CARY AUDIO CAD-50 and CAD-50SL MONO AMPS

Manufacturer's Specifications

Power Output: 50 watts at 1 kHz.

Frequency Response at 1 Watt Output: 20 Hz to 20 kHz, +0, −0.75 dB; 15 Hz to 20 kHz, ±2 dB.

THD at Rated Power: 2.5%.

Hum and Noise: 80 dB below rated output.

Damping Factor: Greater than 30.

Input Sensitivity: 1.5 V for full output.

Input Impedance: 100 kilohms.

Circuit Type: Push-pull amplification in Class AB1.

Tube Complement: One ECC83/12AX7 pre-driver, one 12BH7 phase inverter, two EL34 output tubes.

Power Requirements: 100 to 125 V a.c., 50/60 Hz; export version, 220 V a.c., 50 Hz.

Dimensions: 17 in. W × 5¾ in. H × 12 in. D (43.2 cm × 14.6 cm × 30.5 cm).

Weight: 35 lbs. (15.9 kg) each.

Prices: CAD-50, $1,295 per pair; CAD-50SL, $1,495 per pair.

Company Address: 101J Woodwinds Industrial Ct., Cary, N.C. 27511.

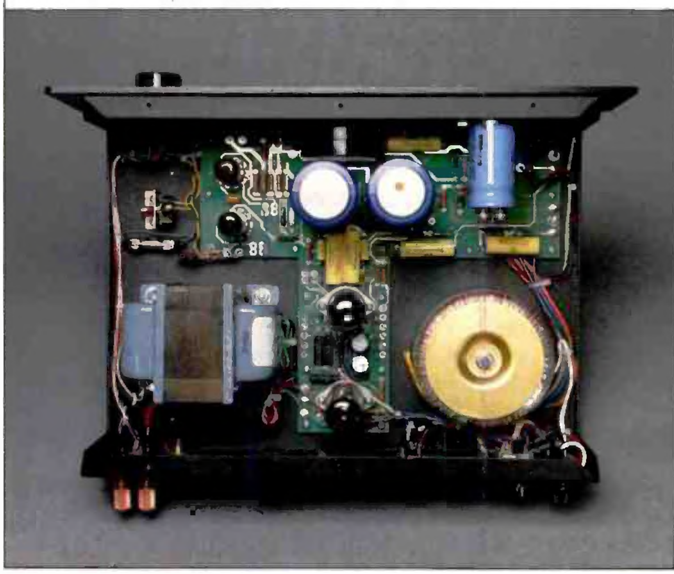
For literature, circle No. 92.

I first learned about Cary Audio Design from an advertisement in an "underground" hi-fi magazine in late 1989 that showed a top view of one of their tube power amplifiers with its cover removed. I was intrigued to see that it used a toroidal output transformer. At the Winter 1990 Consumer Electronics Show, I visited Cary Audio's booth and heard some very nice sound coming out of Dahlquist speakers. I discovered that Cary makes a 100-watt tube power amp with stacked toroidal output transformers, in addition to their 50-watt units. They also make a tube preamp, a CD processor/high-level tube preamp, and a hybrid four-channel power amp using tube front-ends with solid-state output stages.

I then arranged to get some of Cary's amplifiers for review. What they finally sent was two pairs of amps, one the general-purpose CAD-50SL that uses an EI-lamination output transformer, and the other the special-purpose CAD-50, with a toroidal output transformer, whose performance is optimized for bass frequencies. This quartet of amps makes up the Cary Reference System, intended for use as a biamplified system. It just so happens that I have on hand a Martin-Logan Monolith III speaker system that I have been experimenting with and listening to. This system is committed to biamplified use, with a low-level active crossover, and therefore is tailor-made for trying out the Cary Reference System.

I liked the appearance of these units at first sight. They have meters on their front panels, as all God's tube amplifiers should. Other front-panel attributes include a rocker-type on/off switch and a rotary knob for selecting which output tube's plate current will be read on the meter. This control has a third position labelled "Class A" for monitoring the sum of the two plate currents. The use of this term is misleading, in my considered opinion, as it implies the amplifier's mode of operation is Class A when the knob is put in that position.

On the rear panel we find a pair of Edison Price Music Post speaker connectors, outrageously appropriate for large wire and spade lugs; they easily accommodate the thick spade lugs on the Cardas speaker wires that I use.



Also on the rear panel are Tiffany phono connectors for signal "Input" and for "Remote" turn-on and turn-off of the amp, a pair of knobs for adjusting output-tube bias (plate current), two line fuses, a gold-plated ground post, a two-position rotary switch for changing the output tubes' mode of operation from pentode to triode, and the power cord.

Chassis construction is straightforward, consisting of a piece of aluminum bent up to form the rear panel, bottom, and front subpanel. Another piece of aluminum is bent to form the top and side cover. This latter piece is perforated on the top and sides with many small, round holes for ventilation. Inside, the output and power transformers are mounted directly to the bottom of the chassis. A T-shaped p.c. board mounted on stand-offs above the bottom of the chassis carries the amplifier signal circuitry, including the tubes and main power-supply filter capacitors. A $^{3}/_{16}$-inch-thick front panel is mounted to the front subpanel to dress up the finished appearance of the unit.

Parts and build quality are excellent in these units. My only complaint is that there are too many screws holding on the top cover!

Circuit Description

The circuit is quite conventional in topology. A number of tube power amplifiers built over the years have used similar circuitry. The first stage (Fig. 1A) is a common-cathode amplifier with paralleled tube elements, direct-coupled to the second stage. This second stage, configured as a split-load phase inverter, again with paralleled tube elements, is capacitor-coupled to the output-tube control grids. High-quality Sidereal brand 0.22-µF, 600-V film capacitors are used here and are bypassed with Sidereal 0.01-µF, 600-V units. The output stage (Fig. 1B) has a switch for operating the tubes as pentodes or triodes. In pentode mode, the screen grids are connected to the B+ supply; in triode mode, the screens are connected to the tube plates. This feature gives the present-day user the ability to experience the old "Pentode/Triode controversy" by listening to these two types of output-tube operation. When the amps are triode-connected, power output is lower (usually somewhat

Just by flipping a switch on the Cary amps, you can relive the controversy over triodes versus pentodes in amplifier output stages.

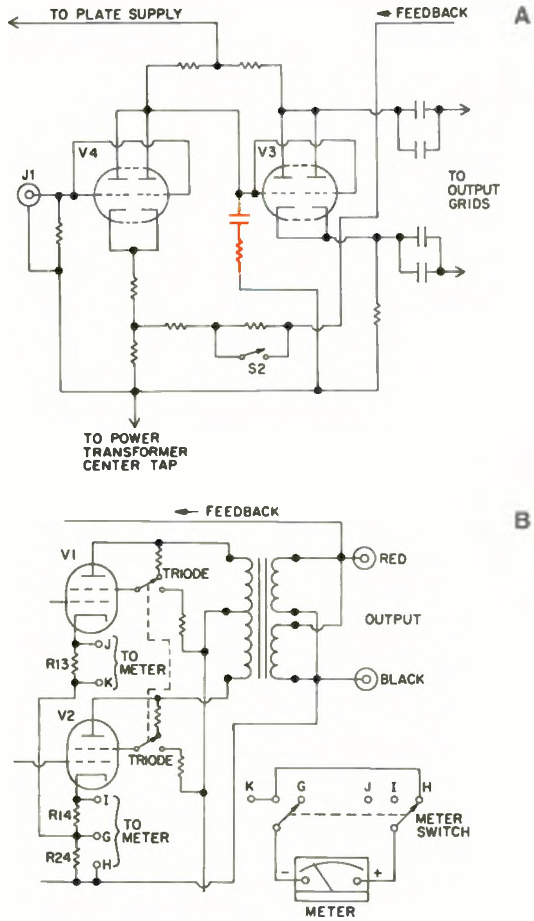


Fig. 1—Initial stages (A) and output stage (B) of CAD-50 and CAD-50SL amps. Note RC circuit used to add mild bass boost to CAD-50, and feedback level switch S2 (A), as well as triode/pentode switch and metering system in output stage (B).

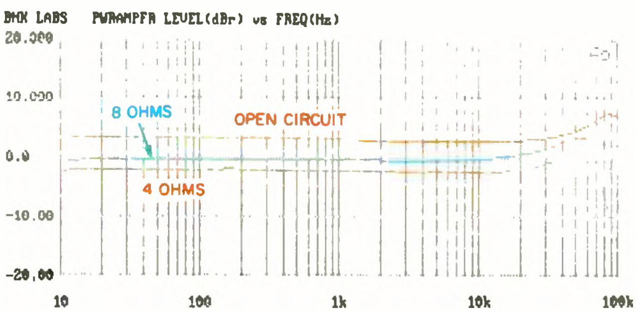


Fig. 2—Frequency response of CAD-50SL vs. load.

less than half that attainable in pentode operation), output impedance is lower, and distortion is less dependent on load conditions. When the tubes operate as pentodes (actually as beam-power tubes, which most of the modern output tubes really are), power output is higher, output impedance is higher, and distortion is more dependent on loading and usually has more higher order odd harmonics. The basic reason for higher power when output tubes are pentode-connected is that saturation voltage, the minimum voltage across the tube when fully turned on, is quite a bit lower in the pentode connection and therefore the voltage swing is larger for the same plate-supply voltage, producing more power output.

A clever arrangement is used in the cathode circuit of the output tubes to measure the plate currents on the front-panel meter. Resistors R13, R14, and R24 are all of the same value. The meter, a milliammeter with a calibrated series resistance which turns it into a voltmeter in actuality, is switched across each of these resistors in turn. When across R13 or R14, the meter will indicate the individual plate currents of each output tube. When switched across R24, the meter will read the sum of the two plate currents because both of these currents flow through R24. It is this latter condition that is termed "Class A" on the front-panel meter switch.

An overall negative feedback loop is connected from the output transformer secondary back to the first-stage cathode. Mounted on the p.c. board is an internal two-position toggle switch (S2 in Fig. 1A) that allows for a change of several dB in the amount of feedback. The units were measured and listened to in the "greater feedback" position. Secondary winding configuration of the output transformer consists of two windings in parallel. Cary's specifications don't indicate what load impedance the transformer secondary loading is optimized for. Dennis Had, designer of the Cary Audio gear, indicated in a conversation that "best match" was set for about 8-ohm loading. We'll find out something about this subject in the measurements section of this profile.

As for the power supply, the high-voltage secondary winding on the power transformer is full-wave rectified with solid-state rectifiers, and loaded with a capacitor input filter consisting of two 320-µF, 450-V electrolytic capacitors. This main filter capacitance is bypassed by one of the Sidereal 0.22-µF, 600-V film capacitors. Interestingly, the rectifier diodes are also bypassed by a pair of these capacitors. This presumably absorbs some of the transient energy when the diodes start and stop conduction, and it may well improve the sonic quality of the amplifier. The tube heaters all operate off a.c. in this design.

Measurements

Voltage gain and sensitivity was measured first for both the CAD-50 and CAD-50SL amplifiers and was found to be 16.6×, or 24.4 dB, for both designs when set for the pentode mode of output-stage operation. The IHF sensitivity, the input voltage for 1 watt into 8 ohms at 1 kHz, was 169 mV for both amps. When set in the triode mode, voltage gain was some 3 dB less, with a commensurate decrease in input sensitivity.

In its triode mode, the CAD-50SL's square-wave response into 4 ohms at 10 kHz is as nice-looking as any solid-state amp's.

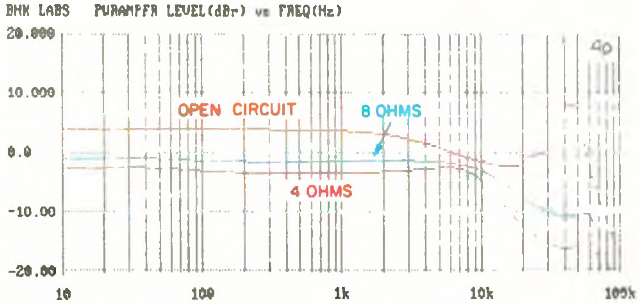


Fig. 3—Frequency response of CAD-50 vs. load.

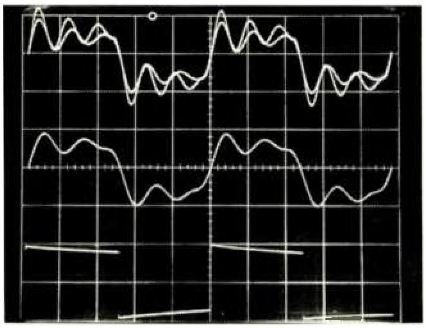


Fig. 4—Square-wave response of CAD-50SL in pentode mode at 10 kHz into 4-ohm and 8-ohm loads (overlaid traces, top), 10 kHz into 8 ohms paralleled by 2 μF (middle), and 40 Hz into 8 ohms (bottom). Scales: Vertical, 5 V/div.; horizontal, 20 μS/div. for 20-kHz traces, 5 mS/div. for 40-Hz trace.

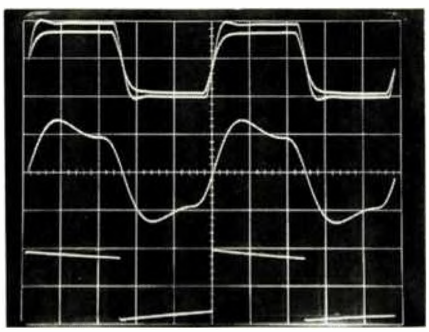


Fig. 5—Same as Fig. 4 but for triode operation.

Frequency responses at the 1-watt level into 8 ohms are shown in Fig. 2 for the CAD-50SL and in Fig. 3 for the CAD-50. Each figure includes curves for open-circuit, 8-ohm, and 4-ohm loading. Doing this gives us a measure of the output impedance's magnitude and its uniformity with frequency, and a good look at the out-of-band behavior of the output transformers. As can be seen, the general-purpose CAD-50SL has the simpler behavior and wider bandwidth. This amp's output impedance is essentially uniform up to beyond 10 kHz and is on the order of 3 to 4 ohms. Of interest, its high-frequency response is more peaked when it is loaded, contrary to the usual behavior of tube output circuits with output transformers. When the CAD-50SL was set to the triode mode, the peaking between 20 and 100 kHz was gone at all loadings from open-circuit down to 4 ohms; output impedance fell to about 2 or 3 ohms.

Looking at the curves for the bass-oriented CAD-50 (Fig. 3), we see just the opposite, the more normal variation of high-frequency peaking or damping with loading. Another attribute of the CAD-50's frequency response is a mild bass boost below a few hundred Hz, about 1 dB at 20 Hz. This was deliberately designed into the amp and is caused by the RC network loading the first tube's plate circuit (Fig. 1A). Needless to say, this network is absent in the CAD-50SL. Note that this boost is virtually absent in the open-circuit load curve, as the greater feedback loop gain under this condition takes out this open-loop frequency response aberration. Output impedance variation is somewhat more complicated in this design, especially in the region above a few kHz. Generally, the output impedance is a little higher in the CAD-50, more on the order of 5 to 6 ohms. Given the measured characteristics discussed, the use of the CAD-50 as a bass amp seems appropriate.

An in-depth look at how the CAD-50SL's behavior changes between triode and pentode operating modes can be seen in its reproduction of square waves (Figs. 4 and 5). In the pentode mode, shown in Fig. 4, the 10-kHz traces (top and middle) show quite a bit of ringing, which relates to the frequency response curves of Fig. 2. The top trace shows response for 8-ohm loading, overlaid on a smaller trace for 4-ohm loading. The amount of high-frequency ringing exhibited by the CAD-50SL in pentode mode is by no means intrinsic to pentode operation of an output stage, but is a consequence of the way this amp's high-frequency compensation was designed. The middle trace shows the effect of adding a 2-μF capacitance across an 8-ohm load. The capacitor actually reduces the amount of ringing and slows down the rise-time. The 40-Hz square wave (bottom trace) indicates relatively good, extended low-frequency response below 10 Hz, the limit of Fig. 2. Figure 5 shows square-wave behavior in the triode mode. High-frequency damping is much better, most likely due to the considerably lower overall circuit-loop gain and lower output impedance of the tubes in the triode mode. The waveshape for 4-ohm loading (smaller of the overlaid top traces) is as nice-looking as that for any solid-state amp. However, putting 2 μF across the 8-ohm load causes more ringing overshoot and slowing of the rise-time than in the pentode mode. The low-frequency droop in the 40-Hz (bottom) trace is also just perceptibly worse than that in the pentode mode.

With the Cary amplifiers and Spica speakers, it was easy to forget amps and stuff and get involved with the music.

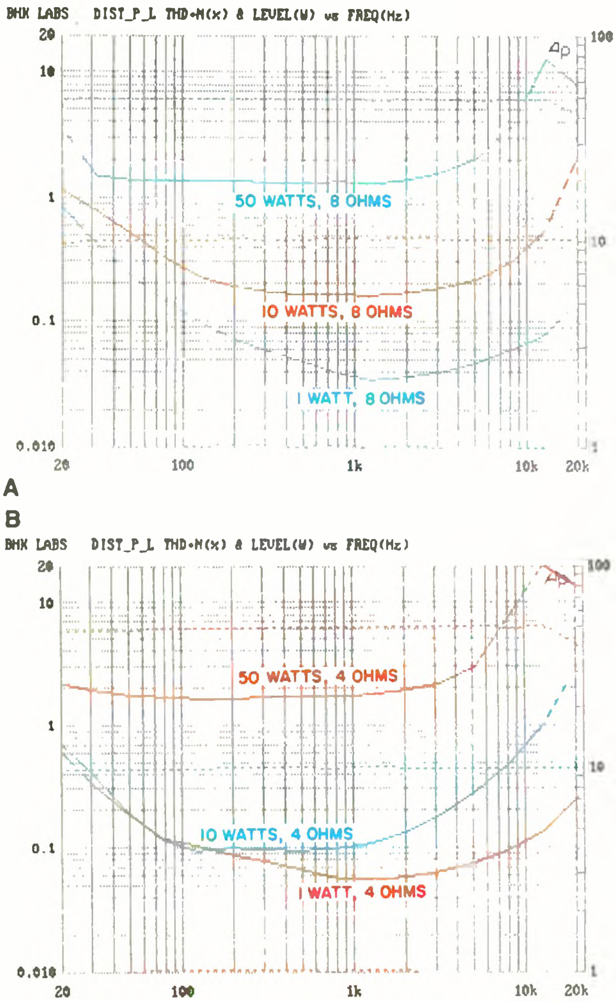


Fig. 6—THD + N vs. power and frequency for 8-ohm load (A) and 4-ohm load (B) for CAD-50SL. Dashed curves are actual power output vs. frequency at the indicated levels (see text); read power from right-hand scale.

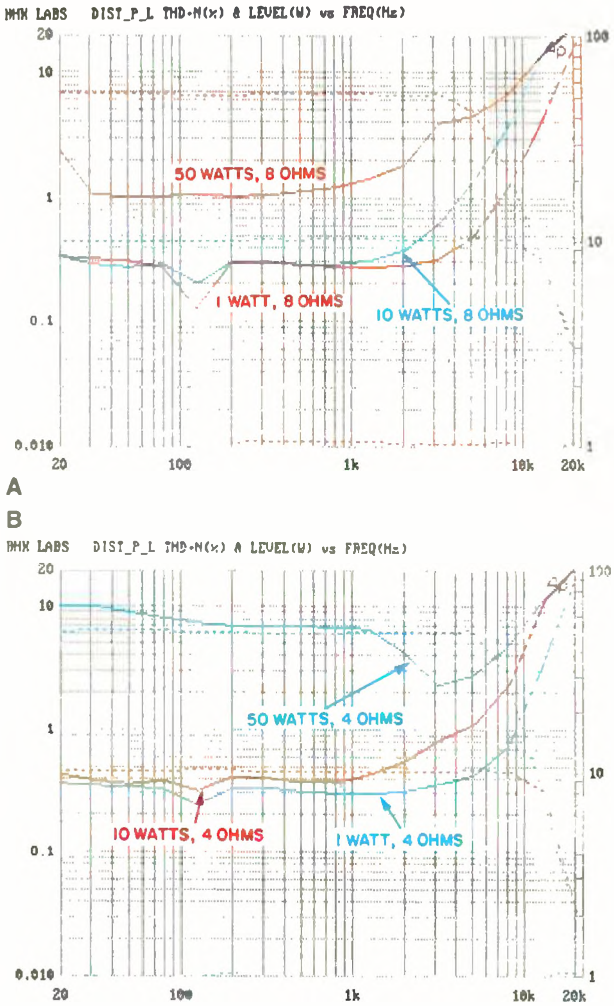


Fig. 7—Same as Fig. 6 but for CAD-50 (see text).

Harmonic distortion plus noise is plotted as a function of frequency, power, and load in Figs. 6A and 6B for the CAD-50SL and in Figs. 7A and 7B for the CAD-50. It's evident from the figures that the CAD-50SL is a somewhat better performer. On these graphs, the solid curves show distortion levels and the dashed curves show power output versus frequency. These tests were done in a regulating mode whereby the generator drive to the amplifier under test is regulated to produce a constant specified power output over the frequency range. In the case of the CAD-50, I let the loop go out of regulation above 4 kHz so the distortion wouldn't get completely out of hand. As a result, the power output dropped below 50 watts above this frequency, as shown by the dashed output curves at the 50-watt level in Figs. 7A and 7B. (For the CAD-50SL, Figs. 6A and 6B, regulation was terminated above about 12 kHz.) Another weirdness in the CAD-50's behavior is the dip in distortion at 120 Hz at lower power levels. This was caused by 120-Hz power-supply ripple in the amplifier output cancelling the distortion residue at this frequency. In Fig. 8, 1-kHz THD + N and SMPTE-IM distortion are plotted against power output and load for the CAD-50SL amp in the pentode mode. The

The amps sounded more refined and sweet in triode mode, but in pentode mode they were livelier.

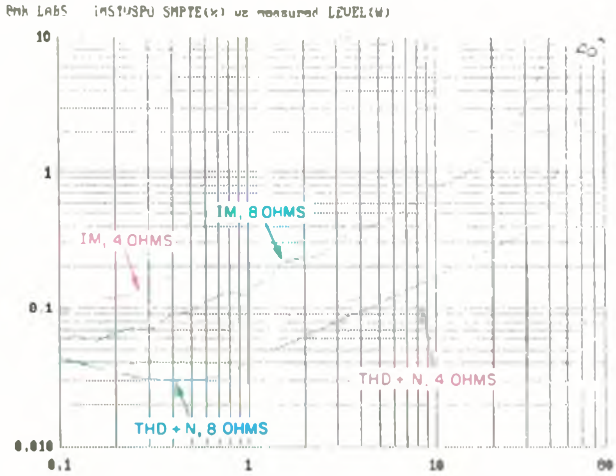


Fig. 8—THD + N and SMPTE-IM distortion for CAD-50SL into 4- and 8-ohm loads.

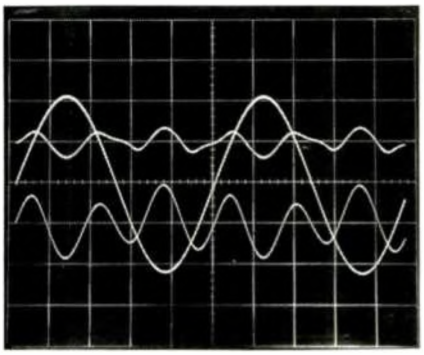


Fig. 9—Output and distortion residue at 10 watts out from CAD-50SL into 4 ohms. Distortion levels were 0.61% in pentode mode (upper residue trace) and 1.6% in triode mode (lower residue trace).

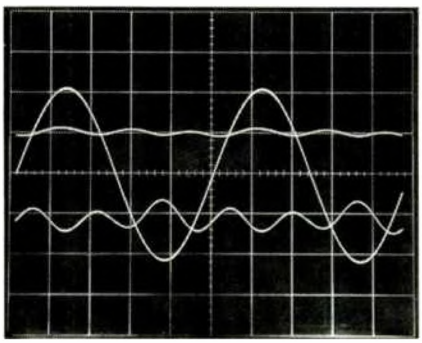


Fig. 10—Same as Fig. 9 but for 8 ohms. Residue was 0.17% in pentode mode (upper trace) and 0.66% in triode mode (lower trace).

wiggles in the 8-ohm IM distortion curve below 1 watt are artifacts of the way my Audio Precision test gear was set and are not really variations in distortion.

The CAD-50SL's distortion residues for a 1-kHz signal at 10 watts output in pentode and triode operation are shown in Fig. 9 for 4-ohm loading and in Fig. 10 for 8 ohms. In each figure, the top distortion-residue trace is for pentode operation and the bottom trace is for the triode mode. The distortion residue for pentode operation into 4 ohms (top trace, Fig. 9) is typical of pentode operation at significant fractions of maximum power and shows an aberration near the signal peaks that produces higher order odd harmonics. When the amp is triode-connected and driving 4 ohms, there is more distortion but it's simpler in nature. The 20-watt level (not shown) was just about at clipping in the triode mode. In Fig. 10, it can be seen that the distortion in both modes is lower in amount when 8-ohm loading is used, and both modes produce dominant third harmonic. Incidentally, these distortion traces show excellent even-harmonic distortion cancellation, a measure of push-pull balance, as all the distortion residues are symmetric about the horizontal zero-distortion time axis.

Output noise measurements for the CAD-50 and CAD-50SL are enumerated in Table I. Some 120-Hz power-supply ripple in the output is the main contributor to the rather high numbers for the CAD-50. This could easily be audible with a high-efficiency woofer system. I don't know why the CAD-50 amps had this 120-Hz ripple in the output, but since the circuits are nominally the same as in the CAD-50SL units, it may be some effect of using a toroidal output transformer. Noise levels for the CAD-50SL are more in line with what they should be.

Data for dynamic and clipping headroom for each unit set in the pentode mode are enumerated in Table II. For some reason, the CAD-50 is a bit weaker than the CAD-50SL, especially when loaded with 4 ohms. All considered, best performance from these amps is likely to come from using speakers with a nominal impedance of 6 to 8 ohms.

Some miscellaneous data and information: Plate current when the meter needle is centered on the red square, indicating correct setting, is about 65 mA. At idle, B+ is about 465 V, and a.c. line draw is about 1 ampere.

To summarize all measurements, good points include excellent push-pull balance, generally low magnitude and low order of distortion products at listening levels with the CAD-50SL, and a relatively constant output impedance over a wide frequency range. Not-so-good points would be the amps' inability to deliver their rated 50 watts at reasonable distortion, excessive ringing and high-frequency peaking in the CAD-50SL, and a very high output impedance that produced damping factors on the order of 1 to 2.

On to what they sound like—which is the real proof of the pudding.

Use and Listening Tests

Signal sources used to evaluate the Cary Audio tube amps were an Oracle turntable fitted with a Well Tempered arm and a Spectral Audio MCR-1 Select cartridge, a Magnavox CDB-560 CD player feeding into a Wadia 2000 decoding computer, a Nakamichi 250 cassette deck, and a

The numbers don't tell you how believable the Cary amplifiers sound, especially when played at full blast.

Technics 1500 open-reel recorder. For LPs, the Vendetta Research SPC-2B phono preamp was used. The outputs from the Vendetta and the other signal sources were connected to my reference selector and switched attenuator unit and thence out to the power amp and speaker location. Other amplifiers on hand were a Berning EA-2101, my own EAR 519s, an Air Tight ATM-1, and a pair of Carver Silver Sevens. Am I a tube freak, or what?

Speakers used were the Siefert Research Magnum III, the Martin-Logan Monolith III, the Spica Angelus, and an experimental model from Genesis Technologies. When I first received the amps, I was using the Siefert speakers, and my listening notes indicated that the CAD-50SL units sounded musical and non-irritating on those speakers. At the time, I thought that the Carys sounded most like the EAR 519s in tonal balance and relative upper midrange softness. After completing the measurements, I got down to some more serious listening with the other speakers.

I first set up the Spica Angelus speakers, and after getting an idea of how these speakers sounded with the various amplifiers on hand, I hooked up the CAD-50SL amps. The overall sound was a little laid-back and smooth in the upper midrange and treble region. Bass quality and extension were good with these speakers. Again, I found the overall tonal balance of the midrange and treble most like that of the EAR 519s. The other three tube designs mentioned are all brighter than these two amps. There are, of course, other very good attributes to the sound of these other amplifiers (covered in my published and forthcoming reviews of them). Since I tend to favor a softer treble presentation, I really liked the combination of the Angelus speakers and the Cary CAD-50SL amps. It was easy to forget amplifiers and stuff and get involved with the music. After all, what are amplifiers for?

I did experiment with the triode/pentode switch quite a bit and generally found the sound in the triode mode to be more refined and sweet. The pentode mode sounds livelier, and I found myself in that mode the most—though at the levels I mostly used, the amplifier was not clipping even in triode mode.

I then set up the Martin-Logan Monolith IIIs, first using a home-built duplicate of the power-amp section of the old Marantz 1120 (which I designed) as a bass amp. I have been using this amp for bass with the Monoliths, and it generally is okay but not great in this application. The Cary CAD-50SL amps were used to drive the electrostatic panels of the speakers. After warming up this arrangement for a while, I put the CAD-50 amps in for the bass and now I had the full boogie going, with all four Cary Audio units being used as Cary intends in their reference setup. I first put on the Telarc recording of Prokofiev's *Alexander Nevsky* (CD-80143) to check bass balance on the bass drums. That was pretty good right off, and I noticed I wasn't getting much, if any, movement of the plate current meters on the bass amps. So I sez, "Let's crank it up a bit and get some MODULATION going here!" I put my switched attenuators all the way up, which simply puts full CD output to the low-level crossover and power amps. Wow! Did that ever sound good! I then proceeded to play a number of things that I like at full blast and found that the Cary amps do play these Martin-Logan speakers quite loudly—and the speakers play quite loudly, too! The believability of the music coming out of the speakers certainly belies some of the less-than-perfect measurements these Cary amps exhibited. Backing down a bit and listening to more favorite music at normal levels, this combination of elements sounded downright outstanding. I noticed that the transition from bass to midrange appeared seamless when I used the same kind of amps for both ranges of the speaker. Boy, if one uses the analogy of good audio gear being like bottles of good wine, and the consideration is which kind of wine do we wish to experience at this moment, I was getting a bit drunk on this great collection of tube amps and speakers.

On a more serious note, the 120-Hz ripple I commented on in the measurements section proved to be easily audible through the woofers in the Martin-Logans. This, I hope, is just a problem of my particular sample pair of CAD-50 amps. Otherwise, they worked without a hitch. These are neat amplifiers and should appeal to those whose musical tastes regarding tonal balance are similar to my own. Do go out and give them a listen. *Bascom H. King*

Table I—Output noise. The IHF S/N was 90.9 dB for the CAD-50SL and 68.1 dB for the CAD-50; see text.

Bandwidth	Output Noise, mV CAD-50SL	CAD-50
Wideband	0.95	7.3
20 Hz to 20 kHz	1.01	7.3
400 Hz to 20 kHz	0.055	0.33
A-Weighted	0.081	1.1

Table II—Dynamic and clipping headroom. Clipping level for the CAD-50SL in triode mode was 21 watts into 8 or 4 ohms.

Dynamic Headroom (Pentode Mode)

	CAD-50SL		CAD-50	
Load	Power, Watts	Headroom, dB	Power, Watts	Headroom, dB
8 Ohms	58	0.64	56	0.5
4 Ohms	55	0.41	47	−0.27

Clipping Headroom (Pentode Mode)

	CAD-50SL		CAD-50	
Load	Power, Watts	Headroom, dB	Power, Watts	Headroom, dB
8 Ohms	56	0.5	52	0.17
4 Ohms	47	−0.27	40	−0.97