of the box with the tweeter situated in the upper left. I suspected this non-symmetrical arrangement might contribute to poor stereo image acoustical focus. By reversing the baffle board in one system, the two speakers were transformed into a symmetrical mirror image pair capable of rendering accurate acoustical focus.

I should mention that these modifications required more physical labor than I like to exert. Removing and reinstalling the baffle board, removing and replacing the drivers and crossover boards, and rewiring and refinishing everything, involved a quantity of raw effort quadrupling the original kit assembly.

RESULTS. In the end, it was worth it. The midrange honk, the upper-bass funk and high-end sizzle are gone. The sound of the modified Sixes now compares to high-end systems priced in the $1000–$2000 range. They produce a very palatable stereo image (Peter on the left, Paul on the right and Mary in the middle) with a smooth response and sense of depth and space. My classical orchestral works now reveal nuances I never heard before, and I am in the process of relearning all the music in my 600-odd analog disk collection.

I set up the rebuilt Sixes about eight feet apart in my listening area, and angled slightly inward. I experimented with horn configuration and found I preferred the midrange horns on the inside. Since theory predicts that a sharp symmetrical cutoff slope, as I used to separate the midrange from the treble, could result in 180 degree phase reversal, I tried reversing the phase of both the midrange and tweeter separately. In each case, the resulting stereo image was not as satisfying as the in-phase connection, so I left everything in phase.

Even with additional attenuation in the revised crossover, I still found the adjustments within the bottom one-third of their ranges. Also note that R2 and R3 dissipation ratings are absolute minimums, and higher ratings are preferable. In several hours of ordinary listening these resistors become noticeably warm, but a single playing of Richard Strauss's *Festival Prelude* Op. 61 (Deutsche Grammophon 2535-208), at elevated volume, is enough to heat them beyond touching.

After this experience, I am convinced more than ever that a crossover can make or break an otherwise decent speaker system. The S-6 components are high quality, but my experience indicates that the stock crossovers were less than successful matching the drivers to make a balanced system. I now wonder how many thousands of dollars audiophiles waste trading in their loudspeakers every year or two in a fruitless search for audio perfection, when their money may be more wisely invested in a few crossover design books and a goodly collection of coils and capacitors.

ABOUT THE AUTHOR

Ben Poehland has a B.S. in chemistry and works on antibiotic drug research in the pharmaceutical industry. He has published several scientific papers on liquid chromatography and new drug discovery. Ben also collects classical recordings, and has been involved in "roll your own" audio for ten years.

Tools, Tips & Techniques

STUFFING STATS

I performed tests to better understand the various acoustic damping materials most commonly used by speaker builders. Some data has been listed in *SB* before, however, I was determined to get a broader look to fulfill my needs and curiosity. I invite other readers to comment and supplement my findings.

I made the measurements in *Table 1* with a 6½″ driver in a 1280 cubic inch closed box. The driver's free-air resonance is 46Hz, and its empty box resonance is 67Hz. The table shows that the various polyesters have similar acoustic properties. QualloFil® has the highest loft, and HolloFil II® the second highest.

All of the tested materials have more effect on F_O when placed closer to the driver in the transmission line than when placed at the far end. I discovered that as I introduced lower F_Os, the impedance curve flattens, and impedance at F_O is also lower. Even past the point where F_O stops decreasing, impedance continues to

TABLE 1
RESONANCE vs. STUFFING MATERIALS

Stuffing oz.	Polyesters (1)	(2)	(3)	Wool (4)	Cotton (5)	Fiberglass (6)	Foam (7)
4	65	64	64	65	64	64	65
8	62	63	62	62	61	62	60
12	62	62	62	62	57	58	56
16	—	—	—	—	57	53	49

(Frequency in hertz)

(1) Common brand, low loft
(2) Dupont, Dacron HolloFil II®
(3) Dupont, Dacron QualloFil®
(4) Long hair wool
(5) Cotton balls and furniture batting
(6) Radio Shack type fiberglass
(7) Open-cell foam bricks (medium grade)

TABLE 2
ATTENUATION vs. FREQUENCY

Freq.	Polyesters * (1)	(2)	(3)	Wool (4)	Cotton (5)	Fiberglass (6)	Foam (7)
50Hz	0.54	2.5	2.73	0.82	0.63	1.83	3.35
250Hz	5.19	6.02	6.02	3.88	5.68	7.33	8.18
800Hz	9.63	10.17	10.17	6.38	12.77	13.98	12.77

(Attenuation in decibels)

*Use number key in Table 1

decrease. Acoustic output, however, also decreases.

I obtained the values in *Table 2* using eight-ounces of stuffing in an 8 x 8 x 20½″ transmission line. The table shows absorption characteristics at different frequencies with a correction factor used for response errors. The low 50Hz attenuation of low grade polyester (1), and of cotton (5), may be due to their low lofting qualities.

Table 3, measured under the same conditions as *Table 2*, shows the delay characteristics of three materials measured with an oscilloscope and a signal generator. The foam seems best for lengthening a line, but it also introduces maximum signal attenuation.

TABLE 3
DELAY LINE INCREASE vs. STUFFINGS

	Delay (mSec)	Distance (inches)	% length (increase)
Empty box	1.5	20.5	—
Wool	1.54	21.06	2.7
Hollofil	1.6	21.88	6.7
Foam	1.76	24.07	17.4

The eight-ounces of stuffing I used is perhaps three to five times the amount normally used in a transmission line of equal length. The percentage of increase shown should equate to a 6–7′ line (for a 6½″ driver) stuffed with eight ounces of material.

I find that improperly placed materials sometimes have a greater effect on damping than the difference between materials. A little experimentation is in order.

Greg Szekeres
Pittsburgh, PA 15236

A TRIO OF HELPFUL HINTS

Here are a few "tricks" which may be of interest to fellow speaker builders:

1. A simple non-porous center dome can be made from styrofoam balls, the kind often used for making Christmas ornaments. I cut them in half with a band saw and use paneling adhesive (such as Liquid Nail) to glue them onto either paper or plastic cones.

2. Bonding lead sheathing to the inside walls is an efficient method for damping resonant plywood cabinets. Use lead flashing, available from industrial roofing suppliers, and glue with a heavy-based adhesive such as bathroom tile cement. Trowel on plenty of cement, and either clamp the flashing in place, or add a few

Continued on page 28

Continued from page 27

screws until the cement sets (usually overnight).

3. Midrange sub-enclosures can be made easily by cutting a length of heavy cardboard tubing (available as junk from carpet warehouses) and installing it between the front and back enclosure panels. The length must be equal to the inside depth. Simply use paneling adhesive (or the more expensive silicone caulks) to hold it in place. Of course, this trick works best if your enclosure has non-removable panels, but even a removable back can be accomodated with foam weather stripping. Don't forget to fill the tube with fibrous material (glass or polyester) before mounting the midrange driver. [Also be sure the cabinet's volume remains adequate after the tube is installed.—Ed.]

Matthew Honnert
Carol Stream, IL 60188

FLUSH MOUNT DRIVERS IN AN HOUR

Here is a simple way to recess circular and irregular-shaped drivers in a speaker board:

1. Screw your drivers face down on a piece of ¼" plywood which is at least 5" larger (overall) than the drivers, and which will overlap the speaker board (for positioning).
2. Using a router, fit a ⅛" straight router bit and cut a ⅛" deep groove by moving the router once around the drivers.
3. Remove the drivers and insert one or more ½" wide, ⅒" thick strips of Plexiglas in the groove. If necessary, heat the Plexiglas so you can round the corners. Join the ends at the straightest section of the groove.
4. If the drivers' mounting holes are already drilled in the enclosure, attach a plywood jig, screwing through into these holes.
5. For future jig positioning, hot-glue strips of wood under the jig against the enclosure sides or other cut-outs.
6. Remove the jig from the enclosure and, using a ¼" straight router bit, cut out the center of the jig base plate inside the Plexiglas ring.
7. Put the jig back on the enclosure. If steps 4 and 5 did not apply, now is the time to "eye" the jig position and attach your wood strips.
8. Fit the ⅛" straight router bit and set it to the required depth plus ¼" (for plywood). Rout the groove with the base plate inside the ring of Plexiglas.
9. You can safely and slowly remove the remaining material inside this groove with the ⅛" bit, or more quickly but less safely with the ¼" bit.

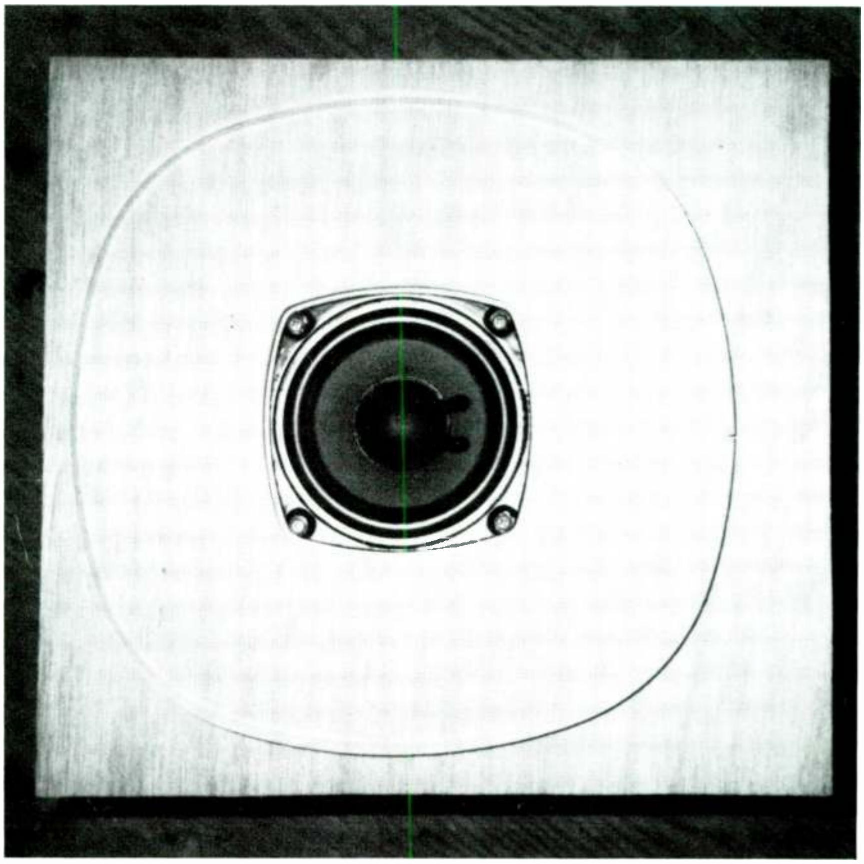

PHOTO 1: When completed, the woofer jig sits on the speaker. Note the small gap between driver and jig created by the ¼" router bit.

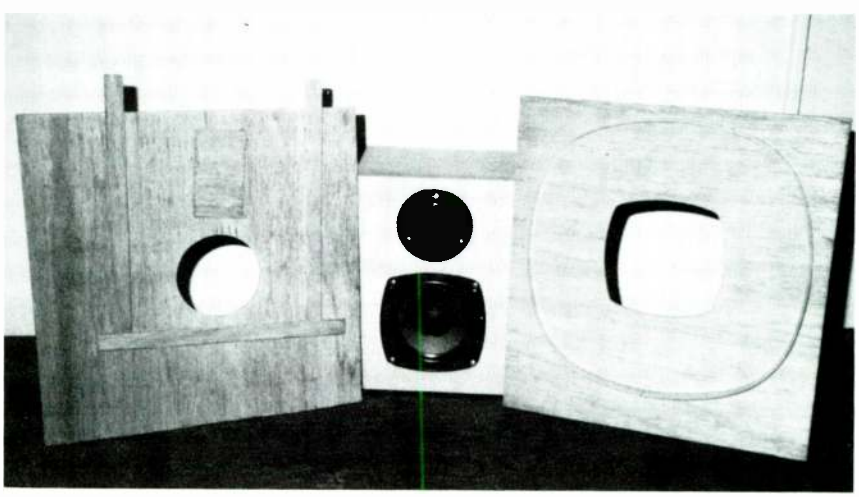

PHOTO 2: Woofer jig (r) shows groove with embedded Plexiglas, while tweeter jig (l) shows locating strips.

If you accurately center the router base plate on the bit, it will produce a very accurate fit—maybe too tight! If the base plate is off-center (mine is by 1/32"), mark the "near" and "far" points on the base plate and use this to your advantage by enlarging the recess. If, however, your base is off-center and you move the router around the drivers more than once, you will get a "sloppy" groove.

Plexiglas, with a nominal thickness, varies considerably. Mine was .112" thick, and fit well in a .125" groove. I cut the strips on a table saw with a carbide-tipped blade.

With this mounting method, you can no longer embed your drivers in silicone sealant if you wish to remove them in the future. Mortite, flattened with a rolling pin and cut into strips, works well.

With the proper materials and a little practice, you will be able to make a jig, and recess two drivers in less than an hour. The end result will be much neater than mounting by "eye."

Nicholas Clifton
Ipswich, MA 01938

A COMPUTER TL TIP

I am working on a computer designed transmission line system, and your back issues and new book of *TAA* reprints are the best sources of information.

You might be interested in printing the following table for *SB* readers (*Fig. 1*). It shows the transmission line length for different frequencies in 1Hz steps. Most papers just state six to eight feet, but it is interesting to see a frequency range that covers 35 to 47Hz. The program listed in *Fig. 2* is for a Commodore 128, but is easily adaptable to other microcomputers. One can cover higher frequencies by increasing the value of S in line 20.

Peter T. Crosby
Claremont, NH. 03743

```
QUARTER WAVELENGTHS       (QW=1127/F/4)
 20 HZ = 169.05",  14'   1.05"        40 HZ =  84.53",   7'   0.53"
 21 HZ = 161.00",  13'   5.00"        41 HZ =  82.46",   6'  10.46"
 22 HZ = 153.68",  12'   9.68"        42 HZ =  80.50",   6'   8.50"
 23 HZ = 147.00",  12'   3.00"        43 HZ =  78.63",   6'   6.63"
 24 HZ = 140.88",  11'   8.87"        44 HZ =  76.84",   6'   4.84"
 25 HZ = 135.24",  11'   3.24"        45 HZ =  75.13",   6'   3.13"
 26 HZ = 130.04",  10'  10.04"        46 HZ =  73.50",   6'   1.50"
 27 HZ = 125.22",  10'   5.22"        47 HZ =  71.94",   5'  11.94"
 28 HZ = 120.75",  10'   0.75"        48 HZ =  70.44",   5'  10.44"
 29 HZ = 116.59",   9'   8.59"        49 HZ =  69.00",   5'   9.00"
 30 HZ = 112.70",   9'   4.70"        50 HZ =  67.62",   5'   7.62"
 31 HZ = 109.06",   9'   1.06"        51 HZ =  66.29",   5'   6.29"
 32 HZ = 105.66",   8'   9.66"        52 HZ =  65.02",   5'   5.02"
 33 HZ = 102.45",   8'   6.45"        53 HZ =  63.79",   5'   3.79"
 34 HZ =  99.44",   8'   3.44"        54 HZ =  62.61",   5'   2.61"
 35 HZ =  96.60",   8'   0.60"        55 HZ =  61.47",   5'   1.47"
 36 HZ =  93.92",   7'   9.92"        56 HZ =  60.38",   5'   0.38"
 37 HZ =  91.38",   7'   7.38"        57 HZ =  59.32",   4'  11.32"
 38 HZ =  88.97",   7'   4.97"        58 HZ =  58.29",   4'  10.29"
 39 HZ =  86.69",   7'   2.69"        59 HZ =  57.31",   4'   9.31"
 40 HZ =  84.53",   7'   0.53"        60 HZ =  56.35",   4'   8.35"
```

FIGURE 1: Output of the Commodore program in *Fig. 2*.

```
READY.
5 OPEN 4,4:CMD4
10 PRINT:PRINT "QUARTER WAVELENGTHS       (QW=1127/F/4)":PRINT
20 S=20:FOR M=20 TO 20+S:FOR N=0 TO 1:F=M+N*S
30 W=1127/F/4*12:T=W/12:O=INT(T):I=(T-O)*12
40 PRINTUSING "###":F::PRINT " HZ =";
50 PRINTUSING " ###.##";W;:PRINT CHR$(34);",";
60 PRINTUSING "  ##";O;:PRINT "'";
70 PRINTUSING " ##.##";I;:PRINT CHR$(34):
80 PRINT "        ";:NEXT N:PRINT:NEXT M
```

FIGURE 2: This short program produces the table of transmission line lengths for frequencies between 20 and 60Hz.

Kit Report

Focal Model 280 Loudspeaker

It jumped out of the ad and caught my eye. An egg?? You've got to be kidding.

My first thought was the interesting looking loudspeaker was probably only a gimmick. Some reflection, however, caused me to reconsider and concede that an egg shape may indeed have some sonic merit. I remembered from reading R. C. Kral's article in *SB* 1/80 that the sphere is the ideal shape for minimizing acoustic wave edge diffraction. In this respect, the egg shape would be similar to the sphere. Also, the Egg has no parallel walls to cause internal standing waves. My interest whetted, I accepted the opportunity to review this novel speaker.

The Egg is manufactured in France by France Filiers under the brand name Focal, which offers the same egg enclosure in several different configurations. As a high-midrange unit used with their "Mini Onken" bass unit, the combination is the 600 kit. The Egg is also offered as a full-range system: the 280. As an option, the Egg can be built as either a sealed enclosure, (designated the 280-DBO), or as a vented enclosure, (the 280-FA). I built and will discuss both the 280-DBO and the 280-FA.

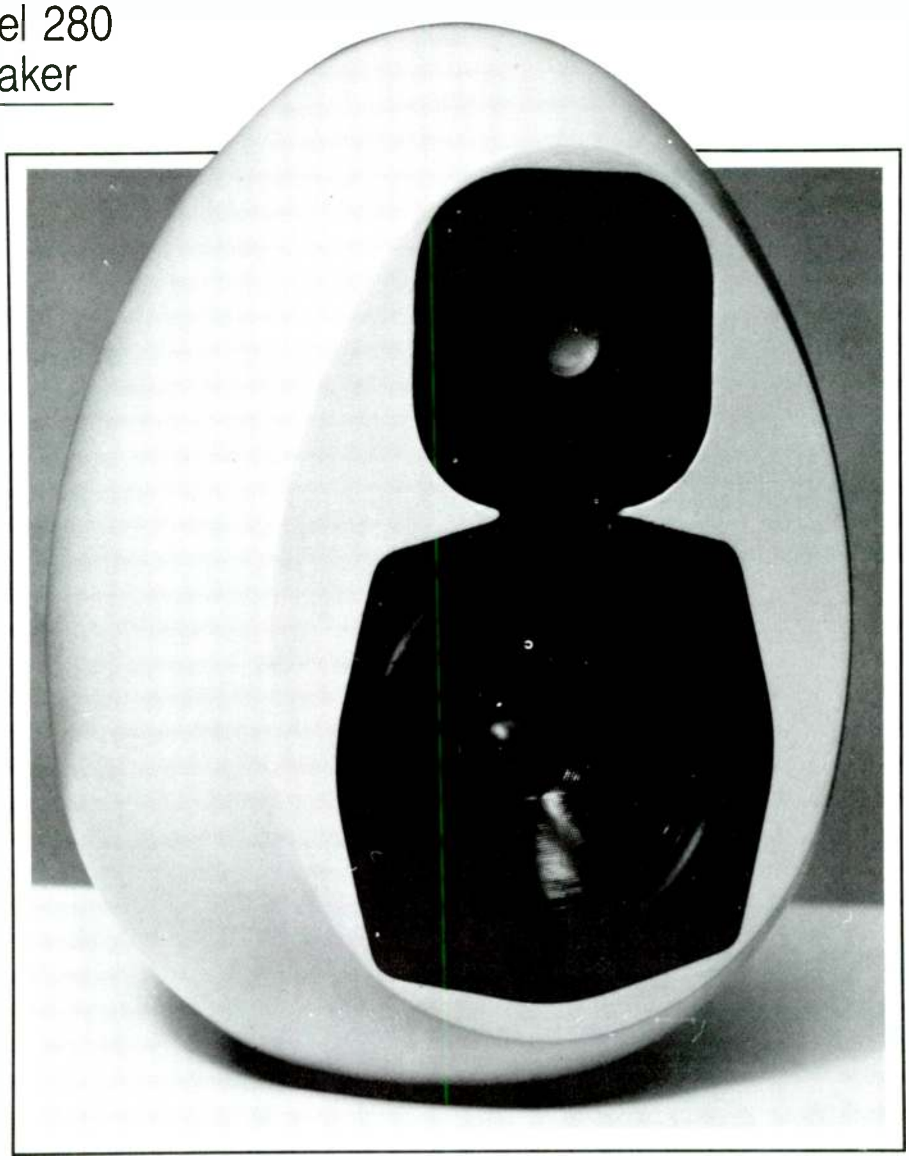

PHOTO 1: Front view of the Egg.

Kit Contents.

The .46-cubic foot Egg is a 16″ high, and 12″ wide casting of fiberglass reinforced plaster. (See *Photo 2*.) The face of the Egg is molded to accept Focal's tweeters and seven″ drivers. 5-mm. metric nuts are molded into the enclosure to mount the drivers. The necessary 5-mm. metric screws are included in the kit. At first, I was concerned that plaster (an ideal material for constructing a practically-inert enclosure) may be fragile. After working with it, however, I think it should withstand anything short of abuse.

If you plan to build the vented version of the Egg, you will have to provide several inches of 2″ plastic pipe, and a pair of right angles. The duct is constructed in a manner similar to those in the Weems article (*SB* 4/85).

Both the sealed and vented versions of the 280 use the Focal T120 tweeter. In a conventional dome tweeter, the convex dome is the same size as the voice coil, and tends to be a ring or annular radiator. The voice coil of the T120 is smaller than its concave dome, which is suspended by a foam surround. According to Focal, the radiating area of the T120 decreases as the frequency increases, and tends to be a point source radiator. Claims made for the concave dome include its ability to disperse a greater amount of acoustical energy, and a superior off-axis response.

The 280-FA uses the Focal 7N402-DBE bass/midrange driver, while the 280-DBO can use either the Focal 7N401-DBE or the 7N402-DBE bass/midrange driver. The 7N401-DBE was originally designed to be used in a sealed enclosure. It was recently redesigned to be better-suited for a vented enclosure, but is still usable in a sealed enclosure. The 7N401-DBE and 7N402-DBE drivers are both 7″ units employing dual voice coils. Focal uses the two coils as if they were separate drivers sharing a common cone, which allows crossing over to two different frequencies on the same unit. The two coils work together in the lower range, while only one is effective in the midrange. An increased efficiency and a simplified crossover is claimed for the dual voice coils, compared to a design employing two separate drive units.

According to Focal, the large magnet required to obtain good sensitivity will often lower the Q_t to an unusable value. The result will be an excellent midrange with a poor bass response. Using both voice coils in parallel halves the resistance, increasing Q_{es} and consequently Q_{ts}. As a result, it relieves the need to choose between an excellent midrange and decent bass response. In addition, adding a small resistance in series with one coil allows the value of Q_{ts} to be adjusted to almost any desired value. This feature is employed in the Focal crossovers by taking advantage of the small resistance inherent in the series inductor.

Most of the popular woofers today have cones made of Bextrene or polypropy-

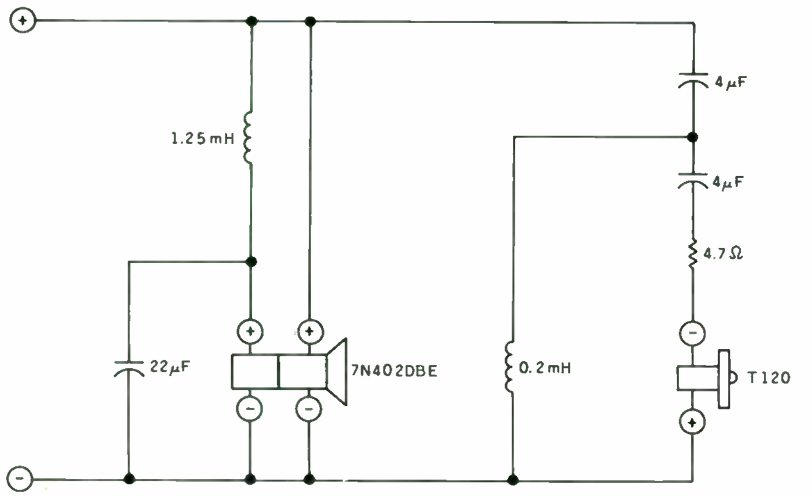

FIGURE 1: The F280-DBO crossover schematic.

lene. Both the 7N401-DBE and 7N402-DBE bass/midrange driver's cones are made of neoflex, which Focal believes to be superior to Bextrene or polypropylene. Neoflex belongs to a family of materials known for their stiffness and ultra light weight, recently developed for the aircraft industry.

The crossovers that Focal suggests be used with the Egg are not overly complex, but neither are they cookbook designs. *Figure 1* shows the F280-DBO Focal recommends for use with the sealed version. One coil of the dual-coil woofer is connected directly to the output of the amplifier, while the second coil augments the bass through a second-order, low-pass filter. At first glance, the high-pass section appears to be a third order filter. Actually, it is a second order filter followed by a first order filter. Focal has found that, because of the natural high frequency rolloff of the woofer, inverting the phase of the tweeter results in better compensation for the phase shift.

Figure 2 shows the F280-FA to be used with the vented version of the Egg. Both coils of the dual-coil woofer are fed through different first order filters, each designed to augment the other. Again, the hi-pass section is a second-order filter followed by a first-order filter, and the phase of the tweeter is inverted. A parallel LC network provides shelving for the tweeter level.

The F280-DBO I received with the kit was an etched circuit board with ferrite core inductors, and Mylar and electrolytic capacitors. For comparison, I also built a F280-DBO with air-core inductors and metallized polypropylene capacitors. Focal distributors carry the F280-DBO but, as far as I know, not the F280-FA, which I built from scratch using air-core inductors and metallized polypropylene capacitors.

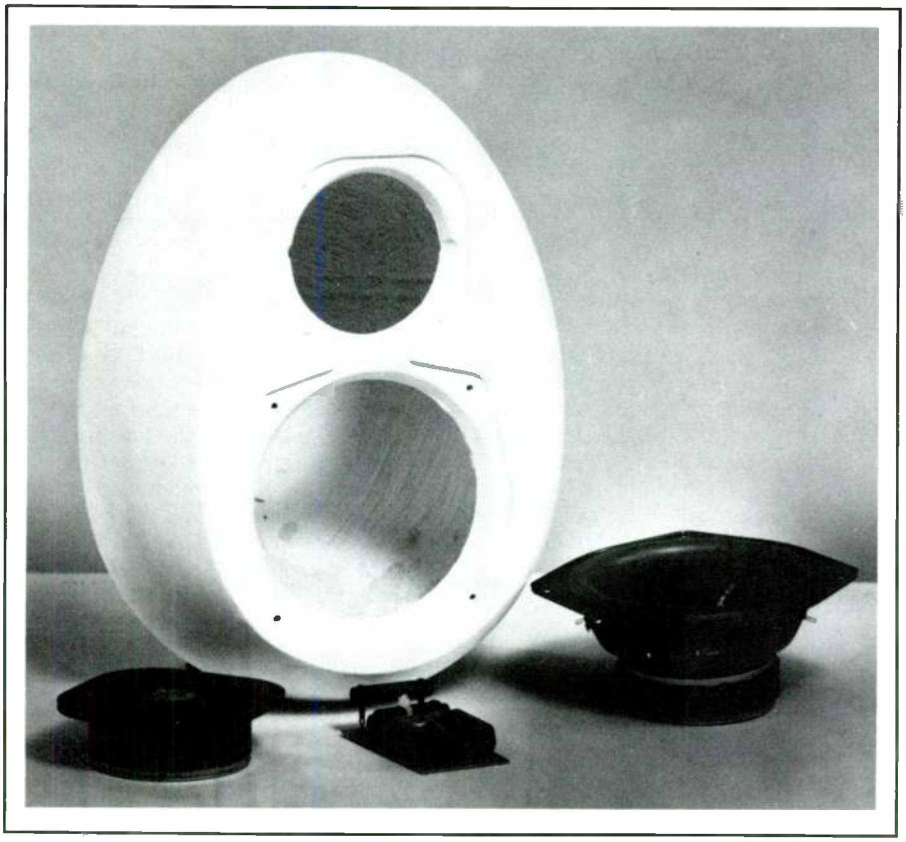

PHOTO 2: The Focal Egg kit prior to assembly.

Constructing the Egg

First, check the enclosure to determine whether all the nuts required to mount the drivers are present. An earlier version of the Egg has four 5-mm. metric nuts embedded in the plaster to mount the woofer, but none for the tweeter. If you have a pair of these Eggs, to mount the tweeter you will have to drill holes for #10 screws. The Eggs currently being manufactured have the required eight nuts to mount the drivers imbedded in the plaster, so you won't have to drill the holes for the tweeter.

Check the holes around the nuts and, if necessary, clear the holes of any plaster. Make absolutely sure the nuts are perfectly aligned with the holes in the drivers. Focal assures me that current Eggs are correct. Both of the earlier Eggs I built, however, had slightly misaligned nuts. There is no play in the screws, so if they are not perfectly aligned, they will bind and, if forced, break the nut loose from the plaster. If one does break loose, don't panic. It can be glued in place with epoxy. (The voice of experience speaking.)

If you have a misaligned nut, clear a small cone of plaster from around the hole and, if necessary, slightly enlarge the hole in the driver. Be careful to keep filings out of the driver magnet.

If you have decided to build the vented version, cut the hole for the duct, glue the duct in place, and fill in any gaps with spackling. Don't be afraid to drill holes in the enclosure. The plaster is surprisingly easy to cut, and mistakes are easy to repair. Fill any small pits in the Egg's surface with spackling, and lightly sand any rough spots. Check the area where the speakers will be mounted to be sure it is smooth, and then slightly enlarge the depressions for the tweeter wires.

You must decide for yourself what to do about terminals or connectors, because Focal does not specify anything. I like neither the location nor spacing of Focal's two small holes for the speaker wires in the back of the enclosure. I recommend that you fill them with spackling, and drill alternate ones.

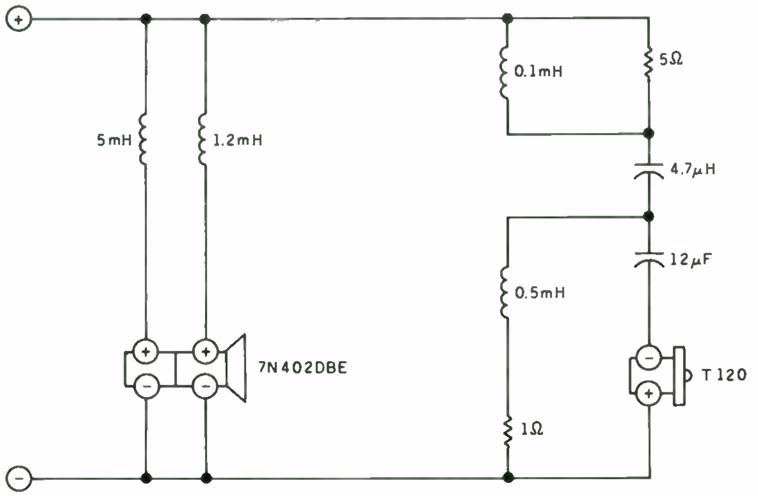

FIGURE 2: The F280-FA crossover schematic.

The Egg should be tilted back so the driver faces are 15° back from the vertical. You can accomplish this either by making a stand to hold the Egg at any angle, or by sanding the Egg's base so it sits on a flat surface at the correct angle.

Finishing the enclosures is pretty much your choice: from a simple paint job to an elaborate work of art inspired by Faberge. Start by sealing the plaster with a coat of latex wall paint, and follow with several coats of spray lacquer.

Pre-wire the crossover and mount it in the enclosure, then cover the rear and sides of the interior with a 1″ thick layer of Dacron batting. You don't need any more than this because of the geometry of the enclosure. Solder the wires to the drivers and mount them in place, using the provided neoprene gaskets. Seal the heads of the screws with a little adhesive to ensure there are no leaks.

Listening to the Vented Egg

It seems to me the true measure of the quality of a product is how well the manufacturer has achieved its objective. I would rather the manufacturer not attempt something than to offer me a failure.

Focal's objective for the 280 was to offer the best possible sound from a medium-priced, physically-small, full-range loudspeaker system. In my opinion, Focal has achieved its goal with flying colors in the vented version of the Egg. What I like most about it is there is nothing of any consequence wrong: I can pick a few nits—but nothing important.

The 280-FA cannot be classified in terms such as "East-coast," "West-coast," or "British." It is neutral, having no noticeable peaks or valleys in its frequency response to cause coloration. It can be described, in a nutshell, as exceptionally detailed and transparent as well as analytical and revealing, with a slightly dry characteristic.

Locating the Eggs in my listening room did not seem to be as critical as with other systems. Placement of the speakers relative to the listener, however, is critical for best results. The optimum position for the speakers is about six feet apart, each one pointed directly at the listener, and elevated so that the top of the woofer is at ear height.

I was amazed at the results of my experimentation with enclosure tilt. When the angle was correct, the "plane of sound" dissolved and a three-dimensional sound stage emerged. I set the Eggs in shallow bowls so I could tilt the speakers back without having them topple over. After much listening and measuring with a protractor, I determined the correct angle to be 15° backward from the vertical. I have never before heard a speaker from which I could notice a difference by adjusting the tilt as little as 5°.

Although the "sweet spot" for listening was limited, the image outside this area was good, and had no tendency to beam. The presence was neutral, generally in the plane of the speakers. The high frequencies were well-extended, providing a good quality to the treble.

I routinely attach a felt diffraction ring around any tweeter that hasn't one already. I have never found a case where it doesn't help, even if only a bit. Even though the egg shape reduces the edge diffraction effects, the drivers are mounted on a flat surface molded into the face of the enclosure. The tweeter's high frequency wavelengths are short enough to be affected by the edge. Sure enough, the felt ring did have a slight but noticeable effect of smoothing the high frequencies, eliminating a barely discernable time-smear.

The 280-FA is the kind of speaker that can give the impression of bass deficiency. Wrong. The bass is there, and in just the right amount. What is missing, however, are those aberrations manufacturers rely upon to provide the appearance of bass: the one-note boom, and mid-bass hump. In character, the bass was a little "soft" or "round," which I attribute to the lack of very low bass. I was, however, impressed by its depth, particularly considering the enclosure volume is less than one-half cubic foot. In fact, while listening to Pink Floyd's "The Dark Side of the Moon," I checked to make sure my subwoofers were disconnected, not believing these little speakers could produce the bass I was hearing.

The vented Egg performed admirably on all types of music, but particularly well on solo voices or instruments, and small groups. At the other end of the spectrum, large orchestras were well-balanced, massed strings were smooth, and the sound stage was realistic. While evaluating this speaker, I noticed one interesting effect I had not experienced before: although the music sounded good at any volume, I became acutely aware of the "correct" level for a particular piece. I really can't explain it except that perhaps the incorrect volume detracted from an otherwise realistic presentation.

Listening to the Sealed Egg

The performance of the sealed version of the Egg is a disappointing contrast to the excellent sound of the vented Egg. The differences between the 280-FA and the 280-DBO: the crossover and the enclosure, each contribute to the problems with the 280-DBO. Let me discuss the crossover first.

Using the crossover supplied with the kit, music sounds stressed as opposed to relaxed, electrical as opposed to musical. The sound has an annoying, astringent characteristic. Also, something was present that shouldn't have been—I had heard it before but couldn't identify it. Was it a smear? No. Was it ringing? Maybe. Then I remembered—it was the sound of a crossover I once had, before I replaced its Mylar and electrolytic capacitors with polycarbonate capacitors.

Does the type of capacitor and inductor used in a crossover matter? You bet! I built another F280-DBO crossover using polypropylene capacitors and air-core inductors. The sound of the 280-DBO using this crossover improved dramatically. Though the aforementioned problems were gone, the overall sound was still not right. Music now sounded hard or glassy, which I diagnosed as a problem with the treble's amplitude response. Rather than redesigning the crossover, I decided to try the crossover that performed so well in the 280-FA. As expected, when using the F280-FA crossover, the sealed Egg sounded much like the vented Egg. After all, the only difference now was the enclosure.

Differences in the sound of the sealed and vented Egg (both using the F280-FA crossover) can be noticed in the bass and

Continued on page 34

LANDES AUDIO

Route 24, Chester Mall
Chester, N.J. 07930
(201) 879–6889

Dear Reader,

Landes Audio has been in the audio-video business since 1945. We still have the first moving magnet cartridge produced some 30 years ago, an Elac from Germany. We have an original Motorola portable TV with electrostatic picture tube that I can't date.

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LUXMAN	MOREL	KENWOOD SATELLITE
AKG	ELAC	PIONEER VIDEO
MOD Z GRADO	DYNAVECTOR	

the warmth of the music. With a sealed enclosure, male voices lack warmth, and sound slightly confined, with a "boxy" quality. The bass is about what can be expected from a half-cubic foot sealed enclosure. The bass quality is not bad, but music seems thin, lacking foundation when compared to the sound of the vented Egg.

Even though the low-pass section of the F280-FA crossover was designed specifically for a vented enclosure, in a sealed enclosure, it performs as well as, if not better than, the F280-DBO. Perhaps Focal can be persuaded to design a F280-FA crossover specifically for the sealed Egg.

Conclusion

Focal prefers to give the kit builder a great deal of latitude in component selection and construction. They recommend certain designs, but encourage the builder to experiment with alterations. Focal is primarily a speaker driver manufacturer, and offers crossovers or enclosures only as an aid to the amateur builder. Thus, the 280 kit is better characterized as grist for the experienced builder's mill rather than a cut-and-dried construction project.

In my opinion, the payoff for the extra effort of sculpting plaster and building your own crossovers is great: the vented Egg is the best-sounding small full-range speaker system I have heard. Not having listened to all contenders, I can't say it's the finest small speaker available at any price, but I wouldn't be surprised if it is. The vented Egg is simply that good.

Although the potential is there, the sealed Egg is not in the same league with the vented Egg. The only place where the sealed Egg (with the F280-FA crossover) might be preferred is as a satellite for a subwoofer, where the weaker bass could be an advantage, producing less interference with the subwoofer.

I strongly recommend building your own crossovers using the highest quality components. This is not an area to be penny wise and pound foolish. The difference is audible. I do not recommend the F280-DBO crossover for any configuration; rather, you should use the F280-FA crossover.

Prices for the Egg enclosure are slightly less than $100 each. Depending on what version of the Egg you decide to build, and what version of the crossover you select, total parts cost for a pair of systems (including enclosures) should run $335—$380. The manufacturer's representative in the U.S., Focal-America, (1531 Lookout Dr. Agoura, CA 91301) is available to answer questions or address problems relating to their products. They do not, however, sell directly to the public. Their products are available from the following distributors:

A & S Speakers
2371 Dahlia Street,
Denver CO 80207

Just Speakers, Inc.
233 Whitney Street,
San Francisco CA 94131

Madisound Speaker Components
8608 University Green
Box 4283
Madison WI 53711

Audio Concepts
1631 Caledonia St., Box 212
La Crosse, WI 54602

Audio Lab of Georgia
5269 Buford Highway
Atlanta, GA 30340

Solen, Inc.
5940 Bergevin
Brossard, Quebec Canada J4Z 1Z2

We often overlook the fact that products are developed by people, not companies. Kimon Bellas, president of Focal America, was intimately involved in the development of the vented version of the Egg. He is the type of individual who always has a project on the fire, and in light of his success with the Egg, I expect to keep *Speaker Builder* readers informed of his future accomplishments.

While discussing the 280s with him, I mentioned I thought they would be an ideal match for a subwoofer. Kimon told me he had recently designed a shared channel subwoofer which uses a pair of Eggs as satellites. The subwoofer is passive, containing crossovers to the Eggs. I told him I thought it was a good idea, but he should provide for a way to vary the output level of the subwoofer so it could be used with a variety of small speakers, and not just the Egg. Kimon agreed, and has incorporated the capability to alter the output level in his subwoofer.

I think this subwoofer will make an interesting project, and I have asked Kimon to send me the parts. I will review the subwoofer in a follow-on article to this one.

David W. Davenport
Raleigh, NC 27615

Focal America replies:

Now being manufactured under the name Focal SA (as of January 1986), the Egg can also be used in the Active 50 kit with the 15N700 bass system. When constructing the vented version, we suggest using ABS pipe schedule 40 (black plastic). Regarding increased efficiency and simplified crossover for dual voice cones, Focal believes it is easier to "shape" the response curve of a dual voice coil driver than with a simple coil unit. We also find it easier to "blend" bass and midrange on a single driver rather than between a bass and mid-driver.

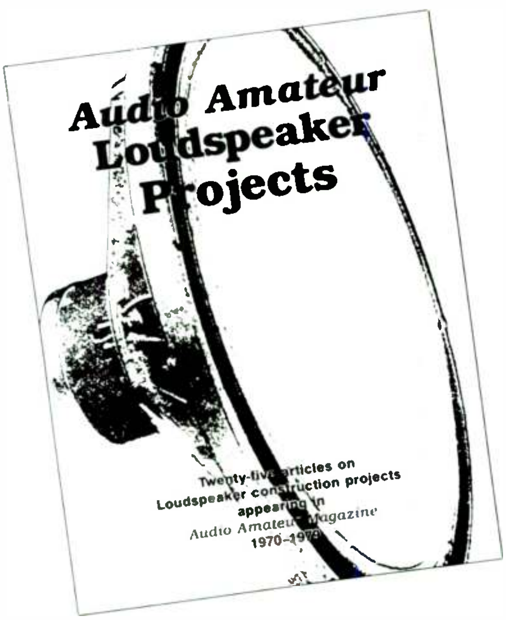
Focal America will soon manufacture the Eggs in California. The problem with the mounting holes will be solved in the American-made Eggs. All models will offer the option of vented or closed enclosures. Currently, we are preparing an Egg for the Focal 5N402 DB, a 5¼" driver which we hope to have on the market by the end of the year. When the smaller Egg is available, we will announce it in Speaker Builder.

Focal America wishes to thank Speaker Builder *for the tremendous job accomplished since its first publication. Americans, and other English-speaking amateurs, can consider themselves lucky. As a dedicated manufacturer in search of improvements, we especially appreciate* SB's *construction-oriented approach.*

Kimon Bellas
President, Focal America

Audio Amateur Loudspeaker Projects

Twenty-five articles on Loudspeaker construction projects appearing in *Audio Amateur Magazine* 1970–1979



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Craftsman's Corner

STYLISH HOME SYSTEM

I built my first pair of speakers more than ten years ago while a freshman in college. The pair featured an 8″ woofer and a simple capacitor crossing over to a 3″ tweeter. Though I was pleased with the sound, I wanted to build something bigger and better.

I began to learn more by reading various publications, and I eventually built a tower speaker approximately 1′ square and 4′ tall, with 30 pounds of cat litter in the bottom chamber to stabilize it. I separated the Audax dome tweeter and midrange from a Seymour Sound Systems 8″ woofer, and bi-amped the speaker. I purchased the crossover (between tweeter and midrange) from A&S Speakers, and the active crossover from Dahlquist.

At this point, I thought I had accomplished what many home builders strive for: an excellent speaker that was enjoyable to listen to, built at a very reasonable cost, and self-designed. Knowing that I have little technical knowledge made it even more satisfying. I will say, however, many of the parts suppliers gladly helped. This is important to know because lack of technical expertise shouldn't deter anyone from trying similar projects.

Then, something wonderful happened—I got married. Fellow speaker builders know this can cause problems, for suddenly, my raw particle board wonders (with no grille) did not match the living room furniture. Furthermore, I could not place them in our new home to my satisfaction.

I had smaller cabinets built at a cabinet shop and transferred the drivers, but I was still not satisfied. Then one day, I received an advertisement from Gold Concepts, the manufacturer of a new ribbon driver. The ribbon gave me an idea: maybe I could build a furniture-quality speaker, with placement and decorating flexibility, that would satisfy my audio requirements. I am pleased to say the answer is "yes."

I spoke many times to Alan at Gold Concepts, sent him my plans, and let him do most of the design fine-tuning and engineering. I cannot say enough about the help and support I received from Alan.

Thanks to a woodworking course at a local community college, I was able to construct a speaker 63″ high, 15″ wide, and only 4⅝″ deep (*Fig. 1*). My drivers were Gold 3.0 ribbon tweeters with four Dynaudio 17W75/8Ω (*Fig. 2*). Gold Con-

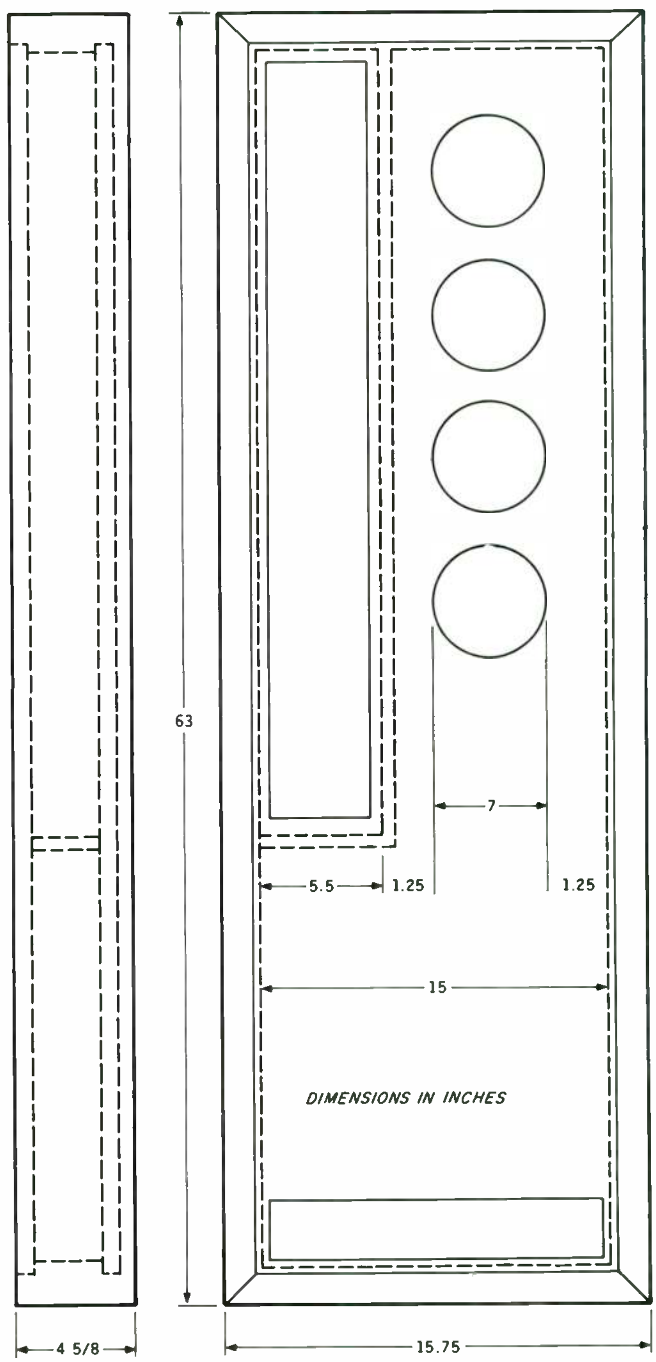

FIGURE 1: Front and side dimensions for one side of author Shea's decorative home system. The matching system front layout should be a mirror image of this one.

PHOTO 1: Two matching panels, covered with an oriental print.

PHOTO 2: The finished system.

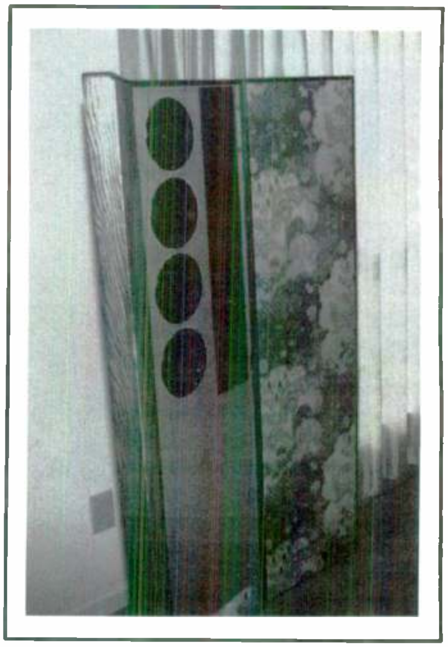

PHOTO 3: Narrow side panels are made of solid oak.

cepts was also my source for the crossover and wiring. I added matching panels on each side of the cabinet (*Photo 1*) and covered the three pieces with an oriental print my wife and I thought would look nice in our home (*Photo 2*). The narrow side panels allowed me to use solid oak (*Photo 3*), with particle board (as the major material) and baffle board in the rear.

The sound is all Alan claimed it would be, and the speaker does not intrude as did so many of my previous projects. The total cost was nearly $2000, so it was expensive as well as time-consuming. Even though you may be a beginner, technically, I'm confident you can build this true audiophile system, which is a pleasure both audibly and visually. Because of the size of the final speaker, I think it would be best to build this design in a workshop.

If you cannot get past the mathematics, engineering, and special terminology, take heart, I have found many product suppliers will not only sell you the needed materials, they'll also provide much of the information to help you build something you'll be proud to have in your home.

Michael Shea
Pineville, NC 28134

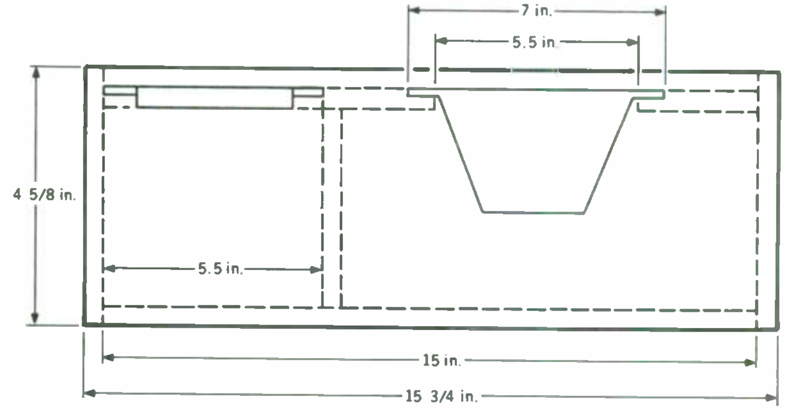

FIGURE 2: Cross-section of the system. The author set the baffle into the frame, leaving ⅜" clearance for the grille. The back is flush with the frame.

SB Mailbox

CORRECTION: INTERIOR ANGLES

In response to Daniel Patrick Coyle's article on pentagonal enclosures (*SB* 1/86), the interior angles of a pentagon should be 108°, not 144° as mentioned. Therefore, the miter cuts should be 54°.

Larry Cartwright
Pittsburgh, PA 15213

RHYMES AND REASONS

I reply
before July
to your letter posted shy
in an airmail envelope
offering more speaker dope.

Had to tell,
Mr. Dell,
"Mr. Postman, please mach schnell!"
after years I never looked at
Speaker Builder, now I'm hooked at.

Midrange horn,
boxes born
with responses uniform
lo' my dearest speaker hinters
such content arouses int'rest

I am back
(with a cheque)
on the rolling speaker track.
So here comes my contribution
to your speaker institution.

Flip through the glossy pages of any German electronics magazine and you will inevitably find at least one article dealing with loudspeakers. The craze is on here, but I wonder where all those paper and plasticone mechanisms go when there are only 60 million potential buyers, including babies and those with impaired hearing. One cheaply (and in my opinion, poorly) made magazine with a bunch of ready-to-build recipes sold 60,000 copies of its first issue. This number is what a glossy magazine would aim for at the end of its first year on the market!

But praise must go to our two most established electronics magazines, *Elektor* and *Elrad*. Both have dedicated many pages and a host of special issues to speaker building. Very seldom, however, is there an innovative thought on the subject from our homeland. Most of the material published here is either an edited translation of foreign material, or the mindless ejaculation of a speaker moron.

Not that there are no skilled builders around. A friend and brainstorming friend of mine, Heinz Schmitt of Essen, West Germany, has proven there is a good way to achieve bass reproduction from a small loudspeaker in a vented box larger than the suggested alignment design of R.H. Small. Schmitt's work helped me draw conclusions concerning vented boxes which were confirmed by my own Turbo-Pascal program calculations. (This program ran on my Apple, but it can also run on other models and is based partly on Bob White's original Applesoft program.)

My work indicates there is indeed an optimum volume for any given driver. Optimum means that, if you use just this volume, you will get the most from a vented design. The term "optimum volume" was first introduced by J.F. Novak. In my opinion, Novak should be called the real genius of compact box design and, though I may be lynched for the next opinion, I think Thiele and Small took this theory a bit too far. Here's why:

The dynamic loudspeaker, outside its use as the moving parameter in a horn, is a lossy device. More than 90 percent of the electrical energy applied to the driving coil is used to produce action other than sound. Why, then, does everybody try to get maximum efficiency from a vented box? Small is correct to show that system efficiency is mainly a function of box parameters alone. From an ecological point of view, one should indeed try to get max output from that lossy driver in a maximum efficiency housing.

Alas, as J.W. Schaefer stated in the letters page of *SB* 1/81, efficiency does not contribute to what one listens to. Any single driver in a box has to work under a gross impedance mismatch because of its limited piston action. Impedance mismatch is what accounts for all kinds of nonlinearities. You can reduce these nonlinearities by applying mechanical damping, i.e. stuffing the enclosure with baffle. Such damping introduces losses.

Losses are what Thiele/Small theory warn us about. Theoretically, no losses mean extended response and efficiency. Practically, losses smooth the response and allow better control on transients, since a low compliance driver with bad mechanical damping will inevitably show ringing in transient deacceleration. That's where damping comes in.

Small, meanwhile, assumes drivers have perfect braking. There is no such thing. In order to work properly, all existing drivers today need their padded cell.

Those who have read Novak's original *JAES* article, after being confronted with T/S theory, may have noticed a discrepancy. Novak states vented designs are of the third order (18dB slope) instead of the fourth (24dB). Could it be that those 6dB came from losses? Could it be that Novak worked with real loudspeakers and their inherent malfunctions, while T/S dipped their noses too deeply into formulas? Let's compare both approaches.

Novak gave a recipe like this: take driver, measure F_s, put driver in box of known volume V_{tb}, measure F_c, take ruler and calculate box volume V_b, build box, and enjoy. No determination of exact response, and no micrometer fiddling either.

T/S theory says: take plenty of measurements, take alignment table, take scientific calculator or preferably mainframe computer to predict all parameters short of maybe L_{sb} (lifespan of speaker in a box, standard earth years...). They also say you must measure the exact response and refit the system into the appropriate alignment, with woodwork done in the angstrom range. (Why is it I must allow for corrections when I apply a perfect theory?)

Then again, look at the Small alignment tables. When using a driver with high damping (low Q_{ts}), we get very small boxes, hand-in-hand with high f_3s. A high F_3 in a vented design is tantamount to no bass, resulting from the high slope of the circuit, be it 18 or 24dB, or whatever. A driver with good electrical damping is more costly than a skimped magnetic version.

What T/S offers is less bass for a greater expenditure. T/S is only good when your driver has Q_{ts} around 0.35 and then, as a rule of thumb, H must be around 1, and alpha (α) around 1.4142.

Please don't misunderstand me. I don't want to rave against applied T/S theory,

SB Mailbox

but we should bring their work to a more practical application. I will follow Novak's approach and show you some interesting relationships from simple analysis.

Novak stated there is an optimum volume for any(!) given driver after

$$V_o = \frac{V_{tb}}{1.44} \times \left[\left(\frac{F_{tb}}{F_S}\right)^2 1.15 - 1\right] \qquad (1)$$

where V_{tb} is the net volume of a text box, F_{tb} is the closed box resonance of the driver in that same box, and F_s is the free air resonance. This relationship holds when H = 1, i.e. $F_b = F_s$.

When I first saw his article, I was pleased to find such a simple way of calculating a vented box. Later, I used this formula in conjunction with the original T/S approach to conduct experiments. A definite application for this method leads to satisfying results, even with drivers outside the normally useful range of Q_{ts} in vented boxes.

One question came to my mind: might there be a "Novak family" of alignments with constant values of alpha and H for values of Q_{ts}?

There could be, at least mathematically. Take formula (1) and put it into the more convenient form used by Cobb in *JAES* 1970:

$$V_o = \left[\, 0.798 \left(\frac{F_{tb}}{F_s} \right)^2 - 0.695 \,\right] V_{tb} \qquad (2)$$

Assume then that, just by chance, the testbox of V_{tb} already happens to have "optimum volume", that is, $V_o = V_{tb}$. Then:

$$0.798 \left(\frac{F_{tb}}{F_s} \right)^2 - 0.695 = 1 \qquad (3)$$

and

$$0.798 \left(\frac{F_{tb}}{F_s} \right)^2 = 1.695 \qquad (4)$$

and

? $$\left(\frac{F_{tb}}{F_s} \right)^2 = 1.695/0.798 = 2.124 \qquad (5)$$

This is a constant property with all drivers! Now, from Small's closed box design, we know:

$$\left(\frac{Q_{tc}}{Q_{ts}} \right)^2 = \left(\frac{F_c}{F_s} \right)^2 = \frac{V_{as}}{V_b} + 1 \qquad (6)$$

This is an approximation, but works reasonably well for our purpose. Let's stop here for a second and review our findings. We deduced that, for any given driver invariable of total Q, the optimum value of box volume is such that this volume, if used as closed box, would raise the resonant frequency by a factor of the square root of 2.2124, that is 1.457. Only for this volume, if we follow Novak, is there maximum bass reinforcement from the box alone, if again the box is tuned to the free air resonance of the driver.

F_{tb} in Novak's formula (1) is nothing more than F_c in (6) related to V_b, which is of the value of V_{tb},

$$\frac{V_{as}}{V_b} + 1 = 2.124$$

therefore

$$\frac{V_{as}}{V_b} = 2.124 - 1 = 1.124 \qquad (7)$$

That means, for any given driver to work properly in a vented box, the compliance ratio (alpha in Small's paper) must be 1.124, if your aim is maximum extended bass response. As I mentioned, formula 6 is an approximation, and the whole overlooks box losses to some extent.

If you apply damping to the box, there will be some gain and, consequently, a reduction of gross volume. Since conditions inside a vented box can't fully change to isothermal, the gain is not really as high as could be expected from stuffing a closed box. Empirically, alpha should have a value of about 1.25 without applying moderate damping.

No smoke without fire, no fire without smoke: alpha, in the order of 1.25, means a large box, especially when you're using drivers larger than 8" in diameter. With badly damped drivers (high Q_{ts}), you might be better off using Small's alignments, giving LF response below driver free air response. If you want to use a driver with values of Q_{ts} below 0.3, try Novak's approach instead.

My preferred approach begins with that optimum volume, and then I try to change the tuning slightly, to one side or the other. This corrects response irregularities, but you need a computer (or something similar) to fiddle around with the T/S response function. I recommend using Bob White's AppleSoft program, which transfers easily to other dialects and computers.

With Novak's approach, you have an easy way to evaluate all necessary parameters for building a working vented design. You might find your beloved 5" Bextrene bass needs more than one cubic foot of airload, but you will certainly get top performance with a minimal effort, even if your measuring equipment is not accurate enough.

What impressed me most when I started to play with Novak's formula was that an old design can still be of great interest and, in some respects, be superior to the latest techniques. So, my next work will be based on an idea by Mr. G.A. Briggs, using styrofoam for special damping applications.

One last question. Why is it that each and every American magazine comes to Germany three months late? There is a definite time lapse between here and there, which may be explained by the fact the American magazines are often marked with the month they go off the market, while in our country they show the month they first appear. Is this irritation caused by some mysterious authority? Perhaps someone out there knows an answer to this.

Jurgen Heinzerling
Ratingen, West Germany

Alas, SB and its sister publication must go to Europe together, so SB waits for Audio Amateur. *When both are large enough to meet our transport vendors with minima, both should arrive in two weeks of US publication.—Ed.*

MAKE IT SHORT AND SNAPPY

I'd like to thank Mr. Zaustinsky for contributing still another aspect of the in-line, double woofer configuration (*SB* 2/86). Perhaps all we need now is a short, snappy name for this alignment. Toward this end, and borrowing from Mr. Noussaine, I submit "The NFL Alignment" (No Free Lunch).

I also found Mr. Zaustinsky's AES paper to be most informative, and I recommend it to all speaker builders. Available from AES as document No. 2032(f-5), it is called "Is Sophisticated Loudspeaker Crossover Design Possible Without Sophisticated Measurements?"

David Meraner
Scotia, NY 12302

Mr. Zaustinsky replies:

I like Mr. Meraner's new concept, the "NFL" alignment, very much. It should be widely useful in other connections, such as crossovers. I greatly appreciate Mr. Meraner's kind words about my paper.

ELECTRICAL POWER FOR ISOBARIKS

After reading John Cockroft's interesting experiment ("An Isobarik System," *SB* 3/85) and subsequent Mailbox comments (particularly the "No Free Lunch" discussion), I am seriously considering this design for my bass/midrange systems. An ideal amplifier/driver relationship would represent the theoretically correct method of drive, since all the excursions are electrically induced, but I would like to understand this before proceeding.

I use reflex designs with drivers wherein the Q_T/F_S ratio is natural for SQB3 or B4 alignments without serious pass-band loss. I set up a computer program using D.B. Keele's scientific calculator method (Weems) as an algorithm. With it, I can generate a family of alignments for any suitable driver of known specs. If the tunability of the driver is satisfactory, relative to pass-band loss and box size, and assuming the cutoff neighborhood is acceptable, I select a power amplifier with an RMS rating as close as possible to, but less than, the manufacturer's stated electrical capability for coil dissipation (preferably as specified relative to EIA or similar "in-house" testing procedures). I then define the low-tuning box enlargement limit by the alignment at which the mechanically-limited electrical power (linear excursion) is as close as possible to, but greater than, the chosen amplifier rating.

This is done by processing the data (cutoff frequency) for each alignment through Small's power constant formula (for phase inverting boxes). In reference to Small's formula, it is only valid (as he points out) when the correct infrasonic filter is used:

$$n_o = \frac{4\pi^2 f_s^3 V_{AS}}{c^3 Q_{ES}}$$

$$P_{AR} = 3 F_3^4 V_D^2$$

$$P_{ER} = \frac{P_{AR}}{n_o}$$

With all constants adjusted for V_D (in^3) and V_{AS} (ft^3), and by algebraic arrangement,

$$P_{ER} = \frac{.03 F_3^4 V_D^2 Q_{ES}}{F_S^3 V_{AS}}$$

$$P_{AR} = 8.06 \times 10^{-10} F_3^4 V_D^2$$

$$n_o = \frac{2.7 \times 10^{-8} F_S^3 V_{AS}}{Q_{ES}}$$

Thus, for the maximum acceptable linear excursion, the electrical power required (permitted) falls as the cut-off frequency is lowered, plus there is a loss of acoustical power output. To get maximum safe use of the driver, I found P_{ER}, which corresponds to the thermal limit and therefore to the amplifier power delivery. Of course, the amplifier should never be allowed to clip.

I found this to be a valid procedure when designing my woofers. I used a Gauss 18″ in a box tuned to a very deep SQB3 alignment, and driven from a Hafler 220 operated in balanced-bridge mono. The Hafler is conservatively rated at 350W RMS into 8Ω (5A fuses). The driver is thermally rated at 400W, with the alignment permitting 375W, maximum linear mechanical for the full half-inch excursion available from it. The damage limit for excursion is ¾″. This is a professional driver with dual spiders and accordion surround. Operation of these systems (there are two) tends to confirm that the box/driver/amp combination is an ideal match.

On the high end is a Heil air motion transformer. I can fill the 90Hz–2kHz midrange with an extended range bass/mid, but I encounter two problems. The first is a need for a small enclosure, and the second is the need for high output.

I am currently using polypropylene 10″ woofers for this, which have the right upper-end sound for crossover to the Heils. Their output is barely acceptable, certainly not what I had in mind. I have them in very small boxes, having made the mistake of believing the 90Hz crossover would intercept the passband at an adequate point. These being severely underdamped, I installed passive radiators with substantial added mass, and filled the boxes with fiber. This helped considerably, but it is not the final solution. I think it is also a mistake to underestimate the acoustical power the lower bass/midrange requires for a really effective natural impact. Even with conservative box design, this area of the spectrum would seem a little thin with those big Gausses underneath.

Now, in light of the "No Free Lunch" correspondence, the equations show that nothing changes in the Isobarik format except that the V_{AS} is halved. While we can then get the same frequency response characteristic out of half the box size, the efficiency is also halved, and our acoustical power is halved as well.

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Mr. D'Appolito says that high SPL for a given distortion level can be attained, but that the cost of the lunch is 3dB, plus the cost of the added driver. It would appear if we double the available power, we'll break even on acoustical power, and we can double the power by connecting the second driver to share the load. If we assume driver/amp matching, as I have done, we're back to the same speaker system in which we traded half the box size for twice the watts.

Since the F_3 and V_D have not changed, we can get the same P_{AR} from the Isobarik as we got from the single driver system. The cost of the lunch is, therefore, the second driver and the second (or bigger) amp. Under these drive conditions, can the distortion improvement be realized, and if so, why?

To take this a step further, we should be able to add another Isobarik pair in the same box, doubling the box size, the minimum vent area, and also the amplifier (again). In this case, we're back to our original one driver box size, with twice the acoustical output, the same frequency response, and four drivers sharing an amp four times larger. The added benefit of thinking along these lines is that the impedance problem is obviated (the driver I want to use is only available in 8Ω). Perhaps I should try a series-parallel arrangement with balanced-bridge feed.

A ramification of reflex systems is that the halved box at the target F_B means you must re-evaluate the vent. While the minimum vent area and the Mach number are the same, the inertance constant of the vent air mass is halved. This results in vent lengths that can be really outrageous. In cases where the problem cannot be overcome, doing creative things with passive radiators may be the solution.

Finally, Francis LeJeune raises a relevant point in Mailbox concerning the possibility of adverse midrange coloration in the higher frequencies. Against this, I have only two defenses: the Heils are crossing over lower than those frequencies at issue because the Heils go lower than most tweeters in popular use; also, the 10" units are selected for an exceptionally well-extended upper end, if this could be construed as mitigating. Since I intend to exploit the latter feature, Mr. LeJeune's comments, derived from actual experimental results, are well taken. I would like more details about his previous work so I can assess this problem.

I do not know yet whether I can tolerate the cost, complexity, and size of the four-driver type unit. Certainly, the concept has appeal. At the very least, it would be an interesting experiment. But on the more practical side, I am investigating the option of a super-efficiency wide-band type unit which can be loaded in a suitably small box, such as a 10" instrument driver.

Paul W. Graham
Independence, MO 64050

Mr. Cockroft replies:

I think perhaps the problem you experience between the sound of your woofer and midrange units is that your woofer is set up to play too loudly in relation to your midrange. Roger Sanders addresses this situation quite well in Part II of his article on electrostatic speakers and transmission line woofers (SB 4/80, pp. 28-29). This seems to be a common dilemma. After the effort and expense of investing in large speakers and huge boxes, you desire to hear the results. Unfortunately, this occurs at the expense of the rest of the spectrum. In normal music, we seldom hear the subwoofer. If it is set so you are frequently hearing it, you have set it too high.

Regarding Mr. LeJeune's experiences, I can only tell you that my speaker systems don't exhibit this behavior, at least not audibly. Judging from the reviews of the Linn SARA speaker, it also seems to be free of the problem. I don't know the design details of the speakers built by Mr. LeJeune, but perhaps his used the configuration used by Focal and others, wherin the inner speaker is mounted on a vertical baffle that divides the enclosure into two equal parts. This places a considerable distance between the two speakers. In the case of a large box, this could be a foot or more, In the SARA and my Projects One and Two, the speakers are located much closer to each other. My speakers are about 3½" apart, and from the cutaway photograph of the SARA that I have, it looks like the magnet in the front speaker extends a little into the open space in the front of the rear speaker, making them about 3" apart. Since all of the above-mentioned speakers cross over at about 3kHz–3.5kHz, you should experience no trouble with your crossover of 1kHz.

I will leave the rest of your letter for others to comment on. Good luck with your system.

Contributing Editor Joe D'Appolito replies:

Your letter is quite long, so I will respond only to selected portions of it:

- *The loss in efficiency is obtained with the second driver connected. If the inside driver is not connected, you'll incur a 6dB loss as pointed out in an earlier letter of mine to SB.*

With the voice coils connected in parallel, you'll obtain twice the input power, yielding the same SPL as that of a single driver. Both drivers must be driven to obtain the distortion reduction advertised for the compound push-pull pair. The distortion reduction comes from the push-pull operation of the pair (the drivers must be mounted in opposing fashion with voice coil polarities reversed) which cancels common even-order nonlinearities in suspension and magnetic circuits. The distortion reduction comes only at low frequencies where excursions are large and significant driver nonlinearity is produced.

- *Of course you can double up on the drivers again, but I don't see the need for a bass-reflex design in this frequency region, and I can actually see many disadvantages to it. I would use a closed box design. The transient response is better, and frequency response is more reliably controlled.*
- *Even with very shallow 10" drivers, it will be difficult to get the diaphragms of the push-pull compound pair closer than 8–10". This spacing corresponds to a half wavelength at 700–800Hz, where you will experience a large response dip due to destructive interference between the two drivers. This is well within the band of your proposed midrange unit.*

As a general comment, if you want to match the power handling ability of your Gauss woofers, you should drop the Isobarik design and use a vertical line source of four high quality 8" units (Dynaudio, SEAS, or Scan-Speak). Place your Heil tweeter in the middle of the line source (two above and two below) for a stable vertical radiation pattern

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with a largely cylindrical pattern in the horizontal plane.

ONE LITER DEFINITION

Regarding the "Cabinet Computations" letter (*SB* 1/86, p.38), the writer apparently isn't aware of the obvious. One liter is, by definition, 1000ml, which equals 1000cm³, which equals .001m³.

To convert from liters to cubic feet, divide by 28.3168 (approximately). Conversely, to convert from cubic feet to liters, multiply by the same number.

Lou Garner
Torrance, CA 90503

DESIGN DILEMMA

I have a number of questions I hope can help me with speaker design. I've read the last three years' editions of *SB* several times, but there are some points I'm still not clear on.

The first question relates to woofer transient response: which driver/box parameters are affected by it, and can it be mathematically predicted?

From course work, I know how to compute the transient response of an active filter. It appears that a vented box with a second-order equalizer offers the best overall low-end performance. Should I use two 6½" or 8" drivers to get better transient response, or just stick with one 10 or 12" driver?

I was originally looking for data on building a transmision line-type enclosure, but the chances of meeting my design goals are better with a "simple" vented box. Does this sound right?

I don't want to get in too deep, because I only have an audio oscillator (Heath IG-5218), oscilloscope, frequency counter, and several meters for test equipment. This sounds like a lot, but I don't have an anechoic chamber in the basement, or any FFT equipment.

I am leaning toward a three-way, bi-amplified system (woofer, then active crossover to midrange/tweeter). This seems to be a decent compromise in terms of avoiding the cost of three amplifiers, but I don't know how much better the performance could be if I went to a tri-amplified system. Any suggestions?

The Jordan module looks too good to be true. If it covers the entire range from 150Hz to 22kHz with low distortion, has very fast transient response and recovery, and eliminates the need for a midrange/tweeter crossover, then why doesn't everyone use it and just play around with the low frequency driver(s)?

It would appear as though I have missed something. Perhaps not everyone agrees with Mr. Jordan about the overall performance of the unit.

There seems to be disagreement on the subject of driver mounting. On one hand, to avoid driver vibration, many advocate isolating midrange drivers from the enclosure by using grommets. On the other hand, I recall one person who wrote he got a clearer sound by firmly attaching the driver to the enclosure. Preventing the driver from moving instead of the cone seems better to me. Is the mass of the magnet, basket, and other parts great enough so it's OK to shock mount a midrange without fear of vibration?

Robert Grieb
Berwyn, PA 19312

Contributing Editor Bullock replies:

Two major advantages of building your systems are the opportunity to use high quality components, and the possibility of adjusting the system until it sounds best to you.

If you are dissatisfied with "transient response," you can try a different loading or different drivers. In my opinion, if you start with high quality low Q drivers, it shouldn't matter whether you use a single large diameter driver or a pair of smaller ones. I use a 15" woofer, and I couldn't be more satisfied with it. There are arguments in favor of "compound woofers." The point is you are free to experiment.

I think vented boxes offer the best trade-off of complexity for performance, but many prefer a transmission line or a closed box on the basis of subjective comparison. If you are up to the cabinetmaking rigors of a transmission line, you can always change to a vented box.

I am a believer in active crossovers, mainly on the basis of subjective comparison. I find they produce a lower background noise level while increasing clarity and impact. Also, they are more convenient for the tinkerer because there is no need to worry about the driver being a resistive load. This means you don't have to change the crossover design just because you change drivers. The biggest problem with going active is the cost of additional amplification.

The Jordan module does sound like a good unit, but as I recall, it is expensive to use because more than one per side is needed to achieve desirable output levels. Using two per side in D'Appolito's configuration may work out nicely, but I see dispersion problems with any more than two per side.

Regarding the matter of driver mounting, I think compliant mounting is used to reduce baffle resonances induced by driver vibration. I try to avoid this problem by putting woofers in their own boxes, and by using high slope *crossovers and a low crossover frequency.*

By these means, I hope to suppress input frequencies in the baffle resonance range. I have considered compliant mounting for midrange drivers, but have never done it because I am not confident my mounting schemes would produce an airtight seal. I try to keep the baffle as small as possible so panel resonances will be at high frequencies, where I understand they are less obtrusive.

BOXRESPONSE ANOMALY

I've encountered an anomaly with BOXRESPONSE by Bullock and White. I've modified the print-out portions so that I get a graph instead of a table, but I have kept the calculations unchanged except for adding the displacement-limited curve suggested by Mr. White.

The anomaly occurred when I used BOXRESPONSE to calculate the closed-box response of a Dynaudio 17 M-75 driver. Dynaudio provides outstanding data sheets. In this case, the sheet included a frequency response graph which specifies the cabinet. When I compared the output of BOXRESPONSE to the Dynaudio for the same box, I discovered they weren't even close! There is almost 9dB difference at 100Hz, and the shapes of the curves are quite dissimilar.

Apparently, there are assumptions in the program that do not match the way the Dynaudio driver works. If I had not had the Dynaudio driver data, I would have rejected it as a possibility based on the program's predictions. I have no idea whether or not this case is unusual. This driver is the first one that I could compare the manufacturer's data on a known box with BOXRESPONSE's output.

I've spent many hours gathering data on drivers of all sizes as well as driver manufacturers, and making trial designs using BOXRESPONSE. I assumed the er-

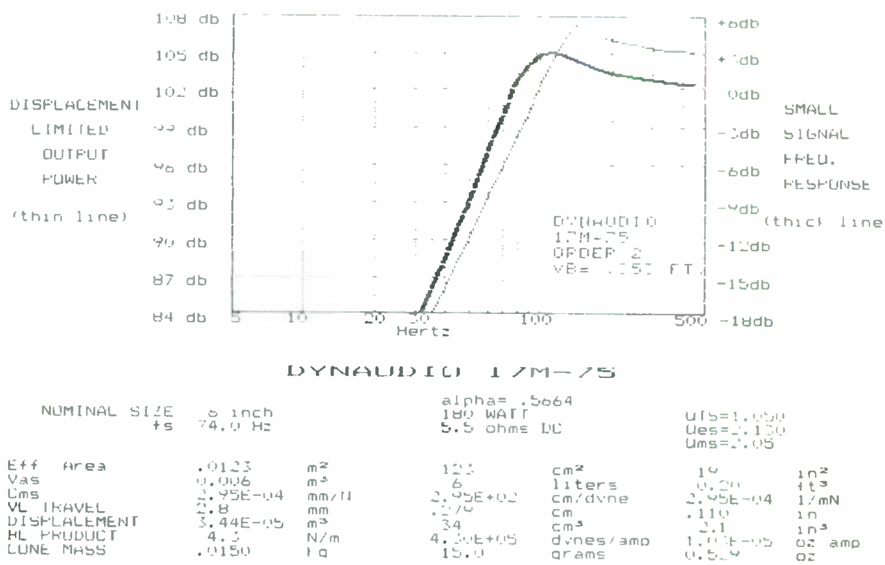

FIGURE 1: Mr. Svendsen's closed- box response calculation of a Dynaudio 17 M-75 driver.

rors would be minor and that I could use these trial designs to select the drivers for a final design. That assumption now appears to have been naive. I suspect other readers of *SB* have been doing the same kind of thing. They might be interested in seeing these two curves (*Fig. 1*). It would give them a calibration on the reliability of the program.

Edgar Svendsen
Littleton, CO 80127

Contributing Editor Bullock replies:

In order to compare response curves from two different sources, you must assume that the conditions under which both curves were generated were similar. It is not at all clear whether this is the case in your example.

BOXRESPONSE assumes that the driver is mounted in an infinite baffle, but you don't know the radiation load under which Dynaudio made their measurements. You are not really sure whether their enclosure measurements are internal or external, so there may be an error in your volume value.

Further, the closed-box model used in BOXRESPONSE does not include a box loss parameter (the only way to take box stuffing into account is to measure the in-box parameters with the stuffing in the box, and then model the system as an IB).

Finally, you don't know whether a variovent is being used in the Dynaudio setup. This last condition alone could conceivably account for the discrepancy I see between your two response curves.

As to the magnitude of the discrepancy, if you take the low point of 86dB on the measured curve as corresponding to the 0dB level on the model curve (your frequency response), I make out about a 4dB difference at 100Hz, rather than the 9dB you claim. Most of that seems to be due to the lack of agreement on the placement of the response peak, and its height. This disagreement leads me to believe that you do not know enough about Dynaudio's test system to make a meaningful, quantitative comparison with BOXRESPONSE's prediction. Even so, a qualitative comparison indicates that the response shape (presence of a peak) and the low frequency roll-off rate are successfully predicted by BOXRESPONSE.

Do not make the mistake of comparing the measured curve with your "displacement limited output" curve. The latter is not a system response curve! It is generated by calculating the output at each frequency using the highest drive level that does not exceed the driver's thermal or displacement limits at that frequency. In other words, the drive level varies from frequency to frequency. Response curves are generated assuming a drive level that is constant from frequency to frequency.

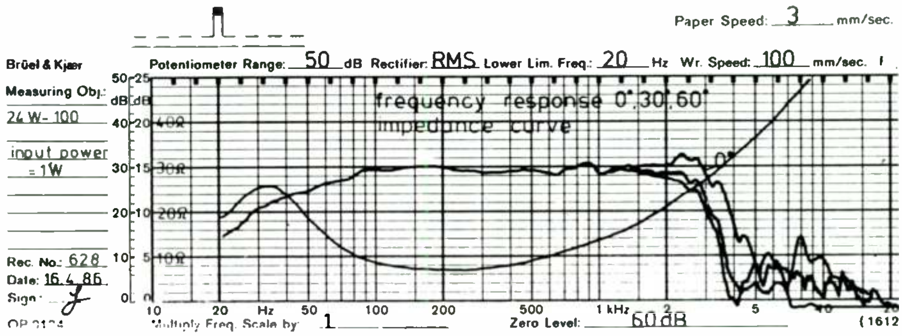

FIGURE 2: The manufacturer's data sheet response curves for the Dynaudio.

You should compare Dynaudio's curve with your "frequency response" curve.

I hope this sheds some light on your anomaly. In general, you can expect BOXRESPONSE to be in close agreement with measured results only when you can closely match all the relevant system parameters by corresponding model parameters.

Mr. White replies:

When I first looked at your problem, I thought there may have been a gremlin which crept into the program code. It did appear that something was seriously amiss, with the discrepancy between the actual measurement of the driver and the computer model. The data provided by the manufacturer, however, reveals the underlying discrepancy.

*On the data sheet (*Fig. 2*) are three response curves for the Dynaudio 17M-75. We are only concerned with the top two. The first shows what appears to be the frequency response of the driver in a 10 liter box. This is not the case. The graph, as presented, is for the driver alone on a DIN (rather large flat) baffle. The manufacturer never states this is a response for the driver in the box they propose, although they show the impedance curve for it on the same graph.*

I thought this was a strange circumstance, so I looked at the other data sheets from Dynaudio. They, too, are measured the same way! Well, now, how about the second case? The manufacturer now claims the driver is in the 10 liter box and has a 6dB filter attached. This is the case, as stated, but requires a clarification. The 6dB filter is a bandpass type with the components chosen to optimize the smoothness and bandwidth of the driver (read marketing).

The give-away in their data is the change in roll- off rate from one configuration to the other. The 6dB filter response plus the second order response of the closed box yield a third order.

ISOBARIK INVENTOR

I would like to comment on John Cockroft's "Isobarik" article (*SB* 3/85). I have been a speaker enthusiast since 1969, and have read every issue of *Speaker Builder* with great pleasure. My special interest is in horn design and unconventional speaker systems. In the mid-1970s, I started collecting private literature and patent research, and ordered and copied what I could get in German university libraries and patent offices.

While doing so, I discovered many interesting inventions, some of which I rebuilt and tried to analyze by modern methods. I found H.F. Olson's books, such as *Acoustical Engineering*, to be true sources of speaker knowledge and principles. In that work, I read about his invention, the "Compound Direct Loudspeaker" (pp. 157-158). If you look at this system, you will also recognize the Isobarik principle. Mr. Olson invented it in the late 1940s, and presented the patent in 1951. This is confirmed by J. Hiraga, a French audio authority and author of many books. In his *Les Haut-Parleurs* (Editions frequences, 1980, p. 224), you will find the Compound/Isobarik principle.

In the 1950s through 1970s, many companies built systems using Mr. Olson's compound principle: the Linn Company, Focal, Dynaudio, Goodmans, and others. I was fascinated by the Compound system because Mr. Olson states in his book that it can produce a lower bass than a speaker in a closed box of the same dimensions. In his patent, he outlined the basic theory, and this led me to establish a mathematical model for modern filter theory on the compound box (such as what Mr. Small did for closed, reflex, and passive radiator systems).

I took Mr. Olson's analog network and derived the system response function, which was, of course, a little complicated because nothing had been published on two-speaker systems. After that, I made Butterworth and elliptical approximation to get a set of equations for the context of cabinet and speaker parameters. With the aid of a computer, plus a lot of time and sweat, I derived parameters (by Butterworth and elliptical alignments) for the speakers' two cases of series and parallel connections.

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This work revealed alignments from which you can get very deep bass with a small cabinet volume. If you choose a Butterworth alignment, transient response is the same. I recalculated some of Focal's designs and put in the speakers' system parameters (such as Q_{ts}, B_l, V_{as}, and f_s) and the two chamber volumes in my equations, and found good agreement with given response data.

For example, consider the Focal Kit 350. This system has the Compound/Isobarik principle in the bass section, with two Focal 8N401 drivers in parallel. I calculated the theoretical response (*Fig. 1*)and found that Focal almost realizes Butterworth alignment. By following Mr. Cockroft's system, I need all of the above mentioned parameters, plus S_d and the series or parallel connection.

I believe my approach is the only one which can reveal the true possibilities of the Compound/Isobarik system, and is better than trial and error (see Small's papers).

Ernst Beck
Emmendingen, West Germany

Mr. Cockroft replies:

At first, I was quite surprised that Dr. Olson discovered the principle, but then it seemed the most natural thing in the world. Why should he have missed this one when he got all the rest? It is interesting that he makes reference to the front speaker and volume behind it, rather than considering the two speakers as an integral unit. I would like to see your findings in more detail, either through an article, or a letter.

As I mentioned in my article, I did not measure the individual speaker units in my Project One, due to circumstances beyond my control at the time. The advertised figures for these speakers (Peerless T0125 5"): F_{sa} 55Hz, Q_{ts} .45 V_{as} .39 cubic feet, S_d 7.5x10-M^2, BL product 4.78 T_m.

The box volume (rear volume) is 450 cubic inches net. The rear volume was filled with 2.5 ounces of polyester fiberfill pillow stuffing at the rate of .6 pounds/cubic foot. In view of the information brought forth in recent issues of SB, I estimate Q_{tc} to be in the neighborhood of .6 (based on the published figures, which are probably not exact for my individual units).

As I stated in the article, I originally wired the speakers in parallel, but then I changed to series in an effort to make an easier load for my amplifier. I would be interested in what you come up with when you apply your equations to the above figure.

SOMETHING DOESN'T MEASURE UP

Congratulations on the article on midrange horns in *SB* 1/86. It seems just what I need to upgrade my home-built Klipschorns.

To get started, I have ordered a pair of Focal 7N303s. While trying to lay out full-size patterns for the horns, however, I discovered the dimensions did not work out.

Just in case Mr. Edgar hasn't noticed, or I have missed something, the triangle for the horn jig with 10" and 3½" sides does not agree with the 11½" hypotenuse.

I decided to charge ahead and discovered a 10" horn length with a 9" by

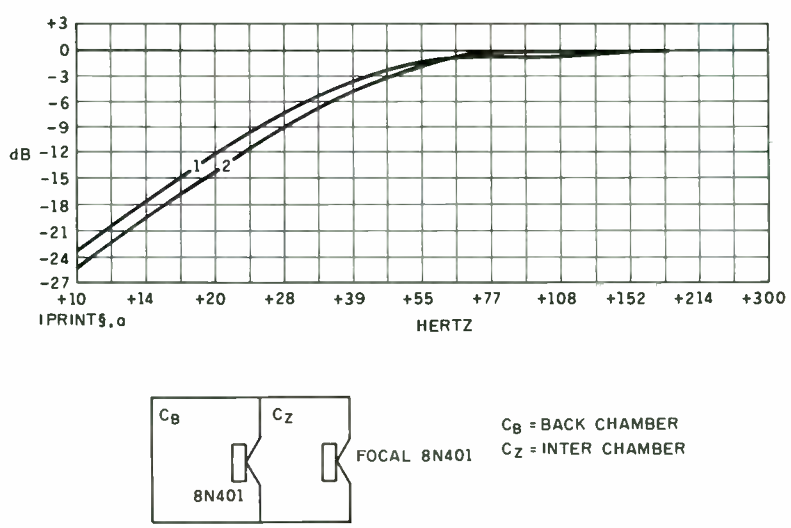

FIGURE 1: (1) Response of Focal Kit 350, and (2) theoretical Butterworth response of Focal Kit 350 with the same C_Z as in catalogue.

18″ mouth would have a 10.59″ hypotenuse and about a 2.1″ throat—not far from his dimensions. When I truncated it to a 6″ length horn (the "short horn" for the Focal), I found it would have a 4.8″ by 3″ throat, not far from the article's 4″ by 2.5″. But the photograph on the magazine cover appears to have a flush opening to the throat on one side, and only a slight shoulder on the other. So, I have stopped and am writing for help.

In the same issue, Mr. Edgar offers help on bass horns. I would appreciate his comments and suggestions on my upgrading plans. The second of my Klipschorns was built with the aid of Speakerlab's drawings (circa 1974), while the first was built from plans in *ElectroVoice* for their Patrician (four speakers including an 18″ woofer). I simply reduced the throat size, left all other dimensions alone, and used 15″ speakers. This was early 1950. Now, both horns have 15″ 4Ω "off brand" speakers from McGee (said in 1983 to be the same as used by Klipsch).

With Mr. Edgar's midrange horns installed, I hope to cross over at 350–400Hz and eliminate the 12″ horn-loaded speaker in the Patrician, which covers the 350–800Hz range. The improved symmetry has to help.

Incidentally, I am still running the four speakers in the Patrician and three in the newer Klipschorn because the Patrician sounds better. It tests better on the low end, but rougher above 500Hz or so.

Any suggestions for additional improvements on the bass end? Over the years, my tests show a roll-off at frequencies above 250–300Hz, with a valley in a frequency in between the adjustments on the equalizer (i.e. 250 and 500Hz).

The lower cutoff on the midrange (if it is flat to sufficiently low frequency) should help, but the components in the crossover become rather large.

Ed O'Donnell
Monroe, LA 71201

Contributing Editor Bruce Edgar replies:

Thank you for catching the error. The on-axis length of the horn should be 11″ instead of 10″. I committed the cardinal sin of relying on my memory instead of going back and checking my original model. For the mid and short horn models, however, the mistake results in only a small error. The full-size horn is where the mistake will make the most impact when lining up the dimensions. I suggest potential horn builders lay out all of the dimensions on graph paper and cardboard to check the design.

Your choice of a Focal driver for the horn will give 100dB sensitivity. A typical bass horn will give 105dB or more. You may have to attenuate (or bi-amp) the bass horn to equalize the system.

The driver on the cover (SB 1/86) is actually offset, although the angle gives the illusion of being flush-mounted. Also note that Polydax

SB *Mailbox*

absorbed Siare last year, and they'll soon be producing the Siare 16VT drivers.

Regarding your bass horns, it is difficult to judge their characteristics by correspondence, but you should be able to cross over at 400Hz with good results. The best bass response results when the horn throat area is equal to the driver optimum throat size, given in square inches by $S_T = 0.8 f_s Q_{ES} V_{AS}$, where V_{AS} is in cubic feet. If there is a significant mismatch, an irregular response can result, as shown by the Speakerlab horn fiasco.

Many times, it is hard to find a modern driver that will match some of the bass horn designs. I've had this experience, and eventually had to junk the old horns. In my own case, I've taken a good bass driver, an EVM-12L, and designed a horn about the driver. Only in this way are you assured of obtaining the optimum bass response.

SONIC AND AESTHETIC PROMISE

I join the increasing number who are most impressed by the work of Mr. D'Appolito (*SB* 4/84), and have noted with interest the voluminous correspondence regarding the "D'Appolito configuration." Just as Mr. Bosch (*SB* 4/85) has requested information on alternate drivers, I would like Mr. D'Appolito's information on the crossover, and other considerations for using the Dynaudio 6½" 17W54ER drivers with the D-28 mentioned in his original article.

The substitution of these larger and more efficient low/midrange drivers should offer me higher sound pressure levels and a smaller amplifier requirement. In addition, the bass output to somewhat lower frequencies will permit the satellites to be used *a la* LS3 as a fine Phase I system until I can afford to expand my system (*Table 1*).

TABLE 1

Phase	Amp.	Xover	Satel.
I	NAD-2200	1.7k-2k passive	(2) 17W54ER (1) D-28
II	Same as I, with added 100Hz	passive	30W54 subwoofer
		active	
III	NAD-2150	>1.7k	D-28
	NAD-2200	100-1.7k	(2) 17W54ER
	NAD-2150	<100	30W54

One of the compelling reasons why I chose the "D'Appolito configuration" is the potential for superb imaging. I am concerned, however, about handling the coloration caused by diffraction losses at the edges of the satellite enclosures (D'Appolito's suggestion of mounting the front panel flush with the listening room wall is frequently impractical in domestic living rooms).

I have a design called a Trispheric enclosure, which I believe offers sonic and aesthetic promise. The three fiberglass-reinforced plastic spheres are light, rigid, have smoothly-receding surfaces from the driver rims, absorb the rear emission of the 6½" drivers, have an enclosed volume of approximately 13.9 liters, and provide approximate geometric voice coil plane alignment.

When the Trispheres are used alone, they can be ceiling-suspended (after Linkwitz, *SB* 2, 3, 4/80). When the Phase II subwoofers are built, they will make appropriate supports for the Trispheres.

My present system consists of four-way towers (home designed and constructed: 12" Becker polypropylene., 150cps crossover; 8" Becker polypropylene, 1000cps crossover; 2" Peerless dome, 5000cps crossover; 1" Peerless dome), driven by a NAD 1155/2200 fed by AR/Rega 300b/Talisman B. Knowledgeable friends admire its sound—powerful, quick, smooth, with good sound-stage. Although its imaging is good, I am not satisfied with the stability of the image locations for all instruments, as they move about in frequency. I believe the Phase III system (described in the table) should be a substantial improvement.

Al Millikan
Victor, NY 14564

Contributing Editor Joe D'Appolito replies:

I am certain the Dynaudio 17W75s can be made to work very well in my (3,2) geometry. They are fine drivers. I started experimenting with them over a year ago, but when I determined they would generate only about 2dB more maximum SPL than either the KEFs or Focals, I lost interest in them.

Your Trispheric enclosure will not eliminate diffraction loss, although it may produce a somewhat smoother response falloff relative to box shape. I believe you are confusing "diffraction loss" with "edge diffraction," which is a different manifestation of the general diffraction problem. Diffraction loss is a function of baffle area, and cannot be eliminated by contouring.

The 17W75s can be made to go about a half-octave lower than the KEF B110s in a sealed enclosure. The volume of your Trispheric enclosure, however, is too small for the 17W75s. This volume will produce a system resonance of 95Hz or so, with a Q of 1.8 or more, which is too high. You need a sealed volume of 25 to 30 liters for the 17W75s, which will yield a system resonance of 60Hz or so, a Q of around 1, and an f_3 of 50–55Hz.

I believe SB readers would be interested in learning how to build fiberglass reinforced enclosures. If you could increase the volume of your Trispheric enclosure, or perhaps consider a cylindrical enclosure which would also minimize edge diffraction, you should have an interesting project.

DUAL DRIVER CLARIFICATION

While trying to understand the various explanations offered by Mr. D'Appolito (*SB* 4/84) concerning the relative power sensitivities of dual drivers in parallel and series configurations, I found a great deal of clarification by not expressing voltage and power ratios in decibels.

In the hope this approach may help other readers, I have tabulated my calculations in *Table 1*.

TABLE 1

Driver(s)	Volt.	Cur./A	Input/W	SPL	SPL/Inp.
1	2.83	0.35375	1	1	1
2*	2.83	0.7075	2	2	1
2*	2.00	0.5	1	1.413	1.413
2*	1.415	0.35375	0.5	1	2
2†	2.83	.17688	0.5	1	2

* Parallel; † Series

The last column represents "power sensitivity". It clearly shows that, "for any given SPL, the amplifier always works harder with a single driver than with a pair of drivers."

While this has clarified the "power sensitivity" issue for me, it has raised another problem: since acoustic output power ought to be proportional to electrical input power, the double drivers, while producing the same SPL, produce only one-half the acoustic power that a single driver would produce at the same SPL. Would Mr. D'Appolito be kind enough to comment on this?

David Meraner
Scotia, NY 12302

Contributing Editor Joe D'Appolito replies:

If different driver configurations produce the same SPL (and have the same polar response), then they will put out the same acoustic power. For a given driver configuration, acoustic output power is proportional to electrical input power, as Mr. Meraner states. Double driver combinations, however, have twice the efficiency of a single driver, and therefore put out the same acoustic power with only one-half the electrical input power. This is a major benefit of multiple drivers.

Another point that may be confusing is that acoustic output power is proportional to the square of acoustic pressure, just as electrical *power is proportional to voltage squared. In the parallel driver cases in Mr. Meraner's letter, input power goes from 0.5 to 2W (a factor of 4 increase), while acoustic pressure only doubles. Acoustic power, however, which is proportional to pressure squared, has gone up by a factor of four, as it should.*

BEWARE OF "USELESS SILICONE"

Since everyone seems intent on using silicone to fasten and seal drivers into their cabinets, you should know that most silicone available today is useless. The most common, such as GE Home Line, are apparently latex or water-based, slow-curing with poor tensile strength, and don't adhere well to anything.

Try RTV type silicone, the stuff TV techs use. It stinks to high heaven (label says, "caution—releases acetic acid when curing"), but it cures quickly, is very strong, and has excellent adhesion. It's harder to find, but works much better than other types of silicone.

Although I use RTV to seal my cabinets, I prefer to mount the drivers with T-nuts mounted to the *inside* of the cabinet. I use auto body ribbon putty to seal the drivers: it's less messy, removable, and reusable. Any auto parts store should have it.

When wood-gluing small pieces together, I find that a small bead of hot glue will usually hold the surfaces together until the wood glue dries. The pieces can be handled and probably won't need clamping. 3M® #76 Spray Adhesive comes in very handy, too.

C.J. Poulos
Hartford, CT 06106

A VETERAN OFFERS POINTERS

As a cabinetmaker and persistent pursuer of excellence in loudspeaker construction, I wish to share a few pointers that have worked well for me.

• If you plan to assemble your own loudspeaker cabinets, look in your area for a rent-all machinery company that can provide a compressor, pneumatic epoxy-tipped staple firing gun, and hose and couplers.

• Adhesives, especially for particle board-type compound material, provide speedy cabinet assembly and a reliable grip. These cabinet materials *do not* readily lend themselves to nails, screw fasteners, or surface adhesion because of their inherent small particle make-up and their thin composition layer. I use a 3/16" crown staple with rosin or epoxy tipping, in conjunction with laminated high-density particle board/lead-type sheeting and other internal composition high-density materials. These meet or exceed the specifications touted by many of today's "advanced" loudspeaker cabinet products. I am currently working with Corian, developed by DuPont. It has many wonderful acoustic and aesthetic properties when used in conjunction with other materials. It costs about $11/square foot, but it's very easy to machine to size and shape.

- I have also had tremendous results with the epoxy products made by Gougeon Brothers, Inc. (Bay City, MI). I have found that using their line of epoxy/filler with a thin foam-backed, high-density material (particle board, plywood, Corian, and so on), makes for a very dead cabinet enclosure.

Comments? Call me at (609) 890-0520.

Kirk Neal
Mercerville, NJ 08619

EQUATION DEBATE

In the article "Custom Wound Inductors" (*SB* 3/82), I believe there is an error in one of the equations. On page 21, author Daniel Patrick Coyle gives the equation:

$$A = \sqrt{(To)(Z)/(5590)(R)}$$

where "A" is a crucial dimension of the winding. The equation as given is correct only for first order crossovers.

I believe the correct equation should be:

$$A = \sqrt{(L)/(5990)(R)}$$

where "L" is the inductance in microhenries. This equation should be correct for inductors of any order crossover.

Kenneth Miller
Mexico, MO 65265

Mr. Coyle replies:

The equation is not in error. I may misunderstand what you intend, but by substituting "L" for (To)(Z), you have created an equation which now describes only the first order parallel Butterworth crossover.

Figure 2 of my article shows only the first order network has an "L" that equals (To)(Z). The values of "L" for other orders have an additional fudge factor, such as the second order, which has an "L" value increased by 2.

By computing the value of "L" as a function of crossover type, speaker impedance, and voice coil inductance (as described in the article), the generality of my equation is retained.

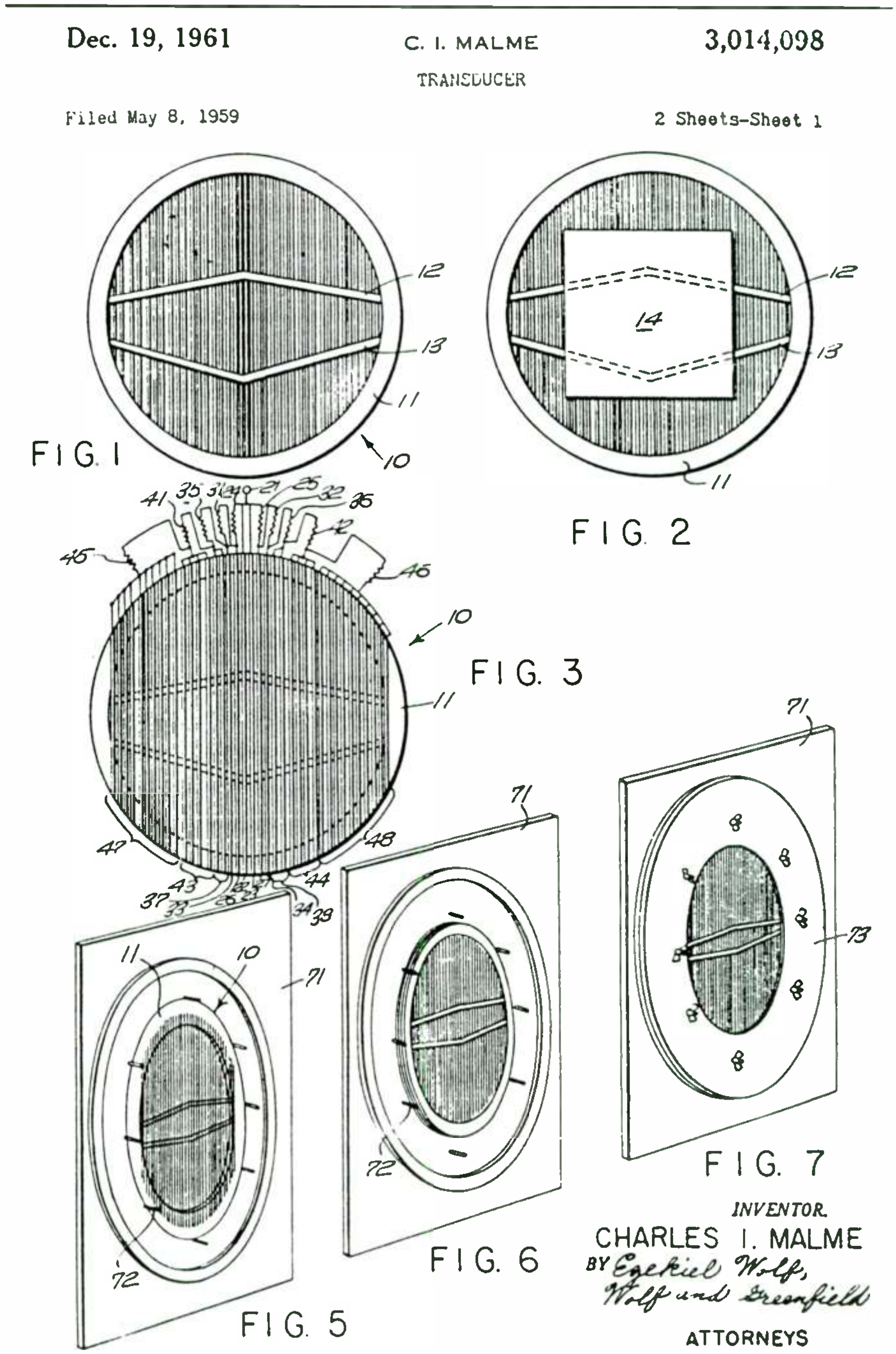

FIGURE 1: Detailed overleaf of Malme's ESL.

MALME'S ESL

My 4/85 issue of *SB* finally came today. It seems to be taking longer and longer for it to reach here from Holland. No doubt, the final 1985 issue of *TAA* will arrive shortly.

In Mailbox (*SB* 4/85, p. 58), Mr. Rice asks about ESLs. Here is a detailed overleaf which indicates one Charles Malme obtained a US patent for a round ESL construction. The patent contains a detailed analysis of the construction, so I hope Mr. Rice can locate the complete papers.

Tony Fitchett
Wellington, New Zealand

TWEETER TESTING

I read, with considerable interest, Alan Smith's letter (*SB* 1/86) concerning his experience with piezo tweeters. It led me to do a couple of experiments with my 2″x 5″ and 2″x 6″ tweeters, and I'd like to share the results.

My setup is shown in *Fig. 1*. For a signal source, I used the CBS Lab 140 record, octave sweeps, right channel. Results from the experiments can be found in *Fig. 2*.

Subsequent to my tests, I came across the published response of the 2″x 6″ piezo and I plotted it as well. Notice that the data

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SB Mailbox

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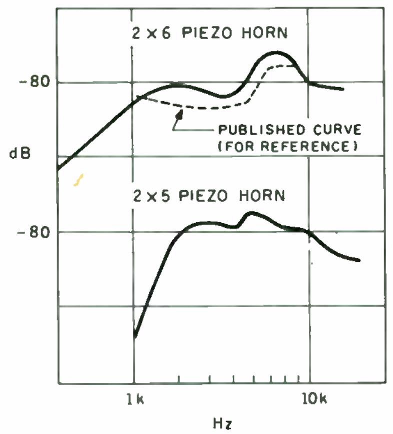


FIGURE 2: Results from the tweeter test.

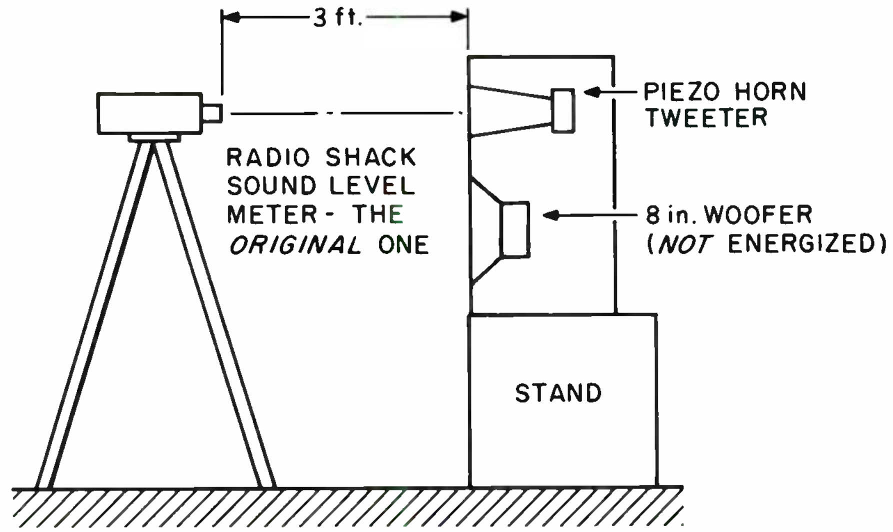


FIGURE 1: Mr. Meraner's tweeter experiment setup.

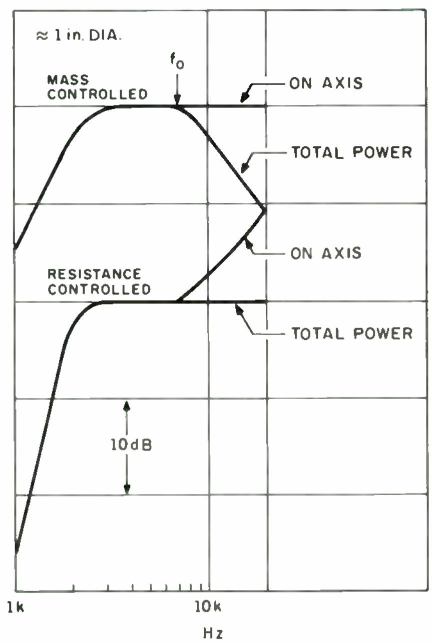


FIGURE 1a: Constant power response and rising on-axis response for a speaker with f_o of 7kHz.

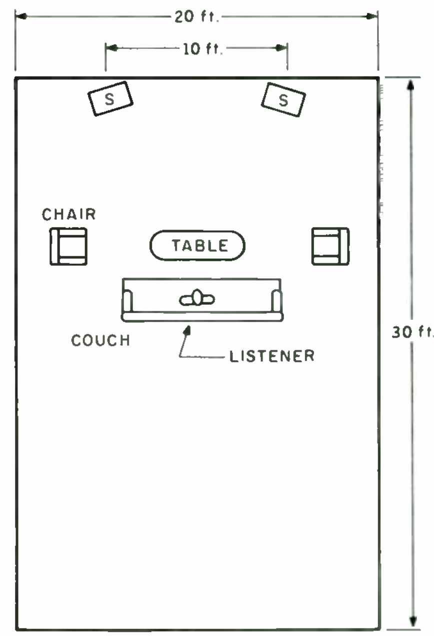


FIGURE 2a: In this listening arrangement, you are closer to the speakers than to ⅔ of the reflecting surfaces.

shows a prominent peak between 5 and 10kHz. I tried, without success, to trap out this peak. Perhaps I'll try again because, with its extended low end, the piezo might make a good midtweeter.

The way it sounds now, I'm not happy, though I agree it sounds better than the 2″ x 5″.

Dave Meraner
Scotia, NY 12302

Mr. Smith replies:

I have been rather surprised by the number of people who have contacted me directly as a result of my letter.

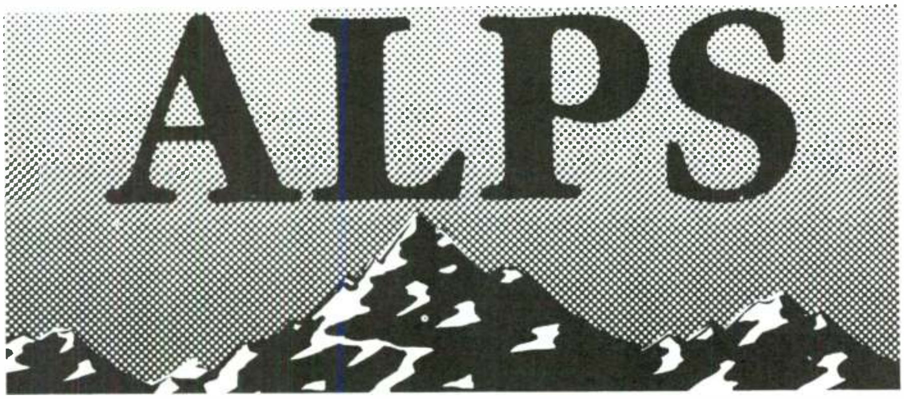
I'd like to offer some comments on your test procedure, testing in general, speaker characteristics, and the nature of perceived frequency response. These interrelated topics should be considered in both the design and use of speaker systems.

Speakers can be divided into two classes: mass controlled (cone or dome) and resistance controlled (horn loaded). Below a frequency f_o, defined as having a half- wavelength equal to the effective diameter of the radiator, both the on-axis frequency response and the power response (my term for total acoustic radiated energy) tend to track one another. Above f_o, the on-axis response of a mass controlled radiator tends to remain constant, and the power response rolls off (at about 6dB/octave). The resistance controlled radiator tends to maintain a constant power response and a rising on-axis response. In both classes, these characteristics result from the narrowing of the dispersion pattern. Fig. 1a *depicts this information for a speaker with a f_o of 7kHz.*

We know both the axial frequency response and power response can be measured, but which measure correlates with the perceived frequency response? Consumer Reports, High Fidelity, *Julian Hirsch, and Roy Allison, among others, place more weight on the power response characteristics. Richard Heyser, Siegfried Linkwitz, at times KEF, and quite a few others give more weight to the axial frequency response. AR, in its most recent designs, attempts to narrow the dispersion of mass controlled drivers and to delay the remainder of the power response, which, in effect, reduces the power response contribution to perceived response. Amar Bose attempts to reduce the axial response contribution to the perceived response (see note on groupings).*

Which school of thought is correct? All are, depending on the circumstances. Picture the listening arrangement in Fig. 2a. *You are closer to the speakers than to two-thirds of the reflecting surfaces. This attenuates the level of sound from off-axis sources. In addition, a longer air path delay occurs, moving much of the power response information out of the human "integration window." On the other hand, consider the more modest listen-*

Continued on page 56



With much of the quality of your audio project depending on its controls, can you afford less than the best? The tactile interface between electronics and listener should feel smooth yet solid. This aesthetic blend of quality sound and quality feel is engineered into a quality line of stereo potentiometers. Because of manufacturing and distribution volume requirements controls such as these have been difficult for the individual to obtain. Old Colony Sound Lab, *through a special purchase, is able to offer the builder of quality audio equipment the finest in rotary controls—**Alps**.*

The **VR100KB** is a stereo volume control. It has logarithmic taper, 100kΩ, with 41 detents. Tracking error is less than 2dB from 0 to −70dB. Case size is 25 × 25.3 × 27mm HDW. Shaft length is ½" beyond mounting bushing. Full shaft rotation is 300° ± 3°. This control accepts standard ¼" knobs. Mounting hardware is included. (Same taper as VR20KB)

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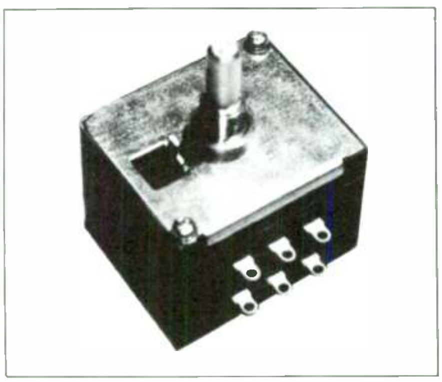

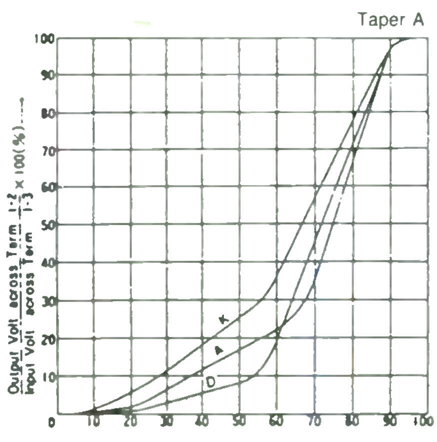

The **VR-20KB** is a stereo volume control without steps or detent. Its full resistance is 20kΩ per section, dual section. The taper is logarithmic (audio). Tracking error is less than 1.5dB from 0 to −60dB. The case is 34 × 33.5 × 40mm. The shaft is ½" long, flatted and accepts standard (¼") knobs. Full rotation is 315° ± 3°. Mounting hardware is included with the control.

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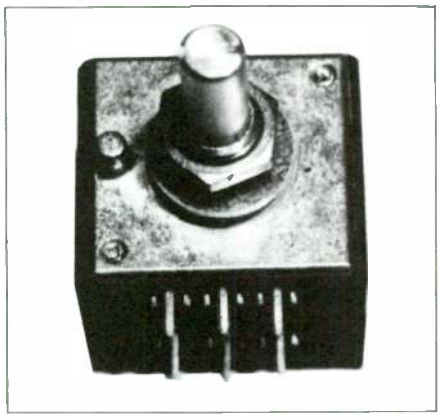
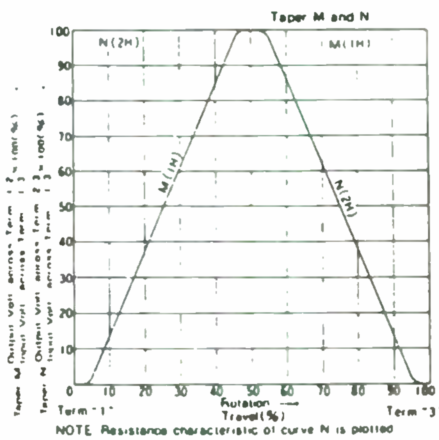


NEW

The VR-250KB is a dual 250k volume control with 41 detents. It is ideal for use in tube-type preamplifiers and especially for all Dynaco PAS preamps. Its two sections are matched within ± 2dB from 0 to 70dB assuring excellent tracking. (The taper is identical to the one shown for the VR-20KB.) Size: body 25 x 25.3 x 27mm (HxWxD) (lugs project 5mm above Ht. measure). Shaft length is 13mm beyond mtg. bushing. 300° shaft rotation ± 3°, accepts standard ¼ knobs. Mounting hardware included. Ppd. Each **$27.00**



The **VR100KD** is a stereo balance control. The sections are M and N tapered. A single detent is provided at the center of the 300° ± 3° rotation. Tracking error is less than 2dB, from 0 to −70dB. The case is 25 × 25.3 × 27mm HDW. The ½" long shaft accepts standard knobs. Mounting hardware is included.

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ing room in Fig. 3. *Three-fourths of the reflecting area is closer to you than to the speakers, so in level alone, the axial contribution to the perceived response is greatly attenuated. In addition, a number of the air path delays are only marginally longer than the axial air path, and, therefore, fall within the human "integration window."*

I suspect that reviewers and designers whose perceived response correlates with their axial measurements have listening situations similar to Fig. 2a, *while those whose perceived response correlates with their power measurements have listening situations similar to* Fig. 3.

By using a 3" distance, you have measured the on-axis output of the 2" x 6" and 2" x 5" piezo horns, while I have measured the power response of both speakers by using a 14' distance between the speaker and the sound level meters (SLM). This also places the SLM about 3' from the wall opposite the speakers. I implied, but did not state, in my original letter to SB *that I am in the power response camp. Six of the seven listening rooms I have had in the past 19 years have been closely modeled after* Fig. 3.

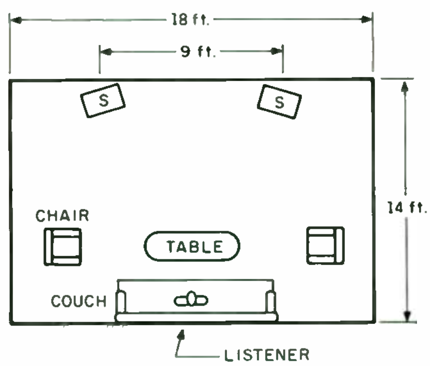

FIGURE 3: Three-fourths of the reflecting area in this arrangement is closer to you than to the speaker.

I am quite familiar with the original Radio Shack SLM. I have two of them. In Stereo Review *(8/82), Julian Hirsch tested the original Radio Shack SLMs and published a response curve based on a comparison with his calibrated microphones. In* Fig. 4, *I have applied a correction, based on the Hirsch test, to your piezo tweeter test results. (I had to redraw your results because my graph paper had a different horizontal scale.) In* Fig. 5, *I have drawn theoretical on-axis curves for: a horn using a 2" driver and a low frequency cutoff of 2kHz (i.e., the 2" x 6" horn); a horn using a ¾" driver with a 5kHz low frequency cutoff (i.e., the 2" x 5" horn). When*

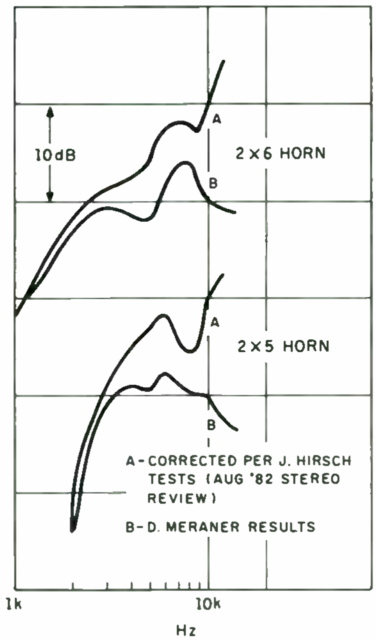

FIGURE 4: Mr. Smith's corrected test results based on the Hirsch test.

you overlay Fig. 5 *on* Fig. 4, *you can see that the 2" x 6" tweeter has a broad (low Q) peak of about 1.5dB centered at 6kHz, and a somewhat narrower (high Q) notch of about 2.5dB centered at 9kHz. This is very good performance for real world speakers (a lot of highly touted speakers don't come close to this performance level). Doing the same analysis on the 2" x 5" tweeter, we find a relatively high Q peak and notch situation, with a peak to trough level variation of a least 4.5dB.*

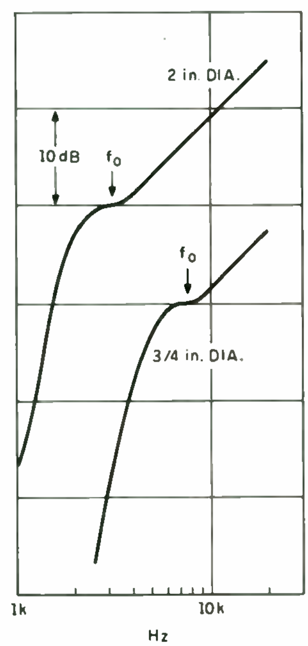

FIGURE 5: Theoretical on-axis curves.

I believe this data supports my conclusion that the 2" x 6" Motorola piezo horn is a viable tweeter for high fidelity use when you are in the reverberant listening area (Fig. 3). *It also supports my view that the 2" x 5" and 3½" horn piezo tweeters (using the small piezo driver) are not suitable for hi-fi applications.*

What if you wish to use the 2" x 6" tweeter and your listening room resembles Fig. 2a? *I offer the following suggestions:*

- *Make the room resemble* Fig. 3.
- *Use the pre-amp tone controls to provide a gentle high frequency roll-off.*
- *Design a frequency dependent acoustic lens that will steadily increase dispersion as the frequency rises, to compensate for the natural narrowing of dispersion above f_0. This is my favorite approach, and likely the most elegant solution.*
- *Suggestions 1-3 will improve the sound of the 2" x 6" piezo, but I don't think electrical notch filters will help. NOTE: Some of the people mentioned in paragraph four may take issue with my groupings, but they are based on my perceptions as formed over the past 20 years.*

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1. Augspurger, G.L., "Electrical vs. Acoustical Parameters in the Design of Loudspeaker Crossover Networks," *Journal* Audio Engineering Society, June 1971.
2. Hirsch, J., "Equipment Test Reports", *Stereo Review*, August 1972.

Continued on page 58

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ordered with 2 kits above, Each **$7.00**

KK-7: WALDRON TUBE CROSSOVER POWER SUPPLY. [3:79] Includes board, x-fmr, fuse, semiconductors, line cord, capacitors to power 4 tube x-over boards (8 tubes), 1 stereo biamped circuit. Each **$88.00**

SBK-A1: LINKWITZ CROSSOVER/FILTER. [SB 4:80] 3-way x-over/filter/delay. 24dB/octave at 100Hz and 1.5kHz and 12dB/octave below 30Hz, with delayed woofer turn-on. Use the Sulzer supply KL-4A with KL-4B or KL-4C.
Per channel **$64.00** Two channels **$120.00** SBK Board only **$14.00**

SBK-C1A: JUNG ELECTRONIC 2-WAY CROSSOVER. [SB 3:82] 30Hz filter with WJ-3 board & 4136 IC adapted as 1 channel x-over. Can be 6, 12 or 18dB/octave. Choose frequency of 60, 120, 250, 500, 1k, 2k, 5k or 10k. Each **$24.75**

SBK-C1B: THREE WAY, SINGLE CHANNEL CROSSOVER. [SB 3:82] Contains 2 each SBK-C1A. Choose high & low frequency. Each **$49.70**

SBK-C1C: TWO CHANNEL, COMMON BASS CROSSOVER. [SB 3:82] Contains 2 each SBK-C1A. Choose 1 frequency. Each **$49.70**

SBK-C2: BALLARD ACTIVE CROSSOVER. [SB 3,4:82] 3-way x-over with variable phase correction for precise alignment. Kit includes PC board ($5^3/_8 \times 9^1/_2$"), precision resistors, polystyrene & polypropylene caps. Requires ± 15V DC power supply—not included. Can use KL-4A with KL-4B or C. Two channel **$134.00**

FILTERS & SPEAKER SAVER

KF-6: 30Hz RUMBLE FILTER. [4:75] 2 channel universal filter card, 1% metal film resistors and 5% capacitors for operation as 18dB/octave; 30Hz, 0dB gain only. Each **$19.75**

KH-2A: SPEAKER SAVER: [3:77] Turn on/off protection & fast opto-coupler circuitry to prevent damage to your system. 4PDT relay & socket for 2 channels. Each **$40.00**

KH-2B: OUTPUT FAULT OPTION. Additional board mounted components for speaker protection in case of amplifier failure. Each **$6.75**

KH-2C: COMPLETE SPEAKER SAVER KIT. Includes KH-2A & KH-2B. Each **$40.00**

KL-5 WILLIAMSON BANDPASS FILTER. [2:80] 2 channel, plug-in board and all parts for 24dB/octave 20Hz-15kHz with precision cap/resistor pairs. TL075 IC's. Each **$31.00**

AIDS & TEST EQUIPMENT

KH-7: GLOECKLER PRECISION 101dB ATTENUATOR. [4:77] All switches, 1% metal film and 5% carbon film resistors to build prototype. Chassis, input/output jacks are not included. Each **$55.00**

KL-3C: INVERSE RIAA NETWORK COMPLETE. [1:80] 1 KL-3R and 1 KL-3H with 1% polystyrene capacitors. Alternate 600 ohm or 900 ohm R_2'/C_2' components for 2 channels. Each **$35.00**

KL-3R: INVERSE RIAA. [1:80] Resistor/capacitor package complete. Contains stereo R_2'/C_2' alternates. Each **25.00**

KL-3H: INVERSE RIAA HARDWARE. [1:80] Box, terminals, gold jacks, and all hardware in KL-3C. No resistors or caps. Each **$13.50**

KJ-6: CAPACITOR CHECKER. [4:78] All switches, IC's, resistors, 4½" D'Arsonval meter, x-fmr and PC board to measure capacitance, leakage and insulation. Each **$78.00**

KK-3: THE WARBLER OSCILLATOR. [1:79] Switches, IC's, x-fmr and PC board for checking room response and speaker performance w/o anechoic chamber. Each **$56.00**

KL-6: MASTEL TIMERLESS TONE BURST GENERATOR. [2:80] All parts with circuit board. No power supply. Each **$19.00**

KM-1: CARLSTROM-MULLER SORCERER'S APPRENTICE [2:81] 4 boards and all parts for construction of the first half of a swept function generator with power supply. No knobs or chassis. Each **$145.00**

KM-2: CARLSTROM-MULLER PAUL BUNYAN. [3:81] All parts except knobs, chassis, output connectors and wire. Includes 2 circuit boards and power supply. Each **$85.00**

KM-3: CARLSTROM-MULLER SORCERER'S APPRENTICE/PAUL BUNYAN [2:81, 3:81] All parts in KM-1 and KM-2. Each **$225.00**

SBK-D2 WITTENBREDER AUDIO PULSE GENERATOR. [SB 2:83] All parts, board, pots, power cord, switches and power supply included. Each **$70.00**

SBK-E4: MULLER PINK NOISE GENERATOR. [SB 4:84] All parts, board, 1% MF resistors, capacitors, IC's, and toggle switches included. No battery or enclosure. Each **$27.50**

SYSTEM ACCESSORIES

KH-8: MORREY SUPER BUFFER. [4:77] All parts, 1% metal film resistors, NE531 IC's, and PC board for 2 channel output buffer. Each **$16.00**

KJ-3: TV SOUND TAKEOFF. [2:78]. Circuit board, vol. control, coils, IC, co-ax cable (1 ft.) and all parts including power x-fmr. Each **$21.50**

SBK-D1: NEWCOMB PEAK POWER INDICATOR. [SB 1:83] All parts & board. No power supply required. Two for **$10.00** Each **$6.00**

SBK-E2: NEWCOMB NEW PEAK POWER INDICATOR. [SB 2:84] All parts & board, new multicolor bar graph display; red, green & yellow LED's for 1 channel. No power supply needed. Two for **$17.00** Each **$11.50**

KC-5: GLOECKLER 23 POSITION LEVEL CONTROL. [2:72] All metal film resistors, shorting rotary switch & 2 boards for a 2 channel, 2dB per step attenuator. Choose 10k or 250k ohms. Each **$36.75**

KR-1: GLOECKLER STEPUP MOVING COIL TRANSFORMER. [2:83] X-fmrs., Bud Box, gold connectors, & interconnect cable for stereo. Each **$335.00**

KL-2: WHITE DYNAMIC RANGE & CLIPPING INDICATOR. [1:80] 1 channel, including board, with 12 indicators for preamp or x-over output indicators. Requires ± 15V power supply @ 63 mils. Single channel. Each **$49.00**
Two channels. **$95.00** Four channels. **$180.00**

• KS-7: SCOTCHCAL® PANEL KIT. [2:84] One 10 × 12" sheet each of 4 types of pressure sensitive panel material (blk on aluminum, blk on transparent poly, blk on white poly, matte clear overlay), one pint of developer plus pads, and instructions. Requires a simple frame and a light source: ultraviolet, photofloods or the sun, plus your own press-on lettering materials. Postpaid. Each **$34.50**

• CLOSEOUT: KITS NOT AVAILABLE AFTER PRESENT STOCK IS GONE.

What's Included? Kits include all the parts needed to make a functioning circuit, such as circuit boards, semiconductors, resistors and capacitors. Power supplies are not included in most cases. Unlike kits by Heath, Dyna and others, the enclosure, face plate, knobs, hookup wire, line cord, patch cords and similar parts are not included. Step by step instructions usually are not included, but the articles in ***Audio Amateur*** and ***Speaker Builder*** are helpful guides. Article reprints are included with the kits. Our aim is to get you started with the basic parts—some of which are often difficult to find—and let you have the satisfaction and pride of finishing your unit in your own way.

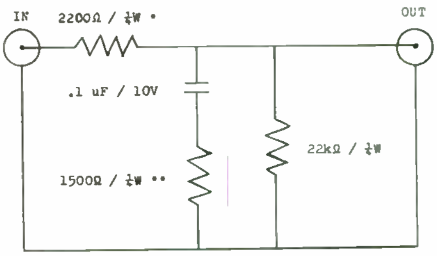
SB Mailbox

Continued from page 56

EXPERIMENTING WITH AUDAX

I have done some experimenting with the Audax AM 78 GSM (nearly identical to the Audax HIF 78 BiSM) 3" full-range driver that I mentioned in "Tools Tips, and Techniques" (*SB* 2/86). When mounted in a narrow cabinet, this driver sounds as though it has a drop in its response below 1000Hz. This is possibly due to "diffraction loss" (see Joe D'Appolito's discussion in *SB* 4/84).

I have come up with a simple and flexible *passive* correction network (*Fig. 1*). To



• Try 3300Ω for larger speakers.
•• Replace with 10kΩ audio taper potentiometer for added flexibility.

avoid loading problems, the network is designed for use in a tape loop, or between pre and power amps. It should also prove useful with other "forward"-sounding speakers. (Martin Colloms used a similar network in his July 1985 *Hi-Fi News & Record Review* construction project.)

Ralph Gonzalez
Philadelphia, PA 19143

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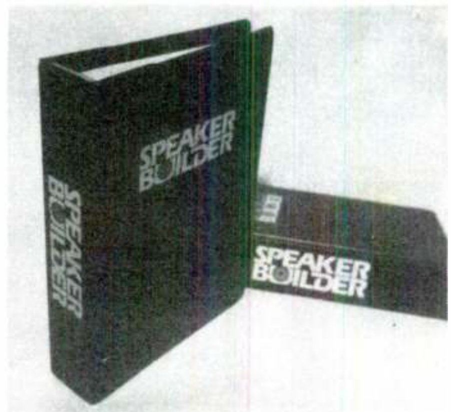

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FALCON ACOUSTICS is one of the largest independent manufacturers of crossover networks and speaker system accessories in the UK, supplying manufacturers, retailers and export. We have outlets in both the USA and Canada. Your guarantee is the trust our manufacturing customers put in the quality and reliability of our networks. **Inductors:** Ferrite (up to 200W), air-cored and transformer; **Capacitors:** Reversible electrolytic 50V/100V, polyester, polycarbonate and polypropylene; **Networks:** choice of over 70 for different unit combinations; **Components & Accessories:** most except for the wood! If you have supply problems, please send for details, $2 air, $1 surface, to our mail order retail outlet. ***FALCON ELECTRONICS***, Tabor House, Norwich Rd., Mulbarton, Norfolk, England NR14 8JT. TTF

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CLUBS

Space in this section is available to audio clubs and societies everywhere free of charge to aid the work of the organization. Copy must be provided by a designated officer of the club or society who will be responsible for keeping it current. Send notices to Audio Clubs in care of the magazine.

MEMPHIS AREA AUDIOPHILE SOCIETY being formed. Serious audiophiles contact J.J. McBride, 8182 Wind Valley Cove, Memphis, TN 38115, (901) 756-6831.

THE INLAND AUDIO SOCIETY IN THE SAN BERNADINO-RIVERSIDE AREAS, recently formed, is now inviting audiophiles in the San Diego, Los Angeles and Orange Counties to join us. Our goal is to share common interests, ideas, construction points, modifications and system changes, and other members' equipment at every meeting. Plans for the future are to invite audio luminaries to lecture, and to incorporate and include "live" music occassionally. We are presently meeting every 5-6 weeks (subject to change). Audiophiles interested contact Frank Manrique, President, IAS, 1219 Fulbright Ave., Redlands, CA 92373, (714) 793-9209.

AUDIOPHILES IN CENTRAL PENNSYLVANIA (also eastern Pennsylvania and Delaware): Interested in forming a serious audio organization? Contact Steve Gray, 625F Willow St., Highspire, PA 17034 or phone (717) 939-4815.

SOUTHEASTERN MICHIGAN WOOFER AND TWEETER MARCHING SOCIETY (SMWTMS). Detroit area audio construction club. Meetings every two months featuring serious lectures, design analyses, digital audio, AB listening tests, equipment clinics, recording studio visits, annual picnic and audio fun. The club journal is *LC, The SMWTMS Network*. Corresponding member's subscription available. Call (313) 477-6502 (days) or write David Carlstrom, SMWTMS, PO Box 1464, Berkley, MI 48072-0464.

CENTRAL FLORIDA AUDIO SOCIETY

meets monthly in Orlando. Come and meet others who share your interest in music reproduction as we audition equipment and recordings or discuss audio related topics.

Contact: Bill Boswell (305) 678-3724
P.O. Box 491, Orlando, FL 32802

CONNECTICUT AUDIO SOCIETY is an active and growing club with activities covering many facets of audio—including construction, subjective testing, and tours of local manufacturers. New members are always welcome. For a copy of our current newsletter and an invitation to our next meeting, write to PO Box 346, Manchester, CT 06040 or call Mike at (203) 647-8743.

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., East 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 hows and whys of audio. Each meeting consists of a lively discussion topic and equipment demonstrations. For information on meeting dates and location, contact Craig Tyau, 2293A Liliha St., Honolulu, HI 96817.

ORGAN MUSIC ENTHUSIASTS: If live recordings of fine theatre pipe organs or electronic organs are your thing, I have over two thousand of them. I lend you the music on reels or cassettes. All operation is via the mail. A refundable dollar will get you more information. E.A. Rawlings, 5411 Bocage St., Montreal, Canada H4J 1A2.

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 annual journal, five bimonthly newsletters, plus participation in meetings and lectures. For more information, send SASE to: CAS, 4506 Osceola St., Denver, CO 80212, or call Art Tedeschi, (303) 477-5223.

THE VANCOUVER AUDIO SOCIETY publishes a bimonthly newsletter with technical information, humor and items of interest to those who share our disease. We have 40 members and meet monthly. Six newsletters per year. Call (604) 299-4623 or write Dan Fraser, VAS, Box 4265, Vancouver, BC, Canada V6B 3Z7. We would like to be on your mailing list.

WASHINGTON AREA AUDIO SOCIETY (N. VA, DC and MD) is looking for sincere audiophiles who are eager to devote their time and get involved with the direction of the society and the publication of a monthly newsletter. Please write: Horace J. Vignale, 5434 Taney Ave., Alexandria, VA 22304-2002.

MINNESOTA AUDIO SOCIETY. Monthly programs, newsletter, special events include tours and annual equipment sales. Write Audio Society of Minnesota, PO Box 32293, Fridley, MN 55432.

FOR SALE

Superphon, gray faceplate, upgraded with factory mods, great sound, $190; Hafler DH-101, unmodified, mint condition, low hours, perfect for Musical Concepts mod, $80; Hafler DH-101 with Musical Concepts Supermod IIIN and LIPS, $170. Plus shipping. Rick Kuroda, 112 S. School St., #410, Honolulu, HI 96813.

Acoustat Model 3 with latest Medallion upgrades, excellent, $1200; Ruby moving-coil cartridge, mint, unmounted, $100; Acoustat RP2a preamp, excellent, $350; SME Series 3 tonearm, $100; Denon DP2000 turntable, mounted in Denon heavy-duty base, excellent, $300. George Sawdy, 9 Long Boot Rd., Bourne, MA 02532.

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An increasing number of readers are telephoning for information about their personal classified ads. Ads are filed as received, set in type late in the magazine production cycle, and put on page approximately one month before the magazine is mailed. Delivery of the mailed magazine can take from four days to three weeks.

Personal classified ad copy that is included in one issue is discarded when it goes on the page, and a new file for the next issue is begun. Ads arriving after the issue closes will be run in the next issue.

We strongly suggest that you keep a carbon or photo copy of your ad. We ask your cooperation in following these rules so that we can give you the best possible service.

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8. If you want an acknowledgment of your ad, including in which issue it will appear, please include a stamped, self-addressed postcard with your ad copy.

Classified Advertising

Warbler oscillator for checking speaker performance (*Audio Amateur* 1/79, p. 22), Old Colony KK-3 kit with reprint (unassembled), $30. Free shipping in USA. Robert Agee, 241 E. Fiesta Green, Port Hueneme, CA 93041, (805) 984-6859 after 5 p.m.

RTR 25″ subwoofer drivers, 6″ voice coil, 11Hz free-air resonance, two matched units available for $1600 or $875 each. Technical help free for cabinet design. Mike Klasco, 39 Menlo Place, Berkeley, CA 94707, (415) 528-1277.

One pair Richard Allen HP10B Bextrene 10″ woofers. Measured specs include Fs=21Hz, Qt=.41, Vas=9.8′, mm=21gr; manufacturer specs include a BL of 20.27, unused, $75 including shipping. Bill Stockler, 2201 King St., Bellingham, WA 98225, (206) 671-3039 evenings.

JBL stage speakers; 15″ E-145s in A7 type enclosures, 12″ E-120s in Ramsdell Audio midrange horns; 2370 horns with 2425H drivers. Complete with EV Tapco cp-x stereo crossover. Speakers used only twice. $1500 plus shipping. Gary Bowling, (713) 795-2085.

Electrostatic custom full-range speakers, $400 (pickup); three pairs Strathearn speakers, $500 (pickup); American Scientific model 910 real-time audio analyzer, $150; Heath model AD-1702 crossover, $135; Stax CPY/ECP-1 cartridge system, $125; Denon 103D (low hours), $50. Bill Meked, (707) 422-2537.

Pair Pyle 15″ woofers, #W-15C 700F, $50 both; MXR Compander Noise Reduction System, $50, (expands dynamic range of tape to 90dB). All items in perfect working order. Includes UPS shipping cost. For information or order, Bob Fontaine, PO Box 158, Marco Island, FL 33937.

Marantz, McIntosh tube amps, Garrand 301, old speaker systems, raw units from Jensen, Tannoy, Altec, JBL, Trusonic, Western Electric. David Yo, PO Box 832, Monterey Park, CA 91754, (818) 576-2642.

JBL LE-5 midranges, $45/pair or best offer. JBL 077 horn tweeter, domestic version of 2405 professional tweeter used in two JBL monitors, 4345 and 4355. Huge, shielded alnico magnet, 6-22.5kHz, leaf country, $75 pair. G. Helman, (718) 858-1587.

NAD 3150, $250; 2150, $165; dbx 2BX, $95. Dan Antle, Box 2092, Vernon, TX 76384, (817) 552-2021.

Four Strathearn ribbons, modified to *SB* 3/85, $300 without transformers. John Vercelli, (415) 558-0254.

Two Panasonic EAS 400 Leaf tweeters, $40 pair; Pair Audax 13PR7 6½″ midrange, $40 pair; Audax Professional Bullet tweeters, new/unused, lists for over $100 each—$60 pair. Don Prock, PO Box 3698, Rubidoux, CA 92509, (714) 683-1677.

Heathkit IG-5218 sine/square wave audio generator with manual, excellent condition, $50. Matthew, (312) 260-1628 or 543-6444.

3D Acoustics three-piece satellite/subwoofer system, excellent shape, walnut veneer finish, original cartons, $220 plus freight. Rafael Lopez, 3340 NW 4th St., Miami, FL 33125, (305) 633-4237 days.

Grace 747 tonearm with extra headshell and new damping reservoir, $100; Hafler DH-101 preamp, $100; Klipsch Heresys black, seldom used, $500. Mark Williams, (717) 888-3220 evenings.

SWTPC 2AS-A ambience synthesizer, stereo bucket brigade delay, good working condition, $55; Hewlett-Packard dual trace 50MHz oscilloscope, works fine except trigger circuits need alignment, $155. Both items complete with manuals and schematics. Joe Blackburn, 4000 Kensington Ave., Richmond, VA 23221, (804) 358-2490.

Marantz 7T stereo console preamp, classic model in near mint condition with both walnut case and accessory handles, $170; Onkyo DX-300 compact disk player, $250. Tom Krehbiel, Box 109, Buffalo, NY 14215, (716) 838-5348.

Heil air-motion transformers. Private collection, great Heils, disco horns, power rings, performance, classics, tempests, more. Some in original factory sealed boxes. Spare diagrams available, $25–$175 each. ReVox A77MIV four-track, 3¾–7½ ips, 150 hours, NABs, manual, original box, stainless faceplate, new condition, $600/trade. Richard Paul Paino, 9536 Bullion Way, Orangevale, CA 95662, (916) 988-0673.

Linn Ittok, $295; Tek 547 scope, $285 (pickup); University 312 12″ two-way speaker, $40; RH 1200Hz horns (no drivers), $50/pair; Proton car amp and separate electronic crossover, $200. Steve Hluchan, (203) 397-4965 (6-10 EST).

SME Series 2 improved arm, non-detachable, $49; *Audio Amateur* back issues, $6/year; Audax HD13D37, Dynaudio D52AF, D21AF, Peerless KJ20DMR, Becker 12″ poly woofer, 40 oz. magnet, Electro-Voice 5P12, SP12B. All best offer. Stephen Fritz, 950 W Chestnut, Apt. D, Lompoc, CA 93436.

WANTED

JBL 8″ speakers perfer LE-8 series; Mac 22S tube cartridges. Steve Hluchon, (203) 397-4965 (6-10 EST).

One pair Strathearn ribbon loudspeakers in new condition. Andy Catanzaro, 3516 Menomonee River Pkwy., Wauwatosa, WI 53222, (414) 466-4863 after 8 p.m.

Radio Systems PW-200 power amp or amplifier modules. Fred Masters, 1622 Goldbach Ave., Bohemia, NY 11716 (516) 589-4260.

Good, used Hafler DH-220 or DH-500 amplifier. Assembled kits ok, if well constructed. Will consider DH-200 if price and condition are right. William D. Payne, 115 Skyline Pkwy., Athens, GA 30606, (404) 546-3187, 8:15-4:30, M-F EST.

Decca ribbon tweeters. C. Zatterlow, 12711 NE 7th Pl., Vancouver, WA 98684. Call collect (206) 254-4719 weekends only.

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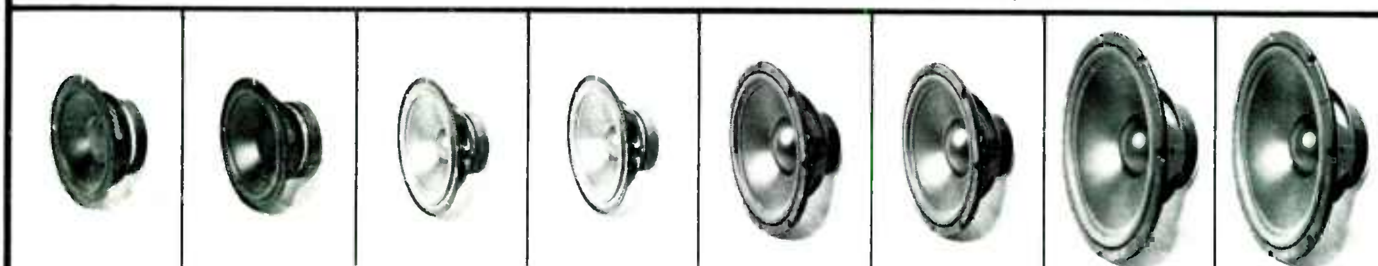

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Speaker:	*Size*	*VC*	*Imp*	*Mag*	*fs*	*Q+S*	*VAS (Cu.Ft)*	*Power**	*Eff*	*Retail Price:*	***McGee Price:***
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TP165R	6-1/2"	1.25	8	15oz.	33	.321	1.41	80	80	38.95	21.95
TX205F	8"	1.25	4&8	20oz.	42	.40	1.73	80	90.5	34.95	19.95
TD205R	8"	1.5	8	27oz.	32	.326	2.12	100	90	47.95	26.95
TX255F	10"	1.25	4&8	20oz.	28	.527	4.31	100	88	40.95	22.95
TD255F	10"	1.5	8	27oz.	23	.252	5.47	150	90	48.95	27.95
TA305F	12"	2.0	8	38oz.	25	.306	6.64	200	89.5	54.95	30.95
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