

BASCOM H. KING

BEL CANTO DESIGN SET 40 SINGLE-ENDED TUBE AMP



In recent years, there has been a resurgence of vacuum-tube power amps with single-ended output stages, commonly called SET (single-ended tube) amps. In these designs, the entire signal is handled by a single output tube—or several tubes in parallel—instead of being split between paired tubes or banks of tubes, as in push-pull amps. Technically, SET amps have higher distortion and lower efficiency, damping factor, and output power than push-pull amps, and their output transformers are more difficult to design. But, say proponents, there is something about the sound of SET amplifiers (with

speakers of suitable efficiency) that makes the music seem more palpable, present, and believable.

The Bel Canto SET 40's rated power output is higher than that of most SETs—37 continuous watts into either 4- or 8-ohm loads. That should be enough to drive any speaker of average sensitivity to reasonable volume levels. As with many other SET makers, Bel Canto does not specify distortion and bandwidth at full power. Those omissions usually imply that the power rating is for output at 1 kHz and distortion as high as 10%.

The SET 40 amp is rather large and, at 70 pounds, heavy. Toward the rear of the chassis, behind the tubes, is a metal enclosure that houses the power and output transformers. This enclosure and the chassis are finished in an attractive charcoal-gray, fine-crinkle paint. Five stacked gold rings surround the large, type 845 output tubes, which are favorites of mine. Their thoriated-tungsten filaments glow a warm-your-heart yellow; the effect of this glow, viewed through the gold decorative rings, is stunning.

On the rear of the chassis are a pair of high-quality RCA input connectors, two pairs of all-metal, five-way speaker binding posts, a toggle switch for speaker imped-

ance selection, the line fuse and IEC power-cord connector, and a rocker switch for power on/off.

A large, thick, well-made circuit board, occupying most of the chassis interior, holds all the amp's components except the main power transformer and output transformers. Wiring is neat, and the construction is excellent. Many high-quality parts are in evidence, including Nichicon Muse electrolytic bypass capacitors, Solen polypropylene-film bypass capacitors, a pair of main coupling capacitors made for Bel Canto, metal-film resistors, and white ce-

**BEL CANTO'S SET 40
DELIVERS MORE POWER
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TUBE AMPLIFIERS.**

ramic sockets (the best kind) for the 845 tubes. Tubes typically last about 1,000 hours in this amp, according to Bel Canto, which sells replacements for \$50 each.

Measurements

The SET 40's frequency response is shown in Fig. 1 for open-circuit, 4-, and 8-ohm loads and for the NHT simulated-speaker dummy load. (For this and all other tests, the rear-panel toggle switch was set for 8-ohm loads unless otherwise noted.) The response aberrations above the audio

Rated Output: 37 watts/channel into 4 or 8 ohms.

Rated Distortion: Less than 0.1% at 1 watt out and 1 kHz, predominantly second harmonic.

Rated S/N: 96 dB, A-weighted, re 1 watt out.

Rated Bandwidth: 6 Hz to 35 kHz, +0, -3 dB.

Dimensions: 19½ in. W x 11 in. H x 15 in. D (49.6 cm x 28 cm x 38.1 cm).

Weight: 70 lbs. (31.8 kg).

Price: \$4,100.

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ASSOCIATED EQUIPMENT USED

Equipment used in the listening tests for this review consisted of:

CD Equipment: PS Audio Lambda Two Special and modified Sonic Frontiers SFT-1 CD transports, Sony CDP-X77ES CD and Panasonic DVD-A310 DVD players, Genesis Technologies Digital Lens anti-jitter device, and Classé Audio DAC-1 and Sonic Frontiers Processor 3 D/A converters

Phono Equipment: Kenwood KD-500 turntable, Infinity Black Widow arm, Win Research SMC-10 moving-coil cartridge, and Vendetta Research SCP-2C phono preamp

Additional Signal Sources: Nakamichi ST-7 FM tuner, Nakamichi 1000 cassette deck, and Technics 1500 open-reel recorder

Preamplifiers: Sonic Frontiers Line-3, Dynaco PAS-2, and First Sound Reference II passive

Amplifiers: Arnoux Seven-B stereo switching amplifier, Quicksilver Audio M135 mono tube amps, Audio Note Conqueror single-ended stereo tube amp, and Sumo Polaris stereo solid-state amp

Loudspeakers: B&W 801 Matrix Series 3s used alone and as subwoofers with Dunlavy Audio Labs SC-III speakers, and Lowther PM5A drivers in modified Lowther Club Medallion II cabinets

Cables: Digital interconnects, Illuminati DX-50 (AES/EBU balanced); analog interconnects, Tara Labs Master, Audio Note AN-Vx, and Music and Sound (unbalanced); speaker cables, Transparent Cable MusicWave Reference, Jena Labs Speakeasy Twin Three, and Madrigal Audio Laboratories HF2.5C

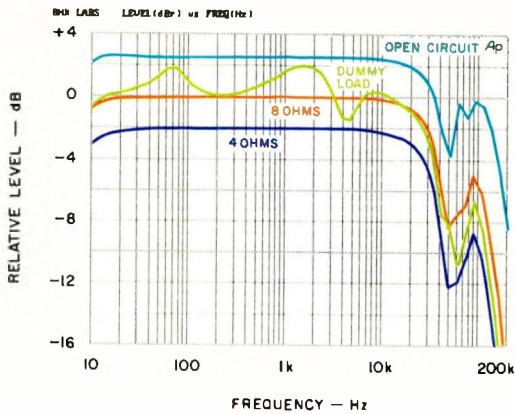


Fig. 1—Frequency response as a function of loading with 8-ohm output setting.

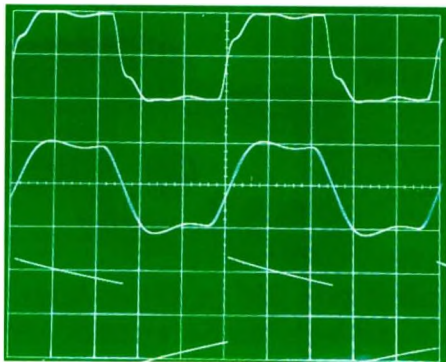


Fig. 2—Square-wave response for 10 kHz into 8 ohms (top), 10 kHz into 8 ohms paralleled by 2 µF (middle), and 40 Hz into 8 ohms (bottom).

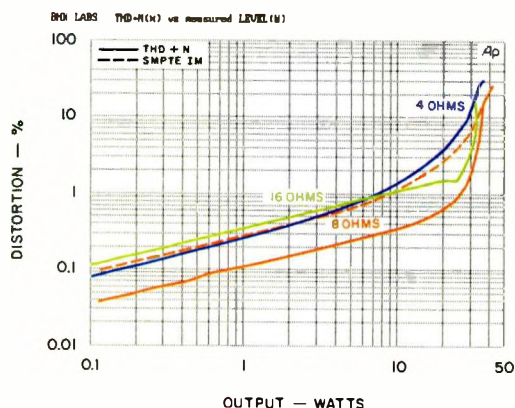


Fig. 3—THD + N at 1 kHz and SMPTE-IM distortion vs. power output, with 8-ohm output setting.

range are caused by the output transformers; it is notoriously difficult to make good ones for SET amps. From these curves, I deduced that the output impedance was

about 2.8 ohms, which could cause audible response aberrations, such as those seen in the curve for the dummy load, with many speakers. The high-frequency aberrations in the 8-ohm frequency response curve also affect the amplifier's square-wave performance (Fig. 2), causing the irregularities in the trace for a 10-kHz square wave into 8 ohms. The trace made with a 2-microfarad capacitor added to the load looks smoother, because the capacitor narrows the bandwidth, rolling off some upper frequencies. The 40-Hz trace has more tilt than you get from most modern push-pull tube amps, likely caused by the output transformers' low-frequency rolloff. Rise and fall times for an output of +5 volts into 8-ohm loads were about 11 microseconds.

A graph of distortion versus power output for various loads (Fig. 3) bears out my conjecture that the SET 40's rated power into 8 ohms is reached at 1 kHz with about 10% distortion. The output transformers' turns ratio and the load consequently reflected to the output tubes clearly make distortion lowest with loads that match the output impedance setting. Using 4- or 16-ohm loads on the 8-ohm tap does not appreciably change output power but does raise distortion. Overall, the Bel Canto's load tolerance is very good.

What's commendable about the curves for the SET 40's THD + N versus frequency at several power levels (Fig. 4) is that distortion doesn't rise very much at high frequencies, although there's a more noticeable distortion increase in the low bass. For further insight into the amp's distortion characteristics, I've plotted THD + N versus output for low bass frequencies (Fig. 5A) and for the treble range (Fig. 5B). In the bass, distortion decreases as frequency increases until, by 60 Hz, the curve begins to look like the 1-kHz mid-frequency curve in Fig. 5B. This increase in distortion near the frequency extremes means that

the available maximum power output at, say, 10% distortion decreases at very high or very low frequencies. Judging from Fig. 5, I would say the SET 40 is good for about 30 watts from 30 or 40 Hz to 10 kHz, which covers most of the essential audio range.

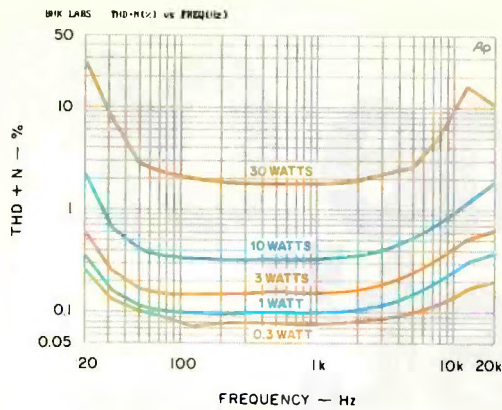


Fig. 4—THD + N vs. frequency.

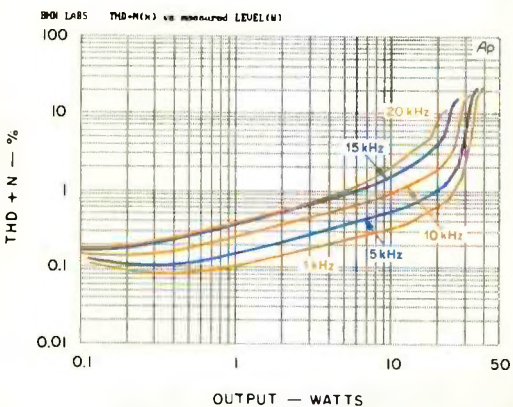
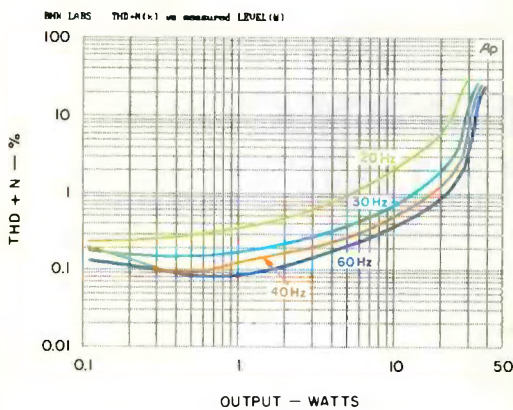


Fig. 5—THD + N vs. power output for low (A) and high (B) frequencies.

The spectral characteristics of the Bel Canto amp's distortion are good. Analyzing the distortion residue of a 10-watt signal at 1 kHz (Fig. 6) reveals that the second and third harmonics are dominant and that the higher harmonics roll off quite rapidly. Both characteristics are common and desirable attributes of SET designs.

I was able to verify my deduction that the Bel Canto SET 40's output impedance was 2.8 ohms at the 8-ohm setting when I tested

A basic advantage of SET circuitry is its simplicity. The signal circuitry of Bel Canto's SET 40, for example, consists simply of an input stage driving an output stage.

The SET 40's input stage has two 12AX7 dual-triode tubes in an unusual arrangement; its designer, John Stronczer, describes this circuit as a shunt-regulated, push-pull cathode follower, though it also resembles a mu follower. The input signal goes to the first tube's two cathodes, which are tied together (as are its two grids). A bypassed cathode resistor, tied to ground, provides self-biasing.

One plate of this first dual-triode tube is directly connected to both of the second tube's grids and is tied to one of its cathodes through a cathode-bias resistor. The other cathode is also biased via a resistor, but from the first tube's remaining plate (The second tube's plates are connected to a 600-volt supply.) Output is taken from this other cathode and is RC-coupled to the type 845 output tube's grid via a pair of custom-made, 0.16-microfarad coupling capacitors and 400-kilohm grid resistor. If you don't count the intervening grid resistor, the output is taken from the first tube via the cathode of the half that does not drive the second

tube's grids; this makes the circuit a sort of paralleled mu follower.

The 845 output tube is operated as a Class-A stage with cathode bias. Cathode bias (another name for self-bias) enables the use of higher grid resistances, such as the 400-kilohm grid resistor employed here. This provides a super-easy load for the input stage to drive, up to the point where current begins to flow in the output tube's grid, at levels of about 30 watts or more per channel.

A directly heated tube such as the 845 doesn't have a cathode per se, so a point in the filament supply is used as the cathode connection. A floating 10-volt DC supply provides the required 3 amperes of filament current. That's 30 watts for the filament power for each output tube! An arrangement of several resistors and bypass capacitors forms the equivalent of a capacitor-bypassed, self-biasing cathode resistor. One end of the output transformer's primary winding is connected to the plate of the 845; the other end goes to a 1,200-volt supply. The operating point for the tube is right at its maximum plate dissipation of 100 watts, with a plate current of 100 milliamperes and a plate-to-filament voltage slightly in excess of 1,000 volts. One of the great advantages

of the amp's damping factor. It was about 2.8 over most of the frequency range, falling to about 2.3 at 10 Hz and 2.4 at 20 kHz. With the 4-ohm output setting, damping dropped slightly to about 2.6 at middle frequencies, with a similar falloff at the frequency extremes. Note, however, that the output impedance at this setting is about 1.5 ohms, so a speaker's impedance variations will cause less voltage variation with this setting than it would if the 8-ohm setting were used.

Another respect in which the SET 40 performs best in the midrange is interchannel crosstalk (Fig. 7), which virtually nulls out at some midrange frequency. This is unusual.

The Bel Canto amp's output at the beginning of an IHF tone burst (full amplitude for 20 milliseconds followed by a 480-millisecond period with the level 20 dB

lower) was about ± 24 volts. This yields a dynamic power figure of about 36 watts, or -0.12 dB relative to the amp's 37-watt power rating. At the end of the burst, the output diminished to about 22 peak volts on the sine wave's positive half-cycle, whereas the negative half-cycle held up at about 23.5 peak volts. The 22-volt output at the end of the burst is equivalent to about 30 watts; when I checked the SET 40's steady-state clipping behavior on an oscilloscope, the positive half-cycle clipped first, at about 30 watts output. This yielded a clipping headroom of -0.91 dB.

Output in the left channel was 1.19 millivolts wideband, 1.16 millivolts from 22 Hz to 22 kHz, 69.9 microvolts from 400 Hz to 22 kHz, and 167.6 microvolts with A-weighting. For the right channel, these readings were, respectively, 1 millivolt, 0.91 millivolt, 59.2 microvolts, and 146 microvolts. Voltage gain with the 8-ohm output

HIGHLIGHTS

of the 845 tube is that it can be run for many thousands of hours at maximum plate dissipation. Normally, the theoretical efficiency of a single-ended output stage operating in Class A1 (no grid current flowing at the peak of the signal swing) is 25% of the standing plate dissipation. This would be about 25 watts under the operating conditions in the SET 40. As detailed in the "Measurements" section of this review, the amp produces a little more than this (about 30 watts per channel) because the input stage can deliver a little grid current on the positive-going signal peaks.

There are secondary taps on the output transformer to match 4- and 8-ohm loads. A switch on the back panel selects which tap is connected to the hot (positive) output binding post. The low (negative) output post is connected to the low side of the output transformer's secondary. There is no overall feedback loop in the SET 40. In fact, the only feedback in the whole amplifier is in the cathode-follower action of the input stage's second tube.

The high-voltage power supply starts out with a full-wave rectifier bridge feeding a capacitor-input filter. The capacitor is made up of three 220-microfarad, 450-

volt units in series, each paralleled by a 270-kilohm resistor to ensure that all three capacitors share the voltage equally. Next in each channel comes a series filter choke, followed by an output filter capacitor that is identical to the input-capacitor stack. The 1,200-volt supply for each channel's output stage is taken from that channel's output filter capacitor. Each of these supplies also feeds a regulator circuit; this circuit consists of several power resistors in series feeding three 200-volt Zener diodes in series to produce 600-volt regulated supplies for each channel's input stage.

Separate secondary windings on the power transformer feed filament supplies for each channel's 845 output tube. Each of these supplies consists of a full-wave bridge rectifier and two 22,000-microfarad, 16-volt filter capacitors separated by a 0.2-ohm series filter resistor. Two more secondary windings feed full-wave rectifiers and capacitor-input filters for the input tubes' heaters. The supply that feeds the second input tubes is biased up to 300 volts by a divider connected to the 600-volt supplies, to keep these tubes' heater-to-cathode-voltages within proper limits. All in all, this is a very interesting (but simple) circuit. *B.H.K.*

setting and 8-ohm loads was 21.15 dB in the left channel and 20.62 dB in the right. This corresponds to IHF sensitivity figures of 277.8 and 263.4 millivolts, respectively, for 1-watt output into 8 ohms. The SET 40's current draw from the AC line was about 4.4 amperes at idle and remained essentially constant over most of its power output range.

Use and Listening Tests

I first used the Bel Canto SET 40 to feed a pair of B&W 801 Matrix Series 3 speakers. It sounded pretty good, driving the B&Ws to quite satisfactory levels on most of the music I played. When I checked with a 'scope across the outputs of the SET 40 to make sure it wasn't clipping, the output voltages I observed corresponded to about 25 or 30 watts at the loudest levels. I used the B&W speakers with the amp at several points during my listening sessions, and the combination sounded quite good.

After I measured the amplifier, I paired it up with Dunlavy SC-III speakers, augmenting their bass below 50 Hz by using the 801s as subwoofers placed against the back wall and behind the main speakers. (The electronic crossover I designed and built for this has a special input circuit that can be driven from the output of the main system amplifier so that the low bass will take on the qualities of that amplifier.)

John Stronczer, the Bel Canto amp's designer, told me the SET 40 should first be broken in a bit and would then sound better. Well, the SET 40 must have broken in nicely—it sounded terrific on the SC-IIIs. Detail, space, dimension, resolution, and tonal honesty were of high order. The bass was very good—reasonably tight and powerful and not at all "tubby" or loose-sounding. The amp drove the SC-IIIs (whose rated sensitivity is 91 dB SPL) to higher levels than I cared to hear on most material.

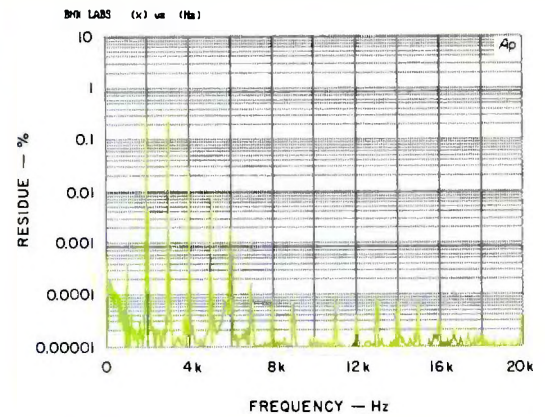


Fig. 6—Harmonic-distortion residue for a 1-kHz signal at an output of 10 watts into 8 ohms.

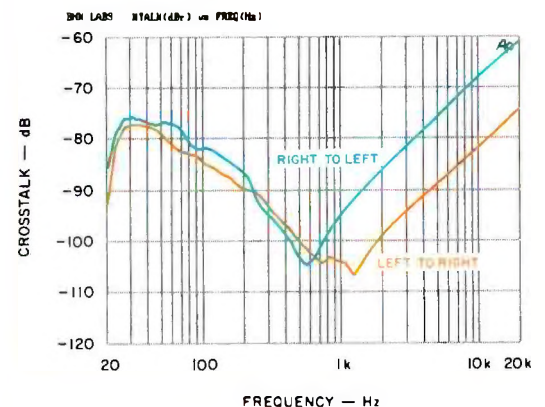


Fig. 7—Interchannel crosstalk.

It was therefore no surprise that the SET 40 worked extremely well with Lowther speakers, which have even higher sensitivity (102 dB SPL). When I played CDs on a Panasonic DVD-A310, connected to the SET 40 via a First Sound passive preamp, I got some of the best sound I've yet heard from the Lowthers. With my ear right at these sensitive speakers, I could just detect some hum from the amp.

I have only two minor complaints about the SET 40. First, I think the metal enclosure behind the tubes gets too hot. Second, when the amp is warming up, there are sometimes a few snaps and pops in its output, which is mildly disconcerting when you're using high-sensitivity speakers.

All in all, however, I think the SET 40 is an excellent-sounding amplifier, and its price is especially reasonable for an amp built in the United States. I heartily recommend giving one a listen. *A*