CARY AUDIO DESIGN CAD-805 MONO AMP

For some time, I have been watching the reemergence of single-ended tube power amplifiers. Currently there are several commercial single-ended triode tube amps on the market, as well as a smaller number of kits.

Remembering the comment of my mentor, Gordon Mercer, that the sound of a single-ended 845 triode amp he built in the '40s was one of the best he had heard, I have long wanted to sample some of this nirvana. Happily, the Cary Audio Design CAD-805 mono amp came into my life. This is a high-power unit, for single-ended triode technology. Most such amps put out 5 to 20 watts, whereas the CAD-805 is rated at 50 watts (albeit at about 10% distortion, I find). This is definitely enough power to run my reference system's B & W 801 Matrix Series 3 speakers.

A standard intellectual argument against single-ended Class-A operation is that it is less efficient than push-pull operation. Theoretically, its efficiency is 25% (in practice, somewhat less), whereas that of push-pull is 50% or higher, depending on the class of operation. This means that, for a given tube's plate-dissipation rating, the amount of output power attainable is very limited, typically 3 to 10 watts. Used in push-pull, the same tubes could deliver perhaps 12 to 25 watts. In addition, single-ended operation lacks push-pull's cancellation of spurious even-order harmonics, so distortion will be considerably higher. Lastly, the high continuous quiescent current in a single-ended stage causes d.c. magnetization of the output transformer's core, which causes added distortion and limits low-frequency power delivery. An output transformer that can mitigate these effects has to be quite large and expensive.

Given all the disadvantages of single-ended operation, why would anybody put up with its limitations of low power and high distortion? The answer is in the sound of music processed by such an apparently illogical mechanism. Many reviewers feel these amps deliver a certain quality of musical ease and believability—a certain midrange magic, if you will—that other design approaches seem unable to match.

SPECS

Type: Single-ended Class A.
Power Output: Class A_1, 24 watts; Class A_2, 50 watts.
Frequency Response: 20 Hz to 20 kHz, ±0.5 dB.
Noise: 80 dB below rated output.
Feedback: Adjustable, 0 to 10 dB.
Sensitivity: 1 V for full output, with feedback at zero.
Input Impedance: 150 kilohms.
Output Impedance: 4, 8, and 16 ohms.
Tube Complement: One 6SL7, one 300B, and one 211, plus 6U5 indicator.
Power Consumption: Operating mode, 230 watts; standby mode, 76 watts.
Power Requirements: 100, 110, 117, 220, or 240 V (factory selected); 50 to 60 Hz.
Dimensions: 12¼ in. W x 10 in. H x 24 in. D (31.1 cm x 25.4 cm x 61 cm).
Weight: 80 lbs. (36.3 kg) each.
Price: $7,995 per pair.
Company Address: 111-A Woodwinds Industrial Court, Cary, N.C. 27511.
For literature, circle No. 94

Photos: Michael Groen

SELF-BIASING IS THE KEY TO THIS AMP'S EXCEPTIONALLY HIGH OUTPUT FOR ITS TYPE.

The shape of the CAD-805 is more elongated than that of most other designs: With the front panel facing out, the amp is unusually deep. Still, it is a very attractive piece, sporting two very large transformers (main power and output), four filter capacitors, and the three tubes. The latter are lined up by ascending size, from the input 6SL7 to the mighty 211 output tube. An interesting decorative touch is that the two knobs (also in the top plate) for setting the "Feedback Output" tap and "Feedback Level" have green "jewels" in them. The front panel is a thick piece of aluminum, anodized in an attractive gold color. In what I consider a humorous twist, Cary uses an old tuning-eye tube, a 6U5, as a relative output indicator on the front panel. (Cary's Dennis Had once told me that they like to have fun doing their thing. I think they must be doing just that.) Two toggle switches on the top surface, near the front panel, select power on/off and standby/operate. The rear panel has three pairs of Edison-Price dual binding posts (for 4-, 8-, and 16-ohm speaker connections), an IEC a.c. power-cord socket, two fuse-holders (one for the a.c. line, the other for a cathode-current fuse for the 211), and a high-quality RCA jack for signal input. On the top surface, near the rear, are a ¼-inch phone jack and potentiometer used in setting the plate current of the 300B driver tube.

Looking inside, we find that the CAD-805 is wired the old-timey way: Point to point, with lug strips for tie points. Much of the wiring itself appears to be Teflon jacketed. Also traditional is the technique of grounding various components directly to the chassis, rather than having a separate ground bus tied to the chassis at only one point. Parts quality is generally excellent, using mostly Kimber Kap film capacitors, Dale RN65D-series metal-film resistors, and several Dale RH-25 chassis-mount power resistors. The main coupling capacitor between the first and second stages is a 0.22-µF, 600-V oil-filled unit. I was surprised (but certainly not dismayed) by the use of a Radio Shack power transformer to deliver the filament supply to the front-end and driver tubes. Wiring is neat and workmanlike. All in all, a very competent, solid, and well-made piece.

Circuit Description

The design utilizes a "King of the Triodes" 211 tube (or the equivalent VT-4-C), which is like the 845 but with a higher amplification (mu) factor. These tubes are wonderful and impressive output devices, having a carbon plate rated for a dissipation of 100 watts and a thoriated-tungsten filament that glows yellow (like an old light bulb) when running. I have had a long-term love affair with this kind of tube; I made a pair of push-pull 845 power amps some 30 years ago that had the honor of driving the Infinity IRS midrange/tweeter panels in their Chicago CES introduction about 10 years later.

Normally, a single-ended 211 would put out some 20 to 25 watts in Class-A operation. (Single-ended amps have to be run Class A, by definition.) How does the CAD-805's circuit achieve about twice this power? The secret is that the design employs a driver transformer (oh, horrors, another *transformer*?!). One end of the secondary winding is directly connected to the 211's control grid, and the other end is grounded. Cathode- or self-bias is utilized, with the filament supply "center tapped" through 20-ohm resistors from each filament lead; the common connection of the two resistors goes to ground through another, larger power

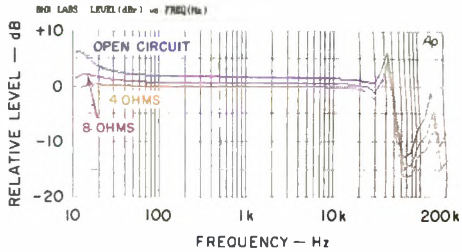


Fig. 1—Frequency response of amp B (see text) at 8-ohm tap, feedback control at mid-rotation.

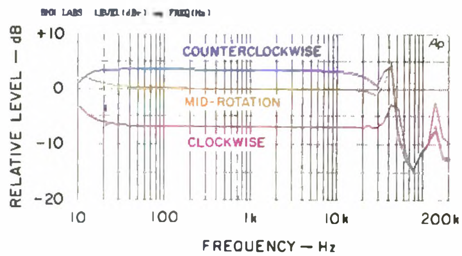


Fig. 2—Frequency response of amp A vs. feedback setting.

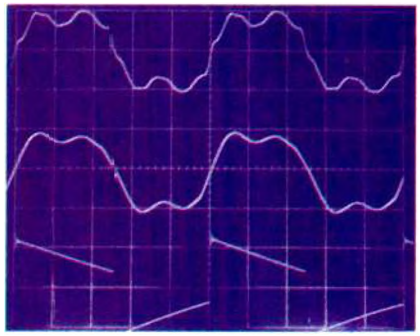


Fig. 3—Square-wave response, 10 kHz into 8 ohms (top), 10 kHz into 8 ohms and 2 µF (middle), and 40 Hz into 8 ohms (bottom).

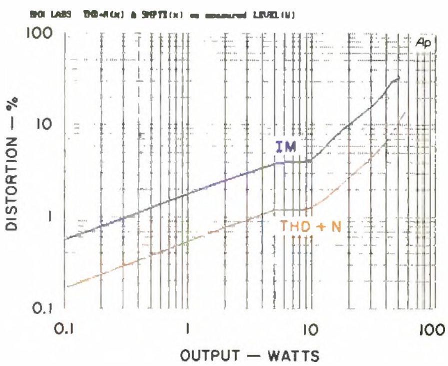


Fig. 4—THD + N and SMPTE-IM distortion vs. output.

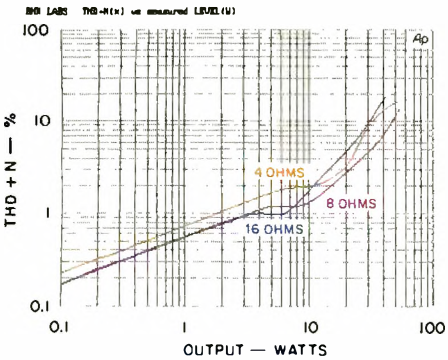


Fig. 5—THD + N at 1 kHz vs. output at the 8-ohm tap.

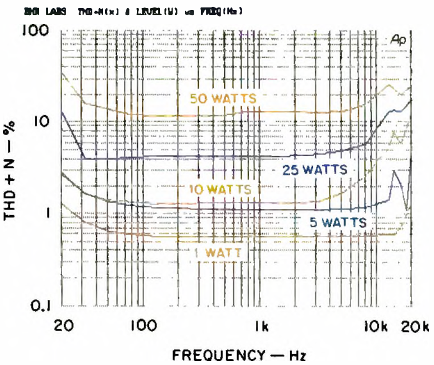


Fig. 6—THD + N vs. frequency.

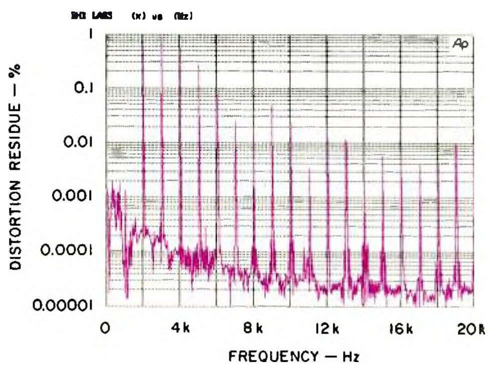


Fig. 7—Spectrum of 1-kHz harmonic-distortion components at 10 watts.

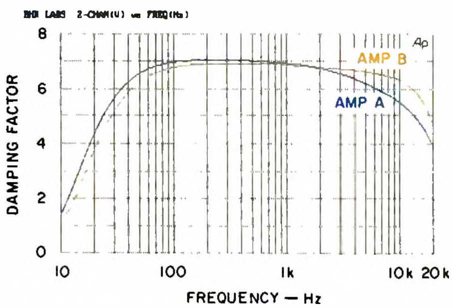


Fig. 8—Damping factor vs. frequency.

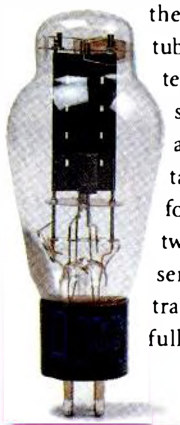
resistor bypassed with a large electrolytic capacitor. The driver transformer permits the 211's grid to be driven positive, resulting in Class-A_2 operation. When the grid goes positive in respect to the cathode (in this case, the filament), its impedance drops dramatically.

To pull this off, the CAD-805 needs power from the preceding driver stage. This is handled by a 300B, one of the best-sounding power triodes and often used as an output tube in many triode amps. The result of driving the output tube's grid positive is that the plate bottoms more (comes closer to zero), permitting a greater plate voltage swing and higher power.

Front-end honors in the CAD-805 go to a 6SL7, a nicely linear octal-base, hi-mu dual triode. This tube is connected in a series arrangement, where the bottom tube acts as a common-cathode voltage amplifier and the upper tube functions as a semi-constant current source load for the lower tube. The upper tube's cathode is capacitor-coupled to the grid of the 300B driver.

Overall adjustable negative feedback is taken from the selected output tap (chosen via a three-position switch) to a potentiometer used as a feedback series resistor and back to the cathode of the input stage. The feedback resistor is wired in series with its built-in, two-position rotary switch. In the counterclockwise position, the switch is open and there is no overall feedback. As the control is rotated clockwise, the switch closes and the series resistance starts to decrease. Maximum clockwise rotation results in maximum negative feedback.

The power supply has one main, potted power transformer and a small auxiliary transformer. Output of the main high-voltage secondary winding is rectified by a full-wave bridge and applied to a filter bank comprising three 100-μF, 450-V capacitors in series. A series filter choke leads to a final filter element of three 1,200-μF capacitors in series. The series connection of the filter capacitors is necessary to handle the supply voltage, which is in excess of 1 kV in the standby mode. The operating B+ for the 211 output tube is about 950 V, applied to the primary of the output transformer. A lower voltage B+ source (some 475 V), for the driver and front-end tubes, is taken from the center tap of the high-voltage secondary winding. The aforementioned "center-tapped" filament supply for the 211 is derived from two secondary windings in series on the main power transformer. This winding is full-wave rectified and filtered, providing d.c. voltage for the 211 filament.



SINGLE-ENDED AMPS HAVE UNMATCHED MUSICAL EASE AND BELIEVABILITY.

The auxiliary power transformer's secondary winding is full-wave rectified and capacitor filtered to provide d.c. voltages to the 6SL7 and 300B filaments.

Measurements

I used a pair of CAD-805s, which will be referred to as amp A and amp B. Measurements quoted are for amp B unless otherwise stated. Voltage gains and IHF sensitivities, for the 8-ohm taps loaded with 8 ohms, are listed in Table I for the middle and full counterclockwise positions of the feedback control.

Figure 1 shows frequency response for open-circuit, 8-, and 4-ohm loading on the 8-ohm output tap, with the feedback control set at mid-position. The ultrasonic response is not very well behaved, exhibiting resonances at about 40 and 130 kHz. It is difficult enough to properly enclose one transformer in a feedback loop, let alone two. One might expect the amp to oscillate at the 40-kHz resonance with the feedback turned up more. That is exactly what happened with the feedback control set past about three-quarters rotation. Not so good. Amp A was high-frequency stable to full rotation of the feedback control. The change

Table I—Gain and IHF sensitivity.

	Gain, dB		Sensitivity, mV	
Feedback Setting	AMP A	AMP B	AMP A	AMP B
Mid-Rotation	24.0	24.8	178.5	162.0
Fully Counterclockwise	27.4	28.2	120.9	110.5

Table II—Output noise levels. The IHF S/N figures for amps A and B were 87.7 and 86.5 dB, respectively.

	Output Noise, μV	
Bandwidth	AMP A	AMP B
Wideband	842.3	853.5
22 Hz to 22 kHz	837.2	854.5
400 Hz to 22 kHz	63.7	84.5
A-Weighted	117.1	133.2

of gain with feedback-pot rotation was not very linear. When the pot was rotated from its counterclockwise position and the switch clicked on, the gain dropped about 3 dB. From this position to about three-quarters rotation, the gain dropped only about 1 dB more, with most of the gain change taking place in the last quarter of rotation. Of interest (and something one seldom sees in modern amplifiers) is the peaking in the region between 10 and 20 Hz, which is a function of load. The main effect of this low-frequency peaking would be large, possibly excessive, woofer excursion in ported enclosures whose lower impedance peak happens to be in this frequency range.

Frequency response of amp A is shown in Fig. 2 as a function of the feedback-pot setting, with 8-ohm loading on the 8-ohm output tap. With full feedback applied, the low-frequency stability becomes marginal, in my opinion.

Square-wave response is shown in Fig. 3. The 10-kHz frequency, used for the top two traces, is kind to the amplifier; a wickedly chosen frequency with third or fifth harmonic at 40 kHz would show a lot more ringing. In fact, for the 40-Hz waveform (bottom trace), high-frequency ringing is plainly visible. The top trace is for a resistive load of 8 ohms on the 8-ohm tap, with the feedback control at mid-rotation. Rise-time is a bit difficult to define for a waveform that doesn't attain steady state in the half-cycle time, but it would appear from the figure to be on the order of 8 to 10 μS. In the middle trace, the addition of a 2-μF capacitor across the 8-ohm load seems to stabilize the amp and to roll off some of the higher frequencies. The degree of tilt in the 40-Hz trace is a bit excessive and portends probable rapid roll-off below the low-frequency resonance.

Both THD + N (with a 1-kHz signal) and SMPTE-IM distortion are plotted in Fig. 4 as functions of power output, with 8-ohm loading on the 8-ohm tap. As you can see here, the distortion reaches some pretty outrageous numbers, by modern standards. (I also measured THD + N versus power for 4-ohm loading on the 4-ohm tap, and for 16-ohm loading on the 16-ohm tap, and got essentially identical results.) The ratio between IM and THD is a little more than 3 to 1, nearly classical behavior for a simple device. Note that the simple second-harmonic-dominant behavior of the amp starts to change at about 5 watts output—which, I believe, is the onset of the grid-current phenomenon, even though grid-to-cathode voltage has not yet reached zero. The positive polarity of the drive signal to the 211 tube matches the "cathode voltage" (i.e., 0-V potential between grid and cathode) at about 8 watts output. Note that these two power levels flank the flat portion of the curve for THD + N in Fig. 4. Another note: The tuning eye closed at about 15 to 20 watts, although the operating manual says that it closes at "full output." The a.c. line current drawn by the amp was substantially constant up to 50 watts, a classic sign of Class-A operation.

I WAS IMPRESSED BY THIS AMP'S EASY SOUND, WHICH SOON BECAME QUITE ADDICTIVE.

Figure 5 shows the effect of 4-, 8-, and 16-ohm loading on the 8-ohm tap. Load tolerance is very good, with very similar results attained for each condition over most of the power range.

Figure 6 shows THD + N as a function of frequency and power, for an 8-ohm load on the 8-ohm tap. Interestingly, the 10-watt curve has the steepest rise in distortion in the high frequencies, and in the 50-watt test my Audio Precision test gear dropped out of regulation at constant power near the frequency extremes.

As a final look at distortion, a spectrum of a 1-kHz signal at the 10-watt level (with 8 ohms on the 8-ohm tap) is plotted in Fig. 7. Things look quite complex at this power level for a simple Class-A amplifier, to be sure. At the 1-watt level (not shown), the spectrum was much simpler. There was about the same amount of second harmonic, but the third was down to about 0.015% and all remaining harmonics were less than 0.002%.

Damping factor versus frequency is shown for both amplifiers in Fig. 8. The drop in damping below 100 Hz is unusual. This could well cause the bass characteristics of the CAD-805 to sound different from those of an amp with a more consistent low-frequency damping factor, all other things being equal.

Table II shows output noise as a function of measurement bandwidth, with the amp's feedback pot set to its midpoint.

Dynamic and clipping levels were substantially the same, about 56 watts, depending on one's interpretation of the 'scope waveforms at the clipping level. There was no amplitude droop during the 20-mS tone burst in the dynamic test—another sign of Class-A operation, since the power-supply current drain is constant with power level. The a.c. line current was 0.76 ampere in the standby state and 2.4 amperes when the CAD-805 was fully operational.

Use and Listening Tests

Signal source equipment used in my system during the review period included an Oracle Audio turntable fitted with a Well Tempered Lab tonearm and a JVC X-1 moving-magnet pickup, playing via my own tube phono preamp or a Quicksilver

Audio preamp. Also, Counterpoint DA-11A and PS Audio Lambda CD transports were used to drive the Sonic Frontiers SFD-2 and other (experimental) D/A converters. Other signal sources included a Nakamichi ST-7 FM tuner and 250 cassette recorder, as well as a Technics open-reel recorder. Preamplifiers included a DGX Audio DDP-1, a Quicksilver Audio unit, Forssell tube line drivers, a First Sound II passive model, and my own passive signal selector/attenuator. Other power amplifiers used were a Crown Macro Reference, Quicksilver M135s, and a pair of VAC PA160 tube mono amps. Loudspeakers were B & W 801 Matrix Series 3s, augmented between 20 and 50 Hz by my subwoofer system, using a JBL 1400Nd driver in a 5-cubic-foot ported enclosure for each channel.

I must admit I was quite impressed with the sound of the CAD-805s when I first got them going. There was, indeed, an ease to the sound that made it a pleasure to listen to music with these amps. In fact, as they broke in a bit more, they became quite addictive! Resolution and space were very good. As I got used to them, I did start to hear certain things that other amplifiers do better. Bass, for instance, although nicely defined and musical, didn't always have the low-frequency extension and impact of some other similarly powered amps of more conventional design. And, of course, the power limitation, and the large amount of distortion that does occur as that power limit is reached, tend to make the sound congested when the CAD-805s are pushed. Don't get me wrong, though, because these amps play most of the music I like, at the playback levels that I customarily use, with no apparent problem. After experimenting with the setting, I found I had a distinct preference for no negative feedback.

The two units operated flawlessly during the review period. Given the operating margin in their design, I would expect them to continue reliably doing their thing for many years to come.

I definitely liked Cary Audio Design's CAD-805s very much and strongly recommend giving them an audition if your musical tastes, speaker efficiency, and playback levels are compatible with them. But in any case, give them an audition to see what all the current interest in single-ended amps is all about. A