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Rebuilding a Cheap Chinese EL84 Amp

By Merlin Blencowe

A cheap and cheerful valve amp gets a lobotomy.

Any hi-fi enthusiasts who, like me, spend too much time on a certain popular Internet auction site can hardly have failed to notice the enormous influx of very cheap Chinese valve amplifiers in the last couple of years. Many of them boast suspiciously remarkable performance at mouth-watering prices. Against my better judgment this was enough to pique my curiosity, so I decided to buy the cheapest one I could find and see whether it would live up to my (understandably low) expectations. I found a tiny little "Mengyue Mini" push-pull EL84 stereo for £100 including shipping (around $200 US).

About eight weeks later it arrived, astoundingly undamaged, and the box read "Aria Mini"—they seem to rebrand these little amps every few weeks. The power valves supplied were actually 6P14s, which are Russian EL84 equivalents. The outward finish was very good—much nicer than I was expecting, and I decided to go right ahead and plug it in; the tasteless blue LED uplights came on and it actually played music as promised! To its credit it actually sounded quite pleasant—worth the money at least—and managed to drive a pair of Leema Xero bookshelf speakers to a satisfactory volume. I also made power, distortion, and noise tests.

Furthermore, after about five hours of continuous playing the transformer cover became very hot, and removing it revealed the power transformer sweating beneath—clearly being overrun. On further investigation I found the EL84s were biased to a scorching 15W each (3W above their rated maximum), the chassis had no safety earth and one of the screen-grid resistors also caught fire after being shorted by some glue near the PCB. Clearly it needed some internal reworking, by which I mean a complete overhaul!

REDESIGNING THE CIRCUIT

I decided to keep the same valve complement of EL84s and 6N3Ps (similar to a 2C51 or 5670), and to reuse some of the PSU smoothing capacitors (I could find no replacements that were so small) but to redesign the circuit. Tracing the PCB indicated that the original circuit consisted of an input triode feeding one power valve and also a potential divider. The divider then fed a second, identical triode, which inverted the signal and fed this to the other power valve. Global negative feedback was applied to the cathode of the input triode from the speaker terminal, though the gain of the amp rose slightly with frequency, implying poor HF stability.

This old-fashioned "paraphase" arrangement offers high gain and moderate power supply ripple rejection (PSRR), but poor noise performance and absolutely no inherent balance at all, making it probably the worst possible design choice. Arranging the triodes as a long-tailed-pair would offer better balance and lower noise but only half the gain, so I decided to use an input triode DC coupled to a *cathodyne* phase inverter (also known as a *concertina* or *split-load*). This offers the same gain as the original design but with lower noise and unquestionable balance, provided the outputs are equally loaded. PSRR is poor, but can be optimized (see below). A further advantage is that this arrangement produces almost entirely second harmonic distortion, whereas the long tailed pair produces mainly third, which is more obnoxious and harder to cure with feedback.

Figure 1 shows the main amplifier schematic. I decided to load the input triode, U1A, with a 68kΩ anode load resistor R2, which was a compromise between keeping noise down and current consumption low. The total load on U1B should be R1 × A, where A is the gain of the cathodyne, which is about 0.95. This ensures that signal current flowing in both triodes is equal but out of phase, causing no modulation of the HT, and this condition is more or less met by setting R5 and R6 to 33kΩ.

Nearly all noise present on the supply rail appears on the anode of U1B, but hardly any appears at its cathode. Because U1B has roughly unity gain, by arranging for half the rail noise to appear at U1A's anode, this will be passed straight to U1B's cathode, and will also be inverted and appear at the anode where it will cancel half of the noise already there! Optimally then, U1B will produce iden-

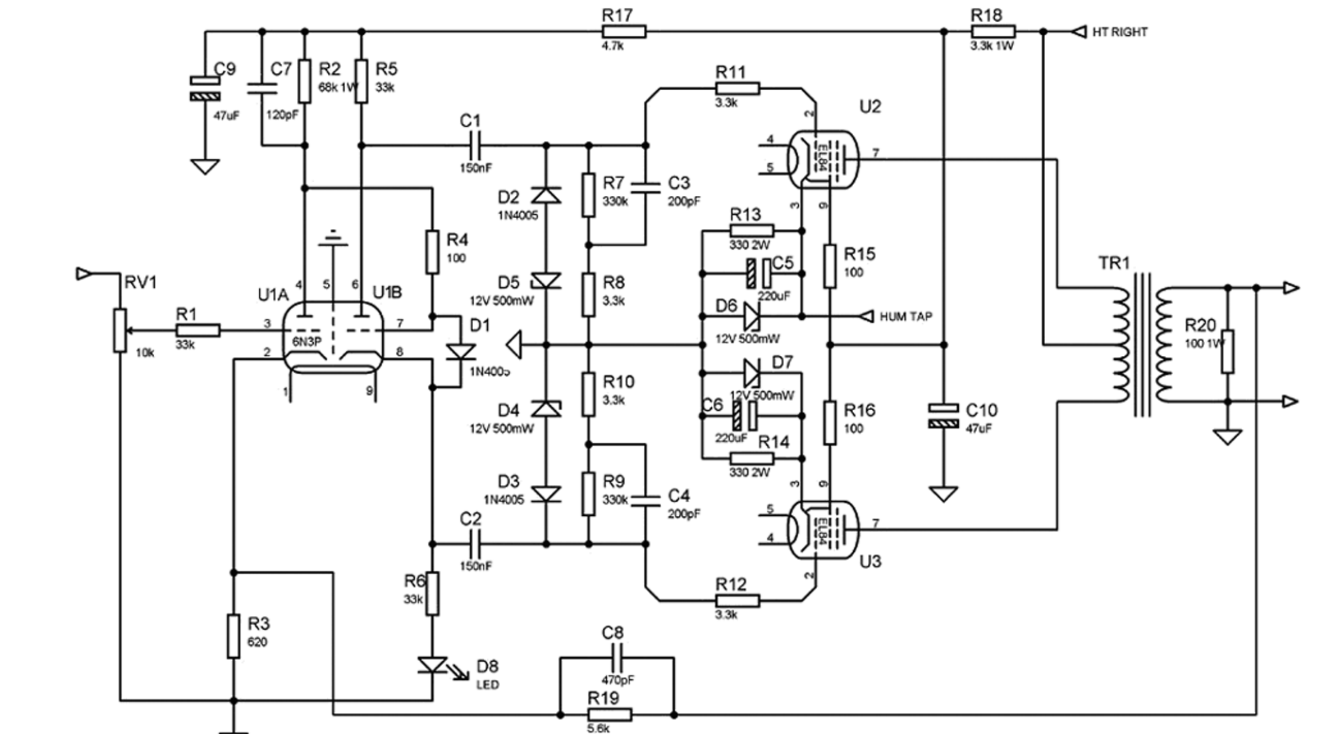


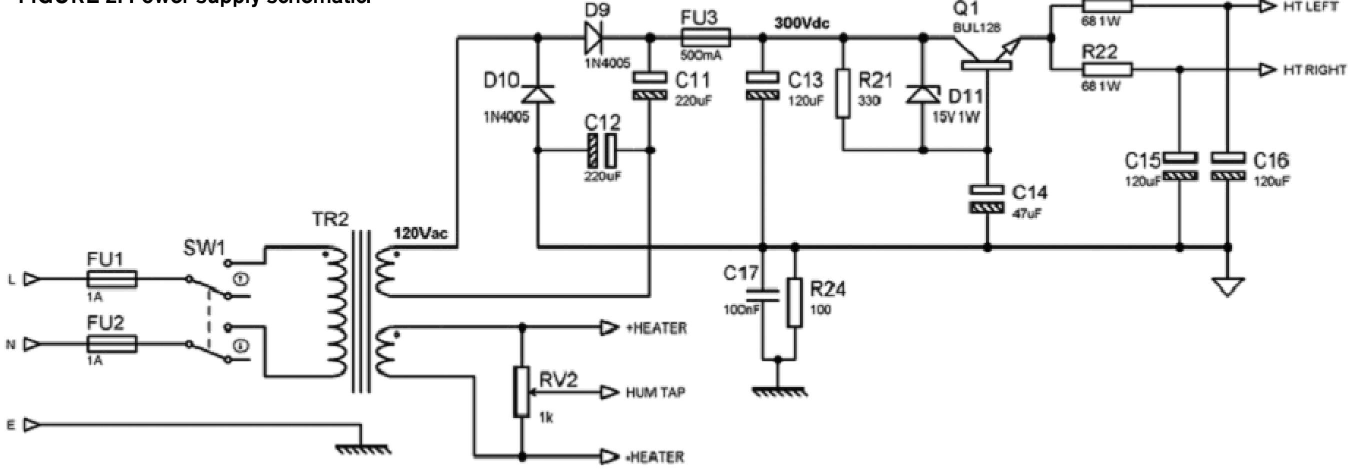
FIGURE 1: Main amp schematic.

tical, but out of phase, PSU noise signals, which will be cancelled by the common mode ripple rejection (CMRR) of the power stage (while it operates in Class A). To produce this, R2 would have to equal ra + R3(μ + 1), where ra is U1A's internal anode resistance, which is about 15kΩ in this circuit. My circuit does not quite achieve this idyll—doing so would demand lower value load resistors, but it comes closer than many similar designs I have seen.

R4 is a grid stopper to prevent HF oscillation and to allow me to check for grid current (there should be none, of course). D1 ensures that at start-up the cathode and grid are kept within a volt of one another until the cathode is fully warmed up. Without it there is risk of arcing between the high-potential grid and the cold cathode. It also provides the bleeder path for the smoothing capacitors at switch-off. D8 lends nothing to the sound—it simply uplights the valve! (Well, it also helps jack up the cathode voltage of U1B, which is always handy when DC coupling.) I used super bright orange LEDs, fitted inside the valve-socket spigot to give an even more "tubey" and less "boy racer" appearance to the amp.

The dominant pole is slugged by C3 and C4 to around 40kHz (the exact frequency is hard to calculate due to the disparity in output impedances from the cathodyne). D2-5 are anti blocking-distortion components which prevent the grid voltage from ever falling below about -13V, which could otherwise bring about a bias shift that would put the valve hard into cutoff for a significant length of time. I first saw this advocated by Paul Ruby[1], and later by Jim Carlyle[2]. It is essential for this amplifier because it is of such limited output power that it will usually be run very close to clipping, and a sudden transient can easily cause a sensitive valve like an EL84 to

FIGURE 2: Power supply schematic.



block, which sounds far more awful than a simple clipped signal.

I biased the EL84s relatively cool—they could probably stand to have their cathode resistors (R13 and R14) reduced to 270Ω, though I am not inclined to fiddle now. The paralleled zeners, D6 and D7 prevent the cathode voltage ever rising above 12V, which is another measure to avoid bias shift. I could have used complete zener biasing m (such as that used by Randy Miller[3]), but I prefer the natural adjustment that occurs with age when using conventional cathode biasing.

THE POWER SUPPLY

The power supply (**Fig. 2**) is essentially the same as the original, except for the addition of a capacitor multiplier. The transformer has a 120V winding, which I suspect is used as the primary whenever Mengyue sells to a US customer. In my case it is used as the secondary and feeds a voltage doubler and reservoir capacitor and develops 300V DC for the EL84s. The original design then fed R22 and R23 directly.

Because the HT was already on the high side I decided to throw away a few volts by inserting a cap multiplier here, consisting of R21, C14, and Q1. Just about any transistor having a sufficient Vce rating would do; I used a BUL128 because it was one of the cheapest 400V transistors in the Farnell catalog. **Figure 3** shows the ripple voltage present at the collector and emitter of Q1, indicating around 170dB of ripple rejection! Initially I had problems with collector-base failure at startup, so D11 was included to prevent Vcb exceeding 15V, and also allows C14 to discharge quickly at switch-off. The whole arrangement is a perfect low-cost, small-size substitute for the smoothing chokes found in innumerate old-fashioned designs. (In fact, why anyone still uses smoothing chokes at all in anything but the largest of amplifiers is beyond me.)

The remainder of the power supply is quite conventional, dropping down to 260V for the screen grids, which pushes operation a little more toward warm class AB. R15 and R16 are screen grid stoppers and are essential for any conscientious design (screen grid overload is a common failure mode in pentodes). R24 and C17 are the usual hum-loop block components and are probably overkill in such a puny amplifier. RV2 is a humdinger trimpot, to allow nulling of heater hum. This was also present in the original circuit, but I have referenced the wiper to the cathode of one of the power valves in order to raise the heater potential above the cathode of the first triode. This offers some further noise reduction and also reduces stress on the heater-cathode insulation of U1B.

I measured the open-loop gain as being 20, falling to 7 with the application of feedback, indicating 9dB of feedback. The inclusion of the stability compensation capacitors C7 and C8 removed all traces of ringing visible on a square wave, and some crude tests suggest the stability margin is about 8dB—a higher quality output transformer would improve this, no doubt. To anyone tempted to build this circuit from scratch the Hammond 1608 is an obvious choice. I do not present any layout information because my turret-board construction turned out to be rather esoteric (**Photo 1**); if I did it again I would make a PCB.

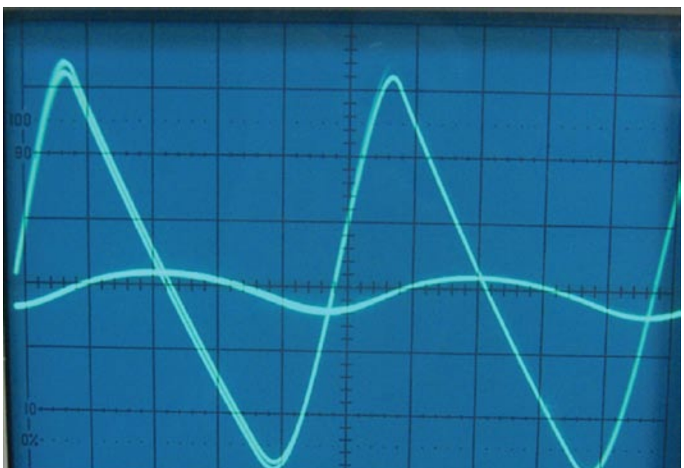


FIGURE 3: Ripple voltage measured at the collector and emitter of Q1 under quiescent load. 0.5V/div vertical scale.

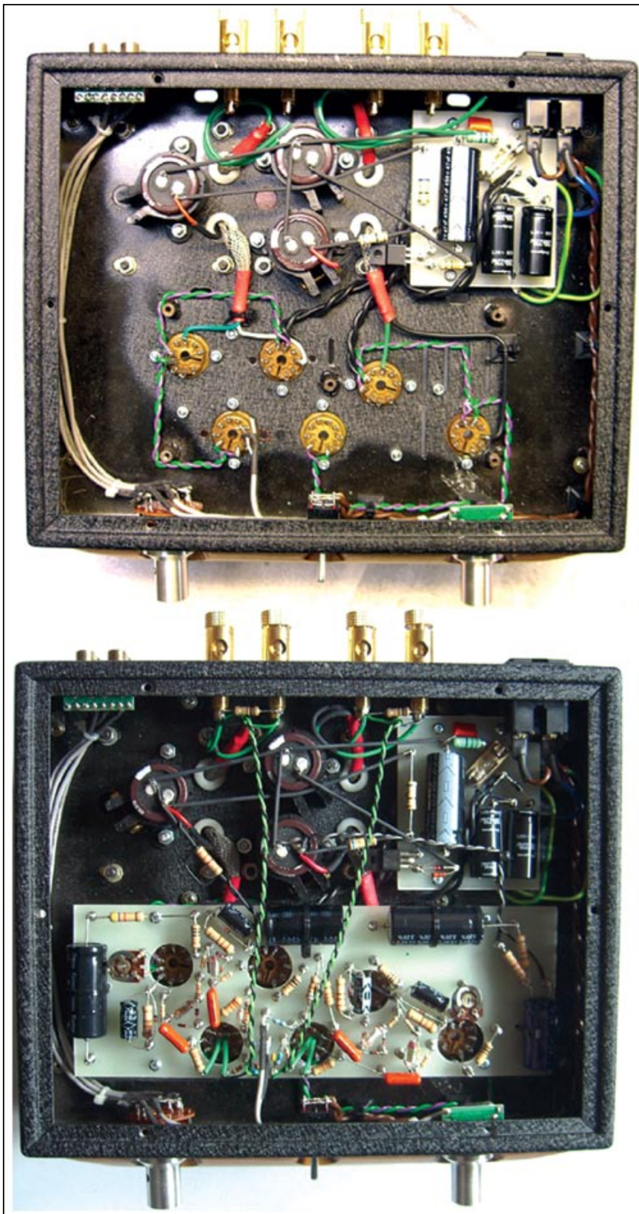


PHOTO 1: Early and late stages of construction, using a mixture of point-to-point and turret-board.

PHOTO 2: Amp.

FINAL THOUGHTS

The final result is very satisfactory. The transformers now only run warm, as they should. Despite the reduction in power (6W into 8Ω, or 8W into 16Ω) the volume is still sufficient for a small living room even when used with modern loudspeakers (I have tried Leema Xeros, Xones, and Epos ES14s), and quite impressive through a pair of sensitive Tannoy Monitor Golds. I am cautious to say so, since we are always convinced that our own creations sound best, but the sound quality also seems to have improved audibly as well as empirically. Despite being played in a professional hifi demo-room this little amp has drawn nothing but compliments. It seems to bring out musical details that I have not noticed in recordings before, and does not exhibit the shrillness that I encounter in some solid-state amps. Even my boss gave a favorable review—high praise indeed! aX

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