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This report details the complete ground up restoration of a pair of EAR 529 500 watt mono tube amplifiers. These were designed by Tim de Paravicini of EAR in England.

These EAR amplifiers came to me from a customer in Hong Kong. He wanted me to restore them and get them working to better than their original specifications.

I received two large wooden crates back in December 2012 and upon opening them was quite surprised. I guess the pictures will tell the story. These amplifiers were in really bad shape and needed a serious "makeover".

One of them had a blown power transformer, the primary windings were shorted and there was no way to repair it and so I had a new transformer made.

The amplifiers inside were a complete disaster. One of the amplifiers had many internal wires cut. Again the pictures illustrate what I mean.

Tim had designed a cute bias circuit to enable the user to set the tube bias (there are 10 output sweep tubes per chassis type PL519) with the aid of a pair of LEDs that when they had the same brightness the bias would be somewhat correct. Not exact as the final setting depended at which angle you viewed the LEDs. However I came to find once the amplifiers were up and running, that setting the bias on the output tubes with this method gave me results that were within 5-10% of optimum.

Sadly when I emailed Tim asking if he could send me a schematic he refused citing that I wanted to copy his design. Nothing could be further from the truth as I already own a magnificent pair of McIntosh MI350s which I had restored to better than new some years ago.

So I had to back engineer these babies and this was no small undertaking as the PCBs were a mess as was the internal wiring. This took me about 30 hours to come up with a schematic. I had no way of knowing whether I had done this correctly but upon entering the schematic into my software program from my hand drawn notes, it all made sense.

A part of the circuit had me perplexed for about 5 minutes. There was a small PCB in the original amplifiers which contained a small transformer with some passive parts alongside. I could not figure out what it was used for as all the wires to it had been cut. Finally it dawned on me that this was the power supply for the LED circuit which showed the bias settings for the PL519s.

A bit messy and so I dispensed with these extra power supplies and then had the new transformer made with an extra 7 volt winding. I added an extra winding on the good power transformer so I could then power the LED circuit from the main transformer.

By this stage the chassis of the two amplifiers had been completely stripped of all parts and the real work began.

My plan was to design new 4 layer printed circuit cards for the 4 different sections of the amplifiers, namely the POWER SUPPLY, the AUDIO DRIVER STAGES, the OUPUT TUBES and lastly the LED DRIVER board.

I spent considerable time taking measurements to make sure that the new PCBs would align with the original holes in the chassis.

In addition I made new artwork files for the eventual re silk screening of the chassis. I kept this as original as possible. I relocated the fuse holder to the hole previously used for the power cord and added a parallel RCA input at the original fuse holder's position. The new silk screen artwork reflects these changes. Due to the fact that I moved the fuse holder so close to the power transformer (That was were the old power cord hole was) I had some aluminium spacers made to lift the output iron up from the chassis by about 30mm and these spacers had a mouse hole to allow access to the fuse holder.

My customer wanted chassis mount IEC sockets to replace the attached power cord of the original design. So I cut the two rectangles on the rear panels and drilled the mounting holes. This was the only modification I did to the chassis in addition to the 4 holes drilled to hold the fan.

The two chassis were taken to a chrome plating company in Los Angeles who removed all the rust, removed the old zinc plating, sanded and ....well the pictures show the result of their work. The bottom panels were subjected to the same treatment as were the top caps for the 4 transformers. Be aware those in California who require plating, it is EXPENSIVE.

All screws used were also chrome plated at $2.00 each!

Each amplifier had an 80mm cooling fan attached with plasticine (Play Doh for Americans). I purchased some nice fan covers with air filters and the fans were finally mounted under the chassis. Due to cosmetic issues my customer will have to run external fans to keep those 10 output tubes cool as this small fan is not up to the task.

Designing new PCBs:

The power supply was in dire need of upgrades. There are several different supplies coming off various windings on the power transformer.

The first is the 7 volt winding for the heaters of the input tubes PCC88. The original had a small rectifier capacitor on the audio drive board. I relocated this to the power supply board. Schottky diodes were used together with 4,400 mfd of low ESR

capacitance in a C-R-C design. There is a further 4,400mfd on the audio drive board for local decoupling of the heater supply together with film bypass capacitors. I decided to forgo the use of PCC88 and substituted 6922 (6DJ8) which is a direct replacement and I adjusted the value of the "R" in the C-R-C filter to give me 5.8v on the filament supply.

The second is the 40 volt AC winding which supplies filament power to the PCL84 driver tubes as well as the PL519 sweep output tubes. Kudus to Tim for using high voltage filament tubes to eliminate the use of wire as thick as your finger for tube types with 6.3 volt filaments. If EL509 tubes had been used the 6.3 volt filament winding would have been in excess of 25 amps! Using the PL519 it needs to be just 4 amps.

This winding serves three circuits: First for the PCL84 filaments which I changed to rectified to DC and another 4,400mfd of capacitance is used together with twin 50 watt dropper resistors feeding the PCL84 filaments in series for a net of 30 volts. Second the raw 40v AC feeds the PL519's filaments. Third the rectified +54v supply is regulated to 36 volts and feeds the relays and time delay control circuits for the in rush current limiting circuits. Twin high current relays control in rush current on both the main +480v and -100/140 volt bias supplies.

The main +480 volt supplies are fed by a full wave bridge rectifier using 1,200 volt high speed 15 amp diodes. The main filter capacitor bank consists of eight 1000mfd 315v low ESR capacitors which I had custom made. Eight are used per amplifier. These are bypassed with polypropylene film capacitors.

On power up the time delay circuits limit the in rush current and after about 45 seconds the in rush resistors are bypassed by the relay's contacts.

Tim used some 33 ohm 25 watt resistors in both the +480v and ground circuits of the main supply. I can only guess as to why but these resistors mounted on a large heat sink ran very hot and I eventually removed them with no ill effects. These are shown in some of the pictures.

The next board was the audio driver board which is a 4 layer design with the bottom layer used as a ground plane..

The input signal was originally routed through a cheap carbon track potentiometer and to the grid of the input tube. Carbon track controls are not really good for high fidelity! These were changed to Bourns conductive plastic types and the input circuit was configured so the potentiometer is used as a shunt type attenuator so the audio signal does not pass through the potentiometer itself. I did the same thing in my McIntosh MI350s. Listening tests done on a blind A-B system proves that the shunt method is superior to having the potentiometer carry audio signal.

I made some changes to the input differential amplifier and cascode as well as the PCL84 driver stage. These changes improved the measured THD of the amplifier which is quite impressive for a tube design which employs NO global feedback from the secondary windings of the output transformer.

The output iron has a feedback winding from which feedback is employed on both cathode circuits of the front end differential amplifier and the driver stage.

Next up was the large board which housed the PL519 tubes and part of the LED bias circuit. This was relatively straight forward and using a 4 layer PCB helped with track routing. The bottom layer is used as a ground plane..

Interestingly Tim copied the bootstrap system around the output transformer which McIntosh employed in their MC series of tube amplifiers up to and including the MI350/MC3500 big mono blocks.

The output transformer has primary windings for the plates, cathodes and screens of the PL519 tubes as well as a feedback winding.

The secondaries are wired for 4 and 8 ohm loads

The last and most difficult part of the initial re design was figuring out how the multi-pole switch used for the bias LEDs worked. I stripped the switches and cleaned off all the oxidization. These are 4 deck type old style British switches with rather fragile solder tags. After cleaning and the switches re-assembled I worked out how to wire them in a simple way to allow the selection of each output tube's cathode current (bias).

PCB assembly:

All the PCBs were hand assembled and soldered. The usual plethora of 1% metal film resistors and polypropylene capacitors were used. All the tube sockets are new with gold plated pins.

This part of the project progressed with no issues.

Final assembly of parts to the chassis:

This part was critical in that I was determined not to make one single mark on the gorgeous chrome finish. Working on each chassis and installing all the standoffs for the PCBs I did all this work on a soft towel and wore soft white gloves.
The RCA sockets, speaker binding posts, fuse holder, IEC socket and the new power rocker switch were installed. I have no idea what the various PEM nuts on the perimeter of the chassis were used for so I installed chrome screws to fill these holes.

Next was the installation of the two transformers on each chassis. I had also painted the laminations black to make a nice contrast with the chrome plated top caps. This completed the fan was installed and finally all the PCBs were bolted in.

I had both amplifier chassis upside down on a workbench and began the tedious task of hand wiring. To avoid errors and to have both amplifiers looking identical, I wired one wire at a time on each chassis. This was time consuming but was worth the effort.

The main high voltage and bias windings were left unsoldered from the transformer for initial testing.

I began the testing on one amplifier. The filament and relay control circuits worked first time. The +480 volt and -100/140 volt were connected, and my Audio Precision was connected to the input. The amplifier was powered up slowly through a variac and a nice looking sine wave was observed on the oscilloscope. All supply voltages were monitored and all checked out to specification. At this time the PL519's bias potentiometers were set for minimum cathode current. The amplifier was kept running for about 2 hours to allow all passive parts especially the large electrolytic capacitors reach a nice stable operating temperature. During testing I always had a 120 CFM fan keeping those ten PL519s cool.

The amplifier was not troubled by having no load connected. The next step was to set the cathode current of the output tubes. Did my thing with the equal brightness LEDs and then checked the actual cathode current of each tube by measuring the volt drop across the 15 ohm cathode resistors. My settings were all within 5-10% which was quite acceptable.

Now to load the amplifier. Using an 8 ohm load I advanced the signal from very low level and observed some high frequency oscillation. A quick sniff with a scope and I saw that that amplifier wanted a snubber across the output transformer's 4 ohm tap to ground. Installed this and 90% of the oscillation was gone. Further analysis and I tweaked the values of the compensation capacitors in the feedback loop connected to the differential amplifier. I also had to lower the gain at high frequencies (240KHz) of the input cascode stage and this eliminated all the nasties. The amplifier was then quite happy driving a load.

I ran a sweep of output power versus THD at 2KHz as my first test. Now keep in mind that the power transformers have two voltage taps for the main B+ supply. I had set it on the lower taps delivering +480 volts under no load. The higher voltage taps would have delivered +620 volts which would have taxed the output tubes close to their limits.

No fear, the amplifier delivered 598 watts at 1% THD which was the onset of clipping. This measurement was done with a line voltage of 208 volts but the amplifiers shall be used at 220v line so output power will increase to 670 watts. True of all good tube amplifiers this one clipped very gracefully. THD was extremely low for a tube amplifier and was typically well below 0.2%. Most of the THD was even harmonics which was to be expected.

Personally I am not intrigued with ultra low THD numbers as they tell only a small part of what the amplifier will sound like. My opinion of damping factor is the same. A DF of more than 20 is a waste of time.

I spent a few hours running plots on the AP and was extremely satisfied with what I measured.

The amplifier was not able to deliver the full 598 watts at the frequency extremes and especially at 20Hz where the output transformer is simply not large enough and does not have enough inductance. High frequency response at power level less than 200 watts was ruler flat to 20Hz-40KHz. At 500 watts it was down less than 0.5dB at 20Hz and 20KHz which is very good indeed.

The second amplifier's testing went substantially quicker than that of the first as I knew that all my reverse engineering was good.

I followed the same rules in powering up the second amplifier and it fired up first time with no issues. Of course I applied the fixes to cure the oscillation problems before powering up the second amplifier.

The full suite of pictures are numbered as I progressed from opening the cartons when I received them to the final pictures. I did install blue LEDs under every tube socket and the visual results I think are spectacular.

Forgive my photography skills as this is not my forte.

Stephen Mantz

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