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Speaker Builder

THE LOUDSPEAKER JOURNAL

BUILDING BETTER SPEAKERS FOR YOUR COMPUTER

PUTTING MUSIC ON THE BEACH

BUILD A REFLEX/TL COMBO

TEST DRIVE NEWFORM'S RIBBONS

Robert Greene
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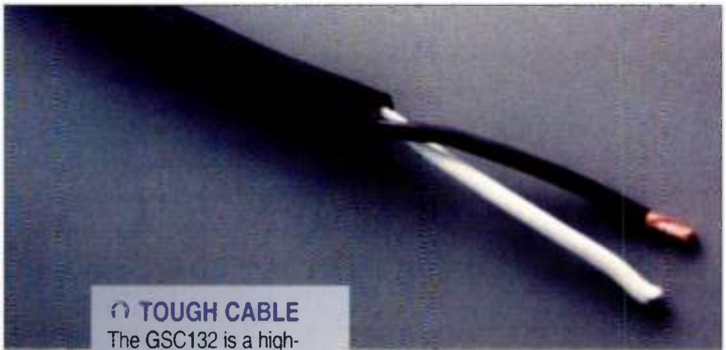
Reader Service #65

World Radio History

Good News



TOUGH CABLE

The GSC132 is a high-definition speaker cable from GEPCO International. It contains high-strand (52 × 30) bare copper conductors insulated with color-coded (black and white) PVC. The round, black TPE overall jacket is tough, yet flexible. GEPCO International, Inc., 2225 W. Hubbard, Chicago, IL 60612-1613, (312) 733-9555, FAX (312) 733-6416.

Reader Service #105

400W TWO-WAY

The Sx500 speaker system is available from EVI Audio. It features an enclosure made of injection-molded polypropylene structural foam, and may be stand-mounted, hung, or arrayed. The horn contains a 75° × 60° coverage pattern and a frequency response of 60Hz–20kHz (–3dB) with 43Hz usable bass response. The system handles 400W continuous, 1,600W short term, and may be biamped with 400W LF/25W HF for more control and output. EVI Audio, 600 Cecil St., Buchanan, MI 49107, (616) 695-6831, FAX (616) 695-1304.

LIGHTEN UP

CLIO Lite is an entry-level test system from Audiomatica that comes with a standard HR-2000 PC board and is upgradable to version 4 or QC (Quality Control). The system features a programmable signal generator, polar plots with turntable control, on-line help, and more. It contains a 130dB SPL maximum level and 16mV/Pa average sensitivity. Audiomatica S.R.L., Via Faentina 244/g, 50133 Florence, Italy, 55-575221, FAX 55-5000402, Website http://www.mclink.it/com/ audiomatica/cliolite.htm.

Reader Service #101

ALTERNATE CROSSOVER

The EC6 stereo electronic crossover from Alternate Audio offers better loudspeaker damping, precise crossover points, and the reduction of an amplifier's required bandwidth, according to the manufacturer. It consists of stereo high- and low-pass outputs, which have a constant phase relationship, and the crossover slope is 24dB per octave. It contains an input impedance of 20kΩ, and a frequency response at DC to 30kHz +0dB to –3dB, and is housed in an aluminum chassis. Alternate Audio, 1768 N. 980 W., Orem, UT 84057, (801) 434-7226, FAX (801) 434-3010, E-mail dpatten@alternate-audio.com, Website www.alternate-audio.com.

Reader Service #106

IT'S COVERED

US Enclosures offers spherical loudspeaker enclosures in sizes ranging from 4″–36″, which will cover all applications, whether you are an amateur or professional loudspeaker builder. The enclosures utilize patent-pending material technology that equates into the same wall thickness as a 2″-thick piece of medium-density fiberboard. Sealed and ported units are available. US Enclosures, 634 Sycamore Ave., Claremont, CA 91711, (909) 399-9706, FAX (909) 946-0173, E-mail Brianonei@aol.com, Website http://members. aol.com/kmetaverso.

Reader Service #102

SUPER SPEAKERS

Now Hear This (NHT) announces the SuperZero Xu and SuperOne Xu compact speakers that offer sonics in rugged thermoplastic enclosures featuring soft lines and flexible mounting options that open a wide range of applications. Both models employ a two-way acoustic suspension design, featuring a 4.5″ long-throw woofer and 1″ soft-dome tweeter. The SuperZero Xu measures 9″ h × 5.5″ w × 4.8″ d with a frequency response at 85Hz–25kHz. The SuperOne Xu measures 11.65″ h × 7.25″ w × 7.25 d and contains a frequency response of 57Hz–25kHz. Now Hear This, 535 Getty Ct., Benicia, CA 94510, (707) 747-3300, FAX (707) 747-1252.

Reader Service #107

General Electric Polypropylene Capacitors

Madisound has acquired a large lot of Metallized Polypropylene Capacitors manufactured by General Electric. We are offering these capacitors to you at a fraction of the normal selling price. We have at least 500 pieces of each value and some values over 15,000 pieces. The voltages of these capacitors make them suitable for use in speakers or electronics. Very low series inductance and series resistance minimize power dissipation and provide an extremely reliable product with unsurpassed performance characteristics.

GE 40L Series Metallized Polypropylene Capacitor; axial; 10%; 50 mm long tinned copper leads; white fire retardant tape with polyurethane potting compound; oval shape; dissipation factor 0.1% maximum

Value µfd	Vdc	Vac	ESR (mΩ)	Dim. H mm	Dim. W mm	Dim. L mm	$ 1-19	$ 20-99	$ 100+
5.0	400	250	7	16	22	43	1.75	1.40	1.12
10.0	400	250	7	20	26	55	2.70	2.16	1.73
0.22	600	330	.34	7	12	31	1.10	0.88	0.70
0.68	600	330	.55	12	18	31	1.25	1.00	0.80

GE 41L Series Metallized Polypropylene Capacitor; axial; 5%; 40mm long tinned copper leads, yellow polyester wrapping with epoxy resin end fill; dissipation factor 5 x 10^{-4} @ 1KHz and $25^{\circ}C$; low ESR (series resistance)

Value µfd	Vdc	Vac	ESR (mΩ)	Dim. Ø mm	Dim. L mm	$ 1-19	$ 20-99	$ 100+
1.5	250	160	3.4	10	31	0.70	0.56	0.45
2.5	250	160	3.3	12	31	0.85	0.68	0.54
3.0	250	160	2.9	13.5	31	0.95	0.76	0.61
5.0	250	160	2.1	17	31	1.40	1.12	0.90
6.8	250	160	1.8	20	31	1.80	1.44	1.15
10.0	250	160	2.1	20	42	2.35	1.88	1.50
1.5	400	250	3.6	14.5	31	0.90	0.72	0.58
2.5	400	250	2.5	16.5	31	1.35	1.08	0.86
3.0	400	250	2.3	20	31	1.45	1.16	0.93
4.0	400	250	3.0	19.5	42	1.55	1.24	0.99
6.8	400	250	2.1	25	42	2.50	2.00	1.60
10.0	400	250	1.8	30	42	3.35	2.68	2.14
6.8	600	330	4.5	28.5	55	3.20	2.56	2.05
10.0	600	330	3.5	34.5	55	3.50	2.80	2.24
0.68	700	400	4.6	17	31	1.35	1.08	0.87
1.0	700	400	3.4	20.5	31	1.40	1.12	0.89
1.5	700	400	4.2	20.5	42	1.50	1.20	0.96
4.7	700	400	5.2	30	55	2.85	2.28	1.82

GE 42L Series Metallized Polypropylene Capacitor; axial; 5%; 40mm long tinned copper leads; yellow polyester wrapping with epoxy resin end fill; dissipation factor 5 x 10^{-4} @ 1KHz and $25^{\circ}C$; low ESR (series resistance)

Value µfd	Vdc	Vac	ESR (mΩ)	Dim. Ø mm	Dim. L mm	$ 1-19	$ 20-99	$ 100+
0.15	850	450	9.5	10	31	1.05	0.84	0.67
0.22	850	450	6.6	12	31	1.15	0.92	0.74
0.33	850	450	4.8	14.5	31	1.40	1.12	0.90
0.47	850	450	3.5	17	31	1.60	1.28	1.02
0.68	850	450	2.7	20.5	31	1.85	1.48	1.18
1.0	850	450	3.1	20.5	42	2.15	1.72	1.38
1.5	850	450	2.3	24.5	42	2.70	2.16	1.73
2.0	850	450	2.0	28.5	42	3.15	2.52	2.02
0.15	1200	500	6.1	17	31	1.20	0.96	0.77
0.22	1200	500	4.5	20.5	31	1.25	1.00	0.80
0.33	1200	500	4.7	19.5	42	1.45	1.16	0.93
0.68	1200	500	2.7	27.5	42	1.90	1.52	1.22
1.0	1200	500	2.3	33.5	42	2.20	1.76	1.41
1.2	1200	500	2.8	29	55	2.50	2.00	1.60
0.022	2000	630	31.9	10.5	31	0.65	0.52	0.42
0.1	2000	630	7.6	20.5	31	1.15	0.92	0.73
0.22	2000	630	5.4	23.5	42	1.55	1.24	0.99

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About This Issue

Computer speakers offer special challenges for those considering replacing the mediocre sound system on their present units. Incorporating Vifa drivers from a Madisound kit, **Mark Zachmann** overcame these problems by designing a pair of unobtrusive, yet powerful, enclosures small enough to fit on his desk ("Simple High-Quality Computer Speakers," p. 8).

In his first speaker-building project, **Jeffrey Viola** constructed a pair of nice cabinets for the Daline drivers. Other first-time builders should take note: The author overcame a few shaky moments to produce floor-standing units that not only look great, but sound terrific ("Doing the Daline," p. 16).

There's nothing fishy about **Bill Fitzmaurice**'s "Music on the Beach" project (p. 26), which finds him on the shores of beautiful Lake Winnepesaukee. Bill found time—in between sun bathing, water skiing, and an occasional dip in the lake—to solve the problem of designing speakers for this unusual venue.

In part 3 of his major restoration project, **Tom Yeago** discusses some theory about the size and structure of the cone before tackling the actual design work, including making the cone and placing the coil ("Rebuilding the AR-3*a*," p. 34).

The NHB speaker system from Newform Research takes center stage in this issue's speaker spotlight. **Robert E. Greene** and **Joe D'Appolito** combined their reviewing and testing skills to provide you a closeup look at this unusual ribbon design which produces superb imaging ("Test Drive," p. 44).

Also in this issue, **Vance Dickason** tests the performance of a couple of Scan-Speak woofers ("Driver Test," p. 52).

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JOHN STUART MILL

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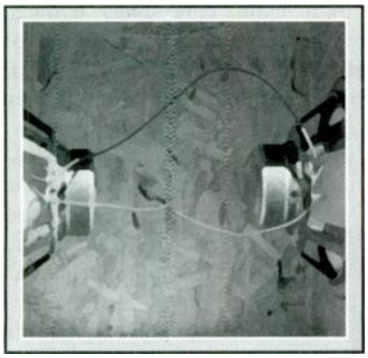

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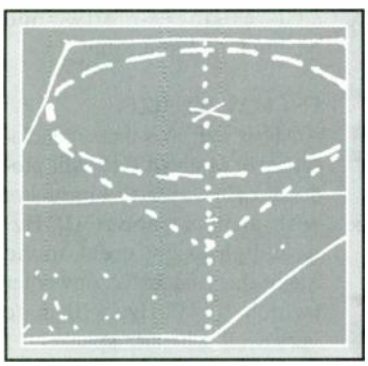

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SIMPLE HIGH-QUALITY COMPUTER SPEAKERS

By Mark Zachmann

What with the advent of lots of good computer games, good computer sound has become more and more important. Recently, I found myself at the local computer store checking out speakers and was distressed to find that most of those available were either inferior or very expensive. Anything for less than about $500 a pair was decidedly less than audiophile quality. Even though I had originally planned to buy speakers, that decision changed abruptly.

Oddly enough, good sound cards are easy to find. My computer has an Audiotrix Pro card in it, and my son's computer a Turtle Beach Tropez. Both boards are rated at virtually flat 30Hz to 20kHz with 0.03% harmonic distortion—and neither one is state-of-the-art. It seemed a shame to mate such a good sound system with mediocre speakers, so I decided to build my own.

PHOTO 1: Computer setup with finished speakers.

PHOTO 2: Kit contents.

SPEAKER SEARCH

A search through my speaker suppliers' catalogs (particularly Madisound's) was very interesting. Computer speakers must use shielded drivers because the distance from speaker to computer monitor is quite short (my right speaker is 2″ away), and such drivers are not easy to find (*Photo 1*). After some reading and thought, it became clear that the best fit for my purposes was two Vifa drivers—the D25ASG and the M13SG-09—a 1″ aluminum tweeter and a 5″ black-coated paper woofer, both shielded.

Even more interesting was my discovery that Madisound actually has a kit using these drivers as A/V speakers—the Vifa Solo. Although I'm not keen about kits, this one includes the LEAP optimized crossover schematic—a huge timesaver, since crossovers are very hard to design, and LEAP is an excellent crossover optimizer.

When I purchased the Vifa Solo from Madisound, I did so without the enclosure. The primary reason for this is that the Solo's enclosure, although sonically good, was just too large for my desk. With the acoustic-suspension design I planned to use, you can easily reduce the internal volume, though at the cost of slightly worse pulse response. Reducing the volume from spec to my design increases the total Q to perhaps 0.85 (*Table 1*). This will result in worse transient response than a Butterworth (0.7 Q), but not by much, and the response is satisfyingly flat down to 100Hz.

While I thought I was getting only the drivers and crossover, what Madisound sent me was a complete kit (minus the enclosure), including wire, solder, terminal cup, preassembled crossover, sheets of open-cell foam, and long-fiber wool. All told, it is a pretty nice kit for the money (*Photo 2*).

This article isn't intended as a kit discussion, but it seems appropriate to discuss the kit occasionally as the need arises. The crossover, by the way, is made with Chatereaux capacitors in all of the series spots, cheaper polyprops in the other spots, 16-gauge air-wound inductors, and 5% sand-cast resistors—pretty good quality for a kit like this.

ENCLOSURE SIZE

Analysis indicates that an enclosure size of about 6 ltr will produce a Butterworth alignment with an f_3 of about 105Hz. Although to get great sound might then require a subwoofer (which, at 100Hz, will mate very well with the speaker), I actually used an old Sony A/V receiver with a built-in equalizer. Because of its acoustic-suspension design, the speaker has no low-frequency power-handling problems, and the last thing you'll do is drive it anywhere near its limits (since the speaker is about 1′ from your ear), so I decided to use bass amplification to make the response near flat down to about 40Hz. A simple 12dB/octave bass boost below 100Hz does this well.

As for wood, it takes one and a half 4′ × 8′ pieces to make a pair of speakers. I bought MDF (medium-density fiberboard) at my local Home Depot (*Photo 3*). With the four drivers plus the prebuilt crossover from Madisound at $190, a free receiver, and $32 worth of wood, I spent under $225 to build a great speaker system.

If you don't have a receiver lying around, they are available on the used mar-

TABLE 1

MANUFACTURER'S DRIVER SPECIFICATIONS

	D25ASG-05-06	M13SG-09-08
Type	1″ aluminum	5″ coated paper
F_S	1.4kHz	54Hz
Q_{TS}		0.35
V_{AS}		12 ltr
Sensitivity	90dB/W	88dB/W

ket dirt cheap. You don't need a lot of power, and you don't need Dolby Prologic. For example, I found one in the demo bin of my local Hi-Fi Buys store for $80. This also gave me a headphone jack, a tuner, and lots of preamp inputs for listening to my tape deck while working, not to mention that you can play the speakers loudly enough to suffer permanent hearing loss. If you can't find a receiver with an equalizer, then just cranking up the bass will have almost the same effect.

You can save some money by scrounging crossover components or buying the pieces individually. The drivers alone run $120 per speaker pair from Madisound.

You might consider building a ported enclosure to get the response flat down to near 60Hz, but I wouldn't do that for two reasons. First, the enclosure doubles in size, and desk space is at a premium. Second, this will hurt the rumble resistance of the speakers, and some games have a lot of low-frequency computer-generated tonality.

TESTING THE KIT

After receiving the drivers from Madisound, I tested them to see what I actually had, first testing the crossovers. While there are many ways to test crossovers, I was primarily interested in consistency, so I placed a single 10Ω resistor across the woofer and tweeter output and measured the input impedance of that circuit. If the crossovers were consistent, these impedance measurements would be consistent. The results were very good. All the crossovers were tightly matched.

Next, I measured the free-air impedance of the tweeters. They were all consistent and within 10% of spec, with the exception that two of them had strange spikes in the upper ranges (one at 6kHz and the other at 10kHz). I assumed that these spikes correlated to undamped resonances in the tweeters—perhaps the surround was loose somewhere. I used them anyway, without audible problems.

To test the woofers, I compared their free-air impedance. *Table 2* shows the average measured results. Although the values for the woofers were annoyingly different from spec, the measurement had a fair amount of imprecision, and for constructing acoustic-suspension speakers, this wasn't all that critical. Make sure your box is big enough and then use fill to get to the desired end result. Plugging the measured values into a box design gives the same 105Hz 3dB down point—the only thing that really matters. Note that a ported enclosure design for the manufacturer's specs would be totally wrong for the measured specs—another good reason to use an acoustic-suspension design.

BOX DESIGN

As with most of my small speaker enclosures, I used butt joints for the box joints. In order to make the box a little more attractive (and improve the sound by reducing internal reflections), the front baffle is sloped a bit (*Fig. 1*). Using the measured T/S parameters gives an optimal box size of about 10 ltr—very close to the Madisound box specification. I actually made the box a bit smaller to fit the desk. Acoustic fill increased the apparent size back to spec.

CUTTING THE PIECES

The final box is 12″ tall, 8½″ deep, and 6½″ wide. I used ¾″ MDF, so the internal dimensions are 10½″ × 7″ × 5″, for a total volume of 368 in^3, or about 6 ltr (use 6″ as the depth if the box is sloped). Take out the internal driver volume and the crossover, and you get a 5.5-ltr box. If you slope the

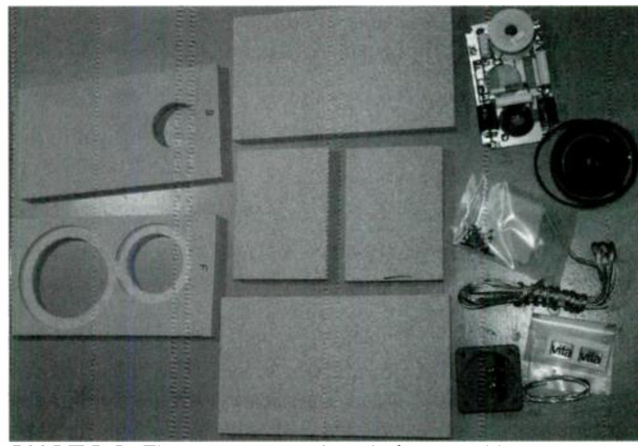

PHOTO 3: The pieces, cut and ready for assembly.

TABLE 2

MEASURED SPECIFICATIONS

	D25ASG-05-06	M13SG-09-08
Type	1″ aluminum	5″ coated paper
F_S	1.7kHz	70Hz
Q_{TS}		0.48
V_{AS}		10 ltr

front, it becomes 4.7 ltr.

With a series resistance of 0.7Ω (about right for crossover inductor, internal connections, and output-amp impedance) and assuming a 30% increase due to stuffing, you get a Q_{TS} of 0.9 for the small box and 0.83 for the larger one. Even the larger Q generates a peak of less than 1dB near 200Hz, and will only slightly affect a subwoofer.

For one speaker, the panel sizes in inches are: top and bottom, 5 × 8; sides, 12 × 8; back, 12 × 6½; and front, 12½ × 6½. This assumes that the top and bottom are placed inside the sides and the front and back are placed on the box. The front is taller than 12″ to accommodate the slope. If you make it 12½″, you can sand it down to meet the rest of the box (trigonometry says it should be 12.2″).

For best acoustics, you should offset the drivers from horizontal center. The woofer has no extra room, but you can offset the tweeter an inch (*Fig. 2*). It isn't critical, but you might want to mirror-image the front baffles for the sake of symmetry.

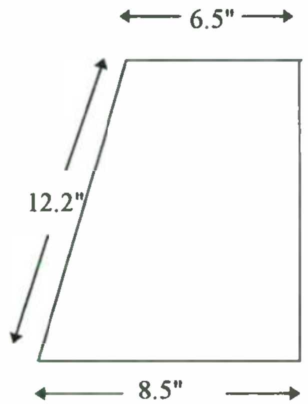

FIGURE 1: Side view; note slanting face.

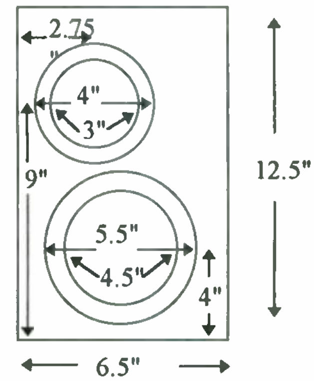

FIGURE 2: Front view.

ASSEMBLING THE BOX

Begin your assembly by gluing the top and bottom within the sides to produce a four-sided box. Then glue on the back (*Fig. 3*). I didn't use screws in this project because they just weren't needed, and they interfere with sanding and routing. Use a good-quality yellow furniture glue. I used right-angle clamps to set the sides correctly, and I glued the back on as a reference. When the five-sided box is dry, saw the front edges of the sides to produce the slope. This is an easy way to get all the angles to line up with no complicated cuts. Two passes with my radial arm saw took care of the sloping.

Prepare the front baffle by routing an area for flush-mounting the drivers and then cutting the holes for them. Routing isn't strictly necessary, but it will improve the sound (particularly for the tweeter) and it makes the project look neater. Little excess room exists on the front baffle, so before you rout, make sure that the drivers fit.

Also, remember that you must sand down the top of the front baffle to match the sloped box, so place the woofer as close to the bottom of the baffle as is practical

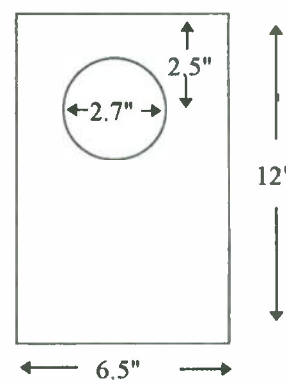

FIGURE 3: Back view.

(don't forget to take account of the ¾″ of the bottom panel). If you plan to use wood screws to hold the drivers in, then you're done. If not, drill pilot holes for the screws and hammer screw-keepers into the back of the baffle, which is my preferred approach.

I normally use good-quality five-way binding posts for the speakers. In this case, however, Madisound supplied me with cups as part of the kit, so I used those, mounting them at the top of the back. This leaves room for mounting the crossover onto the back, below the cups.

Before you glue on the front baffle, you might want to attach the crossover, which comes complete on a 3″ × 7″ circuit card, with the components glued onto it. I like the glue for stability, but really would have preferred to remount the inductors far from the drivers and at right angles to each other.

If you plan to put the crossover on the back with screws, now is the time. Otherwise use my approach and glue it to a wall with silicone sealant after you've glued on the front. This is also a good time to use silicone to seal all of the inner joints (simpler than reaching in through a woofer hole to do it).

Next, glue the front baffle onto the five-sided box. Once all this is finished, carefully seal the front joints and the rest of the inside of the cabinet (I use my fingers to mash the sealant into every joint). Wait at least one day for the silicone to dry. The vapors from the sealer can do bad things to drivers.

Once the box is completely built, rout or sand down the front edges so that they are as rounded as you can make them. Use a minimum radius of ½″. Sand the rest of the cabinet smooth.

Apply any finish you wish. I used Fleck Stone "Manhattan Mist" spray paint, made by plasti-kote, Medina, OH 44256 (*Photo 4*).

After allowing the box to dry thoroughly, insert the crossover and wire everything together. Then place the damping material (Madisound supplies sheets of foam for the sides and wool for the stuffing) in the box around the sides and heavily behind the woofer, but don't let the material touch the driver. Finally, mount the drivers, and you're done.

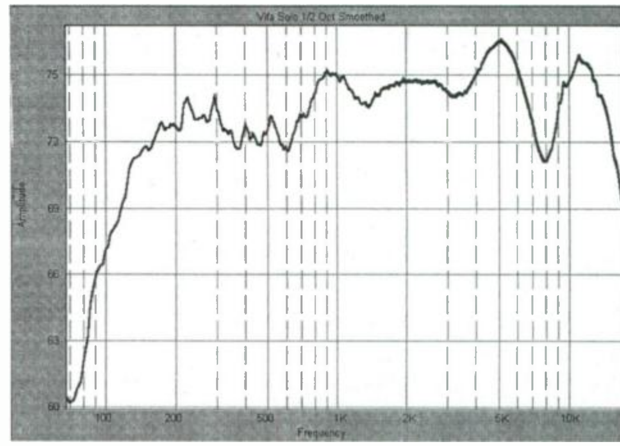

FIGURE 4: Frequency-response curve for Vifa Solo.

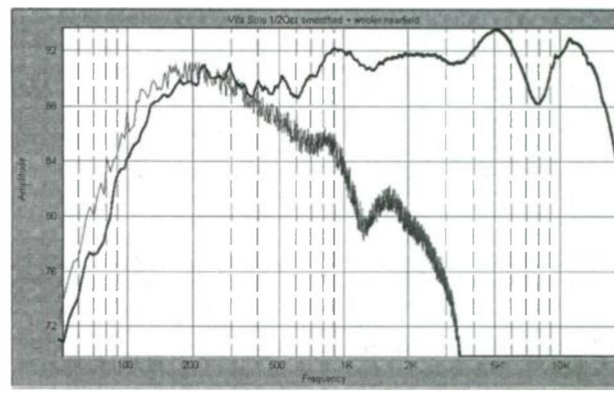

FIGURE 5: Vifa Solo gated and farfield results.

ACOUSTIC RESPONSE

No review would be complete without acoustic response measurements (*Figs. 4 and 5*). I used Vifa car-stereo metal grilles, which work great at keeping the drivers intact in the presence of children and random desk objects (such as pens). Acoustically, they could be better, and so I removed those grilles for all acoustic measurements. Preliminary measurements indicated a resonance around 10kHz and some dropoff to 20kHz due to the grilles, not to mention high-frequency irregularities.

Rough measurements indicated an excellent response, mildly increasing from 100Hz to 10kHz, but within ±3dB over that range. There is a small dropoff at 20kHz and some irregularities in the 5–15kHz range due to driver edge reflection, baffle reflection, and baffle refraction effects. Note that the ½-octave smoothing exaggerates the 20kHz dropoff and the bass droop.

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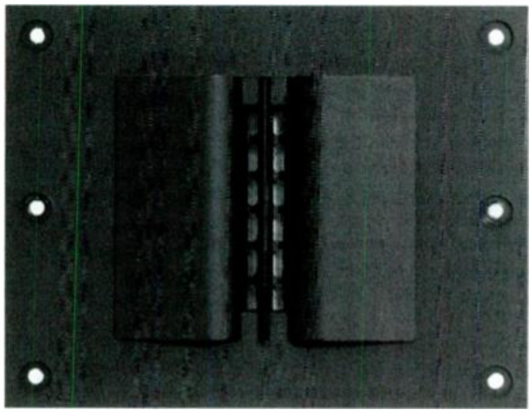
Tweeter



SPECIFICATIONS

Characteristics	Symbol	Value	Units
Frequency Response	(±2dB)	4.7-27	kHz
Nominal Impedance	Z	6	Ω
Nominal Power Handling	Pnom	20	W
Sensitivity (1w/1m)	E	93	dB
Weight	M	0.16	kg

MAGNET

6 Neodymium Bar Magnets

Why we call RT1 isodynamic? Contrary to a conventional electrodynamic driver, this transducer has a driving force distributed evenly over the whole area of vibrating element.

What is special in RT1?

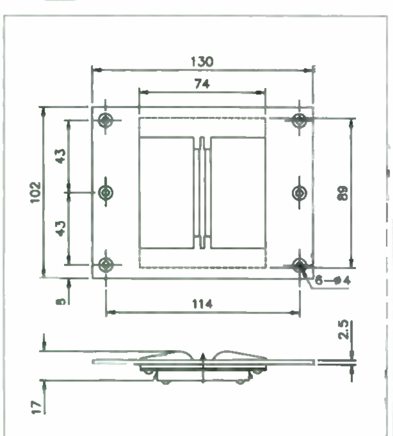
The key element of RT1 is a membrane, which consists of a Kapton™ film with a pattern of Aluminum conductors. The conductors take about 90% of the whole vibrating area. The membrane assembly is placed precisely between two rows of Neodymium bar magnets. A plastic mounting flange with flared waveguide controls the frequency response and directivity of the tweeter. This tweeter is magnetically shielded and is an extremely flat driver. It's depth is only 17 mm including mounting flange! RT1 has resistive impedance in audio frequency range. This unique feature provides an easy load for an amplifier and substantially facilitates a crossover design.

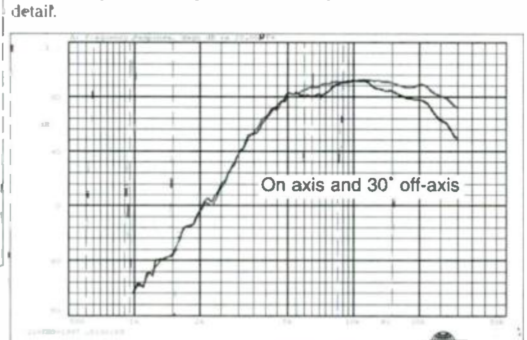
The vibrating element of RT1 is almost weightless in comparison to a dome tweeter. It delivers an immediate and precise response to any transients in original signal.

Unlike other drivers, RT1 has essentially a linear phase response that provides time coherent reproduction resulting in accurate musical rhythm and imaging.

Unlike conventional tweeters and electrostatic speakers, RT1 has an extremely wide sound dispersion in horizontal plane. The radiating area of the tweeter is 50 x 13 mm, where 13mm defines the horizontal dimension. At the same time, RT1 has a well-controlled dispersion in vertical plane, contrary to other dynamic tweeters. This feature helps to avoid disturbing floor and ceiling reflections in home environments. Remarkably, you don't have to use three tweeters in home theater systems anymore in order to achieve desired vertical directivity!

Considering all acoustic properties of RT1, it becomes clear why many critical listeners among audiophiles prize very high planar transducers for their unsurpassed clarity, transparency and ability to deliver every tiniest musical detail.





planar **isodynamic tweeter**

RT1

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PHOTO 4: Closeup of speakers; note the Texturelac finish and slant of front baffle.

Overall, the response is excellent and the bass response is nearly textbook acoustic reflex, at 12dB/octave with resonance near 105Hz.

Measurements were made with a calibrated electret microphone using my Audiotrix Pro card jumpered for direct electret connection. The response was gated at 30mS to remove wall bounce, but some of the irregularity near 500Hz may be due to floor bounce. The gated results and the farfield results were identical in character.

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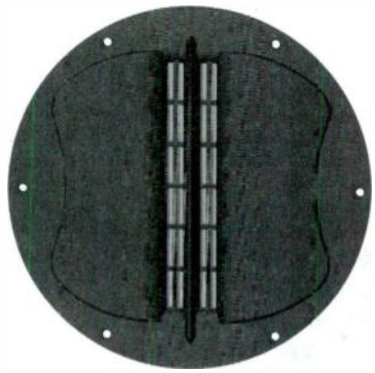
Tweeter



SPECIFICATIONS

Characteristics	Symbol	Value	Units
Frequency Response	(±1.5dB)	1.7-21	kHz
Nominal Impedance	Z	8	Ω
Nominal Power Handling	Pnom	30	W
Sensitivity (1w/1m)	E	93.5	dB
Weight	M	0.6	kg

MAGNET

Neodymium /Ferrite combination

Why we call RT2 isodynamic? Contrary to a conventional dynamic driver, this transducer has a driving force distributed evenly over the whole area of vibrating element.

What is special in RT2?

The key element of RT2 is a membrane, which consists of a Kapton® film with a pattern of Aluminum conductors. The conductors take about 90% of the whole vibrating area. The membrane assembly is placed precisely between two rows of Neodymium and Barium Ferrite bar magnets. The plastic mounting flange with flared waveguide controls the frequency response and directivity of the tweeter.

This tweeter has large membrane area providing higher power handling and substantially extended low end cut-off frequency.

The clamped membrane area is connected to the massive front metal plate. This combined with a special heat conductive compound provide effective cooling of aluminum conductors, dramatically increasing dynamic range of RT2.

The vibrating element of RT2 is almost weightless in comparison to a dome tweeter. It provides an immediate and precise response to any transients in original signal.

RT2 has resistive impedance in audio frequency range. This unique feature makes RT2 an easy load for an amplifier and substantially facilitates a crossover design.

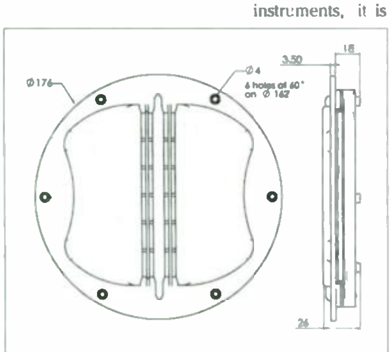
Unlike other drivers, RT2 has essentially a linear phase response that provides time coherent reproduction resulting in accurate musical rhythm and imaging.

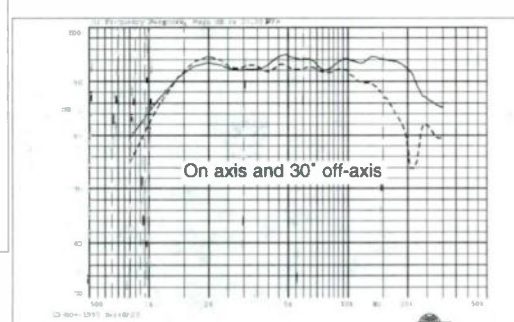
Unlike other conventional tweeters, RT2 has well controlled sound dispersion in vertical plane. This feature helps to avoid disturbing floor and ceiling reflections in a home environment thus enhancing clarity and imaging accuracy. Remarkably, you don't have to use three tweeters in home theater systems anymore in order to achieve desired vertical directivity!

Considering all properties of RT2, it becomes clear why many critical listeners among audiophiles prize very high planar transducers for their unsurpassed clarity, transparency and ability to deliver every tiniest musical detail.

Since RT2 has exceptional sonic resolution and ability to reveal the dynamics of instruments, it is recommended to match it with drivers having the similar properties in order to maximize overall integrity of a speaker system.

Recommended second order crossover cut-off frequency - from 1.8 kHz.





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DOING THE DALINE

By Jeffrey Viola

In 1995, while riding the train to work, I happened to read an enthusiastic review by Julian Hirsch, in *Stereo Review*, of JM Lab's Daline 3.1 speakers. (JM Lab® is the speaker division of the driver manufacturer Focal.)

Hirsch was impressed with the way the "soundstage was simply there, occupying the front of the room," the "overall flat response of ±2.5dB from 300Hz to 18kHz," and the "solid and clean bass to below 50Hz." He also found that the "the group-delay response (a measure of phase linearity) was among the flattest he had ever measured. Being an impulsive person, I decided then and there to build a copy of these speakers (*Photo 1*).

THE DESIGN

The Daline (decoupled resonant line) 3.1 is a hybrid speaker. In its literature, JM Lab says that "The Daline, which is neither exclusively a bass-reflex nor a transmission-line loudspeaker, is in fact a hybrid loading system. The woofer is primarily loaded into a standard loading volume which is then also coupled to a transmission line."

The upper third of the enclosure serves as a single cavity that loads the rear of the woofer. This cavity then opens into a folded transmission line about six feet long, terminating in a port at the lower back of the cabinet. The partitions that make up the line contribute to the internal bracing of the cabinet.

The speaker uses a Focal 5N412DBL woofer, which is a 5″ dual-voice-coil driver, with a coated Neoflex cone. The tweeter is a Focal T90TI02 1 1/8″ inverted Tioxid titanium dome. The Daline's bandwidth is specified as 40Hz to 23kHz at the –3dB points on axis, with a sensitivity of 90dB and nominal impedance of 8Ω.

Being strictly a tube-amp guy, I could see that these would be easy to drive. Since I had read about true transmission lines in *Speaker Builder*, I was sure that this speaker could give that smooth sound with true deep bass so coveted by line builders. Better yet, there was no tricky stuffing to worry about!

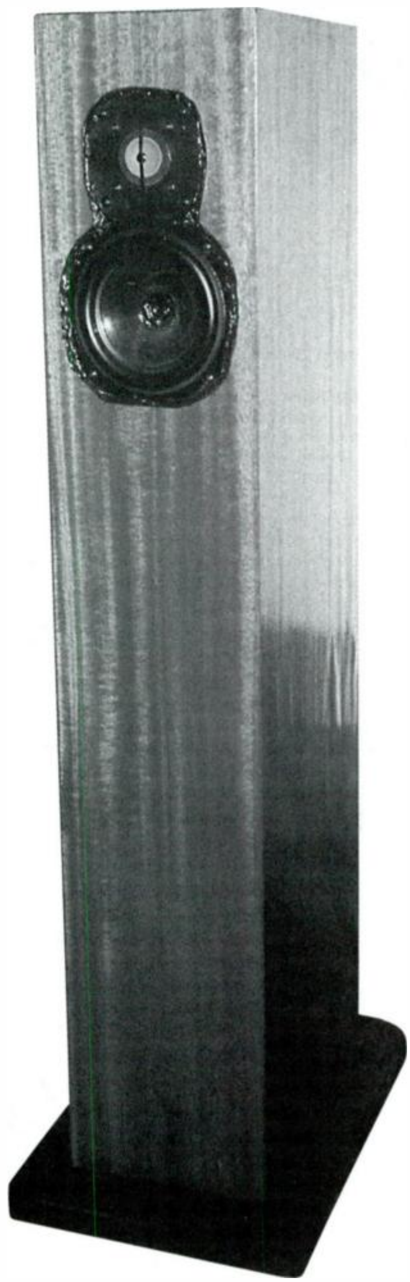


PHOTO 1: Finished speaker, showing ribbon-stripe mahogany veneer and spiked base.

CHOOSE YOUR ALLIES WISELY

Because this was my first attempt at speaker building, I decided that I would need all the help I could get. My first step was to obtain a copy of the cabinet and crossover layout. I contacted Orca Design, the Focal importer for Zalytron, which helpfully faxed me a copy of the original Focal design, including the crossover schematic.

I noticed that all the cabinet measurements on the documentation were metric, so I converted all the dimensions into inches and redrew the layout. Next, I began to form a parts list and search for suppliers for the various components. I thumbed through various issues of *Speaker Builder*, and sent for North Creek Music System's catalog, which, besides top-notch components, offered a small booklet on North Creek's philosophy of cabinet construction, which I purchased.

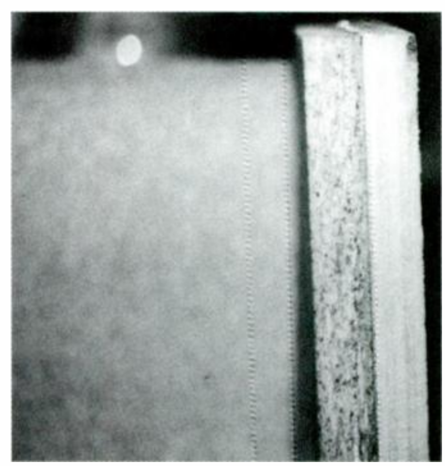


PHOTO 2: Detail of cabinet construction showing double layer composed of ¾″ MDF and ¾″ 5-ply birch plywood.

Focal's Daline plans called for cabinet construction with ½″ and ¾″ particleboard, but I thought this would not give me the correct "knuckle-rap factor" for the cabinets. I liked North Creek's design philosophy of using a sandwich of both particleboard and plywood with a flexible glue. So I decided to use ¾″ particleboard laminated to ¾″ 5-layer birch plywood with North Creek's Soft Glue (*Photo 2*).

Next I tackled the crossover. Since this

ABOUT THE AUTHOR

Jeffrey Viola has worked in the computer and communications field for more than 25 years. He is currently employed by the Systemhouse Division of MCI as a network specialist. His latest project was the design and implementation of the new 911 network for the New York City Police Department.

It can be your solution for **Perfect** LOW MID frequency **reproduction**

Bass-Midrange

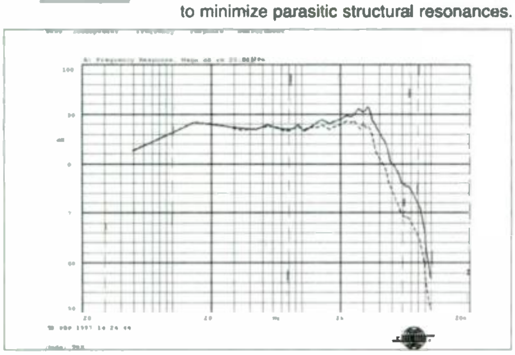
W6 bass-midrange features:

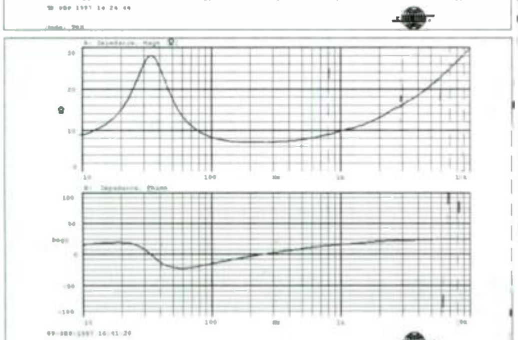
- **PPF composite poly cone;**
- **high loss rubber surround;**
- **double magnet shielded magnetic structure;**
- **high power handling aluminum former voice coil;**
- **vented pole piece;**
- **high density aluminum die-cast frame;**
- **Symmetric Motor Drive (SMD) technology.**

The design of W6 driver based upon a beneficiary idea of an extended pole piece in a magnet system. But here we went further. Using FEA simulation we optimized a complete magnet structure and specifically shaped the pole piece to achieve a symmetric flux distribution along travel path of a voice coil.
This design approach provides better driving force linearity. It considerably reduces VC inductance modulation and DC offset of a moving system at high power levels. The result is - much less distortions and more effective VC cooling.
The cone/surround design is optimized to achieve extended and balanced frequency response without apparent top end resonances. The back of the cone is manually coated to maximize damping properties of the moving system.
To avoid air compression and internal air volume resonance the driver has a vented pole piece. The massive aluminum die-cast frame has been developed to minimize parasitic structural resonances.

SPECIFICATIONS			
Characteristics	Symbol	Value	Units
PRIMARY APPLICATION			
Nominal Impedance	Z	8	Ω
Resonance frequency	Fs	34	Hz
Nominal Power Handling	Pnom	60	W
Max Power Handling	Pmax	90	W
Sensitivity(1w/1m)		87.3	dB
VOICE COIL			
Diameter	ø	26	mm
DC Resistance	Re	6.4	Ω
Inductance(1kHz)	Lbm	0.72	mH
Length	H	14.5	mm
Former	aluminum		
Layers		2	
MOTOR SYSTEM			
Magnet System		shielded SMD	
Force Factor	BL	6.75	N/A
Gap height	He	6	mm
Linear excursion	Xmax	4.25	mm
PARAMETERS			
Suspension Compliance	Cms	1510	mM/N
Mechanical Q	Qms	2.1	-
Electrical Q	Qes	0.435	-
Total Q	Qts	0.36	-
Moving mass	Mms	14.5	g
Effective Piston Area	Sd	0.0127	m^2
Equivalent Air Volume	Vas	34.6	L
Weight	M	2.7	Kg

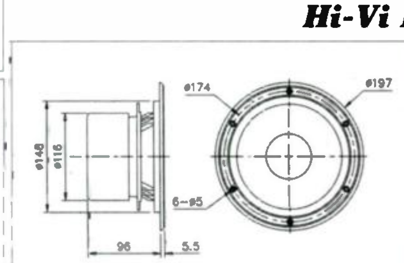
RECOMMENDED ACOUSTICAL ALIGNMENT			
DESCRIPTION	Vb,L	Fb,Hz	F-3,Hz
Medium Vented Box	16	37	46
Large Vented Box	22	37	40





The shielded magnet structure allows versatile audio/video applications.
W6 is a high performance driver with extended bass reproduction. This driver is an excellent performer even in bigger size cabinets so it can be used in top class floorstanding systems. Recommended crossover frequency region is 2-3 kHz.

bass-midrange W6 from Hi-Vi RESEARCH®



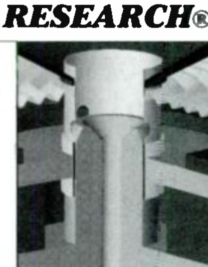


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PHOTO 3: Woofer crossover showing heavy-duty air coils and point-to-point wiring.

would be critical to the final sound, I decided to use only the best components, all from North Creek. For the capacitors, I chose Sprague metallized polypropylene, and for the resistors, Ohmite noninductive wire-wound ceramics. In place of the original Daline coils, which were small-gauge ferrite-core inductors, I used 12-gauge air-core "Music Coil" copper coils.

For internal wiring, I chose Tef-Flex® 14-gauge silver-plated copper with Teflon®, and I purchased fiberglass boards with terminal posts for building the crossovers in a point-to-point fashion (*Photo 3*). Rounding out the list were heavy-duty binding posts, floor spikes, and pan-head screws for mounting the drivers, which I also bought from North Creek. From Zalytron, I purchased the drivers, as well as sheets of BlackHole Pad and BlackHole 5 material for damping the cabinet interiors.

I wished to use real wood veneer for the cabinets, so I took a ride over to Willard Brothers Woodcutters, in Trenton, NJ, an outstanding place run by some great people. They have every type of exotic and domestic hardwood lumber and veneer, so great a variety that I couldn't decide which one to buy. I finally chose some gorgeous ribbon-stripe mahogany in sheets 1½′ wide by 10′ long.

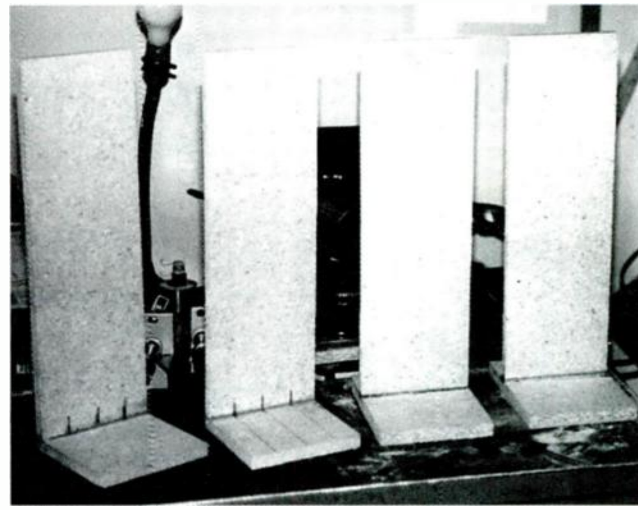

PHOTO 4: Two pairs of MDF assemblies for transmission-line inner chamber (one of each pair per speaker).

THE BEST LAID PLANS

Before I began to construct the cabinets, I had to recalculate all the dimensions because of the change in thickness of the cabinet walls. Also, the original design included a sand-filled chamber below the line port that helped to stabilize the speaker. Instead, I decided to use that chamber to hold the crossover board and binding-post cups, so I redrew it with new measurements.

I decided to cut out the various plywood and particleboard pieces before laminating them together, since I didn't relish the thought of handling a 4′ × 8′ sheet of 1½″-thick laminate! After sawing, I liberally applied the soft white glue to the panel sections and clamped them together to dry. It was at this point that I made a horrifying discovery—I had miscalculated the dimensions for the front and back panels! They were too narrow!

Rechecking my calculations, I found I had made a mistake in converting from millimeters to inches. Luckily, I had enough plywood and particleboard left over, so it was back to the table saw. What's that old saw about measure twice, cut once?

LET THE FUN BEGIN!

Once the panels were dry, I routed a shallow groove up both sides of the inner surface of each front panel, starting and ending about three inches from each end. In each groove I ran a pair of the Tef-Flex wires, with an extra foot or so for connections. I then covered each groove with a bead of silicon rubber caulk.

Having had little experience with a router, I decided against using routed joints for the cabinets, but I also did not wish to use wood screws, so instead I resorted to wooden-dowel/butt-joint construction. Using a dowel collar with a 3/8″ drill bit, I sank holes every 3″ along the edges of the pieces to be joined. I placed a little Elmer's wood glue in each hole, and then hammered in the dowels with a rubber mallet. To join the pieces, I applied

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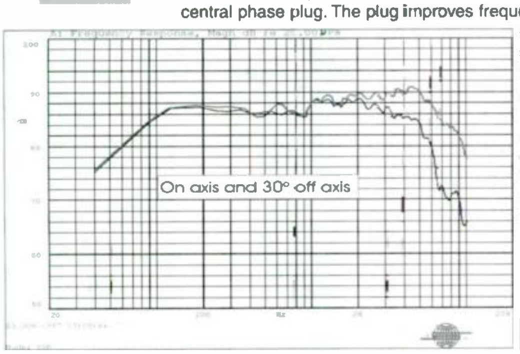
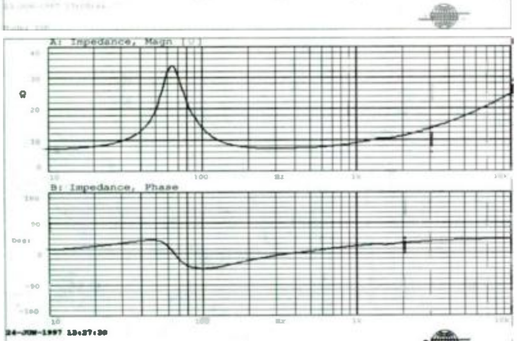
Bass-Midrange

W5 bass-midrange features:

- **PPF composite poly cone;**
- **narrow high loss rubber surround;**
- **double magnet shielded magnetic structure;**
- **high power handling aluminum former voice coil;**
- **central phase plug;**
- **high density aluminum die-cast frame;**
- **Symmetric Motor Drive (SMD) technology.**

The design of W5 driver based upon a beneficiary idea of an extended pole piece in a magnet system. But here we went further. Using FEA simulation we optimized a complete magnet structure and specifically shaped the pole piece to achieve a symmetric flux distribution along travel path of a voice coil.
This design approach provides better driving force linearity. It considerably reduces VC inductance modulation and DC offset of a moving system at high power levels. The result is - much less distortions and more effective VC cooling.
The cone/surround design is optimized to achieve extended and balanced frequency response without apparent top end resonances. W5 has exceptionally smooth rool-off, which allows easy blending with any type of tweeter even with 1st order crossovers.
To avoid air compression and internal air volume resonance the driver has a central phase plug. The plug improves frequency response and dispersion as well. The massive aluminum die-cast frame has been developed to minimize parasitic structural resonances.
The shielded magnet structure allows versatile audio/video applications.
W5 is a high performance driver, which can be used in a vast variety of combinations in top class speaker systems.
Recommended crossover frequency region is 2-4.5 kHz.





SPECIFICATIONS

Characteristics	Symbol	Value	Units
PRIMARY APPLICATION			
Nominal Impedance	Z	8	Ω
Resonance frequency	Fs	65	Hz
Nominal Power Handling	Pnom	50	W
Max Power Handling	Pmax	70	W
Sensitivity(1w/1m)		87.5	dB
VOICE COIL			
Diameter	ø	26	mm
DC Resistance	Re	6.4	Ω
Inductance(1kHz)	Lbm	0.6	mH
Length	H	10.5	mm
Former		aluminum	
Layers		2	
MOTOR SYSTEM			
Magnet System		shielded SMD	
Force Factor	BL	5.8	N/A
Gap height	He	5	mm
Linear excursion	Xmax	2.75	mm
PARAMETERS			
Suspension Compliance	Cms	750	mM/N
Mechanical Q	Qms	2.8	-
Electrical Q	Qes	0.62	-
Total Q	Qts	0.51	-
Moving mass	Mms	8	g
Effective Piston Area	Sd	0.0083	m^2
Equivalent Air Volume	Vas	7.3	L
Weight	M	1.5	Kg

RECOMMENDED ACOUSTICAL ALIGNMENT

DESCRIPTION	Vb,L	Fb,Hz	F_{-3},Hz
Closed Box (When subwoofer is used)	6	-	90
Vented Box	11	52	48

bass-midrange

W5

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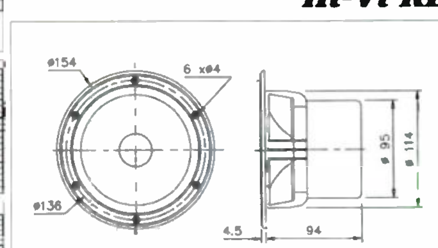

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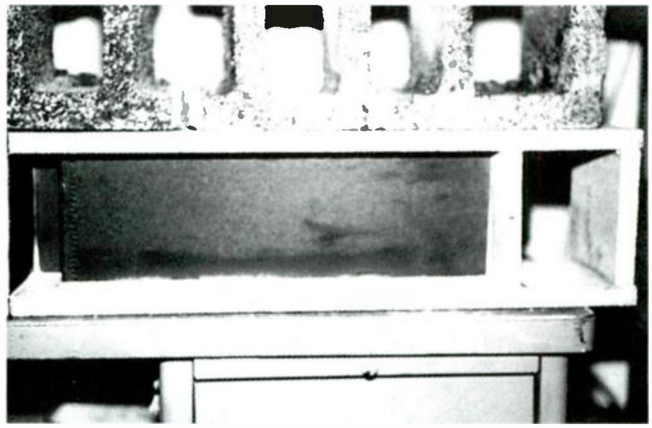


PHOTO 5: Partially completed cabinet showing inner transmission-line baffle covered with BlackHole damping material. Note cinder block weight holding cabinet side in place while glue dries.

glue to the protruding dowels, positioned the other predrilled boards onto them, and hammered the pieces together.

The trick to the dowel technique is to measure the hole positions accurately and to use the dowel collar on the drill bit to keep the hole depths equal. I formed each U-shaped section by joining a side panel with the front and rear sections, and then adding the top and bottom pieces. Next, I doweled in the internal pieces for the transmission line (*Photo 4*) and covered these front and back with the BlackHole Pad damping material (*Photo 5*). The BlackHole material is self-adhesive, so installing it was a breeze. In similar fashion, I next placed the BlackHole 5 in the top chamber, behind where the woofer and tweeter would sit (*Photo 6*).

MARKING THE PIECES

Thinking ahead, I marked each semicompleted piece with arrows and labels as to front/back, top/bottom, and so on, since once I added the final side, I would have a completely sealed box. Without markings, I would not have been able to know where to drill the cutouts for the drivers and the rear port (*Photo 7*).

With all marking completed, I drilled and doweled the U-shaped sections and front baffles, applied glue, and swung away with my rubber mallet! To ensure airtight boxes, I applied extra glue to all seams, then weighted each assembly with cinder blocks as the glue cured over the next week.

With the "box" assemblies now complete (*Photo 8*), I next measured and marked them up for the cutouts for the drivers, the rear port, and the crossover chamber. First I drilled a pilot hole, then with my saber saw I carefully cut out the traced outline for each driver. Next came the rear port and chamber entrance. I didn't veneer the box before cutting the holes because I thought I'd get a cleaner finish by veneering over the cutouts and using my router to reopen the holes.

After completely assembling both boxes, I precut the big sheets of veneer down to pieces about ½″ larger in all dimensions than the cabinet sides, giving me enough overhang to make clean edges with the router. I applied several coats of Constantine's contact veneer glue to both the box side and the sheet of veneer, allowing it to dry just to a

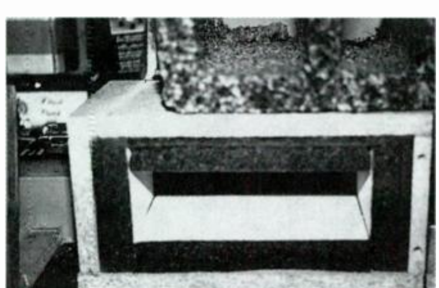


PHOTO 6: Closeup of cabinet showing upper chamber, where speakers will be lined with BlackHole 5 damping material.

PHOTOS 7: Assembled cabinets prior to veneering, showing crossovers, with one installed diagonally in lower chamber.

It can be your solution for **Perfect** HIGHT MID frequency reproduction

Midrange-Tweeter

SPECIFICATIONS

Characteristics	Symbol	Value	Units
Frequency Response	(±2dB)	850-15	kHz
Nominal Impedance	Z	6	Ω
Nominal Power Handling	Pnom	60	W
Sensitivity (1w/1m)	E	90.5	dB
Weight	M	0.4	kg

compact **midrange-Tweeter assembly**

DMNTN28

from ***Hi-Vi RESEARCH®***

DMNTN28 driver assembly features:

* easy to mount compact size common face plate;
* extremely close location of drivers resulting in "point source" radiation;
* 50mm treated fabric dome midrange;
* 28 mm treated fabric dome tweeter with ferrofluid cooled voice coil;
* shielded Neodymium magnet systems;
* drivers with vented central pole pieces and large non-resonant acoustic chambers;
* detachable back caps for critical "flat" applications.

DMNTN28 assembly is the long awaited combination of drivers which will eliminate many limitations in a contemporary loudspeaker design.

The midrange unit is the DMN model with 50 mm aluminum voice coil and hand treated fabric dome. DMN has a uniform acoustic power dispersion in the most critical frequency band. This driver allows an acoustically smooth and natural transition to a tweeter, creating a very open, clean and lifelike sound.

The tweeter is the TN28 model with hand treated fabric dome and 28 mm ferrofluid cooled voice coil.

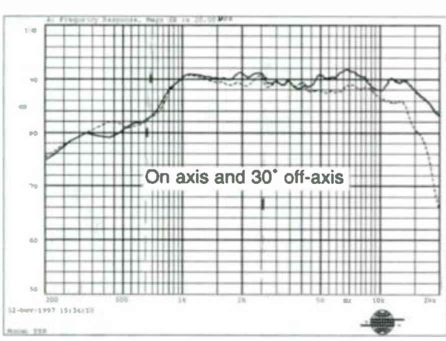
Both drivers have vented magnet systems and streamline shaped rear acoustic chambers, that provide better sound quality suppressing internal radiation.

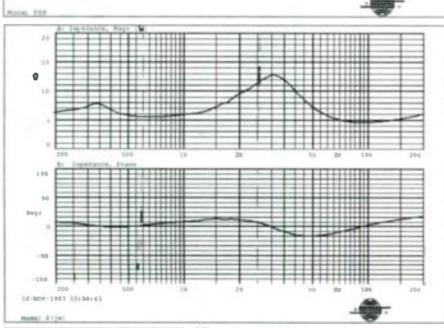
The drivers have symmetrical "sandwich" type Neodymium magnet systems. Two Neodymium magnets from both sides of the top plate create a "sandwich" type system which provides symmetric electromagnetic properties of the motor structure, reducing distortions.

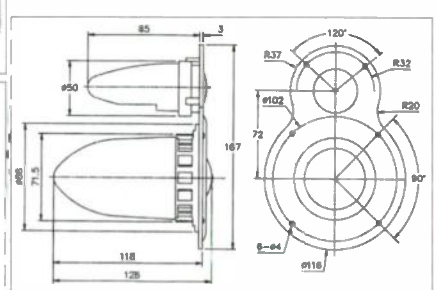
As a result of close proximity, the drivers create a soundfield similar to a "point source" radiator. This results in a wide and open soundstage, balanced and accurate reproduction.

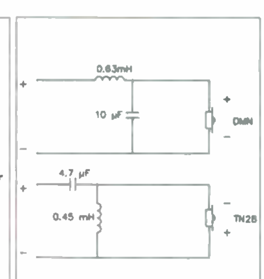
DMNTN28 assembly is a very versatile product, that will support a design flexibility and benefits in a home theater application, compact high performance stereo and in-wall system design.

The frequency response and specifications are given for combination with the recommended crossover shown here.









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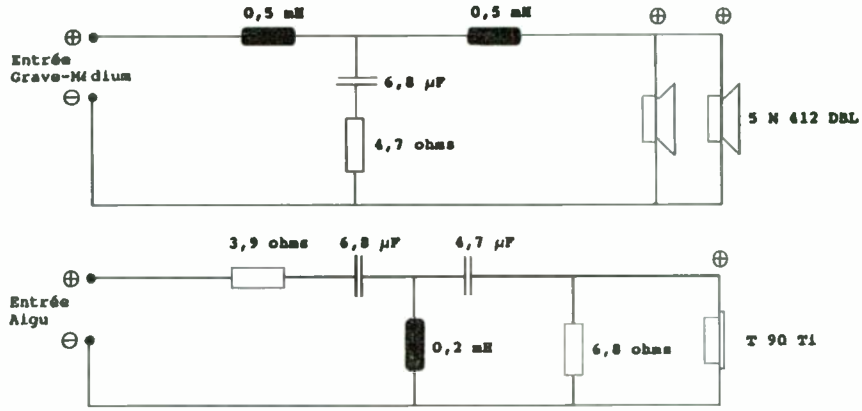


FIGURE 1: Woofer crossover.

tacky state. Then I carefully positioned the veneer and pressed it into place with a wooden roller.

I allowed this to dry for some time before trimming the edges with my router's roller bit. Then on to the next side, until at last I had two completely veneered boxes. After letting them dry for a day, I completed routing out the veneered-over openings, and then sprayed the inside of the line port with flat black paint.

FINISHING STEPS

The next step was to apply finish to the cabinets. Since the mahogany was so good-looking, I decided to use a finish that would bring out its natural grain. The undisputed choice here was Minwax Natural stain and finish, a clear stain that brings out the glow and true grain in any wood. The key here is letting it dry completely for a couple of days between coats. I then sprayed on several coats of clear enamel. If you spray it *lightly*, and thoroughly dry and sand it between coats, it makes for a stunning finish.

While the cabinets were curing, I next tackled the crossovers. *Figure 1* shows the woofer crossover. Due to the size of the components, I decided to use one board and build the high and low filters on opposite sides of it. (The manufacturer's suggested component placement is in *Fig. 2*.) I carefully laid out the circuits so that inductors would not interfere with each other. The board fit was tight, but I was able to install it diagonally in the chamber—no vibration here!

I soldered on the driver leads, and then the wires to the binding posts. I had toyed with the idea of two sets of posts for biwiring, but decided against it since I currently have only one amplifier. The binding posts themselves I mounted in a plastic cup that I then attached to the cabinet opening with brass screws. Next, I soldered the internal cables onto the drivers. Finally, I caulked the driver openings with black silicon rubber, mounted and screwed down the drivers, and re-caulked. Finished at last!

THE HILLS ARE ALIVE...

Finally I was ready for the grand moment. I struggled the 50 lb cabinets into my living room and connected my Golden Tube Audio SE-40 tube amp to them. Loading a Charlie Parker CD, I pushed play, and the sound was...horrible! I couldn't believe it! What had I done wrong? Soldered the crossover incorrectly? Reversed a cable somewhere? It was then that I looked over at the speakers and noticed the woofer cones wildly pumping in and out. Of course, you dummy—the speakers need to break in!

Well, I left that CD on, and over the next day played many others. Every hour that passed, the speakers sounded better and bet-

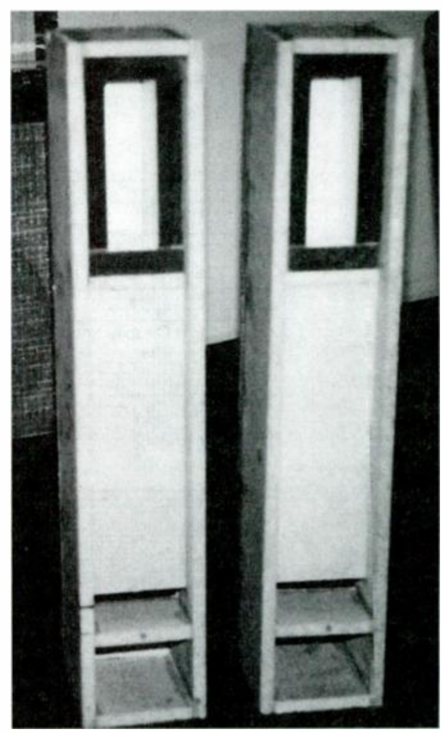


PHOTO 8: Partially completed cabinets prior to installing front and rear baffle boards, showing lined speaker chamber and lower end of transmission line above crossover chamber.

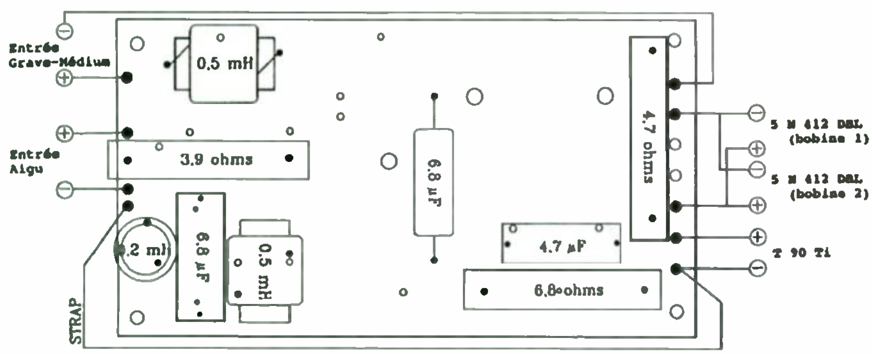


FIGURE 2: Crossover-board component placement.

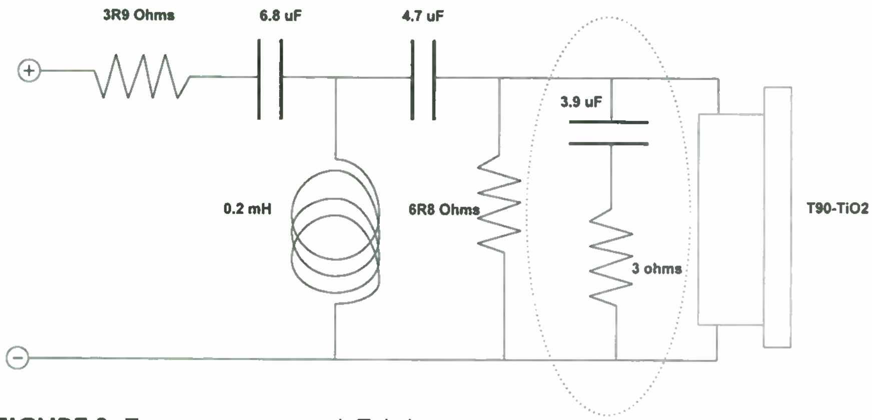


FIGURE 3: Tweeter crossover with Zobel.

ter. Finally I was ready for a real listen. I put on Maurizo Pollini's album of the *Moonlight Sonata*. Wonderful! There was Maurizo in my living room playing his piano. The soundstage was wide and deep, and the sound was "just there," not seeming to come from the speakers themselves. I could hear every little detail, even his feet on the pedals. And the dynamics were stunning! Even off axis, in the kitchen or dining room, the sound was still lifelike and detailed.

One after another CD and album brought that same sense of clarity and realism. I played the Stereophile test CD, and was able to determine that the speakers could go below 40Hz. Success! I later made a base for the speakers, routed out of 2″-thick MDF painted black and spiked. This added to an already stunning sound.

WHEN IN DOUBT...MODIFY

There did appear to be one fly in the ointment, however: some sibilance on the very high end, particularly noticeable in people's voices as a slight "lisp." It was not particularly bad, but once I notice something, it grows to annoy me. I asked the people at North Creek about this, and was told that tweeters, particularly metal domes, are subject to a rising impedance. They suggested adding a Zobel to the tweeter crossover to counter it, which I did (*Fig. 3*).

This modification not only killed the sibilance, but also made the top end sound smoother. In hindsight, the problem may have been caused by my use of 12-gauge coils, which have a lower resistance than the small-gauge coils in the original design.

In the end, I accomplished what I had set out to do—build a full-range, smooth, natural-sounding, floor-standing speaker. This project took the better part of six months to complete, so would I do it again? You bet I would! There is truly nothing like building speakers yourself and having them work well.

SOURCES

North Creek Music Systems
PO Box 1120, Old Forge, NY 13420
(315) 369-2500
Drivers and crossover components

Orca Design & Manufacturing Corp.
1531 Lookout Dr., Agoura, CA 91301
(818) 707-1629

Willard Brothers Woodcutters
300 Basin Rd., Trenton, NJ 08619
(800) 320-6519
Rare veneers and hardwoods

Zalytron Inc.
469 Jericho Tpke., Mineola, NY 11501
(516) 747-3515
Focal drivers and BlackHole products

It can be your solution for **Perfect** LOW MID frequency reproduction

Bass-Midrange

F6 bass-midrange features:

* **light and extremely rigid cone made from Kevlar/paper composite;**
* **specially made high loss rubber surround;**
* **shielded double magnet motor structure;**
* **high power handling aluminum former voice coil;**
* **central phase plug;**
* **high-density aluminum die-cast basket.**

The design of F6 has been optimized for balanced and dynamic low bass reproduction in small or medium vented systems. Midrange clarity and tonal balance is remarkable.

F6 utilizes a newly developed matrix of Kevlar and paper fibers. As a result, the cone weighs less, is more rigid and has an improved dampening factor over conventional Kevlar materials. The back of the cone is hand coated with a special dampening compound to further maximize performance stability and control of structural resonances. The driver utilizes a central phase plug to avoid air compression and internal air volume resonance. The plug improves frequency response and dispersion as well. The aluminum former voice coil and air transparent spider contributes to the linear operation of the transducer at high power levels.

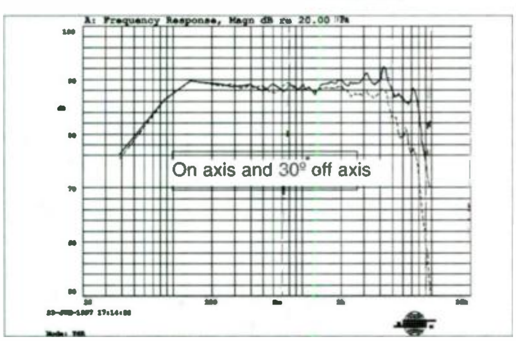
The massive aluminum die-cast basket has been developed to minimize parasitic structural resonances.

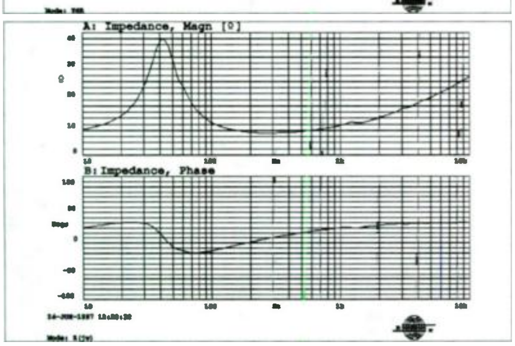
The shielded magnet structure allows the F6 to be easily incorporated into audio/video applications. The driver may be used in a small closed box as a bass-midrange unit, when a subwoofer is employed.

Recommended crossover frequency region for two-way system design is 2-3 kHz.

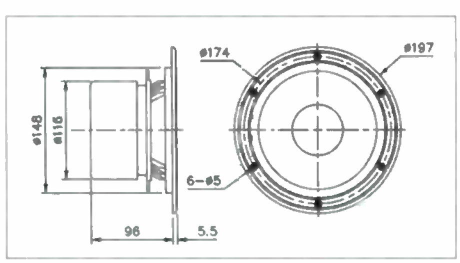
SPECIFICATIONS			
Characteristics	Symbol	Value	Units
PRIMARY APPLICATION			
Nominal Impedance	Z	8	Ω
Resonance frequency	Fs	42	Hz
Nominal Power Handling	Pnom	60	W
Max Power Handling	Pmax	90	W
Sensitivity(1w/1m)		89	dB
VOICE COIL			
Diameter	ø	26	mm
DC Resistance	Re	6.4	Ω
Inductance(1kHz)	Lbm	0.69	mH
Length	H	14.5	mm
Former		high temperature ASV	
Layers		2	
MOTOR SYSTEM			
Magnet System	shielded with compensating magnet		
Force Factor	BL	8.13	N/A
Gap height	He	7.4	mm
Linear excursion	Xmax	3.55	mm
PARAMETERS			
Suspension Compliance	Cms	996	mMN
Mechanical Q	Qms	1.96	-
Electrical Q	Qes	0.368	-
Total Q	Qts	0.31	-
Moving mass	Mms	14.4	g
Effective Piston Area	Sd	0.0125	m^2
Equivalent Air Volume	Vas	22	L
Weight	M	2.7	Kg

RECOMMENDED ACOUSTICAL ALIGNMENT			
DESCRIPTION	Vb,L	Fb,Hz	F-3,Hz
Compact Vented Box	10	53	56
Medium Vented Box	14	48	50





bass-midrange F6 from *Hi-Vi RESEARCH*®



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MUSIC ON THE BEACH

By Bill Fitzmaurice

Most of the speaker designs that appear in these pages strive for the holy grail of flat frequency response in typical listening rooms. But for the professional sound contractor, a typical "room" may be the size of a football-field, making speaker design a very different proposition. The designs in this article reflect special solutions to special problems.

ON THE WATERFRONT

The site in question is the Naswa Resort Beach Bar at Weirs Beach, Lake Winnepesaukee, New Hampshire (*Photo 1*). Some ten years ago, I mounted four weatherproof, dual, 10″-woofer two-way cabinets outside the bar. While they worked well enough, the resort's business had expanded greatly since their installation, and the owners now wished to expand the sound system's coverage area to include the entire beachfront—an area 350′ wide and 50′ deep.

I could simply have spread the existing cabinets, but that would have placed them an average of more than 75 feet apart, resulting in massive hot spots and dead zones. Splitting the woofers and tweeters into eight separate boxes would have worked, but these woofers needed 3ft^3 cabinets, and the clients wanted something less obvious to the eye. We settled on using the existing woofers in four subenclosures of about 6ft^3 each, three of which were to hang out of sight on the rear of buildings (*Photo 2*), with the fourth under a stairway near the far end of the beach.

I would then mate the existing tweeters with mid-bass drivers in eight satellite cabinets, six mounted on the building roofs, and the last two on tree trunks near the stairway concealing the fourth sub. This scheme would give excellent coverage near the bar and grill buildings, and reasonable coverage at the beach end, some 200′ away.

Once I had decided on the layout, cabinet design was next. Using two drivers per sub cabinet was a matter of wiring convenience as much as any other consideration. Series-wiring the drivers for 16Ω per box allowed simple daisy-chain wiring of two boxes per channel for 8Ω, with the dispersion characteristics of the subs making the wide spacing between cabinets feasible. Since I had two drivers per cabinet anyway, it also allowed experimentation with a different alignment.

DUAL-VENTED ENCLOSURES

The average bandpass subenclosure, with one sealed and one vented chamber, has a very narrow and peaked passband. A dual-vented chamber design can overcome that, but with possible patent problems (Bose) in a cabinet made for commercial sale. It occurred to me that I could mount the two drivers on opposite walls of a central sealed

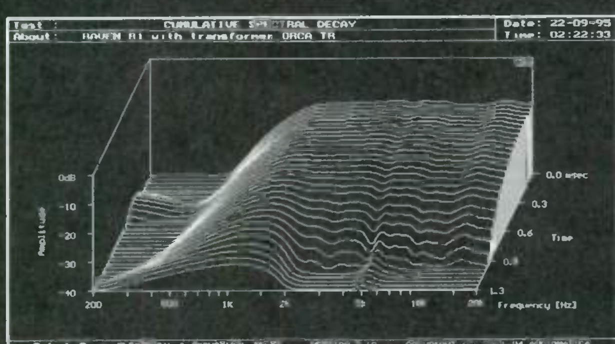
PHOTO 1: The beach at the Naswa—a very large listening room. The coverage area extends from the trees on the far left to the small boathouse on the far right.

PHOTO 2: A subenclosure in place on a building rear wall.

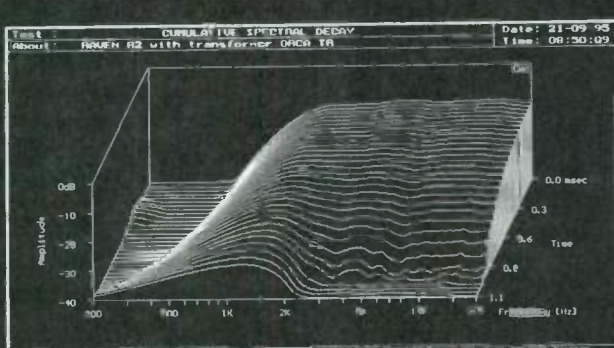
RAVEN

HIGH EFFICIENCY PURE RIBBON TWEETERS

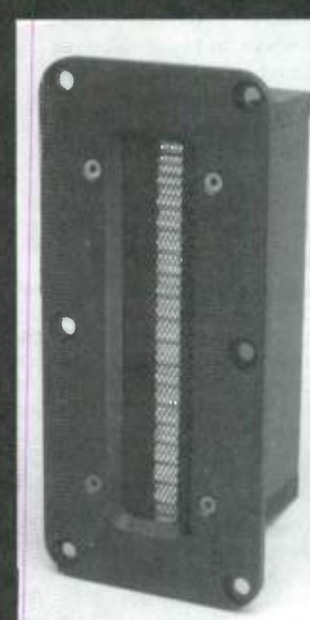
ORCA is sincerely proud of introducing these exceptional high frequency transducers from France. The RAVEN tweeter is a true ribbon tweeter, possibly the purest transducer available today. In a dome tweeter the signal is carried through the voice coil wire, and the sound is radiated by the dome attached to the voice coil. Here, the carrier of the electrical signal and the radiating diaphragm are one and the same part: the ribbon itself. Furthermore, the RAVEN ribbon is 100% pure conductive material, no metalized film. To have an idea of the high frequency performance of the RAVENs, imagine that the moving mass here is about 30 times less than a high quality dome tweeter. The music comes through effortless, almost immaterial. The special and massive NeFeB magnet of the RAVENs is five times more powerful than a conventional magnet. The result: the RAVEN R1 is capable of 118 dB peak with no measurable distortion (R2: 120 dB). At 10WRMS, that is continuous power now, R1 reaches 105 dB with less than 1% distortion, and R2, 107 dB. The RAVENs come with a specially designed matching transformer (very low distortion, low loss and wide bandwidth) for optimum coupling with your power amplifier. Now look carefully at the decay of these units !



RAVEN R1
KGS 1.14
LBS 2.5
92 x 80 mm
3.63 x 3.15 in.
Moving mass:
0.0061 g
0.0002 oz.
dB/W/m 95
2 KHz to 40 KHz



RAVEN R2
KGS 2.22
LBS 4.9
166 x 76 mm
6.54 x 2.99 in.
Moving mass:
0.013 g
0.0005 oz.
dB/W/m 98
2 KHz to 40 KHz



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chamber with each one firing into its own vented chamber (*Photo 3*), and these chambers tuned to different frequencies to widen the overall cabinet passband.

It may be possible to model this arrangement on a computer, but I did not have that luxury. I did, however, have four cabinets to build, so I could experiment to find the best way to fashion this alignment. As with standard B/P alignments, I divided into subchambers the total required box volume of a standard T/S design of 6ft^3 for two drivers (actually 16″ × 16″ × 48″).

My first attempt used a chamber-volume ratio of 2:2:1, with a sealed/vented/vented alignment. Utilizing 6″ PVC pipe for ducts, I tried various combinations of lengths in each chamber, tuning the larger chamber low, the smaller chamber high, and vice versa, with less than optimal results. While able to achieve performance at least equal to a standard sealed/vented alignment, I was not satisfied. The next cabinet used the same scheme, but with the sealed chamber proportionally larger than the first effort—3:2:1—with no improvement in results.

For my third attempt, I divided the box into three equally sized chambers, each slightly over 2ft^3. Using an F_3 of about 42Hz, with maximum efficiency at 50Hz, I set up a sound level meter ½m in front of the cabinet, using various lengths of PVC to duct the first chamber, and sweeping with a tone generator. A 12″ length of pipe in the first chamber gave the desired F_3. I then tried various lengths in the third chamber, hoping to get a second efficiency peak somewhere around 100Hz, with an upper-end rolloff F_3 of at least 120Hz, which would allow the desired crossover point of 150Hz to the satellites.

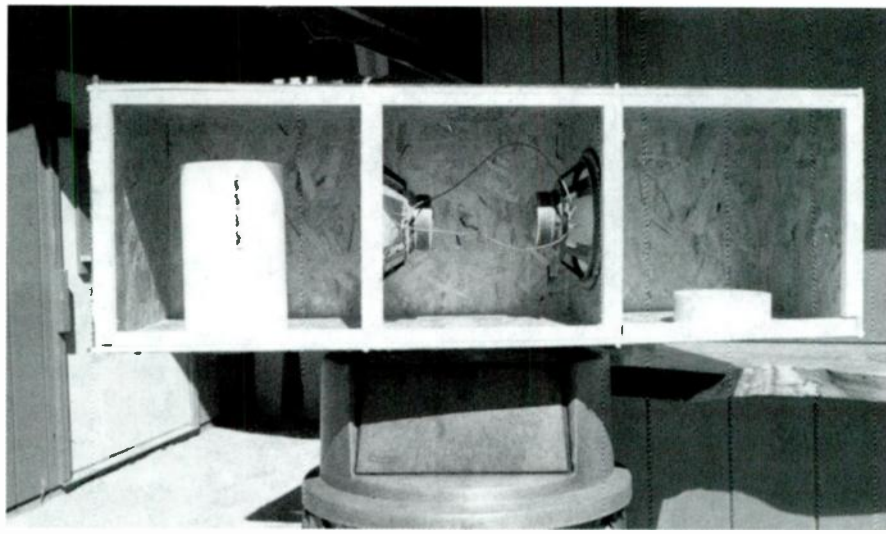

PHOTO 3: The subenclosure cabinet, final design, prior to mounting on building wall and installing the last panel.

The magic size turned out to be three inches—exactly one-quarter the length of the duct in the other chamber. With this ratio, I obtained a near-field response (½W at ½m) of ±3dB from 40–140Hz, with peaks at 50 and 100Hz, and a minimum at 75Hz—a very symmetric response curve (*Fig. 1*). Having achieved my design goal, I made the fourth cabinet identical to the third.

The final step of the alignment experiment was to run an impedance plot. As you would expect, there was an impedance peak (31Ω) at 100Hz, while impedance above and below that was a constant 15Ω. The big surprise came when I got down to 50Hz, where another peak should have accompanied the first. But this simply did not appear—in fact, the impedance held at a constant 15Ω all the way down to 20Hz, as low as my generator would go. So from an impedance standpoint, this cabinet should not have an F_3 of 42Hz, but rather 84Hz. More about that later.

THE SATELLITES

Having finished the subs, I turned to the satellites. Here, cabinet design was more a function of utility than sound. I needed to mount them either on the building roofs or high in trees in order to get the required dispersion. They also had to be completely weatherproof, yet still give a reasonably good sound. Since the subs' output ports faced downward, they would be rain-proof anyway, but the satellites presented more of a design challenge.

I arrived at a triangular design, resembling a lean-to, which would keep their size small, yet make them weathertight (*Photo 4*). With a crossover point of 150Hz from the subs, a sealed cabinet of only 1/3ft^3

Reader Service #45

PHOTO 4: A satellite in place on a building roof.

HZ	dB
32	65
42	86
50	91
64	86
75	85
80	86
100	91
120	90
150	80
180	65

FIGURE 1: Triple-chamber frequency response with response chart plot points measured ½W @ ½m.

would be quite adequate. The final dimensions were 12″ × 12″ × 8″. For drivers, I bought the cheapest I could find that would do the job—some close-out AR 6½″ drivers from Parts Express for only $7.90 each. These would be joined by the existing piezo horn tweeters from the old cabinets.

The efficiency of the mid-bass drivers was 87dB, while the piezos ran at 93dB, which would be a mismatch in a hi-fi application. In order to make the cabinets weatherproof, I would need to cover the baffle with an aluminum louvered vent, which in effect would work sonically as an acoustic lens to broaden horizontal dispersion.

For this application, with an average distance of some 30 feet between cabinets, this widening of the tweeters' usable horizontal axis was an added benefit of the weatherproofing louvers, while the higher efficiency of the piezo horns overcame the high-frequency attenuation also resulting from the louvered baffle.

CABINET MATERIALS

Another compromise with the realities of commercial design was in the materials I used for the cabinets. They were all constructed of 7/16″ OSB (oriented strand board). In the last few years, OSB has become more common as a commercial cabinet material, since it is the cheapest stuff available. While 5/8″ or ¾″ is more commonly used, 7/16″ was viable in this case.

The satellites' triangular shape and small size made vibration a non-issue. In the subs, cabinet-wall vibration was far less than might be expected, and was greatly overshadowed by the vibration induced by the

building walls on which the cabinets were mounted.

Working with OSB is somewhat tricky, but not impossible. It is far easier to cut than MDF, and is lighter than plywood. It has a tendency to flake at the edges, and is very porous to glue, so construction adhesive works much better than woodworking glue. It also splits easily when you drive screws into an edge, so glue-blocking makes the job easier than butt-jointing. But using glue blocks adds expense, which undermines your reason for choosing OSB in the first place.

You can successfully butt-joint it by using drywall screws as long as you do not screw within two inches of the panel end and use the largest possible drill size for predrilling that still allows screw retention. For securing removable panels, blocks are a necessity.

WIRING

Wiring up the installation was almost as time consuming as constructing the cabinets. To keep an 8Ω per channel load, it was necessary to wire the four satellites for each channel in a series-parallel configuration. The distances involved brought the total wire used to over 700 feet. Using 14 gauge on the subs and 16 on the satellites, the wiring expense actually exceeded the cost of the cabinets.

The final results exceeded both my own and my client's expectations. The system is driven with a 180W/channel amp, and when run at 12dB below clipping (amp volume controls set at 12 o'clock) the sound levels are extremely high. Even a ten o'clock setting gives a strong "party" level. Dispersion is very smooth, and the bass is strong. Even outdoors most people say it sounds better than their home stereos—though that may be simply a reflection on the poor quality of their speakers. But what's most important is that the client is very happy with both the product and the cost.

DESIGN NOTES

I arrived at this design to prevent possible patent infringement hassles. Though I have never seen such a design before, it may well not be its first usage. I'll leave that problem to the lawyers. Should you wish to try it yourself in home applications, here are some suggestions.

First, use standard T/S computations with your intended drivers to arrive at a box volume. Since you're using two drivers, double that volume for the actual box size. Divide that result by 3, giving two vented and one closed chamber, all of equal volume. Again, using standard T/S calculations and trial and error, arrive at the correct duct for one chamber that gives the desired F_3. Since this alignment does not result in an impedance peak at the lower resonance point (F_b), you must tune the box using a sound meter as described in the text above.

The duct for the remaining vented chamber is one-quarter the length of the duct in the first. This gives a high resonance one octave above that of the first, with the respective F_3s over one-and-a-half octaves apart. My experimentation with other duct-size ratios shows this to give the widest possible response with minimal peaking.

Trying to achieve wider bandwidth will result in excessive dip between the respective F_3s, while tuning for narrower bandwidth gives higher efficiency, with a peaked response resembling a standard two-chamber closed/vented alignment—attainable just as well without the expense of a second driver.

Driver choices abound, depending on application needs. Using two 8Ω drivers wired in series for 16Ω allows the use of two cabinets per channel as in the above installation. You could use two 8″ dual-coil woofers, allowing a variety of impedance choices and a very small cabinet. Or you could use two 8Ω drivers wired in parallel for 4Ω for a very efficient box, assuming your amp can handle 4Ω loads. But remember that this is not an isobaric design. Despite being physically aligned 180° from each other, the drivers must be wired in phase, or they will cancel each other out.

As to why I did not get a second impedance peak at 50Hz, I have no clue. This design does not work like two separate cabinets wired together—a change of duct size in one ported chamber affects the output of the other as well. The lack of a second impedance peak is no doubt a quirk of this alignment, which I am sure that someone more technically oriented than myself will soon explain.

Having arrived at my design goals early, I did not experiment with chamber ratios beyond finding that the two vented chambers must be of equal volume. It is quite possible that you could make the passband response even flatter or the efficiency higher with a smaller or larger ratio of the closed chamber to the vented ones. I'll experiment further along that line, though if a reader does so, I'd like to hear of the results.

I'm also operating under the assumption that this alignment has not yet been computer modeled or patented, but again, I could be wrong. I am sure that if the boys in Framingham [Bose] have already tried this, we'll know about it soon enough.

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REBUILDING THE AR-3*a*, PART 3

By Tom Yeago

I'm going to embark on a detour through some theory, but don't worry. It's all really common sense once you get past a couple of notions.

THE MASS QUESTION

The first notion you must accept is that moving-coil loudspeakers are supposed to be constant-acceleration devices through their useful range. This means that for flat output, the moving mass is accelerating at the same rate, regardless of frequency. This is a good thing, too, because a constant force applied to a mass gives a constant acceleration.

All that the motor (which supplies the force) cares about is the mass. The acoustic-output part of the load is laughably small compared to the mass of the cone et al. (M_{ms}). This is simple-minded behavior, and it's the operative model most of the time.

Now compare constant-acceleration devices to the two others: constant-velocity and constant-excursion (or amplitude) devices. If you hold acceleration constant, velocity declines directly as frequency increases, and amplitude declines by the square of the frequency increase. Hence the punishing demand for excursion at the low end of a driver's response, where an octave of bass extension (f/2) demands a fourfold increase in displacement.

For constant-velocity devices, acceleration increases directly with frequency, and excursion decreases with the increase in frequency. For a constant-excursion device, velocity increases directly with frequency, and acceleration increases directly with the square of the frequency increase. That is, this sort of device will experience fourfold acceleration with each octave (twofold) move into the treble.

CONSTANT-ACCELERATION DEVICES

With constant-acceleration devices, the mass dominates the load. But as you move down in frequency, you reach a range where the compliance becomes a significant component of the load, then equals the mass as a load component (resonance), and finally increasingly dominates the load as frequency decreases. Below resonance, you have a compliance-loaded system, a constant-amplitude type. So below resonance, you see the cone moving in and out the same distance (given constant voltage input), regardless of how far below resonance the signal is. Now, the demands of acoustics (i.e., the nature of the air load) mandate fourfold excursion increases per octave bass, and constant excursion is received as a 12dB/octave rolloff.

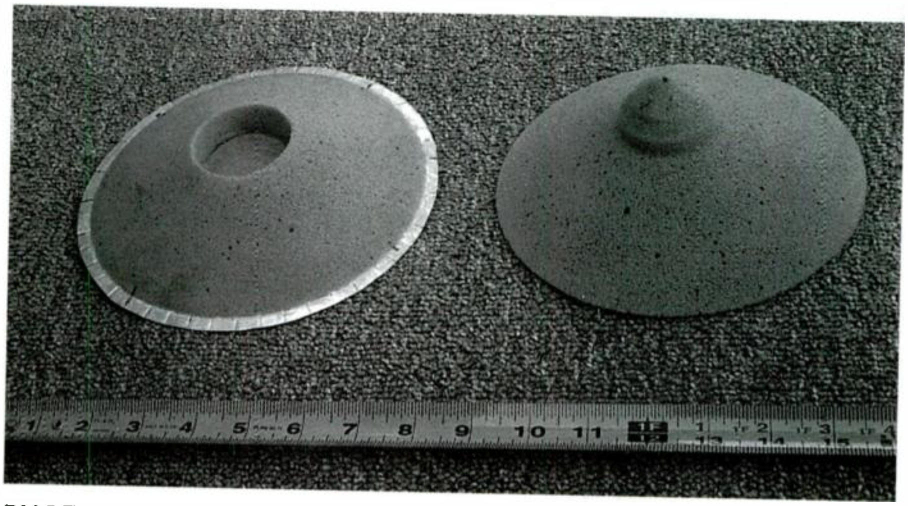

PHOTO 7: Two foam inserts for the woofer cone. At right is a cone after sanding nearly to final shape on the woofer-and-sandpaper fixture. At left is a finished insert, complete with skin glued to the front and the hole at the apex for the motor former. Note the segmenting of the skin's perimeter to conform to the cone's profile.

So much for the low end. At the high end of a driver's response, a number of things are going on. It's a mess. First, the motor often isn't dealing any longer with a simple mass. I refer to cone breakup, non-pistonic operation. This means the motor sees less mass because the cone isn't moving as a solid piston any more; it's flexing.

The energy that goes into flexing comes back to work with or against what the motor's trying to do at different frequencies, depending on the size and structural specifics of the cone (or dome). Many professionals have made peace with this deviltry and profess to be satisfied with the accommodation. I say it's spinach. A hard cone is good to find.

The other troubles at the driver's high end are basically geometry come home to roost, all stemming from a driver trying to reproduce wavelengths comparable to its own dimensions. The pros talk about *ka*, which is defined as the ratio of the circumference of the moving piston to the wavelength (in air) it is radiating. At ka = 1, wavelength equals circumference. At ka = π, wavelength equals diameter. Now, since 1kHz has a 13.4″ wavelength, you can figure out that most drivers' bandwidths involve a ka of much less than 1.

A WATERSHED

At ka = 2, there's something of a watershed. Above that (at shorter wavelengths, i.e., treble range), the air becomes a constant and resistive load for a simple piston. Below ka = 2, the resistive (i.e., useful) part of the load declines precipitously, in accordance with the square of the frequency; that is, for every octave down, ka is halved, and the resistive component of the load drops fourfold. Sound familiar? That's why you need constant-acceleration devices here.

Above about ka = 3, you need a constant-amplitude device for flat-power output. But the motor doesn't care. All it sees is the mass it must move, so excursion still drops fourfold per octave. The air interprets this as a drop in power output of 12dB per octave.

Now you have more geometry to contend with. At short wavelengths, where ka

= 2 and above, your perfect piston, a mass-controlled, constant-acceleration device, starts beaming. It is no longer omnidirectional. Power response drops, but on-axis response holds up.

There are, however, other geometric problems to deal with at these short wavelengths. Wackiness ensues if the cone's depth is comparable to wavelength and if the cone is misbehaving. So I guess the second odd notion you must accept is that geometry complicates things. In *Acoustics*, Beranek points out that a cone really should not be more than one-tenth as deep as any wavelength it hopes to reproduce. Think about that the next time you see a 5″ cone (typical depth, about 0.8″) rolled off at 3kHz (wavelength, approximately 4.5″).

MORE ABOUT MASS

Now you see how mass affects output. Double the mass, and the motor can accelerate it only half as fast, excursion is halved, and output drops fourfold (down 6dB). Currently, conventional wisdom distains massive moving systems. They are cast as the heavies in our little drama where efficiency is a paramount virtue. Efficiency is good, right?

Sure, efficiency is good. But mass has its virtues, too. If you're hoping for good bass extension in a reasonable box with an air-suspension design, you must have mass. Just make sure it's thoughtfully deployed. Use what you need in the motor coil, then apply the rest to structural ends to give you a stiff piston that is in this case—since we're shamelessly copying the B139—also essentially flat across the face.

But another point about massive cones is that they're better at keeping the noise inside the box, where it belongs. On the other hand, all the moving mass means that a lot more power is being fed into the box walls (action and reaction, remember?) via the woofer frame. Think about it. Since loudspeakers radiate so little actual acoustic energy per watt of input, do you really believe airborne power is shaking the panels? No. It must be mechanically borne vibration.

Now consider the mass versus structural attributes of cones and domes. The cone is driven at the apex, so its mass and structure are such that the cone, near the motor, has the structural burden of moving not only its own mass, but all that which is further out. You can add curved profiles and taper the thickness with radius, but most of the mass is still distant from the motive force, where structure doesn't help it much. It's a lot like trying to lift a wedge of spongecake by the pointy end. But, alas, a cone makes for an easily designed motor.

With domes, it's just the other way around, in that the mass of the piston is distributed near the motive force. And as you move inward, away from the motor, not only does the remote area each piece of dome must support become smaller (the wedge gets thin), but the domed structure makes more of a contribution toward keeping things stiff. But a dome motor is a bear to design if you wish good excursion and efficiency.

Now for the actual design work. Since the AR woofer's piston diameter is about 9.15″, that means ka = 2 at just over 900Hz. Since I intended to have a nice strong piston, I planned to roll it out at 500Hz or so, one full octave before any wackiness could possibly ensue. The woofer would be doing all the heavy lifting (re the power spectrum), and I knew the AR domes were pretty capable. I had confidence.

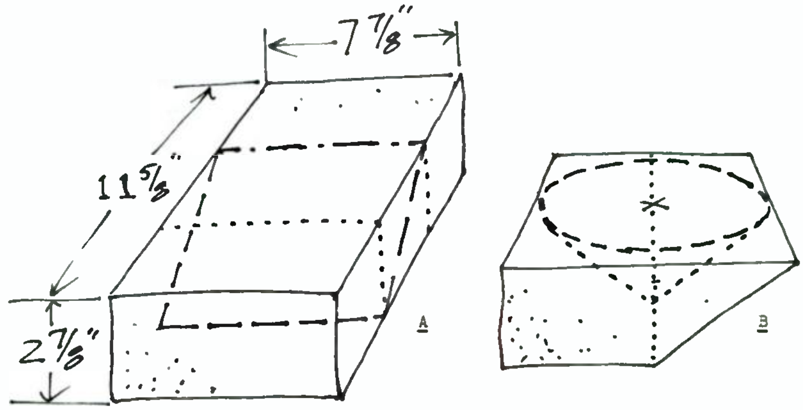

FIGURE 4: Styrene block glue-up and cut-up. A is initial glue-up; dotted lines are glue seams. Dashed lines show how to cut the block in two; B shows how I rough-cut a conic insert from a foam block.

A B139 WANNABEE

So I went shopping for foam and bought some blocks of green, fine-grain, styrene foam at Wal-Mart—the Better Homes brand, three blocks for less than $2. The blocks weren't large enough to carve a cone insert from a single block. (I figured on inserts about 17cm in diameter, which means about 3.5cm thick at the motor former.) By gluing all three blocks together, I saw I could carve out two rough cones, each with a glued seam straight down the middle. In the process, I'd discover how well epoxy works on styrene (*Fig. 4*).

I flattened mating faces with sandpaper taped to glass and by rubbing them gently against each other. Then, when I was sure I had good fits, I blew off most of the dust. (This dust is a major nuisance. Always work outside if possible.)

To apply the epoxy, I used a piece of that tissue they wrap shirts in. Good stuff. (All reference to tissue in this project means this paper, *not* facial or toilet tissue.) I laid out a big piece of bumper-sticker backing paper, mixed up about $3cm^3$ of epoxy, laid a letter-size piece of tissue on the backing paper, and proceeded to work epoxy into the tissue over an area somewhat larger than that to be glued.

Once the paper was saturated with epoxy, I clamped the glue-laden tissue between the blocks to be glued, worked them back and forth a bit, took out the tissue, aligned the blocks, pressed them together, and held them in place with masking tape. I repeated the procedure to glue the third block to the other two. Then I strapped all three tightly together with masking tape, producing two strong glue joints to form the rectangular block from which I fashioned my cones. I let it cure for 24 hours.

DOPING THE WOOFER CONE

The next step is to dope the woofer cone, starting with a clean surface—all traces of surround foam, the dust cap, and motor-coil lead irregularities gone. If any nonspecific residue remains on the cone, an artgum eraser will probably take it off.

Your cone and spider should weigh about 47g. Work epoxy into the cone until it weighs about 54g. That's about $7cm^3$ of epoxy. Since you're presumably using slow-cure epoxy, if you work fast—and you can if you use a playing card as a squeegee—you can get it all on from one batch. Work

MORE ON GLUES

As I mentioned in the section on glues in Part 2, I'm not particularly comfortable using over-the-counter epoxies in high-temperature applications. That's one of the reasons I insist on liquid cooling. If the heat is quickly conducted away from the motor coil, the epoxy will be just fine. Up to the time I wrote this, nearly two years after putting the first unit to work, I've had no discernible problems.

Since I have no access to anything claiming to be a high-temperature adhesive, I didn't pursue it. Whenever I'd run across someone who might have any actual expertise in the area, I'd ask him, but no luck. From what I'd read, the cyano-type adhesives ("super," or instant-setting glues) didn't hold any more promise than over-the-counter epoxies.

Then I was reminded of the class of adhesives known as anaerobic, because they won't set as long as they're in the open air. But put them in a closed container with no oxygen, and they start to set up. You know these glues as "Loctite." You dab a little on a fastener's threads, and when you tighten it, the liquid is deprived of oxygen, so it hardens. Voilà!

I reasoned that since these adhesives were intended for use in auto engines, they'd be able to take the heat, and the information on the display card for Loctite Red (aka 271 high-strength "threadlocker") says it's good up to 300°F. This sounded fine to me. I bought a tube and put it to the test, comparing it with epoxies from Devcon and Duro.

I mixed up small samples of each and let them cure, plugged my soldering iron into the Variac, and applied the heat. Both epoxies behaved pretty much the same. At 60V (about 220°F), they seemed fine; at 70V, still nothing obviously wrong; but by 80V (about 320°), the Duro started to discolor, and while neither one melted, they now had the strength of cheddar cheese: easily crumbled or sliced. The Loctite Red, on the other hand, was just fine at these levels, seeming only a little weakened at 85V (about 350°), meaning you could crumble it a little; but it never smoked or melted.

So when I get around to doing another set of woofers, I'll use Loctite 271. I figure all I need to do is put on the 271, assemble, make sure the parts fit tightly, apply a few good tight turns of Saranwrap, and I'm done. I don't know whether I'll go the Loctite route on the mid and treble units, since they're immersed in the ferrofluid, but I'll definitely use it on the woofer's coil-to-former joint and for gluing the third layer of wire to the stock motor coil.

Finally, if anyone out there has anything to contribute to the glue question, I'd very much like to hear it. —TY from the center out, making sure you apply the epoxy while it's still runny, so it will readily soak into the cone. You'll have plenty of time to work, but don't worry it to death. Just put on an even coat, working any excess toward the center where it will do the most good.

Now turn the cone upside down on a flat, hard surface, weight the apex with a couple of pounds, and the cone will cure to a nice round shape. Let it sit 24 hours. Check your work by weighing the doped cone. If yours doesn't soak up the glue as readily, just go with a good, even coat and leave it at that.

Now to prepare the aluminum skin for the front of the foam. Clean off a flat glass working surface. Tape down a 12″ square of standard aluminum foil (¾ mil, I believe), with the dull side up. Make it good and flat—no wrinkles, no creases, no blemishes. Stretch it evenly with masking tape. Now mix up some epoxy and spread it over the middle nine inches or so, not thick, but making sure the foil is evenly covered.

Now lay a piece of tissue paper onto the glue, covering it entirely. Tape down the corners, stretching the paper flat. Now start rubbing the paper onto the glue, spreading the glue out more evenly and chasing away air bubbles as you go. A hard rubber or plastic roller works well here, but you'll do fine just rubbing with a playing card or something similar.

Wait half an hour or so, and then mix up some more epoxy and spread a thin layer on the tissue where it's glued to the base layer of foil. Place another sheet of blemish-free aluminum foil on the epoxy, and rub it onto the glue layer just as you did with the tissue. Rub or roll it every which way, ensuring even coverage and adhesion. Then stretch the foil flat with masking tape, and rub again. Lay a dozen or so sheets of ordinary copier paper on the best section (you only need a disc 19cm in diameter) and weight that down with some heavy books. Let it cure for 24 hours.

FLYING FOAM

Now back to the foam. Cut the glued-up block in two as shown in *Fig. 4*. Then draw a 7″ circle on the side with a marker, as shown, and mark where the apex of this cone falls on the seam opposite the circle. If you centered the circle, the apex will be at the midpoint of the seam.

Now start hacking off the excess. If you have a hacksaw that lets you turn the blade 90°, that will work well here. As you hack off wedges, test those containing a seam to see how good your glue job is. If you find the joint breaks apart easily, start over with more foam, fashion better mating surfaces, and blow or vacuum the dust off them more thoroughly.

After the rough work with the hacksaw, use a sanding disc to round down the flats and define a good, round 7″ circle on the face. You'll use the actual cone to bring the foam to its final shape.

Cut a couple of wedges of medium sandpaper and tape them to the epoxy-stiffened woofer cone. Apply the tape to the back of the sandpaper, leaving broad margins of tape, and then attach the sandpaper to the cone with another strip of tape fastened to the margin of the first tape strip as well as to the cone (*Fig. 5*). Do *not* try to tape to the grit side of the sandpaper. When this is done, you have a sanding form (see *Photo 4* in Part 2).

You can sand the foam cone down by hand, but it takes quite a while. If you go this route, let the sandpaper inform you of the final cone profile, then use a saw or rasp to remove the bulk of the material, checking as you go by sanding against the cone. These instructions are for a rough cone whose base is only slightly too big, but whose height is about an inch too high com-

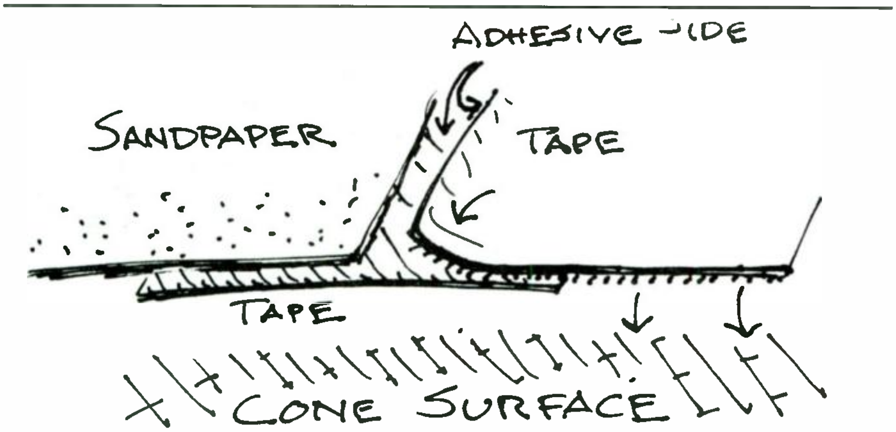

FIGURE 5: How to tape to sandpaper. First you tape to the back, then you tape to the tape. See text for more detailed description.

pared to the final profile. I did this to help the foam cone center itself as you work it. As you proceed, leave a 2″ plug that fits into the cone nicely (*Photo 7*).

Eventually, you get to the point where your foam is shaped to the cone's profile. Stop and make sure that the flat, circular face of the foam isn't tilted when the foam is nested snugly against the cone. If this face *is* tilted, it's better to fix it by refacing the flat surface than by trying to reshape the surface that mates to the cone. Work at it until you have a nicely fitting cone with a front diameter of 17cm.

You should fashion a nice sharp edge at the perimeter. To do this for the final shaping, remove the sandpaper from the cone and shape the foam against the cone itself.

I repeat that the foam dust is insidious. You should do all this foam shaping outside. Also, it's safe to shape both foam inserts on the same cone, but once you get past the sanding, you should do the final shaping of each cone insert on the cone you intend to glue it to.

Now to accommodate the motor former (*Photo 8*). Lay the foam insert on a broad-brimmed bowl or similar support, and fit the woofer cone snugly on top. Now twist the motor former into the throat of the cone over the foam. Keep twisting the former down into position until it has worked its way forward into the body of the cone insert by 1/8″ or so. Take out the motor former. Now start tearing out chunks of excess foam. Dig away with small pliers or a blade until you're down into the body of the foam insert, to the depth of the cut you just made with the motor former.

Now you can look inside the throat of the cone and see how well your foam insert fits. It stands to reason that if your foam fits well at the apex and the perimeter, it also fits well everywhere in between. In a perfect world, your cone and insert would be round and true, so it wouldn't matter how the insert was twisted to fit. In practice, your insert might fit closely in only one position; if so, mark this alignment with a piece of tape on the inclined surface of the insert and with a matching piece of tape on the woofer cone.

GLUING CONE AND FORMER

The next order of business is providing for the motor-coil leads. I brought the wire out through the same grooves in the cone's throat as the original leads. Just clean them out and test-fit to make sure everything's okay. Now you need a fixture to hold the motor former straight up, at right angles to a

PHOTO 8: Modified motor coil on aluminum former mounted on caulk-tube fixture, ready to be glued to the cone. The blackened wire throws off heat better, helping out marginally with power handling.

flat surface (*Photo 8*). You can use the paper tube that fits into a caulk gun. The metal end is mounted square, and the paper tubes are larger in diameter than plastic caulk tubes and easier to shim out to the motor coil's diameter. Shim it out with tape, slip on the motor coil, and double-check that it stands up perpendicularly.

Next do a complete test-fit with the cone. This is an important joint, and you want glue-up to go without a hitch. When you're satisfied, mix up a batch of epoxy and spread some on the cone side of the joint. Now glue the former and wires. You remember marking the former for proper depth after winding the third layer onto the voice coil. If you're not confident you did it correctly, you should double-check it now.

The key is that with the spider flat and its flange resting against the frame, the motor coil should be centered in the gap depthwise, with 0.25″ showing on the 1″-tall coil. You could even do the gluing by starting with the motor coil set in proper position in the gap, adding epoxy to the surfaces, and then setting the cone in place on the former, sliding it down into position until the spider flange just touches the frame.

But it's still vital that the motor former sit square with the cone, so once the former is glued and in place inside the cone, slide your fixture inside the former so its end is even with the front of the cone. Then lay the cone on your flat surface and adjust the fixture inside it so the fixture's end is flat against the same surface as the front of the cone. This references both the cone and motor coil perpendicular to the same flat surface. Secure things in place with tape, weights, or whatever. After a couple of hours, the epoxy will have set.

MORE FOAM WORK

Once the motor former is securely glued in position, you need to carefully twist the foam insert flat against the cone, letting the aluminum former cut into it fully. Route the wire leads flat against the joint around to the gap in the former and through it, out of the way. Tear out more chunks of foam until you're at the bottom of the hole; then dig a shallow concave profile at the bottom (*Fig. 6*).

Now glue the foam to its aluminum/paper skin. Mix up some epoxy, spread it on the aluminum foil, and press on a layer of tissue. Get it tight and bubble free, spread on some more epoxy, and place the foam insert on the best looking section. Work the epoxy into the foam by twisting the foam around gently against the foil/paper skin. Then weight it

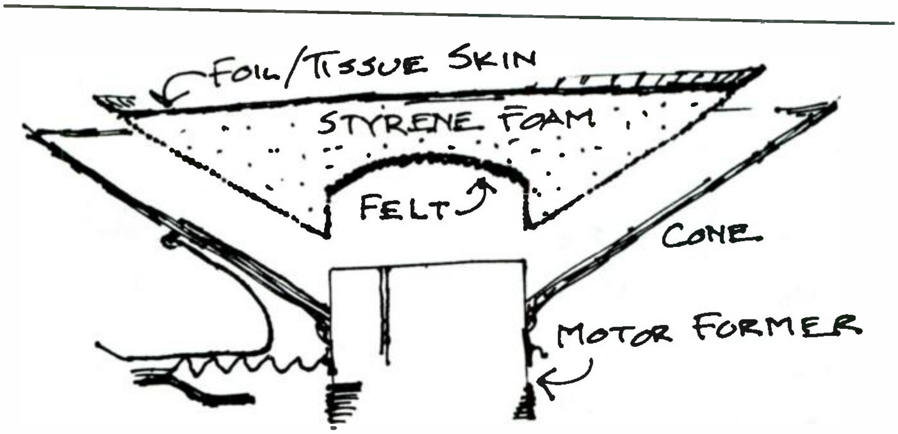

FIGURE 6: A fairly close, if not actually to scale, section of my foam insert and how the parts fit together.

down by placing a bowl upside-down on the foam (to distribute the pressure) and then piling 5 lbs or so on top of the bowl. You should go a little heavy on this glue layer, and spread it out as evenly as you can. Picking up the cone and redepositing it on the glued skin also helps even out the glue layer. Let it cure for 24 hours.

Next seal the domed bottom of the cavity at the apex of the foam insert. Cut a piece of felt 2″ in diameter. Mix some epoxy and spread it out on the foam at the bottom of the hole. Wait until the epoxy starts to set. While it's still tacky, but beginning to stiffen, press the felt disc into place. The setting epoxy will hold it firmly against the profile of the cavity, but work the felt with your fingers, denting it, stretching it so it fits the bottom.

After a couple of hours, mix a little more epoxy and work it into the center of the felt (I used my finger) and around and out, stopping about ¼″ from the edge. Here, you want just to "wet" the felt, not thoroughly saturate it with epoxy. It'll harden, and when you later glue the insert to the cone, it will become a nice interior structural element.

Now detach the skin and foam from the flat surface, taking up all that tape. Cut the excess foil/tissue off, leaving a 5mm lip past the foam. Since the foam is 17cm in diameter here, your foil/paper skin should be a circle 18cm in diameter.

MASS MATTERS

You may recall that I set out to build a 125g system. That's about 120g if you take away the air load. How am I doing? I refer you to *Table 1*. I weigh the cone assembly and foam insert and get a total of 113g. I estimate that the surround contributes a couple of grams, and I throw in 5g or so for glue to fix the foam in place. I'm right on target. If you're a little light, don't worry. You can always add useful mass by working epoxy into the backside of the cone at the apex. I'm assuming you've been keeping track by weighing stuff as you go along.

TABLE 1

WOOFER MASS, IN GRAMS (all figures within about 2%)

	Cone and spider	Motor coil and former	Dust cap and foam insert	Surround	Air load and misc.	TOTAL (M_{MS})
Stock	47	25	1.5	3	5	82
Modified	54	33	26	3	9	125

ALMOST DONE

The skin extending past the foam must bend up to follow the cone's profile, so I cut it into tabs to make this easier. I marked off the edge into 48 segments by laying it out on a big piece of paper, then taping my insert down on it and cutting the foil with a sharp knife. Then I sprayed a light coat of black paint on the front.

Now to deal with the motor-coil leads. Bend them around the throat of the cone left and right until they're 180° apart, then make sharp 90° bends and lead the wires up the sides of the cone. About 2″ away from the former, begin scraping about an inch of the enamel insulation off each lead. Then drill two small holes (snap half the eye off a large needle for a bit) in the cone, about ¼″ apart (*Fig. 7*).

Bend each lead sharply and feed it down

through the hole, give it a slight loop and bring it back up through the second hole. Now make another sharp bend so it lies down against the cone, and cut it ¼″ or so past the last bend. Arrange the leads so they hug the cone closely. Mix up a little epoxy and glue them down. Hold them fast with tape. Do a final check with the voltmeter to make sure everything's copacetic. You should have $R_{dc} = 4.5\Omega$, and the coil should be insulated from the former.

After a couple of hours, the epoxy will be sufficiently set. After bending up the tabs at the edge of the skin to follow the cone profile, press the foam insert into position for the last dry fit. When the insert has bottomed against the cone, jiggle it a little so the lead wires dig into the foam. If you haven't placed index marks on the cone and insert so that you can put them back together exactly the same way, do so now.

Besides denting the foam at the motor leads, make sure the motor former sits properly against the felt in the hole in the apex, and that the tabs flatten nicely against the cone's surface. Now vacuum the last of the styrene dust off the cone and insert.

GLUING THE SURROUND

Now glue the surround to the cone. I laid the surround upside-down on the cone, bent the flange over, and then marked with masking tape how far down it came on the cone. I used the same RTV silicone to glue the surround to the cone that I had used to coat the surround. I spread a thin coat on the cone and the flange, and let it cure about a minute. Then I pressed the flange against the cone and adjusted it for concentricity, using my tape on the cone and the beginning of the half-roll as guides.

Once I had the surround in position, I clamped the two together with about two dozen clothespins, pressing them against the foam through little arc-shaped pieces of cardboard, since I didn't want to make little dimples in the flange. The cone is hard enough to take care of itself.

After you've placed the clothespins, go around the perimeter a couple of times giving the joint a good firm squeeze with your fingers to make sure you've achieved a good bond. Let it cure for 24 hours, and then test for a good even bond across the full width of the flange. Mend any spots that didn't bond by working some RTV into the crevice; clamp with a clothespin.

Now for some more work on the magnet structure. I added two 2″ fender washers to the center-pole piece to extend it about 1/8″ above the top plate. I did this in the interests of symmetry, adding a little fringe on top of the magnetic structure to balance the fringe inside.

To do this, I first epoxied the washers together, clamped nice and tight. Then I used a bolt through the center to clamp them in place, aligned on the center pole. I intended to both screw and glue this extension in place, so I drilled three holes through the washers about 3/8″ from the edge and about ¼″ into the pole piece with a 7/64″ bit.

I then took off the washers and enlarged the three holes to 9/64″, which is a tight fit for 6-32 screws. I held the two washers together with 6-32 screws and nuts, chucked the assembly in my drill, and applied a file to it, tapering down the edge toward the top side at a 30° angle from perpendicular.

OFF FOR BRASSING

Then, leaving them clamped together by the 6-32 hardware, I sent the washers off to be given as heavy a brass plating as the local plating shop thought prudent, given their cheapo cadmium finish. I really desired a copper-plating job, but the local shop does not include copper in its repertoire. Heavy brass will have to do.

I did this (and other) plating in the inter-

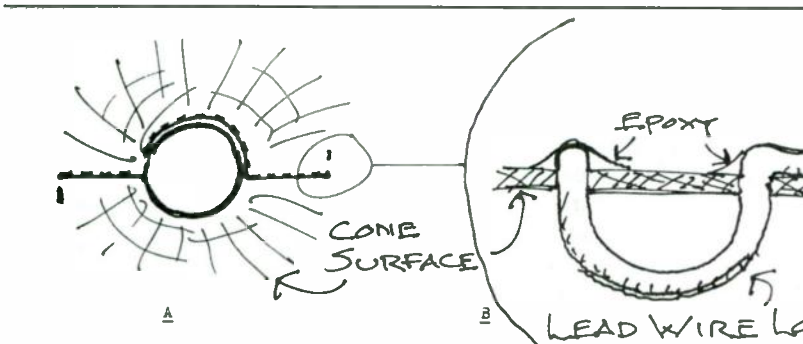

FIGURE 7: How to get the motor leads to the outside world. A is looking at the front of the cone; dashed lines are the lead wires; B is a cross-section view showing bare wire looped through the cone, to be soldered later.

est of Faraday ring effects. I know a little brass here probably doesn't matter in the whole vast scheme of things, but I was sending the iron from the mid and treble domes out for plating, so I sent these little extensions, too. Couldn't hurt.

Back to work, I tapped the three holes in the pole piece for 6-32 threads. I have some broken taps I can use to cut threads close to the bottom of these holes. You might want to drill 1/8″ or so deeper if you can't thread close to the bottom. Then file off the bottom of your 6-32 hardware to a taper to match your hole. You do realize the magnetic gap is still very much masked? I should also mention that I enlarged and tapered the hole in the center of the pole extension to mate with the bore in the pole piece.

When you get your extension back from the plater, clean everything, including your hands, unmask the gap, and screw your extension on for a dry fit. It should be centered, certainly not overhanging the gap. If you've committed such a grievous error, make sure the extension is aligned over the right holes. If that doesn't do it, you must enlarge the three holes judiciously until the pole extension sits properly.

Once that's done, glue up with epoxy, gluing screws and all, and remask the gap when you're finished. Add more clamping pressure with a central bolt down the bore. When the glue has cured, touch up the central bore with a file, cleaning all the steel debris away with masking tape. Then unmask the gap and shave away any glue that may have squeezed out of the joint. Clean and mask.

In the next installment, we continue our exploration of the innards of the box, with special attention to the terminal block, grille frame (with baffle add-ons), and the mid- and treble-dome top plates.

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Product Review

THE NEWFORM NHB SPEAKERS

By Robert E. Greene

***NHB Ribbon System**, available from Newform Research, Inc., PO Box 475, Midland, Ontario, Canada L4R 4C3, 705-835-9000, FAX 705-835-0081, http://www. barint.on. ca/newform/.*

The Newform Research NHB speaker system is an all-out attempt to realize theoretically ideal stereo imaging. As the name suggests—NHB stands for no holds barred—compromises were eschewed. The result is visually unusual, with smallish woofer boxes surmounted by five-foot ribbons (actually two thirty-inch ribbons per channel combined into one), so the NHBs won't fit gracefully into the average home decor.

But the dedication to purely sonic intentions has paid off. The NHBs belong in the upper echelon of speakers as far as imaging is concerned—they are even close to being alone at the top. They have limitations and some problems in other directions, but in the presentation of space, they are superb.

SEEKING BEST BALANCE

The theoretical ideal of speaker behavior for imaging has been understood for a long time. In Alan Blumlein's famous 1931 patent on stereo, it was already clear that the reciprocity between the microphone technique (now called Blumlein miking) and playback required either a point source, a line source, or an infinite planar radiator for the speakers.

The difficulty, of course, is that none of these three ideal types can exist in reality. All real speakers have nonzero but finite extension in two radiating dimensions. Thus began a long history of experimentation trying to find the practical reality that did the least damage to stereo reproduction.

Progress was slow for a long time for two reasons: first, it turned out to be difficult to produce speakers that had just flat response, low enough distortion, and adequate dynamic capability. Stereo imaging subtleties tended to take a back seat to such seemingly more primary considerations.

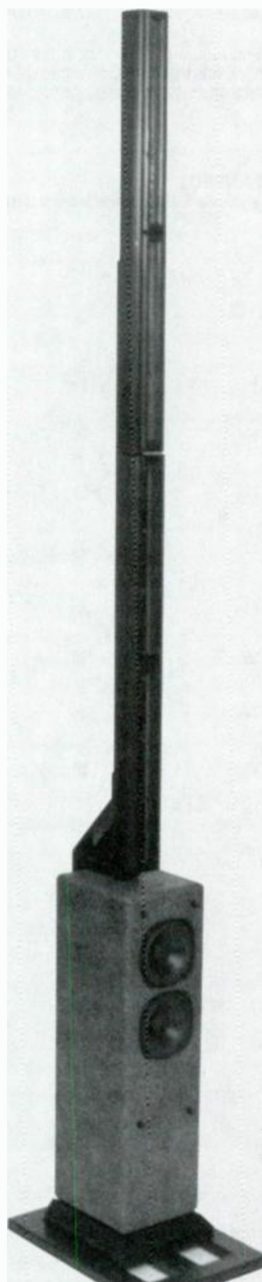

PHOTO 1: The NHB, from Newform Research.

Second, it took a long time for people to realize there was a good deal more to stereo than two good monos that matched, and to appreciate that one or another of the theoretical ideals needed to be approached quite closely before stereo would really work. (Ironically, the Newform NHBs come from Canada, where the stereo-is-just-double-mono school still holds forth!)

In more enlightened quarters, an enormous amount of effort has been expended on finding out what makes for the best stereo on the practical level. One direction has involved simulating the ideal of line or point source via segmented planar radiators and time delays (Stax line, Quad point) or curved panels (Martin Logan, Sound Labs) that would produce a virtual focal-line source. These efforts were unbaffled planars (electrostatics in the cases mentioned).

A second line of thought has focused on trying to minimize or even to use constructively the effects of baffle-loading. The BBC emphasized the importance of minimized diffraction. Unbaffled tweeters for box speakers were utilized (B and W, Ohm's CAM series). And in the case of the Soundwave PS series, an effectively unbaffled point source was synthesized out of a box speaker by using two angled bass/mid drivers and a tweeter mounted on the edge at which the angled baffles met. All these proved to be compromises that were effective to a greater or lesser extent—sometimes very effective indeed.

GOING FOR IT

The NHB just goes for it. On the reasonable assumption that there is no baffle like no baf-

ABOUT THE AUTHOR

Robert E. Greene is a mathematics professor at UCLA, where he teaches courses on acoustics and the physics of music, in addition to mathematics. He is also active as a free-lance musician in the Los Angeles area. He has been a recording and equipment reviewer for *The Absolute Sound* since 1983.

fle, and no ideal like the real ideal, NHB has utilized as a tweeter a true line source, unbaffled. The suspended vertical ribbon really does function as a theoretical monopole (forward radiating in a sense, but with very wide dispersion) line source over much of its range.

At extremely high frequencies, it will have a certain horizontal directionality, and at the bottom of its operating range, where vertical directivity diminishes, there is deviation from line-source behavior because the ribbon does not reach the floor. But overall it is about as close to the unbaffled line-source idea as you can get.

The result is stunning stereo presentation. No speaker I am aware of does a better job of giving you a sense of listening into the acoustic space of the recording and of hearing real sound sources in that space. Moreover, this is accomplished in a way relatively immune to damage by setup.

Often, with other speakers, good stereo in this sense is available, if at all, only with exact positioning of the speakers relative to room boundaries and the precise location of the listener. Of course, no stereo really works ideally except for centered listeners in a symmetric room situation. But the NHBs are remarkably stable.

Their stereo presentation survives small or even fairly large perturbations of perfect setup. I am not claiming that the NHB's stereo behavior is perfectly accurate. Indeed, most microphone techniques do not have anything like a theoretical playback paradigm (Blumlein is an exception). And accuracy thus becomes something of a moot point. Whether or not the original acoustic reality is exactly replicated, some convincing acoustic reality is presented—almost, I am tempted to say, even from recordings that do not deserve it.

SPATIAL REALISM

Why is this sense of spatial realism important in musical terms? After all, space is seldom an explicit part of musical composition and performance. It just arises incidentally—things have to be somewhere, performed inside something, and although the tonal character of a hall is explicitly important, the rest of the spatial business seems a bit beside the point at first sight.

In fact, however, the ear/brain is apparently subtly disturbed if some convincing spatial presentation is not available in reproduced music. You sense something missing, and your musical perception is disturbed.

Moreover, spatial separation enables us better to resolve musical detail. (Ansermet, who conducted many of the early Decca/London orchestral stereos, used to comment on this aspect of stereo with great enthusiasm. It was new then, and now we take it for granted, but the increased resolution of stereo is still a very significant thing musically, as you realize when it is improved.)

Finally, there is the psychological effect of being taken out of your home's acoustic environment. Concert-hall or jazz-club acoustics heard at home do a lot to make you feel you're at a concert or in a club.

I had only two NHBs on hand, so my comments apply as such only to (two-channel) stereo, but I would expect the results to be equally impressive with multichannel surround setups based on the NHBs.

Describing spatial things in words is always a bit of a problem. Hearing is believing here. But not only do the NHBs present a large, expansive, seemingly almost unlimited sound picture (limited only by the recorded information), they also produce unusually real-seeming instrumental or vocal images.

Things like trumpets in the back row of an orchestra that are usually just sort of something back there, somewhere, become individual trumpets in their appointed places. The

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TESTING THE NEWFORM NHB

By Joseph D'Appolito

Newform's NHB (No Holds Barred) system consists of two stacked R30 ribbons mounted above a midbass module containing two 5.25" midbass drivers. It is not a full-range system, and its intended use is with a subwoofer. The bottom-end response rolls off below 100Hz. The stacked R30s constitute a line source of 60" and are active above 1kHz. They behave differently from more conventional drivers because the wavelengths they radiate are much shorter than their length. Before testing the full system, let's look at the special properties of this line source.

For wavelengths much longer than their circumference, conventional circular piston drivers act like point sources in the far-field and produce a spherical radiation pattern. Under this condition, sound-pressure level (SPL) falls off by 6dB for each doubling of distance from the driver.

Contrast this behavior with a line source. For wavelengths much shorter, a line source's polar response is cylindrical. SPL falls only 3dB for each doubling of distance in the near field. Since the far field is not reached until distances on the order of 10–15 times the line length, you are generally in the near field of a line source.

Some simple tests illustrate the polar-response properties of an R30. *Figure 1* shows the microphone locations used during these tests. *Figure 2* plots a set of three frequency-response test results that illustrate the cylindrical polar pattern of the R30. For these tests, I placed the microphone in three locations: on the ribbon centerline, at the ribbon's top edge, and 10" above the top edge—all at a 2m distance.

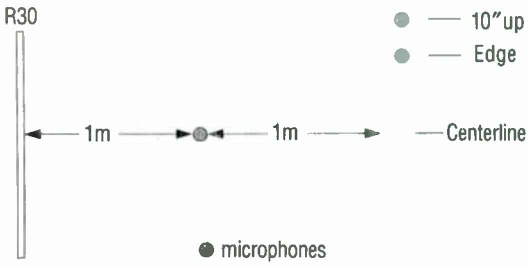

FIGURE 1: Microphone locations for examining R30 polar response.

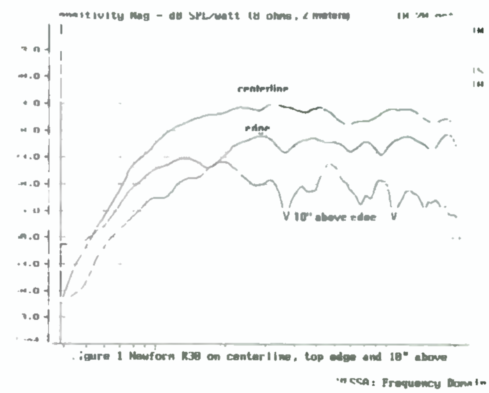

FIGURE 2: Newform R30 on centerline, top edge, and 10" above.

Concentrate on frequencies above 2kHz, where the R30 is at least five times longer than a wavelength. Relative to the response on the centerline, response at the upper edge averages 5dB less across all frequencies above 2kHz. Ten inches above the upper-edge response is, on average, down 15dB. We see that SPL levels fall rapidly beyond the ribbon's edge.

Figure 3 shows R30 response on its centerline at one and two meters distance. The 2m response curve averages 3.4dB less across all frequencies above 2kHz. These tests indicate that the R30 produces an essentially cylindrical 30″-high sound field.

In multiway systems using conventional drivers, all drivers act as point sources in the far field. If SPL levels of the individual drivers match at one distance, they will match at any other distance, because they all fall off at the same rate of 6dB for each doubling of distance.

Hybrid systems using drivers with different distance laws present a problem. In the absence of reflections, driver levels in a hybrid system will match at only one location. Moving toward the system from this location, the conventional driver level will rise above the line-source level. Moving away, the opposite is true. Room reflections will modify this behavior somewhat, but the direct field, which is primarily responsible for imaging, will behave pretty much as I have described it.

Now I'll move on to my tests of Newform's NHB system. The system impedance is plotted in *Fig. 4*. The first impedance peak of 7.7Ω at 89Hz indicates the closed-box resonant frequency of the midbass driver pair. The minimum system impedance occurs at 240Hz, with a value of 3.7Ω. The R30s and their crossover capacitor interact with the midbass drivers and their crossover network to form a parallel resonant condition at 1.68kHz where the impedance peaks to 15.5Ω.

Phase angles lie between +40° and −36° over the entire frequency range. The NHB qualifies as a 4Ω system with fairly benign phase behavior. Most amplifiers should have no difficulty driving this load.

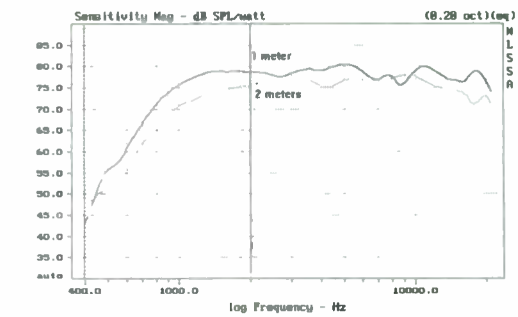

FIGURE 3: Newform R30: 1m (solid), 2m (dotted).

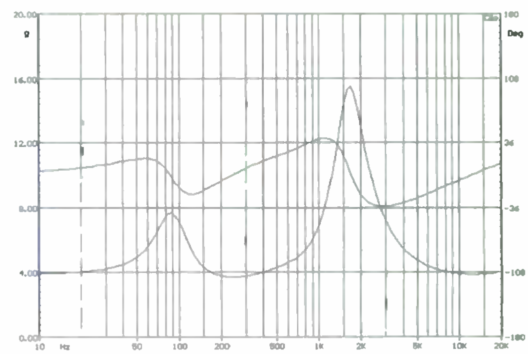

FIGURE 4: NHB system impedance.

I ran a trial frequency-response test to determine proper phasing for the R30s. Newform's literature indicates that phase reversal may be necessary for smoothest response. I placed the microphone at a distance of 2m and a height of 38″ for these and most of the remaining tests. *Figure 5* shows NHB system response with the R30 pair connected in-phase and with reverse polarity. The in-phase condition produced a sharp 26dB response dip at 1.7kHz. The reverse phase connection shows a very smooth transition between the midbass module and the ribbons.

Figure 6 is a plot of the NHB system and individual driver-frequency responses at 2m. These curves are a combination of quasi-anechoic responses taken above 500Hz spliced to ground-plane data below 500Hz. Because of the differing distance laws, this data cannot easily be extrapolated back to 1m for sensitivity evaluation (I'll explain in a moment). Crossover occurs at 1.69kHz.

Examining *Fig. 6* further, notice that the average level of the midbass drivers between 200–800Hz is about 82dB. Relative to this level, the midbass module is down 3dB at 80Hz. The average level of the R30s between 3–10 kHz is roughly 76dB. Between 1–3kHz, the system shelves down 6dB. Based on their differing distance laws, moving out to 4m would reduce the shelving to 3dB. An 8m distance (about 26′) is needed to bring the system to flat response. Be clear that here I am talking only about the on-axis direct-field response.

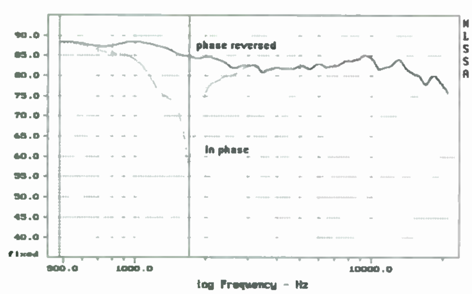

FIGURE 5: NHB tweeter phase: – (solid), + (dotted).

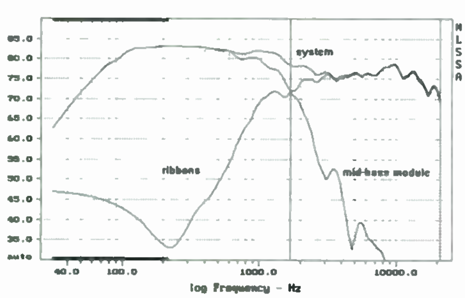

FIGURE 6: NHB system and driver responses.

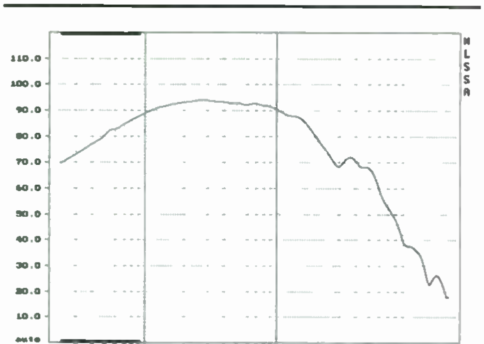

FIGURE 7: Midbass module frequency response.

At normal listening distances of 3–4m, the first arrivals will be deficient in treble energy. The NHB system's horizontal polar response is very broad, however, so that lateral reflections will add to the total sound field. Whether or not the NHB sounds treble-deficient is very much a function of the listening environment.

Figure 7 shows the ground-plane response of the midbass module with its crossover. I placed the microphone at 1m, and response data was then corrected to 1m free-field. This curve places the midbass module sensitivity at 92dB PL/2.83V/1m—which agrees with manufacturer's specification—but the shelved response makes assignment of a single-sensitivity number to the entire system arbitrary.

Figure 8 shows the NHB system's step response. The initial negative spike at about 6ms is the first arrival from the ribbons. The negative spike is consistent with the polarity reversal discussed above.

Excess group delay is plotted in *Fig. 9*. This plot is referenced to the acoustic phase center of the R30 pair and is used to determine midbass module delay relative to the ribbons. Previously, the midbass module was positioned for smoothest frequency response. Because this plot is referenced to the ribbon's acoustic phase center, excess phase delay is essentially zero above 6kHz. Below 6kHz it rises, peaking around the crossover frequency, and then settling back to a value of 0.072ms (72μs) at low frequencies. This value represents the midbass

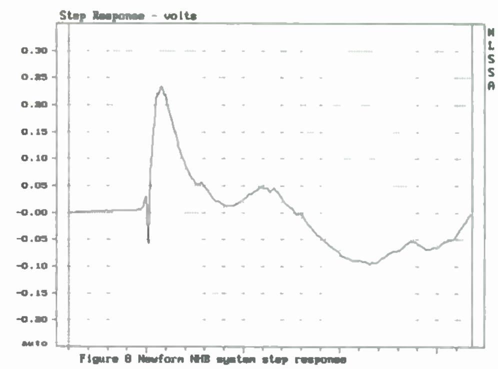

FIGURE 8: NHB system step response.

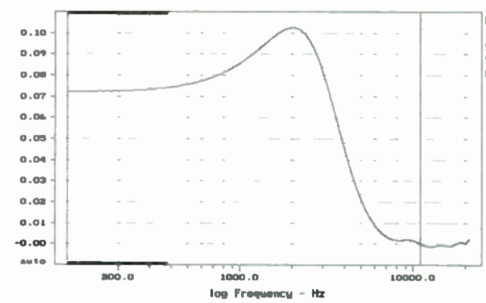

FIGURE 9: NHB system excess group delay.

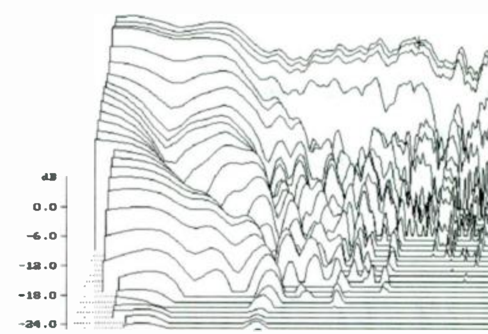

FIGURE 10: Cumulative spectral decay.

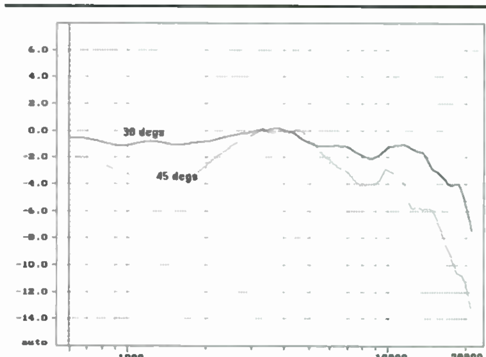

FIGURE 11: Relative polar response: 30° (solid), 45° (dotted).

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whole effect is startlingly convincing. And none of the astronomically priced box speakers I know of do it any better, nor even as well.

PROBLEMS IN PARADISE

If space and imaging were all that speakers are about, the NHBs would rank with the very best, and at their moderate price would be an incomparable bargain. But as it happens, the NHBs have some problems and limitations in some other directions that make them rather a mixed bag.

The most obvious limitation is just a design feature, not a problem. The speakers are designed to be used with a subwoofer and therefore lack deep bass. In my room, they were heading out of there by around 70Hz. They drop out cleanly, so subwoofering for full range is easily and convincingly done. No problem.

Other limitations are more problematical. The most serious is that the 100–1kHz region involves a complicated radiation behavior that at least in my room precluded a setup for really flat response.

What I would suppose was cancellation from floor reflection pulled down the response from, say, 150 to 300Hz. Then the 500–1kHz range came back with a fairly obvious "honk." Above 1kHz, things were generally flat, but at a lower level than the honk region. (The treble is largely flat and smooth, although it has a little bite for some reason, albeit not from being up in general level.)

My room does not allow listening at really large distances, and by design, it is quite damped down in the treble. But at any distance from around 2m to 4m, I was unable to tame completely the honk and upper-bass/lower-midrange depression. In some positions, these were really extreme, in others less so. But I could not get rid of them in any position.

RADIATION COMPLEXITY

Speaker design is complicated, and it ill-behooves reviewers to second-guess designers in detail, but it does seem that the NHBs have an unusually complex radiation pattern around the crossover region.

The ribbon is no longer a true line source (not reaching the floor) and the double bass/mid driver configuration produces a complex floor reflection from there on down. (The bass/mid drivers are rather close to the floor, but not really close, so the nature of the

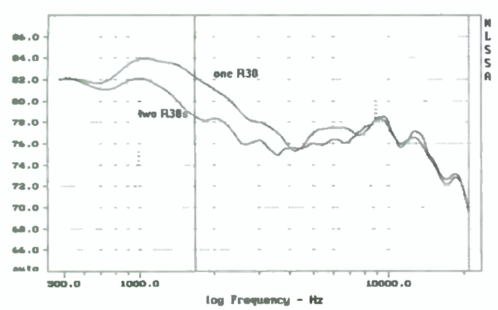

FIGURE 12: NHB system: one R30 (upper curve), two R30s (lower curve).

module delay relative to the ribbons. Most of this delay is caused by the low-pass crossover network and is to be expected.

Figure 10 is a plot of cumulative spectral decay (CSD) for the NHB system. The three-dimensional CSD plot shows the frequency content of the decay energy in the system in response to an impulsive input at time zero. Ideally, all energy should disappear immediately after the impulse. On this plot, frequency increases from left to right and time moves forward from the rear. Each slice represents 0.11ms of time. The total vertical scale covers a dynamic 30dB range. There are no distinct ridges in this plot that would indicate strong resonant modes. There is some hashy response in the ribbons lasting about 1.5ms, but this decay will have no distinct character. The NHB CSD is quite good.

I did not fully investigate horizontal polar response for the NHB; however, *Fig. 11* shows response at 30° and 45° off-axis in the horizontal plane. These plots are referenced to the on-axis response and thus they show the difference between on-axis and off-axis responses. At 15kHz the ribbons are down 3dB and 6dB at 30° and 45°, respectively, relative to the on-axis response. Compare this performance to that of a typical 28mm soft-dome tweeter. The corresponding numbers are –5dB and –17dB. Horizontal coverage of the R30s is clearly much broader.

Figure 12 is very interesting. This plot compares the response of the NHB in its normal configuration using a stacked pair of R30s against the response with only the lower R30 active. In the transition region between the upper- and lower-response shelves, the upper R30 actually reduces system on-axis response. Above 4kHz, the response is the same whether one or two R30s are active. This is just another manifestation of the cylindrical polar-response property of the R30s. At higher frequencies the radiation from the upper R30 shoots over the head of a listener and does not contribute to the direct-field response.

All of the response data shown so far is essentially anechoic. *Figure 13* gives us another look at the NHB system. This is a 1/3-octave RTA analysis with the microphone placed at 3m and 38″ height. This response contains all room reflections and standing-wave effects in my test area. The general shape of the curve is similar to that shown in *Fig. 6*.

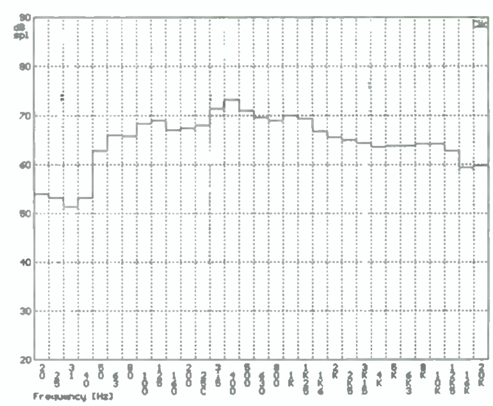

FIGURE 13: In-room response.

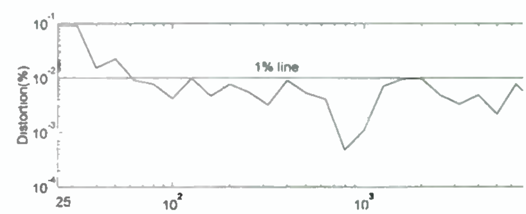

FIGURE 14A: Second-harmonic distortion.

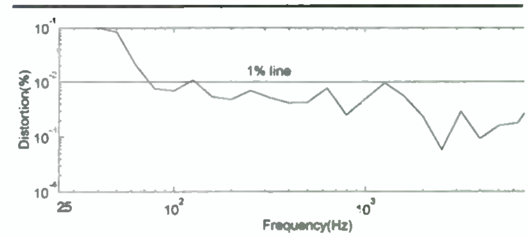

FIGURE 14B: Third-harmonic distortion.

Finally, *Figs. 14a* and *14b* are plots of second- and third-harmonic distortion at 90dB SPL/1m. All distortion is below 1% above 75Hz.

floor reflection shifts in a complex way with frequency.)

Actually, in my quick-and-dirty close-up measurements, the bass/mid driver complex produced a rising response from 100Hz on up to 800Hz (roughly a 3dB rise). Of course, the room gives some lift to the bottom, so the meaning of that measurement is ambiguous. But the mid-prominence was in any case a definite feature of the listening.

The truth is that few speakers do a particularly good job of being flat in-room, compared to how sensitive we are to response deviations. You can, however, by careful placement tweak some speakers into being quite well-balanced and coloration-free. With the NHBs, I could never quite get there. I could hardly miss outstanding imaging, but I could never get really close to the most neutral sound I have had in my listening room.

ROOM INTERACTION

This could be an aspect of the interaction between my room and the NHBs. Usually I can get more nearly flat in-room response. For example, with a conventional, albeit excellent box speaker like the Spendor SP1/2, I can get far flatter response than I could from the NHBs. The Spendors do sound more boxy and speaker-like than the NHBs, but they also sound much more accurate tonally. Designer John Meyer suggested to me that perhaps my room was too overdamped in the treble to be ideal for the NHBs, and this may well be true.

The complex floor-reflection effects seem to me likely to occur in any room except perhaps one where listening at very great distances is possible. (Distance will affect the NHBs more than most speakers, since the essentially point-source bass/mid has a different rolloff with distance than the line-source treble.)

All speakers are compromised by room effects. Anyone who thinks that really flat in-room response is automatic should have a look at the in-room measurements of almost anything almost anywhere!

High price is surely no guarantee, for instance, and indeed sometimes seems to correlate almost negatively above a few thousand dollars, as though high-end designers had their minds elsewhere. Rooms just do a number on speakers unless room-independence is relentlessly pursued by the designer and placement for neutral response is pursued with equal determination by the listener.

If imaging is a high priority with you, the NHBs with their ultimate imaging at a modest price may offer so much that their deviations from neutrality fade into insignificance. But if timbre and tonality are among your main goals, then you should surely listen carefully in your own room before buying the NHBs. (At the least, their perceived balance is room- and distance-dependent.) It won't be easy to go back to boxes afterwards, however. The song may be over, but the soundstage lingers on.

ABOUT THE MEASUREMENTS

Joe D'Appolito's elegantly done measurements (see "Testing The Newform NHB," above) contain no surprises relative to my listening experiences, and I surely agree with his technical comments on the distance dependence of point sources versus line sources.

The measurements that point up most clearly the problem I was having with perceived balance are shown in *Fig. 13*. Note that the scale is 10dB per vertical division, so that even small-looking steps are fairly large response deviations perceptually. In particular, the midbass depression followed by prominent midrange that I commented upon is clearly evident here, as is the shelved-down treble.

The other response graphs show a small but definite treble peak that is presumably responsible for the slight sense of "bite" I noted.

The correlation between measurements and stereo imaging is less precise than that of measured response (in various forms) and perceived tonal character, so I had a lot of good things to say about the NHBs that are not really shown in the measurements as far as stereo is concerned.

But the measurements do tend to confirm that the NHBs have a somewhat idiosyncratic balance to which you should listen carefully in your own room. Those four or five dB ups and downs are very definitely audible. Amazing stereo, but not quite neutral balance in my or Joe's room.

Manufacturer's response:

When we received Robert Greene's fax of his Room Optimizer Form (we encourage all of our customers to complete this, which allows us to give solid advice on model selection, placement, and tweaks), his appeared to be a near-ideal room. But there was a small surprise. The walls were lined with books, which, to the ribbons, make the room emulate an anechoic chamber. Hence, the ribbons stepped down several decibels relative to the midbasses.

Obviously, the soundstage was intact, and Robert certainly appreciated it. The reasons for our ribbons' soundstaging ability are straightforward, but lengthy (if you would like full details, contact us to receive an Info Pack).

Looking at Fig. 13, we saw a shelved response, which again is room dependent. In a "normal" room, or with simple level control, the ribbons would come up to the midbass level for an exceptionally flat response. The only glitch would then appear to be the 400Hz peak of 3–4dB. We don't get this in our room, and Robert's peak appeared at 800Hz. Robert did a good job of describing the perils of real-world listening rooms, which can turn the near-ideal responses of Figs. 2–7 into something with a little more character.

The only note of disagreement I can sound is with Robert's statement that there is something unusually complex happening at the crossover. This is difficult to understand, since the transition is very smooth in Joe D'Appolito's measurements as well as ours. The ribbons are simple devices to work with, and in the case of NHB, the complexity Robert notes may be introduced by the dual midbasses' proximity to the floor. All of our other models have single midbass drivers located higher up.

Robert reviewed the finished No Holds Barred Essential. Many audiophiles have bought the 30″ ribbons as kits and fabricated their own midbass enclosures and stands (or ceiling-mounted hanging brackets). The midbasses they used have been from all of the major audiophile manufacturers and in numbers of one to four drivers per channel. Crossovers have ranged from "factory" passive units to custom creations using the best caps and inductors available to electronic crossovers with multiple amps.

NHB is a simple loudspeaker architecture and requires simple enclosures and brackets. (Simple but strong brackets, because one R30 weighs 28 lbs.) Productive efforts can now be focused on working with room interactions to the satisfaction of the builder's own ear. The results rival (and surpass in some areas) the best and most expensive loudspeakers on the planet for both stereo and home-theater formats.

Robert's comments reach well beyond the topic of the NHB loudspeaker in his room, extending out to cover the Newform ribbon technology and what the ideals of sound reproduction should be. This is just a superb summary of the issues we should all keep in mind, and it elegantly complements Joe's excellent body of measurements.

From a small manufacturer's point-of-view, Joe D'Appolito's detailed measurements and sage observations are a real feast. In most respects, his measurements correspond quite closely with our own.

The response of the ribbons is basically 1k–20kHz ±2dB, with extremely broad horizontal dispersion and very narrow vertical dispersion. The midbass modules (2″ × 5″ Peerless) are 70Hz–1kHz ±2dB, with a sensitivity of 92dB. Distortion is below 1% over the design bandwidth. No Holds Barred

(NHB) covers the basic requirements of bandwidth, smoothness, dispersion, distortion, and dynamics exceptionally well. The cumulative spectral display (CSD) (waterfall) curve shows a great deal of "white space," exceptional for a large planar driver, and even good for a point-source dome.

The ribbons are unique for large planars because they are monopolar with very narrow diaphragms. This gives a unique cylindrical dispersion pattern which we (in our clearly biased self interest) believe is superior for every music format in the home. Certainly the discrete home-theater formats call for this type of dispersion to produce a coherent soundfield, and soundstaging in stereo also benefits.

The midbasses act more as a point source, however, because they disperse hemispherically. The power loss for a point source is 6dB per distance doubling, and for a line source, it is 3dB. These are theoretical values, not real-room values. This explains the shelving noted in Joe's on-axis measurements, where two largely flat bandwidths are on two different levels 3–5dB apart with a smooth integration.

Back in the days of NRC (which was responsible for giving Canadian loudspeaker designers such an advantage), the watchword was octave-to-octave balance. That is, a loudspeaker would sound good if there were no large discrepancies between neighboring octaves, even if overall response was not flat. NHB would appear to fall into this category (but I think it does a little better).

At some point, the power levels of the cylindrical and hemispheric radiation patterns will be even, and it is our experience that this happens in most real-world listening rooms at 8′–14′. How narrow the room is, the ceiling's height, and the side walls' reflectivity (hardness) are all critical factors. Of course, when you see two beautifully flat bandwidths slightly offset in level, a little voice seems to murmur "electronic crossover" over and over again. Our full NHB (the Essential is tested here) comes with external passive crossovers with the clear recommendation to upgrade to actives when it becomes practical for you to do so.

In the passive mode, NHB balances out extremely well in most listening rooms. Two exceptions are extremely absorbent rooms and very large rooms (with the ribbons over 7′ from the sidewalls) where there is no sidewall reinforcement.

Two unexpected results from Joe's testing were the high crossover (Joe's being 1.7kHz and ours 1.1kHz) and the large suckout at crossover with the ribbons in phase. The crossover-point difference is due to the lower level of the ribbons in Joe's tests. In our room tests, where the midbass and ribbon levels are even, the crossover shifts down by 600Hz.

I cannot account for the large suckout in phase. In terms of audibility, there is far less perceived difference between in-phase and out-of-phase configurations compared to the typical dome. This is why, in our literature, we recommend that you experiment. But I will try to duplicate this particular trough in our testing because I am sure we have not encountered it to date.

All in all, I am delighted with the test results and I am very grateful to Ed Dell for going to the expense of retaining someone at Joe D'Appolito's level to do the testing. Thanks to Joe for his thorough and insightful efforts in dealing with a unique and initially difficult "test subject." I only regret that Joe didn't have the opportunity to listen to the complete system. His comments would have been invaluable.

John Meyer
Newform Research Inc.

Driver Test

TWO WOOFERS FROM SCAN-SPEAK

By Vance Dickason

This report focuses on two woofers from Scan-Speak—a Kapton® voice-coil version of the well-respected 18W/8545K 6½″ woofer and a new 10″ version of the same motor system, the 25W/8565-01.

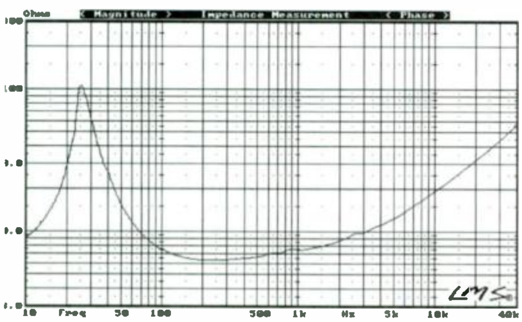

FIGURE 1: Scan-Speak 18W/8545K impedance magnitude.

Features: The Scan-Speak 18W/8545K is a 6½″ woofer combining a magnesium cast frame, Kapton voice-coil former, a carbon fiber-filled paper cone, the Scan-Speak SD-1 motor system (symmetric-pole, copper-shorting ring-type of system), low-resonance low-loss linear rubber surround, inverted paper dustcap, vented pole piece, and elevated type spider.

The Scan-Speak 25W/8565-01 is a 10″ woofer version of the 18W/8545 and has been available since August. The components in the 25W version are similar to those of the 18W/8545K: a magnesium cast frame, Kapton voice coil, carbon fiber-filled paper cone, the Scan-Speak SD-1 motor system

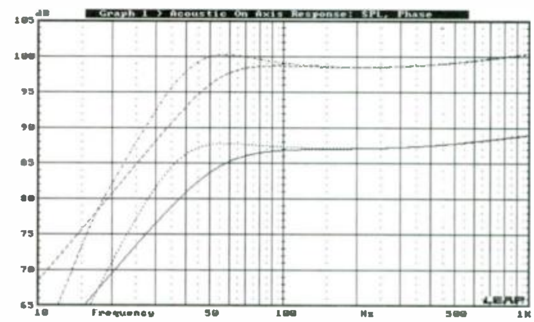

FIGURE 2: 18W/8545K sealed- and vented-box simulations at 2.83V and 12V (solid = sealed box 2.83V, dot = vented box 2.83V, dash = sealed box 12V, dash/dot = vented box 12V).

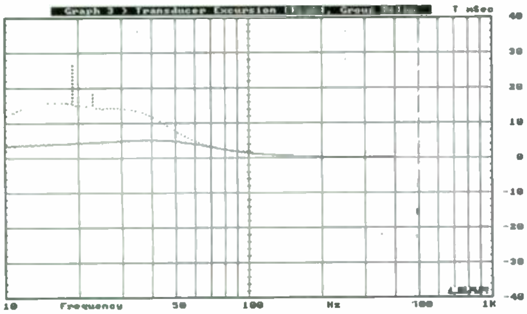

FIGURE 3: Group-delay curves for 2.83V plots in *Fig. 2.*

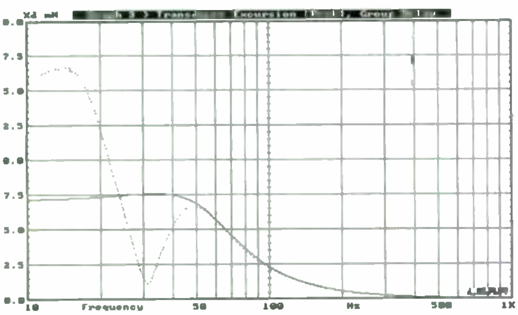

FIGURE 4: Cone-excursion curves for 12V plots in *Fig. 2.*

(symmetric pole, copper-shorting ring-type of system), low-resonance low-loss linear rubber surround, inverted paper dustcap, vented pole piece, and flat spider (the 18W/8545K has an elevated-type spider).

Measurements: I performed initial impedance measurements on the 18W/8545K using the LinearX LMS (*Fig. 1*). I imported the data into LEAP speaker-design software to produce the T/S parameters listed in *Table 1*. Total Q was somewhat higher than the factory measurements, but not significantly. I then loaded this data into the LEAP CAD software and generated box simulations for both sealed- and vented-type enclosures. *Figure 2* shows the SPL curves for a 0.46ft^2 sealed box and a 0.7ft^2 box tuned to 31Hz, both displayed at 2.83V and 12V. *Figure 3* demonstrates the associated group-delay curves at 2.83V. f_3 for the sealed box is 50Hz with a phase angle of 95°, roughly equivalent to a box Q_{TC} of 0.8; f_3 for the vented box is 36Hz.

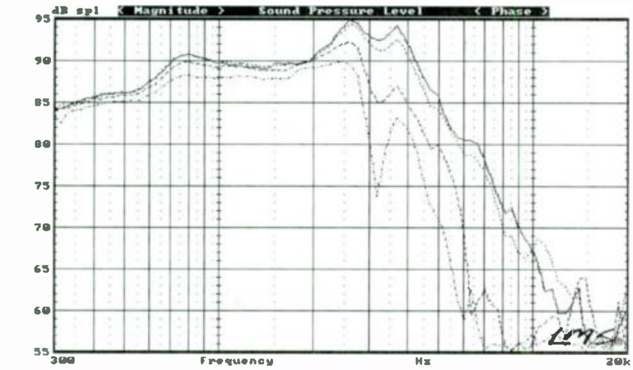

FIGURE 5: 18W/8545K on- and off-axis frequency response (solid = 0°, dot = 15°, dash = 30°, dash/dot = 45°).

FIGURE 6: 18W/8545K SPL comparison for two samples.

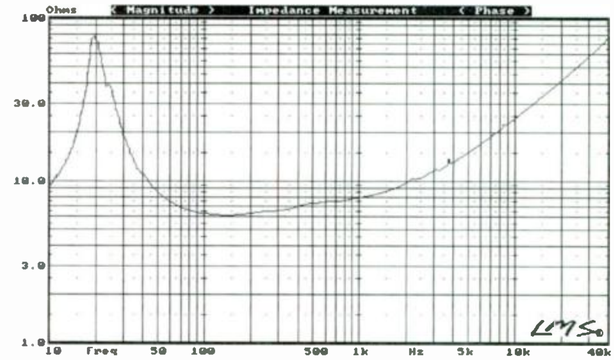

FIGURE 7: Scan-Speak 25W/8565-01 woofer impedance magnitude.

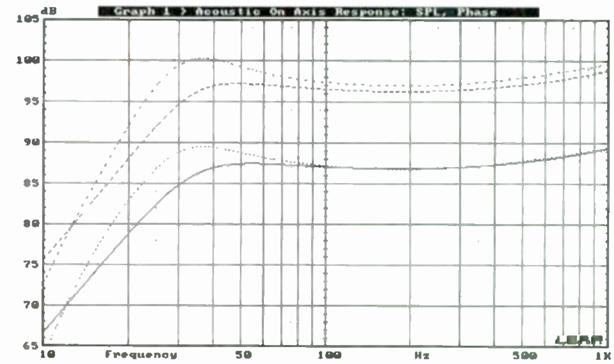

FIGURE 8: 25W/8565-01 sealed- and vented-box simulations at 2.83V and 9/10V (solid = sealed box 2.83V, dot = vented box 2.83V, dash = sealed box 9V, dash/dot = vented box 10V).

The 12V SPL curves represent the output, which achieves an excursion equal to X_{MAX} + 15% (7.48mm), the approximate maximum linear excursion of the driver as shown in *Fig. 4*. Both box types achieve nearly a 100dB output at this input voltage. The vented design achieves a 7.5mm max. linear excursion at 24Hz at this SPL level. All of these measurements are fairly spectacular for a 6½″ driver.

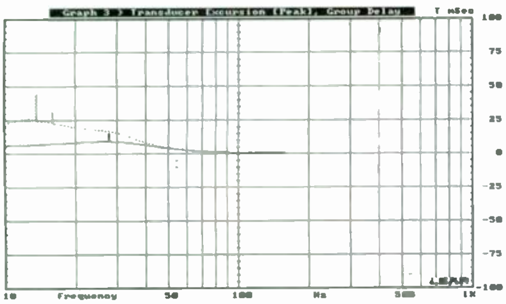

FIGURE 9: Group-delay curves for 2.83V plots in *Fig. 8*.

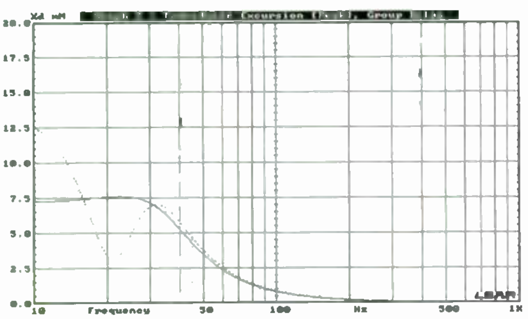

FIGURE 10: Cone-excursion curves for 9V/10V plots in *Fig. 8*.

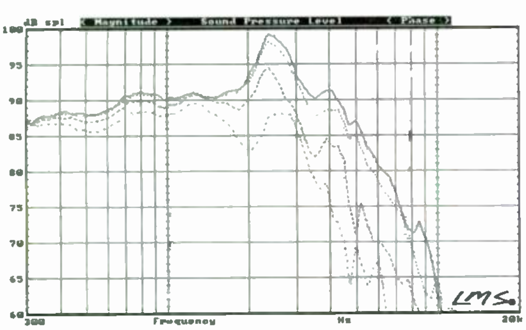

FIGURE 11: 25W/8565-01 on- and off-axis frequency-response curves (solid = 0°, dot = 15°, dash = 30°, dash/dot = 45°).

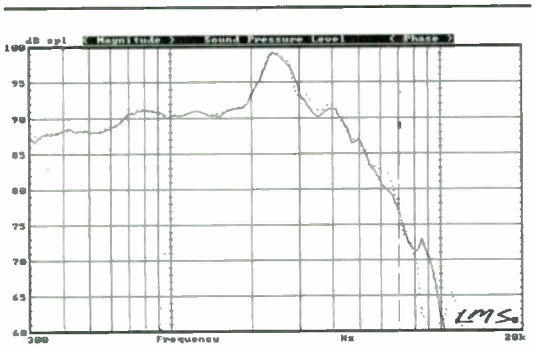

FIGURE 12: 25W/8565-01 SPL comparison for two samples.

Next, I mounted the 18W driver on a small enclosure with a baffle dimension of 8″ × 15″. I used LMS to produce the on- and off-axis anechoic frequency-response curves illustrated in *Fig. 5*. The response profile of this product, which is being used in some rather high-priced high-end designs, is very smooth out to 4kHz with only minor evidence of edge resonance at 2.7 and 3.8kHz. The 30° off-axis response indicates that a likely crossover frequency of 2.7kHz or lower would be appropriate for this product. *Figure 6* contains the two-sample SPL comparison showing excellent matching between the drivers, typical of high-quality European manufacturers such as Scan-Speak.

As with the 8545K, I made impedance measurements on the 25W/8565-01 using the LinearX LMS analyzer (*Fig. 7*). The LEAP T/S parameters and the factory-published data were in reasonably close agreement (*Table 2*). I then produced box simulations for a 3.5ft² sealed box and a 4.3ft² vented box tuned to 20Hz. The graph depicted in *Fig. 8* shows both enclosures at 2.83V, the sealed box at 9V, and the vented box at 10V for the maximum linear excursion curves. *Figure 9* includes the group-delay curves for the 2.83V display. f_3 for the closed box is 29Hz with a −3dB phase angle of 100°, equivalent to a box Q_{TC} of 0.9. The f_3 of the vented box is 24Hz.

SPL for the sealed box at 9V was 97dB with the peak in response at 10V, while that of the vented box was 100dB. *Figure 10* shows the excursion curves that produce a maximum excursion of X_{max} + 15% at 7.47mm, as with the 18W/8545. Max. linear excursion for the vented box occurred at a low 16Hz, indicating that this woofer is capable of increased linear output providing that program material below 20Hz is not introduced.

Figure 11 shows the on- and off-axis frequency response of the

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Classifieds

VENDORS

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Antique Electronic Supply	*Tubes, Transformers, Books, More!*	1-602-820-4643
Gasoline Alley L.L.C.	*Acoustasheet*	1-785-827-9337
Goertz	*Inductors*	1-203-384-0586
Harris Technologies, Inc.	*BassBox and X*over*	1-616-641-5738
Kimber Kable	*Speaker Cables, Interconnects, Etc.*	1-801-627-6980
LinearX Systems Inc.	*LMS*	1-503-598-9258
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Mouser Electronics	*Free Electronic Components Catalog*	1-817-483-0931
Orca Design & Manufacturing Corp.	*Raven Ribbon Tweeter*	1-818-991-3072
Sound Clearing House	*Speaker Drivers*	1-541-343-3112
True Audio	*WinSpeakerz & MacSpeakerz*	1-760-480-8961

AD INDEX

CLASSIFIEDS

GOOD NEWS/NEW PRODUCTS

ELECTROSTATIC electronics, transformers, Mylar®, information. From author ***ROGER SANDERS***, (505) 759-3822.

VERY LIMITED QUANTITIES, all new, cheap: Focal, Dynaudio, Seas, Peerless, Vifa, Audax, Airborne, Eminence, and plenty of caps, coils, ports, etc. Jeff, (940) 723-7900.

FOR SALE

Pair of Altec 617 horn-loaded bass cabinets with 515G woofers, 1285 crossovers and 299 1.4″ horn drivers, extremely sensitive, great for use with triode amps. Also pairs of 291, 806, and 902 horn drivers; 811 and 511 horns; E-V ST-350A tweeters, JBL 2470 drivers. David, (914) 688-5024.

NAD 4150 tuner, $125. DBX 3BXIII range expander, $200. Pair Scan-Speak 21W8553 woofers, $80. Kenwood C2 preamp, $75. All items mint condition. Nick, (209) 583-6511.

LEAP v4.5 with Windows updates (v4.6) and manuals, $850; Liberty Audiosuite v2 with ECHO DSP card, calibrated mike, preamp, probes, $350. Drivers: pair Scan-Speak D29/ 9300 tweeters, $50; four Dynaudio 15W75 mids, $200; pair NHT 1250 woofers, $150. Don Vogel, (207) 797-5940, E-mail dvogell@maine.rr.com.

Audiophile Collector's Estate Sale

Some items are new (N). Others are like new (M). Most in original cartons and packing.

NAD517 five-disc CD player	N	$350
Two Adcom GFA-565 power amplifiers (with fans)	N	$1200 (pair)
Rotel 865BX CD player	M	$320
Marantz 7T preamp		$500
db Systems DBR 15B/2A in walnut cabinets	M	$700
Adcom GFP-565 preamp	N	$550
NEC T710BU tuner	M	$160
Marantz 15 amplifier		$500
Adcom GFP-555II preamp	M	$350
NAD 1020 preamp		$75
Adcom GFA-555II amplifier	M	$550
Adcom GTP-50II preamp/tuner	M	$350
Variance Hi-Fi (Germany) FM tuner/headphones	N	$60

William, 603-642-4338 (Lv. message on machine if necessary), up till 10:30PM EST; P.O. Box 666, Danville, NH 03819.

WANTED

Altec horn speakers, woofers, horns, crossovers, 515, 515B, 515C. Horns: 805, 1005, 1505A/B, 311-90, 329, 604, 605; 288B/C 288-16 G/H. Larger corner speakers and console speakers, Laguna, Paragon; Western Electric horns, woofers, drivers, parts; Tannoy dual concentric. Goodman, E-V Pratician. Sonny, (405) 737-3312.

Seas H204 dome midranges and JVC ribbon tweeters sought. Also used frequency counter for audio range use. Scott, (850) 235-5144, E-mail sellis@arinc.com

Pioneer HD-100 (or similar) flat-diaphragm headphones, $200 working, $100 as is. Call Rob, (510) 559-9075.

One pair Focal 8K415s 8″ Kevlar® woofers, reasonable. Will trade for one pair Focal 7K415 7″ mid-bass drivers or one Scan-Speak 18W/8545 7″ plus cash. Vu Pham, (703) 631-1751, weekends only.

Panasonic Leaf tweeters, Model EAS 10th 400A. Any quantity, from one on up. Ken Fritz, (800) 426-1828 (days).

JBL 2344A bi-radial horns, JBL 1″ Alnico drivers, JBL 2421A, JBL 2470, JBL 2425, JBL 2426, (301) 596-5637.

Cash for 48″ or 60″ Carver ribbons, any condition. Kevin, (216) 941-6490.

STATEMENT OF OWNERSHIP, MANAGEMENT AND CIRCULATION

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Free distribution complimentary	403	0
Total Distribution	9,597	9,879
Office use, leftover	4,420	3,121
Return from News agents	858	0
Total	14,875	13,000

I certify that the statements made by me above are correct and complete. Publication No. 529-310.
Edward T. Dell, Jr., Publisher

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25W/8565-01 woofer mounted on a 15″ × 28″ baffle. The SPL profile is smooth to the upper rolloff response peak at 2.5kHz. The 30° off-axis curve indicates that this speaker could be crossed as high as 1.8–2kHz. This makes a 10″ two-way possible (perhaps using an LCR filter at 2.5kHz), a format which has all but disappeared from the marketplace.

In a more likely three-way design, such as one using a dome midrange, the response of this woofer would easily allow the use of small 1¼″ dome mids. *Figure 12* shows the two-sample SPL comparison for the 25W woofers, attesting again to the high level of quality control and material consistency you would expect from this type of driver.

For more information on these two Scan-Speak products, contact Scan-Speak USA, 2920 Wolff St., Racine, WI 53404, (414) 635-3099, FAX (414) 632-5393, and website at http://www.vifa-usa.com. Both the 18W/8545K and 25W/8565-01 are available to consumers from these distributors: Madisound Speaker Components, (608) 831-3433; Meniscus, (616) 534 9121; Solen Inc., (514) 656-2759; and Speaker City USA, (818) 846-9921.

TABLE 1

18W/8545K T/S PARAMETERS

	SAMPLE A	SAMPLE B	FACTORY
f_S	26.9Hz	28.2Hz	28Hz
R_{EVC}	5.61	5.54	5.5
Q_{MS}	7.72	8.57	5.25
Q_{ES}	0.35	0.37	0.30
Q_{TS}	0.34	0.35	0.29
V_{AS}	49.9 ltr	42.2 ltr	48 ltr
Sens.	87.4dB	87.4dB	87.5dB
X_{MAX}	6.5mm	6.5mm	6.5mm

TABLE 2

25W/8565-01 T/S PARAMETERS

	SAMPLE A	SAMPLE B	FACTORY
f_S	20.5Hz	20.3Hz	20Hz
R_{EVC}	5.52	5.50	5.5
Q_{MS}	6.27	7.18	5.65
Q_{ES}	0.46	0.48	0.45
Q_{TS}	0.43	0.45	0.42
V_{AS}	202.7 ltr	200 ltr	222 ltr
Sens.	88.6dB	88.3dB	87.5dB
X_{MAX}	6.5mm	6.5mm	6.5mm

SB *Mailbox*

WELL DONE

Congratulations on the first speaker-kit review ("The Audax A651 Loudspeaker," *SB* 6/97), by Dennis Colin and Joe D'Appolito. Everyone involved deserves congratulations on a fine job. I believe readers will be enthusiastic about this kind of article, and think readers would love an article that details how Joe conducts the tests—I know I would. I'm looking forward to more such reviews.

G.R. Koonce
Liverpool, NY

NOTHING'S PERFECT

Regarding my product review "The Woofer Tester," (*SB* 5/97), I wish to add some comments.

I have found the Woofer Tester (WT) to be useful in measuring impedance of speaker systems with installed crossover networks. You can quickly make impedance runs of two systems to see if they have identical curves. Any significant variation will indicate a problem with the value of a crossover component or a driver.

If you print an impedance file, such as NOMINAL.WOO, the file will list phase angle, as well as impedance degrees. The WT uses phase crossings to identify f_s. I noticed that the phase angles reported by the WT varied from phase angles I found on drivers, so I ran a test with a noninductive resistor that I measured at 7.94Ω. The WT measured the impedance at about 8.1Ω at most frequencies, but reported no phase angle at zero. Up to about 200Hz, "phase degrees" were reported at –0.25 to –0.90, but above 200Hz, phase degrees were reported at increasingly erratic values.

I notified Brian Smith—the inventor of the WT—of this, and he said there had never been a comment on this anomaly. The fact that the system does not report a 0° phase angle indicates that the system is not perfect, but Mr. Smith says that it is able to locate f_s within a small fraction of a hertz.

Apparently, the digital systems respond to delays that cause insignificant errors at low frequencies, but produce larger and larger errors as the frequency increases. I asked Mr. Smith why he didn't eliminate phase results above 200Hz, and he explained he could have, but didn't consider it necessary.

If you use the WT, be aware that the report of phase degrees is not dependable above 200Hz. This in no way alters my opinion that the WT is a useful tool and a good buy for its rather modest price.

By the way, the caption for Fig. 3 in my review should cite an anomaly above 10kHz, not 18kHz, as printed.

David Weems
Newtonia, MO

A CHEAP SUBSTITUTE

I have lived with Klipsch horns for over 25 years. I love my K2s, but having brought up two musically-talented children and one aspiring one, I have intently listened to their opinions of how to improve the sound picture.

When listening to various types of music—from classical to jazz, and now rock—the K2s always sound as though the music were coming from a horn. The frequency response is as flat as can be expected—within 2–3dB across the audible range. I attribute the horn-sound image to the phase distortion of the three horns.

My oldest son loves to listen to David Winston and Keith Jarret. After attending a live concert, he came home and said that the K2s made the grand piano sound like an upright. This led me to believe that the K2s' phase distortion was the problem. I am an electronic design engineer of analog circuitry, so my solution was to design phase-compensation circuitry. Whatever kludges I came up with, the grand piano never came down flat.

One day we bought some nice-looking and cheap ($10) loudspeakers and connected them in parallel to the Klipschs. To our great amazement the grand piano came down flat!

The Klipsch horns are so much more acoustically efficient than regular loudspeakers that the sound really comes from the K2s and not from the other speakers, but apparently the regular speakers fill in enough of the sound image so the Klipschs no longer sound like horns. We have been living with this solution for 12 years, and still do not get tired of the sound.

I wanted to share this experience with *SB* readers and fellow Klipsch horn owners (especially chuxin@aol.com, whose letter in the 5/97 issue prompted my response) before you go out and spend time and money on phase-and time-equalization equipment. With yard sales full of working, but somewhat old-fashioned and cheap speakers, I believe that the solution is simpler (and less expensive) than expected.

Please let me know if my solution works for you. My "satellite speakers" are some "off brand" 15″ × 47″ × 12″ deep three-way speakers, sitting within 6′ of the K2s. Placement does not seem critical. I also have a very large subwoofer, but that is another story.

Hans J. Weedon
Salem, MA

WEBSITE WEDDING

My letter, "Made in Heaven," in *SB* "Mailbox" 4/97, mated the Linaeum tweeter used in the Radio Shack LX 5 Pro with the bass/mid driver used in the NHT Super Zero. I've received (and answered) several inquiries regarding this item, and wish to inform you there are pictures and a brief description of this "wedding" at http://www.spiceisle.com/audiodiy/projects/wedding/.

Bill Eckle
wmeckle@primenet.com

HELP WANTED

My question pertains to "EZ Concrete," cited in *SB* "Mailbox" 2/88. I called the local Builder Emporium inquiring about the size and price of a sheet of Dur-A-Rock. A 3′ × 5′ sheet costs $19.95, which scared me because my wallet is not that rich!

I wish to know whether regular ½″ drywall (4′ × 8′ sheet, $3.50) would work as well by screwing and gluing, as the article stated. Has anyone tried this, or does anyone know of any other cheaper options?

Frank L. Peyton
PO Box 1010
Canon City, CO 81215

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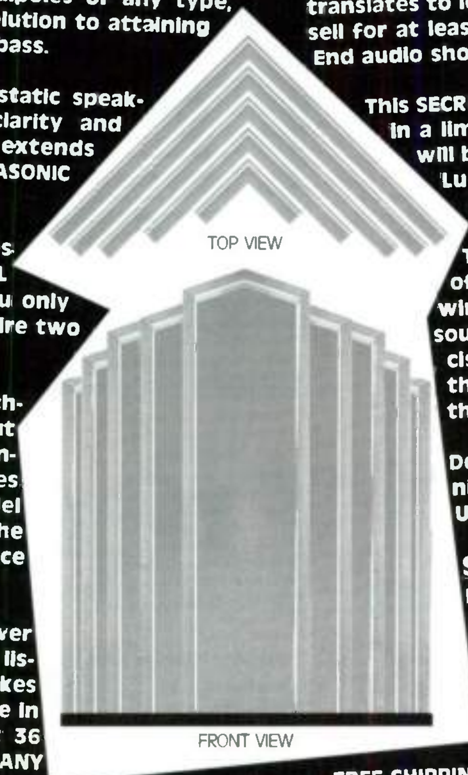
But the best part is that it connects into your system without the need of conventional active or passive crossovers (set your crossover point with a simple resistor from Radio Shack). AND YOU DON'T NEED A SECOND AMP TO DRIVE IT! Use your current amp for stereo or mono bass. Frequency response is 10. Hz to 500. Hz. Nominal impedance is 8 ohms and it requires only 30. watts to drive it (300. watts max.).



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WHERE CREDIT IS DUE

In *Speaker Builder's Loudspeaker Projects #1*, the name of the designer who invented the "Reference Monitor" (page 37) was inadvertently omitted. The design of this two-way loudspeaker should have been credited to Rolph Smulders.

LETTERS/INQUIRIES

Speaker Builder encourages reader feedback in the form of letters, queries, and comments. Send your correspondence to:

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Parts Express Speaker Kits

Each kit includes the loudspeaker drivers, unfinished cabinet plus grill frame and 1 yard black grill cloth, grill guide kit, pre-routed baffle board, pre-cut internal brace, port tube, acoustic foam, premium air core inductors, Solen polypropylene capacitors, crossover PC board, internal wiring, terminal cup, F-disconnects, black oxide screws, and cabinet/crossover assembly instructions. Each unfinished cabinet features 1-3/4" thick medium density fiberboard front baffle(!), 3/4" thick MDF shell, oak laminate veneer finish, and solid oak rounded corners. To complete the project requires the following steps: ◆Assemble and solder crossover components to the printed circuit board ◆Cut hole for terminal cup ◆Glue in internal brace ◆Mount crossover PC board to cabinet wall ◆Install internal wiring ◆Cut acoustic foam and put in place ◆Glue in baffle board ◆Finish cabinets to your preference ◆Install port tube and terminal cup ◆Wire and mount the drivers ◆And that's it; you're now ready to enjoy your new speaker system! *Note: Basic woodworking and soldering skills are recommended.*

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2 Way, 5" Morel System

Perfect for smaller rooms or for use in a home theatre system, this loudspeaker is housed in a diminutive .22 cubic ft. enclosure. It offers the soundstaging and superb imaging reminiscent of the classic British mini-monitors. Combines the impressive Morel MW 142, 5" woofer and MDT 20, 1" soft dome tweeter. The MW 142 features a huge 3" voice coil for very low distortion and exceptional control. The port tube is mounted on the rear panel (port hole is *not* pre-cut). The crossover features 6 components; one 16 gauge CFAC air core inductor, one 14 gauge air core inductor, two Solen polypropylene capacitors, and two wirewound resistors. Frequency response: 63-20,000 Hz (+/-3 dB). SPL: 85 dB w/2.83V @ 1 meter. Crossover frequency: 2,400 Hz. Impedance: 8 ohms. Power handling: 150 watts RMS. Dimensions: 12" H x 8" W x 8" D. Net weight: 15 lbs.

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SB-300-720	1.55 Cubic ft. cabinet	75.50
SB-300-725	2.70 Cubic ft. subwoofer cabinet	91.50
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Reader Service #19

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Through the course of the years Morel brought many unique and innovative products to the speaker industry. The introduction of the 3″ voice coil in a 5″ basket, using hexagonal shaped aluminum wire, utilizing a double magnet system and ducted design woofers and mid-basses are a few examples of the company's breakthroughs. Also introduced were the Integra concept (single motor system for both the tweeter and woofer) and the Push-Pull 8″ and 10″ subwoofers (dual motor system, dual voice coils with a single cone).

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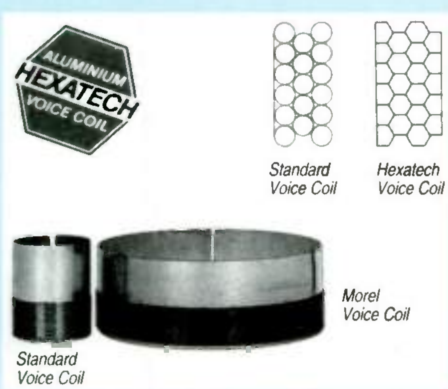

Typical double magnet ducted woofer.

For further information please contact:

Double magnet tweeter

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