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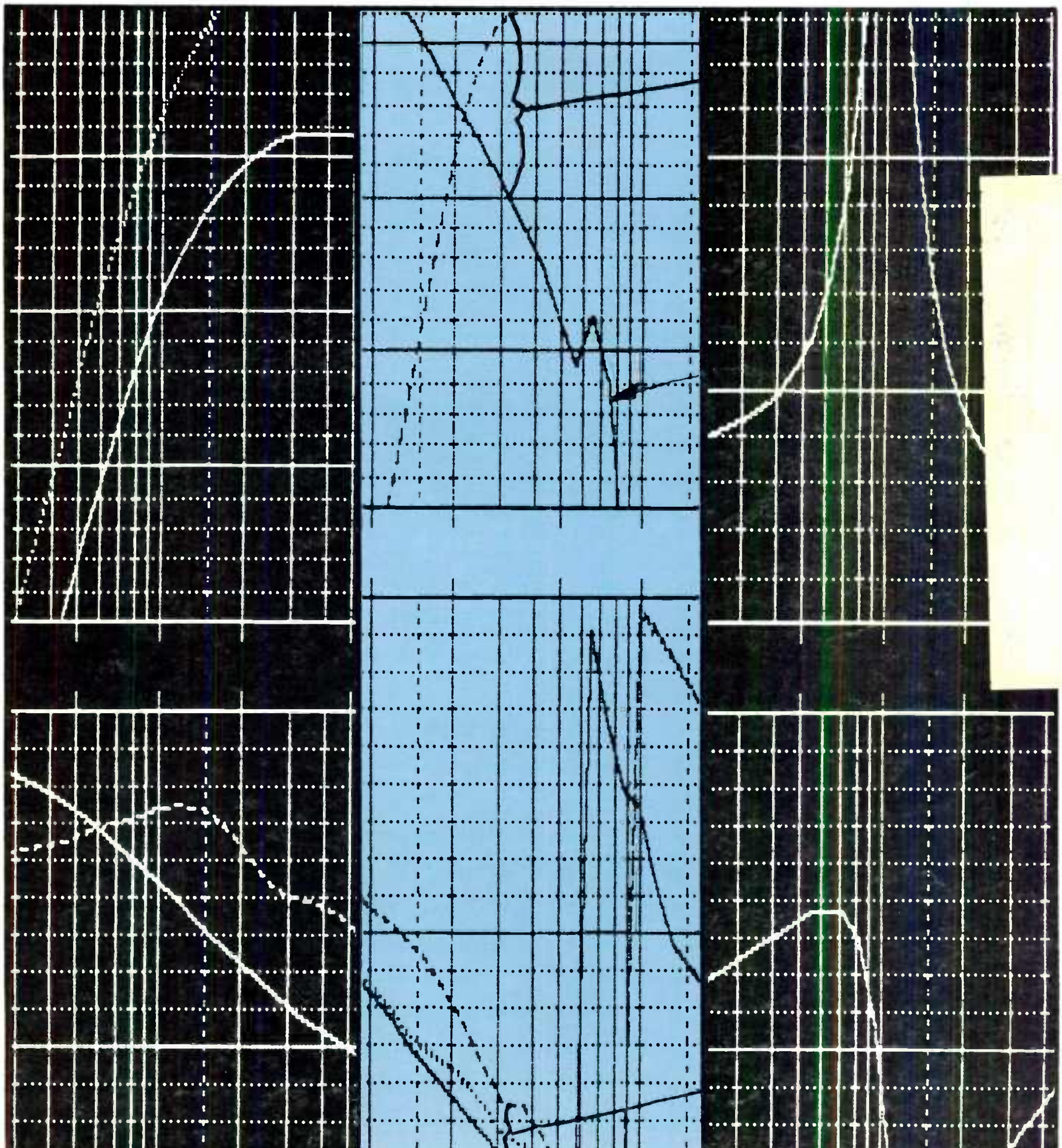
alignment from p 14

Speaker Builder

THE LOUDSPEAKER JOURNAL



ACI Sound that Satisfies...™

The Sapphire IIs and Sub 1s are the top of the ACI line of fine loudspeakers sold factory direct in kit form or assembled and backed by a money back guarantee. Here are a few comments from owners and reviewers.

"*It fills a genuine need by providing deep, clean bass in small and medium-sized rooms at a ridiculously low price in a very compact package.*" Editor Peter Aczel writing about the Sub 1s in the Winter 1991-92 issue of The Audio Critic.

David Rich, reporting in the 1991 Spring-Summer edition of The Audio Critic said, "*In summary, this is an excellent speaker when used in conjunction with a good subwoofer... After eight years, I decided to sell the Spicas and purchase the Sapphire IIs.*"

"*The Sapphire II/Sub 1 system has become my new reference loudspeaker, and I plan to purchase the review samples. They have given me months of musical satisfaction, and I'm looking forward to many more.*" Contributing editor Gary Galo Speaker Builder, Issue Three, 1991.

"*I have owned Magneplaners, Dahlquist and DCM. The Sapphire IIs were the best yet!... and then they broke in!* Mark G., Portage, MI

"*Performance is the best I have ever heard from a direct radiator speaker system. Very realistic sound quality.*" Ronald J., Hampton,VA

"*Quality, Accuracy of sound fantastic imaging, sound similar to best electrostatics I've heard. Getting me to give these speakers up would be impossible. My brother has B&W 800s driven by Krell 300 watt amps. I am in no way dissatisfied listening to my system nor am I broke.*" Ray P., Highlands, NJ

"*I can listen for a long time and not get tired of listening or feel moved to turn the volume down. Voices are very natural...The soundstage is very spacious - wide, deep and stable; localization of voices and instruments is excellent. I didn't think I'd be satisfied after listening to the Magnepans (which are very spacious) for several years but I am.*" Ken C., Morristown, NJ

"*Deep, wide soundstage with height; accurate tonal balance; excellent treble, mid, bass balance, coherence. The music, not the speakers, draw the listener in.*" Chris H., Madison, WI

"*Superb soundstage, precise palpable images, neutral tonal balance, amazing dynamics, very revealing (great detail) without being overly analytical, beautiful finish, easy to assemble! Love the placement flexibility of the satellite/subwoofer arrangement-best of all possible worlds. These are the finest speakers I've owned and I've owned some very sophisticated/expensive competitors: (Snell A's, Celestion SL600's, Accoustat 2+2s etc.) Don't change a thing!*" Neil W., Elgin, IL.

"*Reality: At low listening levels I was at the original recording session. Speaker Builder magazine reviewer Gary Galo's description of these speakers is right on the mark-This is one system the adjectives used are not advertising hype. Thanks for providing more than I've ever heard in any speaker system, reality!*" Rich P., Las Vegas, NV

"*Incredible depth and imaging-solid bass foundation, very musical.*" Robert F., Davis, CA

"*Transparent, detailed sound; easy to listen to. Gives a sense of always hearing timbres right and in a natural space. What goes in is what comes out!*" Jon A., Silver Springs, MD

"*Excellent bass, soundstage very musical and transparent. Excellent product, superior to other speakers three times the price.*" William R., Oshawa, Ont. Canada

"*Rarely do you find all the things said about a speaker (or anything) to be true but there's no hype here. They're exactly as stated. The strongest things are probably the resolution of detail and the incredible extension and ease of the highs. In a "speaker showdown" the Sapphire II's won by consensus. They made the music sound alive. Not bad considering they were the least expensive.*" Larry N., Scotts Valley, CA

"*Depth, separation clarity, uncolored . I sold a pair of Martin Logan CLS = $2500 for them...Imaging, soundstage, definition palpable presence, lively, smooth!*" William B., Staten Island, NY

"*The performance vs. the cost is outstanding. Not only are the Sub 1s worth double their cost, they have greatly improved my Spica TC50's performance.*" Tony W., Tucson, AZ

"*Finally, after searching for 12 years I found a good sounding reasonably priced speaker.*" Dieter Z., Milledgeville, GA

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1-800-346-9183
Questions? call (608) 784-4570
Fax (608) 784-6367

ACI
901 S. 4th St.
La Crosse, WI 54601

Good News

INFINITY SYSTEMS' three-piece satellite/subwoofer system, Micro II, uses two internal 6½" polypropylene-coated woofers to achieve bass response to 40Hz. Each satellite houses a ½" polypropylene tweeter and a 4" polypropylene woofer. Power handling is rated between 20W and 100W RMS (root mean square).

Micro II satellites come with mounting brackets making it possible to install them either vertically or horizontally and rotate them up to 120°. Measuring 8" high and 5½" in diameter, the satellites are magnetically shielded so you can place them safely near video monitors.

You may purchase individual satellites ($179) to use as an outdoor speaker or as a center channel speaker in home surround-sound systems. The complete three-piece system retails for $779. More information is available from Infinity Systems, Inc., 9409 Owensmouth Ave., Chatsworth, CA 91311, (818) 407-0228 FAX (818) 709-9486.

Fast Reply #HG146

PROFESSIONAL AUDIO JOURNALS, INC. announces the publication of the 1957 classic, *Acoustical Engineering* by Harry F. Olson, RCA's legendary acoustical research scientist/engineer. Known for its coverage of loudspeakers and microphones, this reference book is a reprint which will help you solve electroacoustical problems and can be a useful guide for audio professionals. It covers information theory, speech control of machines, underwater acoustics, and ultrasonic applications.

For details, contact Professional Audio Journals, Inc., PO Box 31718, Philadelphia, PA 19147-7718, (215) 465-1975, FAX (215) 336-7743. Also available from Old Colony Sound Lab, PO Box 243, Peterborough, NH 03458, (603) 924-6371; FAX (603) 924-9467.

Fast Reply #HG101

HARBETH ACOUSTICS, manufacturer of one version of BBC-designed LS3/5A monitor loudspeakers, publishes a newsletter devoted to the Harbeth HL-P3. The HL-P3 has low sensitivity similar to the LS3/5A; it is 4–6Ω whereas the LS3/5A is about 10Ω. Overall, the HL-P3 can be driven about 2–3dB louder before running out of capacity. The newsletter includes excerpts of relevant reviews.

For information, contact Harbeth Acoustics, Unit 1, Bridge Rd., Haywards Heath, West Sussex RH16 1UA, England, 011-44 (444) 0955, FAX 011 44 444 0688.

Fast Reply #HG1449

ABILENE RESEARCH AND DEVELOPMENT CORP.'s new textured finish, Texturelac Low VOC, is compliant in most states at 4.7 lbs./gal. Possessing the same physical characteristics as the previous formula, the user can develop variations of textured patterns resembling stone, leather, pebble, cobblestone, stucco, and the like. The maker claims Texturelac saves you 70% in labor and dries within an hour. Swatch samples are available.

For details, contact Abilene Research and Development Corp., PO Box 294, Hewlett, NY 11557, (516) 791-6943, FAX (516) 791-6948.

Fast Reply #HG1057

TECHNICAL AUDIO DEVICES (TAD), a division of Pioneer Electronics, has developed a studio monitor intended to significantly reduce spurious resonance by utilizing non-traditional materials. The monitor features include a frequency response range of 25Hz–20kHz and a sensitivity of 100dB/W/M.

TAD built a model at the Seattle-based Studio X, to adapt advanced technologies to a refined acoustical environment. Replacing the traditional wood/composite construction that normally houses monitor components, TAD created a well of 40 ft.^{3} of concrete to eliminate resonance and the changes in tonality it may cause. The poured enclosure also improves system linearity to produce high-quality sound at low- and high-sound pressure levels.

TAD is the professional audio products division of Pioneer Electronics. The division designs and manufactures loudspeaker components and systems for professional sound reinforcement applications. Division headquarters are located at 2265 220th St., Long Beach, CA 90810.

Fast Reply #HG1459

INFINITY SYSTEMS, INC. introduces a center channel loudspeaker, the Infinity Video 1, for applications in surround sound. The drivers are magnetically shielded to prevent stray fields from interfering with the video picture. This permits you to install the speaker above, below, or in close proximity to the video monitor.

The Infinity Video 1, which costs $189, has dual 5½-inch polypropylene woofers, and a polycarbonate tweeter with ferrofluid to increase power handling. It is designed to accommodate amplifiers rated between 10 and 100W RMS.

For details, contact Infinity Systems, Inc., 9409 Owensmouth Ave., Chatsworth, CA 91311, (818) 709-9486.

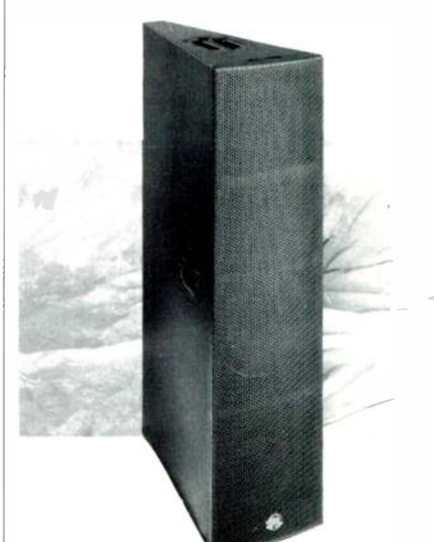
Fast Reply #HG354

CLAIR BROTHERS AUDIO SYSTEMS, INC. offers the P-4 piston system, a three-way, full-range speaker designed for portable and permanent installation applications. Its size is minimized with the use of recent cone transducer and enclosure design technologies. The front of the P-4 measures 13″ with side walls that taper to a rear dimension large enough to accommodate an EP-8 connector.

The P-4 uses 12″ woofers for low and mid frequencies, and a 2″ compression driver coupled to a 60° by 40° constant-directivity horn for high frequencies. Applications include theaters, auditoriums, and industrial and music-sound reinforcement.

Contact Clair Brothers Audio Systems, Inc., PO Box 396, Lititz, PA 17543, (717) 665-4000, FAX (717) 665-2786.

Fast Reply #HG1451



MOUSER ELECTRONICS announces the release of purchasing manual #570. It provides new product data and pricing on more than 36,000 electronic components from over 80 manufacturers. Products are tab indexed on the page edge for speedy research.

For a free copy, contact Mouser Electronics, PO Box 699, Mansfield, TX 76063, (800) 992-9943, FAX (817) 483-8157.

Fast Reply #HG1450

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Fast Reply #HG1428 →

Speaker Builder

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About This Issue

It's funny how things happen. One minute you're building a pair of speakers for your brother and his bride and the next thing you know, you've won first prize in a speaker building contest. **Robert Spear** and **Alex Thornhill** fill in the blanks in the first installment of "A Prize-Winning Three-Way TL," a three-part series beginning on page 10.

On page 14, **G.R. Koonce** and **R.O. Wright** share some insight on the low Q_{TS} drivers generally used with QB_3 alignments and their approach to lowering f_3. The pair presents the mathematics behind "Alignment Jamming" and some suggestions on how you can put the technique to practical use.

In the first part of another series, **Marc Bacon** describes building his system, "The Danielle" beginning on page 22. As a bonus, Marc discusses his Loudspeaker Design Powersheet, a CALSOD compatible spreadsheet that can help you calculate SPL, phase, group delay, and impedance.

Paul Spurgeon's "Double-Chambered Isobarik Speaker" offers the advantage of using two woofers in a compound system in an attempt to reduce harmonic distortion. Turn to page 38 to see how he incorporates compound and double-chambered bass reflex designs in the same enclosure.

On page 40, Contributing Editor **Gary Galo** places ORCA's Aria 5 under the microscope in this issue's Kit Report. Gary puts the Aria 5, a complete speaker-building kit, through its paces and offers some suggestions to ORCA.

SpeakerBuilder
THE LOUDSPEAKER JOURNAL

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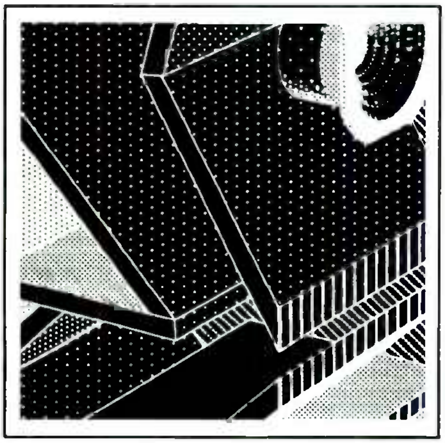

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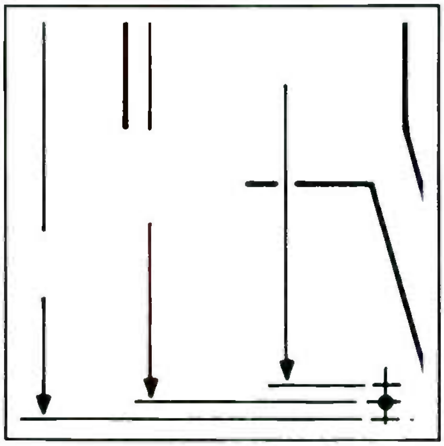

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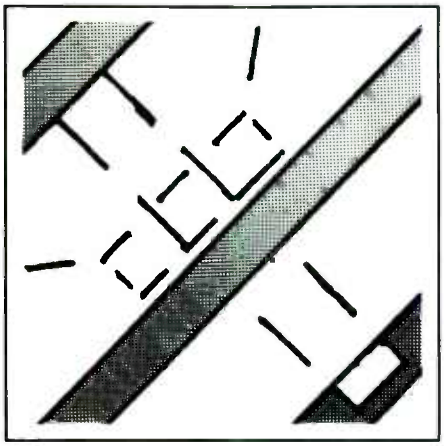

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FEATURES

DEPARTMENTS

Editorial

HORSE AND BUGGY SOUND

The other day I dug out the oldest parts catalog on my shelves and looked up ceiling "baffles" for speakers. Allied's offerings in the 1962 edition (30 years ago) lists Lowell-brand spun-aluminum perforated types for 6" drivers for $2.94 each.

The same day, I visited a brand-new grocery store (I know, I know: supermarket is the current style). After two or three banzai attacks on my hearing equipment from above my head, I looked up and thought I recognized the spun aluminum circles from which the audiobolts had been launched. They looked familiar. And indeed they should have. They were exactly the same design, holes and all, but probably spun and punched in Taiwan.

Until recently, I expected very little variation in the type of sound blasted toward me throughout public places from untrained operators obviously trying to project their voices throughout the store by lung power alone. These blasts are rendered more projectile-like by the limitations of the driver, the distribution transformers, and the frequency response (sic) of the public address amplifiers.

When I consider my everyday experience of reproduced sound in public places: movies, TV (for which improvements are on the horizon), stadiums, elevators, public transport (trains, buses, planes), it seems to me we need an audio environmental protection agency. The likelihood of getting one is very slim, and probably a good thing too. Bureaucrats generally make quality more expensive.

Fortunately, it is possible to have good sound in public address situations and some few contractors have figured out the process. I became sensitized to the problem only because of the contrast between the experience I mention above, and the sound in the establishment of my regular grocery supplier. This store, part of the Shaw's chain here in New England, is also new. The ceiling has special sound and lighting treatment in the form of fabric baffles which produce much wider range and better-balanced sound. Shaw's well-trained announcers speak normally, enunciate clearly, and seem relaxed rather than strident in their approach to the microphone. As a result, it is much easier to be patient with my fellow shoppers who block the aisles with overloaded carts and three kids in tow.

Three remedies for our nearly universally bad public sound come to mind. First of all, as especially educated consumers, we audiophiles know what quality of sound is possible and what it should be, unlike the majority of the population. For everyone's sake, we ought to complain about the kind of sound generally thrown at us. Unless customers let the management know that bad sound is offensive, nothing will change.

I, for one, am paying slightly higher prices in Shaw's because the PA system sounds so bad in the other store (one of over 200 in the New England region). But like most of us, I have not sought out the manager to complain.

Why should we do so? Unless we speak up, our commitment to good sound will be only a private, effete, and selfish avocation. Our knowledge of what sound ought to—and can—be should move us to call for improvements in what we are offered in any environment. The difference in cost cannot be all that much. We can demonstrate the customer dissatisfaction effect better than most, and owe it to ourselves to ask for better treatment. I suspect the quality of what we hear is a result of sheer neglect and ignorance.

The second line of action is one readers of this magazine may be the best equipped to handle. We spend a considerable amount of time pushing the boundaries of sound reproduction, searching for the best set of compromises to make loudspeaker sound just a bit better. We also possess the means to gather data about public sound and its general quality—or lack of it. Such reporting could not only be revealing but also raise the issue graphically. In some cases, this cause may well be merely poor equipment adjustment, or neglected maintenance.

The third effort concerns market research. If some master's degree candidate is looking for a good doctoral project, design a careful, scientific study of what effect, and if so by how much, sound has on customer buying levels. Some studies exist about music's effect on buyer response in all sorts of situations. Such a study might well lay the foundation for a fidelity revolution in public sound. If bad sound hurts sales and better sound improves them, the bean counters will invest.

The prospect is not encouraging for any of this. Witness how long it took for anyone to notice that better sound can enhance sales in TV commercials. And TV sound is still generally poor, although efforts to improve it continue.

Sound contractors have begun to wake up to the possibilities of home theater, and include full-house installations during construction of upscale private homes for hi-fi in every room. A good study demonstrating the dollar value of quality sound in a retail environment could boost not only the quality of the sound, it could further improve sound contracting business income, and improve the quality of life for all of us who wait in check-out lines.—E.T.D.

Continued from page 4

SOUNDTECH introduced three series of STS speaker systems—Universal, Bantam Series Trapezoids, and Radial Trapezoid—all based on the company's newest driver.

The all-purpose rectangular Universal speakers feature either constant directivity, horn, or piezo horn tweeters and heavy duty woofers. The simplest model is a basic 12″ woofer with tweeter and the top of the line model features a three-way 18″ cast-frame woofer and a 10″ mid and CD tweeter (model US1810C). Five subwoofers are also available in 1 × 18″, 2 × 15″, and 4 × 15″ models.

The 11 two- and three-way Bantam Series Trapezoid systems are uniform in width and depth to make it easier to combine them for clustering.

For details, contact SoundTech, 255 Corporate Woods Pkwy., Vernon Hills, IL 60061, (708) 913-5511, (800) 877-6863, FAX (708) 913-7772.

Fast Reply #HG1456

ABILENE's new paint finishing product is appropriate for use on many types of metal surfaces such as iron, steel, chrome, polished and plated metal, aluminum and galvanized metal. According to Abilene, Metal Primer adheres to most surfaces—including galvanized metal. The company carries 1463 white and 1363 black in stock and will match specified colors.

Contact Abilene Research and Development Corp., PO Box 294, Hewlett, NY 11557, (516) 791-6943, FAX (516) 791-6948.

Fast Reply #HG1452

CAT WIRE AND CABLE CORPORATION introduces a line of flexible multiconductor Catoprene cables for use in electronic control, audio, instrumentation, and general interconnect applications. The Catoprene jacket, available in 12 colors, offers high and low temperature performance, is abrasion-, flame-, and oil-resistant, and an alternative to rubber-jacketed cables. They are available in both shielded and unshielded versions from 2–30 conductor in AWG sizes 10–26.

Catoprene cables are also available in zero halogen constructions. For details, contact Cat Wire and Cable Corp., 1139 NW 72nd St., Miami FL 33150, (305) 836-3600.

Fast Reply #HG1458

SYNERGETIC AUDIO CONCEPTS (Syn-Aud-Con), the Indiana-based research facility, received a new address assignment due to some reorganization within the county. Their new address is 12370 W. Co. Rd. 100 N, Norman, IN 47264, (812) 995-8212, FAX (812) 995-2110.

Fast Reply #HG41

Part I

A PRIZE-WINNING THREE-WAY TL

BY ROBERT J. SPEAR and ALEX THORNHILL

A fellow can feel a bit schizophrenic the first time he designs a speaker system for someone else. In 1989, I promised to build a pair of loudspeakers for my brother and his bride as a wedding gift. While Jon and Mary Lou were interested in the cabinet's appearance, I was more concerned with the speaker's performance. They thought about the cabinet's finish and grille cloth color; I thought about attaining solid imaging, a 32Hz cut-off, and a flexible design to allow future upgrades.

The couple wanted a small tower-style cabinet with a footprint of no more than 144 in². Alex Thornhill and I originally proposed a transmission line (TL) system just 32″ in height to prevent the enclosures from dominating the room, but Jon and Mary Lou thought the drivers should be high enough to clear the furniture. Still trying, we built two particle board prototypes, one in our original deign and another similar system, only 10″ taller. We spent an afternoon listening to classical and popular CDs, comparing the two systems. The last movement of Camille St. Saens' mighty *Organ Symphony* settled the issue. Mary Lou pointed to the taller system and exclaimed, "That one!" When I saw their new living room, I had to agree, the taller cabinet was the better choice.

While my speaker-building partner Alex and I began this project as a wedding gift, our resulting design brought us a different kind of success. Our speaker, which we called the Brother Jon, went on to win first prize in the A&S Sound-Off, a speaker designing contest held in San Francisco in the fall of 1991 ("The 1991 A&S Audiophile Sound-Off: A Special Report" *SB* 2/92 p. 39). The following is the first part of the story behind the speaker, from its inception to crowning achievement.

FOLD THE LINE. Alex and I set out to design a system with a cabinet 42″ tall, 10″ wide, and about 14″ deep, preoccupied with the notion a TL needn't be the size of an upright freezer to deliver solid bass. While our goal of a −3dB cut-off frequency anywhere under 40Hz dictated an 8–9 ft. line, we soon realized we would have to trade off some bass extension to gain a compact enclosure. We also decided a three-way system offers greater power handling and midrange clarity. We chose a passive crossover (CO) since my brother owns just a single stereo power amplifier. After we made these decisions, the hard part—making the concept actual—came next. Accomplishing our goals required tradeoffs; the "NFL" factor (No Free Lunch) came into play.

To gain maximum length, we ran the line from the enclosure's top to bottom. This allowed a possible woofer-mounting location only at the top or the bottom of the front baffle. We anticipated a woofer-to-mid-cross point no lower than 300Hz or 400Hz, so the woofer would produce plenty of the musical midrange frequencies. That alone ruled out low woofer placement. Rough sketches of our next design—with the woofer on top—at first looked odd to us, but we decided to explore the concept anyway.

We borrowed an idea gleaned from the classic Webb TL (*TAA* 1/75, p. 3) and folded the line around the midrange chamber. Unlike the Webb method, we controlled the line taper by adjusting the angle of the chamber's back wall, resulting in a nonparallel rear wall. By tilting the front of the chamber floor downward, we were able to regulate the line taper around the mid-chamber. While the adjustment yielded a desirable nonparallel floor alignment, the chamber became too shallow at the top to allow placing the midrange driver next to the woofer.

At this juncture, we decided to place the tweeter next to the woofer and mount the midrange just below it. The speaker grouping looks like a quasi-D'Appolito configuration ("A High-Power Satellite Speaker" *SB* 4/84; "The Swan IV Speaker System" *SB* 4/88) but since the drivers are not symmetrical, it does not exhibit the same type of wavefront. The final design allowed us to group the drivers closely, but it also resulted in a lower-than-usual tweeter placement. Time would tell whether or not this was a good idea.

TWIXT TWO TWEETERS. When cabinet size is the controlling factor, woofer size is constrained. In our case, we were limited to an 8″ driver—not much of a handicap as an 8″ driver has many advantages. From the number of fine units available, we selected the cast-frame Focal 8K415-S because it had a low Q_{ts}, high compliance, a free air resonance of 19Hz (ours measured 20Hz after it was broken in) and a relatively long peak-to-peak excursion of 11mm. The Focal 8K415-S was originally intended for small vented enclosures of about 1.1 ft³. This is a fussy woofer, but when properly loaded it can play fast and go low. Its performance in a transmission line system was unknown, however.

After listening to a number of cone midrange drivers, we selected another Focal unit, the 5K013-L. We liked this driver because it permits low-frequency crossover and offers an extended, flat high-frequency response. Apparently, other designers also prefer this driver—it's well-known as the bass/mid driver in the Aria 5 as well as in a number of other high-end systems. Although Focal claims an F_s of 44Hz for this unit, ours measured closer to 59Hz. With this driver in the middle, our woofer and tweeter choices expanded considerably.

Our tweeter choice was the Focal T90-K. Despite being the smallest and least expensive unit in the Focal line, it has a wonderfully flat response. It suffers, however, from a persistent problem—an edgy quality as the inverted Kevlar dome breaks up. Fortunately, we'd kept our options open by designing the Brother Jon's midrange enclosure to accommodate a larger and more powerful tweeter such as the T120-K or other brands similar in size. By repositioning the tweeter and midrange downward by the appropriate amount, we gained enough space for a larger tweeter on the front baffle.

A BAFFLING EXPERIENCE. The benefit from using one manufacturer's drivers is the availability of well-tested CO networks or plans. The latter was true in our case. The stock Focal F433 network uses 18dB/octave slopes and comes with high quality metallized polypropylene capacitors (read: not cheap). We bought the parts and assembled the CO ourselves.

We removed the components from the cramped and hostile environment within the enclosure and mounted each CO externally in a separate enclosure. A bypassable CO makes it a snap to bi-wire or bi-amp the system, and the modular design makes upgrading or replacing components easy. As things worked out, it was a fortunate decision.

One of our original goals was to have the midrange driver play the full range of violin fundamentals (196–1,600Hz). Because the F433 crosses over at 350Hz, this would not be possible without substituting larger and more expensive components and increasing the midrange chamber volume to support the lower frequencies. We could afford neither, so we decided not to modify the F433. Careful listening convinced us there were no audible detrimental effects on the solo violin G string.

Folding the line around the midrange chamber allowed us to lay out the line divider partitions horizontally. This increased the number of pieces needed to build two enclosures and made it impossible to cut everything from a single sheet of MDF. Horizontal dividers offered a thoroughly braced enclosure with more weight toward the bottom third for better stability.

While this design change appeared to make cabinet construction a lot more difficult at first, installing the numerous 45° reflectors turned out to be the easiest part of the job. The scheme also provides superior support for the stuffing fibers. Our tests revealed a better bass response with multiple short line sections instead of several long ones, although we can't (as yet) explain why. We used full-sized reflector baffles at each 90° bend. The apparent restriction of the line at each bend has no detrimental effect on the system's performance.

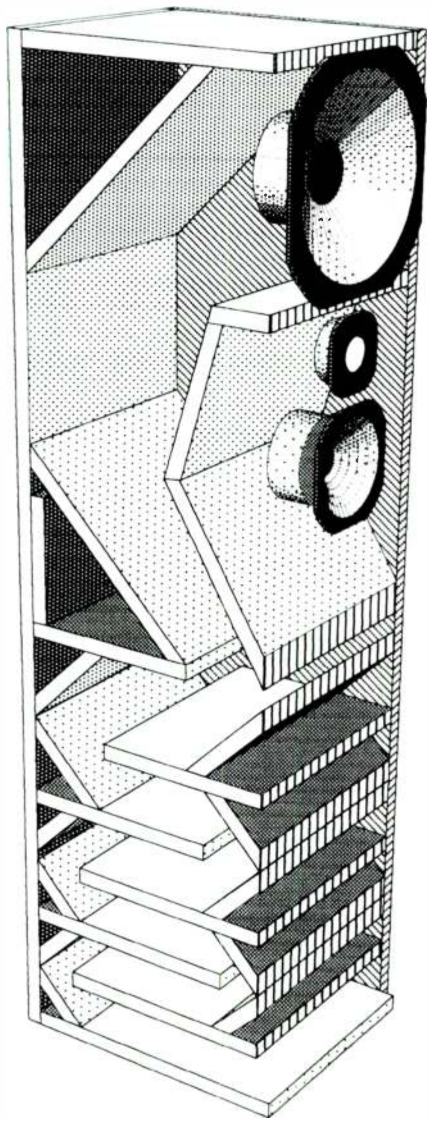


FIGURE 1: An orthographic view of Brother Jon minus two side panels.

LINE LENGTH. In a tall and narrow enclosure, the line cross-sectional area is small. The area immediately behind the woofer is about 72 in². Anything smaller would have made it physically impossible to mount the woofer. Our desired line length had to fit into the enclosure, which dictated that most of the line reduction occur in the first few feet. Once beyond the midrange cavity, the line tapers rapidly to its minimum cross-sectional area.

The merits of certain taper rates were traded against the need to keep the midrange chamber at least 5 liters in volume and not change the outside dimensions of the enclosure. Our research with the Focal woofer convinced us this driver operates optimally in a relatively small line area, so (throwing caution to the wind) we calculated the smallest practical cross-sectional area to meet our low frequency goals. The total volume of the line came to a scant 1.6 ft³, not far off the 1.1–1.3 ft³ the Thiele/Small parameters recommend.

Low frequency sound goes almost anywhere. In vented systems, most of the low frequency energy at resonance comes from the port, a short length of tube usually 3″ in diameter (7.069 in²). We settled on an area of 20 in² in the line's last 4′. This change translated into a flare ratio a little greater than 3.5:1, a somewhat drastic difference by conventional TL standards. The Brother Jon's line taper was the best we found for our box height of 42″. The loading worked well with our chosen woofer, but we can't say whether it will suit other woofers.

About this time we discovered the original version of Bob Bullock's TL modeling program, TLine, on the Madisound computer bulletin board. Just for fun, we plugged in the parameters of our driver and line. The program predicted that the flare ratio was just about right, and little if any improvement would occur by flare ratios greater than four. I wish we had found this little gem of a program sooner. It would have saved us an entire year of box building!

GETTING REAL. After listening carefully to how the system sounded, we realized that some things needed improvement. The tweeter was probably the most vexing problem—it sounded hard and edgy. For some reason, the T90 exhibited a 6dB rise at 16kHz. We added a capacitor to the filter's high-pass section to roll off the tweeter 6dB at that frequency. While the result was not wholly satisfying, we decided we could live with it. During the process of refining our design, Focal introduced its new titanium-dome tweeter, the T90-ti. The minute we listened to one, we knew the T90-Ks and the roll-off capacitors were out. Focal has since redesigned all its tweeter suspensions, so the elements that bothered us should no longer be present to bother you.

Although pleased by the original 8K415-S performance in Brother Jon, the driver output tended to rise with frequency as low as 400Hz, and the bass was not as substantial as we'd hoped. Then, the Focal 8V416 became available, and we gave it a try. Knowing that many audiophiles listen to their speakers without the grilles, I hesitated when I saw the new woofer. The old woofer's yellow Kevlar cone was visually appealing. In comparison, the 8V416's dull gray cone elicited about as much excitement as watching concrete cure.

Appearances aside, there was no hesitation once we'd heard the new woofer perform. It is simply outstanding. It has a 3dB greater output at 32Hz and a falling response with rising frequency. Because TLs tend to encourage rising responses, the two canceled each other and the result was a nearly flat woofer curve (+1dB) from 50Hz to the crossover point—a real transmission line driver!

Once we replaced two of the three original drivers, we needed to replace the crossover. Upon recommendation, we chose another Focal design, the F444, to use with the new drivers. We made only one alteration: We added a simple L-pad to attenuate the tweeter by 3dB. Meant for a different woofer in a vented box, we used the new CO in the competition version without testing it because we were running short of time. We almost ran out of luck—I'll explain why in Part II. (We have since returned to the F433.)

RACING THE CLOCK. At long last, we delivered the wedding gift in June of 1991—just in time for my brother's second anniversary. Next, we began building the competition version, working against an August shipping deadline. We refined the enclosure design again, shaving an inch off the front width and off the depth. The dimensions of the final MDF enclosure were 9″ wide and only 13″ deep, a very modest size for a TL with an 8.5′ length. The internal line design was also modified slightly to improve the wave flow around the midrange chamber. This increased the flare ratio to about 4:1, and decreased the line's internal volume to 1.36 ft^3.

When unexpected family matters required my presence away from home in the middle of August, it was clear we would not finish in time. Zalytron's Elliot Zalayet answered our cries for help and routed the speaker recesses into the front baffles for us. Elliot turned our job around in just 24 hours, and UPS delivered them the next day. The baffles fit perfectly, so we resumed construction project with only 48 hours left to go.

We experienced another setback while preparing the speakers for shipment—each of them weighed just over UPS' 70lb. weight limit. We called Art Rosenblum at A&S, the competition's sponsor, and explained our dilemma. If we removed the drivers, each carton weighed just under the limit. Art agreed to mount the drivers, so they travelled in separate cartons. (The morning after, when I was 200 miles down the road, I realized we had neglected to provide mounting gaskets for the drivers.)

BALANCING THE ISSUES. Ironically, the hysteria was for naught because scheduling conflicts between the judges delayed the contest for almost two months. The big event finally took place on October 26, 1991 at A&S Speakers in San Francisco with a $500 first prize and bragging rights in the offing. The judges included Keith Johnson of Reference Recordings, Ken Kantor of NHT, and Corey Greenberg of *Stereophile*; who also tested and reported the winner and runner-up systems (Cory's report appears in the March, 1992 issue). Bruce Edgar covered the event for *Speaker Builder*.

Having been eliminated in the final round, the Brother Jon made a dramatic comeback to win first prize. Art personally called us with the good news, the effects of which have yet to subside. Due to the experimental nature of the project, we were grateful merely to hear the judge's comments regarding the line design. We learned a lot from them.

On the positive side, the judges liked the system's tonal balance, big staging, and fast, tight bass. They felt the system was smooth, articulate and capable of full dynamics. Its greatest strength was in its excellent overall reproduction.

On the negative side, two judges felt the tweeter was a bit bright, although not overbearing. One wished for a bit more low end. The judges singled out the

Continued on page 74

ALIGNMENT JAMMING

BY G. R. KOONCE and R. O. WRIGHT, JR.

Although I have always preferred the sound of vented box (VB) systems built with low Q_{TS} drivers ("The QB_3 Vented Box is Best," *SB* 5/88, p. 22), one disadvantage remains. When low Q_{TS} drivers are used in the common QB_3 alignment, the systems suffer from rather high cutoff frequencies (f_3). I developed an approach of deviating from the QB_3 alignment to obtain a lower f_3, using trial and error design, which led to the second article ("Improved Vented Box With Low Q_{TS} Drivers," *SB* 6/90, p. 23).

After this second article appeared in print, my co-author, R.O. Wright, informed me of a direct mathematical way to "force" low Q_{TS} drivers into other alignments thereby producing VB designs with lower cut off frequencies. The technique is called alignment jamming.

In the following, Wright describes the mathematics of alignment jamming (AJ) and then we offer some practical applications. We also provide a simple GW BASIC program for designing your own fourth-order jammed alignments.

TABLE 1

DEFINITION OF TERMS

QB_3	Quasi third-order Butterworth alignment
B_4	Fourth-order Butterworth alignment
Be_4	Fourth-order Bessel alignment
IB_3	Inter-order Butterworth alignment—In his article, R. M. Bullock identifies this alignment as being of order 3½. He refers to it as IB_4. I mistakenly coded it into software identified as IB_3. We will stay with the IB_3 designation throughout this article for consistency.—G.R.K.
V_{AB}	Volume of air having the same acoustic compliance as the enclosure. For design purposes, the net internal volume of the enclosure (V_B) would equal V_{AB}.
V_{AS}	The equivalent air volume compliance of a driver—same dimensions as V_{AB}.
Q_B	The total Q of speaker box which includes losses.
Q_{TC}	The total Q of a closed box system at resonance f_C.
Q_{TS}	The total Q of a driver at resonance f_S.
f_B	The frequency to which a VB enclosure is tuned.
f_C	The resonant frequency of a CB system.
f_S	The free air resonant frequency of a driver.
f_3	The −3dB lower cutoff frequency of a speaker system.
N1–N3	Complex AJ coefficients, see text.
h	f_B/f_S ratio.
α	V_{AS}/V_{AB} ratio.
a_1–a_3	Filter-function coefficients—no losses.
a_1'–a_3'	Filter-function coefficients with losses.
K_3	Small's ratio f_3/f_0. See Small[2], Part IV. Where f_0 is the resonant frequency of a system.

Note: Xy′ = any parameter Xy when losses are included.

MATHEMATICS OF AJ. Alignment jamming is divided into two categories; Simplex and Complex. Simplex AJ is based on second-order alignment formulas. Vented-box designers very likely used this technique even before Thiele and Small.[1,2] I am not aware of any work referencing the original development of Simplex jamming. The Complex AJ first appeared in Thiele's initial alignment article.[1]

Simplex AJ is represented mathematically as:

$$V_{AB}/V_{AS} = [(Q_{TC}/Q_{TS})^2 - 1]^{-1} \quad (1)$$

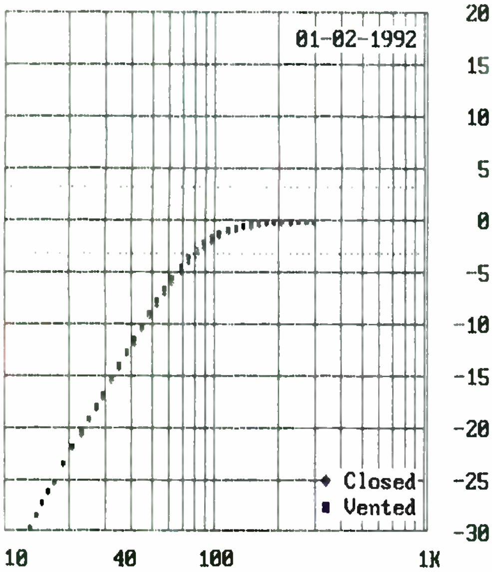
$$f_B/f_S \leq 1 \quad (2)$$

Q_{TC} represents the total system Q of the

TABLE 2

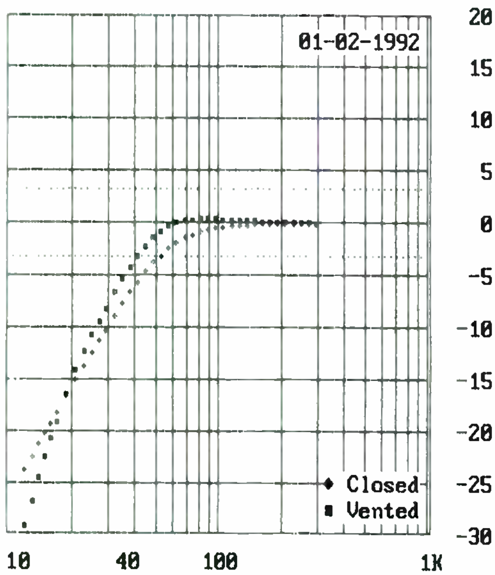
NATURAL ALIGNMENT AND JAMMED COEFFICIENTS

Q_B	Q_{TS}	h	α	f_3/f_S	N1	N2	N3
For Butterworth B_4 ($f_B = f_S = f_3$ for natural alignment)							
3	0.4386	1.000	0.6543	1.000	7.9449	0.4386	0.4386
5	0.4144	|	0.9316	|	6.2507	0.4144	0.4144
7	0.4048	|	1.0613	|	5.7502	0.4048	0.4048
10	0.3979	|	1.1629	|	5.4314	0.3979	0.3979
15	0.3927	|	1.2444	|	5.2110	0.3927	0.3927
20	0.3901	|	1.2861	|	5.1094	0.3901	0.3901
For Bessel Be_4							
3	0.3535	0.9696	1.4036	1.4911	5.7014	0.3428	0.5271
5	0.3376	0.9725	1.7488	1.4933	5.0171	0.3283	0.5041
7	0.3312	0.9735	1.9076	1.4941	4.7789	0.3224	0.4948
10	0.3266	0.9743	2.0311	1.4947	4.6157	0.3182	0.4882
15	0.3230	0.9751	2.1296	1.4951	4.5009	0.3150	0.4829
20	0.3213	0.9756	2.1797	1.4953	4.4441	0.3135	0.4804
For Butterworth Inter-Order IB_3							
3	0.3835	1.1397	1.1722	1.2432	5.8005	0.4371	0.4768
5	0.3647	1.1241	1.5206	1.2347	4.9444	0.4100	0.4503
7	0.3572	1.1184	1.6802	1.2315	4.6646	0.3995	0.4399
10	0.3513	1.1145	1.7998	1.2294	4.5021	0.3915	0.4319
15	0.3477	1.1117	1.9030	1.2278	4.3466	0.3865	0.4269
20	0.3457	1.1103	1.9533	1.2270	4.2838	0.3838	0.4242



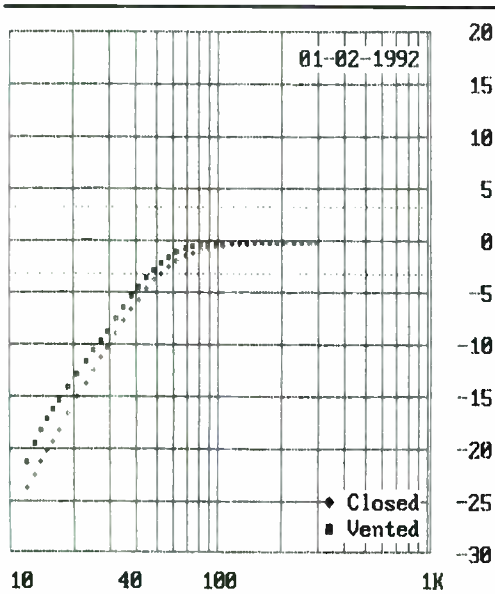

```
Simplex Qts=.22
------ Vented Box Design ------
Modified Standard B4 Alignment
Vent diameter      2.0   inches
Vent length       27.6   inches
Vent volume       87.0   cu.in.
Vb                11.3   Liters
                   0.4   Cu.Ft.
                 689.6   Cu.In.
Fb                27.0   Hz
Rg                 0.0   ohms
------ Closed Box Design ------
Alpha              9.12
Fs                27.0 Hz
Fc                85.9 Hz
F3                86.8 Hz
Qts/Qtc            0.22/ 0.70
Rg                 0.0 ohms
Vb                11.3 Liters
                   0.4 Cu.Ft.
                 689.6 Cu.In.
```

FIGURE 1: Results for Simplex AJ—Q_{TS} = 0.22 Q_{TC} = 0.7 f_B = f_S.




```
Simplex Qts=.40
------ Vented Box Design ------
Modified Standard B4 Alignment
Vent diameter      2.0   inches
Vent length        4.5   inches
Vent volume       14.0   cu.in.
Vb                42.0   Liters
                   1.5   Cu.Ft.
                2562.9   Cu.In.
Fb                31.0   Hz
Rg                 0.0   ohms
------ Closed Box Design ------
Alpha              2.09
Fs                31.0 Hz
Fc                54.5 Hz
F3                54.8 Hz
Qts/Qtc            0.40/ 0.70
Rg                 0.0 ohms
Vb                42.0 Liters
                   1.5 Cu.Ft.
                2562.9 Cu.In.
```

FIGURE 2: Results for Simplex AJ—Q_{TS} = 0.40 Q_{TC} = 0.7 f_B = f_S.




```
Simplex Qts=.40
------ Vented Box Design ------
Modified Standard B4 Alignment
Vent diameter      2.0   inches
Vent length       11.5   inches
Vent volume       36.0   cu.in.
Vb                42.0   Liters
                   1.5   Cu.Ft.
                2562.9   Cu.In.
Fb                21.0   Hz
Rg                 0.0   ohms
------ Closed Box Design ------
Alpha              2.09
Fs                31.0 Hz
Fc                54.5 Hz
F3                54.8 Hz
Qts/Qtc            0.40/ 0.70
Rg                 0.0 ohms
Vb                42.0 Liters
                   1.5 Cu.Ft.
                2562.9 Cu.In.
```

FIGURE 3: Results for Simplex AJ—Q_{TS} = 0.40 Q_{TC} = 0.7 f_B = 21Hz.

second-order prototype response your VB should simulate. V_{AS}, f_S, and Q_{TS} are the driver's design parameters. V_{AB}/V_{AS} and f_B/f_S define the VB design. (Simplex AJ examples will follow later.)

The mathematics of Complex AJ are as follows:

$$N1 = 1/(\alpha\, Q_{TS}^2) \qquad (3)$$

$$N2 = Q_{TS}\, f_B/f_S = Q_{TS}\, h \qquad (4)$$

$$N3 = Q_{TS}\, f_3/f_S \qquad (5)$$

N1, N2, and N3 are AJ coefficients. All the other parameters represent the prototype's fourth-order response. Once you have established the coefficients, follow this jammed alignment enclosure design procedure:

$$V_{AB} = N1\, V_{AS}\, Q_{TS}^2 \qquad (6)$$

$$f_B/f_S = N2/Q_{TS} \qquad (7)$$

$$f_3/f_S = N3/Q_{TS} \qquad (8)$$

Where V_{AB}, f_B/f_S and f_3/f_S define the jammed alignment enclosure, V_{AS}, f_S, and Q_{TS} represent the enclosure's driver.

When using complex AJ, you must first establish a prototype response, or more simply, the response shape you wish to emulate with your specific driver. Once you have made a shape selection, you must establish that shape's parameters. Parameters for common alignments appear in *Table 2*, the mathematics for parameter derivation in general are quite complicated when losses are considered. For help, the Sidebar shows derivation of the parameters for the Butterworth B_4 and Bessel Be_4 prototype alignment responses.

THE PRACTICAL SIDE. To use the Simplex AJ equations when building

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G.R. Koonce is a principal design engineer for an organization producing audio frequency equipment for military application. Since the 1950s he has enjoyed the hobby of designing and building audio equipment, test gear and speaker systems. He also enjoys playing at computer programming and is a member of the AES.

Robert O. Wright, Jr., a mechanical engineer once with the Tennessee Valley Authority, now owns a custom design engineering firm in Knoxville, TN. He has a BS from the University of Tennessee. He has been associated with audio/hi-fi since the early 1950s and sound design, consulting, electronic circuits, speaker design and construction. He has also been active with the local amateur speaker builders in developing design techniques oriented toward the beginning hi-fi enthusiast.

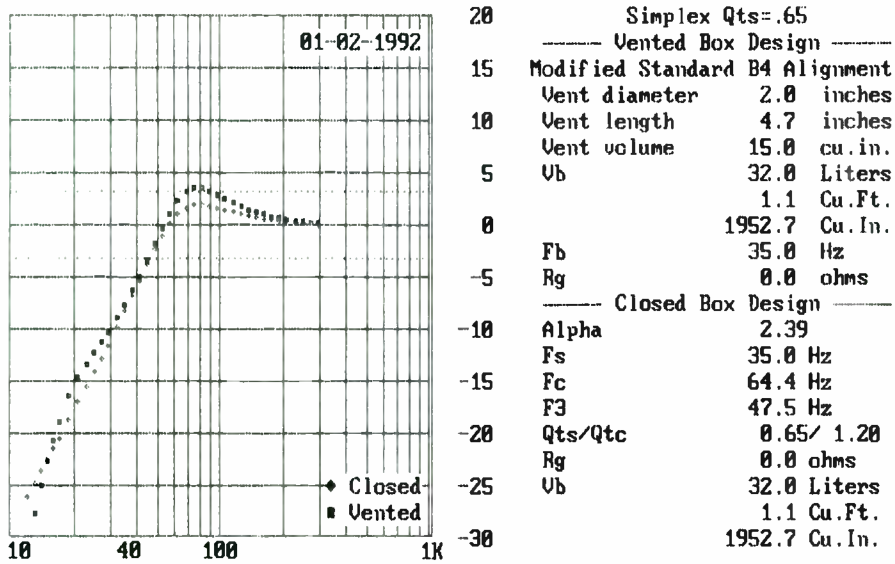

FIGURE 4: Results for Simplex AJ—Q_{TS} = 0.65 Q_{TC} = 1.2 f_B = f_S.

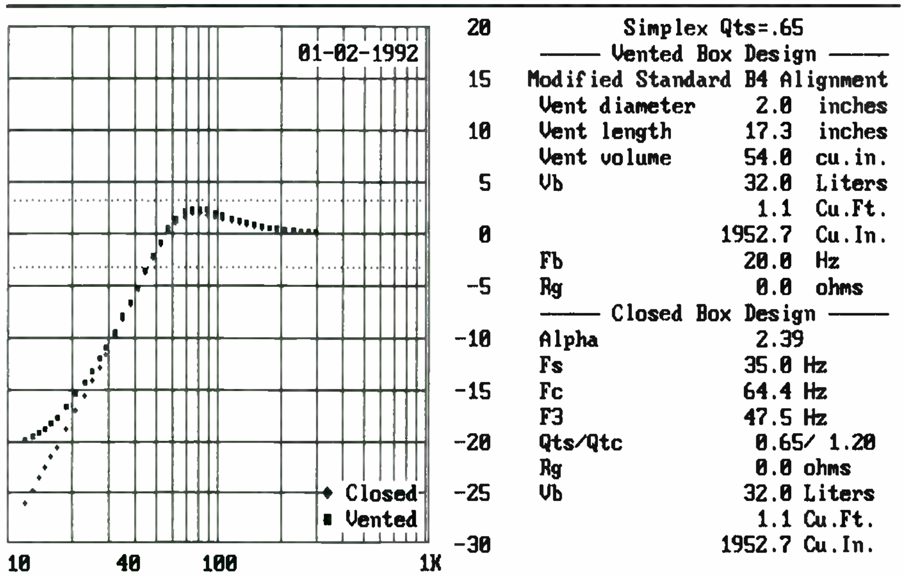

FIGURE 5: Results for Simplex AJ—Q_{TS} = 0.65 Q_{TC} = 1.2 f_B = 20Hz.

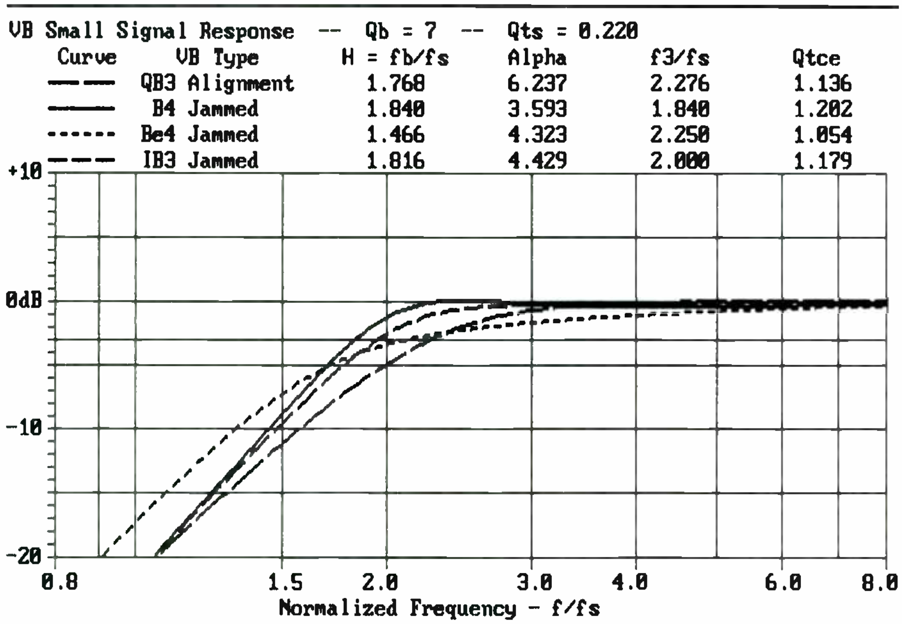

FIGURE 6: Results for Complex AJ—Q_{TS} = 0.22.

your own VB system, first select a closed box response shape by considering its Q_{TC}, and design a prototype CB system based on your selection. Next, build a VB system, using the same box size according to your prototype's design. Finally, tune the VB system so that f_B equals f_S, or a bit lower.

By using this Simplex AJ technique, your vented box system will perform similarly or somewhat better than what the CB prototype design offers.

Figures 1-5 show the Simplex AJ results on three drivers having a Q_{TS} of 0.22–0.65. We generated these figures with an enclosure design program called Quick Box (developed by Sitting Duck Software and available through Old Colony Sound Lab), which lets you simultaneously plot CB and VB designs. In *Fig. 1*, we forced a driver with a Q_{TS} of 0.22 to match a second-order Butterworth CB response, a Q_{TC} of 0.7. Placing the driver into a VB matching the CB's volume and tuning (f_B = f_S) produces a VB with a nearly identical response.

Figure 2 shows the results of using the Simplex AJ formula on a driver with a Q_{TS} of 0.4 against the same second-order Butterworth CB. With f_B set to f_S, the match is not as good. The match greatly improves as f_B is reduced, as suggested by *Equation 2.* A better match is obtained with f_B set to 21Hz, shown in *Fig. 3. Figure 4* shows results for Simplex AJ on a driver with a Q_{TS} that equals 0.65—rather high for VB design. When Q_{TC} = 1.2, the CB prototype shape peaks slightly, the driver's Q_{TS} being too high for a CB design of Q_{TC} = 0.7. While the match in *Fig. 4* is not optimum, *Fig. 5* shows the improvement with f_B lowered to 20Hz. The VB-jammed design matches the CB prototype's small signal-frequency response down to about the −15dB response point.

Simplex AJ VB designs match a second-order CB prototype response with a fair amount of accuracy. The CB prototype and the VB have the same enclosure volume with the VB tuned to f_S or lower.

THE LOW ROAD. While Complex AJ truly lives up to its name, it offers a greater reward because it allows low Q_{TS} drivers to be forced into alignment shapes which you may prefer, such as the Butterworth B_4. We will now investigate how to use the Complex AJ techniques for the Butterworth B_4, the Bessel Be_4, and the Butterworth Inter-Order IB_3 alignments as developed by R.M. Bullock

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Deriving AJ Coefficients for B_4 and Be_4 Alignments

When box losses are included in the Complex AJ, the process becomes quite complicated as indicated in the following. The AJ parameters for the prototype Butterworth B_4 and Bessel Be_4 alignments will be developed including losses. Throughout this work, when a parameter includes loss, its name will be changed from Xy to Xy′. Starting with the work of Thiele and Small,[1,2] the required formulas are as follows:

$$f_B/f_S = h = a_3/a_1 \quad (A1)$$

$$\alpha = ha_2 - h^2 - 1 \quad (A2)$$

$$Q_{TS} = 1/(a_1\, a_3)^{1/2} \quad (A3)$$

$$f_3/f_S = h^{1/2}K_3 \quad (A4)$$

Without losses:

$$a_1 = 1/(h^{1/2}\, Q_{TS}) \quad (A5)$$

$$a_2 = [(\alpha/h) + 1/h + h] \quad (A6)$$

$$a_3 = (h^{1/2})/Q_{TS} \quad (A7)$$

$$K_3 = (f_3/f_S)/h^{1/2} \quad (A8)$$

From Thiele,[1] the lossless parameters for a Butterworth B_4 alignment are:

$$Q_{TS} = 0.383$$
$$h = 1$$
$$f_3/f_S = 1$$
$$\alpha = 1.41$$

Then calculating the filter-function coefficients and K_3 for a lossless B_4 alignment results in the following:

From equation A5: $a_1 = 2.613$ (A9)

From equation A6: $a_2 = 3.414$ (A10)

From equation A7: $a_3 = 2.613$ (A11)

From equation A8: $K_3 = 1$ (A12)

Including losses described as a single parameter, box Q (Q_B), produces approximate equations; we have:

$$a_1' = a_1 - [(h^{1/2})/Q_B] \quad (A13)$$

$$a_2' = a_2 - [1/(Q_{TS}\, Q_B)] \quad (A14)$$

$$a_3' = a_3 - [1/(h^{1/2}\, Q_B)] \quad (A15)$$

Then calculating the values for the B_4 alignment with losses of box Q = 7:

$$a_1' = 2.613 - (1/7) = 2.470 \quad (A16)$$

$$a_2' = 3.1414 - [1/(7 \times 0.383)] = 3.041 \quad (A17)$$

$$a_3' = 2.613 - (1/7) = 2.470 \quad (A18)$$

Therefore, using coefficients including losses, we have by equation:

A1: $(f_B/f_S)' = h' = 1$ (A19)

A2: $\alpha' = 1.041$ (A20)

A3: $Q_{TS}' = 0.4049$ (A21)

A4: $(f_3/f_S)' = 1$ (A22)

3: N1 = 5.859 (A23)

4: N2 = 0.4049 (A24)

5: N3 = 0.4049 (A25)

Note that the value of α' (at A20) and N1 (at A23) are in error by about 1.9% relative to the values shown in *Table 2*. Typically the simple form used for coefficient a_2' (at A14) will yield a result accurate to within 2%. This effects the computations for α' and N1. An exact form of the equation for a_2' is (A26) below:

$$a_2' = a_2 - [1/(Q_{TS}^2\, Q_B^2) - h/(Q_{TS}\, Q_B^3) - 1/(Q_{TS}\, Q_B^3) + 1/Q_B^4]^{1/2} \quad (A26)$$

An alternate approach to improved accuracy is as follows:

1. Compute a_1' via equation A13.
2. Compute a_3' via equation A15.
3. Compute Q_{TS}' as in A21.
4. Now compute a_2' using the value of Q_{TS} with loss, as:

$$a_2' = a_2 - [1/(Q_{TS}'\, Q_B)] \quad (A27)$$

5. Compute h′ as in A19.
6. Compute α' as in A20.
7. Compute N1 as in A23.
8. The other coefficients are computed as shown above.

With this approach:

$$a_2' = 3.1414 - [1/(7 \times 0.4049)] = 3.061 \quad (A28)$$

$$\alpha' = (1 \times 3.061 - 1^2 - 1) = 1.0613 \quad (A29)$$

$$N1 = 1/(1.0613 \times 0.4049^2) = 5.747 \quad (A30)$$

These values are in good agreement with the values shown in *Table 2*. Looking now at the Bessel Be_4 alignment, from Small[2] we can establish the following lossless alignment parameters:

$Q_{TS} = 0.3162$ $h = 0.9759$

$f_3/f_S = 1.456$ $\alpha = 2.333$

The lossless filter-function coefficients and K_3 are:

By A5: $a_1 = 3.2011$ (A31)

By A6: $a_2 = 4.3916$ (A32)

By A7: $a_3 = 3.1239$ (A33)

By A8: $K_3 = 1.5143$ (A34)

Including losses for $Q_B = 7$, using the approach yielding accurate results:

By A13: (A35)
$$a_1' = 3.2011 - [0.9759^{1/2}/7] = 3.060$$

By A15: (A36)
$$a_3' = 3.1239 - 1/(0.9759^{1/2} \times 7)] = 2.979$$

As in A21: (A37)
$$Q_{TS}' = 1/(3.060 \times 2.979)^{1/2} = 0.3312$$

By A27: (A38)
$$a_2' = 4.3916 - [1/(0.3312 \times 7)] = 3.9603$$

As in A19: (A39)
$$h' = 2.979/3.060 = 0.9736$$

As in A20: (A40)
$$\alpha' = 0.9736 \times 3.9603 - 0.9736^2 - 1 = 1.9079$$

As in A22: (A41)
$$(f_3/f_S)' = 0.9736^{1/2} \times 1.5143 = 1.4942$$

As in A23: (A42)
$$N1 = 1/(1.9079 \times 0.3312^2) = 4.7782$$

As in A24: (A43)
$$N2 = 0.3312 \times 0.9736 = 0.3225$$

As in A25: (A44)
$$N3 = 0.3312 \times 1.4942 = 0.4949$$

Examination of *Table 2* shows these coefficients agree well with those listed for the Be_4 alignment at $Q_B = 7$.

Use the techniques developed in this sidebar to develop the complex jamming coefficients with losses for any prototype fourth-order response for which you can establish the lossless parameters Q_{TS}, α, h and f_3/f_S.

Continued from page 16
(*SB* 3/81, p. 18—The IB_3 is really Bullock's IB_4 alignment, see *Table 1*). *Table 2* contains the natural alignments coefficients at various box Qs from the Bullock article. The AJ coefficients are generated as follows:

$N1 = 1 / (\alpha \times Q_{TS} \times Q_{TS})$ (From *Equation 3*)

$N2 = h \times Q_{TS}$ (From *Equation 4*)

$N3 = Q_{TS} \times f_3/f_S$ (From *Equation 5*)

Alpha, Q_{TS}, h, and f_3/f_S are all values for the desired prototype alignment in *Table 2*. The AJ coefficients for these alignments are also present in *Table 2* so you need not generate any of your own unless you wish to work with other Box Q values or prototype alignments.

Use the coefficients to develop a jammed design as follows:

$$V_{AB} = N1 \times V_{AS} \times Q_{TS} \times Q_{TS}$$

V_{AB} is equal to the net enclosure volume in the same units as V_{AS}. V_{AS} and Q_{TS} are for the actual driver being used.

$$f_B = N2 \times f_S/Q_{TS}$$

f_B is the box tuned frequency and again f_S and Q_{TS} are for the actual driver.

$$f_3 = N3 \times f_S/Q_{TS}$$

f_3 is the system −3dB frequency and again f_S and Q_{TS} are for the actual driver.

Let's work out actual examples of jammed VB designs for the following driver with Q_B equaling seven:

$f_S = 23Hz$ $V_{AS} = 3.22ft^3$ $Q_{TS} = 0.22$

1. Natural QB_3 alignment design ($Q_B = 7$):

$$\alpha = 6.2372$$

so:

$$V_{AB} = V_{AS}/\alpha = 3.22/6.2372 = 0.516ft^3$$

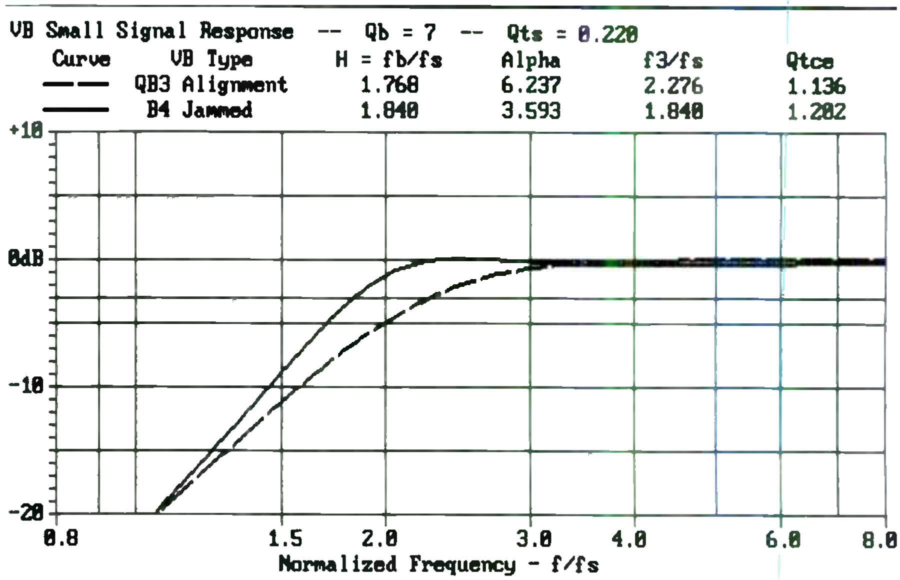

FIGURE 7: Results for Complex AJ—Q_{TS} = 0.22 QB_3 and Jammed B_4 alignments only.

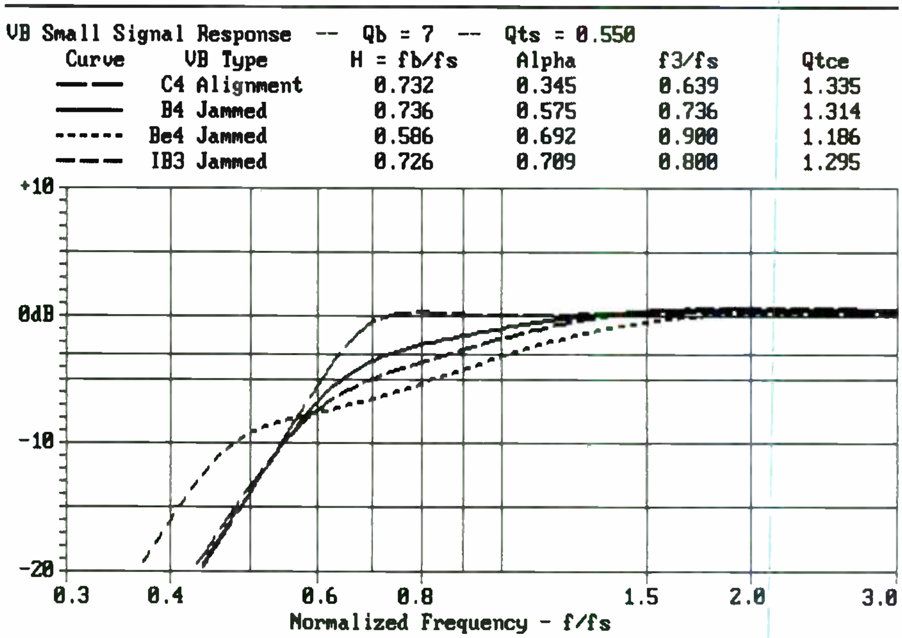

FIGURE 8: Results for Complex AJ—Q_{TS} = 0.55.

$$h = 1.7678$$

so:

$$f_B = f_S \times h = 23 \times 1.7678 = 40.7Hz$$

$$f_3/f_S = 2.2759$$

so:

$$f_3 = f_S \times f_3/f_S = 23 \times 2.2759 = 52.3Hz$$

This quickly identifies the QB_3 alignment problem, a driver with f_S at 23Hz produces a system with f_3 of 52Hz. *Figure 6* shows normalized responses for the various alignments studied in this exam-

TABLE 3

LOW Q_{TS} DRIVER ALIGNMENT RESULTS

Driver Data	f_S = 23	Q_{TS} = 0.22	V_{AS} = 3.22 ft³
Alignment	V_{AB} – ft³	f_B – Hz	f_3 – Hz
Natural QB_3	0.516	40.7	52.3
Jammed B_4	0.896	42.3	42.3
Jammed Be_4	0.745	33.7	51.7
Jammed IB_3	0.727	41.8	46.0

FURTHER READING

The following articles contain original information on alignment jamming concepts not directly referenced in this article:

1. Benson, J.E., "Theory and Design of Loudspeaker Enclosures," Parts 1, 2 and 3, *A.W.A. Technical Review*, Vols. 14, No. 1 (1968), No. 3 (1971) and No.4 (1972).
2. Keele, D.B. Jr., "A New Set of Sixth-Order Vented-Box Loudspeaker System Alignments," *JAES*, Vol. 23, 6/75.
3. Ashley, J.R., Postscript to: "Loudspeakers in Vented Boxes," *JAES*, Vol. 19, 6/71.
4. Snyder, P.J., "Using Thiele/Small Parameters to Design Loudspeaker Systems," *Speakerlab Technical Compendium* 11, 1979.

```
10 REM This is JAMMING7.TXT - Text file for GW-BASIC program - 5/31/91
20 REM This designs jammed B4, Be4 and IB3 alignments at Qb=7
90 KEY OFF                              'disables function key display
100 BN1# = 5.7502:  BN2# = .4048:  BN3# = .4048
110 BEN1# = 4.7789: BEN2# = .3224: BEN3# = .4948
120 IBN1# = 4.6646: IBN2# = .3995: IBN3# = .4399
130 CLS
140 PRINT "Alignment Jamming Program for Qb = 7                  "; DATE$
150 PRINT
160 PRINT "You may enter a driver name for reference ";
170 PRINT "on the next line."
180 LINE INPUT "Name= "; DVRNME$
190 PRINT
200 PRINT "Driver Data:  ";
210 INPUT; "fs in Hz= ", FS#
220 INPUT; "        Qts= ", QTS#
230 INPUT "        Vas in Cu Ft= ", VAS#
240 PRINT: PRINT
250 PRINT "Jammed Alignment       Vb in Cu Ft       fb          f3"
255 PRINT
260 VB# = BN1# * VAS# * QTS#^2
270 FB# = BN2# * FS# / QTS#
280 F3# = BN3# * FS# / QTS#
290 PRINT "Butterworth B4           ";
300 PRINT USING "  ###.###"; VB#;
310 PRINT USING "         ###.##"; FB#;
320 PRINT USING "      ###.##"; F3#
330 PRINT
340 VB# = BEN1# * VAS# * QTS#^2
350 FB# = BEN2# * FS# / QTS#
360 F3# = BEN3# * FS# / QTS#
370 PRINT "Bessel Be4               ";
380 PRINT USING "  ###.###"; VB#;
390 PRINT USING "         ###.##"; FB#;
400 PRINT USING "      ###.##"; F3#
410 PRINT
420 VB# = IBN1# * VAS# * QTS#^2
430 FB# = IBN2# * FS# / QTS#
440 F3# = IBN3# * FS# / QTS#
450 PRINT "BW Inter-Order IB3    ";
460 PRINT USING "  ###.###"; VB#;
470 PRINT USING "         ###.##"; FB#;
480 PRINT USING "      ###.##"; F3#
490 PRINT: PRINT
500 LINE INPUT "X to Quit, nul to Rerun: "; X$
510 IF X$ = "X" OR X$ = "x" THEN END
520 GOTO 130
```

FIGURE 9: BASIC Program for COMPLEX JAMMED ALIGNMENTS Q_B = 7.

ple, while results have been tabulated in *Table 3* for easy comparison.

2. Jammed Butterworth B_4 alignment design (Q_B = 7):

$$V_{AB} = N1 \times V_{AS} \times Q_{TS}^2 = 5.7502 \times 3.22 \times (0.22)^2 = 0.896\text{ft}^3$$

$$f_B = N2 \times f_S/Q_{TS} = 0.4048 \times 23/0.22 = 42.3\text{Hz}$$

$$f_3 = N3 \times f_S/Q_{TS} = 0.4048 \times 23/0.22 = 42.3\text{Hz}$$

The jammed B_4 alignment has dropped f_3 by about 10Hz at the cost of an increase in box size and some mild passband ripple. As with the natural B_4 alignment, $f_B = f_3$ (*Fig. 6*). For clarity, QB_3 alignment and jammed B_4 alignment response curves are shown alone in *Fig. 7*.

REFERENCES

1. Thiele, A.N., "Loudspeakers in Vented Boxes: Parts I and II," *JAES*, Vols. 19, 5/71 and 6/71.

2. Small, R.H., "Vented-Box Loudspeaker Systems Parts I-IV," *JAES*, Vols. 21, 6/73, 7-8/73, 9/73, 10/73.

3. Jammed Bessel Be_4 alignment design (Q_B = 7):

$$V_{AB} = N1 \times V_{AS} \times Q_{TS}^2 = 4.7789 \times 3.22 \times (0.22)^2 = 0.745\text{ft}^3$$

$$f_B = N2 \times f_S/Q_{TS} = 0.3224 \times 23/0.22 = 33.7\text{Hz}$$

$$f_3 = N3 \times f_S/Q_{TS} = 0.4948 \times 23/0.22 = 51.7\text{Hz}$$

While jammed Bessel Be_4 alignment's f_3 value is slightly below that of the QB_3 natural alignment, it exhibits the slow fall off with decreasing frequency characteristic of the Bessel alignments. Professional sound equipment manufacturers seem to prefer this characteristic (*Fig. 6* and *Table 3*).

4. Jammed Butterworth Inter-Order IB_3 alignment design (Q_B = 7):

$$V_{AB} = N1 \times V_{AS} \times Q_{TS}^2 = 4.6646 \times 3.22 \times (0.22)^2 = 0.727\text{ft}^3$$

$$f_B = N2 \times f_S/Q_{TS} = 0.3995 \times 23/0.22 = 41.8\text{Hz}$$

$$f_3 = N3 \times f_S/Q_{TS} = 0.4399 \times 23/0.22 = 46\text{Hz}$$

This alignment provides an f_3 between the QB_3 and the jammed B_4 alignments (*Fig. 6*). We do not know of any special characteristics for this alignment, refer to "Alternative Alignments" (*SB* 3/81, p. 18).

In general, the Complex AJ equations work for drivers of any Q_{TS}. It is possible to design the various jammed alignments with high Q_{TS} drivers using the coefficients shown in *Table 2*, but as *Fig. 8* shows, once Q_{TS} gets above 0.5, the results are not useful.

The listing appearing at the end of the article shows a simple program that runs under GW BASIC and takes in the data for a driver and provides the enclosure design parameters for the B_4, Be_4 and IB_3 jammed alignments with a box Q of 7. You can easily change box Q by changing the coefficients in lines 100–120 to those for a different box Q from *Table 2*.

SUMMARY. Although Simplex AJ probably offers little practical value today, you can use it to build a VB which will match the small signal-frequency response of a specified CB design. Complex AJ allows low Q_{TS} drivers to be "forced" into alignment shapes that normally require a specific and higher Q_{TS}. Jammed Butterworth B_4 and Butterworth Inter-Order IB_3 aligments with low Q_{TS} drivers offer a lower f_3 frequency at the expense of a bigger box and a small amount of passband ripple relative to the classic QB_3 alignment. The jammed Bessel Be_4 alignment allows low Q_{TS} drivers to be used in designs having the very low cutoff slope associated with the Bessel alignment. *Table 2* provides jamming coefficients at a variety of box Qs for the B_4, Be_4 and IB_3 jammed alignments. In addition, by using equations provided in this article, you can develop AJ coefficients for other prototype alignments. The simple BASIC program provided helps you design the B_4, Be_4 and IB_3 jammed alignments at a box Q of 7.

SOURCES

Old Colony Sound Lab
PO Box 243
Peterborough, NH 03458
(603) 924-6371
FAX (603) 924-9467

Sitting Duck Software
PO Box 130
Veneta, OR 97457

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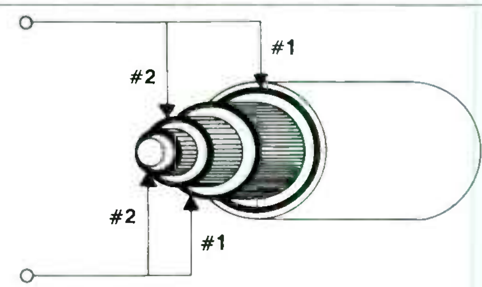

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Auburn, CA 95603
(916) 823-1186 FAX (916) 823-0810

For International Inquiries:
MIT Components
760 Pacific Road. Unit 19
Oakville, ONT Canada L6L 6M5
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Part I

THE DANIELLE

BY MARC BACON

My introduction to using computers for loudspeaker modeling was a TRS-80 BASIC program that appeared in a Radio Shack book in the early 1980s, written for calculating the bass response of closed and vented boxes. At the time, IBM had not yet created a PC standard, so I copied it to an HP9835 desktop and proceeded to put Thiele/Small theory into practice to make bass boxes. Screen graphics were primitive in those days, but I had access to a good nine-pen plotter and thus could get a feel for results.

SPREADSHEETS. With time, better computers and software became available, including spreadsheets. These appeared in three generations: Visicalc and Multiplan; Lotus 1-2-3 and compatibles; and Excel and compatibles. Perhaps due to timing, Lotus 1-2-3 eventually emerged as a *de facto* business standard.

I first applied a spreadsheet to my engineering work in order to develop a quick means of calculating pressure vessels. The ability to apply "cookbook" formulas rapidly with very little restriction on input and instantaneous output quickly turned me into a convert. In spite of a decade of development, no other means of computing on the market offers the flexibility of structure, expandability, and graphics capability of a spreadsheet.

```
a) Bass Section Design
b) Enclosure Design
c) Crossover Design
d) Driver parameters/Losses/Misc. tests
e) Miscellaneous Functions
f) Exit
Press Alt & your selection simultaneously
Press Alt-Z for HELP
```

FIGURE 1: LDP main menu.

```
a) Closed Box
b) Closed Box + 1st order equalizer
c) Closed Box + 2nd order equalizer
d) Vented Box
e) Vented Box + 1st order equalizer
f) Vented Box + 2nd order equalizer
g) Passive Radiator
h) Transmission line
i) Bandpass(Front vent/sealed rear)
j) Type i + resonant circuit
k) Combined a & j
l) Bandpass (Vented front and rear)
m) Series vented bandpass
n) Bandpass (PR front/sealed rear)
o) Bandpass (PR front and rear)
p) Bandpass (PR front, vented rear)
q) 3 chamber vented bandpass
r) Type q + resonant circuit
s) Mass loaded passively assisted
   closed box
t) Vent length calculator
u) Return to main menu
Press Alt & your selection simultaneously
Press Alt-Z for HELP
```

FIGURE 2: LDP bass-section design menu.

DESIGN SOFTWARE. My interest in using computers for speaker design increased with the purchase of LMP (Loudspeaker Modeling Program) from Old Colony Sound Laboratory. Here was a low-cost alternative to physical system testing that gave decent results as long as the designer used loudspeakers without sudden jumps in frequency response and properly compensated for impedance variations. My "Integrite" article that appeared in *SB* 3/91 showed some of what could be done for bass design when LMP and spreadsheets were coupled with the rational pursuit of design objectives.

During the past two years we have seen an ever-increasing number of design programs intended for bass modeling, system and crossover modeling, or both. Many have good graphics capability, but most really good ones are inaccessible to the amateur due to their cost.

After carefully considering several alternatives for system modeling, I decided to purchase CALSOD (Computer-Aided Loudspeaker System Optimization and Design) from Old Colony. This program has excellent graphics, a very good optimizer, and a well-written instruction manual. Furthermore, I have yet to find a bug in the software, which is unusual for a program of this size. Kudos to the programmer! CALSOD does have one small glitch, though, in my opinion: in-

ABOUT THE AUTHOR

Marc Bacon is the general manager of a company specializing in the manufacture of pressure vessels. An American making his home in Quebec, he builds speakers in order to combine the learning process with the eventual pleasure derived from listening to music through his creations. For the past five years he has directed much of this free time to software development, with the majority of the emphasis on loudspeaker modeling.

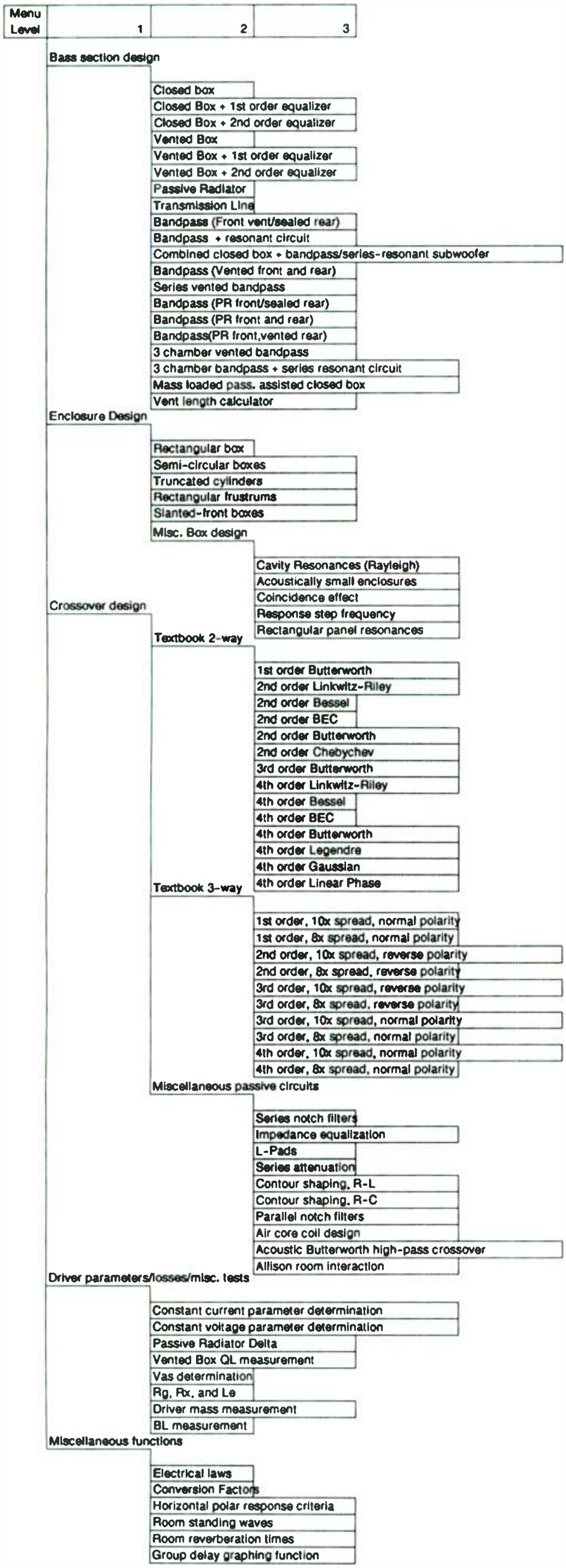

FIGURE 3: Loudspeaker Design Powersheet main menu tree.

put can be difficult to learn at first, and without an intuitive feel for starting values and which components to vary, optimization can be frustrating. As with any good program, however, several hours of practice will transform you from a bumbling novice into a confident designer.

DESIGN FEATURES. Over time, I have steadily increased the number and content of my spreadsheet speaker design programs to a total of 78 at last count. These include:

1. Design programs for 19 (yes, you read that right!) different types of bass loading.
2. Five programs to calculate box volumes for different shapes.
3. Five other miscellaneous box design programs, including cavity resonance approximation, acoustically small enclosures, and panel resonances.
4. Twenty-four programs for generating textbook values for two-way and three-way crossovers. (This is an extremely quick way to determine starting values for system optimizers such as CALSOD or XOPT.)
5. Ten programs covering miscellaneous crossover design circuits such as notch filters, Zobels, and L-pads; air-core coil design, and room interaction.
6. A series of programs for determining driver parameters, losses, passive radiator delta, V_{AS}, and so forth.
7. Miscellaneous programs for conversion from English to metric units; room acoustics; and RLC electrical circuit laws, to name a few.

Twice I have tried to write a system modeler in spreadsheet form for optimizing crossovers, but have given up for now. Spreadsheets are simply not conducive to iterative modeling. They are, however, unbeatable aids in speeding up cookbook calculations, so I now do loudspeaker design with a combination of CALSOD and my own spreadsheets. These allow me to quickly try many possibilities, print out the results and graphics, and have confidence when I begin to buy components or building materials. The system modeler allows excellent prediction of SPL, phase, group delay, and impedance.

THE LDP. Working with Old Colony, I've now made available to other amateurs the design spreadsheets, bundled together as the Loudspeaker Design Powersheet (LDP). Offered at two levels, the different LDP design programs are arranged in a menu tree *Fig. 3*) which makes access simple. Many readers are

Continued on page 26

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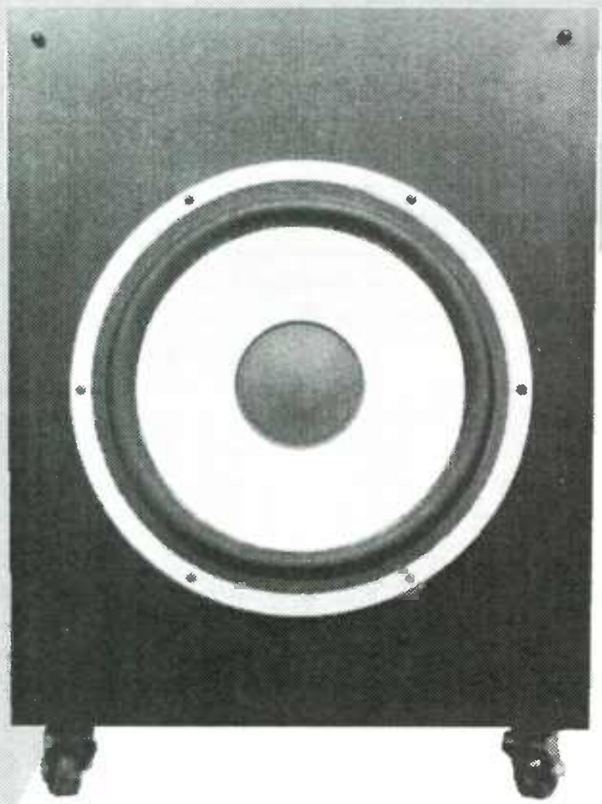

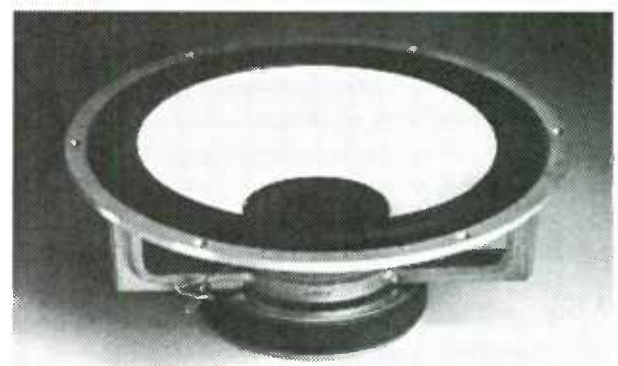

VIETA L100XAC

Driver:

Nominal Diameter	D	=	10 Inches
Free Air Resonance	f(s)	=	22.63 Hz
Total Driver Q	Q(ts)	=	.4
Driver Electrical Q	Q(es)	=	.527
Driver Mechanical Q	Q(ms)	=	1.652
Equiv. Volume	V(as)	=	5.4908 cubic ft.
Nominal Impedance	Z(nom)	=	8 Ω
DC Resistance	R(e)	=	2.33 Ω
Max Thermal Power	P(t)	=	200 Watts
Peak Excursion	X(max)	=	.25591 Inches
Piston Area	S(d)	=	54.25 Sq. Inches
Efficiency	n(0)	=	0 %
Sensitivity (1W/1m)	SPL	=	95 dB
Voice Coil Inductance	L(e)	=	.29 mH
Magnet Weight	Magnet	=	0 lbs.
Voice Coil Diam.	Diam(vc)	=	1.5551 Inches
BL Product	BL	=	5.86 T * m
Flux Density	Flux	=	1.35 Gauss
Dynamic Mass	M(as)	=	(Kg)
Voice Coil Length	L(vc)	=	.7874 inches
Magnetic Gap Length	L(gap)	=	.27559 inches

vb	1 cu ft	1.5 cu ft	2 cu ft
F3	45 hz	40 hz	33 hz
Sealed Qtc.	.998	.847	.760

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VIETA L120 XAC/134

Driver:

Nominal Diameter	D	=	12 Inches
Free Air Resonance	f(s)	=	22.63 Hz
Total Driver Q	Q(ts)	=	.644
Driver Electrical Q	Q(es)	=	.853
Driver Mechanical Q	Q(ms)	=	2.629
Equiv. Volume	V(as)	=	8.4615 cubic ft.
Nominal Impedance	Z(nom)	=	4 Ω
DC Resistance	R(e)	=	3.97 Ω
Max Thermal Power	P(t)	=	200 Watts
Peak Excursion	X(max)	=	.29528 Inches
Piston Area	S(d)	=	79.05 Sq. Inches
Efficiency	n(0)	=	1.549 %
Sensitivity (1W/1m)	SPL	=	94 dB
Voice Coil Inductance	L(e)	=	.01 mH
Magnet Weight	Magnet	=	0 lbs.
Voice Coil Diam.	Diam(vc)	=	2.0276 Inches
BL Product	BL	=	7.14 T * m
Flux Density	Flux	=	1.25 Gauss
Dynamic Mass	M(as)	=	(Kg)
Voice Coil Length	L(vc)	=	.86614 inches
Magnetic Gap Length	L(gap)	=	.27559 inches

vb	2 cu ft	3 cu ft
F3	36 hz	40 hz
Sealed Qtc.	.808	—
Vented	—	Fb 27 hz
Port diameter	—	4"
Port length	—	12.663

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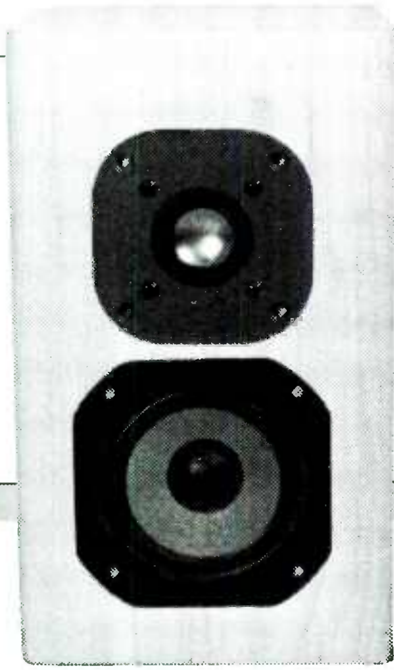

FOCAL 4 1/2" 2-WAY SYSTEM

Nowadays everyone is asking for satellite/subwoofer systems. Since the question comes up at least ten times a day I thought it was time to show our most popular choices. The new Focal 4-1/2 inch woofers make a beautiful little system. The small cabinet takes up every little space and sounds enormous. This coupled with the new Vieta 10 inch dual voice coil subwoofer is just amazing. The best part of the Vieta 10 inch woofer is the small box size needed. You can even get great sound in one cubic foot. Thus for small size and big sound this combination can't be beat.

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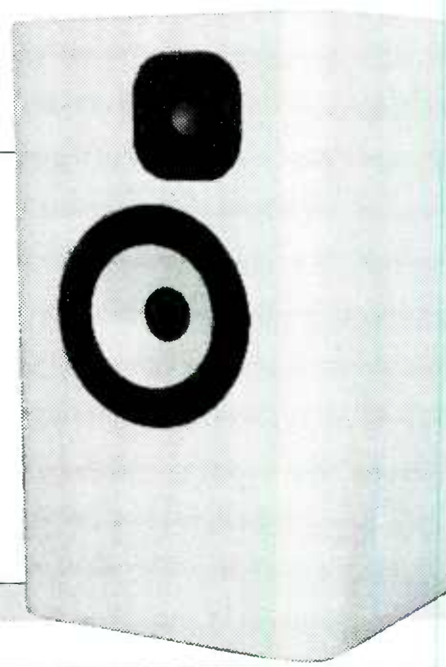
For those who can have a bigger system the new Focal 6-1/2 inch woofers coupled with the Vieta 13-1/2 inch subwoofer is really amazing. The satellites sound great by themselves but when you add the solid bass of the Vieta subwoofer you really will be shocked. The price is not that high so anyone can now own a terrific system.

$285
Cabinets Extra



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```
                         Name     Type        Title

Graphs available:        LOG      XY          SPL response - log scale
                         NORMAL   XY          SPL response - linear scal
                         POWER    XY          SPL and power handling

                         INPUT PARAMETERS
                         =========
                    Qms:      1.5 *
                    Qes:     0.28 *
                    Qts:    0.236

              Rg, ohms:      0.48 *
              Re, ohms:       3.2 *
                   Qes':    0.322
                   Qts':    0.265

               Fs (Hz):        55 *
                Vas(l):        12 *
     Thermal rating (W):       120 *

               Fs/Qts':   207.47

   Optimum Box available? NO
  ( If 'NO', Optimum Box will read ERR)
        or wrong values
                          Box 1        Box 2
       Optimum Fb (Hz): n/a      n/a
        Optimum Vb (l): n/a      n/a
          Optimum Qtc: ERR      ERR

              Xmax(mm):         3 *
     Max. excursion(mm):       12 *
             Sd(cm^2):        110 *
   Vd(m^3), calculated: 3.30E-05

        n0, calculated:   0.0069 free air
 Given sensitivity 1W 1m:    92.2 free air *
 Calc. sensitivity 1W 1m:    92.2 free air, incl. Rg

                         CLOSED BOX DESIGN
                         =================
            Chosen Qtc:     0.53 *

                     a:     3.00

                 Vb(l):     4.00
                 Fb(Hz):   110.0
                 F3(Hz):   157.4

                 Par(p):   0.568
            Per(watts): See graph
         Max. linear SPL: See graph
  Damage limited power (w):    120
               Max.SPL:    112.9
```

FIGURE 4: LDP closed-box design menu.

Continued from page 23

familiar with and will be able to use Lotus 1-2-3 or compatibles such as Quattro; most other spreadsheets have utilities to translate Lotus .WK1 files. It is important to note here that the Loudspeaker Design Powersheet DOES NOT INCLUDE SPREADSHEET SOFTWARE; instead, it is intended for use with the spreadsheet you already have. There is no need to learn how to use the LDP if you are already familiar with spreadsheets; you just need to load the main menu and read the on-screen instructions. Release 2.0 includes context-sensitive HELP screens, making use very simple. The program code is unprotected except by copyright, in order to allow maximum expansion and customization. I firmly believe that this program offers the widest range of applications (except for system optimization) available today, in the most flexible format, and at the lowest cost.

THE DANIELLE. The remainder of this article will describe my design of a speaker by using a combination of the LDP and CALSOD. In honor of my wife, whose patience in putting up with my passion for speakers and whose love of good music were invaluable in encouraging this project, I have named this speaker the Danielle. In Part 2 of this article I will describe how to build this system, as well as the results.

I set out to better my Integrites by providing for the following:

1. Lower F_S, and lower-Q midrange/woofers with longer excursion limits in order to tighten the midbass and reduce IM distortion.
2. More volume displacement and bass extension for the subwoofer.
3. More constant impedance in the midrange.
4. Improvement of the already-fine D'Appolito array for imaging.
5. Less low-frequency information reaching the tweeter.
6. More constant group delay and phase response.
7. Better control of resonance in the woofer cabinet.

The Integrites were already rather good performers. My previous experiences with the combination of a bandpass subwoofer and a midrange-tweeter-midrange (MTM) array in an acoustic suspension enclosure have always been rewarding. This arrangement avoids a low-pass electrical section in the midrange crossover, limits cone excursion, loads the subwoofer symmetrically, and gets good bass extension for a given efficiency and maximum SPL. The bandpass enclosure, while more complicated to build, benefits from the extra internal baffle in terms of stiffness, and the acoustic filter effectively blocks most harmonics.

I wrote a program included in the LDP specifically to allow users to combine acoustic suspension and bandpass drivers. Furthermore, it permits matching the desired rolloff of the midbass driver and bass extension by allowing the user to add a series-resonant circuit of varying Q and center frequency and by allowing the front volume to be tuned to a different frequency than the rear. More on this later. Although I dearly would have liked to experiment with Kevlar midbass drivers and Focal's new titanium dome tweeter, Canadian discretionary income restrictions brought me back to reality. Hence, this speaker was built using SEAS 11-FGX woofer/midranges, Morel MDT-30 tweeters, and Zalytron TA-305F clones for subwoofers.

SEAS practices value engineering—quite simply, providing superior quality for less money—and the 11-FGX has become a classic used by reputable manufacturers such as ProAc and Thiel. It features a low resonant frequency, smooth response, huge magnet, cast magnesium frame, small V_{AS}, long excursion, ex-

```
                 DRIVER PARAMETERS                        ENCLOSURE PARAMETERS
                 =================                        ====================
              Qms:      2.64 *                           S:    0.576 *
              Qes:      0.38 *                 Desired SPL:     88.2 *
              Qts:     0.332

        Rg, ohms:       0.62 *              SPL difference: 0.126530
        Re, ohms:       5.34 *                          B:   0.9927
            Qes':      0.424
            Qts':      0.365                            Q'T   0.8744
                                                    Fs/Qts:    60.21
                                                   Fo (Hz):    52.64
          Fs (Hz):        22 *                   Vfront (l):    31.90
           Vas(l):       180 *                    Vrear (l):    38.09
                                                 Vtotal (l):    69.98
         Xmax(mm):       6.1 *
Max. excursion (mm):      20 *          Approx. Bandwidth:      62.89
       Sd (cm^2):        539 *                          Fl: See graph
Vd(m^3), calculated:  3.29E-04                          Fh: See graph
    n0, calculated:   0.0050
Given sensitivity 1W 1m:  90.0 *                          F1:    32.64
Calc. sensitivity 1W 1m:  89.0                            F2:    84.90
Sensitivity with Rg:      88.1                       (F2-F1):    52.26
     Chosen Ref. SPL:     88.1 *

 Chosen center (Hz):     50.33 *(Normally choose vent tuning frequency)
                                        Vent tuning (Hz):     44.0 *(Normally choose Fo)
     Chosen Filter Q:     0.531 *         Vent dia. (in.):       3 *
   Filter capacitor: 9.992E-04  Farads    Number of vents:       1 *
    Filter inductor: 1.001E-02  Henries   Vent area (in^2):  7.069

                                     Equivalent dia. (in.):    3.00
                                      Required length (in):    6.54
```

FIGURE 5: LDP sixth-order bandpass with staggered tuning.

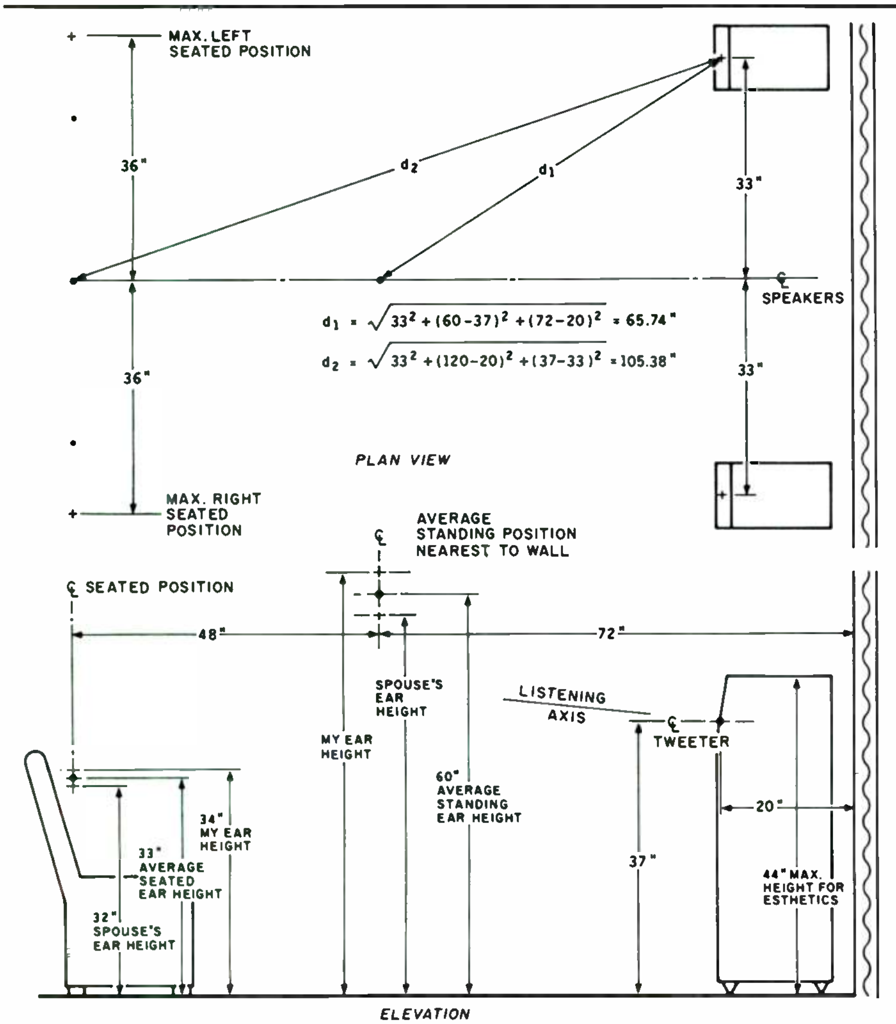


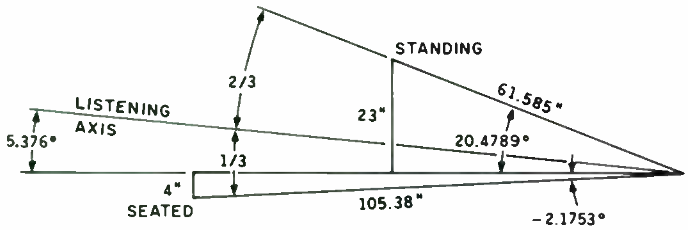
FIGURE 6: Listening room geometry.

tremely fast acceleration, and good power handling. The down side, a relatively low efficiency, can be overcome by using two drivers in parallel in a D'Appolito configuration for a 6dB gain.

I have used the MDT-30 previously, and find it very close to the much more expensive Dynaudio D28-AF in sound and quality. Although metal domes are becoming popular due to their timbre with ringing bells, chimes, and so forth, soft domes are still my favorites because they aren't plagued with audible breakup. The MDT-30 features a very low Q, low resonance, hexacoil, high power handling, double chamber, and stranded tinsel wire leads—as well as an amplifier-straight response. It is easy to model, shows no compression, and has excellent transient response.

Elliot Zalayet of Zalytron has found a winner with the clones he developed with Carbonneau, now that Precision Loudspeakers is out of business. They have a very low V_{AS} for 12″ drivers, move a lot of air, are well built, and don't cost much. With a brace behind the magnet to avoid resonances in the stamped frame, they are excellent to nearly 1kHz.

USING THE LDP. The Loudspeaker Design Powersheet is accessed through a main menu (*Fig. 1*) by loading the file MENU.WK1 from the Lotus main



CHOOSE LISTENING AXIS ONE-THIRD OF WAY BETWEEN SEATED AND STANDING POSITION

$$\frac{20.4789 + 2.1753}{3} - 2.1753° = 5.376° \text{ ABOVE HORIZONTAL}$$

FOR 2M TARGET, ADD 6DB INPUT VOLTAGE

TARGET	X (METERS)	Y (METERS)	Z (METERS)
ON-AXIS	0.0	0.187	1.991
SEATED	0.0	−0.076	1.999
STANDING	0.0	0.700	1.874

MTM BAFFLE GEOMETRY (ACOUSTIC CENTERS) IS AS FOLLOWS:

DRIVER	X (METERS)	Y (METERS)	Z (METERS)
TOP	0.0	0.107	−0.010
TWEETER	0.0	0.0	0.0
BOTTOM	0.0	−0.107	0.010

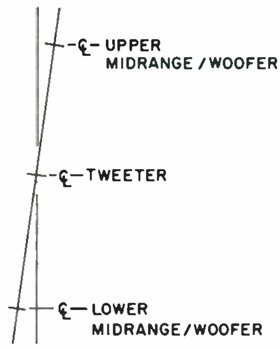


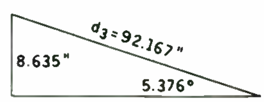
FIGURE 7: Speaker geometry.

DETERMINING TARGET:

$$d_3 = \frac{(d_2 - d_1)2}{3} + d_1 = \frac{(105.38 - 65.74)(2)}{3} + 65.74 = 92.167"$$

$$\text{HORIZONTAL DISTANCE FROM WALL} = \sqrt{92.167^2 - 8.635^2 - 33^2} = 85.622"$$

$$\text{ANGLE} = \tan^{-1}\left(\frac{33}{(85.622 - 20)}\right) = 26.696°$$



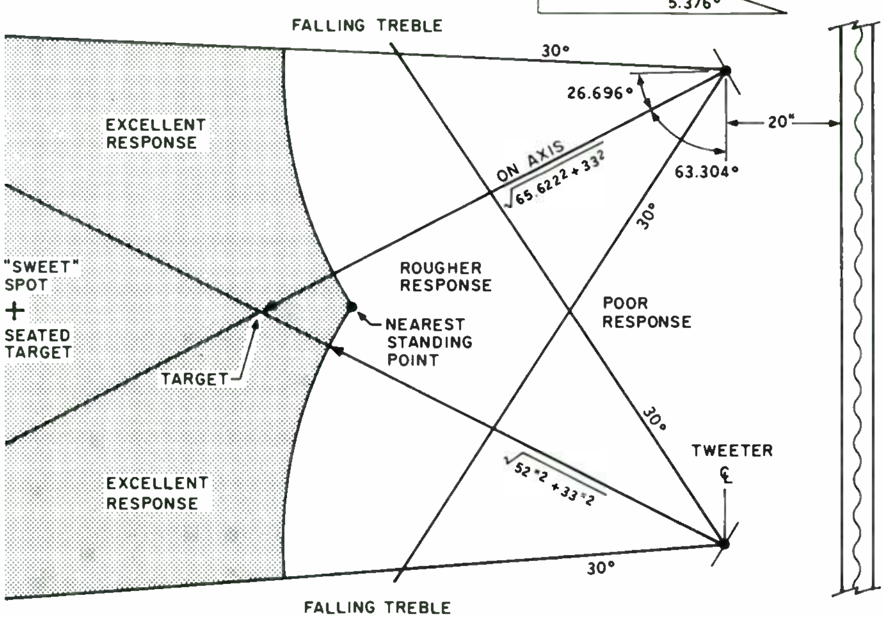


FIGURE 8: Optimized listening position.

```
a) Textbook 2-way
b) Textbook 3-way
c) Miscellaneous passive circuits
d) Return to main menu

Press Alt & your selection simultaneously

Press Alt-Z for HELP
```

FIGURE 9: LDP crossover design menu.

screen. Access to all subprograms is done by pressing Alt and the desired selection simultaneously. This sequence activates a macro which retrieves the subprogram. You then need only to follow screen instructions.

Pressing Alt-A from the main menu brings up the bass section design menu (*Fig. 2*). Again, you can make the necessary choices easily by pressing Alt-selection combinations. HELP is available by pressing Alt-Z from any screen.

Options A, J, and K of the bass-section design menu (*Fig. 2*) were used to develop the bass loading. After a bit of playing with numbers and some discussion with my wife regarding aesthetics, I limited the total volume to 75 liters and the overall height to 44". At this stage, I worked with the LDP and various drivers to get maximum bass extension, reasonable efficiency, and smooth response for minimum cost. For preliminary work in adjusting Q_{TS} values, I used 0.5Ω DCR for the subwoofer and 0.2Ω for the woofer/midrange.

Bass extension in bandpass enclosures is a function of the F_S/Q_T ratio. Maximum SPL depends on the limits of cone excursion. I played for over a month with different woofer/midrange combinations before choosing. The LDP permitted investigating options quickly, including dual 8" woofers, a long-excursion 10" woofer, and (4) 5" woofers, combined with 4", 5", and 6½" drivers. The TA-305F clone and SEAS drivers gave a combination with lots of air moved and a tight midbass (Q_{TC} = 0.53).

The final closed-box spreadsheet is shown in *Fig. 4*. Note that the V_{AS} is 12 liters (for two drivers) and that I modified the sensitivity by 3dB for the parallel connection. Such modifications are very simple with a spreadsheet, but nearly impossible in compiled programs. The sixth-order bandpass spreadsheet is shown in *Fig. 5*. The computer greatly simplified evolutionary changes which took place, especially as I varied R_G (the series resistance) in CALSOD system optimization to match driver sensitivities and achieve constant impedance. The final total box volume is 74 liters.

ROOM GEOMETRY. With the rough work on driver selection complete, I moved to room geometry considerations. *Figure 6* shows the geometry of my listening room. Working from the 44" height limit, I decided that the tweeter would be 37" from the floor and 20" from the rear wall. I then worked out two extreme positions:

```
a) 1st order Butterworth
b) 2nd order Linkwitz-Riley
c) 2nd order Bessel
d) 2nd order Bullock Equivalent Compromise
e) 2nd order Butterworth
f) 2nd order Chebychev
g) 3rd order Butterworth
h) 4th order Linkwitz-Riley
i) 4th order Bessel
j) 4th order Bullock Equivalent Compromise
k) 4th order Butterworth
l) 4th order Legendre
m) 4th order Gaussian
n) 4th order Linear Phase
o) Return to Crossover Design Menu
Press Alt & your selection simultaneously
Press Alt-Z for HELP
```

FIGURE 10: LDP two-way crossover submenu.

```
3.1.5 2nd Order Butterworth Crossover - Input values marked *
For HELP, read the Loudspeaker Design Cookbook
Reverse polarity sums to +3dB
Q = 0.7
Press Alt-M to return to previous menu
                                                  + ---0000---.----
 Woofer impedance (ohms):          4 *                 L2     |      \
Tweeter impedance (ohms):        6.5 *                        |       \ +
                                                         C2 ===     Woofer
Crossover frequency (Hz):       2400 *                        |       /
                                                  -  ---------.----  /
           L1 (Henries):   6.10E-04
           L2 (Henries):   3.75E-04
            C1 (Farads):   7.21E-06               + ----| |---.----
            C2 (Farads):   1.17E-05                      C1   |      \
                                                              0       \
      For flat response:                                  L1  0     Tweeter
             F  low (Hz):       1846                          0      /+
             F high (Hz):       3120              -  ---------.----/

           L1 (Henries):   4.69E-04
           L2 (Henries):   4.88E-04
            C1 (Farads):   5.55E-06
            C2 (Farads):   1.52E-05
```

FIGURE 11: LDP second-order Butterworth crossover.

```
        Press Alt-Z for HELP
a) Series notch filters - driver resonance control
b) Impedance Equalization - voice coil inductance
c) L-Pads
d) Series attenuation
e) Contour shaping. R-L
f) Contour shaping, R-C
g) Parallel notch filters
h) Air Core Coil Design
i) Acoustic Butterworth high-pass crossover
j) Allison room interaction
k) Return to Crossover Design menu
Press Alt & your selection simultaneously
```

FIGURE 12: LDP miscellaneous passive circuits submenu.

```
.3.2 Impedance equalization - input values marked *

Press Alt-M to return to previous menu

     Driver Re (ohms):          2.85 *
  Driver Le (Henries):      3.00E-04 *

          C (Farads):       2.36E-05
           Rc (ohms):           3.56
```

FIGURE 13: LDP Zobel calculator.

1. A seated position on the couch facing the speakers.

2. A standing position as near the speakers as we normally go for serious listening.

In three-dimensional space I found distances d1 and d2 to those two points, and then calculated the vertical angles to each. The listening axis was arbitrarily chosen to be twice as close to the seated position as the standing, as that was the preferred listening position. In our listen-

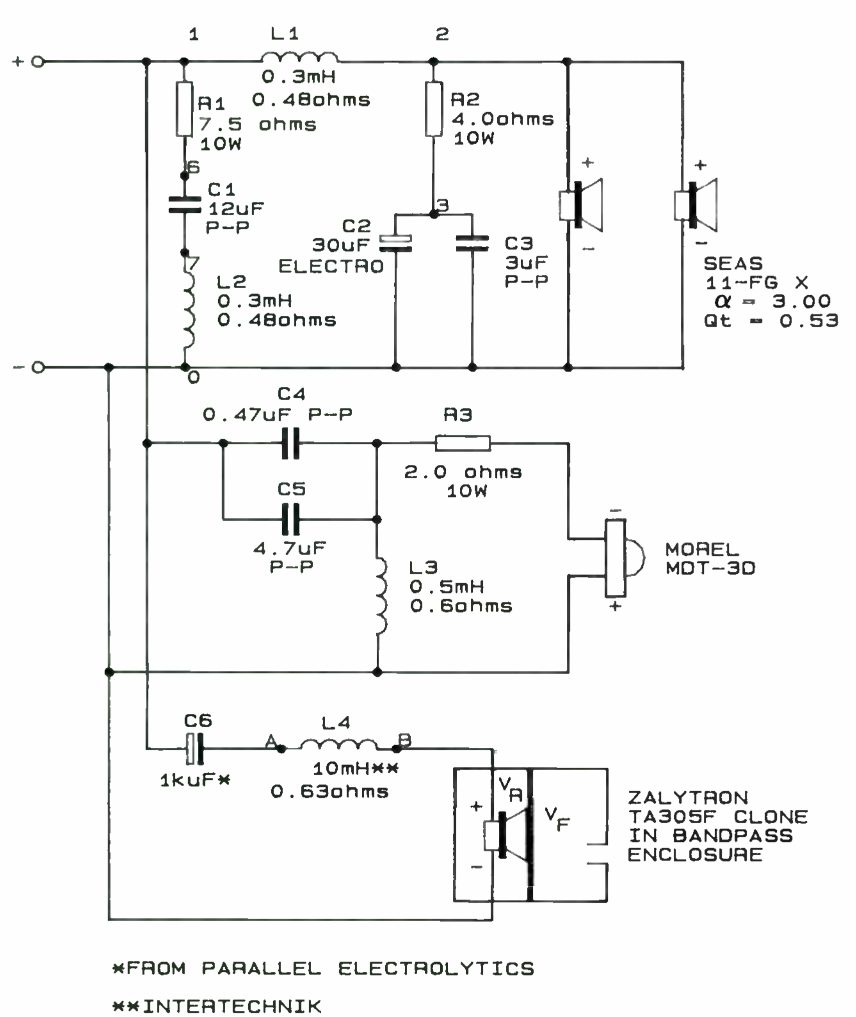


FIGURE 14: Danielle crossover schematic.

RELATED PRODUCTS

The following products mentioned in this article are available from Old Colony Sound Laboratory, PO Box 243, Peterborough, NH 03458-0243; (603) 924-6371; FAX (603) 924-9467. USA surface shipping cost is $3 per item; others, please inquire.

Loudspeaker Modeling Program (LMP)		
SOF-LMP1A5	LMP w/out graphics Apple II	$17.50
SOF-LMP1C5	LMP w/out graphics Commodore	17.50
SOF-LMP2B5	LMP w/out graphics IBM	17.50
SOF-LMP2M3	LMP w/out graphics Macintosh	17.50
SOF-LMP3B3G	LMP w/ graphics IBM 3½"	49.95
SOF-LMP3B5G	LMP w/ graphics IBM 5¼"	49.95
SOF-LMP3M3G	LMP w/ graphics Macintosh	39.95
CALSOD		
SOF-CAL2B4G	CALSOD w/ graphics IBM 3½"	67.50
SOF-CAL2B6G	CALSOD w/ graphics IBM 5¼"	65.00
Loudspeaker Design Powersheet (LDP)		
SOF-PSH1B3	LDP basic version IBM 3½"	49.95
SOF-PSH1B5	LDP basic version IBM 5¼"	49.95
SOF-PSH2B3	LDP Professional version IBM 3½"	69.95
SOF-PSH2B5	LDP Professional version IBM 5¼"	69.95
Loudspeaker Design Cookbook		
BKAA2	Fourth edition, 1991, 154pp.	29.95

ing room, this worked out to be a 5.376° slant on the front baffle between acoustic centers of the MTM array, as shown in *Fig. 7*. Also shown in that figure are the CALSOD target values for the drivers and three listening positions, normalized to a 2m listening distance.

I chose to toe-in the speakers to aim at the vertical target on the speaker centerline in front of the seated position. The math consists of working backwards from the target distance on the desired vertical angle. The results are shown in *Fig. 8*. The stereo image remains stable with little variation in direct energy response throughout most of the listening room. Although the Danielle was designed for our home, it is typical in size and will work for many listening rooms with no modification.

```
!TWO-WAY REFERENCE ON-AXIS + SUBWOOFER
!
CIRCUIT
!SEAS 11-FGX D'APPOLITO CONFIGURATION
!
SPK 1 0 2 0.0 0.107 -0.01 POSITIVE
SPK 1 0 2 0.0 -0.107 0.01 POSITIVE
!WOOFER/MIDRANGE IMPEDANCE EQUALIZATION
CAP 33.0E-6 2 3 FIXED
RES 4.0 0 3 FIXED
!CROSSOVER
IND 3.0E-4 1 2 0.46 FIXED
!
TARGET
VIN 6 DB
SEN 91.7 DB
XYZ 0.0 0.187 1.991
!
DRIVER 1
Woofer/Midrange
SOUND PRESSURE
SEN 87.0 DB
SCB 50.0 0.24 3.00
MPE 1200.0 2.8 2.0 DB
MPE 5500.0  6.0 -3.0 DB
MPE 6800.0  4.0 4.0 DB
MPE 10000.0 9.0 -5.5 DB
MPE 11000.0 10  8.0 DB
BUT 8000 4 LOWPASS
!
IMPEDANCE
ICB 55.0 6.4 1.1E-3 1.5 0.28 3.00
MPE 8E4 0.25 0.15 LINEAR
!
!MOREL MDT 30 TWEETER
!
CIRCUIT
!CROSSOVER
CAP 4.7E-6 1 4 FIXED
CAP 0.47E-6 1 4 FIXED
IND 5E-4 0 4 0.6 FIXED
RES 2.0 4 5 FIXED
!SPEAKER
SPK 2 0 5 0.0 0.0 0.0 NEGATIVE
!
!GLOBAL IMPEDANCE EQUALIZATION
RES 7.5 1 6 FIXED
CAP 12E-6 6 7 FIXED
IND 3E-4 0 7 0.48 FIXED
!
DRIVER 2
Tweeter
SOUND PRESSURE
SEN 91.6 DB
HLR 700.0 0.0 0.65 0.85 0.0
MPE 200.0 1.8 8.0 DB
MPE 600.0 1.7 5.0 DB
MPE 3500.0 10.0 -2.0 DB
MPE 6000.0 10.0 -2.0 DB
MPE 2200.0 2.0 1.7 DB
BUT 24000.0 4 LOWPASS
!
IMPEDANCE
ICB 700.0 5.2 0.09E-3 0.65 0.85 0.0
```

FIGURE 15: CALSOD input file for MTM.

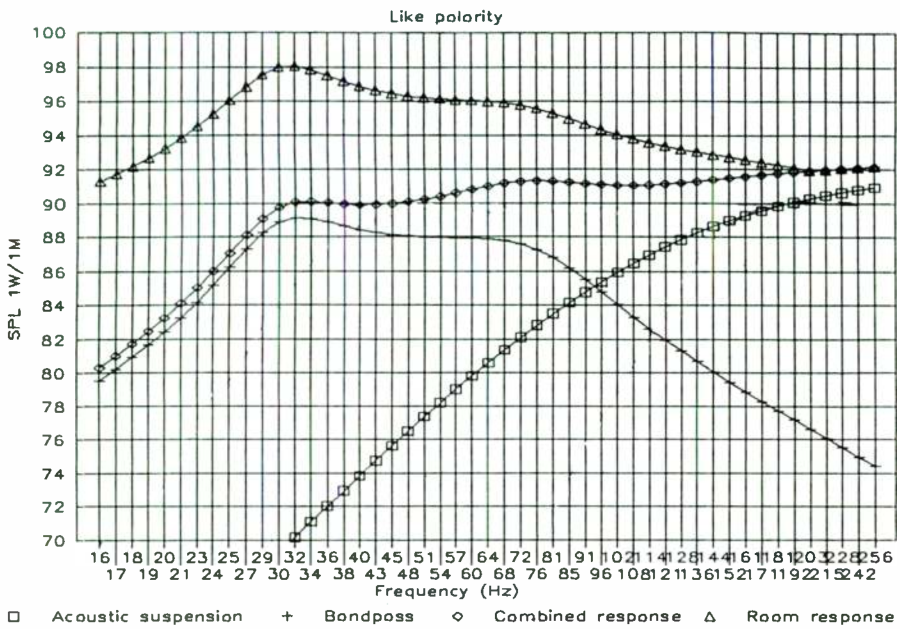


FIGURE 16: LDP combined satellite/subwoofer response.

CALSOD. System design on CALSOD was evolutionary, with many back-and-forth runs to the LDP to get basic input values, check the effect of series resistances, and so forth. Modeling is not an exact science, but rather an exact mathematical calculation in which output is no better than input and program assumptions. From personal experience, however, I can say that a careful person using today's design tools will easily come up with better systems than the best available as little as five years ago—without the previously required man-years of trial-and-error component testing and resulting need for a large junk-box of spare parts.

I chose a starting crossover frequency of 2.4kHz between the midrange and tweeter using a second-order Butterworth crossover and assuming that the tweeter

Continued on page 35

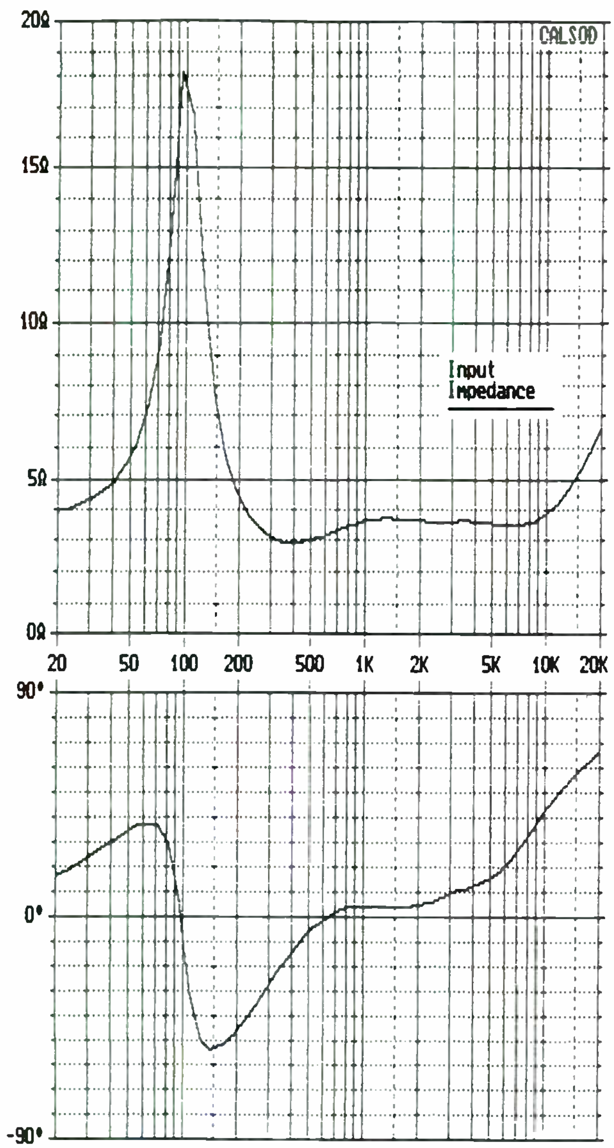


FIGURE 17: CALSOD MTM input impedance.

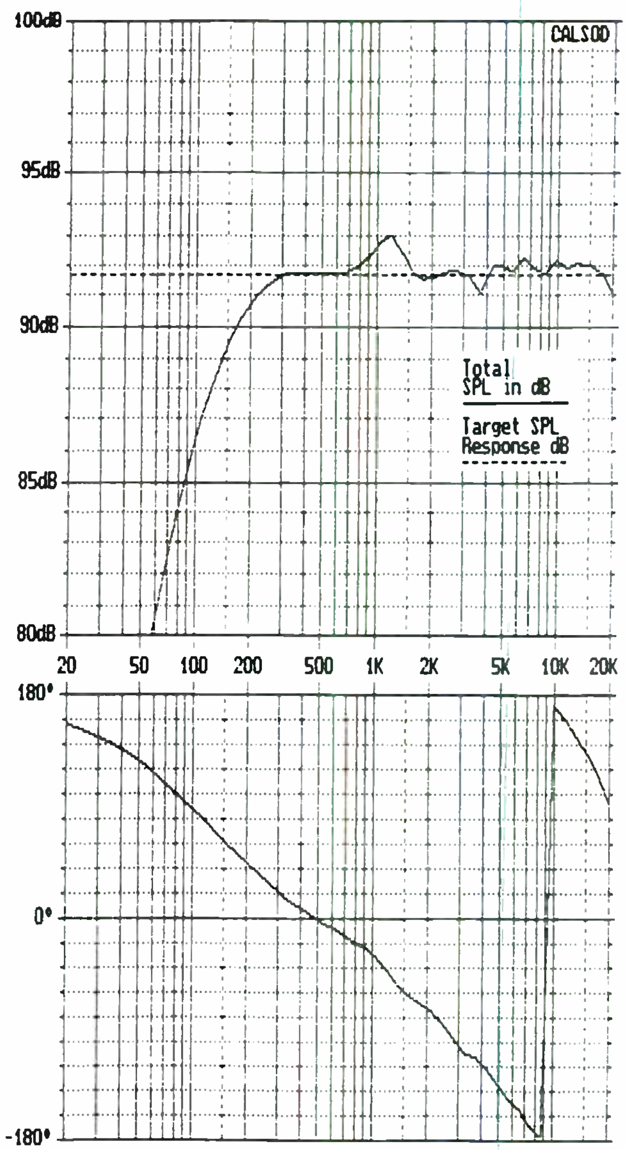


FIGURE 18: CALSOD MTM on-axis response.

NEW FROM OLD COLONY

HIGH POWER AUDIO AMPLIFIER CONSTRUCTION — **BKEV18** — **$10.95**

R.A. Penfold

This book provides background information on high power audio amplifiers, together with some practical designs capable of output powers of up to around 300-400Wrms. Included are types having power MOSFETs in the output stage, which give excellent performance over the full audio range and offer good reliability in what are relatively simple circuits. Printed circuit designs are included for these MOSFET circuits, as are suitable power supply designs. For those who prefer to use bipolar output transistors, inverting and non-inverting circuits are provided. These can be used in single-ended or bridge configurations, and provide output powers comparable to those of the MOSFET designs. United Kingdom, 1991, 76pp., 4⅜ × 7, softbound.

LOUDSPEAKERS FOR MUSICIANS — **BKEV19** — **$10.95**

Vivian Capel

In this unique handbook, the author sets out to narrow the gap between the technician and the musician by relating technical expressions to musical terms. It contains all that a working musician needs to know about loudspeakers: the different types; how they work; and those most suitable for different instruments, for club/cabaret work, and for vocals. In addition, the author gives tips on constructing cabinets, wiring, when and where to use wadding/damping (and when not to), finishing, how to ensure they travel well, how to connect multi-speaker arrays, and much more. Ten practical enclosure designs with plans and comments are given in the last chapter, but by the time you've read that far, you should be ready to design your own. United Kingdom, 1991, 163pp., 4⅜ × 7, softbound.

ACOUSTIC FEEDBACK–HOW TO AVOID IT — **BKEV20** — **$10.95**

Vivian Capel

While feedback usually cannot be completely eliminated, many things can be done to reduce it to a level at which it is no longer a problem. Much of tne trouble is often the hall itself, not the equipment, but there is a simple and practical way to greatly improve acoustics. Some microphones are prone to feedback, while others are not. Certain speaker systems are much better than others, and the way the units are positioned can produce or reduce feedback. All these aspects are fully explored in this book, in addition to electronic aids such as equalizers, frequency shifters, and notch filters. The special requirements of live group concerts are also considered, as well as the related instability problems sometimes associated with large setups. Some unsuccessful attempts at curing feedback are even explored, in order to save readers wasted time and effort in duplicating them. The design, layout, and operation of a highly successful twin notch filter is also included in this handy overview. United Kingdom, 1991, 92pp., 4⅜ × 7, softbound.

PREAMPLIFIER AND FILTER CIRCUITS — **BKEV21** — **$10.95**

R.A. Penfold

This book provides circuits and background information for a range of preamplifiers, plus tone controls, filters, mixers, and so forth. The use of modern low-noise operational amplifiers and a high performance audio preamp IC results in circuits that have excellent performance yet are still not too complex. All the designs featured can be built at relatively low cost. Preamp designs featured include: microphone preamps (low impedance, high impedance, and crystal); magnetic cartridge pickup preamps with RIAA equalization; a crystal/ceramic pickup preamp; a guitar pickup preamp; and a tape head preamp (for use with compact cassette systems). Other circuits are: an audio limiter to prevent overloading of power amps; passive tone controls; active tone controls; PA filters (high pass and low pass); scratch and rumble filters; a loudness filter; audio mixers; and volume and balance controls. No construction details are provided for the circuits in this book, and it is not really intended for beginners. On the other hand, the circuits are all pretty simple, and you do not really need much previous experience in electronic construction in order to tackle them. Where appropriate, any setting up procedures and notes on tricky aspects of construction are provided. Mainly intended for use in conjunction with BKEV18, *High Power Audio Amplifier Construction*. United Kingdom, 1991, 91pp., 4⅜ × 7, softbound.

PRACTICAL ELECTRONIC FILTERS — **BKEV22** — **$12.95**

Owen Bishop

Filters play a vital part in almost all electronic circuits, yet many people believe they are difficult to understand. This is probably because so many of the books on this topic are extremely mathematical. By contrast, this book deals with the subject in a nonmathematical way, reviewing the main types of filters and explaining in simple terms how each type works and is used. The book also presents a dozen filter-based practical projects with applications in and around the home or in the constructor's workshop. These include a number of audio projects such as a rhythm sequencer and a multi-voiced electronic organ. Project descriptions include circuit diagrams, explanations of their operation, and detailed instructions for building them. A number of the projects are suited to the beginner, while others will be of interest to the more advanced constructor. Concluding the book is a practical step-by-step guide to designing simple filters for a wide range of purposes, with circuit diagrams and worked examples. United Kingdom, 1991, 188pp., 4⅜ × 7, softbound.

LOUDSPEAKER DESIGN POWERSHEET SOFTWARE

Marc Bacon

Surely at the front of the spreadsheet speaker-design wave of the future, The LOUDSPEAKER DESIGN POWERSHEET was written by professional engineer Bacon with one purpose in mind: to make computer-aided speaker design accessible to everyone. The program covers a wide range of knowledge taken from the most recent publications in the field, yet is extremely simple to use and low in cost. The Professional version covers 19 different kinds of bass loading with extensive graphing capabilities; volume calculation for 5 different enclosure shapes; evaluation of cavity resonances, rectangular panel resonances, and the coincidence effect; 24 different types of crossovers; 10 miscellaneous programs for shaping circuits, zobels, room interaction, and coil design; 8 programs for evaluating driver parameters and losses; electrical laws; conversion factors; room acoustics; and more. A Basic version which includes 41 of the above programs is also available.

An unprotected source code allows the user to customize and build upon individual spreadsheets for his own use. Individual programs are accessed through a user-friendly menu tree, and context-sensitive HELP and an introductory README.1ST file are also included. Requires IBM PC or compatible with 640K of memory, preferably a hard disk, and Lotus 1-2-3, Quattro Pro, Excel, or another spreadsheet which can use Lotus *.WK1 files. PLEASE NOTE THAT SPREADSHEET SOFTWARE IS NOT INCLUDED. From *SB*. Upgrades from the Basic to the Professional version are available for $25 plus proof of purchase.

Purchasing options available:

SOF-PSH1B5	LOUDSPEAKER DESIGN POWERSHEET Basic version for IBM, 2 × 5¼"	$49.95
SOF-PSH1B3	LOUDSPEAKER DESIGN POWERSHEET Basic version for IBM, 1 × 3½"	$49.95
SOF-PSH2B5	LOUDSPEAKER DESIGN POWERSHEET Professional version for IBM, 5 × 5¼"	$69.95
SOF-PSH2B3	LOUDSPEAKER DESIGN POWERSHEET Professional version for IBM, 3 × 3½"	$69.95

NEW FROM OLD COLONY

LAYO1 PCB CAD/CAM SOFTWARE

Baas Electronics BV

Spectacular LAYO1 from The Netherlands features elegant schematic capture, autoloading of part shapes, continuous control of all electrical connections with simultaneous manual intervention option, easy-to-find optimum parts placement via a rat's-nest feature, high speed autorouting, and much more. This revolutionary package easily serves as an OrCAD™ add-on, its utilities and related functions implementable through its user-friendly Project Manager command shell. OrCAD SDT III or IV schematics input seamlessly to LAYO1.

The menu-driven Output Driver allows you to select up to forty recently used files and graphically preview pads and layers. Options include not only extensive scaling facilities for pen width and/or speed, "blackscale" for generating normal or extra-black plots, and pads and pens for mask generation purposes, but also selection features for image move, rotate and mirror, pad hole centering for facilitating drilling, automatic/manual pen change, drill program, pads, 15 different layers, extra pen for grid drawing and file name, date/time stamp, and automatic flash/selection for GERBER output. Most options can be directly verified and adjusted. Output can be directly to device or disk, the following output standards being supported: DMPL, HPGL, GERBER, EXCELLON, SIEB & MEYER, and POSTSCRIPT. Prototype output can be generated directly to HP LaserJet and Epson-compatible printers.

Requires IBM or compatible XT with EGA display adapter, 640K main internal memory, MSDOS 3.x, EGA monitor, hard disk with at least 5M free space, 3-button mouse, printer. Includes 119-page User Manual and 204-page Reference Manual, as well as registration information. Registered users receive update and upgrade information, as available, directly from Europe. Package "levels" indicate the relative density possible and are based on the number of "vectors" available, the latter essentially being X-Y coordinates on the board. Most hobbyists will find 4,000 vectors more than enough for normal creative use. Without question, we think LAYO1 is the ideal package for today's state-of-the-art electronics designer. Please allow five weeks for delivery.

Purchasing options available:

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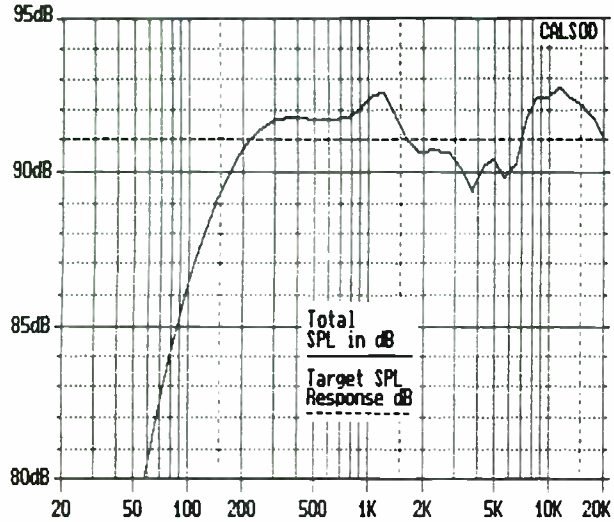

FIGURE 19: CALSOD MTM seated response.

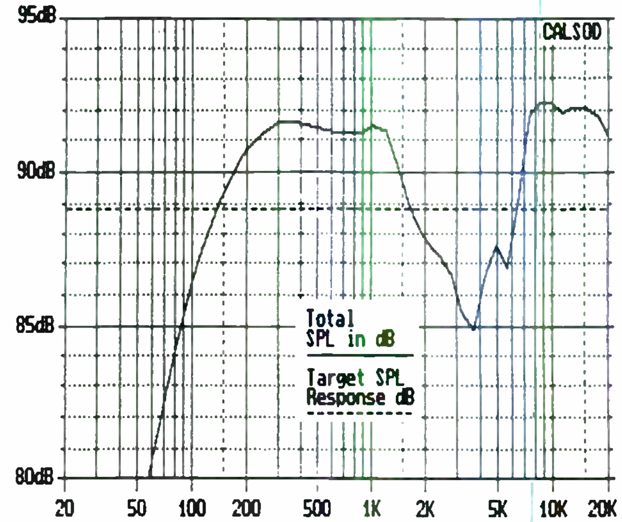

FIGURE 20: CALSOD MTM standing response.

Continued from page 31
rolloff would give near a third-order response. The menus for generating the cookbook crossover with the LDP are shown in *Figs. 9, 10,* and *11*. I also developed a Zobel circuit for the woofer/midranges by using the LDP, as shown in *Figs. 12* and *13*. Without a system optimizer, this would have yielded results typical for an amateur using a calculator and the *Loudspeaker Design Cookbook*—fine, but not optimal.

Using CALSOD involved modeling the responses of the midwoofers and the tweeter as well as their impedance. The procedure is too involved to reproduce here, but is well explained in the manual. A word to the wise: careful modeling of the driver's response is necessary before optimization. Rushing here may give you mediocre results.

I then specified a target SPL and position, and allowed the optimizer to generate circuit values. Zillions (!) of trials

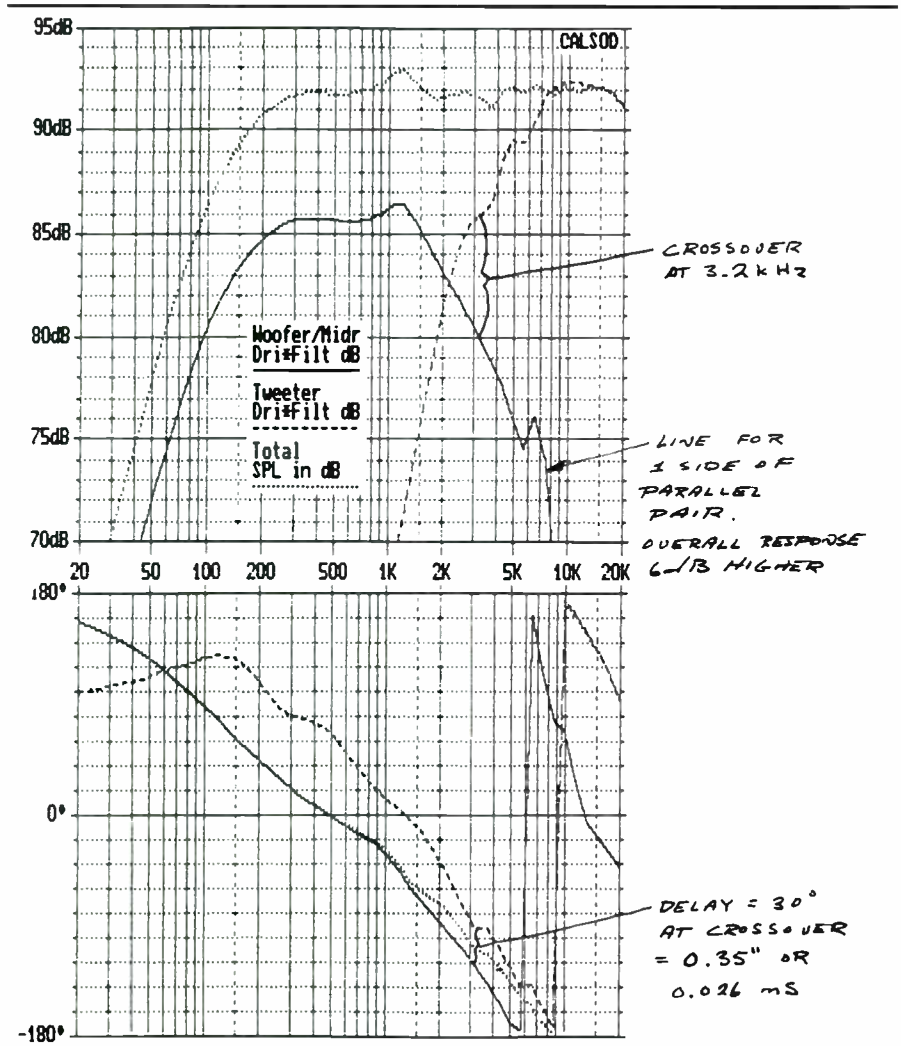

FIGURE 21: CALSOD crossover and phase response.

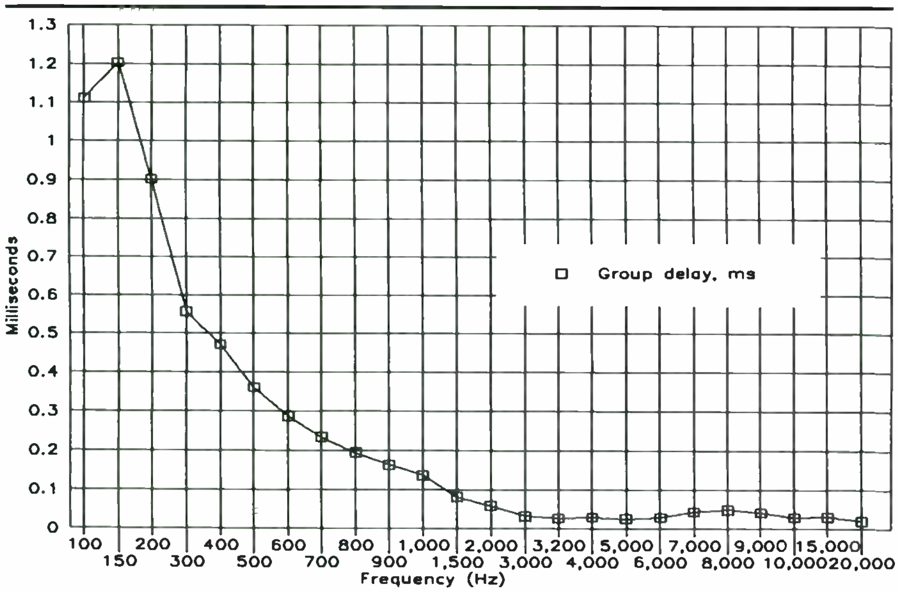

FIGURE 22: Danielle group delay versus frequency (note linearity above 1kHz).

later, I settled on the crossover shown in *Fig. 14*. The input file for CALSOD is shown in *Fig. 15*.

Zalytron provided indispensable help in the crossover development. Elliot Zalayet worked with me on the phone to custom-make inductors of proper series resistance, including the 0.3mH, 0.48Ω inductor in the midrange section which served both as an inductor and series attenuator. He also supplied a high-quality Intertechnik 10mH coil for the woofer bandpass circuit to give the required resistance. The level of personalized service was outstanding.

CROSSOVER FEATURES. Final crossover design consists of:

1. A series-resonant circuit with a Q of 0.535 tuned to 50.3Hz in series with the subwoofer. This, combined with the vent tuning of 44Hz, the box resonance of 52.6Hz, and an S (damping factor of the front volume) of 0.576, yields a crossover to the woofer/midrange at 94Hz as shown in *Fig. 16*.
2. A second-order low-pass rolloff with a Q_{TC} of 0.53 for the woofer/midranges.
3. A first-order electrical high-pass filter to the woofer/midranges and a second-order electrical low-pass filter to the tweeter, combined with a 2.0Ω resistor for series attenuation. In highly absorbent listening rooms, this resistor could be varied. The high (0.48Ω) series resistance for the coil was chosen to keep the minimum impedance above 3Ω. Most transistor amplifiers can drive nominal 4Ω loads with 3Ω minimums, and thus should have little problem with this speaker. The crossover point ended up being 3.2kHz for the best response.
4. A Zobel section on the woofer/midranges.
5. An impedance compensator across the input terminals to avoid a hump near 2kHz. This keeps input impedance between 3 and 4Ω from 200Hz to 10kHz, and phase angle between −30° and +30° from 300Hz to 9.5kHz, as shown in *Fig. 17*. This is much better than most loudspeakers and very much better than the Integrite.

Predicted anechoic frequency response and phase for the MTM are shown in *Fig. 18*. Sensitivity is 91.6dB 1W/1M. Phase is linear throughout the entire spectrum. Response is ±0.5dB from 300Hz to 20kHz, save for a +1dB bump

RESOURCES

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Mineola, NY 11501
(516) 747-3515

at 1,250Hz. When this curve is spliced with the bandpass subwoofer, the –3dB anechoic point is 29Hz, with less than 0.5dB ripple (*Fig. 16*). In a listening room, the bass response is even more outstanding. Due to the staggered heights of the woofer/midranges, dips due to floor reflections are minimized.

The seated response is shown in *Fig. 19* and the standing response in *Fig. 20*. The curves are rougher, yet within ±3dB. The MTM array effectively causes nulls at the crossover frequency at large vertical angles, reducing the amount of floor and ceiling reflections and improving imaging.

Figure 21 shows the crossover response. The woofer lags the crossover by 0.026mS at the crossover frequency, and this delay is nearly linear with frequency. *Figure 22* shows a plot of group delay versus frequency that I made working from the CALSOD results, using the LDP group delay graphing program.

DESIGN RESULTS. The design on paper (or on screen) has met its objectives. These included bettering my Integrites with:

1. Tighter midbass and lower IM distortion.
2. Deeper, louder bass.
3. More constant impedance.
4. Even better imaging throughout most of the listening area.
5. Less low-frequency information reachng the tweeter.
6. More constant group delay and phase response.

As an added bonus, the speaker is 1.6dB more sensitive, costs somewhat less, and is smaller in size.

NEXT TIME. Part 2 of this article will deal with actual enclosure design and construction. The Loudspeaker Design Powersheet deals extensively with resonance suppression, a subject largely untouched by other software. I will detail how to use the box volume calculator as well, and include photos and listener criticism of the final result.

A DOUBLE-CHAMBERED ISOBARIK BASS SPEAKER

BY PAUL SPURGEON

When I was younger, speakers that could reproduce frequency spectrum extremes were more alluring to me. Now, I look to the middle frequencies (where most of the music is) for enjoyment. While some may attribute this shift to a loss of hearing acuity, I prefer to think of it as a refinement of my listening taste. Nevertheless, for this project, I chose to optimize for transient response and low distortion, while minimizing cabinet size (for maximum spouse acceptance). I also targeted a 3dB down point of 40Hz.

When designing bass enclosures, the compromises between frequency response, efficiency, transient response, and cabinet size are no doubt well known to many of you. The advantage of using two woofers in a compound, or Isobarik, system over a single woofer system is reduced harmonic distortion and one-half the V_{AS}. You'll find the double-chambered bass reflex attractive because the smaller drivers make it capable of extended bass response. In addition, since the woofer is loaded over a range of frequencies, its transient and distortion characteristics are theoretically better than the same woofer tuned to a single f_B.

I decided to investigate the advantages of incorporating both the compound and double-chambered bass reflex designs in the same bass enclosure. The trick was to find drivers with a Q_{TS} that would allow an enclosure large enough to accommodate the compound mounting tunnel, vents, and two chambers while maintaining the proper relationship between V_{AS} and the volume of the cabinet. Low Q_{TS} drivers require a relatively small enclosure for flat response—at the expense of low frequency output—while units with a high Q_{TS} exhibit peaking inappropriate for optimum bass-reflex designs.

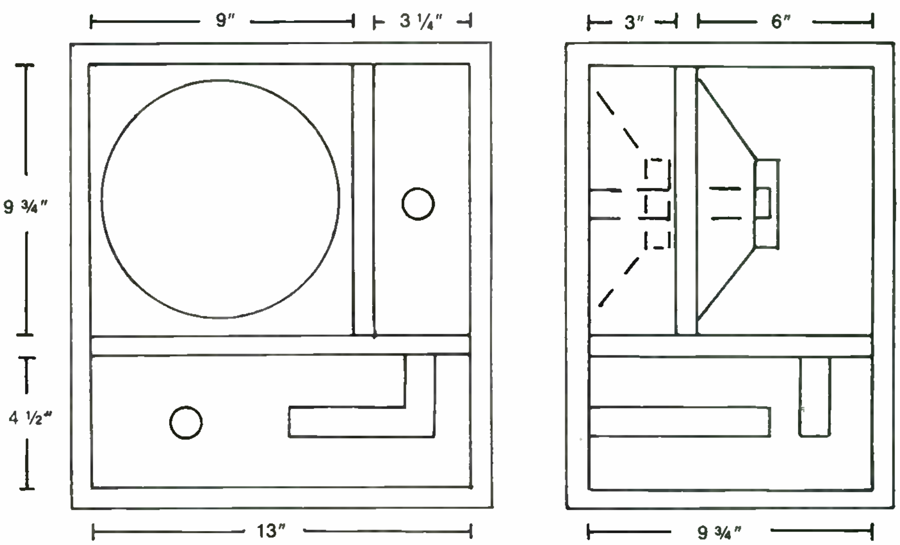


FIGURE 1: Spurgeon Isobarik design.

I decided to use the 8″ Peerless 220WR/8 because of its advertised parameters of F_S = 25Hz, Q_{TS} = 0.38, and V_{AS} = 83 liters although the 10″ version might also operate successfully. Because my design criteria required an optimal transient response, I chose the SBB4 alignment and used Dickason's tables to find a V_B of 0.95 ft³ (assuming V_{AS} should be halved), and a vent length of 6.5″ for the three 1″ tube vents.[4] After allowing for the volume, the compound tunnel, chamber partition, and braces added, cabinet volume totaled 1.2 ft³

BASS LEVEL ANGST. The basic construction techniques for compound and double-chambered bass reflex systems are covered elsewhere (see References) and need not be repeated although some additional details may be of interest.

Initially, I covered all internal surfaces with several coats of Audio Concepts Acoustical Magic. As shown in *Fig. 1*, the ¾″ particle-board partition dividing the chambers doubles as one side of the tunnel. The vents are 1″ PVC pipe. I lined the tunnel with felt and the smaller chamber containing the tunnel with bonded Dacron. Silicon sealant secured the driv-

REFERENCES

1. Augspurger, George L., "Double-Chamber Speaker Enclosure," *Electronics World* 12/61.
2. Cockroft, John, "An Isobarik System," *SB* 3/85, p. 7.
3. Cockroft, John, "The Demonstrator: A Vented, Compound Speaker System," *SB* 2/87, p. 29.
4. Dickason, Vance, *The Loud Speaker Design Cookbook*, Audio Amateur Publishing Group, 1991.
5. Marsh, Richard, "The Double-Chamber Speaker Enclosure," *SB* 3/80, p. 7.
6. Weems, David, *Building Speaker Enclosures*, Radio Shack, 1981.
7. Weems, David, "A Small Double-Chamber Reflex," *SB* 4/85, p. 14.

TABLE 1

CHANGE IN DECIBEL LEVEL

Hz	ON THE FLOOR	RAISED 1′
125	0	0
100	0	+ 1
80	− 1	+ 1
63	− 1	0
50	− 3	− 3
40	− 7	− 7
31	− 11	− 9
25	− 15	− 13
20	− 22	− 20

ers. I allowed the sealant to harden for about twenty minutes before mounting the drivers so, when set, they would not touch the baffle.

The internal wiring is 18 gauge Straightwire connected to gold-plated terminals. The drivers connect in phase and in series. While I could have used a parallel connection for some applications, my electronic crossover network made it easy to match bass levels with the rest of the system without worrying about component sensitivity.

THE SOUND. With a speaker placed three feet from the rear wall and four feet from the side wall, I tested the bass response using *Stereophile*'s test CD and a sound level meter. The response was determined with the cabinet resting on the floor and also by raising one foot with the microphone placed at a distance of one foot (*Table 1*).

Although Dickason's formulas indicate an F3 of about 30Hz for this configuration, the actual low frequency cutoff is above that level and the targeted F3, when measured in the near field. Naturally, the listening room acoustics play a large role in the system's response characteristics when measuring from a distance. From six feet away, bass is down only 5dB at 31Hz in my room, although as expected, the rolloff is not nearly as smooth as when measured much closer.

When listening to music, I compared the new system to two other bass systems I constructed. One, a compound loaded enclosure, employs two 12″ Gold Sound woofers and the other, a 1 ft³ acoustic suspension model, contains two 6.5″ Morel 164s. While the new system cannot compete with the low frequency output of the Gold Sound speaker, its upper bass was more detailed, seemed to contain less distortion, and blended better with the low-mid units (Morel's 164s crossed at 125Hz). The Morels I used as woofers sounded better in the low midrange but were not as clean as the new system at the lowest frequencies. The imaging with the new system was also superior. (In hindsight, slightly larger cabinet dimensions may have delivered more low extension at the risk of a more uneven response higher in the frequency spectrum.)

All in all, the double-chambered compound bass reflex may not be the easiest design to construct, but it offers an acceptable compromise for those who demand full, clean bass from a relatively small enclosure.

About the Author

Paul Spurgeon is an amateur piano and saxophone player who has been building stereo speaker systems for about fifteen years. When not involved in music, he manages a market research department for a large coal-mining company near St. Louis.

Kit Report

ORCA/D'Appolito Aria 5

By Gary Galo
Contributing Editor

Aria 5, ORCA, Design & Manufacturing Corp. (formerly Focal America), 1531 Lookout Drive, Agoura, CA 91301, (818) 707-1629, FAX (818) 991-3072.

Specifications: Tweeter: Focal T90K; Woofers: two Focal 5K-013Ls; Frequency response: 62Hz–20kHz ±3dB; Nominal impedance: 4Ω; Sensitivity: 90dB, 1W/1M; Crossover: True 24dB/octave acoustic slopes. Crossover frequency: 2.5kHz. Dimensions: 18½" × 8½" × 9¾".

Price: Full kit including black MDF cabinet: around $600; Full kit including hardwood cabinet: around $750; Parts kit, without cabinet: around $450; (Exact prices set by dealers).

The Aria 5 loudspeaker system is a joint effort between ORCA and designer Joe D'Appolito. Mr. D'Appolito, an *SB* Contributing Editor, is well-known among speaker-building hobbyists and professionals for his symmetrical 3/2 driver geometry. The 3/2 configuration uses a single tweeter vertically flanked by a pair of identical woofers or mid-bass drivers. A well-known benefit of the D'Appolito arrangement is its stable vertical polar response. D'Appolito designed the Aria 5 at ORCA's request.

The Aria 5 is a vented design using a pair of Focal 5K-013L mid-bass drivers. These drivers are Kevlar-sandwich designs with a rubber surround and center phase plug. The cones are exponentially flared. The tweeter is a Focal T90K, a 1" inverted Kevlar dome. The enclosure plans, as supplied by ORCA, are shown in *Fig. 1*. A pair of internal dividers form the vent, which exit to the rear. The front baffle must be constructed so the drivers are flush with the baffle board. This is especially important for the tweeter. Even differences of $\frac{1}{16}$" between the tweeter flange and the front baffle will cause diffraction, degrading the system's performance.

The crossover network is shown in *Fig. 2*. Although on paper it appears to be a third-order crossover, the actual acoustic roll-off is a true fourth-order Linkwitz-Riley characteristic. The L/C combination resembling a Zobel network across the woofers is not a Zobel at all. According to Joe D'Appolito, it is a contouring circuit which reduces the output 5dB at 800Hz. The peak resonant filter across the tweeter is exactly what it appears to be. The woofer response is a true bandpass, since the high and low acoustic roll-offs are symmetrical fourth-order. The low frequency roll-off is a result of the cabinet alignment.

The graph Joe provided for the Letters section (*SB* 3/90, "Mailbox," pp. 90–91) shows the Aria 5 woofer response. We've reproduced it here as *Fig. 3*. As Joe also explained in the 3/90 issue, he's not a believer in Time Alignment®, especially when it is accomplished by physically staggering the drivers. He is convinced good frequency and polar response are more important and that Time Alignment should not be accomplished at the expense of these characteristics.

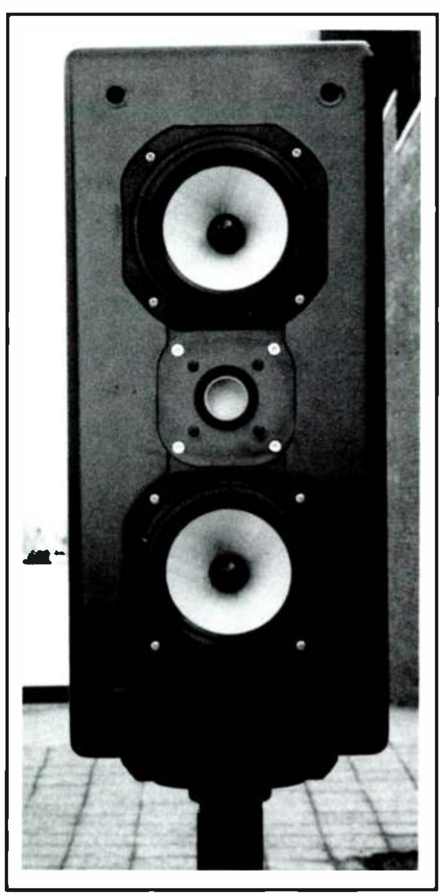


PHOTO 1: The assembled Aria 5 loudspeaker mounted on custom-built stands.

The Project

The Aria 5 is not a kit in the normal sense of the word. The word "project" rather than "kit" best describes the Aria 5. D'Appolito and ORCA made the design public domain so that any speaker builder could attempt the project. The plans have been available free for the asking from ORCA. Parts are sold by many of *SB*'s advertisers, including Madisound Speaker Components, Zalytron, Meniscus Systems, and Audio Concepts.

ORCA has marketed the Aria 5 in a rather loosely controlled fashion. Since their goal was to make the design freely available to anyone who wants to build it, a number of possible variations are likely. First, ORCA doesn't manufacture the enclosure. At ORCA's request, my review samples were sent to me by Transducer Technology, a division of Watters Sound Wave Co. (4352 J, Spring Valley Rd., Dallas, TX 75244, (214) 490-9933), which sells the complete kit, as well. These are the enclosures recommended in the ORCA plans. Several loudspeaker component suppliers well-known to *SB* readers have had their own enclosures made. ORCA makes a crossover (mine were genuine ORCA), but dealers are free to build their own from the plans. The drivers must be genuine ORCA components, available from any ORCA dealer. My review samples were sent to me by Zalytron, at ORCA's request.

A typical Aria 5 full kit consists of a pair of assembled and finished enclosures, a pair of crossovers, and the raw drivers. My review kits did not include any internal damping material, internal wiring, or terminals. If you purchase a parts kit, you must build your own enclosure, in addition to supplying the foam, wiring, and terminals.

The plans call for ¾" MDF (medium density fiberboard) as the enclosure material. However, no particular grade of MDF is specified. The MDF used in the Watters enclosures is the hardest I've ever encountered. It is *much* harder than that used in the Audio Concepts kits. (This isn't a qualitative statement. Obviously D'Appolito determined the hard

MDF was appropriate for this design. It may not be appropriate for others.) If you intend to build your own enclosure, I don't know how you can determine which type of MDF is best.

The Aria 5 plans call for ½" thick open-cell foam for the sides of the enclosure and 2" thick convoluted foam for the top, bottom, and back. What the plans don't specify is what foam, if any, should be placed on either side of the internal dividers which form the vent. I called Kimon Bellas at ORCA and was told 2" foam "might be a bit much" in this location. I was a bit surprised the manufacturer couldn't provide a more definitive answer. Joe D'Appolito, on the other hand, said 2" foam was fine here, as well. Audio Concepts sells both smooth ⅝" foam (which Joe said would be fine) and a 2" convoluted type, so I ordered one of each which was more than enough for the project. I also ordered a pair of AC cups with gold-plated terminals and 12′ of AudioQuest F-14 cable for the internal wiring. I spent around $60 for materials not supplied with the review kits.

Assembly

All of the parts for my Aria 5 had arrived by the end of April, 1990. I began the project by cutting holes in the center of the lower portion of the backs of the enclosures to accommodate the AC cups. The MDF was hard as nails. The fresh blade I put in my saber saw was smoking by the end of the second hole! The Aria 5 plans don't provide any indication of where or how the crossover networks should be mounted. I decided to mount them on the side of the lower enclosure chamber, orienting them so the lower woofer wouldn't hit them when it was installed. I fastened the crossovers with silicone rubber glue (G.E. or equivalent).

Before you mount the crossovers, solder the wiring to the crossover PC boards. I cut four lengths of the F-14 cable per speaker, one for the input, one for the tweeter and two for the woofers, making sure each piece was labeled for polarity and destination and would be long enough to reach the installed crossover. After soldering the wires to the crossover, I applied several generous beads of silicone glue to the foil side, slid the board through the woofer opening, and pressed it firmly into place. I did so with the enclosures mounted on their sides, and allowed 24 hours for the glue to cure before moving them.

Next, I carefully cut four pieces of the ⅝" foam for the sides of each enclosure, fastening them with silicone glue. One of these pieces must be glued to the top of the crossover network. I ran a bead of glue across the top of each of the capacitors on the board and pressed the foam into place. Six pieces of the 2" convoluted foam are needed make sure the foam pieces mounted on either side of the vent

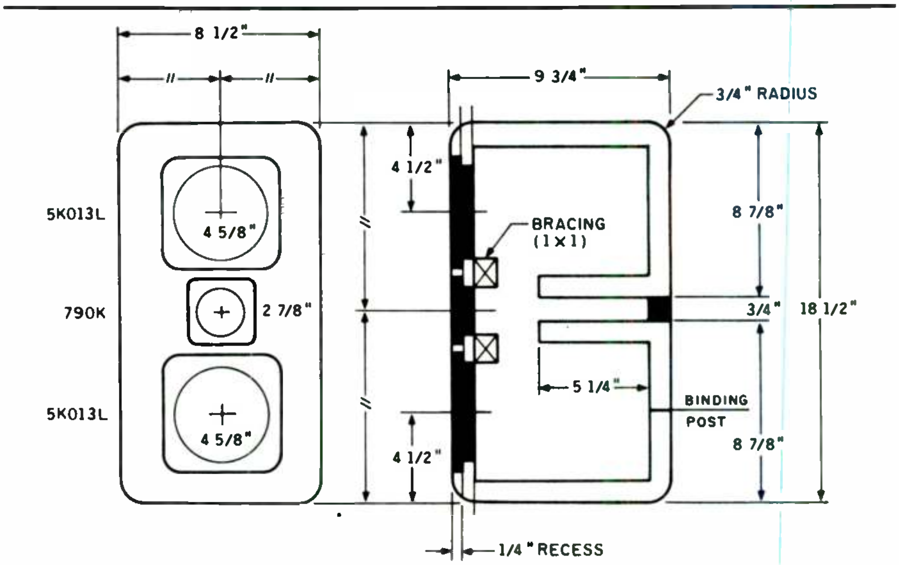


FIGURE 1: Construction diagram for the Aria 5 as supplied by ORCA, which includes the cross-over schematic and a few assembly notes.

are cut so they don't extend beyond the vent *at all.* Now route the tweeter and woofer wires to the appropriate mounting holes.

Next, solder the input wires to the AC cups. Poke a small hole through the bottom rear foam piece as a path for the input wiring through the hole in the enclosure back. Fasten the AC cups in place with small flat-head screws. Drill the pilot holes to mount the AC cups large enough to avoid breaking the screws if the holes are too tight. The AC cup gaskets prevent leaks.

Gasket material for the drivers was another item missing from my "kit." I called Kimon Bellas and asked if ORCA made the right gaskets. They do, and he promptly sent me a package of them. You can also use ¼" foam weatherstripping with adhesive backing for the gaskets. As it turns out, the weatherstripping is a good idea. ORCA's gaskets are usable only once. For reasons I'll explain below, I had ample opportunity to remove and replace drivers in my Aria 5s during the preparation of this review. The first time I removed a driver, the ORCA gaskets were completely compressed. I doubted I could get an airtight seal a second time, so I replaced all of the ORCA gaskets with foam weatherstripping.

Before mounting the drivers and soldering wires, mark and drill pilot holes for them. Use #6 flat-head screws for the tweeters and #8 pan heads for the woofers. The tweeter screw heads should be flush with the tweeter flange to avoid diffraction. After you drill proper-sized pilot

Continued on page 48

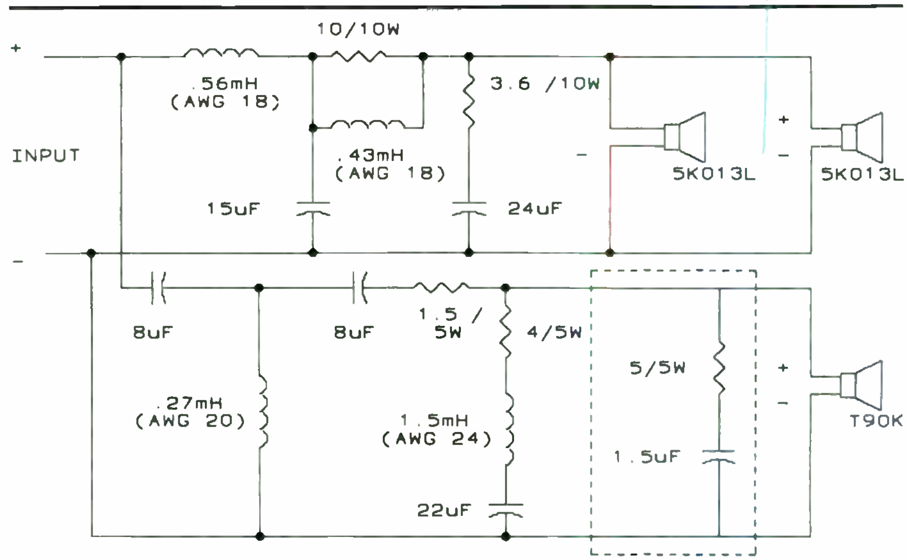


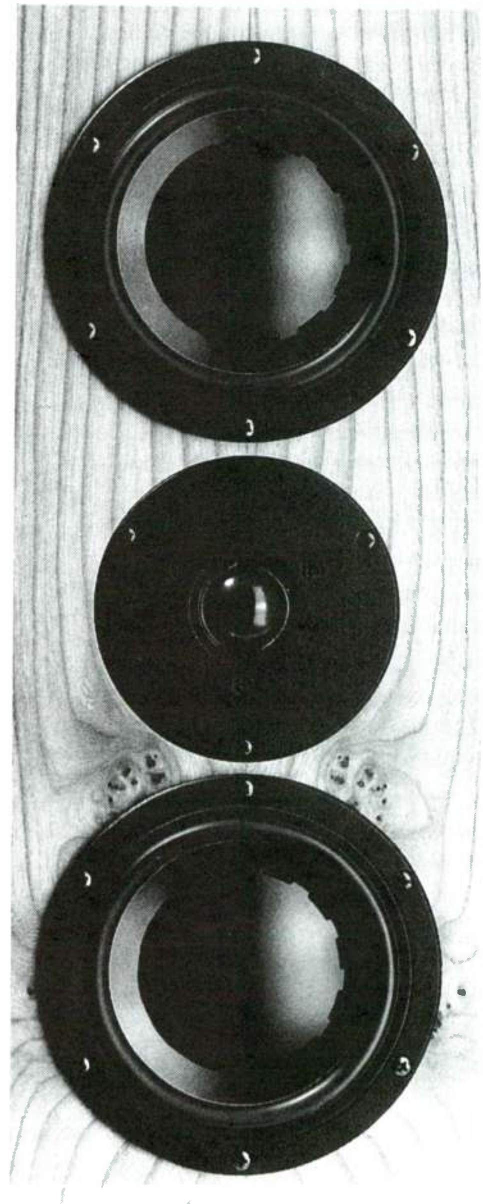
FIGURE 2: Aria 5 crossover network. The Zobel network inside the dashed line was included with the prototype tweeter upgrade. It should not be used with the original T90K.

DYNAUDIO

AUTHENTIC TECHNOLOGY

CONSISTENCY IN KITBUILDING

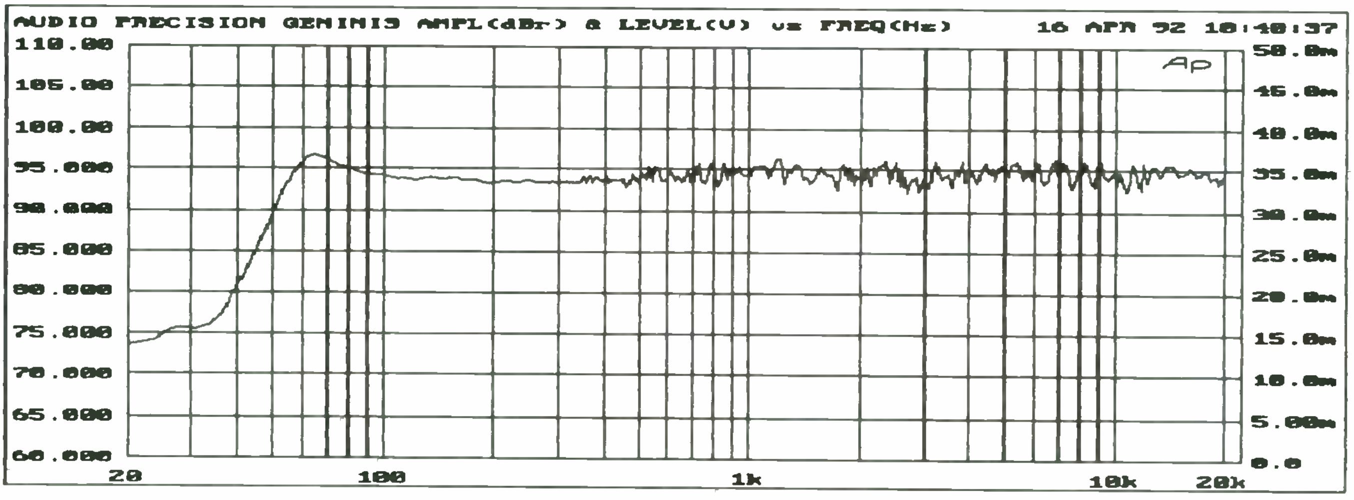
GEMINI



The GEMINI is based on the principle of creating the very best in the design of small yet sonically accurate loudspeaker systems. Such an idea is of special interest to audiophiles. The Dynaudio 15 W-75 possesses almost unbelievable qualities for a driver of such a small size, particularly if it is used in a cabinet that designed to enhance its remarkable performance capability.

To increase the dynamic range and efficiency of the 15 W-75, the GEMINI system uses two of these woofers. It represents Dynaudio's first kit system incorporating the 15 W-75.

In combination with the ESOTEC D-260, also one of Dynaudio's latest driver designs, the speaker arrangement in the GEMINI follows concepts recognized and developed by the American designer, Joseph D'Appolito. It is a design with integrity, the GEMINI is capable of precisely fulfilling the basic conditions of D'Appolito theory.



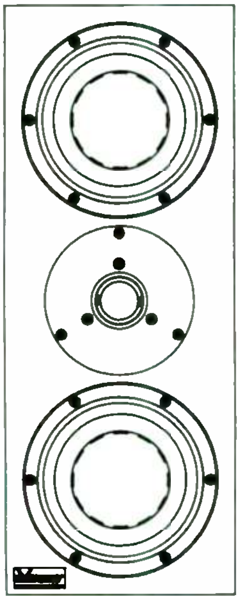
A basic requirement of D'Appolito theory is the symmetrical design of the speaker system. The GEMINI offers an absolutely symmetrical driver and cabinet arrangement with the tweeter as its center.This requirement is maintained if the GEMINI is mounted on a stand featuring an open design. In so doing, the GEMINI presents a symmetrical design that is difficult to achieve with floor standing speaker systems.

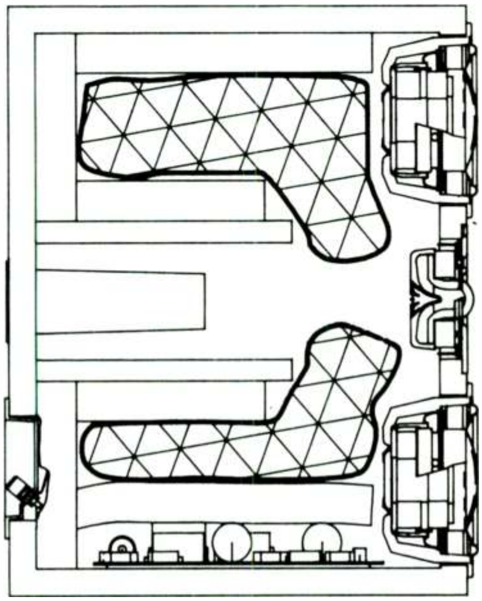
In spite of its compact size, the GEMINI cabinet is constructed with very rugged materials and rigid design. Medium density fiber board (MDF) with a thickness of 25 mm, further braced by internal reinforcement, eliminates unwanted cabinet resonances.

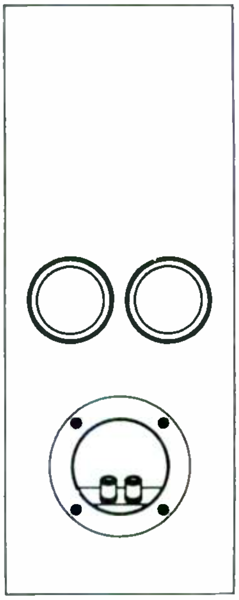
The Woofers

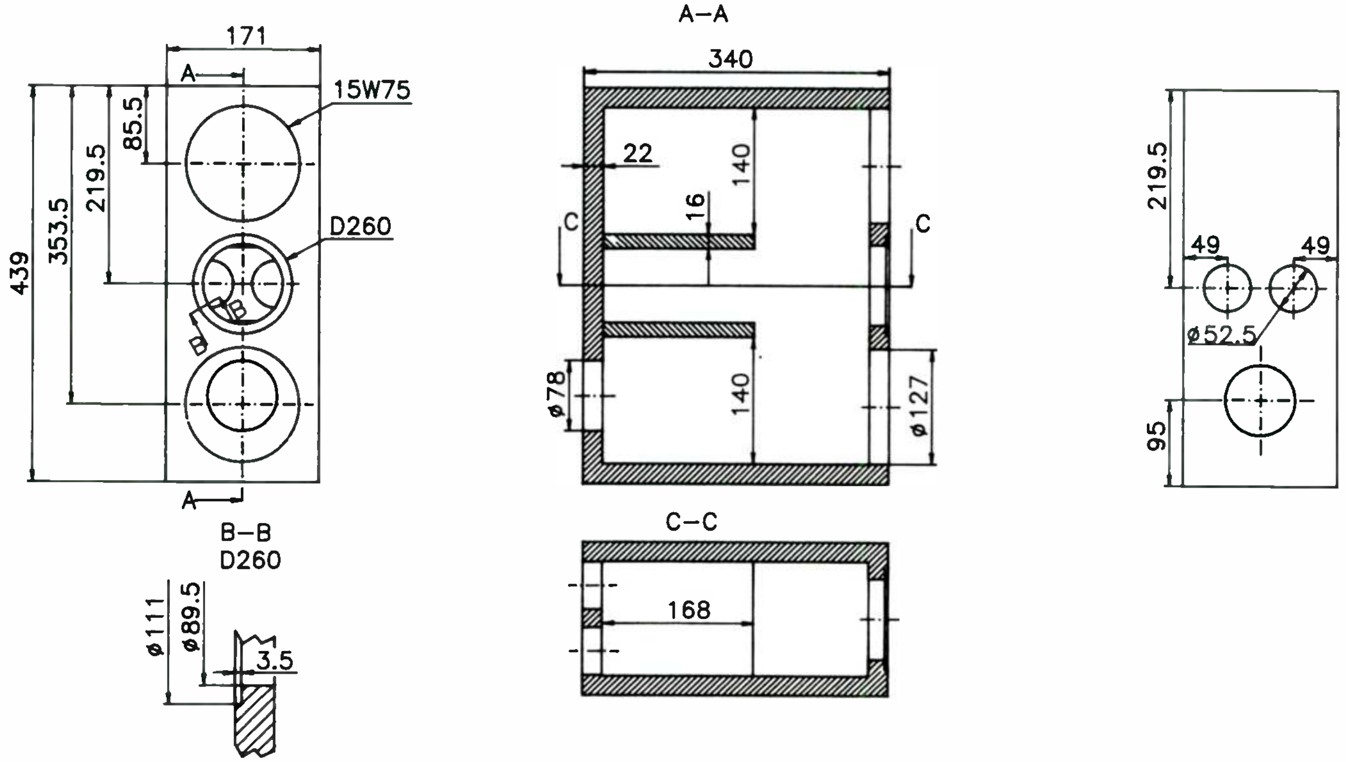
▶ The Dynaudio 15 W-75 is a unique loudspeaker driver: no other system has a 75-mm voice coil operating in a speaker with an overall diameter of 15 cm! This design creates a completely controlled powerful diaphragm drive and the absence of undesired vibrations.

The parameters of the magnetic assembly have been designed so that the 15 W-75 works best bass reflex enclosures. Consequently, dramatic and lifelike bass reproduction can be realized in cabinets that are very small. In addition the complete absence of boominess is particularly impressive.

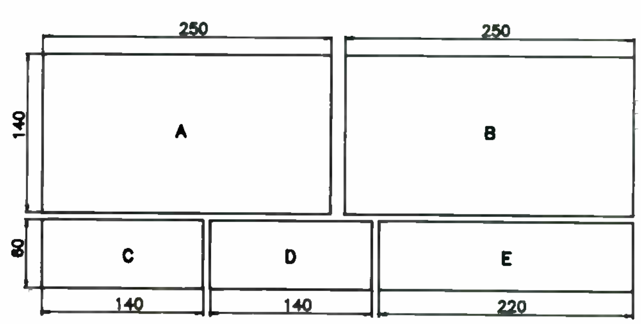








The external dimensions of the Madisound assembled cabinets are slightly larger in order to accommodate a grill; Height 18 ½", Width 7 ¾", Depth 11".



The Tweeter

In the tweeter range, Dynaudio's new development, the ESOTEC D- 260, is used. This tweeter is the result of several years of research based on the experience gathered with the now legendary ESOTAR T-330 D. The overall frequency range is extremely flat, and even above 20 kHz there are no peaks or dips.

To achieve natural music reproduction, it is of particular importance that the energy generated by the back wave of the dome is absorbed completely, so that it is not reflected and remixed to the front wave after a delay. This is a problem that has long plagued other tweeter designs, and its elimination in the design of the ESOTEC D-260 ensures faithful musical reproduction.

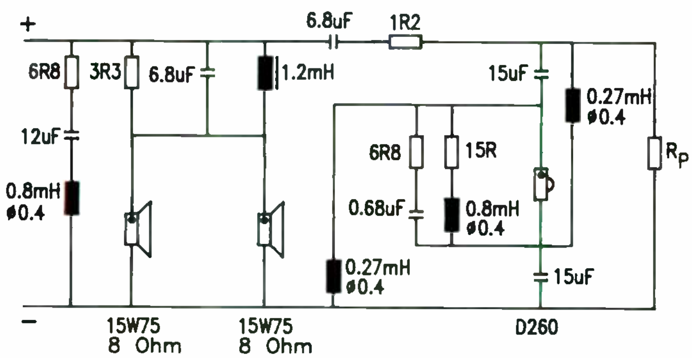
The Crossover Filter

In the D'Appolito design, 6 or 18 dB crossovers are required. The Dynaudio drivers are wide band so that the best results are achieved with 6 dB crossovers. Consequently, the disadvantages encountered in filters with a high slope, particularly in regard to difficulty in reproducing pulse response without ringing, can be avoided.

In the GEMINI, a 6 dB crossover with phase correction is used for the tweeter. The woofer can be operated without a true crossover, since its frequency response is cut back toward the higher frequency range. Then, at an additional octave above, the acoustical energy is attenuated with an actual filter.

All drivers feature impedance correction; and the entire design consisting of driver and crossover provides additional compensation circuitry.

Without exception, the filter uses the highest grade components. The metallized polypropylene capacitors are the best the world market currently offers.



The Kit

2 Gemini cabinets
2 Esotec D-260 tweeters
4 15W-75 woofers
2 Gemini crossovers
2 DB-cup input terminals
1 Foam dampening
1 Long hair wool
1 LX2 sealing glue
screws
wire
instructions

Price $860.00

The Damping Material

A special damping material made of foamed plastic is enclosed in each kit for constructing the Gemini. The material is precut and can be installed easily and precisely. No other or additional damping material is recommended.

It is important to note that to guarantee the high sonic standard of the GEMINI, the builder must meticulously follow the assembly instructions. Even seemingly unimportant details may have considerable influence on the sound.

For maximum resolution and imaging, the speaker should be placed in such a way that the axis of the tweeter is directed toward the listener. Depending on the height of the stand and the distance to the listener, the GEMINI may need to be tilted upward.

The Result

The Gemini is a speaker system for demanding music lovers who wish to build a small system but are not willing to accept any musical compromise. With its compact dimensions the Gemini represents a "concentrated charge" of power and technology. It will fascinate experienced audiophiles who understand the difficulties inherent in creating a full bodied dynamic sound in a very small package.

Ordering Information: All speaker orders will be shipped promptly, if possible by UPS. COD requires a 25% prepayment, and personal checks must clear before shipment. Add 10% for shipping , residents of Alaska, Canada and Hawaii, and those who require Blue Label air service, please add 25%. There is no fee for packaging or handling, and we will refund to the exact shipping charge. We accept Mastercard or Visa on mail and phone orders.

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DYNAUDIO®

TECHNOLOGY UNLIMITED

Audiophile Price List

March 1992

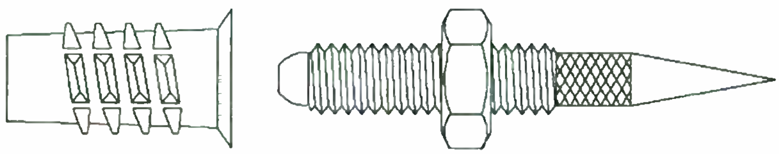
Model	Imp. Ω	Fs Hz	Qts	Vas Ltrs	Power Program Watts	Efficiency db 1W/1M	Price
D-21AF 21mm dome tweeter flat flange	8	1300	.41		100	91	$61.50
D-28 28mm dome tweeter	8	700	.39		130	93	$62.00
D-28/2 28mm dome tweeter flat flange (Replaces D-28AF)	8	880	.41		130	90	$62.00
D-260 ESOTEC-28mm dome tweeter flat flange	8	1000	.48		130	90	$87.00
T-330D ESOTAR-Ultra Hi-Fi -28mm dome tweeter flat flange	8	750	.15		130	92	$458.00/Pair
M560D-ESOTAR Ultra Hi-Fi 54mm dome midrange flat flange	8	325	.35		100	90	$680.00/Pair
D-52AF 54mm dome midrange flat flange	8	350	..4		100	91	$99.00
D-54 54mm dome midrange	8	350	.36		100	96	$130.00
D-54AF 54mm dome midrange flat flange	8	350	.36		100	94	$130.00
D-76 75mm dome midrange flat flange w/ chamber	8	280	.87		100	90	$98.00
17M-75 170mm cone bass-midrange 75mm voice coil	8	74	1.35	5.95	180	89	$85.00
15W-75 150mm woofer 75mm voice coil	4 or 8	55	.40	7.5	130	89	$106.00
17W-75 170mm woofer 75mm voice coil	8	39	.74	18.8	150	89	$90.00
17W-75Ext 170mm woofer convex cone, 75mm voice coil	8	39	.74	18.8	150	86	$90.00
17W-75XL 170mm woofer 75mm voice coil	4 or 8	42	.44	22.6	130	89	$99.00
20W-75 20mm woofer 75mm clvoice coil	4 or 8	30	.4/.5	64/65	150	89	$120.00
21W-54 210mm woofer 75mm voice coil	8	30	.30	59.6	160	92	$158.00
24W-75 240mm woofer 75mm voice coil	8	33	.84	88.2	120	90	$93.00
24W-75XL 240mm woofer 75mm voice coil	4 or 8	32	.46	92.4	130	89	$105.00
24W-100 240mm woofer 100mm voice coil	8	30	.47	64.5	200	90	$177.00
30W-54 300mm woofer 54mm voice coil	8	22	.36	257	180	92	$197.00
30W-100 300mm woofer 100mm voice coil	8	20	.48	409	250	91	$292.00
30W-100 300mm woofer 100mm voice coil	4	19	.41	340	250	91	$292.00
Variovent	Resistive vent for "sealed box" woofers						$12.00
Dynaudio LX2 adhesive	Constantly elastic rubber glue for loudspeaker units						$7.00
Dynaudio Grills	D21/D28G-$6.00		D52/D54G-$7.50		17WG-$8.00	24WG-$10.50	

Suggested Alignments

Model	Box Volume Vb Liters	Bass ½ Power F3	Fill in Box	Qtc	Peak at Resonance db	Fb	Vented Ql	Port Diameter Inches	Port Length Inches
17W-75	20	46	Yes	.83					
	28	45	Yes	.78					
17W-75 with Variovent	14	52.6	Yes	.73					
	21	51.4	Yes	.69					
17W-75XL	25	40			+.5	41	7	2	4.25
	30	37			+0	28	7	2	4
	35	35			-.35	37	7	2	3.55
20W-75	26	57	Yes	.70					
	30	40			+.6	32.7	7	2	6
	49	34			0	32.7	7	2	3.1
21W-54	23	45			+0	40	7	3	9.4
	35	38			-.5	37	7	3	8.5
24W-75	110	36	Yes	.89					
	115	36	Yes	.88					
	150	34.5	Yes	.85					
24W-75 with Variovent	100	39.8	Yes	.75					
	143	39.0	Yes	.72					
24W-75XL	20	60.6	Yes	.86					
24W-100	60	30			+1.5	31	7	3	7.8
	90	25			+.5	27	7	3	7.4
	110	24			+0	25	7	3	6.33
30W-54	110	31			+1	29	7	3	2.92
	140	28			+.5	27	7	3	2.73
	172	26			+0	25	7	3	2.45
30W-100	120	34.5	Yes	.87	+.5				
	150	33.5	Yes	.82	+0				
	200	32.5	Yes	.76	+0				
30W-100 with Variovent	60	43.6	Yes	.79	+.1				
	86	41.2	Yes	.71	+0				
30W-100 4Ω	150	34.6	No	.71	+0				

NEW PRODUCTS! from Madisound

Fowler Toes



The new Black Fowler Toe is cut from machine grade steel, has a sharp point on one end and a ball on the other. The threaded insert mounts into a 3⁄8″ hole drilled into your cabinet. The spike threads into the insert. A 7⁄8″ thread length and locking jam nut allow easy adjustment of speaker tilt. A 6 mm allen wrench is needed to screw in the insert.

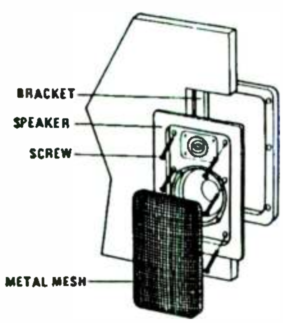
Price $2.00 ea. or 10% off on a set of 8.

In-Wall Speakers

We are proud to introduce the **WS006** speaker system for in wall mounting. The **WS006** is a complete system consisting of a Polypropylene 17 cm (6.5″) woofer, a poly dome 25mm tweeter, a 12db crossover filter, housed in a sturdy baffle with an attractive metal mesh grill and beveled frame.

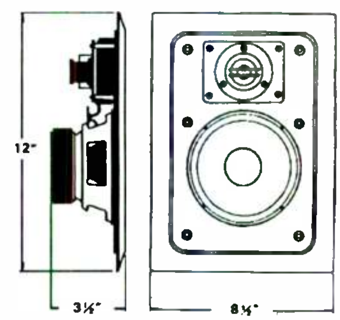
Outside measurement is 8 5⁄8″ x 12 1⁄16″ with a depth of 3″ and is designed for easy installation in between 16″ O. C. 2x4 stud walls. Cut out size is 7 3⁄8″ by 10 3⁄4″ , a template and thorough instructions are supplied.

Whether you are an experienced installer who is trying to find a way to give your clients a better system and still have some margin left for you, or you are a hobbyist who is building or remodeling and wants access to quality audio installation products, the **WS006** is what you are looking for.



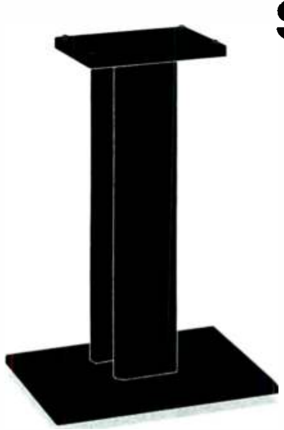
Specifications:

Impedance	8 ohms
Frequency Response	45 to 20K Hz
Power Handling	40 Watts Nom.
Sound Pressure Level	90db
Resonant Frequency	50Hz
Woofer	6.5″ Polyprop., 1″ VC 10oz magnet
Tweeter	1″ soft dome, 6oz magnet
Crossover Frequency	3000Hz @ 12db
Speaker Weight	69.68oz



Introductory Price $140 / pair, New construction kit $15 / pair

Sanus Systems Speaker Stands



- ❒ Black medium density fibercore (MDF) construction for stability and minimized resonance. Satin finish and beveled front on base and riser offer an appealing design that will compliment the decor of virtually any room.
- ❒ Available in 10″, 17″ and 24″ heights to accomodate all speaker sizes. Top plate is 6 7⁄8″ x 6 7⁄8″ and the base plate is 11″ x 11″.
- ❒ Rubber Bump-ons are supplied for the top plate and base of each stand to protect the speaker and floor and to provide acoustic isolation.
- ❒ All stands include black steel spiked feet for use on carpeted floors to ensure stability and minimize the transfer of resonance.

Price Per Pair: Model S10 (10″ tall) $40; Model S17 (17″ tall) $42; Model S24 (24″ tall) $45

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Continued from page 41
holes into the hard MDF, vacuum any sawdust and install the foam gasket material. Next, solder the wiring to the driver terminals, *carefully noting polarity.* After soldering, drop the drivers into the holes and screw them in place. As with most new loudspeakers, the Aria 5s should be broken in before you begin serious listening. I ran the test pair for two days with low level pink noise. *Photo 1* shows the completed Aria 5.

The ideal listening height for the MTM geometry locates the tweeters at ear level. This will vary depending on your listening chair. My director's chair places my ears 38″ to 40″ above the floor (depending whether I'm at attention or relaxing!). Since I had no stand of proper height, I decided to build one. (See "Building a High-Performance Loudspeaker Stand," pp. 50-51.

The Sound

After breaking in the Aria 5s, I fastened them to my custom stands for some serious listening. I was quite disappointed with their performance. First, the tweeter was incredibly bright, making listening uncomfortable on most musical material. Second, soundstage reproduction was rather poor. Left-to-right imaging was vague with little front-to-back depth.

I ran ⅓-octave frequency response curves on both samples (*Fig. 4*). As you can see, the response between 1,600 and 2500Hz varied substantially. Sample #2 (which I used as the right loudspeaker) showed a severe dip in response in this region. I measured the electrical response of the crossovers, to see whether I had either a defective driver or a crossover network. The woofer electrical response of the two samples turned out to be quite different. Sample #2 appeared to have a defective crossover. In a few days, I had a new pair of crossovers from ORCA.

I began with sample #2, since I thought sample #1 was probably OK. Replacing the defective crossover was difficult. With a combination of a large screwdriver and a stiff putty knife, I literally broke the crossover out of the enclosure. It came out in three pieces.

After removing the old silicon from the enclosure, I reconnected the wiring to the new crossover and glued it and a foam piece in place. After waiting another day for curing, I resoldered the wiring to the drivers. Fortunately, the driver terminal response of sample #2 measured the same as sample #1. I was pleased to avoid repeating this aggravation with sample #1.

I replaced the flattened Focal gaskets with weatherstripping. The reinstalled drivers in #2 measured with ⅓-octave warble tones measurement were now within 1dB of sample #1 across its entire range.

In a second round of serious listening, the speakers were greatly improved. They now had excellent soundstage reproduction. Left-to-right imaging was precise and depth perspective was very good. But, the tweeters were still offensively hot. The tonal balance on every recording was tipped up toward the top. Recordings which are bright to begin with, such as Charles Dutoit's London CD of Respighi's *Pines of Rome*, were virtually impossible to listen to for any extended period of time. Massed strings were bright and edgy, and cymbal crashes sounded downright raucous. On well-recorded vocal material, such as Karajan's 1959 recording of Verdi's *Aida* or Solti's complete Wagner *Ring*, singers sounded thin, lacking in warmth and body. ORCA claims the Aria 5s have exceptional midrange clarity and detail but the excessive treble brightness made it difficult to focus on any other portion of the spectrum.

Subwoofer Required

For a second opinion on the Aria 5s, I invited Lorelei Murdie to listen. Lorelei is concert halls manager at The Crane School of Music whose job brings her in contact with live classical music daily. She found the Aria 5s to be downright fatiguing. After 15 or 20 minutes of listening, she didn't care to continue.

I explained all of this to Joe D'Appolito. He said the T90K did have some high-frequency resonances which make it a little bright. He told me a few listeners had mentioned a slight brightness with the T90K, but no one had found them to be nearly as bad as we did. I sent the tweeters to him for measurement. As it turned out, one of the tweeters was 3-4dB hotter above 4kHz than his own. The other wasn't as bad— there was actually 2dB mismatch between them. Kimon Bellas confirmed the tweeters were out of spec. Unfortunately, the average builder may have no way of knowing whether the tweeters they've received are within published tolerances. This experience hasn't improved my confidence in ORCA's quality control.

Joe said he and ORCA were working on an upgraded version of the T90K, and promised a pair when ready. The new prototypes arrived with a rear vented pole piece which was aperiodically damped. To make the new tweeters compatible with the existing crossovers, Joe supplied a Zobel network, shown inside the dashed line in *Fig. 2*. Joe said a completely updated Aria 5 would contain a new crossover, with frequency raised from 2.5kHz to 3kHz.

I installed the new tweeters and Zobels and did more listening. The updated units were certainly an improvement over the originals. They were still a bit brighter than I'd like, but much more listenable. Still, these modified Focal tweeters weren't nearly as smooth and natural sounding as the modified T120KTs used by Audio Concepts in their Sapphire II. Bass clarity and detail were quite impressive. In fact, the Aria 5 has a bit better low frequency extension and punch than the Sapphire II. But, it's still not a full-range loudspeaker and will require a subwoofer if the listener wishes low bass. ORCA markets several subwoofer kits designed by D'Appolito, including the Aria 10 and Aria 8.

Comparison

Soundstage reproduction was still very good, though I found the Sapphire IIs to be a bit deeper and more precise in localization. In the midrange, the Sapphire IIs were clearly superior in clarity, smoothness and detail. Around the crossover region, I found the modified Aria 5s to be rather unrefined. Whenever instrumental scoring gets heavy, the speaker loses clarity and focus, and sounds somewhat coarse and "trashy." I don't know whether raising the crossover frequency will solve this problem, or the modified tweeter is still less than ideal.

I consider the modified Aria 5s greatest sonic weakness to be the lack of upper midrange refinement. The tonal balance still favors the treble, to some degree, giving the loudspeakers a rather thin tonal character, lacking in warmth. The Aria 5's strengths are soundstage reproduction and low frequency definition and punch (within their operating range, of course).

At this stage, ORCA promised to send me a "fully revised" Aria 5, complete with the new crossover, which was well over a year ago. So far, the promised upgrade hasn't arrived, so it seems ORCA isn't interested in pursuing this review any further. Also, ORCA has not marketed a revised Aria 5 using the modified T90K tweeters they sent to me.

Many dealers still carry plans and parts for the original Aria 5, but I'm afraid I can't recommend this loudspeaker. In the same price range, the Audio Concepts Sapphire II is a vastly superior performer. The Aria 5 is a fundamentally excellent design, and there's no question Joe D'Appolito's 3/2 geometry can produce superb performance. I believe the key to a sonically acceptable Aria 5 lies in selection of a better tweeter and redesigning the crossover to integrate it properly with the 5K013L mid-bass drivers. There's great potential here, but the T90K tweeter has gotten in the way.

A number of variations on the Aria 5

Building a High-Performance Loudspeaker Stand

by Gary A. Galo
Contributing Editor

A number of available loudspeaker stands are suitable for mounting the Aria 5s and other "mini-monitor" loudspeakers. Unfortunately, most of these are expensive. You can build your own for a fraction of the cost of a commercial stand. My version for the Aria 5s is shown in *Photo A*. *Table A* displays the materials list.

I built each stand with a 2" iron pipe and a pair of pipe flanges. You must determine pipe lengths yourself, matching your listening chair's height. I had mine cut 28" long. Your local plumbing supply shop can cut the two pieces of pipe and thread the ends for you.

The base of my stand is made of two 12" square pieces of high density particleboard (or use MDF). Screw the two together after a generous application of Tightbond® or Elmer's Carpenter's Glue®. Use twelve 1" × #8 flat-head wood screws. If you use a Stanley "Screw Mate"® to drill, counterbore, and countersink your pilot holes in one operation; 1" screws are just right. The screws go into the bottom of the base. Adjust the "Screw Mate" depth so the pilot holes don't puncture the top.

Locate these screws no closer than 2" from any of the base's four corners and avoid locations for the four flange mounting holes. Temporarily position the flange in the center of the 12" × 12" piece to mark the hole locations. A bevel on the edges of the assembly makes a neat appearance.

I use Audio Concepts AC Spikes on my stands. To provide secure mounting for the spikes, I use ¾" × ¼-20 T-nuts held in place with 1¼" × ¼-20 hex-head bolts. Mark and drill four 5/16" holes for the T-nuts. These should be located near the four corners, at a distance of 1¼" from the edges of the base. Drill these four holes through the two layers of MDF. Hammer the four T-nuts into the bottom of the base. Insert the four hex-head bolts, with flat washers, through the top of the base and thread them into the T-nut sleeves. Tightening these bolts will firmly hold the T-nuts in place. You'll still have enough thread in the bottom of the T-nuts to mount the AC Spikes later.

One pipe flange is bolted to the base with 1¼" × 5/16" flat-head bolts, flat washers, lock washers, and nuts. You should drill four 5/16" holes through the top of the base for the bolts. Since the bolts must not extend below the base, I use a 1" wood boring bit to sink four ¾" deep holes into the bottom of the stand (no deeper). Use the four 5/16" holes as a guide for the center of your wood-boring bit. Run a small bead of silicone glue around the bottom of the flange, near the threads. This will keep the sand, which we'll use to fill the pipe, from leaking out. You can now bolt the flange to the base with the 1¼" × 5/16" bolts, washers, and nuts. Place

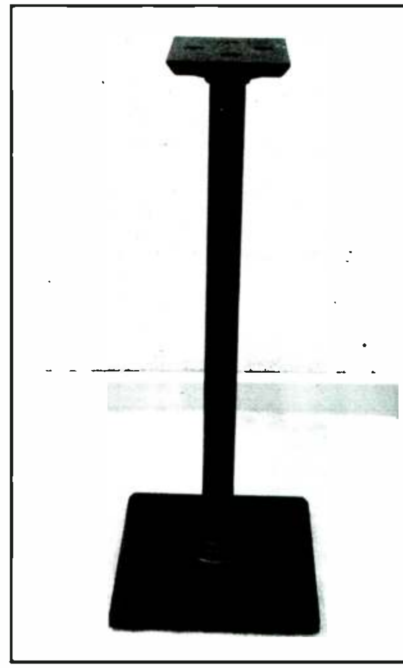

PHOTO A: Galo's custom-built, high-performance loudspeaker stand. The main support is 2" iron pipe, filled with sand. The pipe flanges on each end are fastened to the MDF base and top plate.

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theme are sold by various dealers. A&S and Madisound still sell the original Aria 5 kit with the T90K tweeter. Zalytron has advertised two new versions of the Aria 5, one with a new ORCA titanium dome tweeter and another with the Accuton tweeter. I have no idea what ORCA considers an "official" Aria 5 loudspeaker. A clarification would be welcome.

Kimon Bellas, President of ORCA, Design & Manufacturing Corp., replies:

Gary Galo's review offers a good opportunity to explain what a Focal kit or any other kit from ORCA is. In many ways, Gary makes an interesting suggestion to call it a project rather than a kit. So right, in fact, we will probably start calling our "kits" Speaker Projects.

ORCA, a company importing, marketing, and supporting a selection of the finest drivers and speaker-related products, is not in the same position as the stocking distributors, such as Madisound, Audio Concepts, Zalytron, Just Speakers, Speakers Etc..., Speaker City, Big Cove Research, and so on. ORCA does not sell anything directly to the amateur speaker builder (SB). On the other hand, we consider it to be our responsibility to provide directly to the end users a maximum of quality technical information and technical support for its products. At ORCA, we also want our customers to benefit from resources that are understandably not available to most of them:

- *Professional measurement and test instruments, professional software (in house at ORCA, and at ORCA's associates)*
- *Professional engineering assistance, such as engineering services provided by Dr. D'Appolito.*

Our goal is to help the amateur SB select a project, design it, and manufacture his own speakers. Our objective is definitely not to deliver a carton including all necessary components and parts, precut boards, and so on, where all that is required from the amateur would be just the assembly while simply following instructions. We know, from talking to them every day on the phone, sometimes many times a day and for hours, that the amateur SBs interested in sophisticated products, such as the products we represent, do appreciate the core information we provide, but they are also eager to do their own experiments on cabinet material, cabinet finish, crossover components, crossover layout, wiring, and even crossover design.

Building your own speakers is a hobby; it is fun, exciting, and it can be challenging. For some amateurs it becomes a combination of art, science, and craftsmanship. If at first it seems that the direct benefit of building your own speakers is the tremendous savings compared to the cost of similar quality ready-made speakers, the real attraction comes from custom manufacturing your own speakers. We have seen amateur SBs putting together speakers that no high-end manufacturer of ready-made speakers can afford to make, and even less to sell.

In short, ORCA's first mission is to do what we can do best and what the amateur SBs can't do: to bring to the market at the best possible cost the best possible components for making loudspeakers, whether we source it (Focal, Cabasse, Accuton, Vieta drivers, Atelier spikes) or we design it and have it specially made (SCR caps, Black Hole damping, soon a no-nonsense cable). ORCA's second and directly complementary objective is to support its products with direct and free assistance to the end users in order to make sure the end user will be able to enjoy every penny of his investment in our products. Hence the "kits" produced by ORCA. The rest is duly left to the skill, creativity, and the pride of the passionate amateur SB.

Now to a few precise points:

Enclosures: *as for most of ORCA designs, the enclosure design we publish is the smallest common denominator: it can be followed* the washers in the bottom of the 1″ × ¾″ recesses you cut with the wood-boring bit. Put a flat washer on first, then a lock washer, followed by a nut. Make sure these are tight. You'll need a large screwdriver and a ½″ socket wrench. Insert the pipe into the flange and tighten as firmly as possible.

Next, thread another flange on the other end of the pipe and tighten. Cut a rectangular piece of MDF for the top plate that is 1″ smaller than the loudspeaker base on all sides. For the Aria 5, this is 7¼″ × 6″. A bevel on what will be the bottom edge makes a neater appearance. Mount this piece on the top flange with the beveled edge down. Since it's impossible to predict where the four mounting holes in the top flange will land when the pipe and flanges are tightened in place, carefully position the MDF on top of the mounted flange, centered and square with the base, and mark the four mounting holes' locations.

Now, drill four ⅜″ holes at these locations. Using your 1″ wood-boring bit again, drill a recess into the top of this piece to a depth of no more than ⅛″. Do this for each of the four holes. Now drive a 5/16″ × ½″ T-nut into each of these holes. The ⅛″ recesses allow clearance for the tops of the T-nuts. Fill the pipe with dry "play" sand, an extremely fine type, available at Agway and other "lawn and garden" dealers. Shake the stand so the sand settles and

TABLE A

MATERIALS LIST—FOR ONE STAND

QTY.	DESCRIPTION
2 pieces	¾″ MDF or high-density particleboard, cut 12″ square
12	1″ × #8 flat-head wood screws
1 piece	¾″ MDF or high-density particleboard, cut 7¼″ × 6″*
1 piece	2″ iron pipe, cut 28″ long, threaded both ends**
2	pipe flanges for 2″ iron pipe
4	¼-20 T-nuts, ¾″ long
4	¼-20 hex-head bolts, 1¼″ long, with flat washers
4	5/16″ flat-head bolts, 1¼″ long, with flat washers, lock washers, and hex nuts
4	5/16″ T-nuts, ½″ long
4	5/16″ flat-head bolts, ¾″ long
4	Audio Concepts AC Spikes
4	¼-20 hex nuts for AC Spikes
4	1¼″ drywall screws

** Size is for Aria 5 enclosure. Should be adjusted for other loudspeakers. ** Length is for Aria 5 with tweeters 38″ to 40″ off the floor. Should be adjusted for other loudspeakers and/or listening heights.*

fill the remainder, repeating until the sand won't settle any more. Brush away any excess. Run a bead of silicone glue around the top of the flange, near the threads. Place the MDF piece on top of the flange, insert four 5/16″ × ¾″ flat head bolts, and tighten them firmly into the T-nut threads.

Now mark and drill four holes near the corners of the top piece, 1″ from the edges. These are for the 1¼″ drywall screws, which you will thread into the bottom of the loudspeaker. Place the speaker upside down, on the floor. Center the top piece on the bottom of the loudspeaker and mark the locations of the four pilot holes for the drywall screws. Drill the pilot holes large enough so the drywall screws will fasten firmly. The exact drill size will vary, depending on the density of the MDF used for the enclosure. You need not countersink drywall screws.

If possible, drill the pilot holes in the enclosure's bottom piece *before* assembling it. If you mount crossover components on the enclosure bottom, make sure the drywall screws don't damage them. Once the stand is firmly fastened to the speaker, turn the whole assembly on its head.

Thread a ¼-20 nut fully onto each AC Spike and then thread the AC Spikes into the four T-nuts on the base. Use a 7/16″ wrench to tighten snugly (just to make sure they're not loose). When you finally put the stands in position, adjust one of the spikes to ensure all four make contact evenly with the floor. You don't want the stand to rock. Tighten the nut on the adjusted AC Spike to prevent wobbling. Materials cost is around $60 for a pair of stands. You'll spend at least twice as much, and possibly a lot more, if you buy them in a shop.

exactly, or improved upon. Better and more expensive materials can be used. Thicker walls can be used: in that case it is important not to modify the front baffle geometry too much, and to keep the net internal volume equal. For some models, such as the Aria 5, ORCA has approved third-party cabinets based on our generic design (as shown on the Aria 5 pamphlet we mail upon request). This was done in order to make cabinets available at the lowest possible cost. Following its policy of free support of its products, ORCA does not collect any royalty on these cabinets.

Damping material: *there is a wide variety of damping material available. To specify 1″ or 2″ foam makes relatively little sense by itself, as foam from different sources tends to have differing densities, sizes, and proportions of cells, and are made from different plastics. The sensible approach is for the amateur to try to find what will be best for him in his set up. To introduce some rationale in this all-important domain of loudspeaker engineering, ORCA introduced recently the Black Hole products, especially conceived for this application.*

Crossover location: *what you want from a crossover is that it works exactly as it was designed. Driving under the influence here also can get you in trouble: keep it away from the magnet of the drivers, isolate it from non-desirable vibrations, and make sure the inductors (especially air-core inductors) do not talk to each other. As much as you can, have the high, mid, and bass sections of your crossover at least a few inches apart from each other. It is always a good idea to leave the crossover outside for easy adjustment and testing until done with it.*

Is there something wrong in my system? *Well, if something sounds strange, look carefully at the whole assembly. If you can trace it to a driver, like Gary did to a "hot" tweeter, ask your distributor to check it. If it is out of specs, it will be replaced at no charge—just like we did for Gary. We believe "the average builder" does have a way of knowing: just listen. Nature gave us a pair of superb instruments, just for that, one on each side of our heads. Let's face it: we can assure you the manufacturers who do their best to develop and manufacture advanced technology drivers also do their best to build them under the highest QC: a defective driver in the field is always a losing proposition. That being said, unfortunately for everybody, there will be defective drivers occasionally. What counts then is how it is dealt with. ORCA, and the distributors we have selected, are committed to fairness. If you are not satisfied, call us.*

The T90K: *one of our most successful drivers. It has undergone several improvements since its debut seven years ago. The current version, shipped since March 1991, incorporates a sophisticated damping system (on top of the pole piece and inside the magnet) which improves considerably the decay time and makes the T90K sound "smoother." Same is applied to all Focal tweeters. It is important to note the moving assembly and the damping system are exactly identical on both the current T90K and the Focal tweeter used in the Sapphire II.*

Arias: *Today there are three Aria 5s, all designed by Joe D'Appolito and myself:*
- *Aria 5: with the current T90K tweeter and a new crossover.*
- *Aria 5 TI: with the T90TI.*
- *Aria 5-Accuton: with Accuton C2-11 tweeter.*

Plans and crossover are available at no charge directly from ORCA.

Which sound? *While a Concert Hall Manager can't listen to a T90K for more than 20 minutes, one of the most highly regarded designers of recording studio control and mixing monitors in the U.S. uses the T90K and the T120K exclusively on all his models. These are played for hours at high levels. They are also sold successfully worldwide. In fact, the Aria 5 itself, marketed in Europe*

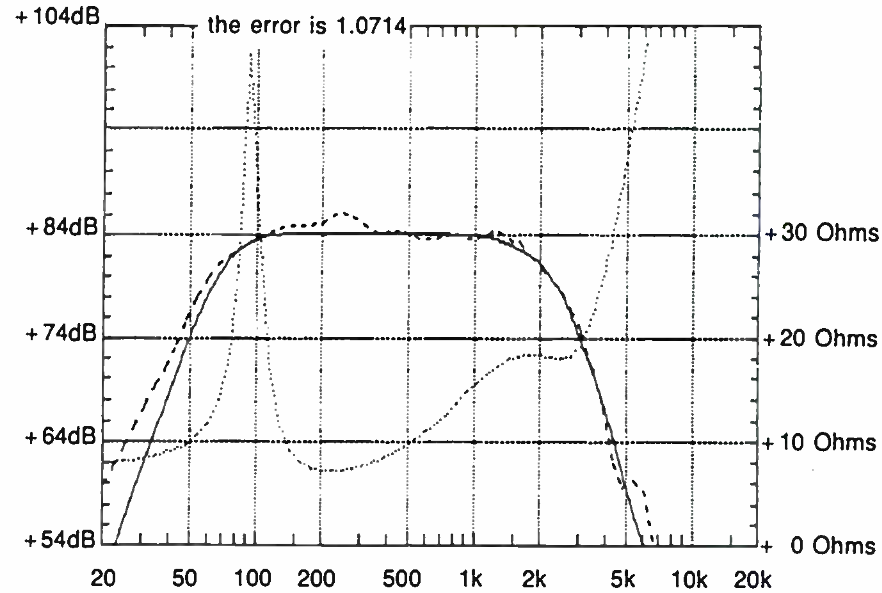

FIGURE 3: Response of the dual 5K013s in the Aria 5 enclosure (dashed line) and the ideal fourth-order response (solid line). The woofer impedance curve is also shown (from *SB* 3/90, p. 90).

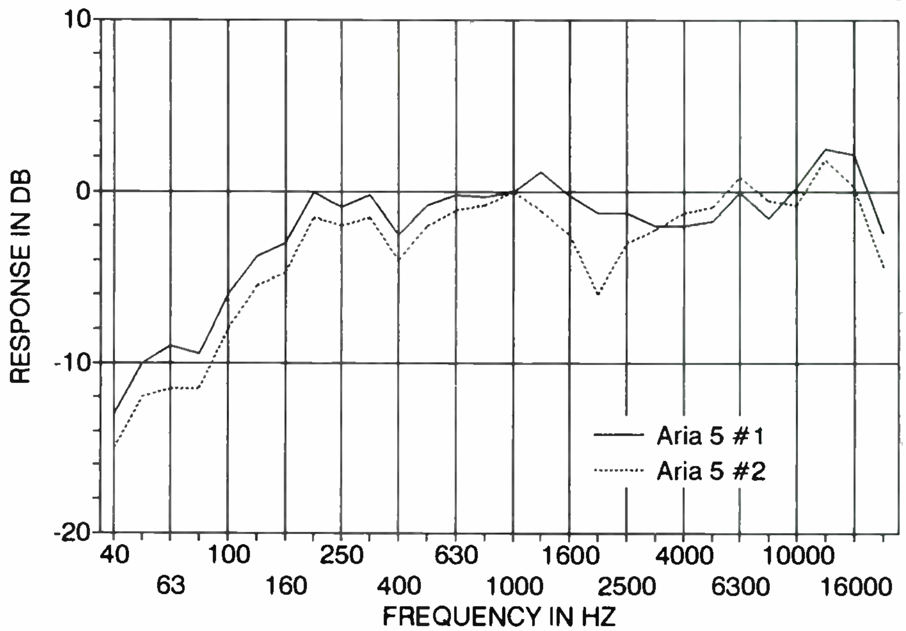

FIGURE 4: ⅓-octave, 1W/1M response of the original Aria 5 samples. After replacing a defective crossover in sample -2, its response was within 1dB of -1 across the band.

as a ready-made speaker, earned the Tenor award for best speaker in the selection of best components of the year in March 1991 of HIFI Video *magazine.*

What this is telling us is that the flat on-axis target response in a very well controlled environment (the studio) may not be everybody's taste at home. Joe and I believe it best to let the end user decide, and that's why we will now offer a "smoothing" option in our crossover designs.

As for this review, I appreciate the effort and the time Gary Galo spent with the Aria 5 and I certainly regret he did not review the current "fully revised" version. Had I understood Gary was still interested in reviewing our latest version after this one year of silence, I would have been glad to make it available to him. In fact, it is still an open invitation, for any of the Aria 5 models.

I also wish to say thank you to Ed Dell and his team for the magazine which keeps us all together.

Craftsman's Corner

Great Sounding Furniture

Photo 2: Close up of monitor showing ⅛" oak plywood face which allows the tweeter flange to be flush with the cabinet front.

My furniture building friend, Neil, wished to construct a one-of-a-kind, relatively compact system with deep bass that he could use with his video system. We also required a minimum of tweaking since this would be his first home built speaker system.

We considered the Focal 133, the Aria 5, and the Dynaudio monitor. Neil decided on the lower cost Dynaudio because of its simple first-order crossover and reputed high power handling. The latter was important because we intended to use the monitors full-range with no crossover to the subwoofer.

We purchased all of the components from Meniscus. The monitors feature Dynaudio D28af tweeters, the 17W75 mid-bass, and the Dynaudio variovent which fits on the cabinet back. The crossovers are standard units for the above drivers, which Meniscus supplies with polypropylene capacitors in the signal path. For the subwoofer, we purchased two Eclipse W 1246-R units (now discontinued).

We constructed all three cabinets of ¾" high-density particle board covered with ¼" oak veneer plywood and filled the ¾" solid oak integral monitor stands' hollow

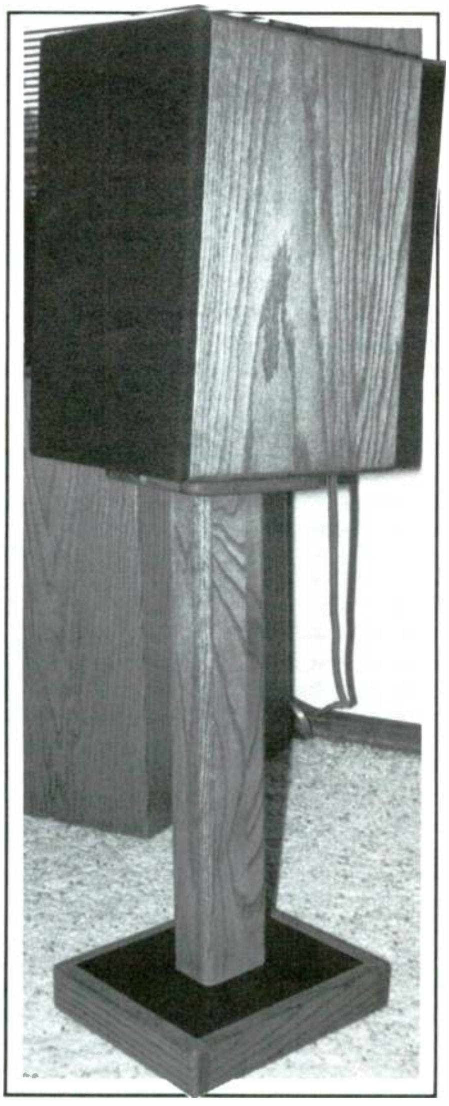

Photo 1: Monitor and integrated sand filled stand with subwoofer in background.

Photo 3: Subwoofer with grille removed showing removable vent.

centers with clean dry sand. We mounted the two 12" drivers face-to-face onto the fourth-order bandpass subwoofers' angled internal baffles, which makes for a relatively small cabinet. The angled baffle allows the vent to clear the woofer's magnet structure which protrudes into the vented compartment. This made the project more interesting for Neil to build. Access to the drivers is through a removable panel on the cabinet bottom. The result is a very attractive unit since it is finished on all exposed sides. As a final touch, we recessed a piece of ¼" smoked glass into the cabinet top.

When we first powered up the subwoofer, we heard a strange wheezy sound coming from the vent—not exactly what we expected. We removed the access panel and the woofers and realized that the rubber surrounds were contacting. When installing drivers such as these face-to-face, both black fiberboard washers (the ones normally not used when installing a driver with the flange on the outside of a cabinet) are required for adequate spacing. Once we installed a second gasket and used longer bolts, we were off and running again.

Another small incident occurred involving our choice of CDs during the first listening session. After about an hour of listening, we put a budget classical CD into the player. In the middle of the first cut played, there was audible distortion from the right channel. Our first assumption was that we had a bad component; we were greatly relieved to discover it was only a bad CD!

The completed system has good detail and image depth without sounding harsh. The bass is deep, but not at all exaggerated. A second subwoofer and biamplification would be great, but the owner-builder is quite content with his system as it is.

Rod Hickerson
Portland, OR 97206

Neil Unger
Portland, OR 97015

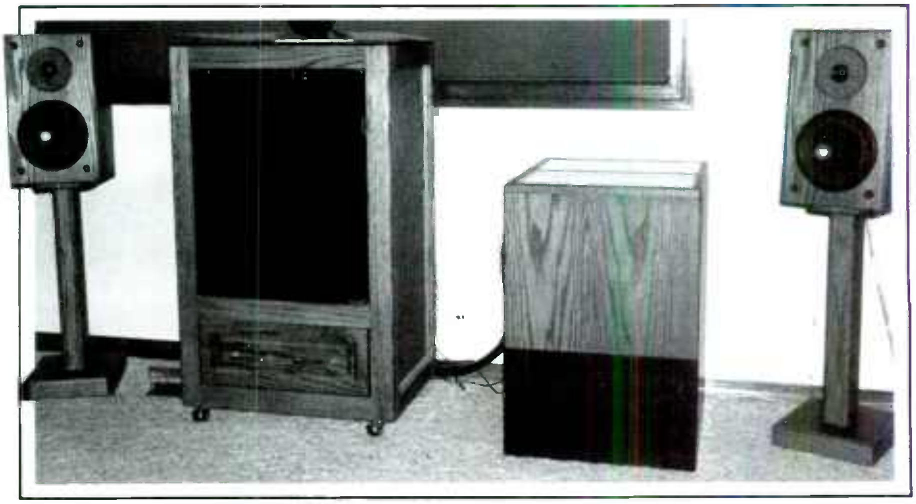

Photo 4: Completed system in Neil's listening room.

SOURCES

Meniscus
2575 28th St. SW, Unit 2
Wyoming, MI 49509
(616) 534-9121
FAX (616) 534-7676

Tools, Tips & Techniques

CROSSOVER TIPS

After 18 years of building speaker systems and associated crossover networks, I wish to share what I have learned about various construction methods. Circuit topology is not the issue here; that is threshed out elsewhere within these pages.

First I'll define some cardinal points of crossover assembly (CA):

- CA must not occupy internal volume to the extent that the tuning is affected.
- CA must fully support all components. Separately mount any components (e.g., large inductors) that will cause the CA to sag or put strain on the mounting.
- Consider mutual inductance effects when mounting inductors.
- Position the CA as far away from driver magnets as possible.
- Provide adequate strain relief for all leads.
- Maintain electrical with mechanical integrity.

In addition, if the box is altered for an input terminal panel, cover the hole with a stout piece of material. Many commercial input cups and panels are made of thin molded plastic. These can act like high-impedance ports, causing bass loss and resonances.

Make a builder-constructed panel of sheet plastic or metal, no less than ¼″ thick, exposing the smallest area possible. From a cost and labor standpoint, it's not desirable to make the CA from this same material. Rather, it's best to make the CA a separate assembly from the cover.

Many constructors will first think of using PC boards for CAs. My advice: *Forget it.* The cost and time making PCBs for typical crossover circuits is prohibitive. Careful point-to-point wiring, using the largest practical gauge of wire (I usually use 16) is the best technique. However, higher-order (third- or fourth-order) topologies can benefit from PCBs.

A high-order circuit is composed of multiples of lower-order ones; therefore these can be "cloned" onto small, discrete PCBs, saving some time over a hard-wired assembly. Also, sectionalizing the crossover makes it easier to adjust components or topology later, such as when converting from a symmetrical network to an asymmetrical network.

Perforated board (perfboard) is inadequate for CAs. Most perfboard is meant for the small leads (22 or smaller) of active electronics. Perfboard is made from laminated phenolic paper, and easily snaps under strain. My favorite material is low-tech: oil-tempered Masonite. It is easy to machine, strong for its thickness, and pretty cheap. However, it does have some quirks. For example, holes over ⅛″ tend to "bloom" on the opposite side of the drill bit.

You can control this with two tactics: drill pilot holes (¹⁄₁₆″ maximum) prior to drilling larger ones, and mask the opposite side with contact paper or paper tape. If possible, use a slow speed on the drill, and avoid any lateral twisting motion of the bit after it punches through. A drill press with variable speed is ideal. Cut the Masonite with heavy knives or regular saws. Most cuts will have a rough edge. Smooth the edges with 80-grit (medium) garnet paper, and then apply a thin coat of varnish to the cut edge. This will minimize any tendency to flake.

After finalizing the circuit topology, I determine an appropriate board size. Then I place the circuit on self-adhesive label paper (such as Avery™ brand, available at office-supply stores), arranging the components for minimum interference. I draw outlines around each component and connector and write the reference designator (C1, L1, etc.) beside it. This makes the finished CA easy to follow.

Apply the paper to both sides of the Masonite and drill the holes. Then dry-fit the components to ensure adequate lead spacing and strain relief. To save space, I usually wire the Zobel capacitor/resistor pair directly across the driver terminals, as opposed to mounting on the CA. Since a given driver requires a specific Zobel, it makes sense to treat them as a unit.

I almost always use loop clamps or plastic wire ties to mount components, since it is easier to change them if they are not glued. Use pads of weatherstripping tape between the wire ties and capacitor bodies. Bolt and glue connector blocks to the board for added strength. For inductors weighing less than 8 oz., I use Masonite washers, cut with a hole saw, and nylon machine screws. Secure heavier coils with a simple bracket (*Fig. 1*) made of ¼″ wood or plastic stock.

Mount the finished CA on wooden stand-off blocks with nuts and lockwashers over mounting studs. I make mounting studs by gluing 8-32, 1″ machine screws head-first into holes drilled in the stand-off blocks. The stand-offs are usually about ½″ high to accommodate the under-board wiring, and are permanently epoxied to the cabinet wall or floor. (*Make sure the screws are set at 90° to the blocks.—Ed.*)

For complex circuits, or small speaker enclosures, I mount the CA outboard in a box, using polarized connectors for the input and output leads. Very small (five liters or less) boxes, not used as satellites with active crossovers, are a special case. For these, I use tantalum capacitors, rated at least 35V. Tantalums are the most size-

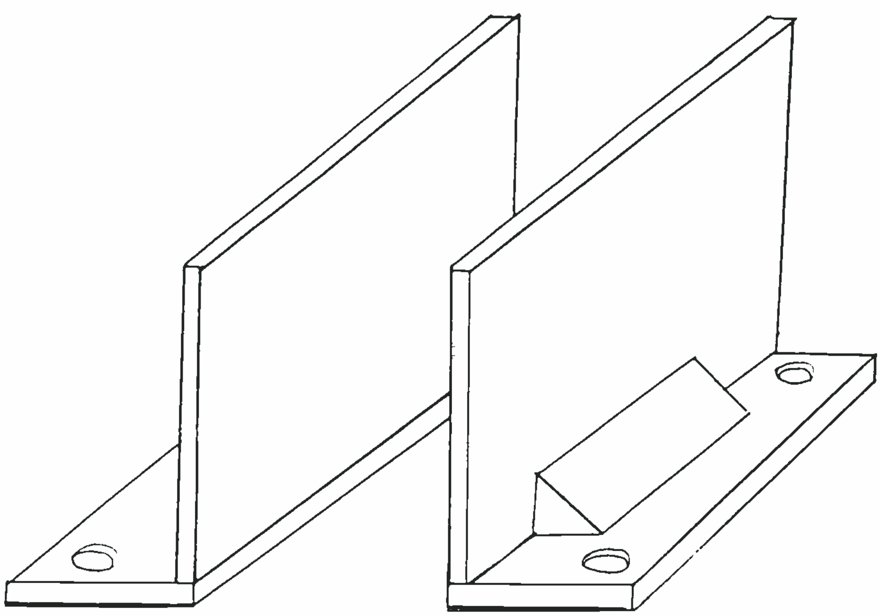

FIGURE 1: Inductor bracket—size to suit.

effective capacitors made; a 15μF unit can be as small as a 0.33μF film type. Although their dissipation factor is higher than film types, it is significantly lower than that of aluminum electrolytics. Tantalums are more expensive than aluminum types; they are comparable in cost to high-quality film capacitors. Good quality iron-core inductors are also more compact than their air-core brethren. *(Tantalums and iron-core inductors may have sonic effects less than ideal.—Ed.)*

CAs for auto systems must be compact, and should be mounted to avoid shorting against a metal part of the car chassis, which is used as ground return. To prevent this, after testing, I mummify the CA in electrical tape prior to installation. In many American cars, I've found a ledge between the top of the glove compartment and the underside of the dash that can hold a CA.

At one point in my speaker career, I potted most capacitors in epoxy resin. I now think it is appropriate only for car units. The epoxy will offer some protection against heat and vibration. The added mass of the potting resin must be securely fastened to the board, lest it cause fatigue-cracking of leads. Potting components, in the final analysis, is not necessary. A car CA I built in 1988, without potting, still performs flawlessly today.

Scott S. Ellis
Falls Church, VA 22042

TABLE-SAW STOP BLOCK

Your table saw's miter gauge helps to cut boards to the proper length, but cutting several to exactly the same length is a problem. If you measure each one and mark it, there can still be some variation in measuring and marking, as well as feeding each board correctly to the saw blade. You could use the miter gauge in combination with the rip fence to ensure each board is cut at exactly the same place, but this is poor practice. Trapping a board between the miter gauge and the rip fence when cutting invites an accident. A stop block is a simple and safer solution.

Clamp the stop block to the rip fence (*Fig. 1*). Position the block so the board loses contact with it before it touches the saw blade. Position the rip fence and stop block to give the desired board length by measuring the distance between the blade and the block. Lock the rip fence in place. Place the board against the miter gauge, which has been set to the desired cutting angle. Butt the board against the stop block. Move the miter gauge and board past the saw blade. Using this method, each board will be exactly the same length.

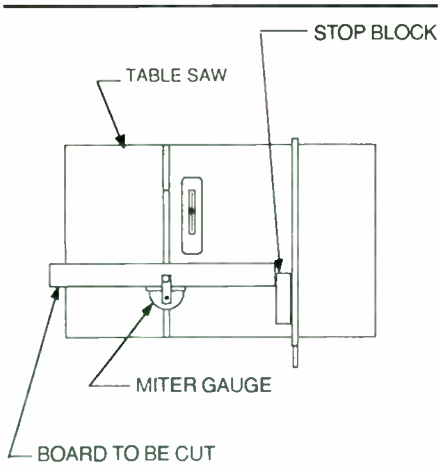

FIGURE 1: Plan view of the stop block.

James T. Frane
Orinda, CA 94563

TABLE-SAW PANEL-GAUGES

Square and precise angle cuts are straightforward using the miter gauge on a table saw. This versatile device simply slides in a groove on the saw table. One of its most significant limitations in speaker-cabinet

Continued on page 61

MORE NEW PRODUCTS!

PULSAR ADVANCED DIGITAL CIRCUIT SIMULATOR SOFTWARE

Number One Systems Ltd.

This digital designer is easily among the best in the world, complete with fully programmable signal sources, a printable logic analyser display capable of catching glitches down to 1 picosecond, adjustable component models, and much more. It is designed to relate directly to existing methods of breadboarding and testing designs. You build your circuit from components held in the libraries and then drive it from pulse generators, displaying the results on a familiar logic analyser screen. Features include simulation speed of over 1000 gate states per second (12MHz 286); circuit complexity of over 1500 gate equivalents (640K RAM); maximum simulated events of over 40,000 gate states (640K RAM); timing resolution of 1 picosecond in over 250 hours; and 16-level subcircuit nesting. Requires IBM PC/XT/AT/386/486 or compatible; minimum 512K RAM; VGA or EGA monitor; hard drive with MSDOS 3.x. Mouse or trackerball recommended. 9/24-pin dot matrix or LaserJet II compatible. From the United Kingdom. Supplied in both 3½" and 5¼" disk sizes. Full documentation. Please allow five weeks for delivery.

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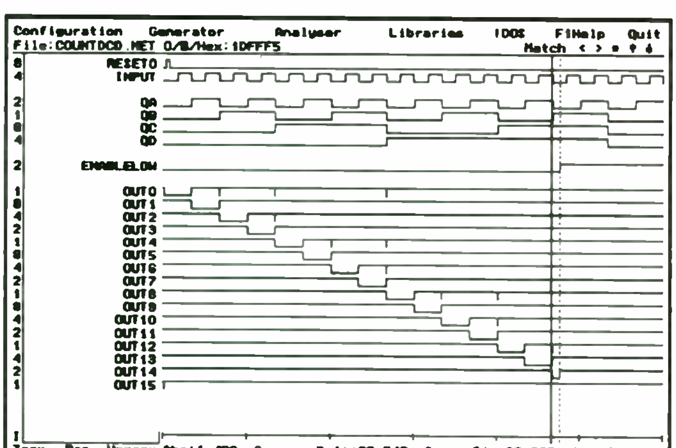

PULSAR screen.

Z-MATCH II SMITH CHART RF DESIGN SOFTWARE

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This package is the software implementation of the well-known paper Smith Chart developed by Philip Smith at Bell Laboratories in 1939. Over the past fifty years, the Smith Chart has become the standard analysis tool for RF engineers. Z-MATCH II retains all of the graphical advantages of the original chart while incorporating many features to eliminate repetitive calculation and to make the chart more accessible to the occasional user. Features include: high-resolution chart display, menu- or command-line driven; linear and circular cursor movement; output to dot matrix printer; impedance or admittance charts; open circuit/short circuit points; normalized or actual parameters; rectangular or polar impedances; wavelength and actual distance; polar reflection coefficient; standing wave ratio; equivalent inductance or capacitance; characteristic impedance; frequency in use; dielectric constant or velocity factor; and network Q value. Requires IBM PC or compatible with minimum 256K RAM (384K for EGA and VGA displays); CGA, EGA, or VGA graphics adapter and monitor (preferably color); DOS 2.x. Math coprocessor usable but not required. From the United Kingdom. Supplied in both 3½" and 5¼" disk sizes. Full documentation. Please allow five weeks for delivery.

SOF-ZMT1B5G Z-MATCH II for IBM **$375.00**

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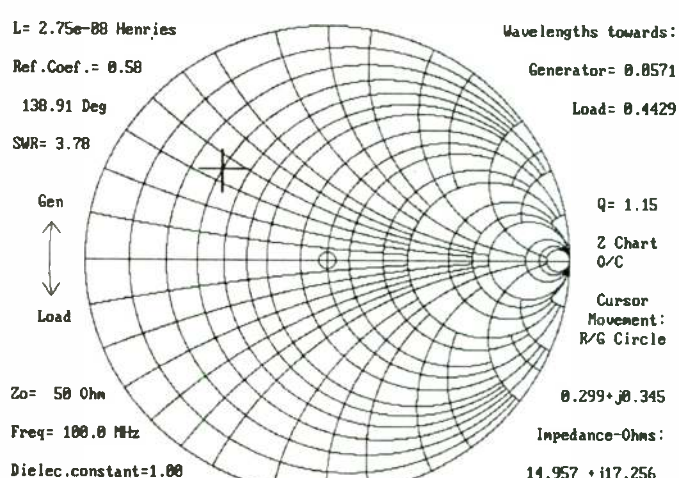

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MORE NEW PRODUCTS!

ELECTROSTATIC LOUDSPEAKER DESIGN AND CONSTRUCTION — BKT6 — $19.95

Ronald Wagner

This classic, once produced by TAB Books, is now published by Audio Amateur Press for the first time. Both a "how-to" book and an informative text on electrostatic speakers, it provides a step-by-step sequence for building full-range electrostatic speakers as well as acquaints the reader with their basic operating principles. The book also describes the important parameters of an electrostatic speaker and indicates how each affects performance. Intended for the audio amateur, musician, craftsman, or anyone else who is not only interested in this type of speaker, but would also like to obtain the very best in sound reproduction. Chapters include: How It Began; Electromagnetic Speakers; Speaker Measurements; Electrostatic Loudspeakers; Building a Full-Range Electrostatic Speaker; Frames and Ribs; Preliminary Assembly; Preliminary Speaker Testing; Stretching Frame; Final Speaker Assembly; Speaker Mounting Frames; Electronics for Electrostatic Speakers; Speaker Evaluation; and Commercial Electrostatic Speakers. (Because of rights difficulties, not included from original book is the Chapter 15 article by Malme.) Appendix with construction info, Index, Bibliography. 1987, 1992, 244pp., 7½ × 9½, softbound. IN PRODUCTION; PLEASE CHECK AVAILABILITY.

RADIO AND ELECTRONICS ENGINEER'S POCKET BOOK — BKHN2 — $27.95

Keith Brindley

This completely revised and enlarged seventeenth edition of the invaluable standby is a great compendium of facts, figures, and formulae indispensable to the designer, student, service engineer, and all those interested in radio and electronics. The author's main criterion in choosing what to include was to ask himself, "What do *I* look up?" He thus has tried to include anything and everything of relevance to radio and electronics referred to in literature. A considerable amount of new material relating to recent developments in radio and electronics has been added, including new sections on batteries, cables, and connectors. In addition, all the broadcasting information (for the United Kingdom) has been updated. This is a pocket book, in a very handy size. United Kingdom, 1987, 201pp., 3¾× 7¾, hardbound.

DIGITAL AUDIO AND COMPACT DISC TECHNOLOGY — BKHN3 — $49.95

Sony Service Centre (Europe)

Edited by Luc Baert, Luc Theunissen, and Guido Vergult, this is the definitive book on CD players and technology and is essential reading for audio engineers, students, and hi-fi enthusiasts. All modern and proposed sound transmission/storage systems use digital techniques, specifically pulse code modulation (PCM). This is a clear and easy-to-follow introduction which also includes a technical description of DAT (digital audio tape). BKHN3 is produced by Sony, using all of their resources and expertise as one of the forerunners in this field and co-inventor of the compact disc digital audio system. Contents include: Principles of Digital Signal Processing; Sampling; Quantization; A/D Conversion Systems; Codes for Digital Magnetic Recording; Principles of Error Correction; The Compact Disc; Compact Disc Encoding; Opto-Electronics and the Optical Block; The Servo Circuits in CD Players; Signal Processing; Digital Audio Recording Systems; PCM; Video 8; R-DAT; S-DAT; and DASH. United Kingdom, 1988, 253pp., 7¾ × 10, hardbound.

THE TAPELESS DIRECTORY — BKSY1 — $39.95

Yasmin Hashmi, Stella Plumbridge

This valuable reference, now in its second edition, is the only independent source of information on over 70 tapeless audio recording and editing systems. It is divided into two parts: The first gives a comprehensive background to the technology, explaining terminology, operational procedures, and design strategies and including useful pointers for those considering investing in a system. The second part provides detailed information on the systems and is organized according to type. The data provided for the systems is in an easily comparable format and includes target market(s), operational and technical specifications, anticipated developments, and cost and supplier details for the USA and Europe. United Kingdom, 1991, 72pp., 8¼ × 11¾, softbound.

USING TIME CODE IN THE REEL WORLD II — BKSR1 — $19.95

Jim Tanenbaum, C.A.S., with Manfred N. Klemme

Time code, such as 50/60Hz Neopilot or FM sync, provides a way of maintaining the relationship between the sound recorded on audio tape and the image recorded separately on film or videotape. In addition, it provides an initial reference point without clapstick slates; in fact, it provides a continuous reference inherently, without edge coding or other external means. This manual, now in its second edition, will help the reader understand time code and know what standard to use for every possible application. Its level varies from elementary to somewhat advanced, but it develops each subject area in a comprehensible manner, sometimes including a touch of humor. It is assumed that the reader knows non-TC sound recording techniques and understands (somewhat) the operation of the Nagra IV-STC, Denecke TS-1 slate, and so forth. Index, Glossary, Bibliography. 1992, 110pp., 8½ × 11, Velo bound with vinyl covers.

THE NEW STEREO SOUNDBOOK — BKT23 — $18.95

F. Alton Everest, Ron Streicher

This book is a comprehensive, nontechnical guide to stereo sound principles and techniques, explaining all of the underlying facets of stereophonic perception, recording, and reproduction. The authors provide easy-to-follow experiments and all the diagrams, tables, and photographs the reader will require in order to modify and enhance his stereo system. Topics include the development of stereo from its earliest stages to the present; using microphones to achieve special stereo effects; recording binaural signals with the use of a dummy head; making a stereo signal from two or more mono signals; controlling sound reflections for optimal stereo listening; auditory spaciousness; multidimensional and surround sound systems; and much more. 1992, 296pp., 7 × 10, softbound.

DESIGN & BUILD ELECTRONIC POWER SUPPLIES — BKT24 — $17.95

Irving M. Gottlieb

Power supply technology has come a long way in the past few years, largely as a result of new techniques that allow higher switching rates with no significant loss in performance. This practical guide to modern power supply design and new construction techniques will bring the reader up to date on today's most advanced power supply circuits, components, and measurement procedures. The author includes full coverage of the older 20kHz power switch standard, as well as describes how new high frequency devices are reducing production costs and dramatically improving power supply efficiency, reliability, compactness, and volume. New advances covered include electronic and synchronous rectification; resonant-mode switching; sine-wave power supplies; current-mode control; IGBT power switches; MCT thyristors; and more. 1991, 163pp., 7 × 10, softbound.

MORE NEW PRODUCTS!

THE MODERN OSCILLATOR CIRCUIT ENCYCLOPEDIA — **BKT27** — **$12.95**
Rudolf F. Graf

This valuable reference contains an assortment of more than 250 ready-to-use oscillator circuit designs representing the latest engineering practices. Organized by application for easy reference, the circuits are in their original form to prevent transcription errors. Each entry includes a schematic and a brief explanation of how the circuit works. The author also lists the original source for each circuit in a section at the back of the book, making it easy for the reader to obtain additional information. Types covered include audio, burst, sine-wave, Miller, Colpitts, Wien-bridge, bias, multivibrator, crystal, RF, square-wave, Pierce, TTL, code, voltage-controlled, and function generators. 1992, 184pp., 7 × 10, softbound.

DAT: THE COMPLETE GUIDE TO DIGITAL AUDIO TAPE — **BKT25** — **$12.95**
Delton T. Horn

Everything you need to know about the latest development in sound reproduction–digital audio tape–is clearly explained in this easy-to-understand book: what DAT is, how it works, and how it differs from competing analog and compact disc technology. After a brief overview of basic analog and digital recording concepts, the reader will find in-depth coverage of DAT techniques and equipment, manufacturer's information on available (and soon to be available) systems, and what the future holds for DAT technology. 1991, 254pp. 7 × 10, softbound.

TROUBLESHOOTING AND REPAIRING ELECTRONIC MUSIC SYNTHESIZERS — **BKT26** — **$16.95**
Delton T. Horn

This illustrated manual is enjoying a growing audience among musicians who want to save money on repairs, as well as among technicians and hobbyists who want to learn more about the new generation of musical synthesis equipment. The author provides complete, step-by-step instructions for servicing or replacing all synthesizer components and circuitry, from that found in older analog devices to today's most advanced digital systems. Musicians will also find plenty of solid advice on how to refurbish old or unusable equipment and how to modify and expand existing setups. Entire chapters are devoted to MIDI circuitry, cabling, and other aspects of computer-controlled digital synthesis technology. 1992, 206pp., 7 × 10, softbound.

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Continued from page 57
building is its inability to accommodate large panels. Because the edge of a large panel rests against the narrow rail for such a short distance, maintaining a precise cut is very difficult. The panel has a tendency to skew in relation to the rail, and hence to the saw blade. The short guide bar doesn't let you pull the miter gauge far enough away from the saw blade to handle a panel wider than 16″.

The cure for all this is a variation of the miter gauge you can make yourself. This design only allows you to make cuts that are square to the axis of the panel (no angle cuts), but this should serve your needs for speaker cabinets. I'll call this device a panel gauge.

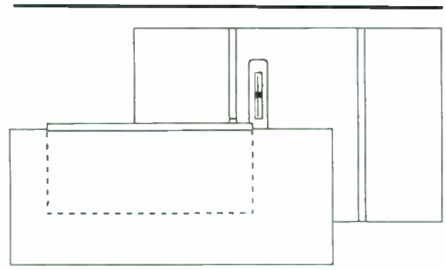

FIGURE 2: Panel gauge plan view.

Squareness is the panel's most important characteristic. Take great care to square the plywood perfectly to the guide bar. You can secure the panel to the bar with screws through countersunk holes in the plywood. The countersunk holes ensure that the screw heads will be flush or below the surface of the plywood. A little woodworker's glue will strengthen the joint considerably. Attach the front rail to the plywood with glue and a few 4d finishing nails while the glue sets.

Figure 2 shows a plan view of the panel gauge (in phantom) supporting a panel. The panel gauge helps in making those panel cuts for where the rip fence isn't the right tool.

James T. Frane
Orinda, CA 94563

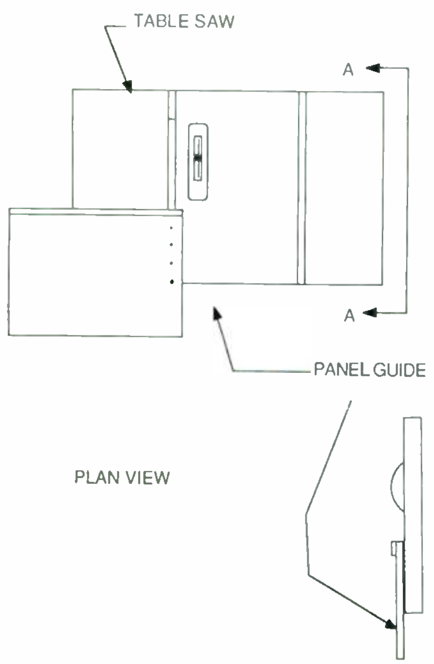

FIGURE 1: Two views of the panel gauge.

Figure 1 shows two views of the device. It is designed to fit snugly into either of the existing slots in your table saw top and to provide a rail long enough to bear on a longer length of the panel edge for better cutting accuracy. The gauge consists of a sheet of ½″ thick plywood about 22″ long and 15″ wide. You can vary these dimensions.

Fasten the plywood to a wooden guide bar cut to fit snugly into the slot in the table. A rail along the front, or saw-blade side, of the plywood extends about ¾″ above the top surface. The other end is flush with the bottom of the plywood. Place the panel to be cut on top of the plywood with its edge tight against the rail on the front of the plywood. Push the gauge and panel past the saw blade and make the cut in the panel. Since the rail is at the front edge of the panel gauge, the size of the panel you push through the saw is limited only by what you can manage.

SB Mailbox

TO ERR . . .

The following are corrections to "A High Quality Speaker Cabinet," (*SB* 3/92, p. 14):

1. 63 board-feet should be 6.3 board feet. The former is a lot of wood.
2. Epoxy smears on the plywood should be cleaned up *immediately* with lacquer thinner.
3. The original Swan IV article appeared in *SB* 4-5/88.

Mark Florian
Austin, TX 78746

CAPACITOR SWITCH ERROR

As often happens, an error has crept into my TT&T as published (SB 2/92, p. 34). This single error—though important—would most likely be recognized by anyone familiar with electronic circuitry. Position one (1) of SW1 must be labelled "OPEN" and position six (6) of SW1 labelled "SHORT." Position one, allows the "OPEN" condition so that the absolute half-decade values of SW2 may be selected separately. Position six (6) allows the "SHORTED" condition so that the effects of both SW1 and SW2 may be removed from any networks that happen to be configured in a series state. To put it another way, the effects of the capacitor switch would be removed from parallel network configurations by the "OPEN" condition and removed from series networks by the "SHORT" condition—a very important distinction.

This should clarify the matter and if any questions arise, I would be more than happy to answer them.

Frank B. Horner
Spring Lake Heights, NJ 07762

AND ANOTHER THING . . . .

I have some minor corrections to my article, "The Disappearing Loudspeaker," (*SB* 3/92, p. 42).

In Tables 2 and 4, the correct units for the crossover inductors are millihenries (mH). The numerical values are correct as given in the Tables. Only woofer L1 is ferrite cored; the rest are air cored.

Under the heading "Cutouts and Mounting," the driver mounting layout is actually shown in *Fig. 7*, and not in *Fig. 6c*, as stated.

The woofer mounting gasket of foam is actually ¼″ by ⅛″.

The second sentence in the next-to-last paragraph in the article should read, "I just used low rubber stick-on chassis feet on the bottom of my enclosures, positioned near the corners to avoid the possibly flexing bottom panel."

Victor Staggs
Orange, CA 92669

PLACEBOS & MEASUREMENTS

I was interested to read David Moran's report on the October 1991 AES Convention (*SB* 2/92, p. 79). Much of his commentary concerning *Stereophile*'s participation in that convention was obviously a matter of opinion and therefore does not require comment. (Though I would like to point out that there is nothing unusual in Robert Harley or myself attending the convention, both of us having joined the Audio Engineering Society over a decade ago, unlike David, who is *not* a member, at least according to the 1991 AES Directory.) There are three factual points he made to which I shall respond, however.

First, Mr. Moran referred to a brief conversation I had with him at the convention, during which I told Mr. Moran that if he felt that *Stereophile*'s value judgments were suspect, he should not read the magazine. He then described a subsequent dinner conversation in which friends who were professionals in other fields-marketing, the law, and journalism-expressed concern and disbelief when he told them there were people at the AES Convention who had a problem with blind testing. (Interestingly, *Stereophile*'s 1991 readership survey reveals its readers to be predominantly the kind of people mentioned by Mr. Moran. 93% possess college degrees, with almost one-third holding some kind of postgraduate qualification.)

Mr. Moran seems to have taken my remark about him not reading *Stereophile* as being flippant. But I said this to him in all seriousness. You see, I strongly believe that anyone making value judgments in public has to be prepared for those judgments to be examined critically. To that end, I believe that hi-fi reviewers have a responsibility of making clear in their writing all the necessary contextual information that would enable their readers to test their opinions for themselves. Thus it is that you see, in every equipment review in *Stereophile*, details of the ancillary components and recordings used by the writer to reach his value judgments. Without such information, how can a reader do otherwise than take what has been said on trust? I am deeply suspicious of reviewers who hand-down value judgments and descriptions of sound quality as though these were absolute, without the reader being given any of the supporting structure behind those opinions. Instead, if a magazine makes it possible for its readers both to see how those opinions were arrived at and to test its published opinions for themselves, then the veracity of those opinions doesn't have to be a matter of faith alone.

Mr. Moran seems to feel that without prior independent affirmation of a magazine's testing regime, it should not publish reviews. However, I assume the law of the marketplace operates: If *Stereophile*'s readers find what it says fits in with their own experience, then the magazine will be both successful and respected; on the other hand, as there is no law that compels those who don't find the magazine's value judgments to be reliable or transportable to continue reading it, *Stereophile* will lose the respect of its readers and fail commercially. This is what I meant by my remark to Mr. Moran. If he neither trusts our opinions nor is prepared to test them for himself, then he isn't compelled to read *Stereophile*. With our audited circulation now standing at over 61,000, there are many other readers who *do* find what we say to be of use.

Second, both at the convention and throughout his *Speaker Builder* report, Mr. Moran referred to what he calls the "Placebo Effect," whereby value judgments made by reviewers who know the identity of the components to which they listen are invalid. Only by exclusively performing blind testing, apparently feels Mr. Moran, can a reviewer be "taken seriously." Reviewers should "cover up the faceplate when they're listening for review," he wrote.

As its regular readers will be aware, *Stereophile* does occasionally perform blind tests when appropriate—see the loudspeaker reviews in our July 1991 and May 1992 issues, for examples. Nevertheless, the thrust of the paper that Robert Harley gave at the AES convention (his third AES paper, by the way) and which was criticized by Mr. Moran, was to point out that while sighted listening has drawbacks, so does blind testing, which introduces a different set of interfering variables. (Not the least of which is the impracticability for the reviewer working alone of a completely blind test regime, something of which I am sure David Moran is aware—"cover up the faceplate" actually involves the reviewer *never* being aware of what the component is.)

As Bob explained in his paper, the responsible reviewer performing sighted listening has the obligation of being aware of his prejudices and putting them aside. However, Mr. Moran stated that this is impossible. "To state aloud and practice in your journalism and writing, the conviction that the placebo effect is a matter of will . . . is to live in another time," he wrote. "It's quaint . . . such a trait keeps the field of audio ever a comic endeavor, an object of mirth . . . There can be no credibility whatsoever from the investigation."

Strong words, but if David Moran's argument has merit, it appears to call more than *Stereophile*'s reviews into question. If sighted listening as practiced by *Stereophile* is invalid, then by the same token, so is that as practiced by Mr. Moran. A quick survey of back issues of *CD Review* and *Speaker Builder*, the two national magazines to which Mr. Moran has contributed loudspeaker reviews (I counted 19 models reviewed by him, meaning that his statement on page 85 of the *SB* 2/92 that he has reviewed "dozens of loudspeakers" is perhaps somewhat exaggerated) appears to reveal that Mr. Moran doesn't practice what he preaches. To judge by what he has written, all *his* review listening has been under sighted conditions. And in the same issue of *Speaker Builder* as his AES report, he echoes his previously published praise for Roy Allison and his products by starting a review of the Allison AL 130 with the statement that the only loudspeakers he has spent his own money on "have been designed by Roy Allison." This might be thought by a supporter of the placebo effect to invalidate any subsequent comments made by Mr. Moran on the sound quality and value of any Allison model.

Of course, I don't believe Mr. Moran's review of the AL 130 to be invalid, because, as a careful reviewer, he doubtless puts his self-admitted admiration for Mr. Allison's talent to one side in order to make valid value judgments. Robert Harley said this in his AES paper: the responsible reviewer must act in a disinterested manner. If Mr. Moran continues to insist this is impossible, it seems to me he must admit his own reviews are also invalid.

I do note, however, from reading his published reviews, Mr. Moran does *not* include any details of the components or recordings from which he derives his value judgments and would disqualify him as a *Stereophile* reviewer for the reasons outlined earlier. I would also take issue with his description of why the Allison tweeter has wide dispersion. Surely dispersion is purely a function of frequency, geometry, and diaphragm break-up, voice-coil position being irrelevant unless it contributes to the latter behavior.

My final point concerns Mr. Moran's

statement that "if [Robert Harley], John Atkinson, or indeed KEF's Laurie Fincham . . . knows drawbacks to pink noise as a signal for this kind of testing, that would be a good research paper for an AES convention." I cannot speak for Mr. Fincham, but David Moran touches on this subject in his column (*SB* 1/92, p. 86). The problem mentioned by Bob Harley in our January issue does not concern pink noise *per se* but the whole notion of steady-state testing of loudspeakers in rooms. Using pink noise and a spectrum analyzer integrates the speaker's output over time, meaning that there are only two kinds of rooms where a steady-state test will give valid (but different) results. In a totally reverberant chamber, the technique measures the total power the speaker delivers into a 360° solid angle; in a totally anechoic chamber, it measures the amplitude response on the chosen axis (as do all techniques).

The situation in a real room is far from either of these two limiting cases. In a real room, the listener sits in a soundfield comprising the direct sound of the loudspeakers, the initial reflections of that sound from nearby boundaries (including the floor, of course), and the room reverberant field. The exact contribution of each of these factors to a loudspeaker's perceived tonal balance will vary widely according to how close the listener is to the speaker, how large the room is and how far away the room boundaries are from both speaker and listener, the room furnishings and acoustic treatment or lack thereof, and the overall dispersion of the loudspeaker—i.e., the way its radiation pattern varies across the audio band. All measurement techniques examining the sound of a loudspeaker in any particular room also react in different ways to these three factors.

To assume that only the direct sound matters would only be true in an anechoic chamber; to assume that the room reverberant field predominates would only be true in a very large bare room with the listener a long way away from the loudspeaker. In all real rooms, the balance between the direct sound and the reverberant field is unique for every listening/microphone position. In addition, as Mr. Moran points out in his AES paper, unless the loudspeaker is a long way away from the boundaries, the initial reflections of its sound arrive at the listening position soon enough behind the direct sound the ear/brain might—but not necessarily—assume them to be part of it.

How, then, do you measure the "sound" of a loudspeaker in a room? If you use an FFT, MLS, or TDS technique, you can window out the reflections and reverberation to obtain a reasonably accurate idea of the speaker's anechoic response on any particular axis. (This is what I do with the DRA Labs MLSSA system in my loudspeaker reviews for *Stereophile*.) The frequency resolution is limited by the time windowing, however, and the technique doesn't tell you how the speaker will sound in a room as it eliminates the influence of the room by definition.

If you use pink noise and a spectrum analyzer, as David Moran does exclusively and I do occasionally, you are in effect measuring the steady-state sound power in the room as perceived at the microphone position, which depends on all three factors mentioned earlier (as well as on the directivity of the microphone used). This technique *also* doesn't tell you how a speaker sounds in a room, as it downplays the psychoacoustic contribution of the direct sound, that which the listener hears first. However, because it includes the full contribution from the early reflections of the loudspeaker's sound, the constructive and destructive interferences from these result in large measured peaks and dips in the lower midrange when measured with a steady-state technique—the "Allison Effect" to which Mr. Moran referred in his AES paper.

The question to ask is: Does this measured problem correlate with the perceived sound of the loudspeaker, or is it an artifact of the measurement technique? In my experience, at least with respect to the floor reflection (which is almost always the strongest), it is too simplistic to assume that because the Allison Effect is measurable with a steady-state technique, it is therefore a real effect as far as the listener's perception is concerned. I have reviewed or measured 130 different loudspeaker models for *Hi-Fi News & Record Review* and *Stereophile*, within the last ten years or so, all of which (with the exception of those specifically designed to compensate for the Allison Effect) produce lower-midband "suckouts" of various depths in their measured, steady-state, in-room responses. Yet, in all that time, I cannot remember ever *hearing* a corresponding lack of energy in this region. Conversely, speakers with woofers placed next to the floor boundary to move the Allison Effect out of its passband such as the Icon Parsec, tended to sound as if they had an *excess* of energy in the Allison "floor-bounce" region. This admittedly anecdotal evidence suggests that this kind of measurement doesn't tell the whole story, at least as far as the early reflection from the floor is concerned.

Why shouldn't it tell the whole story? Remember that the ear/brain is *not* a microphone; it takes an active role in perception. The floor reflection, which typically follows the speaker's direct sound between 2 and 4mS after it, may be relatively high in amplitude, but, psychoacoustically speaking, it is in an ambiguous time zone. It arrives too long after the direct sound to be definitely considered part of it; but not long enough after the direct sound for the brain to recognize it as a copy and therefore be completely temporally masked. It appears, however, as reflections from the floor confront the ear/brain with every sound source it encounters, it downplays their effect in much the same way as the eye/brain almost totally ignores the effects of color temperature. Supporting evidence for this view was recently offered by David Griesinger of Lexicon. After presenting his paper on the measurement of architectural acoustics during the 92nd AES Convention in Vienna, he stated during questions that if the reflection from the floor of a direct soundsource is more than 4dB down in level from the direct sound, it is completely masked.

This suggests that the Allison Effect will only be valid for loudspeaker reflections in the same plane as the listener's ears or above; i.e., from the ceiling, rear-, and side-walls. Then, only if those reflections follow within 2mS—implying a speaker-boundary distance of one foot or less—will they affect a timbral change on a speaker's sound quality that will be accurately reflected by the steady-state measurement technique advocated by Mr. Moran.

None of this information is in any way new or controversial. There has been a good deal of published research into the audibility and effects of delayed versions of a signal in the presence of that signal; an excellent summary can be found in

William Morris Hartmann's "Localization of a Source of Sound in a Room," reprinted in the 1991 AES anthology *The Sound of Audio*. However, I believe that the only specific research exploring the subjective effects of loudspeaker boundary reflections—i.e., comparing the sound with and without any particular reflection—is currently taking place in Denmark under the aegis of the European Eureka Archimedes project. (See Tom Norton's report in *Stereophile*, Vol. 14 No. 11, p. 49.) As far as I know, the Archimedes researchers have yet to report on their findings in this area.

The moral of this tale is just as the responsible reviewer has to be very careful to put aside everything except the component's sonic performance, so he mustn't get hung up on any one test procedure, whether it be steady-state spectrum analysis, quasi-anechoic testing, or even blind vs. sighted listening. If you become committed to a "magic bullet" test, it is all too easy then to ignore valid data that doesn't fit into the model implied by the chosen methodology or to accept an artifact of that methodology as being real. My own postgraduate qualification is in the teaching of science; I know from first-hand experience both how easy it is to set up experiments so that they will produce "objective" results at odds with reality, and how much care needs to be taken to avoid the same. The responsible reviewer must avoid committing to over-simplistic measurement regimes. Instead, it is essential to use any and every kind of technique to produce measured results that correlate with the listening experience and ultimate value judgments transportable to the reader. The former is something made much easier with available low-cost test equipment; the latter is what distinguishes magazines that fail from those that flourish.

Thanks to Edward Dell for allowing me the space to respond to Mr. Moran's article. This response may be long, but I hope it initiates a dialogue in *Speaker Builder* to examine how loudspeakers behave in real rooms and how they should be measured.

John Atkinson
Editor, *Stereophile*

NO SECOND COMING

In David R. Moran's column "The Measure of Man and Speaker" (*SB* 1/92, p. 82), the author unsurprisingly prefers his own speaker system and discredits others, meanwhile shooting down our many comfortable presumptions. No believer in mere listening, Mr. Moran (who in real life I call David) *measures everything*. (I happen to be that man whose VMPS Tower IIs measured painfully shy in the bass. The stereo pair tracked amazingly close throughout the range, however, as he noted). It also happens I was there when he performed the test. *Speaker Builder* readers may benefit from that episode, in this letter I entitle, "The Measure of Moran."

Not to digress, but twice I have hosted the Boston Audio Society (BAS) at my business premises, The Listening Studio. Instead of their usual 15-20 attendees, I drew nearly 60 participants both times. (We conducted a hearty room-wide discussion reminiscent of the good old "pre-clique" days before membership dwindled from 1,500 to 250.)

Just as David reported, the studio is indeed "very large" (50′ × 23′ × 14′ and very good-looking too, I might add). As for "very damped," he should have added it was regulation LEDE, but the cream pie's on my face as I have since renounced LEDE and taken up RoomTunes, greatly enlivening the soundstage and honing every transient attack. Did that radical surgery change the amplitude response? Probably not, particularly in the bass, yet I invited our man back anyway, just to see. No reply came, until this: "[Clark] called recently to tell me he has treated the room somehow, with reflectors as I recall, and to ask that I come back to remeasure. I haven't done so yet, but I fear the results if I do."

Now, about David's test procedures, tenderfoot readers may wish to be sitting down. How does he perform the sacred ceremony? In my case the ritual occurred towards the end of the second BAS session here, with perhaps a dozen people still milling about. I was occupied backstage with questioners when he stuck his head in and asked permission to do his pink-noise thing. Granted, of course! In retrospect, that was a boneheaded decision, although seeing this letter in print greatly mitigates my folly.

I should add, besides the various warm bodies floating around, furniture had been rearranged and augmented to accommodate the throng. Not only that, the event included RE Design Electronics, then unfamiliar to the Studio. In short, the situation was far beyond my control. Yet David not only seized the occasion to "measure the VMPS," he later published the opinion he formed (from his position most of the night behind many other heads) that the speakers "didn't sound so great." Ladies and gentlemen, how can he blame the speakers? *He never measured anything else!*

There's more, don't get up. Besides all the other changes, I had been forced to reposition the VMPSs and everyone knows the first three rules for successful loudspeaker sales: location, location and location! Somewhere I have a study that demonstrates response-curve self-similarity among five very different loudspeakers at one point in a room, contrasted to wild incongruities from one speaker at five different places. Nevertheless, we have a man today in *Speaker Builder* asserting this discredited mensuration dogma: Sweep some frequencies through some electronics over some wire into some microphone put someplace, to assess a loudspeaker somewhere in some room. Not only that, but DRM waves a magic wand (yes! the microphone!), ostensibly to eliminate (by manual averaging) receiver and reproducer beaming, room hotspots and whatnot (although he may not do this every time). Hence his measurements are non-repeatable. Nor can his RTA-1 computer process data speedily; it proceeds sequentially across the spectrum, segment by segment. The whole technique is fraught with peril, nowhere more so than when measuring low frequencies.

Is everyone still seated? Listen, David fully realizes the speaker-placement problem, as revealed in a speech he gave to the AES 91st last fall in New York. Some readers may have missed it, but here is the transcript as rendered by the author himself in *Stereophile* (March, 1992): "I would often stagger it deliberately ('it' being speaker placement with respect to frontwall, side wall and floor) because I wanted to run as flattering curves in the magazine [*Speaker Builder*]. . . I wanted it to look as least ripply, as least swaybacked as I could." In other words, make 'em look good when you want 'em to look good; when you don't care, print bass-shy curves."

So what? Do VMPSs have bass or not? Good question. Recently The Listening Studio was visited by E. Brad Meyer and John S. Allen, who have given history the answer, although their purpose was to study the *Fantasia* soundtrack, of which I have a fine early stereo LP edition and the latest LaserDisc and VHS hi-fi versions.

After auditioning the Disneys, plus heavy drum thwacks on a Prokofiev disc and an Aaron Neville, I spoke my dismay that VMPS should have measured 10dB down at 30 cycles (reverting here to natural nomenclature) and wondered how the bass would sound were it "flat." Brad responded, "Well, I brought my pink-noise tape and Ivie ⅓-octave analyzer, let's see. But I expect those drums in the *Scythian Suite* (Mercury CD) were in the low thirties and they sounded OK to me." Naturally I agreed, never for a moment having doubted VMPS bass capability. So what happened next? As we proceeded with the experiment, who should ring up but David R. Moran. For only the third time I can recall—to prove that everything is neatly, cosmically connected, somehow. That was Saturday, February 29th, 1992 with numerous witnesses present. No squirming out of this, Brad Meyer's Ivie pegged me only minus two at thirty on my $1,500 Tower IIs. Not bad! Visitors to Boston are cordially invited to come judge for themselves. Just call first, please.

While I have your attention: I too presented a paper at the AES 91st, entitled "Proofs of an Absolute Polarity." It detailed blind tests in which 100% confidence level was achieved, the Absolute Polarity is absolutely audible and represents a distinct improvement in music reproduction. It was received with merry laughter, occasional applause and intelligent questions afterwards. It was significantly bracketed by corroborative efforts from two *bona fide* fellows of the AES, Richard Greiner and Don Keele. Nevertheless my lecture was characterized later to the BAS by President Moran (who also calls me a "polarity preacher") as "disorganized . . . rambling . . . pointless." Nothing of the sort! It was precisely to the point, as both tape-recording and preprint prove. But why should BAS types so studiously disparage and ignore polarity? And why are they joined by such contrary writers such as Harry Pearson, Julian Hirsch and Peter Aczel? (Dr. Richard Heyser, in *Audio*, September 1979, put Polarity on the Rosetta Stone of Audio and issued a clarion call for its observance.) Their dismissive attitude not only snubs my famous motto, "Better Sound for Free," but also disregards two separate sets of double-blind test, darling concept of the "objectivist camp." Could it be, they go blind when seeing themselves contradicted scientifically?

Contrast their collective myopia to John Cockroft's insights. In these very pages (4/89) he said in a review of *The Wood Effect*: "I have become a disciple of Mr. Johnsen's dissertation . . . The book is fascinating reading...You will gain insight into the machinations, philosophies and august personalities of the audio industry." David Shavin thought likewise in *21st Century/Science and Technology*: "R.C. Johnsen has fired a barrage at the audio-recording industry. A combination of moral outrage, hard work and intellectual acumen, mixed with wit, humor and even street-theatre antics, makes this book a rare and refreshing expose, guaranteed to miss the audio industry's puff sheets." Strangely that description so far includes *JAES, JASA* and *TAS*, but definitely not *Audio, Stereophile, BASS*, and *Speaker Builder*. However, my VMPS "Minimum Phase System" loudspeakers continue to reveal polarity like no others in my experience, else I should never have had the experience.

Finally, *The Wood Effect* may be ordered from Old Colony Sound, I am pleased to say.

Clark Johnsen
Boston, MA 02210

I'M OK, HE'S NOT

I was saddened to see the excellent pages of *Speaker Builder* being used as a platform to perpetuate what seems to be a personal quarrel ("The Placebo-Immune vs. The AES" by David Moran, *SB* 2/92, p. 80).

I propose that David Moran and Robert Harley sit down to a table facing each other and write down 250 times:

"I'm OK, you're OK. Now let's see how you and I may improve audio technology using the best of our talents."

It should work.

Andrew Tanos
Cleveland Heights, OH 44118

FOCUS ON ARIA

After enjoying four Altec A7-800 speakers since the late '60s in a four-channel, bi-amped system, I decided to go smaller and donate my Altecs to a local church.

I built a pair of Joe D'Appolito's Aria 7s and was impressed, having just completed the Aria 5s. The 5s are good but need bass, so my next project is to build D'Appolito's bandpass subwoofers with

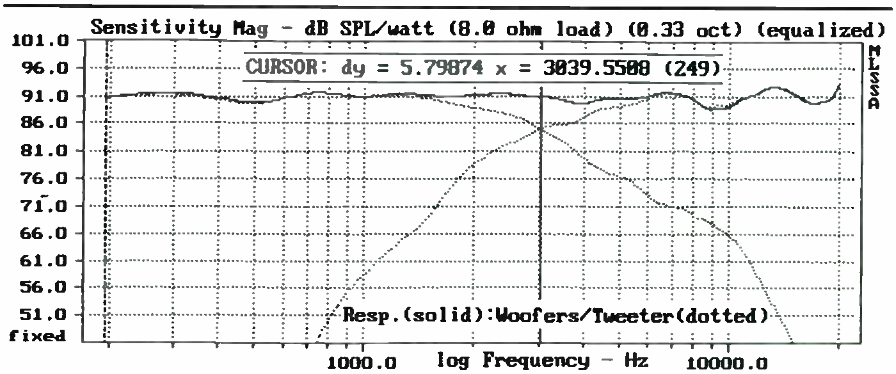

FIGURE 1: The quasi-anechoic ⅓-octave smoothed response of the Aria 5 Ti from 200Hz–20kHz.

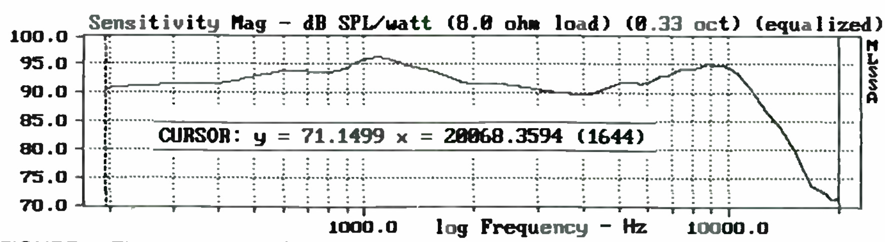

FIGURE 2: The quasi-anechoic ⅓-octave smoothed response of the 5K013L pair in the Aria 5 enclosure without a crossover.

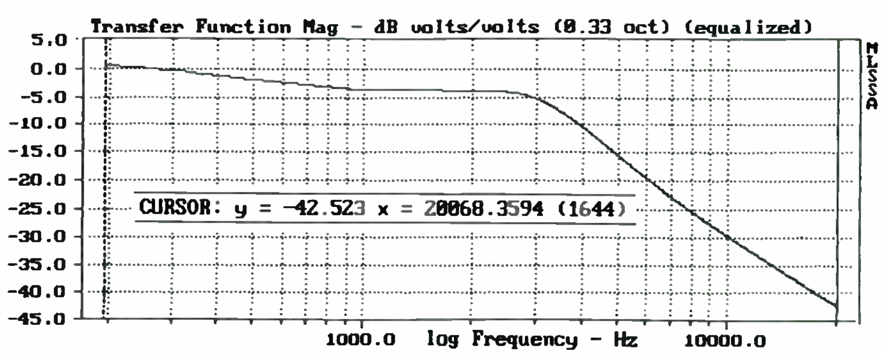

FIGURE 3: The voltage response of the woofer crossover network for the Aria 5 Ti.

Glad you asked that! Good Idea!

You really have some great ideas, so why not share them with your fellow readers? We love to receive typed letters (or even better, a word processor file or output) including clearly written comments and questions. Not everyone's penmanship is easily discernable—please don't make us guess.

If you are responding to a previously published letter or article, please identify it by author; it helps us research and get the answers or comments you seek. In addition, include your full name and address on your letter in case we need to contact you (and your envelope goes south).

Direct your comments, questions, and concerns to Mailbox, *Speaker Builder*, PO Box 494, Peterborough, NH 03458-0494. One more thing . . . include a SASE if you expect a reply.

two Focal 10V516s per side in a compound arrangement.

Since I have the necessary electronic crossovers (24dB Linkwitz-Riley), and the extra amps, I would like to use them in a tri-amped design for the 5s and subwoofers (80Hz? and 2.5kHz?), and use the 7s for the rear channels in a bi-amped design (2.4kHz?).

Would Mr. D'Appolito recommend keeping or adding passive devices for impedance matching/Zobel network? If so, I would like a simple schematic of his recommendations.

I have enjoyed reading D'Appolito's work and that of other contributors to *SB*. I "retired" from the hi-fi scene for 25 years and am just getting my feet wet again. I'm amazed at the wealth of information now available, compared to the '50s and '60s when I was last active in the scene. I'm desperately trying to catch up.

I recorded many four-channel tapes of bands; hence, the four-channel system, and I still enjoy listening to these tapes. I wish the performers could hear these tapes through your speaker designs.

Thanks for giving me much pleasure in building and listening to your designs. Thank you in advance for your reply.

William Eckle
Phoenix, AZ 85035

Contributing Editor Joe D'Appolito replies:

First of all, I'm going to answer the question you did not ask. Of course you can bi-amp the Aria 5. You may even like what you hear, but it won't be accurate and please don't tell your friends it's an Aria 5, because it's not one anymore.

The crossovers in the Aria 5 (and in all my other designs) are carefully tailored to compensate for a driver's actual response in its associated enclosure to produce an overall acoustically correct crossover. In all my experience with speaker system design I have *never* found a stock, textbook crossover that led to an acoustically correct system response.

Perhaps some detailed discussion of the Aria 5 design will bring this point home. *Figure 1* shows the quasi-anechoic ⅓-octave smoothed response of the Aria 5 Ti from 200Hz-20kHz. (The "Ti" uses Focal's new titanium dome tweeter.) Between 200Hz and 8kHz the response is flat within ± 1dB. This plot also shows the response of the woofer pair and the tweeter (dotted curves) with their associated crossover networks. Notice the smooth transition between drivers. The crossover occurs at 3kHz where both drivers are down 5.8dB relative to the system response. Thus the drivers are essentially in-phase at crossover.

Figure 2 shows the quasi-anechoic ⅓-octave smoothed response of the 5K013L pair in the Aria 5 enclosure without a crossover. The response level averages 91dB between 200 and 400Hz and thus becomes the target level for the overall system response. The 5k response then rises to about 96dB at 1.1kHz. This is the rise due to the infamous diffraction loss that I and many other authors have discussed at length in the pages of *SB*. The response then follows a broad shallow dip between 1.1kHz and 9kHz. Above 10kHz, response falls off at roughly 24dB per octave. I think you can see already that a stock 24dB/octave crossover will not give the correct overall acoustic response. What does work?

Figure 3 shows the voltage response of the woofer crossover network for the Aria 5 Ti. Notice that the crossover output falls smoothly by 4dB between 200Hz and 1kHz. This corrects the corresponding rise in woofer response. The crossover is then essentially flat from 1-3kHz, falls off at a 15dB/octave rate for the first octave above crossover, and finally transitions to 12dB/octave over the remainder of the audio band. The tweeter crossover has comparable response corrections, but I won't detail them here. I think you can see that this crossover response in no way resembles a stock Linkwitz-Riley. A stock crossover will result in a 4dB response peak at 1kHz and a dip of about 3dB in the crossover region.

I do not recommend bi-amping the Aria 5 unless you have the electronics expertise required to modify your crossovers for the correct response. The Aria 5/subwoofer combination, however, can benefit greatly from bi-amping. The Aria 5 was designed as a full-range mini-monitor system, but keeping the deep bass energy out of the 5″ woofers can greatly reduce system distortion and increase dynamic range.

I am confused by your reference to my bandpass subwoofer (the Aria 10?) with two 10″ woofers in compound arrangement. The Aria 10 uses single 10″ woofers. If you plan to change this design you're on your own. For the same passband, the compound woofer combination will require a front volume of only 21 liters. This in turn will require an excessively long tunnel to tune the front volume to the correct frequency. You will lower efficiency by 3dB, limit maximum output, and cause severe organ pipe resonances in the tunnel. Beyond this, bandpass subwoofers are their own crossovers—that's where the "bandpass" part comes in. The Aria 10's response falls off at 18dB/octave above 85Hz and below 25Hz. In theory it needs no crossover network.

In practice the Aria 5/Aria 10 combination can benefit from a electronic crossover. The Aria 5 response falls away at roughly 18dB/octave below 60Hz. The Aria 10 rolls off above 85Hz at 18dB/octave. A simple 6dB/octave electronic crossover at 72Hz will provide an overall 24dB/octave crossover for both systems. This does not produce much reduction in bass energy for the Aria 5, but it's better than nothing and works well sonically. If more protection of the Aria 5 woofers is desired, an 18dB/octave crossover at 72Hz may work. I have not tried this myself so you are in virgin territory on this one.

Regarding your question on Zobels, this is really a function of your amplifier's response to varying load impedance. The high frequency rise of the 5K woofers can be controlled with a 25-30μF capacitor in series with a 4-5Ω resistor. The series RLC network across the T90 tweeter in the Aria 5 crossover is designed to smooth out the large impedance peak at resonance. High-frequency impedance rise of the T90 can be controlled with an 8Ω resistor in series with 1-2μF.

STUDY IN F_3

I have several questions concerning the performance of Isobarik speakers in closed boxes. On page 114 of *High Performance Loudspeakers*, 4th edition, Martin Colloms writes:

"The composite dual driver has the following characteristics if compared with the single device: twice the moving mass, half the compliance, half the impedance for which it draws twice the input current and hence double the power. In a sealed box, the rear chamber air spring is much less compliant than the driver suspensions, and is the dominant restoring force."

All that makes sense to me, however, he goes on to say:

"Hence the main Isobarik result is a reduction in system resonance of nearly 2**0.5 or 1.4. Typically, if the single driver-in-box resonance was 40Hz, −3dB, then this technique would offer a reduction to typically 30Hz, −3dB, with some improvement in power handling and linearity."

Now I really want this to be true, but I wonder if the truth isn't that for the same size box where V_B(iso) = V_B(cb), the in-box resonance F_C (and Q_{TC}) are reduced by approximately 1.4, and that F_3 follows the rules for the new alignment.

Christopher Ambrosini, Ph.D (*nom de plume*) writing in Issue No. 17, p. 21 of *The Audio Critic*:

"A sealed-box Isobarik is in principle an acoustic suspension speaker, one which takes acoustic suspension principles further than is normally the practice, using a very large woofer mass to obtain lower system resonance. . . . I can only say that the bass response of a properly executed Isobarik is almost unbelievable on first hearing. Not so long ago I heard a tiny bookshelf Isobarik made by Dynaudio, which had a listed −3dB point of 25H2 and used a 6½″ woofer."

That's two for the lower F_3 camp.

In "An Isobarik System," John Cockroft (*SB* 3/85, p. 9) states:

"In this case, F_3 was about 0.632F_C in a system with a Q_{TC} of 0.707, or about

58% lower bass. The system retained a flat curve and extremely clean and detailed sound."

When he refers to a Q_{TC} of 0.707 I believe he means the standard closed-box single driver alignment. It seems he would agree with the first two sources although later in "The Mini-Dancer: A Push/Pull Constant Pressure Speaker System," (*SB* 3/86, p. 9) he disagrees:

"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_3 and Q_{TC}."

In the same article he also refers to the Q_{TC}(iso) of a speaker being below 0.6 where the Q_{TC}(cb) equalled 0.645.

Bill Schwefel in "SB Mailbox" (*SB* 1/90, p. 3) presented some measured data which shows that F_S, Q_{MS}, Q_{ES}, and Q_{TS} remain relatively constant between single speaker and Isobarik configurations and that V_{AS}(iso) is roughly ½V_{AS}(cb). In his article, "The Wonder of a Symmetrical Isobarik" (*SB* 5/90, p. 10), he appears to be seeing a lower Q_{TC} than calculated for a closed box and he had to double the volume of his boxes in BOXRESPONSE to approximate the actual response.

Finally, Vance Dickason in the 4th edition of *Loudspeaker Design Cookbook* states that the Isobarik Q_{TS} and F_S will be the same as a single driver, that V_{AS} (and Vb) will be half of a single driver and, "your box size should be calculated as a closed-box system, using a single driver Q_{TS} and $V_{AS}/2$"—implying Q_{TC} will remain the same.

The last three sources I think would agree with the statement that Q_{TC} and F_3 would remain the same for an Isobarik speaker with half the box volume, or conversely, if the box volume remained the same then the Isobarik Q_{TC} and F_C would be less and that F_3 would be calculated based on the new alignment.

Most of the above sources note the significant qualitative sound improvement. My question is this: Is a closed box analysis of an Isobarik configuration a reasonble approximation of actual performance and if so, is the following analysis correct (based on closed box formulas from the *Loudspeaker Design Cookbook*)?

Case 1) Smaller Box

If $V_B(\text{iso}) = V_B(\text{cb})/2$
then $\alpha(\text{iso}) = \alpha(\text{cb})$, since $V_{AS}(\text{iso}) = V_{AS}(\text{cb})/2$
and since $F_C/F_S = (\alpha + 1)^{**}0.5$
and $F_S(\text{iso}) = F_S(\text{cb})$, then
$F_C(\text{iso}) = F_C(\text{cb})$
and $Q_{TC}(\text{iso}) = Q_{TC}(\text{cb})$

Case 2) Same Box

If $V_B(\text{iso}) = V_B(\text{cb})$
then $\alpha(\text{iso}) = \alpha(\text{cb})/2$,
$F_C(\text{iso}) = ((0.5\alpha(\text{cb}) + 1)^{**}0.5)F_S$
and $Q_{TC}(\text{iso}) = ((0.5\alpha\ (\text{cb}) + 1)^{**}0.5)Q_{TS}$

Example:

Audio Concepts AC10 where $V_{AS} = 5.10\text{ft}^3$,

Q_{TS} = 0.39, F_S = 23Hz. Assume a closed box single driver alignment where Q_{TS} = 0.707, α(cb) = 2.286, and V_B(cb) = 2.23ft³.

Case 1)
$V_B(iso) = V_B(cb)/2 = 1.12ft^3$
$F_C(iso) = F_C(cb) = 42Hz$
$Q_{TC}(iso) = Q_{TC}(cb) = 0.707$
and $F_3 = F_C = 42Hz$

Case 2)
$V_B(iso) = V_B(cb) = 2.23ft^3$
$\alpha(iso) = \alpha(cb)/2 = 1.14$
$F_C(iso) = ((1.14 + 1)^{**}0.5)F_S = 34Hz$
$Q_{TC}(iso) = 0.571$
and $F_3(iso) = 1.291F_C(iso) = 44Hz$

Whether my understanding of the Isobarik system is correct or not the qualitative sound improvements would seem to make this a good project and a fun experiment.

Daniel C. Lewis
Walpole, NH 03608

Martin Colloms replies:

The paragraph quoted from *High Performance Loudspeakers* was essentially descriptive and was not intended to be taken literally as a specific. In this respect, I may have misled Mr. Lewis concerning the –3dB point for the Isobarik form. He is right to point out that for a given box volume there is a reduction in system resonance but also a reduction in Q_{TC}.

Thus if the –3dB point is the criterion, it is possible that no theoretical improvement in bass extension will occur with the addition of the second driver. Conversely, if you accept my contention that for typcal rooms there is a progressive averaged bass lift of between 4.5 and 5.5dB/octave below 70Hz than a free field, maximally flat response to low bass frequencies is no longer the design objective.

The Isobarik condition for a maintained box size will provide a desirably slower rolloff in the bass, thus matching the room characteristic better and in combination it will ultimately give the clean extension sought.

CORRECT EQUATIONS

I have found no equation for calculating SPL dB from one side of a vibrating piston in either the end of a long tube or an infinite baffle. From information provided by R. Small and some "Letters to the Editor," I have inferred that for a tiny driver with the microphone distanced 1M that:

$$(SPL)\ dB = 112 + 20\log_{10}\ [x\ S_P f^2/1.535]$$

$$1.535 = 1/\sqrt{(4\pi^3 P_O)/C}$$

$$P_O = 1.18\ kg/m^3$$

$$C = 345\ m/S$$

1. What is the correct equation for a piston in the end of a long tube?
2. What is the correct equation for one side of a piston in an infinite baffle?

Thanks for a fine magazine. I have every copy.

C. J. Hornbeck
Allentown, PA 18103

Contributing Editor Bob Bullock replies:

The formula you give for (SPL) dB seems to be derived from a formula for finding the steady state SPL in a room provided by a source of known efficiency. It has nothing to do with calculating the SPL produced by pistons. The 112 term results from making certain assumptions about room absorption, room size, and source directivity.

These values will not necessarily reflect the conditions under which the source is used. For example, in the appropriate room the 112 might be 117, 120, or 108, etc. If you are interested in details relating to this formula, you should consult Chapter 10, Part XXIV of Leo Beranek's *Acoustics*. (Book #BKAC5 is available from Old Colony Sound Lab for $27.95 plus $2 S/H.)

The log term in your formula seems to be related to the radiated acoustic power of a simple source, although I think the parameters are incorrect. Even so, it is not at all clear what you are trying to quantify. If you want to know the "sensitivity" of the driver, then this kind of formula could be used. If you truly want to know what the sound pressure as a function of frequency is, then no such simple formula exists.

Finally, the difference between a piston in an infinite baffle and a piston in the end of a tube is primarily in the off-axis response. The pressure formula for a piston in an infinite baffle is given in Beranek's *Acoustics* (formula 4.17, p. 102). There is no nice closed form expression for radiation from a closed tube, although Beranek shows radiation patterns in *Fig. 4.12*, p. 104.

CW15 QUERY

I need information concerning how to use a pair of University CW15 woofers. These drivers were used in both the University "Dean" and "Classic" in a front-loaded folded-horn configuration.

Does anyone have specs on these dual voice-coil drivers? I'd like to utilize them as subwoofers. I need specifications, enclosure drawings, and/or schematics to get this project underway.

James M. Annal
Evergreen Park, IL 60642

NEW QUICK BOX

Many thanks to Mr. Koonce for his comprehensive and favorable review of our Quick Box program (*SB* 3/92, p. 14).

Besides my comments following the

review, Version 2.1 (the current version) contains the following changes:

Vented box design can now be done with Ql values of 3, 7, and 15 rather than only 7 as in the previous version.

When first doing a vented design for a newly loaded driver, the program now selects an alignment appropriate to the driver rather than defaulting to a B4 alignment.

For closed boxes, the inside, and outside (assuming ¾″ material) dimensions are displayed for the following box fills:

No filling.
100% fiberglass
100% Dacron

Regarding the attempt to evaluate a driver listed in a catalog when the necessary parameters are not given, I suggest to everyone who phones me that they simply refuse to buy from distributors who are unwilling to print complete information. Why speaker building hobbyists have to beat their brains out trying to collect basic technical information is beyond my understanding.

Anyone with a version of Quick Box earlier than 2.1 can send me the manual cover, serial number, plus $5 and I will send the latest version. No library will be supplied since they have probably modified the original library, adding their favorite drivers.

Bill Fitzpatrick
Sitting Duck Software
PO Box 130
Veneta, OR 97487

DESIGN CHALLENGE

Thanks for the article on "real-world" crossover design by Ralph Gonzalez.

One item mentioned in Mr. Gonzalez's article on which I would like to see further input concerns the enclosure. Referring to the 20-liter sealed box, Mr. Gonzalez states, "The bass response could be extended by venting the enclosure." As a service to your readers and an incentive to contribute, I propose a limited forum or design challenge where readers could submit various box designs based on Mr. Gonzalez's components and crossover. Such a forum might produce a variety of enclosure designs (vented, transmission line, sealed) as well as aesthetic considerations (i.e. unusual shaped bookshelf or floor-standing systems, PVC pipes, or exceptional cabinetry and woodwork). While many of us are interested in great inexpensive sound, I, for one, am tired of building and viewing unadorned six-sided boxes. Are there any readers who have an enclosure design to complement Mr. Gonzalez's system? Would you care to send schematic drawings and/or pictures of your work? I would really appreciate an extended *Craftsman's Corner* or companion article that presented a variety of enclosure options that use an established set of drivers and a well-constructed crossover.

Darren C. Pennington
Independence, OR 97351

Ralph Gonzalez responds:

I'm glad you found my "Real-World Two-Way Crossovers" article useful. Your suggestion of inviting a group of readers to present designs based on the drivers and crossover of my example using a variety of enclosure types is flattering. The only problem is that for a different enclosure design, it is likely that a different choice of drivers will be preferred.

I think the purpose of your idea—to present a variety of solutions to a given design problem—is excellent. I submit that greater flexibility in the choice of drivers might solve the above problem. Therefore, I'd like to ammend your proposal. Let's place several restrictions on the design, and invite interested *SB* readers to relate their priorities and their design decisions when producing a speaker given these restrictions.

For example, we could require a two-way system with a 6½″ woofer with parts costing under $200. If I were one of the designers, then I would probably contribute a design like the example in my aforementioned article. I would detail why I chose these drivers and the crossover, and would describe the form of bass loading which I feel would work best with these drivers. I'd also discusss details about enclosure damping and any unusual features. Of course, I would construct the design (remember it has not been verified except by computer simulation) and perform objective and subjective tests. Another designer, however, may choose entirely differnet drivers and bass loading to match his or her own priorities.

I think *Speaker Builder* readers would enjoy seeing a discussion on the priorities of different designers faced with similar objectives. After all, these priorities are responsible for the innovative and vastly differing designs seen in *SB*'s pages.

SWIVEL SLIPS

Regarding the "Stable Satellite Swivels" (*SB* 2/92, p. 14), the drawings depicted in *Figs. 1 & 2* are reversed with respect to the captions and the textual references.

The "photo" referred to in paragraph 1 under "Virtues," page 74 was not published.

Paul W. Graham
Independence, MO 64050

Brother Jon

continued from page 12

crossover as an area with room for improvement. We expected this particular criticism because even a pair of keen ears can take you only so far. The midrange driver or loading may also need attention; two judges noted an odd distortion in the midrange sound that neither could pin down. One attendee (not a judge) commented that the low tweeter placement was quite obvious even when the speaker was behind the screen. Some of the mysteries were solved later on by thorough testing with equipment much more sophisticated than we have at our disposal. More on this later.

That brings us to the present, and to the end of Part I. Soon Alex and I will begin designing our next competition system. We encourage all serious hobbyists to consider entering the 4th Annual Sound-Off to be held at A&S in November of 1992. Since this year's winner was our three-way eight, and the runner-up was Ralf Patterson's two-way seven, it shows you needn't send a monster system with four 15″ woofers per side to win.

Art Rosenblum has created a wonderful event, and since the judge's comments are the real prize, no one loses this contest. The Sound-Off provides an outlet for your creativity and an opportunity to receive some recognition. See you there?

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Magnacord 1024 reel, mint, $200; Carver C-4000, $275; Phase Linear 4000 SII, $175; Sherwood DD-1230R dual cassette, mint, $135; Apature digital interconnects, 1 + 2M, cost $200, $85; JVC R-577, 120W receiver, retail $560, little use, $200; Earthquake MD5 cast mids, $85 pair. (414) 458-2057 6–9 p.m. CST.

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Electro-Voice T35 tweeters, new type, $79; pair Pioneer A339 integrated amps, 40W/channel, $185; PDM550 6-disc CD changer, $219; F449 tuner, $175; all mint, less than 6 months old; Classical CD list. SASE. Steve Fritz, 29 N. Main, Lexington, VA 24450, (703) 463-5675 or (703) 464-1100.

Strathearn ribbons, $150/pair; baffles for 3 pair Strathearns, $150/pair; SpeakerLab RD57 ribbons, stainless steel, new, $800/pair or best offer; Gold Ribbon drivers, $700/pair; Quad 405A, $200; Magnum Dynalab signal sleuth, $150. Bill Buchanan, 427 E. 73rd St., NYC, NY 10021, (212) 988-7818 answering machine.

PAS A-40 Class A power amplifier I built from Old Colony kit, power supply on separate chassis, modified for improved local supply bypassing, $300 including UPS ground. Gary Galo, 72 Waverly St., Potsdam, NY 13676, (315) 265-4268.

Heath AD-1308 ½-octave spectrum analyzer with accessories, rack mount case and noise generators, original owner, manuals, mint, $225 or trade for pair MK IIIs. Don May (716) 652-6107 EST.

Acoustat Spectra II, mint, 2 years old, $500/pair; Phase Tech 2-piece 60 and 2-piece 50 subwoofers, $500; 4 pieces *Stereophile* rated; moving. Dale Lamos, 1008 Cherry Lane, Arlington Heights, IL 60004, (708) 255-4496 evenings or leave message on machine.

NEC AV-250 surround, $100; Pioneer VSX-5000, $100; Infinity RS-8 speakers with stand, $100 or best offer; turntable, $50; Marantz Quad-4 amp, $100; AKG-240 phones, $50; Advent sound control 500, $150; Marantz 2225 tuner amp, $100; Azden phones, $50; Marantz 2220-B, $75; Marchand Electronic crossover, $50; everything good condition. Dave, (305) 931-7131.

Nelson PAS-40A stereo amp, assembled on chassis, Boak regulator boards, has ground loop hum, $300 plus shipping. Joe, (609) 397-8315 evenings/weekends NJ, EDT.

Phase Linear 200 amp, 2000 preamp, 5000 tuner, $500 complete; Thorens TD-125 turntable with Shure V15 type V cartridge, $175. Larry, (217) 732-6486.

Highly modified Audio Concepts speakers, all Dynaudio, 21W54MPS, D52, D28, multi-enclosure, minimum baffle enclosure cabinets, poly crossover, AudioQuest wire, etc, must pick up Western Mass., Northern CT. area, sacrifice, $350/ pair. Jack Ollson, 77 Sanford St., E. Longmeadow, MA 01028, (413) 525-1678.

VMPS Tower II speakers, 200W Morel tweeters, walnut finish. Klipsch Lascala clones, birch veneer cabinets, $1,100/pair, each type OBO. Peter Groth, 384 Trestle Lane, Clinton Corners, NY, (914) 266-4183.

Vintage KEF speakers, $200; Infinity speakers, $100; AKG and Azden phones, $50 each; Pioneer VSX-5000 tuner amp, $100; Advent Dolby home sound processor, $150; 3 Marantz amps, $100 each; 2 turntables, $50 each. Everything works, call for more details. Ed, (305) 891-2267.

2 Marchand XM-9s with power supply, $90; 2 JBL-2235H 10 hours, $350/pair. Many poly capacitors, coils and resistors. Call for list. Jerry (601) 264-6971.

Electrostatic loudspeaker design and construction, by Ronald Wagner, or any ESL theory and material resource. Call James, (916) 737-6148.

Ampex AX-300 7½" open reel deck; Response 20–22kHz, 3 motors, 6 heads, solenoid controls, wire remote, auto reverse, sound on sound, mike input, slider input volume controls; sound on sound $450 OBO plus shipping, no box or manual. Tapes sold separately. Mr. Willes, weekdays (800) 227-3390.

Lazarus H-1 improved amp, $550 or B/O; Spectral DMC-10 Alpha, $875; Swan 305 woofers, mint, boxed, $175/four; mint matched Focal 5K013Ls and Vifa D25AG-35s w/grilles, $175; Nakamichi OMS-7AII, $775; JVC XPA1000 processor, see reviews, $800. Steve, (203) 397-3888.

General Radio oscillator, model 1210-C, may need new tubes, $50; Rowan frequency counter, model EC-612, $50; Lambda regulated bench power supplies: 20-105V DC at 4A, $100, at 8A, $150; Hickok vacuum tube tester, model 539-B, $200. Shipping extra. Call Don (215) 660-1802 weekdays.

Rogers LS3/5A monitor loudspeakers, matched pair, Teak finish, like new, $325/pair. Fred Janosky, (215) 693-6167.

Audax MHD17B37R $50/pair; Jordan modules, new pair, $100; Ferrofluid modified Jordan, used, $75/pair; Snell EC-2 crossover, $275; ST-35 modified, excellent, $150; GSI ST70 (Triode), $375; CJ PV4, $275; MIT MI-330 (WBT) 6', $150/pair; monster M1000, 10' $150/pair; M-1, 4', $55/pair. Chuck, (209) 892-4041, evenings PST.

Hafler DH-200 amplifier, $219; Sony KVPM-2501/ VTX-1000R Profeel TV/Tuner, $570; CD-150U CD ROM drive (IBM) card, etc., $369; SLHF-450 (MTS), $245; SL/TT2000, great for camping, $245; NP-1 batteries, $35; U-Matic VO-2600 VCR, $329; U-Matic tapes, $9.75; Panasonic high resolution B&W TV camera Model WV-1410, $179; Nakamichi LA-100, $45; Blaupunkt Frankfort AM/FM stereo car radio, $59; Roland MT-32 MIDI with IBM interface card and software, $299. Michael Marks, 2334 Morgan Lane, Dunn Loring, VA 22027, (703) 641-5824.

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KEF B-139s, $180/pair; nice walnut speaker cabinets, internal dimensions 22½" by 14½" by 9 ⅛", cutout for 8" speaker, $90/pair; ACE model 6000, crossover 4kHz and ACE rumble filter, $100/set; B&W Bextrene midrange tweeter, super tweeter $60/set, one only of each. Jerry Feldstein, (212) 364-3485, 7–10 p.m. NYC, no machine.

Continued on page 78

SpeakerBuilder
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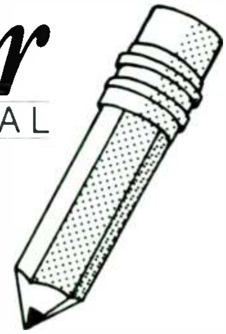

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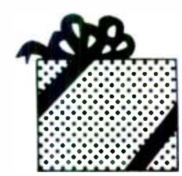

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VTL-100 deluxe mono-blocks, EP music posts, brand new Tesla tubes, large power supply, original VTL double boxes, mint condition, $1,750/pair. Eduard, (310) 395-5196.

Hafler DH-100 preamp, black, new, still in box, good entry level, $125 but will sell to B/O; Q.E.D. headphone amp, practically new, w/Tandy power transformer, nice quality, B/O; oak stereo cabinets, no veneer, beautiful construction, can't ship, very reasonably priced. Walt Fleming (203) 889-5018, 5 p.m. best EST.

Preamps: Carver 4000T, $450; Carver C-4000, $350; Phase Linear 4000SII, $175; sealed new phono cartridges: ADC PSX-30 (retail $150), $35; Audio Technica PC550ML ($300), $75; Audio Control C-101 equalizer, $200; Magnecord 1024 reel w/travel case, mint, $200; Apature 1 + 2 meter interconnects ($200), $85. Andy, (414) 458-2057.

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Back issues of *Speaker Builder*, 1980–1991, complete set, $100. Richard Dolbow, 562 Susan Dr., King of Prussia, PA 19406, (215) 265-6649 evenings.

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Technics SB 7070 speaker systems. Cabinet must be in good condition. Margherita, (904) 392-0622.

One pair original tweeters for large Advents built in November 1975. Alex Rigodanzo, 305 Case, Kingsford, MI 49801, (906) 779-2174.

Old Klipsch catalogs, JBL literature; *Throne of Merlin*, (R.C. Schaller), *Light Emitting Diodes*, (Bergh & Dean); old books showing point contact transistors; old Hewlett-Packard and Tektronix catalogs. D.R. Schaller, 6704 Schroeder Rd., Suite 6, Madison, WI 53711.

Harman-Kardon HK250 tube amp; pair of Dynaco MK IVs. Mike, (206) 754-7339.

Gold Ribbon 3.0 drivers four $1,000 + ship. Joe, (609) 397-8315, NJ (EDT), evenings-weekends.

Heath 1500 tuner in working condition, with the manual and case. Ray Stanton, 610A 28 Ave., San Francisco, CA, (415) 386-0990.

Crown EQ-2 equalizer; Dynaco C-100 energy storage system; dbx 5 box expander; Dynaco, Autoquad, or similar passive 4-channel matrix Surround Sound ambience recovery type system; Altec 802, 808 Tangerine drivers; Altec 811B horns. Artie, (516) 741-1605.

Dynaco ST-416 power amp. Reasonable to good condition preferred, repairable condition accepted. ST-400 considered, must be working. Peter Groth, 384 Trestle Lane, Clinton Corners, NY 12514.

TAD TL-1601As, ET-703s, JBL-2370As. Steve, (203) 397-3888.

MIDI software. Michael Marks, 2334 Morgan Lane, Dunn Loring, VA, 22027, (703) 641-5824.

Acrosound, Dyna, Eico, Fisher, Harman-Kardon, Heath, Peerless, Scott and U.T.C. output and power transformers; old movie theater equipment. Dennis Boyle, 1707 S Ervay St., Dallas, TX 75215, (214) 428-1707.

Hewlett-Packard 8050A (built for Altec Lansing) or Crown RTA; (2) real time audio analyzers working or not; will pay top dollar. Don, (608) 325-5111.

Audio Concepts D1 or D2 speakers; must be in working condition. Dave Lamb, 1917 Meadowaire Dr., Ft. Collins, CO 80525, (303) 482-3961.

VTL-120/50 monoblocks, dead or alive, or transformers only. Eduard (310) 395-5196.

Two JBL 2245H 18" drivers. Fred Grunewald, 1204 Randolph St., Watertown, WI 53094, (414) 261-4384.

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AUDIOPHILES IN THE DAYTON/SPRINGFIELD, OHIO AREA: We are forming an audio club. Please contact me if you're interested in construction, modifications, testing, recording or just plain listening to music. Ken Beers, 1756 Hilt Rd., Yellow Springs, OH 45387, (513) 767-1457.

ARIZONA AUDIOPHILE SOCIETY Located in Metropolitan Phoenix is a growing and active club in the pursuit and reproduction of recorded music. New members are welcome. Meetings are last Tuesday of each month. Receive monthly newsletter and biannual journal. Club discounts with local high-end audio dealers. Send inquiry to Arizona Audiophile Society, PO Box 13058, Scottsdale, AZ 85267, or call Bob Williams, (602) 944-5929.

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LONDON LIVE D.I.Y. HI-FI CIRCLE meets quarterly in London, England. Our overall agenda is a broad one, having anything to do with any aspect of audio design and construction. We welcome everyone, from novice to expert. For information contact Brian Stenning, 081-748-7489.

THE CATSKILL AND ADIRONDACK AUDIO SOCIETY invites you to our informal meeting. Join our friendly group of audio enthusiasts as we discuss life, the universe and everything! Toobers, Tranzzeestors, vinyl canyons or digital dots. No matter what your level of interest, experience, or preferences, you are welcome. Contact CAAS at (518) 756-9894 (leave message), or write CAAS, PO Box 144, Hannacroix, NY 12087. See you soon!

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: Richard Thompson, 129 Newgate Rd., E. Granby, CT 06026, (203) 653-7873.

ELECTROSTATIC LOUDSPEAKER USERS GROUP is now a world-wide network for those interested in sharing valuable theory, design, construction, and parts source information. If you are interested in building, or have built, your own SOTA ESL we invite you to join our loose-knit organization. For information, send a SASE to: Barry Waldron, 1847 Country Club Dr., Placerville, CA 95667.

WANTED

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(Good singing voice not required)

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THE INLAND EMPIRE AUDIO SOCIETY (soon to become) **THE SOUTHERN CALIFORNIA AUDIO SOCIETY — SCAS** is now inviting audiophiles from all areas of Southern California and abroad to join our serious pursuit for that elusive sonic truth through our meetings and the **IEAS'** official speaker, *The Reference* Newsletter. For information write or call, Frank Manrique, President, 1219 Fulbright Ave., Redlands, CA 92373. (714) 793-9209.

IF YOU ARE an "Organ Music Lover" and like to test your audio system, **SFORZANDO** has room for a few more members. We have about three thousand "Live," on-the-spot, cassette tapes that are not available in the stores. We are happy to lend them to you via the mail. Just ask EA Rawlings, 5411 Bocage St., Montreal, Canada, H4J 1A2.

SPEAKER BUILDERS/AUDIOPHILES in the Milwaukee, WI area. I am a speaker builder with test gear looking to join or form an audio club. Anyone interested contact, Kirk Rontti, (414) 355-7509 leave message.

THE WESTERN NEW YORK Audio Society is an active, long established club located in the Buffalo area. We issue a newsletter and hold meetings the first Tuesday of every month. Our meetings attract many prominent manufacturers of audio related equipment. We are involved in all facets of audio—from building/modifying to exposure to the newest high-end gear, and the chance to hear more types of music. For information regarding our society, please write to WNY Audio Society, PO Box 312, N. Tonawanda, NY 14120.

WASHINGTON AREA AUDIO SOCIETY Meetings are held every two weeks, on Fridays from 19:00 hours to 21:30 hours at the Charles Barrett Elementary School in the city of Alexandria, Va. Prospective members are welcome but must register in advance in order to be admitted to the meetings. No exceptions please. If interested please call Horace Vignale, (703) 578-4929.

MEMPHIS AREA AUDIO SOCIETY being formed. Serious audiophiles contact J.J. McBride, 8182 Wind Valley Cove, Memphis, TN 38125, (901) 756-6831.

NEW JERSEY AUDIO SOCIETY meets monthly. Emphasis is on construction and modification of electronics and speakers. Dues includes monthly newsletter with high-end news, construction articles, analysis of commercial circuits, etc. Meetings are devoted to listening to records and CDs, comparing and A-B-ing equipment. New members welcome. Contact Bill Donnally, (201) 334-9412, RD2, Box 69D, Miller Dr., Boonton, NJ 07005; or contact Bob Young, (908) 381-6269, or Bob Clark, (908) 647-0194.

PACIFICNORTHWEST AUDIO SOCIETY (PAS) consists of 60 audio enthusiasts meeting monthly, second Wednesdays, 7:30 to 9:30 p.m. at 4545 Island Crest Way, Mercer Island, Washington. Be our guest, write Box 435, Mercer Island, WA 98040 or call Bob McDonald, (206) 232-8130 or Nick Daniggelis, (206) 323-6196.

PIEDMONT AUDIO SOCIETY Audio club in the Raleigh-Durham-Chapel Hill area is meeting monthly to listen to music, demonstrate owner-built and modified equipment, and exchange views and ideas on electronics and speaker construction. Tube and solid state electronics are of interest and all levels of experience are welcome. Kevin Carter, 1004 Olive Chapel Rd., Apex, NC 27502, (919) 387-0911.

THE ATLANTA AUDIO SOCIETY is dedicated to furnish pleasure and education for people with a common interest in fine music and audio equipment. Monthly meetings often feature guest speakers from the audio manufacturing and recording industry. Members receive a monthly newsletter. Call: Chuck Bruce, (404) 876-5659, or Denny Meeker, (404) 872-0428, or write: PO Box 361, Marietta, GA 30061.

THE BOSTON AUDIO SOCIETY invites you to join and receive the bi-monthly *B.A.S. SPEAKER* with reviews, debates, scientific analyses, and summaries of lectures by major engineers. Read about Apogee, Nytal, Conrad-Johnson, dbx digital, Snell, music criticism and other topics. Rates on request. PO Box 211, Boston, MA 02126.

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THE HI-FI CLUB of Cape Town in South Africa sends a monthly-newsletter to its members and world-wide subscribers. To receive an evaluation copy of our current newsletter, write to: PO Box 18262, Wynberg 7824, South Africa. We'll be very pleased to hear from you.

THE OREGON TRIODE SOCIETY We are dedicated to the art and craft of music, audio DIY projects, and quality sound reproduction. Our 125+ members meet 8 times a year in the Portland area and our news magazine, *Positive Feedback*, has grown to 48 pages of challenging commentary, fun and information and is published six times annually. Ladies and gentlemen, you are cordially invited to join us. For information contact, David Robinson, 4106 N.E. Glisan, Portland, OR 97232, (503) 235-9068 or Ian Joel, (503) 233-1079.

TUBE AUDIO ENTHUSIASTS. Northern California club meets every other month. For next meeting announcement send a self-addressed, stamped #10 envelope to Tim Eding, PO Box 611662, San Jose, CA 95161.

SOUTHEASTERN MICHIGAN WOOFER AND TWEETER MARCHING SOCIETY (SMWTMS). Detroit area audio construction club. Meetings every two months featuring serious lectures, design analyses, digital audio, A-B listening tests, equipment clinics, recording studio visits, and audio fun. The club journal is *LC, The SMWTMS Network*. Corresponding member's subscription available. Call (313) 544-8453 or write David Carlstrom, SMWTMS, PO Box 721464, Berkley, MI 48072-0464.

LOS ANGELES AREA ARIA AND SWAN Loudspeakers Users Group. If you have built or plan to build any of the Aria or Swan loudspeakers and would like to meet for listening sessions or have any questions or modifications that you would like to share, please call Geoffrey, (213) 965-9173 or Edward, (310) 395-5196.

GREAT BASIN AUDIO SOCIETY. A club for those interested in better recording and reproduction of music, who live in Northern Nevada and surrounding parts of California, Idaho and Utah. Everyone is welcome to come to our monthly meetings, held in Reno on the last Sunday of each month. We also seek contributions to our quarterly newsletter, *The Singing Sagebrush*. For more info, contact the GBAS, c/o E.A. Barbour, 552 N. McCarran, #284, Sparks, NV 89431 or leave a message on (702) 358-2019.

THE PRAIRIE STATE AUDIO CONSTRUCTION SOCIETY. (PSACS) meets every other month. Meetings feature audio construction, design, and analyses, blind listening tests, equipment clinics, autosound, lectures from manufacturers and reviewers. PSACS, PO Box 482, Cary, IL 60013, call Tom, (708) 248-3377 days, (708) 516-0170 eves.

Advertising Index

Moran in the Market

WE GET MAIL

By David R. Moran

David's column has kept the postal service busy with numerous comments and responses. The Atkinson, Johnsen and Tanos letters appear in Mailbox, starting on p. 62. The Martin Colloms' letter ran in SB *3/92, p. 77.—Ed.*

John Atkinson

It would be great to report that this reasonable-sounding letter (page 62) represented a fruitful step in a discussion of reviewers, reviews, carefulness, and "how loudspeakers behave in real rooms and how they should be measured." But from matters personal to matters physics-related, it purveys such error and nonsense that can only be answered shot by shot and point by point. I am afraid that, over and over, *Stereophile* editor John Atkinson has facts wrong, or doesn't know what he's talking about.

Status Symbols

No one who knows would ever imagine that being accepted for AES membership stands for much, or is a guarantee of anything. But I do appreciate Atkinson's sharing his recent updates to what is evidently his Moran file, in this case concerning the 1991 AES membership directory. For the record, I am a member of the AES—a full member—and was in 1991 too (and before that as well). I am fascinated that anti-science subjectivists are members. But AES membership does not matter. (I can see that I too might be sensitive about such status if I had an entire AES convention devoted to criticizing my recent life's work.)

Meritocracy in the Marketplace

About the "law of the marketplace," Atkinson regularly cites the yuppie success of *Stereophile*, which deeply dismays many of us who find ourselves, year after year, having to counter its harmful spread of mistakes. Atkinson suggests that its growth has to do with intellectual worth or accuracy rather than reader stroking and appeals to mysticism. By such popularity reasoning, of course, Bose and Radio Shack should be considered for the magazine's recommended-component lists. But any 7th-grader who knows about popularity, knows that the marketplace is not meritocractic. When a snob publication enjoys increased circulation, it necessarily represents a genuine philosophical predicament.

Why read it? Like many audio people I know, I read *Stereophile* for the occasional interview and classical-related article; to keep up with contributing editor Peter Mitchell's still dignified opinions; and for sheer amusement and masochism. (Also because recently Atkinson's junior editors Corey Greenberg and Robert Harley have been taking misfounded shots at me.)

Blind Testing, Chapter 1131

The magazine's blind speaker tests are a start, and a departure. But differences among speakers generally are not subtle. While blind testing ideally would apply to all audio reviews, the effort they require is better spent on detection of tiny differences, authentic or bogus, such as are raved over at length in *Stereophile* pages. When may we expect blind *Stereophile* tests of preamps, amps, CD players, digital converters, cabling, and polarity settings? They constitute the real issues in audio fact vs. fantasy, and blind-test results would likely be a hoot.

This is not as important with large differences among products like loudspeakers, where there is very good correlation between measurement and perception (at least concerning frequency response and horizontal radiation pattern, as opposed to time-related behaviors and the various distortions).

To put it another way, most readers know to read loudspeaker comparisons at least a little skeptically. Blind testing is better aimed toward the extravagant allegations about truly similar or identical (undifferentiable) phenomena. *How* different on music are two amps, preamps, digital converters, pairs of wires, or polarity settings? Enough to hear the difference in sharable and reproducible fashion? Enough to care? Most important (and often overlooked), different enough to say one is more accurate and therefore preferable, and the other is not?

As for my work, Atkinson's practice-what-you-preach blind-listening charges are disingenuous. It would be a fine regimen were it as feasible as it is with electronics and cables. But it is generally not speaker testers who make outrageous statements when no measurable difference can be found, or none that correlates with what is known about human audition. All of my own review judgments concerning quality and my commendations are written to allow for addition of salt. In Atkinson's dogmatic terms, they are all invalid as to their conclusions.

Also, I write to persuade, plausibly and reasonably, in a wary reviewer prose: careful in diction, usually deferential with respect to hearer tastes. Quite apart from the acceptability of my electronic equipment (addressed presently), I try to avoid handing down "value judgments and descriptions of sound quality as though these were absolute." I welcome comparison of my conclusions and language—my tester style—with reviews in *Stereophile* since Atkinson took over as editor.

Plus, I measure frequency response by angle rather thoroughly. From Atkinson's letter you would think I showed room response and nothing else.

Blind Man's Bluff

To suppose that sighted and blind testing are both worthy procedures, that each has valid, knowable, maybe even somehow similar drawbacks, and are two views of the same problem or are comparable or parallel views of similar problems, is, again, a case of "you just don't get it." It is refusing to believe in proof. Blind testing is the essence of scientific work. Otherwise, why not waste some more time "testing" laetrile as a cancer cure? It *could* work. I mean, some recipients *feel* it does; proponents *say* it does. What more does anyone need than the honesty of believers (ironic soundtrack starts here)? Maybe subjects in blind studies get stressed out when they don't know what they're getting or taking, and their immune systems get impaired, and, y'know, bummer. That invalidates blind testing. And subjects go on to die of treat-able cancer even though *laetrile does work*! It could happen.

Fortunately audiophilia is not a mortal matter.

Atkinson evidently still believes the placebo effect is volitional, under control of the will, as Robert Harley likes to maintain. One can put one's admitted admiration aside, as I am presumed to do with mine for Roy Allison's work, and can "act in a disinterested manner." Well, to yell for a second, No! Not possible. We're not made like that. That's the whole point and purpose of blind testing, for heaven's sake. Saying otherwise misunderstands the human unconscious: suggestibility is almost infinite.

Not only does Atkinson not fathom what the placebo effect is and does, he seems not to know the difference between perception and taste, between stating that something is so and saying that one likes or enjoys or approves of it. *Stereophile*'s is a form of fascist aesthetics: "I like what I hear, so it must be superior" and "It is obviously superior, so of course I like what I hear." The superiority clause is what demands that science be employed. Why not just stick with the pleasure clause? Why not simply enjoy the overpriced gear and write it up at length, without snake-oil technical explanations? Let the rest of the world enjoy the highly faithful playback of their early-generation CD players, Japanese receivers, and *Consumer Reports*-favored (usually Allison) loudspeakers?

Oh, by the way, it's entirely possible to get useful, i.e. disinterested data and still have known beforehand what one was about to compare.

Exaggerations, and My Equipment

About Atkinson's tracking of how many loudspeakers I have reviewed: it's dozens. What has been published only in *CD Review* and in this periodical may total 19, but that's a subset, not counting many reviews in the *Boston Audio Society Speaker*. However, thanks again for sharing your notes in your Moran file folder.

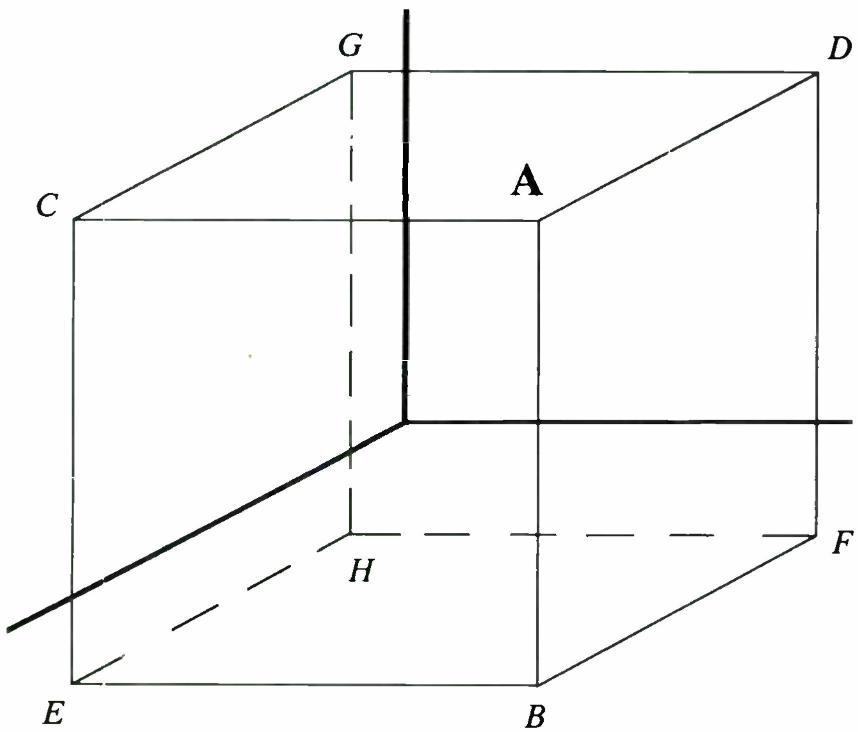

FIGURE 1: The three heavy lines represent a corner, and points B through H are the seven boundary augmentations when A is an equi-omni sound source like a loudspeaker. (B, C, and D are axial reflections, E, F, and G are tangential, and H is oblique.) See text.

Space limitations in magazines which are edited for length more than *Stereophile* usually preclude extended discussion of playback equipment. More important, past a certain easy-to-reach threshold of quality, such things are utterly trivial when compared with speaker performance. (In *CD Review* I did occasionally list both source components and CDs.)

To enhance credibility, here are the gory details: My dbx BX1 power amp is a 400–1500W/channel (depending on load) class A/B bipolar design, with inaudible noise and distortion and huge current capability. I find it most useful for measurements because its audio-band frequency response is speaker-invariant (<0.1dB) due to its extremely low output impedance (high damping). Upstream in the signal path is the dbx CX1 preamp, an extremely low-noise (>100dBA below 1V) flat-response (<0.1dB audio band) solid-state design. Both pieces were designed and built in the USA, by dbx engineering and manufacturing.

Feeding the preamp is the dbx DX5 CD player, a Japanese (Kyocera)/dbx design with flat frequency response (<0.25dB) and excellent low-level and phase linearity, achieved through trimmable 4x-oversampling dual D/A converters.

My system's "throughput" does not invert signal polarity.

Interconnects are all standard unbalanced phono-type cabling, unbranded and completely conventional. Speaker wire is short runs of the new Radio Shack 12-gauge.

As for test-measurement accuracy, pink noise from the dbx RTA-1, two uncorrelated channels, settles to < 1dB within 5 seconds, to <0.5dB within 10 seconds, and to <0.2dB after 30 or 45 seconds. The nominally Class III RTA-1 filters are quite a bit steeper than that. The test microphone is an AKG C460B with a CK62-ULS capsule; it's quite flat in its own right but gets mildly corrected by the RTA-1 software to match, within a dB, two ¼" and three ½" B&K instrumentation microphones. All my RTA-1 measurements are continuously averaged and thus are readily repeatable, which is unique for pink-noise-based RTAs so far as I know. The system's results have correlated very well with those from LMS, MLSSA, B&K and other tone-based procedures. (Note that the RTA-1 is now reincarnated as the Sound Technology RTA-4000.)

Let me conclude this subsection with a description of the playback gear in language Atkinson honors, even though no credence can be put in sighted comparative pronouncements about amps and power amps. In the September 1988 *Stereophile* (V. 11, No. 9), the magazine's founder and chief tester, J. Gordon Holt ("in whose ears we trust," Atkinson likes to remind readers), wrote of the BX1's sonic performance that "the first and lasting impression was of tremendous solidity and imperturbability. The sound has an ingratiating quality of relaxing ease to it, at listening levels up to the positively insane . . . Bass detail is absolutely superb . . . as are its heft and impact. . . . Soundstage presentation was excellent. . . . All in all, one hell of a nice power amplifier . . . ." Of the CX1 he wrote that it "is one very suave-sounding preamp . . . . It shares much of the smoothness and musicality associated with the best tube equipment [but] its sound is surprisingly neutral . . . . The CX1 proved to be one of the most nearly perfect preamps, in terms of accuracy, I have auditioned. . . . These are superbly thought-out and engineered products."

The Allison Tweeter

It was startling that Atkinson so blithely shared his ignorance about the Allison tweeter's design. Yes, its smooth performance and unsurpassed dispersion result from its novel geometry; for the details, he could have consulted Holt, who gave a brief, accurate, and appreciative description of it in the October 1985 *Stereophile* (V. 8, No. 6). Peter Mitchell also thoroughly understands its drive mechanics and the astonishing consequences thereof. Best yet would be to call Allison directly to get their lucid technical literature: (800) 225-4790; (508) 966-1800.

Reflections on Corners

Atkinson's entire floor-reflection musings are a fog of physical and psychoacoustical misunderstanding.

The frequency region we are talking about is one where the driver is about a quarter-wavelength from room surfaces. The total power produced by that driver (direct output included) *is reduced* by the time a half-wave is generated. This is effectively one event, and one "loading." In other words, not conceivable as separate events or reflections. (Indeed, you can't even say there *is* a frequency if less than a half-wave of it happens; it always helps to remember that we are talking about *vibration* here, not about billiard balls or bouncing rays.) Another way of saying this is that you cannot have a situation where the sound is not seriously notched when the boundary distances and frequency are such as to produce a notch in the steady-state output; reflected impedance acts on the speaker power output irrespective of the mike or listener position. It's a package.

The floor-only notching can be said to get filled in, or it can even get deepened, by the other six augmentations (two other single-surface ones, three 2-surface, one 3-surface—not just "initial" reflections, as Atkinson has it). See *Fig. 1*, where A is a loudspeaker (perhaps on a stand), B is the floor augmentation and C and D are side- and front-wall augmentations; E, F, and G are tangential augmentations; and H is the final, oblique augmentation.

Point A is an omni source, and B through H are images of that source ("image sources"). In any practical home listening situation their levels are never 4dB below A alone, or close to it. (For a primer, refer to Harry F. Olson, *Acoustical Engineering*, D. van Nostrand, 1957, p. 32, and most recently to the late Glyn Adams, "Time Dependence of Loudspeaker Power Output in Small Rooms," AES *Journal* April 1989 [V. 37 no. 4], p. 203—although do note that Adams assumes an atypically long one second small-room reverb time.)

Along with the source, the seven augmentations form the eight corners of a solid rectangle, as can be seen in *Fig. 1*. I recently discovered that it's instructive to set up three 8″ mirror tiles as a dollhouse-size corner and place a birthday candle as the make-believe loudspeaker: sort of a junior-high-school science project. It is when distances AB, AC, and AD are equal or close to it that the worst sound results, and it is when they are markedly different (well-staggered) that the sound can be smoothest and most accurate.

Alternatively: if Atkinson will experiment with the free Allison speaker-placement software and examine the sine x/x columns of the augmentations, perhaps the nature of the fraction summing (each augmentation individually is <1 where the direct output level is 1) and the plus/minus result (i.e., ripple) might become clear arithmetically. I have sent Atkinson a copy of the Allison software program.

Judging Timbre

It is thus a profound error to write that corner reflections including the floor one arrive "too long after the direct sound to be definitely considered part of it." But more generally, it is just not so that the "room reverberant field predominates [only] in a very large bare room with the listener a long way away from the loudspeaker." The sound we hear in a room only *seems* to come straight from the speaker. We localize it there, but the actual direct sound does not account for the spectral balance.

As I wrote recently (*SB* 1/92, p. 86) and will expand on presently in my reply to

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Martin Colloms, this fact is easy enough to check by changing a room from bare wood floor to rugs, from absorptive "acoustic" tile to bare ceiling, and/or from bare ceramic tiles to drapes. Or you can block off the direct sound. Or surround the speakers' back and sides with dressing mirrors, or alternatively with rolls of carpet. Or simply relocate the speakers.

The "psychoacoustic contribution of the direct sound" to the overall timbre heard in any typical listening room is not primary until you are virtually wearing the speakers on your shoulders. The common wisdom has been that the first 30 or so milliseconds of output in aggregate are what govern the signature or character of the sound. To the ear appraising this character, the reflections in the vast majority of domestic listening situations immediately overwhelm the direct sound, *however counterintuitive this may seem.* It is crucial not to confuse localization with spectral balance.

But Atkinson, the veteran reviewer of 130 loudspeakers, stumbles in confusion even as he follows his own premises. If floor reflections are inaudible, as he argues, it cannot matter whether they are present, and if they don't matter, then why do speakers designed not to produce them sound to him as if they have an excess of energy in the floor-bounce region? I mean, make up your mind.

Also, just because we occasionally may be used to boundary-augmentation ripple in nature does not mean we want to hear it twice, that is, again in playback. This is supposed to be high fidelity, after all.

Griesinger Heard From

Naturally I discussed the specific Griesinger citation in Atkinson's letter with David Griesinger himself. I wanted the latest authoritative explication and amplification of the known physics, and any corroboration or, especially, contradiction of the common wisdom. He was kind enough to write the following:

"Atkinson is correct in remembering my saying that a floor reflection 4dB down from the direct sound is not audible. However, in Vienna I was referring to *any* reflection which arrives in the medial plane—that is, from the front, below, above, or behind the listener. Thus ceiling or rear-wall reflections are equally inaudible if the *sum* of all of them is 4dB or more lower than the direct sound. Atkinson's misunderstanding comes in part from separating only the floor reflections, and then in assuming that it is 4dB lower than the direct sound. It is not. It is often only 1dB or 2dB down, and it creates an obvious timbre effect. More importantly, the reflection off the floor in front of the loudspeaker is not the only floor reflection: the front-wall bounce is followed by another floor reflection, as are the side-wall bounce, the ceiling bounce, the rear-wall bounce, etc. You cannot escape it.

"Another problem with Atkinson's discussion is his contention that a low-frequency reflection of 4mS can be separated by the human ear from the direct sound. Four milliseconds is only half a cycle at 100Hz and this is far too brief an excitation of the basilar membrane to detect as a separate wavefront. We cannot separate out a single cycle of a soundwave at any frequency. Like any detector, the ear needs a certain amount of information to reach a conclusion. In general, the time sensitivity of hearing is proportional to frequency: if we can detect a 4mS reflection at 1kHz (this is four cycles), we would expect to need four cycles to detect a reflection at 100Hz, which will require a reflection of at least 40mS delay. Measurements of the audibility of room impression have exactly this result: at least 40mS of delay is required to generate room impression from a lateral reflection of ⅓-octave-filtered noise at 100Hz.

"With respect to ⅓-octave testing of loudspeakers, I have found the technique has considerable merit. At frequencies below about 200Hz we have found that you cannot hear a sound which you cannot measure with an omnidirectional microphone and a noise signal. In other words, if you place your head in the pressure null of a standing wave in your room, you will not hear sound at the frequency of that pressure null, even though the sound velocity at the position of your head might be quite high. Reflections and standing waves can thus make a large difference to the perceived balance and smoothness of low-frequency sound.

"You can test this yourself by exciting a loudspeaker with pink noise and walking around the room; it is easy to find places where the lower frequencies sound quite different. The noticed imbalances with a noise signal are not removed in some magical way when transients are applied (and noise is highly "transient" in its statistics); the ear is simply not able to detect on a short transient the timbre alterations which result from reflections. The integration time for timbre detection is rather long, particularly at low frequencies. If the transient is brief enough it will sound reasonable even though a Fourier analysis of the sound pressure at the listener shows gross anomalies."

Ear Training

Here are some ideas for calibrating oneself specifically in these matters. First, latch on to any octave equalizer and connect it into a preamp or receiver tape loop with the 125Hz slider almost fully depressed and the 60 and 250Hz sliders at around +5dB (the markings are always way off, but no matter). Through headphones, listen to a range of music while pressing the tape-monitor switch in and out. This will begin to sensitize you to depressions in the Allison-effect frequency range.

It would be nice to be able to do similar comparisons with a good clean delay, adding in 5, 10, 15 and 20mS-delayed copies to the original music. But most of us don't have access to such a component. So try the following if you're so inclined. It's crude but, with time, can prove effective:

Take a basketball to a schoolyard with an asphalt court next to a high brick wall, and slowly dribble around. Start close to the brick wall (only a few feet away) and then slowly move farther and farther from it, out to 30 feet or so. Face the wall while doing this and also repeat it sideways, with the wall to your right or left (you may have to be a fair dribbler). For some audiophiles, this may begin to serve as a quick and coarse test of your ears' fusion capabilities at different angles and distances (delay times).

Final Words

Let me conclude this response with further subjective description. Concerning this very Allison effect which Atkinson does not ever remember hearing, Gordon Holt described its surprising quality quite well (again in *Stereophile* October 1985, pp. 99–100): "It did not take more than a few minutes of listening [to an Allison loudspeaker system, the CD9] before I picked up what sounded like a chesty kind of 'woofiness' in the sound. This was not corrected by changing room placement, and I was prepared to put it down as a spurious coloration until I realized that male voice, tympani, large brasses, and cellos somehow sounded more 'right' than usual. The reason should have been obvious. It wasn't that these had a lower-middle range peak; the 'problem' was that there was substantial output through that part of the audio range where I have grown accustomed to hearing more or less of a cancellation *suckout.*"

There are few better sonic descriptions of the problem and its solution, in all their reality.

Atkinson mentions he once was a science teacher. Lucky for students he turned to journalism.

Clark Johnsen

Clark Johnsen's reply to my 1/92 column (page 66), which was partly about the potential for touchiness from audiophiles whose favored loudspeakers measure suboptimally, is a jaundiced but not really inaccurate account of what happened. (The reason I omitted all details of loudspeaker ownership and location throughout the article should be obvious.)

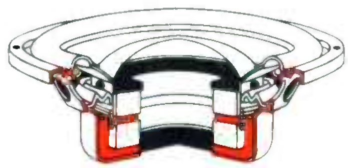
A few corrections are called for, though.

For the BAS meeting Johnsen's VMPSes

Continued on page 86

MW142

DPC Cone Double Magnet 5" Woofer



A 5" unit with a unique design, incorporating an extremely large diameter aluminium voice coil for such a small unit.

Vented double magnet system with steel chassis — damped polymer composite cone — rubber surround — smooth response to upper limit of 5 Khz with excellent on and off axis response and good roll off.

High power handling emanates from this unique design, resulting in a very impressive small bass/mid or mid range unit.

Specification

Overall Dimensions	Ø 142mm(5.5") x 52mm(2")
Nominal Power Handling (Din)	150 W
Transient Power — 10ms	1000 W
Voice Coil Diameter	75mm(3")
Voice Coil Type / Former	Hexatech Aluminium
Frequency Response	48-5000 Hz
FS — Resonant Frequency	52 Hz
Sensitivity 1W/1M	86 dB
Z — Nominal Impedance	8 ohms
RE — DC Resistance	5.2 ohms
LBM — Voice Coil Inductance @ 1 Khz	0.5 mh
Magnetic Gap Width	1.35mm(0.053")
HE — Magnetic Gap Height	5mm(0.196")
Voice Coil Height	12mm(0.47")
X – Max. Linear Excursion	3.5mm(0.137")
B — Flux Density / BL Product (BXL)	0.6 T / 5.0 NA
Qms — Mechanical Q Factor	2.14
Qes — Electrical Q Factor	0.62
Q/T — Total Q Factor	0.46
Vas — Equivalent Cas Air Load	7 litres (0.25 ft³)
MMS — Moving Mass / Rmec	13gm / 2.06ns/m
SD — Effective Cone/Dome Area	90 cm²
Cone/Dome Material	DPC (Damped Polymer Composite)
Nett Weight	0.97 kg

Specifications given are as after 24 hours of running.

high fidelity range

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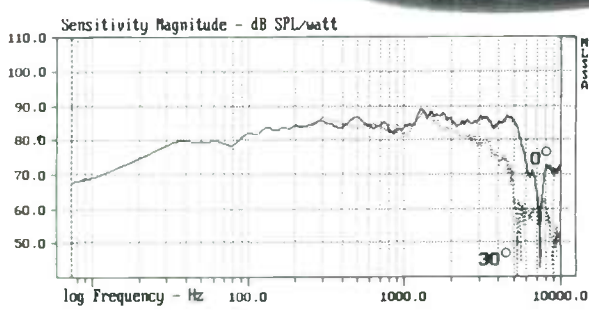

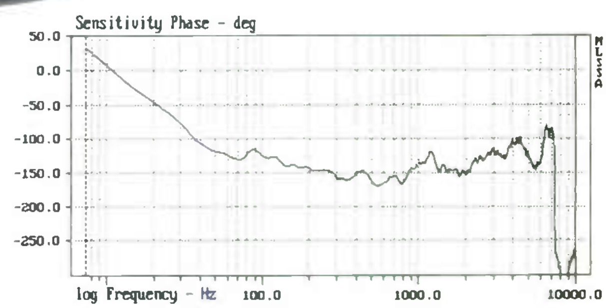

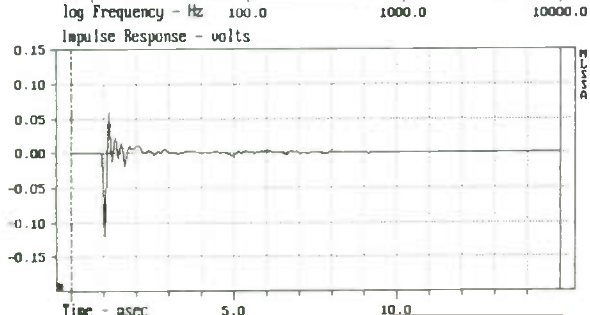

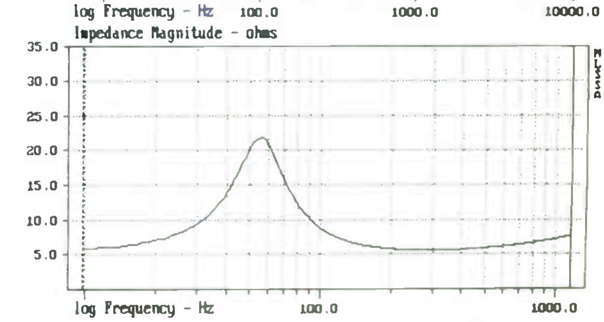

Morel operate a policy of continuous product design improvement, consequently specifications are subject to alteration without prior notice.

Fast Reply #HG1407

Continued from page 84
were quite nicely and reasonably positioned in his wonderful room: moderately well-staggered with respect to floor and walls, left-right symmetrical (the individual channel responses match extremely closely, even below 400Hz!); and in a pleasing triangulation with the center sweet-spot listening position. That is where I moved the mike through approximately a cubic foot or two of space at seated ear level. It may not have been the best spot for 30Hz levels, which of course can vary by 10dB or more with position—but that's how it always is with speakers in rooms. The great virtue of the continuous-averaging capability of the dbx RTA-1 is that in a large room like the Listening Studio's, a loudspeaker's frequency response above a few hundred hertz will change predictably as a function of position, with genuine room "hot spots" (whatever those are) being accurately analyzed, not averaged out. The "wild incongruities" Johnsen cites from other measurement techniques are not real to the ear, which integrates spatially; they are a liability of all fixed-location measurement procedures. RTA-1 continuously time-averaged measurements, which in my work are also slightly spatially averaged, appear to be unique in their consistency and repeatability from environment to environment. (I have no idea what Johnsen might mean about the RTA-1 being unable to process data speedily.) Its only drawback is in being frequency-averaged as well; ⅙- or ⅑-octave averaging would be ideal, although anyone who's experimented with a ⅓-octave equalizer knows how audibly fine that bandwidth is and how limited the ear is in this regard too.

I do regret printing VMPS response curves which appear shy in the low bass if that's what seems grossly unfair. However, unless one favors corner placement and/or seating near a wall, that's life with all speakers (that's how the physical world is, in other words). Moreover, low bass is the least of the Tower II's problems. At the meeting, numerous BAS members with highly respected hearing (probably keener than mine) and evaluative experience thought these VMPSes sounded only fair at best. Private comment was harsher than that, and harsher than anything I wrote. Finally, except for being a few dB louder at 32Hz, Brad Meyer's shorter-period Ivie measurement matches the one published in *SB* 1/92 surprisingly closely, and his lukewarm sonic assessment also correlates perfectly well with mine and that of other BAS listeners.

Martin Colloms

While I thank you for the kind comments in your letter (*SB* 3/92, p. 77), I believe your premises are mistaken, specifically that you vastly overvalue the contribution and significance of axis frequency response, whether flat or otherwise. Although it seems the opposite, at any reasonable listening position in any typical domestic room, even a fairly close-up seat, we really do judge the quality of loudspeaker reproduction—how smooth the playback sounds—from hearing the totality of the output.

A speaker with a smooth flat room response as measured a good listening distance away (say 8 or 10 feet) will sound timbrally pleasing and accurate to listeners, although it may well image like hell if individual angular responses vary dramatically with angle. An anechoic (or anechoic-with-floor, as I perform outdoors) examination of its horizontal radiation pattern will then show why and how its imaging is so inconsistent. And except as it affects frequency responses, "phase" response has little to do with it.

Try equalizing several known loudspeakers' power responses out in a room until they measure smoothly, and observe how good they sound afterward. Do this even with models with lumpy and erratic off-axis responses, like multi-driver driven-in-parallel designs (i.e., not phased arrays), which will have bad lobing, as well as 2-ways misconceived with a 12″ or 10″ woofer taken up to 1–2kHz.

If axis response were as primary as you and so many others believe, room furnishings, room size, room proportions, and distances to the three nearest boundaries (see response to Atkinson) would matter much less than they do. Speaker location would matter little; experimentation with placement would produce not much change. To put it another way, try to imagine what it would be like if, while you were listening in your favorite room, the front wall were moved back 10 feet, the ceiling dropped one foot, the side walls each were shifted two feet to the left, and the floor turned into polished marble. Provided you hadn't fled the room, would the frontward output ensure that the sound was hardly altered? Of course not; what you heard would change because the environment changed.

Flatness within a 40° horizontal window is a much too narrow criterion for goodness, if you were specifying ±20° from a front axis. It assumes too much influence for that angle of radiation. (You are not even including, in most instances, the first strong reflection from the left and right walls.) What would happen if you took such a speaker and connected on its back a 3″ driver, well-sunk in foam, and ran that extra driver rather loud? Frontal frequency measurements within your criterion might not pick up its contribution, or not enough to go out of spec, but you sure would hear it—at virtually any distance, near or far. (Of course frontward output does count for something, especially in the treble, as is evident in *SB* 2/92, p. 79. Compare the bottom Allison AL130 room-response curve, taken with the speakers almost facing each other, with the other two.)

If, however, you meant ±2dB 60Hz–18kHz within ±40° horizontally, instead of ±20°, I have measured no speakers that even come close to meeting such a tight "forward equi-omni" specification.

A number of recent 2- and 3-ways that have been well-reviewed in high-end periodicals for their clarity, "etched" playback, ambient and crystalline highs, and so on, show for an axis frequency response a fairly smooth tweeter shelving in several decibels louder than a fairly smooth midrange—sometimes even ramping up a bit above 8kHz. In a room their total output measures pretty flat, though, and they are adjudged smooth (if on occasion a bit bright).

Finally, I do not understand what might be the problems in assessing measurements of large-panel systems. Nor did I find the Carvers, the only panel speakers I have measured outdoors, to be "less accurate. . . than conventional boxes." They have a much different horizontal radiation pattern from dynamic-driver/cabinet speakers, with very broad upper-midrange dispersion and not nearly as much figure-8 dipolarity as claimed (why should a thin ribbon be markedly dipolar at all?). But I thought they sounded—and in a room measured—quite good.

Andrew Tanos

I am sorry you formed an impression of pettiness. (Page 68) Your idea of joint enterprise is a nice one—on paper.

However, Robert Harley wrote to an audience of 60,000 that I publish deliberately falsified loudspeaker measurements. That includes reviews for this publication. Clarifying the truth in such a matter actually is something quite other than just a "personal quarrel." My tone could have been casual or cordial, I guess, but if Tanos is ever so libeled, a certain vigor about accuracy and journalistic hygiene might become understandable.

As for reporting on Harley's own paper, Tanos should examine for himself its hostility and straw men, and also should regularly read Harley's and his cohorts' monthly attacks on scientific spirit. Colleaguiality is nowhere in the picture; quite the opposite, in fact. A shame, too, for Harley evidently is a keen listener.

I did suggest some research topics for Harley *et al.* into the reflections that cause the Allison effect.

The purpose of my own testing work is getting speaker designers to pay attention (1) to that effect (and its easy cure), and also (2) to lumpy off-axis frequency response seams (producing variable-width imaging and often honky sound), which result from blindness to driver/baffle horizontal radiation pattern and, consequently, misguided crossover design. In these campaigns I welcome anyone's help.

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