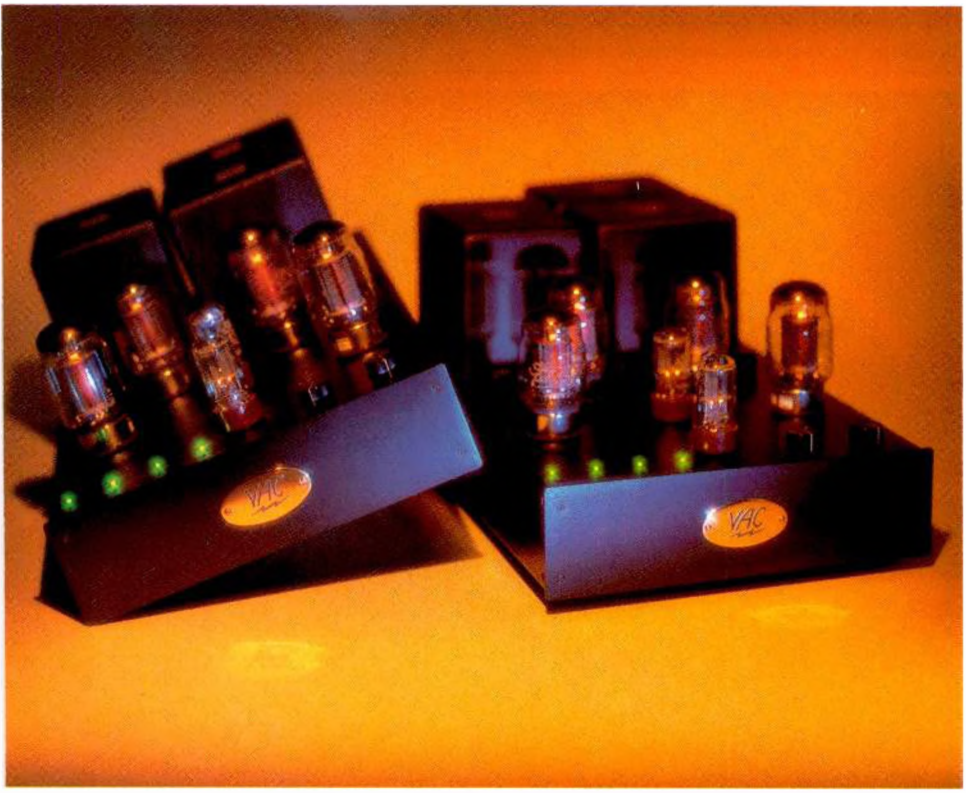
VAC PA160 MONO AMPLIFIER



In 1990, the Valve Amplification Company introduced its PA series of tube power amplifiers. These amps struck me as truly beautiful, and, presumably, they were well executed. I am also considerably impressed with company president Kevin Hayes' knowledge of vacuum-tube design.

The PA160, one of the newest products from VAC, has a variety of user adjustments that should enable it to satisfy a wide range of musical tastes. For starters, there is a three-position rotary switch for triode, Ultra-Linear, or pentode (beam-power) output-tube operation. Another three-position switch selects bias range and B+ voltage for three families of output tubes, and a six-position switch allows you to vary the amount of negative feedback. Output tubes associated with the three bias/B+ switch positions are "6L6/KT66," "EL34/KT77," and "6550/KT88." (That last position will also accommodate KT90s, according to VAC.)

THANKS TO ITS VARIETY OF USER ADJUSTMENTS, THE PA160 SHOULD SATISFY A WIDE RANGE OF MUSICAL TASTES.

The amps are normally supplied with Golden Dragon KT88s, from China, which VAC feels possess a nice combination of image size, tonal weight, and openness. With the supplied KT88s, power output is a healthy 160 watts in pentode mode and a very usable 80 watts or so in triode mode.

The aforementioned controls are on the top surface of the amplifier chassis, as is the rotary power switch plus four green LEDs and four access holes for bias adjustment. Also atop the chassis, just up from the rear panel, are four binding posts for matching loads of 1 to 2, 2 to 4, or 4 to 8 ohms—ranges chosen to let you select a tap to match a speaker's nominal or minimum impedance. (VAC suggests putting a 4-ohm speaker on the "4-8" tap for maximum power.) A small, two-position toggle switch can be used to bypass the chassis connection to the a.c. third-wire ground via a paralleled resistor and capacitor. The bypass breaks d.c. ground loops that could cause hum and noise. On the rear panel are a combination fuse-holder and IEC power-cord socket, plus RCA and XLR connectors for unbalanced and balanced signals.

Taking off the bottom plate of the all-aluminum chassis reveals an interesting wiring technique not often seen in audio products. A large fiberglass board, about ⅛ inch thick, covers the internal area of the chassis and is spaced away from the chassis by perhaps another ⅛ inch. This board carries all the top-mounted chassis components except the transformers, but does not connect them. All connections are hard-wired, via turret terminals staked to this board. (The only actual p.c. board is small and holds the bias pots and LED-indicator circuitry; it is mounted to the main board.) Teflon-insulated wire is used; the general appearance and neatness of the wiring are nothing to write home about, but VAC says this wiring arrangement is deliberate, to avoid the stray couplings that can occur with wires paralleled in neat bundles. Parts quality looked to be appropriate, with a number of metal-film resistors and by-passed specialty film capacitors in the signal path. The main chassis piece is bent to form the top and sides. Front and rear panels are separate pieces, bolted to corner brackets that tie everything together. Half-inch lips at the bottom of the main chassis piece are lined with Pemm nuts for bolting on the bottom plate.

Circuit Description

A 6SN7 octal-based dual triode, known to be a linear and good-sounding tube, is used in both the first and second stages of the PA160. The first stage is configured as

Photos: Michael Groen

what is known as a floating paraphase phase inverter. In this arrangement, the input signal is applied to the grid of a triode acting as a common-cathode amplifier, which provides one phase of the stage's output signal. This output is resistively coupled to a point that I shall call "point x." The other triode's plate, also resistively coupled to point x, provides the other phase of the stage's output. A coupling capacitor from point x drives the grid of the second triode. In actuality, this amounts to a stage that provides one output phase directly and couples that output to another stage, which has 100% inverting feedback, to provide the other output phase. From a circuit purist's standpoint, this scheme has the disadvantage that the second generated phase goes through one more tube than the first generated phase. Further, the output impedance of the two phases is likely to be quite different.

The two output phases of the phase-inverter first stage are capacitively coupled into the grids of the second stage. This stage acts as a short-tailed push-pull amplifier with cathodes returning to ground through a common, unbypassed cathode resistor; the plate outputs of this second stage are capacitor-coupled to the output tube grids. According to VAC, the modest differential function of this stage helps to offset any imbalances from the paraphase inverter.

All four output tubes have potentiometers to provide adjustable negative grid bias in two ranges, as controlled by the tube-type switch. Each output tube's cathode returns to ground through a 10-ohm sampling resistor. In an arrangement used successfully in a number of other tube power amplifiers, the voltage drop across each cathode sampling resistor is compared, in a quad comparator, to a reference that represents the correct cathode current. The outputs of each comparator drive the appropriate LED indicator. Correct bias for each output tube is obtained at the adjustment point where the LED just goes out. The overall negative feedback, which is taken from the "4-8" output tap, goes to the feedback switch. At this switch, adjustable feedback resistors are selected and applied to the cathode of the signal input tube of the first stage.

Two power transformers are used in the PA160. One is for the high-voltage supply, and the other provides tube heater power, bias voltage, and power for the output tubes' bias-setting circuitry.

The output of the high-voltage supply transformer is rectified by a full-wave bridge; it is then applied to four 330-μF, 450-V filter capacitors in a series-parallel arrangement. This arrangement yields the

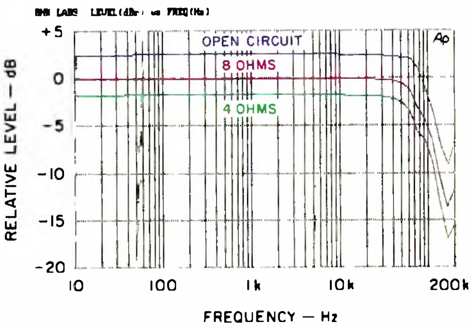


Fig. 1—Frequency response at "4-8" output tap.

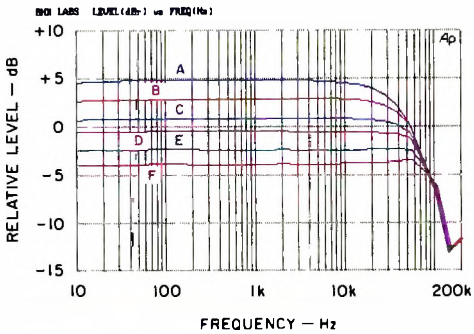


Fig. 2—Frequency response vs. feedback setting, 4-ohm load on "4-8" tap.

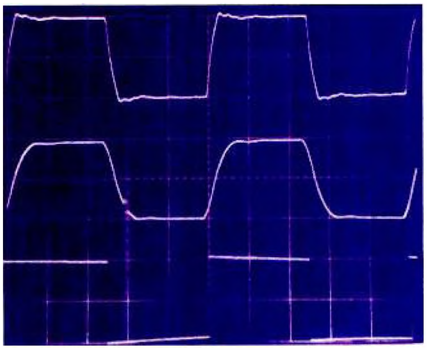


Fig. 3—Square-wave response for 10 kHz into 8 ohms (top), 10 kHz into 8 ohms paralleled by 2 μF (middle), and 40 Hz into 8 ohms (bottom).

SPECS

Power Output into 4 Ohms: With KT88 output tubes, 160 watts in pentode mode, 152 watts in Ultra-Linear mode, or 79 watts in triode mode; with other tubes, in pentode mode, 125 watts with KT77s, 150 watts with EL34s, or 100 watts with 6L6GCs.

THD: At full rated power, less than 2%; at 10 watts, typically 0.23% at 1 kHz, less than 1% from 20 Hz to 20 kHz.

Power Bandwidth, Ultra-Linear Mode, with KT88s: 12 Hz to 42 kHz, +0, –0.5 dB; 8.5 Hz to 75 kHz, +0, –3 dB.

Frequency Response at 1 Watt: 5 Hz to 48 kHz, +0, –0.5 dB; 3 Hz to 82 kHz, +0, –3 dB.

S/N: Greater than 88 dB.

Output Noise: Less than 1 mV.

Sensitivity: 0.34-V input for full output, with KT88 tubes, Ultra-Linear mode, and feedback setting "D."

Power Consumption: At idle, 288 watts; at full power, 528 watts.

Dimensions: 11¾ in. W x 20½ in. D x 8½ in. H (29.9 cm x 52.1 cm x 21.6 cm).

Weight: 53 lbs. (24 kg) each.

Price: $4,990 per pair.

Company Address: 164 Sarasota Center Blvd., Sarasota, Fla. 34240.

For literature, circle No. 95

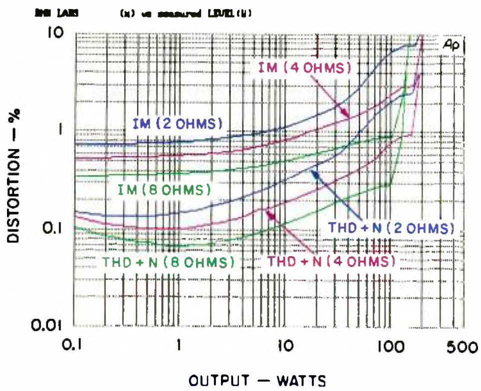


Fig. 4—THD + N at 1 kHz, and SMPTE-IM distortion, vs. power.

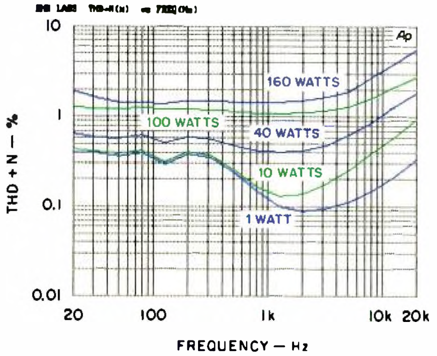


Fig. 5—THD + N vs. frequency.

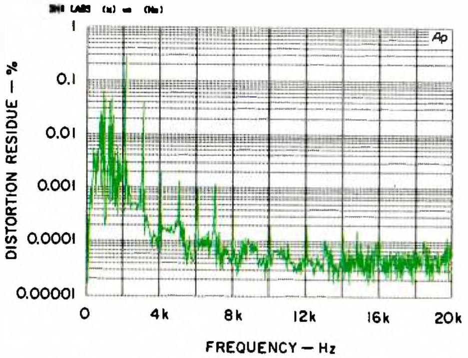


Fig. 6—Harmonics for 1-kHz test signal.

equivalent of a 330-µF, 900-V capacitor, which can withstand the operating B+ of over 500 V. The secondary voltage applied to the rectifier and filter system is controlled by the three-position tube-type selector. The highest voltage is for the "6550/KT88" position, with successively lower voltages applied to the "EL34/KT77" and "6L6/KT66" positions.

Supply voltage to the second stage is developed through a resistor connected to the main B+, and is bypassed with another 330-µF, 450-V capacitor. In a similar fashion, the supply to the first stage is derived from the second stage's supply point through a resistor and a final 330-µF, 450-V bypass capacitor.

One aspect of the PA160's circuit bothered me. The balanced input, which I assumed was balanced because of the XLR input connector, is actually not balanced at all. Pin 2 of the XLR is tied to the hot pin of the unbalanced RCA input connector. Pin 1 is tied to circuit common. Pin 3, which would be the negative phase of an incoming balanced signal, is not utilized at all and is merely terminated with a resistor to ground. Blasphemy! While VAC never explicitly claims this is a balanced input (the owner's manual only says it's "for compatibility with balanced . . . sources"), I think that they should clearly and explicitly state in the manual what was done. According to Kevin Hayes, however, "The XLR jack merely provides a place to plug a [balanced] source in without a clumsy adaptor, and provides a balanced load to each phase of the source."

Measurements

Since there were so many operative combinations available with the PA160s, I selected the following as the nominal condition for my testing: Ultra-Linear operation, feedback at position "D," the supplied KT88 output tubes, and loading on the "4-8" output taps.

The voltage gain of the PA160 amplifiers is somewhat higher than normal. This can cause such system problems as audible noise from preamp output stages or preamp volume controls restricted to just the first few degrees of travel. The manufacturer realizes this, and a modification will be available in the near future to lower the overall gain if needed. (Kevin Hayes says that, in many instances, higher overall gain can result in superior sound quality.) Voltage gain and related input sensitivity are presented in Table I for the three operating modes, with feedback set to position "A" (no feedback) and to position "D."

Frequency response in the Ultra-Linear mode—as a function of open-circuit, 8-, and 4-ohm loading on the "4-8" tap—is plotted in Fig. 1. As can be seen, response is well behaved to beyond 100 kHz. The spacing between the curves is uniform (suggesting uniform output impedance with frequency); the amount of spacing suggests a fairly high output impedance (no surprise for tube amplifiers, especially those with low negative feedback). Figure 2 shows how gain and frequency response change with different feedback settings. For the pentode mode (not shown), the open- and closed-loop gains were higher; the curves were thus more widely spread between maximum and minimum gain, and the curves for higher amounts of feedback had some high-frequency peaking. In the triode mode (also not shown), the gains were the lowest and the curves were more closely spaced than in Fig. 2.

Rise- and fall-times for an output of ±5 V into 8 ohms on the "4-8" tap were 4.3 µS. Figure 3 is a 'scope photo of square-wave response. The top trace, for 10 kHz into an 8-ohm load on the "4-8" tap, is fast and well damped. In the middle trace, with a 2-µF capacitor paralleled across the 8-ohm load, the damping is superb, with rise- and fall-times of perhaps 8 to 10 µS. This amp would do well with electrostatic speaker loads. Tilt, or pulse droop, at 40 Hz (bottom trace) is quite low, indicating extended response below the audio band. Square-wave response in the pentode mode did have some overshoot and ringing at the higher feedback settings, whereas the responses for triode mode were a bit slower than seen in the photo but otherwise very well behaved.

THE SQUARE-WAVE TEST SHOWS THE PA160 WOULD DO WELL WITH ELECTROSTATIC LOADS.

The THD + N at 1 kHz, and SMPTE-IM distortion, are shown in Fig. 4 as a function of power output and load on the "4-8" tap. The curves for the triode and pentode

THE POWERFUL AND WELL-DAMPED BASS SHOWS THAT THE PA160s CAN DEFINITELY KICK BUTT!

modes were, surprisingly, very similar in magnitude and shape to the Ultra-Linear curves shown, save that the clipping point was lower in triode mode. In Fig. 5, THD + N versus frequency and power for 4-ohm loading on the "4-8" tap, we see some unusual behavior below about 1 kHz. This is evident as a distortion increase that is most noticeable at lower power levels. It turns out that there is some 120-Hz power-supply ripple modulating the distortion. Figure 6 is a spectrum of the harmonic-distortion residue for a 1-kHz signal at 10 watts into 4 ohms on the "4-8" output tap. While the actual harmonics fall off with order in a desirably rapid manner, you can see the aforementioned 120-Hz sidebands on each side of the gap where the 1-kHz fundamental frequency has been nulled out.

Amplifier output noise, as a function of bandwidth and operating mode, is listed in Table II. For wideband measurements and those taken over the range from 22 Hz to 22 kHz, the readings are mostly hum, a mixture of 60 and 120 Hz. This amount of hum is a bit much and, as I later found, was sometimes audible when I was near the speakers.

Damping factor in the Ultra-Linear mode on the "4-8" tap was about 3, referred to an 8-ohm load, and was very flat with frequency. In pentode mode, the PA160 had a damping factor of about 2 and was similarly flat with frequency. In triode mode, the damping factor was the highest, at 4.2, but fell off slightly above 2 to 3 kHz.

Dynamic power in the Ultra-Linear mode was about 116 watts into an 8-ohm load on the "4-8" tap. With a 4-ohm load, the equivalent sine-wave power at the visual onset of clipping was 171 watts at the beginning of the burst and 162 watts at its end. For 2-ohm loading, power at the beginning and end of the burst was 182 and 163 watts, respectively. With 4 ohms as a reference load and the manufacturer's spec of 152 watts, the dynamic headroom worked out to 1.0 dB at the beginning of the burst and 0.55 at its end. Clipping power (steady-state power at the visual onset of clipping) was 115 watts for 8 ohms, 158 watts for 4 ohms, and 145 watts for 2 ohms. The readings for a.c. line current were 3.0, 3.9, and 4.8 amperes for the same loads. At idle, a.c. line draw was 2.4 amperes. With the 4-ohm load as a reference, clipping headroom was 0.34 dB.

Use and Listening Tests

Record-playing equipment used in my system during the review period included an Oracle turntable fitted with a Well Tempered Arm and Stanton's 981HZS moving-magnet pickup, feeding either a Quicksilver Audio preamp or my own preamp (a tube phono stage with a passive selector and volume control). For CDs, I used Counterpoint's DA-11A and PS Audio's Lambda transports to drive a Sonic Frontiers SFD-2, a Resolution Audio Reference 20, and other (experimental) D/A converters. Additional signal sources

Table I—Gain and IHF sensitivity. Position "A" is for operation with no feedback.

	Gain, dB		IHF Sensitivity, mV	
	LEFT	RIGHT	LEFT	RIGHT
Feedback at "D"				
Triode Mode	36.3	36.2	42.1	43.7
Ultra-Linear Mode	39.2	39.1	31.1	31.4
Pentode Mode	42.1	42.0	22.2	22.4
Feedback at "A"				
Triode Mode	39.8	39.6	28.9	29.5
Ultra-Linear Mode	44.4	44.3	17.0	17.3
Pentode Mode	50.9	50.7	8.0	8.2

Table II—Output noise levels.

	Output Noise, mV	
Mode and Bandwidth	LEFT	RIGHT
PENTODE MODE		
Wideband	3.17	2.36
22 Hz to 22 kHz	2.88	2.14
400 Hz to 22 kHz	0.243	0.175
A-Weighted	0.430	0.341
ULTRA-LINEAR MODE		
Wideband	2.26	1.63
22 Hz to 22 kHz	2.19	1.54
400 Hz to 22 kHz	0.183	0.128
A-Weighted	0.323	0.242
TRIODE MODE		
Wideband	1.77	1.32
22 Hz to 22 kHz	1.74	1.26
400 Hz to 22 kHz	0.123	0.103
A-Weighted	0.245	0.199

Table III—IHF S/N ratios.

	S/N, dB	
	LEFT	RIGHT
Pentode Mode	76.4	78.4
Ultra-Linear Mode	78.8	81.3
Triode Mode	81.3	83.1

were Nakamichi's ST-7 FM tuner and 250 cassette recorder and a Technics open-reel recorder. Preamplifiers included a DGX Audio DDP-1, a Quicksilver Audio model, Forssell tube line drivers, a First Sound II passive unit, and the passive selector and attenuator sections of my preamp. Power amplifiers on hand for comparison were a Crown Macro Reference, Quicksilver Audio M135s, and a pair of Cary Audio Designs CAD-805 single-ended triode tube amps. The speakers hooked up in my reference system were B & W 801 Matrix Series 3s, augmented from 20 to 50 Hz by my two subwoofer systems, each using a JBL 1400Nd driver in a 5-cubic-foot ported enclosure.

The owner's manual for the PA160s is very informative. It covers the expected sound, reliability, and various types and manufacturers of tubes. The manual encourages you to experiment with the amp's various settings to get the best sound in your system. One item deserves special mention: VAC indicates that the "initial break-in time of high-resolution equipment is infuriatingly long. The PA160 will continue to season for at least 200 hours." When I first tried out these amps, I left them in the factory-set mode of Ultra-Linear operation, with the feedback switch at position "D." Initially, I thought the amps produced a gutsy rendition of the lower midrange in louder orchestral passages, but there was a noticeable glare and irritation that bothered me. After loaning the units to a friend and beating up on them in the lab, I returned them to my system for more listening. Soon afterward, I got the feeling that these puppies were beginning to break in and mellow out a bit. The glare and irritation were now greatly reduced, and I wasn't even close to 200 hours of operation.

Experimenting with the various operating modes and amounts of feedback, I settled on the pentode mode, with feedback in the "D" or "E" position. Now I was getting somewhere! These amps had a presentation that was slightly more up front than is my usual preference. However, the sound was very realistic, with great dynamics and dimensional properties. Bass was powerful and well damped. The PA160s can most definitely kick butt! Ambient sounds, such as audience and performer noises, were rendered with great clarity.

I then tried a new set of Shuguang Chinese EL34 tubes, from a set of 12 that Kevin Hayes had kindly given me at a CES for my Quicksilver M135s. After letting these output tubes break in for a while, I went through the operating modes and quickly settled in on the triode mode, with no feedback. These amps sounded *wonderful* this way! The sound was more refined than with the KT88s, more like my Quicksilver M135s. Bass had excellent heft and punch, and resolution, space, and delicacy were of a high order.

THE SOUND OF THE PA160s IS VERY REALISTIC, WITH GREAT DYNAMICS AND DIMENSIONALITY.

In using these amplifiers, I did have some problems with their extra-high gain. For instance, when I used my preamp, which is active only in its phono stage, I was frequently operating at the lowest two positions of its passive volume control. One position was too low in volume, and the next one up was too high. Using a preamp with line-stage gain would be most problematic in this regard. Also, any line-stage output noise might be audible. In fact, I could hear some hiss coming from the speakers when using the Forssell balanced line stage with the Sonic Frontiers D/A converter. I could also hear some 120-Hz amplifier hum from the speakers, mostly in the pentode mode. The bias adjustment did drift with time and a.c. line voltage, and I found myself doing a lot of tweaking of the bias pots—more so with the KT88s than with the EL34s. But, hey, what do you expect? I am a tweak, and the VAC amps are really bias-stable enough.

In conclusion, I think the PA160s are damn good amplifiers, and I definitely recommend a serious listen. A

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close to 20 Hz yet never lost definition and control or the ability to move the room at loud volumes. Its sheer bass power and deep bass extension were not quite up to the super-subwoofer level, but I have yet to hear a subwoofer more musically realistic and accurate. Upper bass and midrange were excellent in virtually every respect. I detected no significant tonal variations not attributable to my listening room. Detail, transparency, and timbre in this frequency range were as good as anything I've heard, but it did require the right amp to get the proper warmth.

The upper midrange was *really* excellent! It was musically natural; it had the air and resolution that were once the province of electrostatics, combined with a musical "life" just short of the best ribbon speakers. The treble was sweet and natural, with outstanding resolution; it was fun to listen to, not simply an exercise in technology.

Only a few of the larger (and more expensive) ribbon/subwoofer combinations have better dynamics than the CS7. This Thiel speaker could handle both low-level and large-scale dynamics with excellent definition and without shifts in sound character and timbre. The CS7 handled rapid musical transients equally well. I got every nuance of the differences in transient response, and only a few ribbon drivers sound "faster."

The CS7's transparency, harmonic naturalness, and detail really demonstrated how good dynamic speakers have become: Both accurate and musical. The soundstage was stable over a wide listening area. Width and depth were very faithful to the content of my reference recordings; there were no surprises, shifts, contractions, or exaggerations. Soundstage detail was better than that of any other dynamic speaker I have heard to date, and the focus was much closer to that of a point source than in any other large dynamic speaker I know of. The imaging focus was possibly the best in both width and depth I have heard from any cone speaker, and was stable over a relatively wide listening area.

The CS7 is definitely a reference-quality speaker whose only major drawbacks are price and amplifier sensitivity. It helps define the current state of the art in high-end sound. A real pleasure to review! A