Bo Gast Brings The Collective a Blown Up Amp for Diagnosis

General musings on tube physics and amp debugging by Niels "Petco" Nielsen

Bo's amp, a very stoutly built Bassman 70 from the 1970's, failed during use due to a fire inside the chassis and overheated output tubes. The fire may have been unrelated to the overheated tubes, but the overheating suggested a problem with what is called the BIAS SUPPLY. Normally this would cause a blown fuse, but in this case some bonehead had stuck a 15 amp car fuse in it instead of the 2.5 amp slo-blo fuse that the amp requires!! NOT GOOD. This led to a discussion of the three basic parts of a power supply and the three parts of the tube that are fed from the supply. I summarize these things below.

The power supply is the hardest-working part of any tube amp. The constant stress it experiences means that it often is the most failure-prone subsystem. The first thing to test upon pulling down a tube amp that has failed catastrophically under load will therefore be the power supply, which is done with all the tubes pulled out. The tubes of course have to be tested too, but that's done with a tube checker.

To function, a tube needs three things: 6.3VAC for its HEATER, -1 to -56 volts DC for its GRID BIAS, and +250 to +550 volts DC for its PLATE. These voltages are furnished by the power supply, although in small amps (using 6V6 or 6BQ5 output tubes) the grid bias is often derived in a way that eliminates the need for a separate grid bias circuit in the power supply. Bo's amp, being a big one with 6L6GC output tubes, has a grid bias supply. Now, what do these voltages do?

To conduct electricity through the vacuum inside a tube, free electrons need to be produced. The HEATER FILAMENT does this by getting hot, which is what happens when the 6.3VAC flows through it. It heats up the CATHODE to red heat, at which temperature electrons are being boiled out of it in great quantities. If you shut the heater voltage off, the tube fades out and goes dead and cold without damaging itself or its surroundings.

To establish current flow through the tube, the electrons need to be pulled across the vacuum. This is done by applying a strong positive DC voltage (often referred to as "B+") to its PLATE. The negatively-charged electrons see this positive voltage and go flying towards the plate. The higher this voltage, the greater the pull and the more current flows through the tube. Voltage times current equals POWER, so high B+ voltage means high power. If you shut off the PLATE voltage, the tube shuts off and no signal comes out -again with no damage to itself or the surrounding circuitry. This is exactly what the standby switch on a tube amp does: it disconnects the B+ supply from the output tube plates.

To control the power output of the tube, we put a GRID between the CATHODE and the PLATE. A little voltage on the GRID is enough to shut off the flow of electrons, so a little voltage wiggle on the GRID makes a big power wiggle in the PLATE circuit. However, to ensure that the tube is “standing at attention” and ready to rock at the instant that a little wiggle appears on its GRID, the tube requires a small amount of steady (DC) bias voltage be superimposed on the input wiggle. This GRID BIAS fixes the amount of current that “idles” through the tube in the absence of an incoming signal. Every different 6L6GC tube has a slightly different idle current specification which must be met in order for it to deliver its full rated output, so most amp designers make the GRID BIAS supply adjustable to accomodate all these different tubes. If you set the grid bias wrong, either the tube will go into shutdown (near-zero idle current) and it will “ignore” the input signal, producing a very weak and distorted output (or no output at all), or the tube will sit there and draw more and more idle current and soon overheat enough to glow red-hot and create sparks between its interior parts. VERY bad for the tube, the output transformer, and the power supply.

TO SUMMARIZE: the three parts of the power supply are the 6.3VAC heater supply, the B+ (plate) supply, and the grid bias. Each goes to a different part of the tube to perform a critical function. With no B+ or no 6.3VAC, the tube goes inert and silent. With the wrong grid bias, the tube can either go inert and silent OR run wildly out of control and overheat. Now you can see why we suspected the grid bias supply.

So we replaced the fuse with a 2 amp slo-blo and cautiously, we plugged in the amp and turned it on. Nothing exploded, so we checked the voltages using my multimeter and discovered the 6.3VAC and the B+ voltages were reasonable but the grid bias was way off. Working the grid bias trimming control back and forth resulted in voltages that jumped around semirandomly, indicating that the red-hot tubes and sparks that Bo saw may have been caused by a fault here.

The fire in the amp was in the region of the 120VAC power line input, the ground polarity switch, and the auxiliary 120 VAC output socket and could not have been caused by a grid bias fault. It could have been caused by a dust bunny or some other source of a short circuit which would ordinarily have blown the 2.5A fuse, but not a 15A fuse. Several wires there were sufficiently charred to warrant replacement. In addition, soot from the burn had coated the ground polarity switch housing and the back side of the auxiliary 120VAC output jack. The soot has to be carefully cleaned off, otherwise the next time the amp gets warm the soot can start leaking electricity across the dirty surfaces and start another fire.

Bo now needs to get a schematic off the web for this amp, buy a pack of 2.5A slo-blo fuses, replace the bias balance control pot, throw out the 6L6GC’s that were in the amp when they overheated and sparked, clean out the soot, re-tube the chassis after testing all the small-signal tubes, and reset the grid bias balance per the service spec’s WITH the new tubes in it AND a speaker connected AND the standby switch in the “operate” position.