PAL 350-500- observations during restoration

Chris Bolkan KI7NXY

First, I have to state my qualifications for writing this up. None whatsoever! I have been communicating with John Poulton who has been a fantastic resource and become a friend. I am relatively new to ham radio and a complete newby to tetrode amplifiers. A lot may be just plain wrong, but if I had known this stuff when I started it would have helped me a lot.

1) **PAL 350 and 500 power output capabilities-**

The big HV power transformer for both the PAL 350 and PAL 500 is the same part number. I do not believe that other than changing the final tube tubes and overload trip point in the power supply there is any difference between the PAL 350 and 500 potential output power. In fact, the PAL 350c switched to 4CX350's but kept the same power rating until they made the PAL 500.

2) **To Key or not to Key-**

I have come to the conclusion based on looking at the circuitry of all of the 350-500 variants that these amps are not intended to be "keyed" with every push-to-talk button push or telegraph keystroke. I believe that they were intended to be operated turned on and biased on continuously. Any "keying" was most likely done in the signal provided by the exciter. This did not make sense to me at first because of my experience with noncommercial amateur radio amplifiers, but as I have worked on these it now does. They are rugged and underrated enough to be biased on constantly. In addition, the amplifier operated in this configuration will not produce any key clicks.

3) **I tried Bias Keying anyway-**

I did rewire one power supply to "bias key" the finals. It was very simple to do and works quite well functionally. I do not know if keying the amp on and off with bias produces key clicks that are objectionable or not, but it greatly reduces standby power consumption, power relay clicks (more on this later) and is elegantly simple. The schematic for keying in this manner is in the (https://www.tmchistory.org/tmc_manuals/manuals_db/pal-500/tm_pal-500_5_66.pdf) PAL 500 manual on John's TMC history site. I know TMC sent out some power supplies and amps with bias keying configuration (I have one), but they also sent out a change notice to go back to the original wiring (mine was converted back to original but evidence of bias keying was there) I suspect that the bias keying idea came along with the advent of the PAL 500, but it ended up not compatible with the fleet of existing units in the field or it induced eventual screen grid resistor burnout, or maybe the amps produced key clicks. Who knows? I did increase the screen grid resistor wattage per John's recommendation. I like this mod and plan to keep it unless actual transmission on-off clicks are objectionable.

4) **Testing output tubes-**

Unknown condition final tubes presented a big problem for me. The best way I found to "test" them at home without a tester is to first ohm out the filament, then ohm out between the elements of the tube (better if you can hipot or megger test between elements). If they test good to that point, they are *probably* safe to put into the amp. Fortunately, the power supply

does a very good job of protecting things (as I found out many times). Before plugging the tubes into the amp, I preset the tube bias voltage by measuring and setting it with a VOM on the center pin of the 4CX tube sockets with the plates switch on but HV switch off*. I found that -60V is a good starting point. Then plug the tubes in, let the filaments warm up good and turn on HV. If they are in reasonable condition you might see around 150mA of plate current. I first tried setting the voltage to the tube data sheet's -55V recommendation, but that consistently drew more current than I was comfortable with for initial tube testing. Assuming you don't get crazy low or crazy high plate current the tube(s) are most likely functional. If you do get crazy low bias current or the HV breaker pops from a short, the offending tube is probably weak or bad.

*You might want to ground the HV while setting the bias voltage as current lighting the HV off lightbulb still energizes the HV circuit with a couple hundred volts even when it is switched off. I got bit good once and after that always ground the HV when the HV switch is turned off if I am going to be messing around in there.

5) **Setting the bias-**

At this point you can turn both bias pots full CCW and set quiescent current per TMC setup procedure. It looks like TMC wanted about 70ma of bias current per 4cx250 tube. There is about 20ma of bias current flow without the tubes which is why they want the first tube set to 90 and the second to 160. That had me stumped until I figured it out. The same offset applies to 4CX350 tubes, but the final bias current is higher.

6) **Neutralization.**

I went down this rabbit hole and spent a bunch of time trying different things that led to different settings on the neutralization cap but nothing really made a difference in the end. I tried setting it by minimizing leakage signal through the finals using a signal generator feeding a signal into the driver and looking with a scope on the output terminal, and tried setting it to 1V per the procedure in the manual using a high frequency high impedance detector probe circuit I found on the internet. The two procedures led to different settings on the neutralization cap, but neither setting seemed to produce instability. So, I'm at a loss on this. Fortunately, it just seems to work. If anyone can provide good input on this, I will update this, or just send the procedure to John.

7) **Dirty/contaminated relay contacts**

I found one problem to be particularly difficult to diagnose and common to both of my units, which means it might be common to others. Fortunately, it ended up being an easy fix. I would see varying amounts of drive to the finals for a given drive from the signal generator. Sometimes there would be great Drive. Sometimes less. And sometimes I could watch the drive start out high and slowly drop to a lower level. Once in a while it dropped to nothing. Sometimes turning on and off the plate switch would bring it back to full or partial drive and then it might stay or slowly drop off or slowly increase. It was very hard to troubleshoot. I did not know if it was in the circuit of the 6CL6, 6146, ADLC, feedback or what. I disconnected the ALDC circuit from the driver stage. Problem was still there. Then one time the drive dropped out, I moved the scope probe from the output of the 6146 to the output of the 6CL6 and it was still out, so that

narrowed it to the circuitry around the 6CL6. I would frequently check voltages. The +150, -150 and -155 bias were always present no matter how much drive it was putting out. The bias on the 6CL6 was rock solid and was always the same voltage generated in the power supply. What I finally discovered was that the -150Vsupply voltage, while always present, was changing within a range of about 5V. It would drop to -145 or so and the driver would drop out. At -150 it was full drive. In between the drive was in between. It turns out relay K102 in the power supply* had something weird with the contacts. It always produced something between 0 and 5 volts drop in the contacts. Enough to change the bias of the first stage dramatically, but the voltage never dropped enough that it was really noticeable. Bottom line is that both the -150 and -155V supplies have a profound effect on the bias of the 6Cl6, and the -150V supply goes through a relay.

I took the relay apart and used Deoxit and emery paper on the contacts and now it works great. My other power supply was doing the same thing and cleaning the relay fixed it too. This really changed the way the amp behaves. It is completely consistent now. This was a funky problem since every fraction of a volt drop through the relay of the -150V rail greatly affects the gain of the 6CL6!

*Both of my power supplies are later models for the PAL-500. Early PAL-350 power supplied are a bit different circuit. I have not traced them out to see if the relay in them can produce this same problem but it is certainly worth a look if your PAL 350 is misbehaving.