Dear Customer,

Congratulations with your **Harley Benton Legendary 18 Watt Mod Kit**!

Successfully implementing the modifications described in this manual will transform your GA-15 from an ugly duckling among guitar amplifiers into a great sounding tube amp! Hopefully, it will be an enjoyable process too – the journey is the destination :)

Please be aware that some of the mods may be quite challenging to perform. Improper implementation of the described changes may render your GA15 unusable and can even be dangerous! Opening up and changing your GA15 is entirely for your own risk and should only be done by properly trained personnel. The modifications described in this manual do not necessarily comply with any electronic safety standards. **Disclaimer: Cosmic Ampworks® assumes or undertakes NO LIABILITY for any damage suffered as a result of the use, misuse or reliance on the information and content in this manual.**

Figure 1. Modified Harley Benton GA15.

1. About the mods

The mods in this manual can be grouped into five main parts: (1) Rewiring of the preamp and introducing a passive tone control, (2) adding a presence and negative feedback control, (3) rerouting the heater wiring, (4) using the now obsolete LM7912 voltage regulator to power the preamp heater filaments with DC and (5) substituting power ampi components to match the 18W circuit. It is advisable to implement the mods one-by-one, and checking carefully whether your amp is still functioning properly after each mod, before proceeding. Oh… and don't forget to listen to the sonic changes along the way! We'll start out with the simplest of all mods, view it as a little test 😊:

1. **Adding a grid leak resistor to V2A (oddly, the first preamp tube is numbered V2 in the schematic (p.9, p.28) and on the circuit board; p.10)**. This will make sure the correct bias is maintained at all times.
2. A lot of parts related to the (TL072) IC-based EQ and effects buffer can be removed (figure..), as well as some components related to V2. Those latter can be removed because:

3. **The two triodes of that tube (V2A and V2B) will be wired in parallel**, for better noise rejection and lower output impedance (p.11). From experience; leaving some parts in place that are no longer used after the mods may still affect sound quality and even result in fuzz-like background sounds!

Then it's time to do some real modding:

4. **Soldering a tonestack and volume control on the back of two potmeters (p.13).** This way, we create a purely tube-based signal path (no solid state components). The tone control circuit is, of course, derived from the tremolo channel tone control of the legendary original 18W amps. Might be a bit challenging!
5. **Optional: Wiring a DC power supply for the preamp heater filaments and rearranging the heater wiring (p.16).** This will largely eliminate the GA15's hum problem. As the active op-amp based tonestack was removed (with mod 5.), the DC power supply that powered the TL072 op-amp ICs can be used to power the pre-amp tubes – which are most sensitive to hum. Generally, heaters of (preamp) tubes are wired in parallel, from a 6.3V AC supply. Here, we will wire them in series, from 12V DC.
6. **Optional: install a presence and negative feedback control (p.21)**. With the presence control, some more aggressive highs can be dialed in. Adding negative feedback will result in a more modern, flatter sound and may also serve to eliminate some remaining hum**.** Moreover**,** the two additional potmeters will fil the remaining empty mounting holes in the front of your amp.
7. **Optional: rerouting the wiring for the power tube heater supply (p.25).** This is an optional mod; very likely, mod 5 already resulted in a very quiet amp. When the mods were developed, power and preamp tubes were rerouted all at once, so it is difficult to tell the effect of only rerouting the power amp heater wiring. Normally, in a push-pull power amp, most of the hum in the opposing tubes cancels out.
8. **Optional: change some power amp component values to exactly match 18W specs (p.27).** Personally, I haven't bothered doing this, as I already love the sound of my HB15, err HB18 as it sounds right now. But if you like, you can bring it even closer to the original specs. In terms of sound, I am actually curious what the difference will be. **Warning: these mods are a bit more risky, as they are in the high voltage department of the amp!**

Before starting, a few words on safety. If you have not been trained to work with high voltages, then please have a qualified amp technician modify your amp. Cosmic Ampworks does not recommend you to start working on the GA15 amplifier yourself if you don't have the right skills and knowledge! For those *with* the appropriate skills, a number of safety warning are included below.

2. Safety

2.1 Safety warning

Always unplug the amp before doing any work on it. A tube amplifier chassis contains lethal high voltages even when unplugged - sometimes over 500 volts DC! If you have not been trained to work with high voltage then have an amp technician service or modify your amp.

High voltages in a tube amp don't disappear directly after you unplug the unit's power chord. The internal filter capacitors can store lethal voltages for days or even weeks. Before working on the GA15, it must be ensured that the amp is unplugged and that these filter caps have been de-charged. The filter caps in the GA15 look like little black cylinders (Figure 2). The encircled row of 3 large capacitors (Figure 2) are the ones that supply HT (High Tension!) power to the electron tubes, hence these are the most dangerous ones. But… **you can't easily see what parts are connected to which filter caps - so maintaining the highest level of caution AT ALL TIMES is required!** There is only one way to verify that the filter caps have been drained and the amp is safe to work on: by checking for remaining voltages with a multimeter, after having switched off and unplugged the amp.

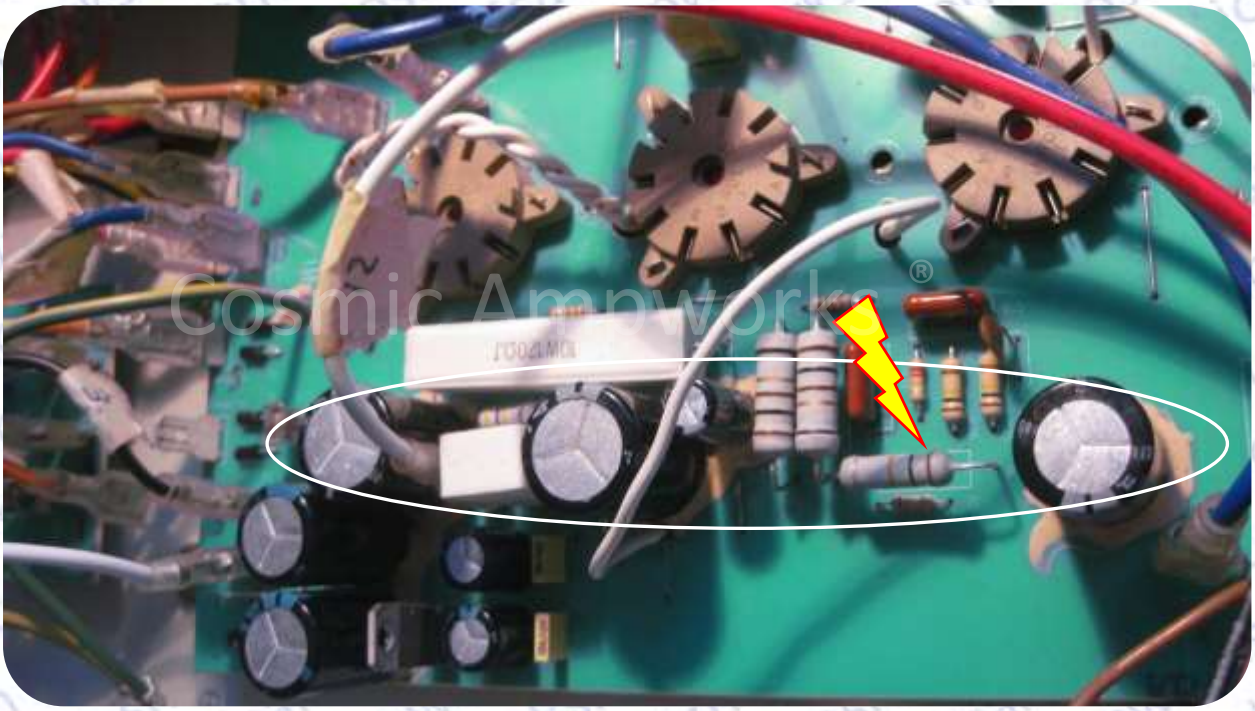

Figure 2. Filter capacitors and most parts of the HT (High Tension) section of the Harley Benton GA15 printed circuit board (seen from the back of the chassis).

2.2 How to - safely - measure voltages in a GA-15?

Never touch the amplifier chassis with one hand while probing with the other hand. Use just one hand when working on an amp that potentially still contains high voltages. Also, wear safety goggles, in case you accidentally cause a short circuit!

Ideally, your multimeter has a clip-on ground probe that you can attach to the (negative) grounded chassis. You can then use one hand to carefully measure voltages in the circuit with the positive (red) terminal of the multimeter, keeping the other hand in your pocket, away from the chassis. To ensure that you don't accidentally create a short circuit between two component legs with the red probe, cover the probe with insulating tape, leaving only the very tip exposed.

If you don't have a clip-on ground probe, a makeshift (but less safe!) alternative is to hang the negative (black) multimeter probe in one of the cage nuts of the GA15 chassis (Figure 3). Use the front left one if you're right-handed (Figure 3) and vice-versa. Then use one hand to check for remaining high voltages with the red probe.

Figure 3. If your multimeter does not have a clip-on ground probe, a (less advisable) alternative is to hang the negative terminal in one of the cage nuts (after switching off and disconnecting the amp), so you can keep one hand free for safety and take measurements with the other hand.

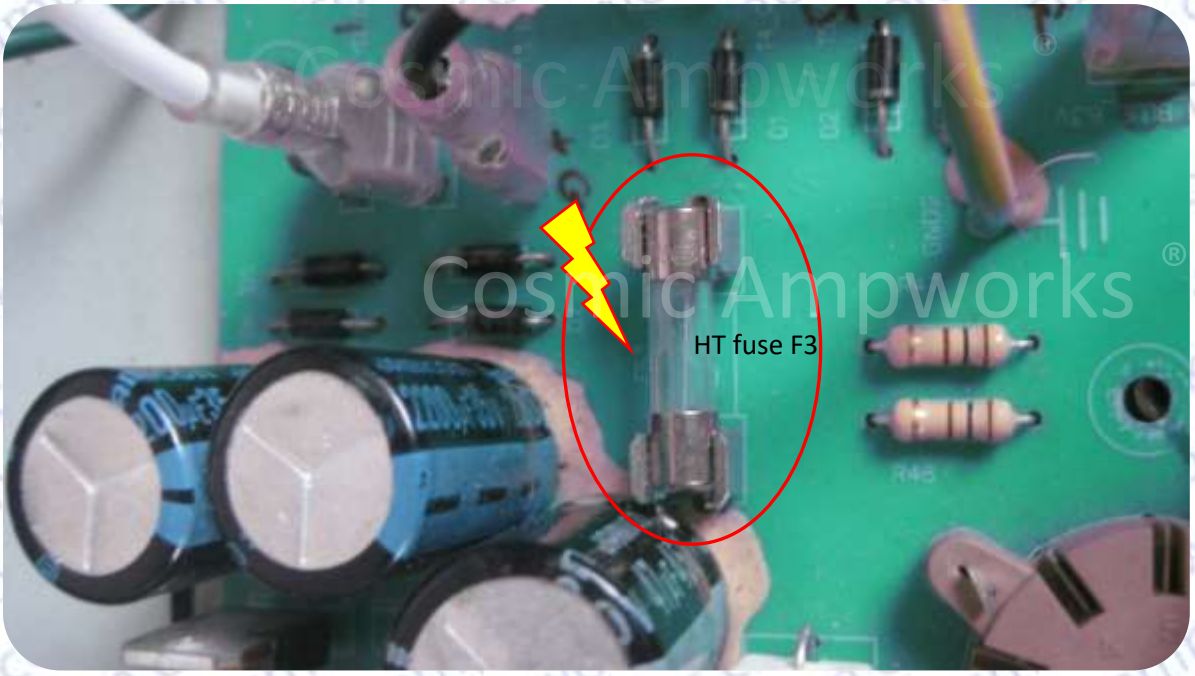

Figure 4. The HT fuse F3 (DON'T TOUCH IT!) is a good place to check for remaining high voltages after switching off and disconnecting the amp. Hang the black (negative) multimeter probe in one of the cage nuts (as described in the text), so that you only need to use one hand. With that hand, hold the red multimeter probe carefully against the HT fuse and check the voltage.

2.3 Where to check for remaining high voltages?

The legs of the 3 HT filter caps themselves are inaccessible, as they are mounted flush with the board. However, in the amp schematic we can see that some components directly connected to those legs: the HT fuse F3 (Figure 4) and both legs of R38 (Figure 5), for instance.

So, again, attach the black (negative) multimeter probe to the chassis, keep one hand in your pocket, hold the uncovered tip of the red multimeter probe carefully against the HT fuse F3 (Figure 4) and check the voltage. Then do the same by holding it against the legs of R38 (Figure 5).

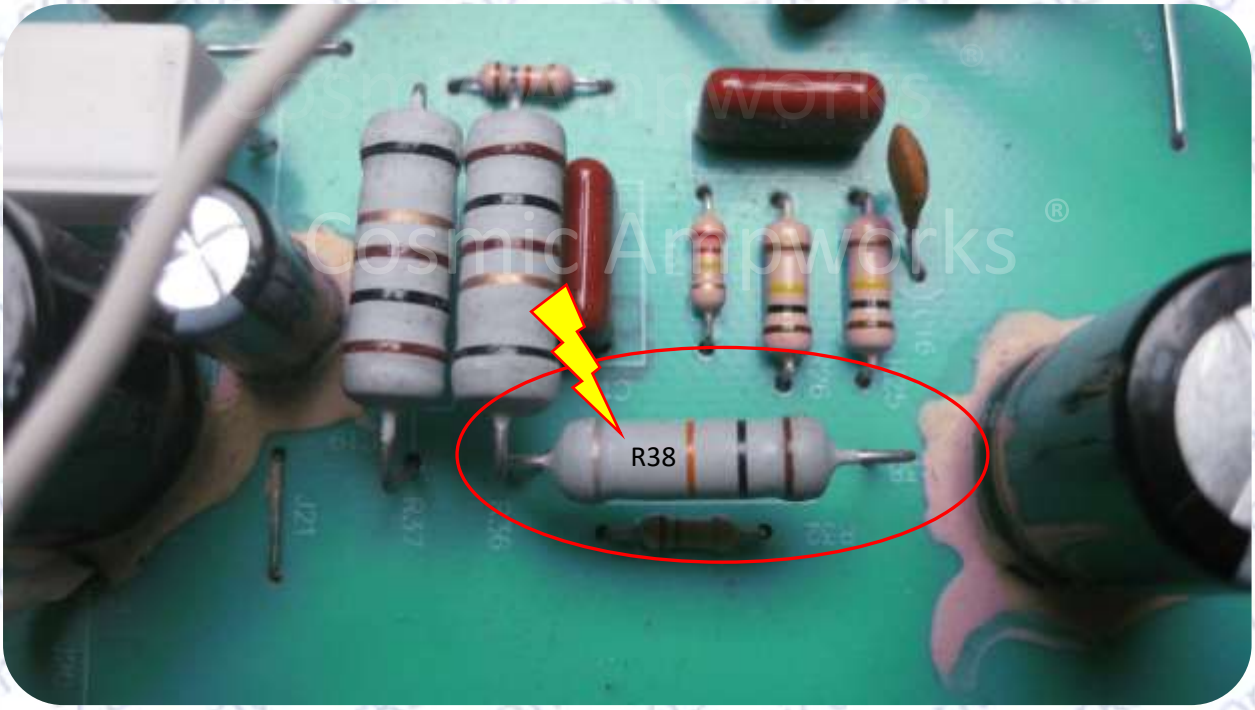

Figure 5 R38 (the voltage dropping resistor for the preamp tubes- DON'T TOUCH IT!) is a good place to check for remaining high voltages after switching off and disconnecting the amp. Hang the black (negative) multimeter probe in one of the cage nuts (as described in the text), so that you only need to use one hand. With that hand, hold the red multimeter probe carefully against the resistor's legs and check the voltages.

Not measuring any remaining voltages at F3 or R38, shortly after switching off the amp, is a reason for suspicion! Put down the red probe, slightly wiggle the black probe in the cage nut, put it down and measure again with the red one. If there's still no voltage, select a more sensitive range on the potmeter – some low voltages (< 1V) should still be measurable. With tube amps you never know, so by all means take a few additional measurements in other places to double check! In any case, wait until the voltages are below some 20V. From experience: the GA15 filter caps will discharge quickly enough by keeping the multi (voltage)meter connected for a minute or two. Don't short them to chassis ground!

Also, after having taken a break, check again for high voltages: capacitors can self-recharge due to dielectric memory. Cosmic Ampworks does not guarantee you that the GA15 is safe to work on if you don't measure any remaining high voltages at R38 or HT fuse F3. Always also rely on your own insights and measure and doublecheck everything.

Some further essential safety advice at this excellent site: (https://robrobinette.com/Tube_Amp_Safety.htm).

3. Required materials and tools

3.1 Contents of The Ultimate Harley Benton GA 15 Mod Kit:

1. This manual (full-color printout is optional);
2. De-soldering wire;
3. Soldering wire with resin core (20cm);
4. Tie wraps (x2);
5. Vintage solid cloth wire (green, **for heater wiring**; 60 cm);
6. Vintage solid cloth wire (different colors, for preamp wiring; total 60 cm);
7. Double stranded speaker wire (for audio signals; 50 cm);
8. Heatsink (for voltage regulator);
9. Dab of thermal grease;
10. Crocodile clip;
11. Potmeters:
    a. 2 x **500k** (**A**udio taper);
    b. **1M** (1 x **B**, linear taper) - 5k (1x **B**, linear taper)
12. Resistors: **820 Ohms** (1W, 2x), **8.2k** (1W, 2x), **47k** (1x), **120k** (1W, 1x), **470k** (4x), **1M** (1x)
13. Capacitors: **470pF** (or 500p, 1x), **4.7nF** (2x, "yellow"), **10nF** (2x, polyester wine red), **100nF** (=0.1uF, yellow), **47uF** electrolytic, radial).
14. Nut and bolt for attaching voltage regulator to heatsink.

3.2 Additional requirements

Apart from the items included in this mod kit, the following things are required for successfully implementing the Ultimate GA15 mod:

1. Safety goggles;
2. Soldering iron (ca. 30W is best for our purpose);
3. Multimeter, capable of measuring high voltages (up to 600V), preferably with a clip-on ground probe;
4. Masking tape (the paper type, that you can easily write on) and a ballpoint;
5. Duct tape or gaffer tape;
6. A simple file, a rotary drill or a Dremel tool, plus some small drill bits for metal and, optionally, a little sanding/grinding tool or disk;
7. Needle nose pliers;
8. Philips screw drivers (some different sizes).

Preferably work on your amplifier in a place where children (or spouses) cannot accidentally touch the amp's interior or a hot soldering iron, or swallow small electronic components. Work is best done on a clean work desk, but make sure to protect it against burn marks from the soldering iron and scratches from the amp chassis. Wear safety goggles, even during soldering – when really concentrated, the soldering iron sometimes may stray a bit too close to one's face.

4. Preparations

1. Remove the power chord.
2. Unscrew the 8 screws on the back panel of the amp's cabinet and remove the panel.
3. Remove the tubes (2 x 12AX7 preamp tubes and 2 x EL84 power tubes) from underneath the chassis by carefully pulling and wiggling a bit if necessary. Mark on the bottom of the chassis where the power tubes (the taller EL84 tubes) and the pre-amp tubes belong, e.g. with a permanent marker. It is all too easy to put the tubes back in the wrong location afterwards. Make sure the tubes won't roll off your desk; best put them in a little tray.
4. Unplug the internal speaker from the speaker jack on the back of the chassis and
5. Use a little kitchen knife to lift and remove the brown plastic plugs that cover the screw holes on top of the cabinet. Remove the screws too, using a suitable Phillips screwdriver; then you should be able to remove the chassis from the cabinet by slightly lifting and sliding it backwards.
6. **Carefully check for any remaining high voltages stored in the filter caps, using a multimeter, as described above (p. 3 - 5) and keeping the safety warning and advice in mind.**
7. Number all the wires (e.g. 1 - 15) that are attached to the circuit board with spade connectors, by copying the numbers printed on the board next to each connector on pieces of masking tape. Wrap those around the correct wires (Figure 6).

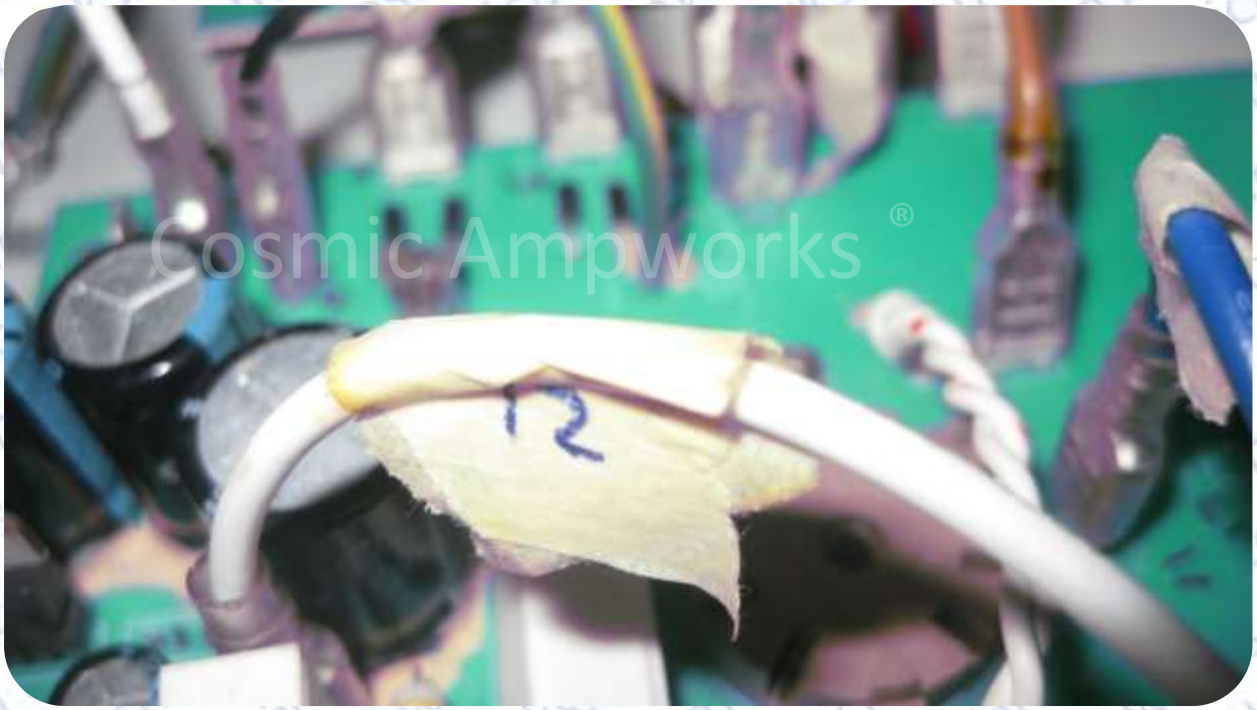

Figure 6. Label the wires with little pieces of masking tape before disconnecting the spade connectors, to make sure you put them back in the correct locations later on. NOTE: I used my own numbering and just wrote those numbers on the circuit board with a permanent marker.

8. Disconnect all spade connectors (after first having completed point 6.), by carefully pulling and wiggling. Pliers may be helpful.
9. Remove the jack retainer bolts from the front of the amp with a small socket spanner.
10. Remove the knobs from the potmeter shafts by pulling carefully. Then unscrew the retaining nuts and remove the potmeter washers.
11. Now it should be possible to remove the PCB (printed circuit board) from the chassis.

5. Removal of parts that are to be replaced or become superfluous after the mod

Heat up the soldering iron and keep de-soldering wire and needle nose pliers handy. **Preferably wear safety goggles:** when applying some force to a component that suddenly comes loose, the soldering iron or a blob of molten solder may suddenly jump towards your face.

A lot of parts need to be removed, particularly those that are part of the (TL072) op-amp tone control circuit and effects loop, because we're going to replace the tonestack with a passive 18W circuit, removing the effects loop and ICs altogether. The DC power supply, including the LM7912 voltage regulator that was originally used for the ICs will be wired to power the preamp tube heater filaments with DC instead, to reduce hum. As the LM7912 will generate substantially more heat performing its new task, the included heat sink needs to be attached to it.

From experience; leaving some parts in place, even if they are no longer operational after the mods, may affect sound quality and even result in fuzz-like background sounds!

Figure 7 shows the schematic of the stock Harley Benton. Take note of each component's number in the red fields in the schematic (e.g. R4), find the number on the actual circuit board of your GA15 and remove the component. If you haven't done this before: remove the solder from the components' legs underneath the circuit board by holding the included *de-soldering wire* against it with one hand, then with the other hand heat the spot with the soldering iron, until the solder melts and is absorbed by the de-soldering wire. With most of the solder removed, try to gently pull the components away from the top of the board by gripping them with the needle nose pliers. The following components should be left in place:

1. The phones jack (front right of the board), because it provides an important mechanical connection between the board and the chassis. Just remove R41 to ensure that the phones jack is no longer functional: its design seems questionable and might present the output tubes with an incorrect load impedance. Also remove the wires going into connections P9 and P10 to the right of the phones jack.
2. The input jack (front left) should be left in place, of course.
3. **Leave the wire bridges J3, J4, J9, J18, J19, J21 in place**; all other wire bridges can be removed.
4. Remove connectors SCN1, CN2 and CN11 and the little circuit board in the rear of the chassis, which holds the effects loop and line out jacks.

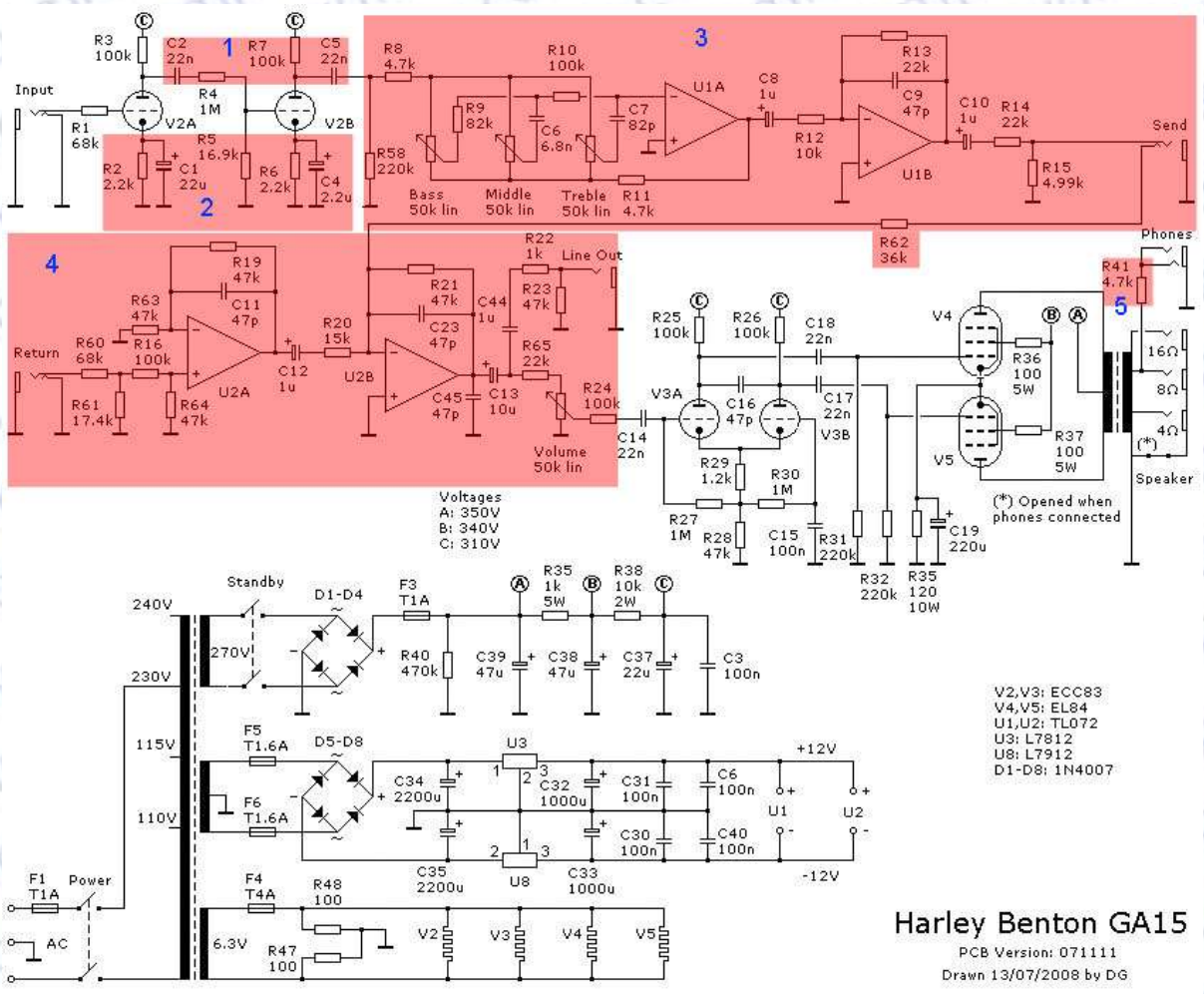

*Figure 7 Schematic of the Harley Benton GA15 (credits of original schematic: DG, 2008). Parts that are to be removed for "the Legendary 18W Mod" are in the red fields. **NOTE**: If you're not so confident in your soldering and electronics skills yet, it may be best to start with removing only the parts that are replaced in block 1 and 2 (mods 1 and 3., Section 1, p.2). Before proceeding with the other blocks, you could first test whether the amp still works.*

6. Installing new components (wear safety goggles!)

1. **Solder a 1M grid leak resistor across the connections of the input jack** (Figure 8). If you don't know how to solder: heat both the conductive area of the circuit board and the component leg for some time, whilst holding the included soldering wire against it until it melts. Hold on for a moment until sufficient solder has molten and has become hot enough to form a good conductive connection. From experience: poor soldering connections negatively influence your tone and can lead to circuit failure over (years of) time.

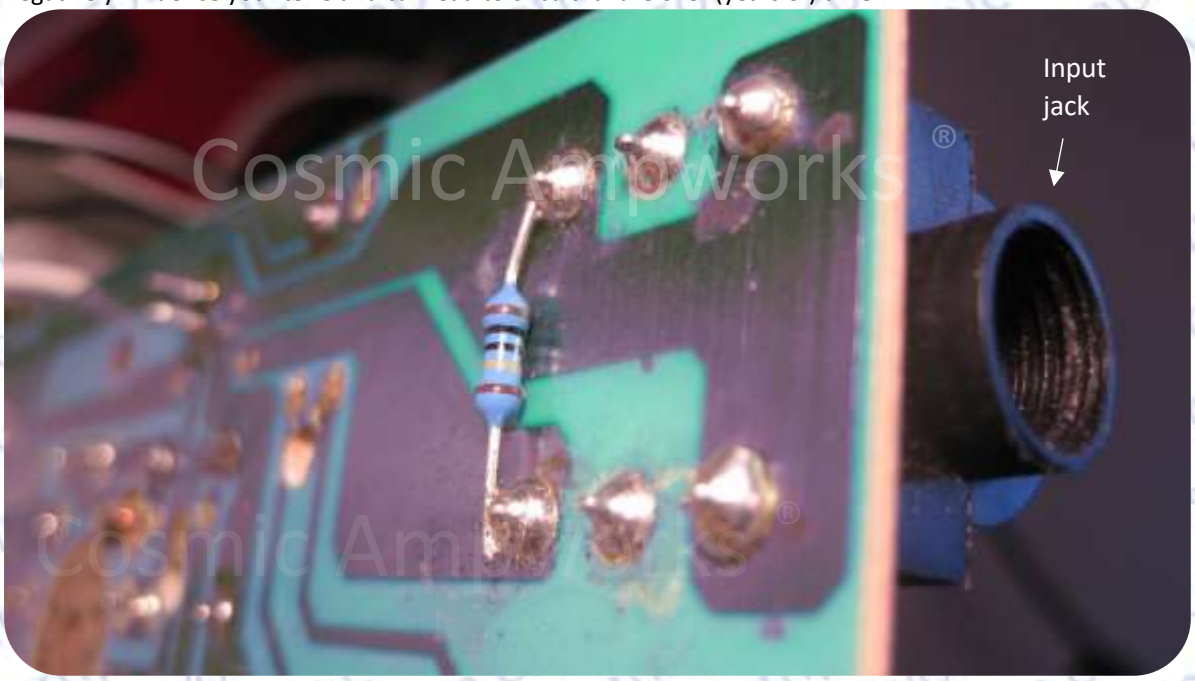

Figure 8. A grid leak resistor keeps the grid of triode 1 at DC ground potential, so that the correct bias is maintained.

2. **Solder a 820 Ohms resistor (blue) in the place of R2** (Figure 9). This resistor provides the right cathode bias. Obviously, all soldering is done on underneath the board (not shown), just like in Figure 8.

*Figure 9. A **820 Ohms resistor** should be installed in place of **R2**. Ignore the blue wire (and text box) for now, it will be explained in one of the next steps.*

3. **Wire the two triodes of the first preamp tube, V2A and V2B, in parallel:**
    a. Cut a length of some 10 cm of colored single-stranded wire. Solder one end to the spot of the positive leg of the former C1 (see **Figure 9**). Then solder the other end to the leg of the removed R6 closest to the tube socket (**Figure 10**, blue wire). Now the two cathodes of V2 are connected!
    b. Cut another length of some 4 cm colored single-stranded wire. Solder one end to the spot of the leg of the removed C2 that is furthest away from the tube socket (**Figure 10**, red wire). Then solder the other end to the hole of R7 that is closest to the tube socket (**Figure 10**). Now the anodes ("plates") are also connected (high voltage!).
    c. Connect the input grids of V2A and V2B. Solder some 3cm colored single-stranded wire to the leg of R1 that is closest to the tube socket, this time, **on top of the board** (Figure 10). Then solder the other end to the spot of the (removed) R5 leg closest to the tube socket (Figure 10). This wire is going to conduct the guitar signal which is two be amplified.

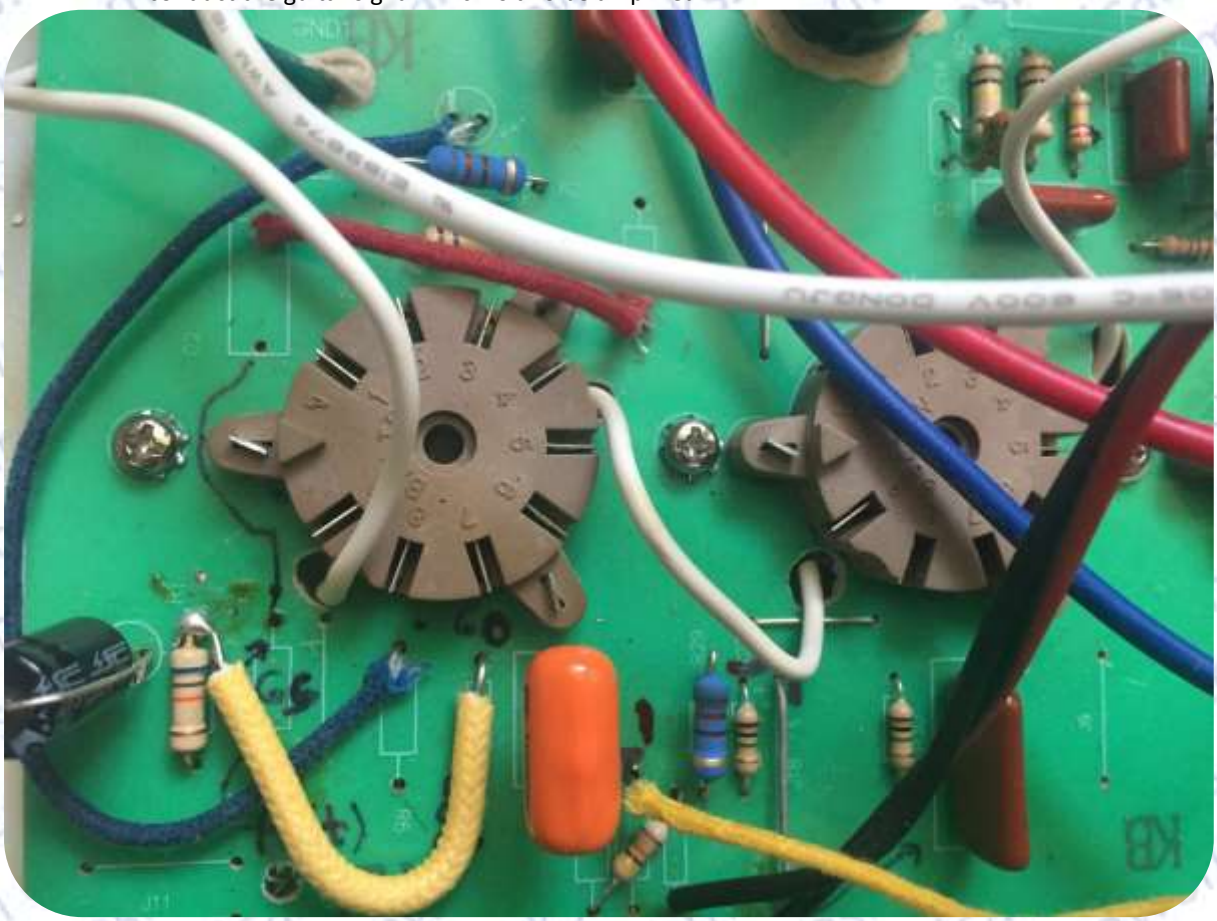

Figure 10. Wire the V2A and V2B in parallel by connecting their cathodes, plates and grids. Please don't pay attention to the scribbles on the circuit board ☺. Note that soldering to the leg of R1 was done on top of the board… it does not deserve a beauty prize. You could also decide to run this wire or all wires underneath the board, potentially.

4. **Solder a 47uF electrolytic capacitor in the spot of C4.** Electrolytic caps have a positive and a negative side, so make sure to insert the **negative** pin (indicated on the capacitor **label**) on the side of the **minus sign** in the little round symbol on the circuit board (Figure 11).

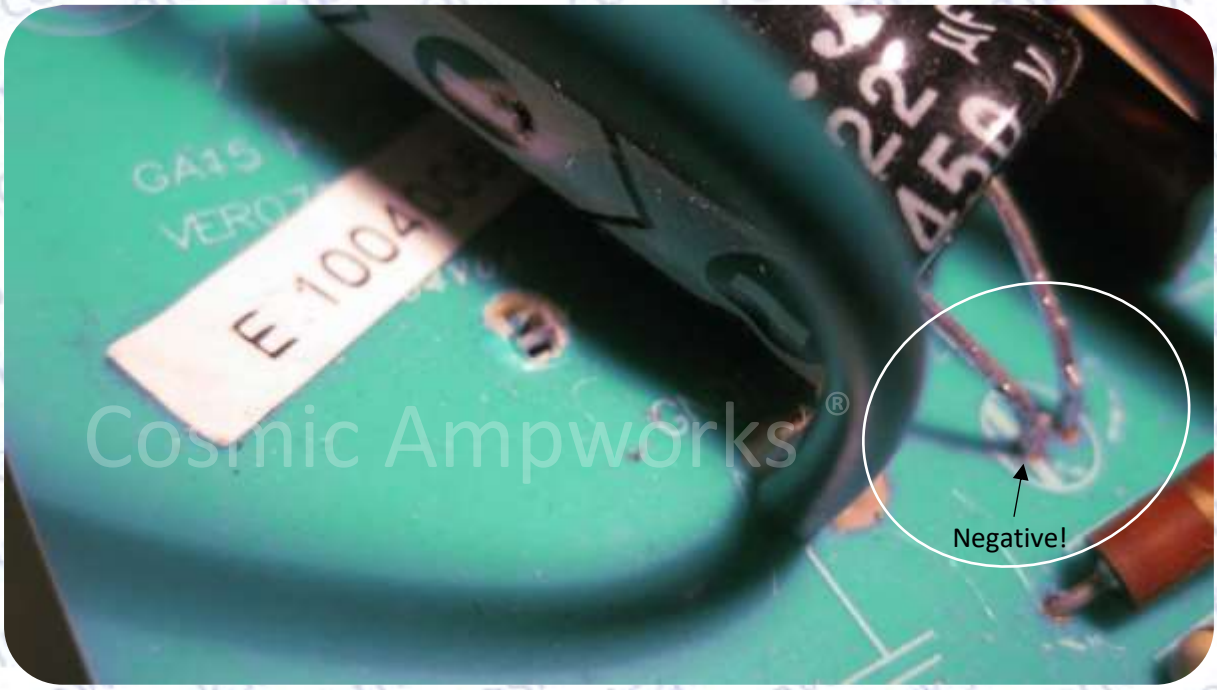

*Figure 11. **A 47uF replacement for C4** has been installed here. Make sure to insert the negative pin (minus symbols on capacitor label) on the side of the minus sign in the little round symbol on the circuit board. Part of the original **R2** is still visible, but you should have already replaced it with a blue 820 Ohms resistor (see Figure 9). This picture was taken for a previous version of the HB GA15 mod kit, that's why.*

5. **Solder a 5nF coupling capacitor in the spot of the removed C5 (Figure 12, view is reversed, or also see Figure 10)**.

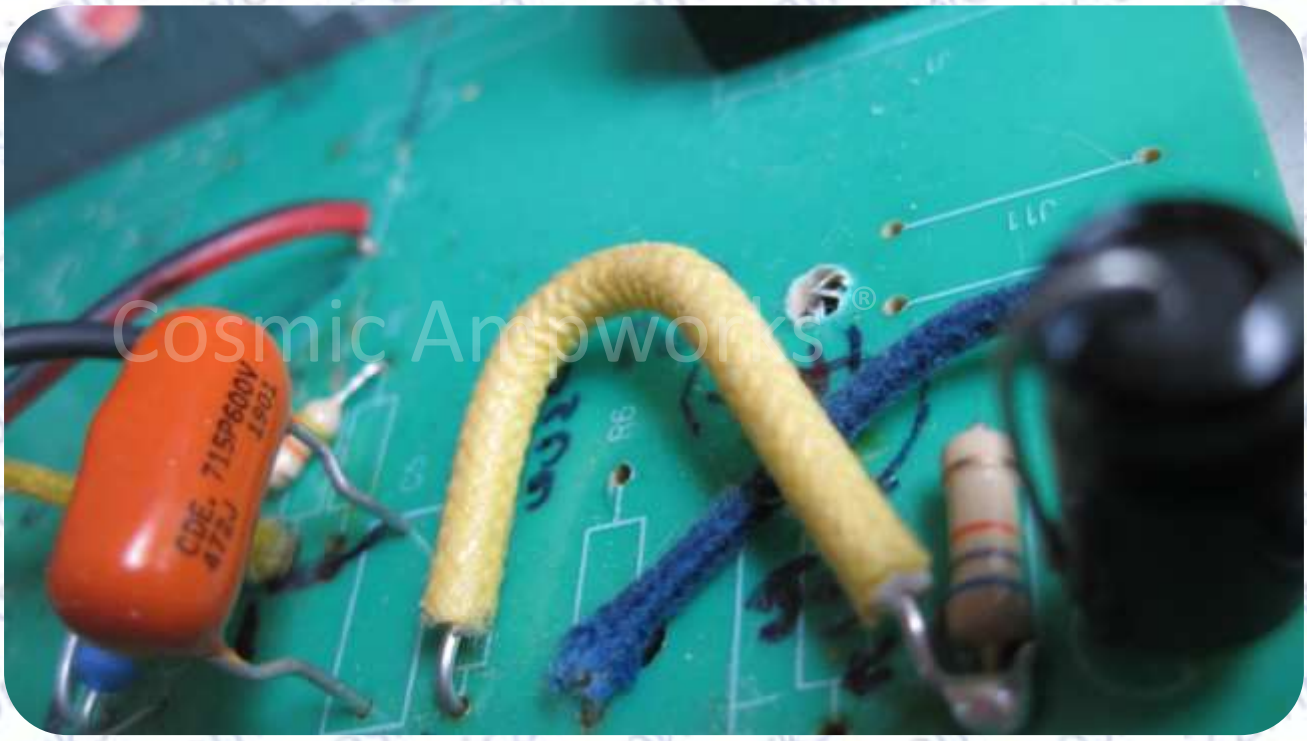

*Figure 12 Solder a **5nF (0.005uF)** capacitor in place of the removed C5. Shown in picture is an **'orange drop'** type of capacitor. Depending on parts availability, instead, a **yellow 'mustard'** cap may be included in your kit. **There are also two 5nF polyester caps in the kit, but those are for a different purpose.** Here, we want high-grade components for preserving the signal.*

6. **Assembling a tonestack and volume control on the back of two 500k potmeters and installing it (Figures 13, 14). Make sure *not to overheat the potmeters*, as they can become scratchy or even start producing spluttering sounds later on! Use a crocodile clip heat sink and only heat the components for brief amounts of time.**
    a. It is recommended to first temporarily fix the pots in their mounting holes in the front of the chassis, *from the outside,* so you have a kind of template top work with. Then solder a short (~5 cm) wire between the center wipers/soldering lugs of the two 500k pots. It is probably easiest to first bend the wires around the soldering legs of the potmeter, using pliers. Before soldering, also attach an output wire (~5cm) to the center lug of the volume pot (Figure 13). Then solder.
    b. Secondly, solder the 4.7nF yellow mustard capacitor so that it connects the left lugs of both 500k potmeters. **Before** soldering however, also attach a ground wire (~5cm) to the left lug of the volume pot (Figure 13). Then solder. In order not to accidentally fry the component, it is a safe idea to attach a **crocodile clip** to the leg that you are soldering, to serve as a mini-heatsink.
    c. Thirdly, solder the 470pF (or 500pF) black silver mica capacitor so that it connects the left lugs of both 500k potmeters. **Before** soldering however, also attach a **long** input ground wire (~15cm) to the right lug of the volume pot (Figure 13). Then solder. In order not to accidentally fry the component, it is a safe idea to attach a **crocodile clip** to the leg that you are soldering, to serve as a mini-heatsink.

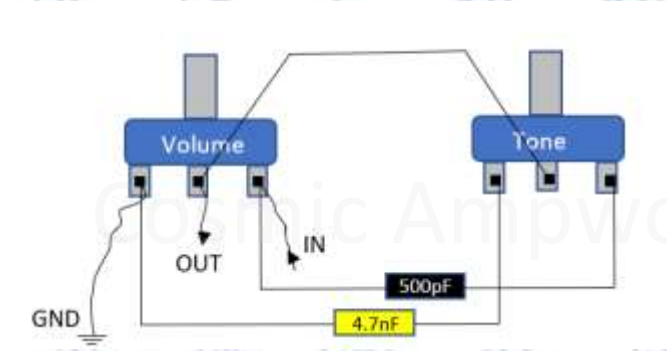

*Figure 13. Layout of a 18W volume and tone controls on the back of two 500k potmeters. Soldering lugs are pointing upwards/towards the viewer (as in Figure 14 below). Crossing wires in the picture should **not be in contact** in reality. Also make sure no wires touch the metal amp chassis.*

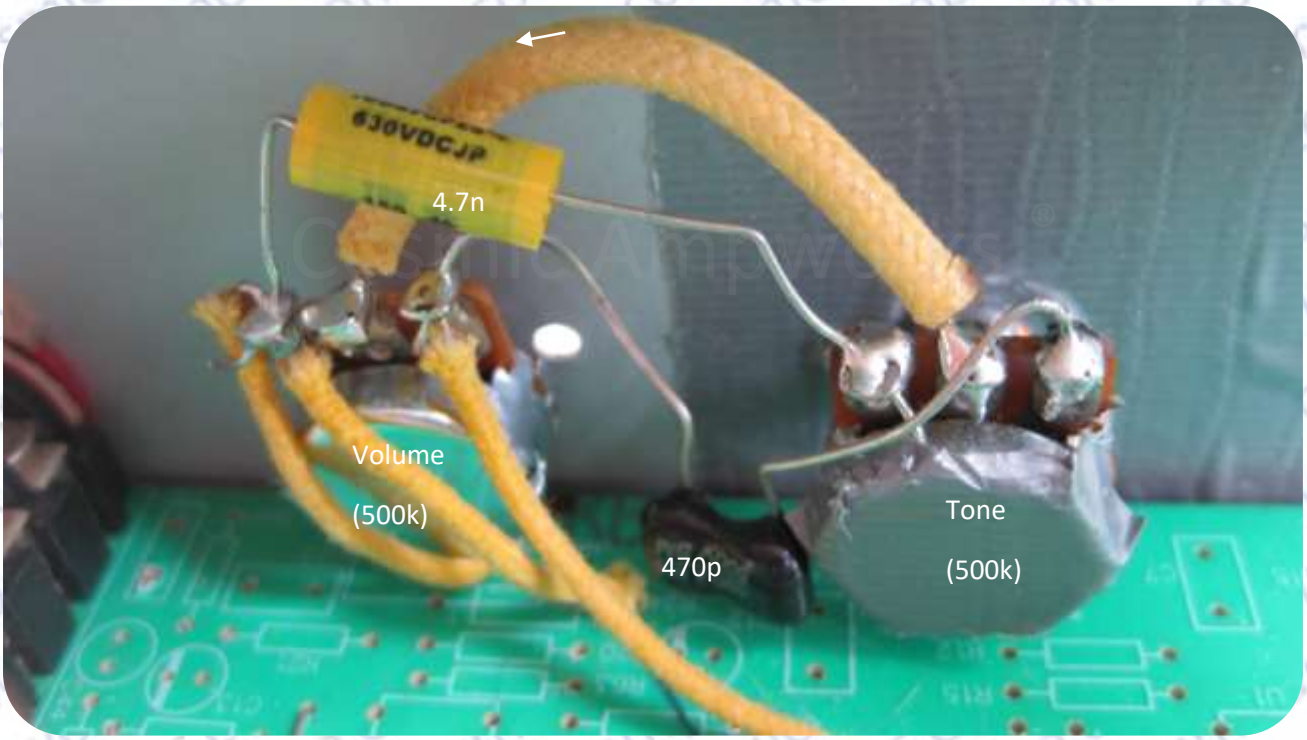

Figure 14. Tonestack and volume control for the GA18. As this is only a 2-dimensional picture, parts may seem connected that are not; for soldering best rely on Figure 13. Also refer to Figure 15. Just ignore the duct tape on the back of the pot – this was a recycled component.

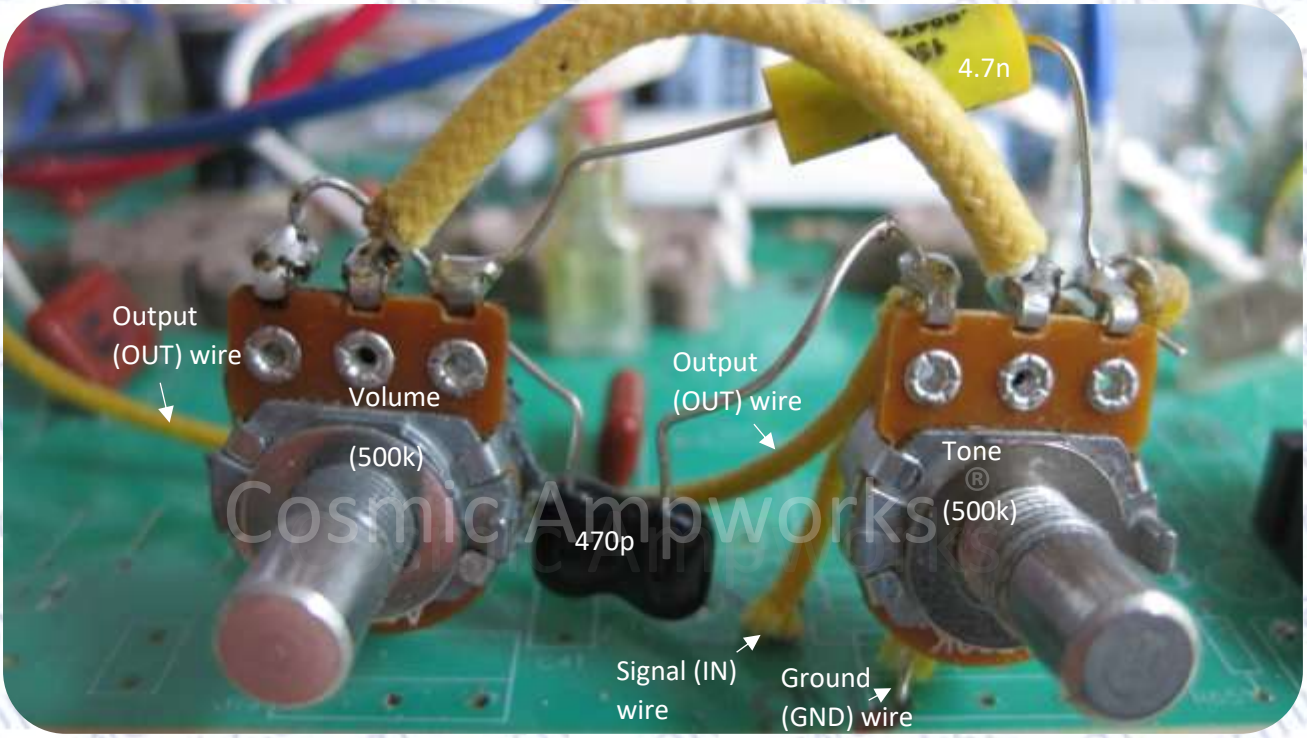

Figure 15 Tonestack and volume control for the GA18 – view from the front.

d. Connect volume control and tonestack assembly to the circuit board:

i. Solder the ground (GND, Figure 13) wire from the volume pot to the leftmost hole (seen from the front of the circuit board) of VR1, the original volume control (Figure 15).

ii. Solder the signal ("OUT", Figure 13) wire from the center wiper of the volume control to the left hole of the removed R24 (Figure 15, "signal out").

iii. Solder the 15cm long input wire of the tonestack ("IN", Figure 13) to the rear hole of the removed R58 (Figure 16 – "wire to tonestack").

iv. To finish installing the tone and volume controls, drill some new holes in chassis for attaching the new potmeters (Figure 17).

Figure 16. Solder the input wire of the tonestack ("Wire to tonestack") to the rear hole of (the removed) R58. For now, ignore the diagonally mounted resistor and the other two wires (they are part of the presence control and modified phase inverter, see further down). Also note the replaced 4.7nF "orange drop" capacitor, which in your case may be a yellow "mustard" cap.

Figure 17 Drill some new holes in chassis for attaching the new potmeters

7. Optional: wire a DC power supply for the preamp heater filaments.

a. Carefully de-solder and remove the L7912[1] negative (12V) voltage controller from the board (Figure 18). Make sure to only briefly heat the legs, as the L7912 is a heat-sensitive part (!) If possible, clamp the included crocodile clip to the leg that you are de-soldering, as a makeshift mini-heatsink.

b. Drill 4 small holes in the heatsink (Figure 19), large enough to accommodate a tie wrap.

c. Drill 5 holes in the chassis (Figure 20): a larger one for the three wires running to the voltage regulator and four smaller ones, for attaching the heatsink with tie wraps (Figures 19, 20). Copy the layout of the four smaller holes from the four holes in the heatsink (see 6 b), with a marker or pencil. Then drill. The distance between hole 1 and the center of the imaginary line that connects holes 2 and 5 should be about 1.5 cm (Figure 20). After drilling, smoothen the edges of hole 1 with some sanding paper and/or a file and remove any burrs.

d. Clip three lengths of speaker wire, of some 7 cm each. Separate the strands of one of them (so you have one single stranded and one double stranded wire). Solder one strand to each of the voltage regulator's legs. Make sure the legs don't touch each other or even come close – careful soldering and minimal quantities of soldering wire required! It is probably easiest to lay the wires parallel to the component legs for soldering. NOTE: if you clip the wires too short, it may be difficult to get underneath the circuit board later on! Again, make sure to only briefly heat the legs, in order not to damage the component. For that reason, if possible, it would perhaps be better to *first* mount the L7912 to the heatsink (with some thermal grease put on the contact surfaces), *then solder*.

e. Attach the L7912 to the heatsink with the little nut and bolt that are included and put some thermal grease on their contact surface.

f. Run the wires that you soldered to the L7912 through hole 1 (Figures 19 and 20) and solder them to the correct (doublecheck!) holes in the component's original place (Figure 18).

g. Attach the heatsink and voltage regulator assembly to the chassis with the tie wraps. Don't worry about the combination of plastic and heat; the heatsink has such a large capacity that its temperature will not noticeably increase. It might be a good idea to stick some pieces of gaffer/duct tape to the underside of the chassis surface where it will be in contact with the heatsink, for some extra protection/stability.

[1] NOTE: if things should fail with the L7912 and the component gets damaged, please note that it is then still possible to use the remaining voltage regulator, the L7812, instead of the L7912. Instead of -12 V DC, it supplies +12 V DC. See point 7.j.ii.

Figure 18. Carefully remove the L7912 voltage controller (empty space encircled) by de-soldering it, NOT by clipping its legs (encircled area in Figure 20 shows protruding ends of wires that are soldered underneath the board, not clipped component legs). Make sure not to heat the L7912's legs for too long, or the sensitive component may be damaged.

h. Drill two holes (best from the underside of the board) near **the second preamp tube** (second tube from the left of the chassis - V3 in the schematic):
    i. Drill hole 1 right next to the tube socket solder connections for pins 4 and 5 (Figures 21 and 22); the location is not particularly critical.
    ii. Interrupt the circuit board trace running to and from pins 4 and 5, on both sides (Figure 21). Use a file, rotary drill or Dremel tool, for instance.
    iii. Drill hole 2 just above the tube socket solder connection for pin 9 (Figures 21 and 22). Make sure not to accidentally damage the wire bridge on top of the board. Ideally, also interrupt the circuit board trace in go, because the heater traces spread hum throughout the circuit in their stock layout.

i. Drill two holes near **the first preamp tube** (leftmost tube, seen from the front of the chassis - V2 in the schematic), much similar to the holes drilled near V3 (see f.):
    i. Drill hole 3 right next to the tube socket solder connections of pins 4 and 5 (Figures 23 and 24); the location is not particularly critical, but make sure not to damage the trace running from pin 6 of the tube (anode) to R7 (load resistor).
    ii. Drill hole 4 just above the tube socket solder connections of pin 9 (Figures 23 and 24). Make sure not to accidentally damage the wire bridge on top of the board! Ideally, also interrupt the circuit board trace in go, because the heater traces spread hum throughout the circuit in their stock layout.

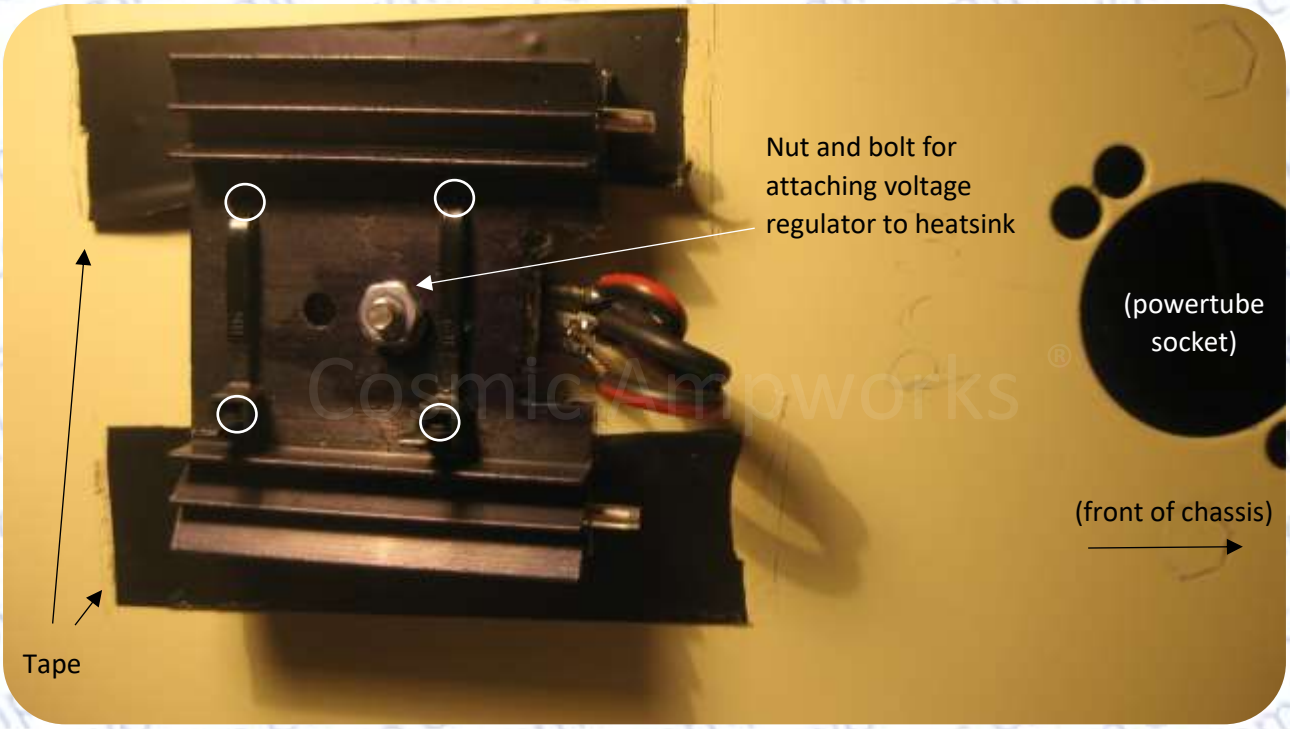

Figure 19. Drill four holes in the heatsink (locations indicated with white circles), for attaching it to the chassis with two tie wraps. Don't worry about the heat, because the heatsink has such a large capacity that its temperature will not noticeably increase.

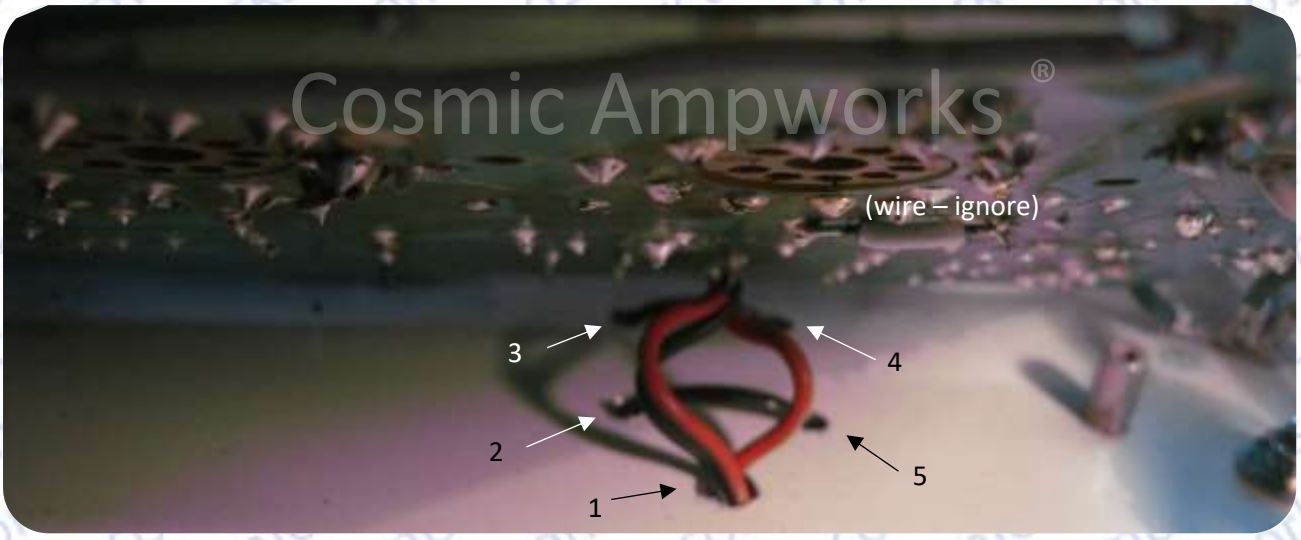

Figure 20. Drill five holes in the bottom of the chassis for attaching the heat sink that cools voltage regulator L7912 (viewed from inside the chassis). Hole no. 1 needs be wide enough to accommodate the 3 wires connecting to L7912 – smoothen its edges with a file. The other holes should be wide enough for attaching the heat sink with two tie wraps.

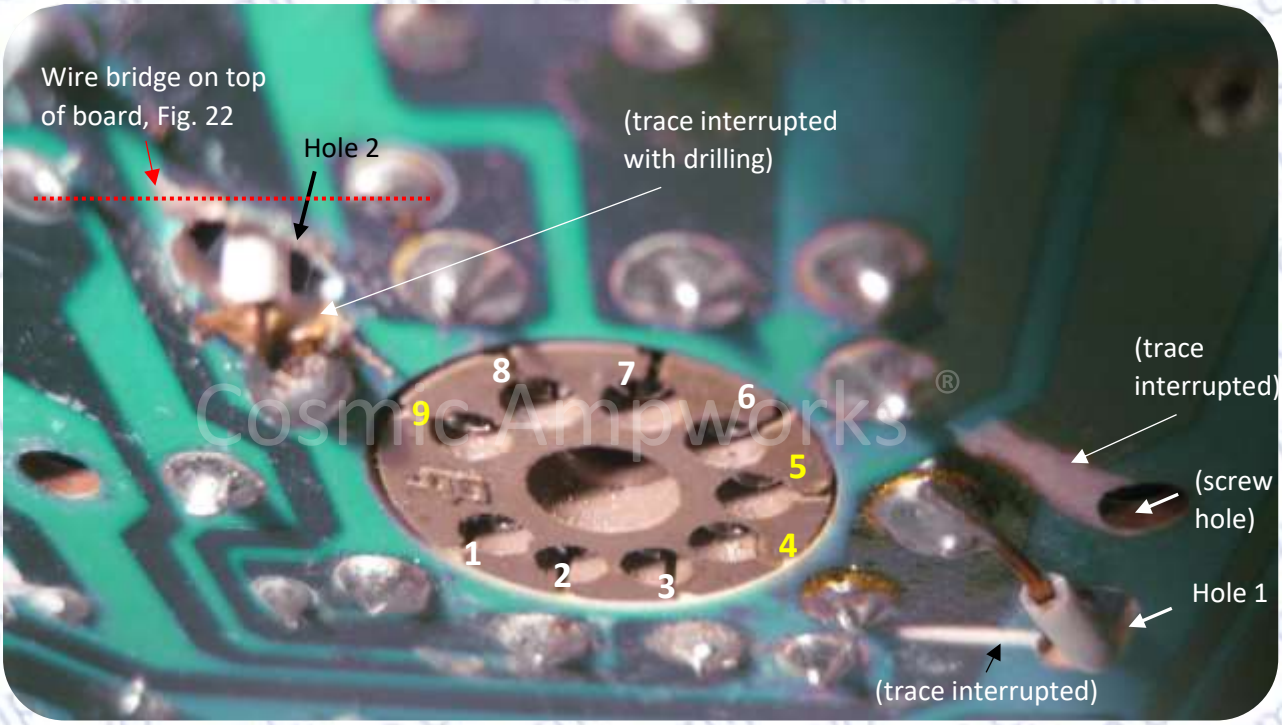

Figure 21. Drill two holes near the second preamp tube: hole 1 right next to the tube socket connections to pins 4 and 5 (Figures 23 and 24); the location is not particularly critical. Drill hole 2 just above the tube socket solder connections of pin 9, but make sure not to accidentally drill through the wire bridge (Figure 22)! Also, interrupt the indicated circuit board traces (the trace near hole 2 can be interrupted when drilling the hole), because the heater traces spread hum throughout the circuit in their stock layout.

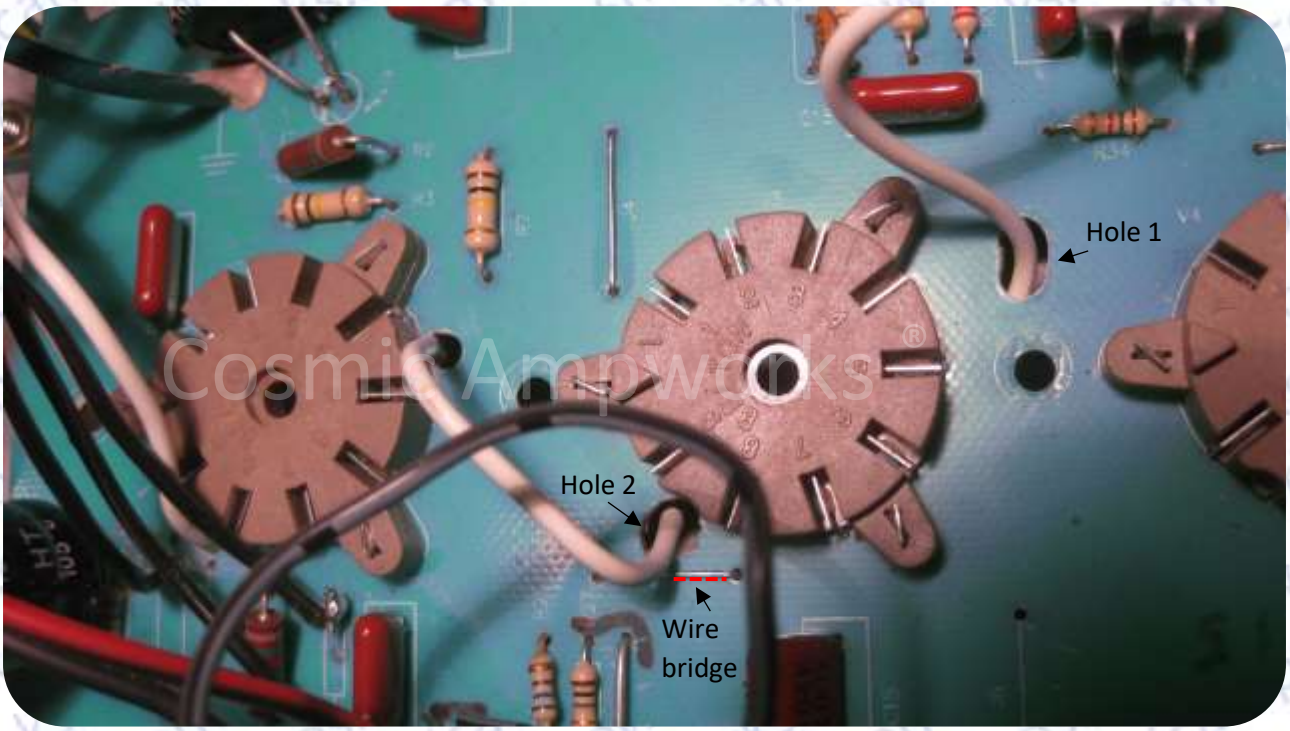

*Figure 22 Drill two holes near the second preamp tube: hole 1 right next to the tube socket connections to pins 4 and 5 (Figures 23 and 24); the location is not particularly critical. Drill hole 2 just above the tube socket solder connections of pin 9, but **make sure not to accidentally drill through the wire bridge**! Drilling is best done from the underside of the board. Note: don't pay attention to the other components – this picture was also used for the classic HB15 mod kit.*

j. Run a wire (use the **green wire**!) from the L7912 output (-12V DC) to the **second preamp tube (V3)** heater filaments:
   i. Cut some 12-13cm of wire and solder one end to the front hole of (the removed) wire bridge J20 (Figure 18 – see "heater wire").
   ii. (If, for some reason, the L7912 got damaged and you need to use the L7812 instead, carry out steps 6a.-g. again, but substitute L7812 for L7912 in the text. Then, solder the 12-13 cm wire mentioned under the previous point to the left hole of the (removed) wire bridge J10 instead).
   iii. Bend the wire, so it runs some 4 cm above the board and lead it through hole 1 (Figures 21 and 22). Then to solder it to the tube socket connection of pins 4 and 5 (Figures 21, 22, 2);

k. Solder a **green** wire **between the heaters of V3 and V2**:
   i. Lead some 5 cm of wire through hole 2 (Figures 22, 24), then solder it to the tube socket connection of **pin 9, V3** (Figure 21)
   ii. Bend the wire, so it runs a couple of centimeters above the board and then lead it through hole 3, then solder it to the tube socket connection **of pins 4 and 5, V2** (Figure 23).

l. Lastly, close the DC heater circuit by connecting the other heater connection of the first (leftmost) preamp tube **V2 to ground**:
   i. Cut some 1-12 cm of **green wire** and lead one end through hole 4 (figures 25 and 26), then solder it to the tube socket connection **of V2's pin 9** (Figure 23)
   ii. Bend the wire around the edge of the circuit board and solder the other end to **ground**; the underside of the ground wire that runs to the chassis (on the large trace) is a suitable place (Figures 23, 24).

*Figure 23. Drill two holes near the first preamp tube: Drill hole 3 right next to the tube socket solder connections of pins 4 and 5; make sure not to damage the trace running from pin 6 of the tube (anode) to R7 (load resistor). Drill hole 4 just above the tube socket solder connections of pin 9. Make sure not to accidentally damage the wire bridge on top of the board! Ideally, also interrupt the circuit board trace in go, because the heater traces spread hum throughout the circuit in their stock layout. Use the **green wire** for the heater supplies (picture actually show whpite/grey wire).*

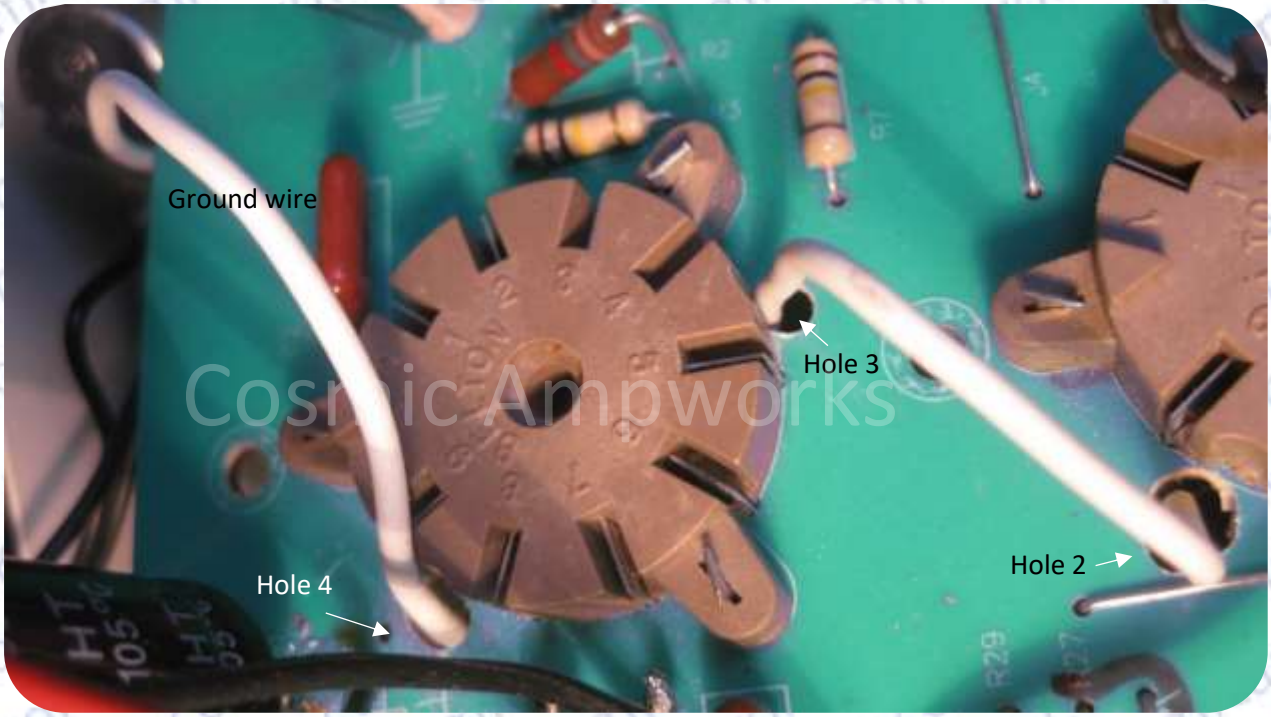

Figure 24. Drill two holes near the first preamp tube: Drill hole 3 right next to the tube socket solder connections of pins 4 and 5; the location is not particularly critical, but make sure not to damage the trace running from pin 6 of the tube (anode) to R7 (load resistor). Drill hole 4 just above the tube socket solder connections of pin 9. Note: don't pay attention to the other components – this picture was also used for the classic HB15 mod kit.

8. **<u>Optional:</u> install a presence and negative feedback control (5k and 1M potmeters, B = linear tapers) and modify the phase inverter. The advantage is that the two additional potmeters will not only give you some additional sonic options, but also fill up the two remaining potmeter holes in the front control panel.**
    a. Mount the included 47k resistor diagonally to the circuit board by soldering one leg into the rear hole of (the removed) R28; solder the other leg into the front hole of R8 (Figure 25).
    b. Take about 20 cm of double stranded wire. Tear the two strands about 2 cm apart on one end. Solder one strand into the front hole of R28. Solder the other strand into the rear hole of wire bridge J12 (Figure 25). `
    c. On the other side of the double stranded wire, pull the strands apart for some 4 cm and remove some 5mm of insulation from the ends. Solder the end that runs from the rear hole of J12 to the left lug of the 5k potmeter (Figure 26 & 27). Solder the other strand to the right lug. Solder the legs of the 0.1uF capacitor to the right and center (wiper) lugs of the 5k potmeter. Solder one leg of the 120k resistor to the left lug of the 5k potmeter and the other leg to the left lug of negative feedback control (1M potmeter, B = linear taper, Figure 26 & 27). The run some 10 cm of wire from the center tap of the 1M potmeter to P3, on the left rear of the board (Figure 28).

d. Get a Dremel with a grinding or sanding attachment, a rotary drill with a small drill bit or a file. Underneath the board, carefully interrupt the PCB traces on either side of the front leg of C15 (Figure 29), by grinding right through it, at about 5 mm distance from the soldering point. Then restore the ground connection for parts to the right of C15 with a wire bridge (Figure 29).

e. Cut a length of single stranded wire about of 4.5 cm. Underneath the board, solder one end of it into the rear hole of J12 (Figure 29); solder the other end to the front leg of C15 (Figure 29; also underneath the board). Be careful not to heat the leg of C15 for too long with the soldering iron, because it is very short and the heat might damage the capacitor!

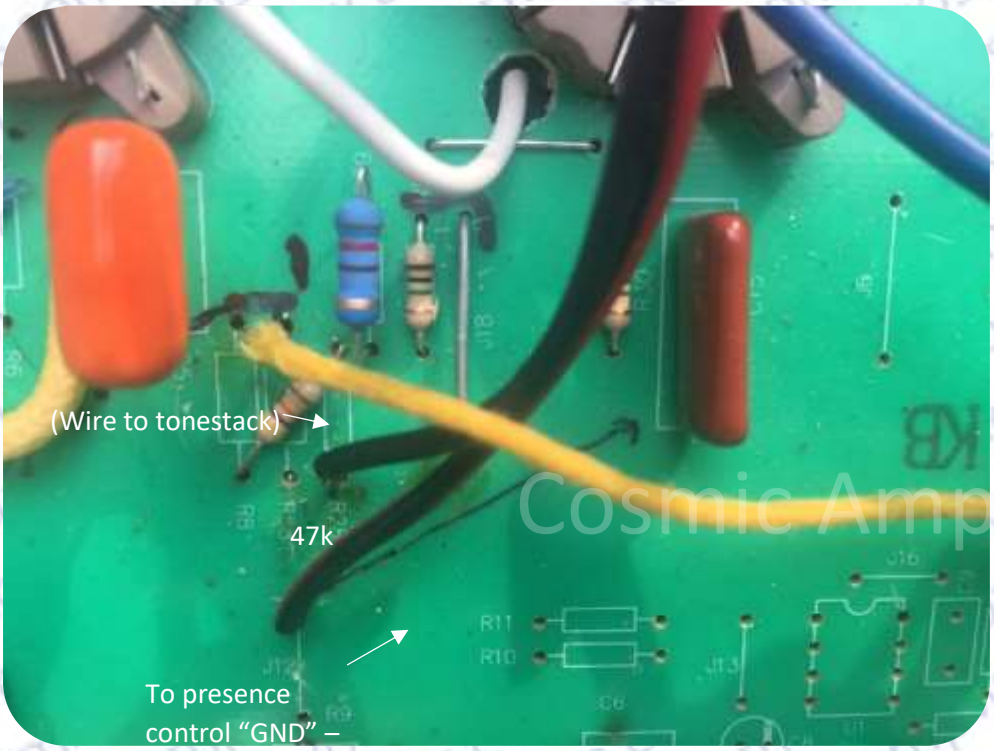

Figure 25 The tail resistor R28 of the phase inverter is replaced by mounting the included 47k resistor diagonally to the circuit board, with one leg in the rear hole of (the removed) R28 and the other leg in the front hole of R8. Presence wire are soldered to the front hole of R28 (ground) and the rear hole of (removed) wire bridge J12. Also visible is a wire that runs to the new tonestack.

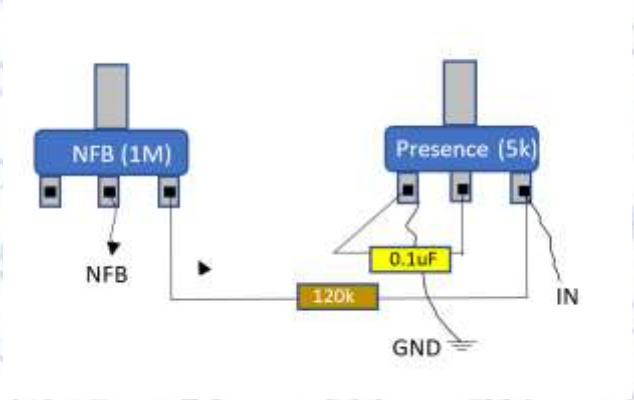

*Figure 26. Presence and negative feedback (NFB) assembly on the back of a 5k and 1M potmeter. Soldering lugs are pointing upwards/towards the viewer (as in Figure 14 for instance). Crossing wires in the picture should **not be in contact** in reality. Also make sure no wires touch the metal amp chassis.*

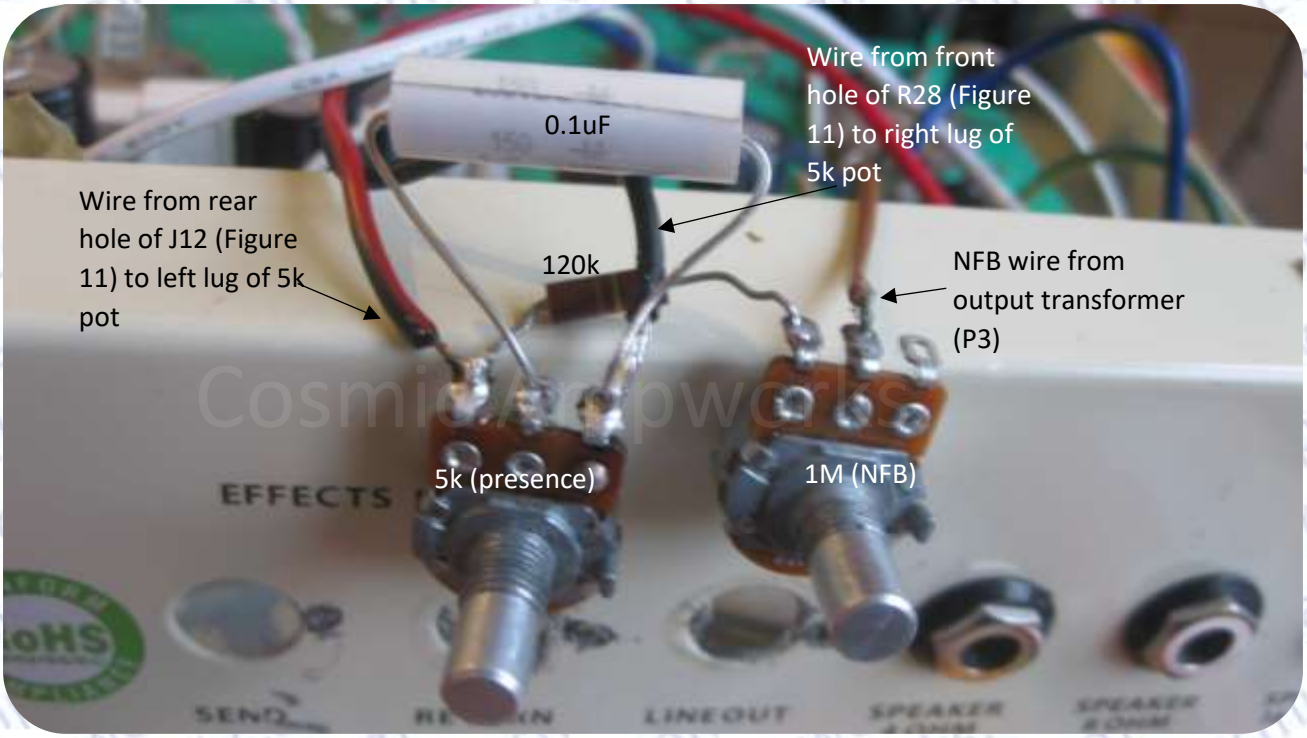

Figure 27. Connect the presence and negative feedback (NFB) controls: solder the wire that runs from the rear hole of J12 to the left lug of the 5k potmeter. Solder the other strand to the right lug. Solder the legs of the 0.1uF capacitor to the right and center (wiper) lugs of the 5k potmeter. Solder one leg of the 120k resistor to the left lug of the 5k potmeter and the other leg to the left lug of negative feedback control (1M potmeter, B = linear taper). Keep the legs long enough, so they can bridge the distance between the two pots when they are mounted in the holes where the Bass and Middle potmeters used to be (with the classic mod kit, they were mounted in place of the effects loop jacks on the back of the amp, you could still do that if you like). The run a wire from the center tap of the 1M potmeter to P3 (Figure 28), on the left rear of the board.

Figure 28. Negative feedback for the presence control (running to the center wiper of the 1M NFB potmeter; Figure 12) is taken from point P3, connected to the 8 Ohm output transformer speaker tap. P3 may be covered in some insulating substance from the factory – if it's difficult to remove, just solder the wire to the ***trace on underside of the board (which also holds spade connector T14)****.*

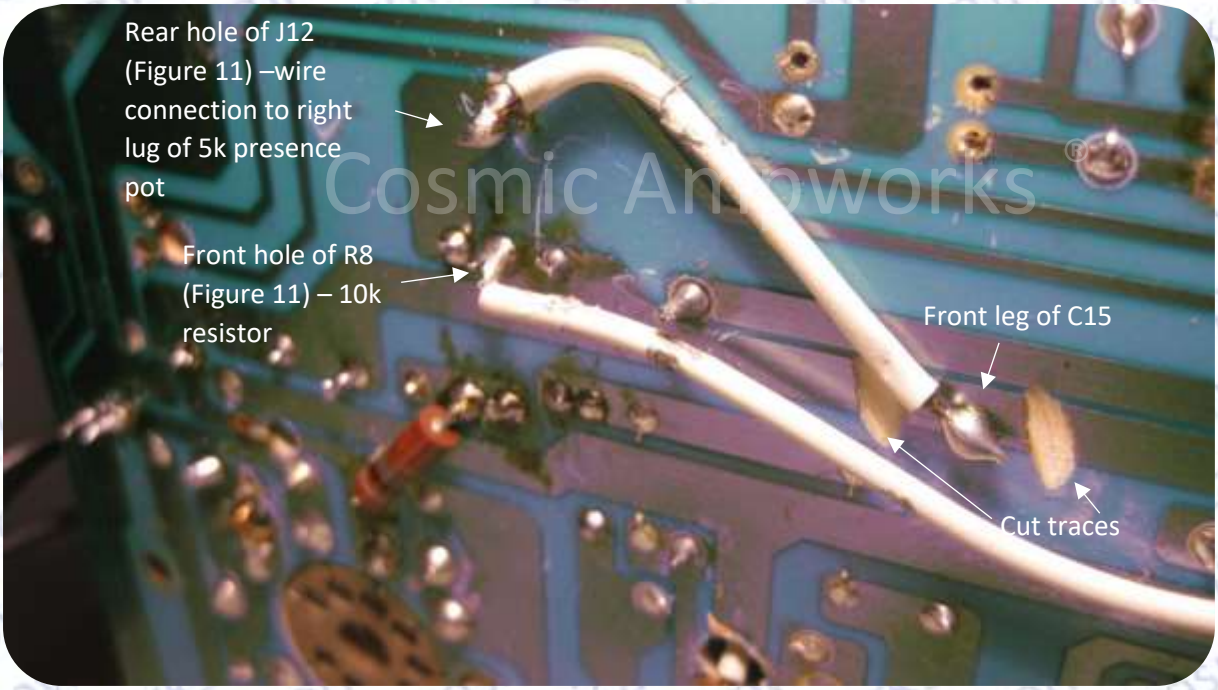

Figure 29. Interrupt the PCB traces on either side of the front leg of C15. Cut a length of single stranded wire about of 4.5 cm. Underneath the board, solder one end of it into the rear hole of J12; solder the other end to the front leg of C15 (also underneath the board). Be careful not to heat the leg of C15 for too long with the soldering iron, because it is very short and the heat might damage the capacitor!

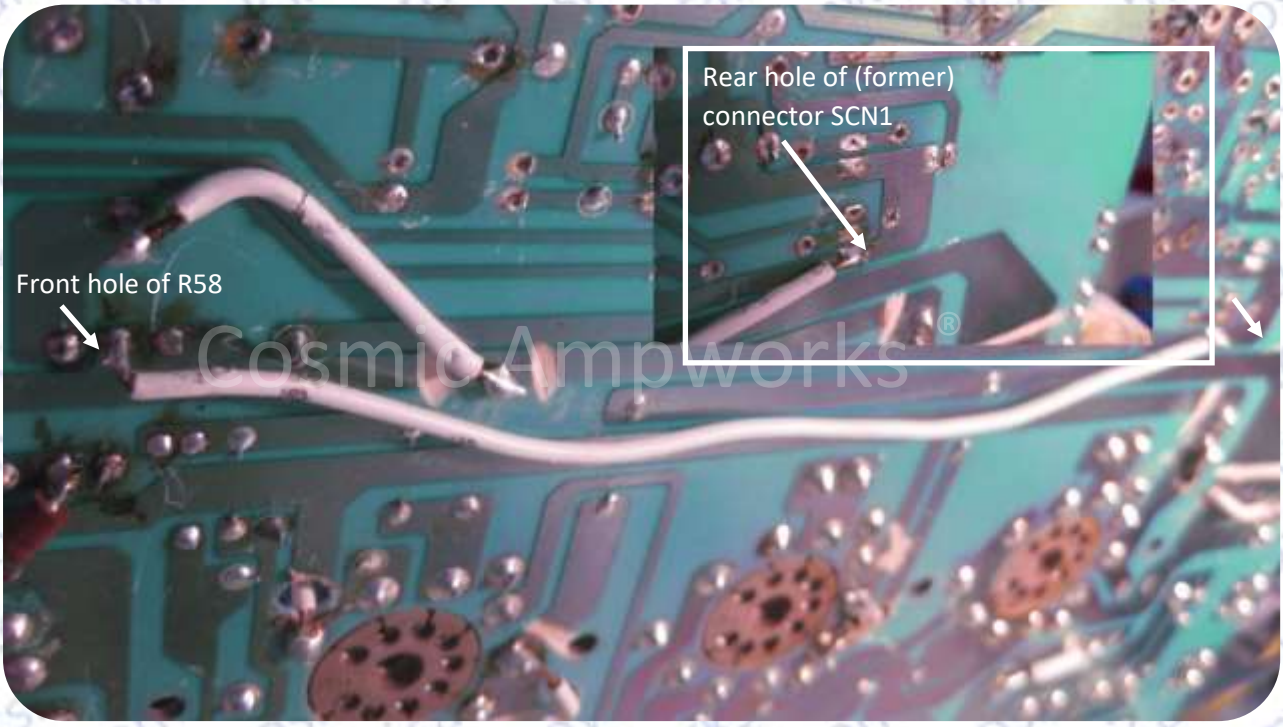

Figure 30. Re-establish ground connection for components to the right of C15 with a wire between the front hole of (the former) R58 and the rear hole of the removed connector SCN1. The ground connection will be needed for the new volume control (see further down).

9. **Optional: Rewire the power tube heater supply.** It is quite likely that mod 6 (DC power supply for the preamp heater filaments and rearrange the preamp heater wiring) already resulted in a very quiet amplifier. When the mods were developed, power and preamp tubes were rerouted all at once, so it is difficult to verify what the effect is of only rerouting the power amp heater wiring. Normally, in a push-pull power amp, most of the hum in the opposing tubes cancels out.
    a. First cut the two circuit board traces that conduct 6.3 V AC to the power tube heaters (Figure 31) with a Dremel tool with grinding attachment, with a rotary drill or with a simple file.
    b. Then, drill three holes in the circuit board:
        i. Drill holes 1 and 2 close to the spade connectors that connect the board to the 6.3V DC power supply (Figures 30, 31)
        ii. Drill hole 3 close to the 2nd power tube, near the circuit board screw hole (Figures 31, 32)
    c. Twist two lengths of single stranded wire (Figure 32). Run (solder) one strand from pin no. 4 of one EL84 output tube to pin 4 of the other. With the other strand, do the same for pins no. 5 of the two output tubes. By mixing up the wires, i.e. accidentally connecting pin 4 to pin 5, the heater current in both tubes will be out-of-phase, hence any hum caused will no longer be cancelled out by the push-pull stage. If it is necessary to use wires of identical color, use a marker to distinguish them. Make sure that there is no contact between the wires near hole 3!

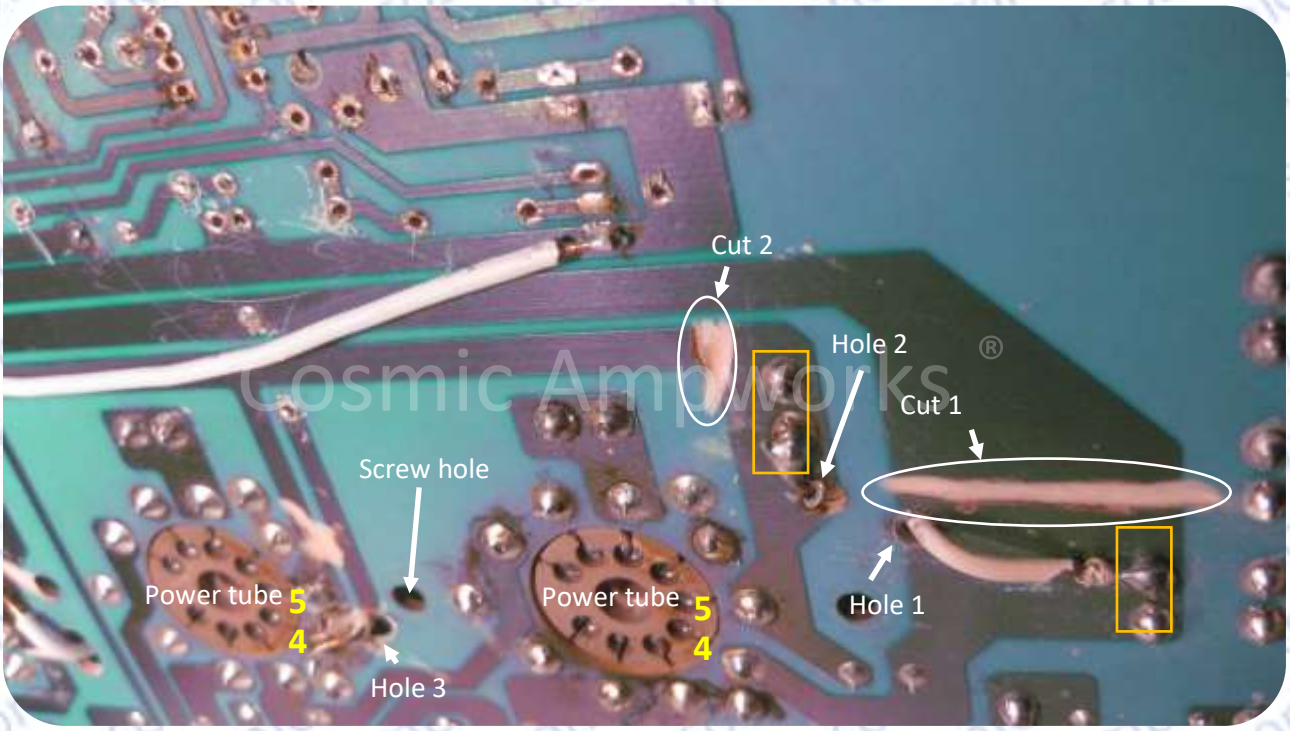

Figure 31. Cut the circuit board traces that conduct electricity to the power tube heaters (cuts encircled). Then drill three holes for the new heater supply wiring (6.3 V spade connectors marked with orange rectangles). Tube heaters are connected to tube pins 4 and 5.

Figure 32. Drill three holes (1-3) for the new heater supply wires. Then twist two lengths of single stranded wire. Connect pins no. 4 of both output tubes to each other and so he same for pins no 5. If using wires of identical color, use a marker to distinguish them.

Figure 33 A last look at the circuit board.

Optional: change some power amp component values to exactly match 18W specs. Locate the components in below table on the ciruit board, unsolder them and replace them with the included components.

Component number on circuit board:	Original value:	New value:
R33 and R34 (not in schematic)	**1.5k**	**8.2k**
R15 and R16	**220k**	**470k**
R27 and R30	**1M**	**470k**
C17 and C18	**22nF**	**10nF**

…and that's a wrap! Hopefully, modifying your amp has yielded satisfactory results and some agreeable hours! One thing that was not covered but is advisable is swapping the speaker for a better one! Lastly, please don't hesitate to provide comments or feedback via https://cosmicampworks.com/contact/

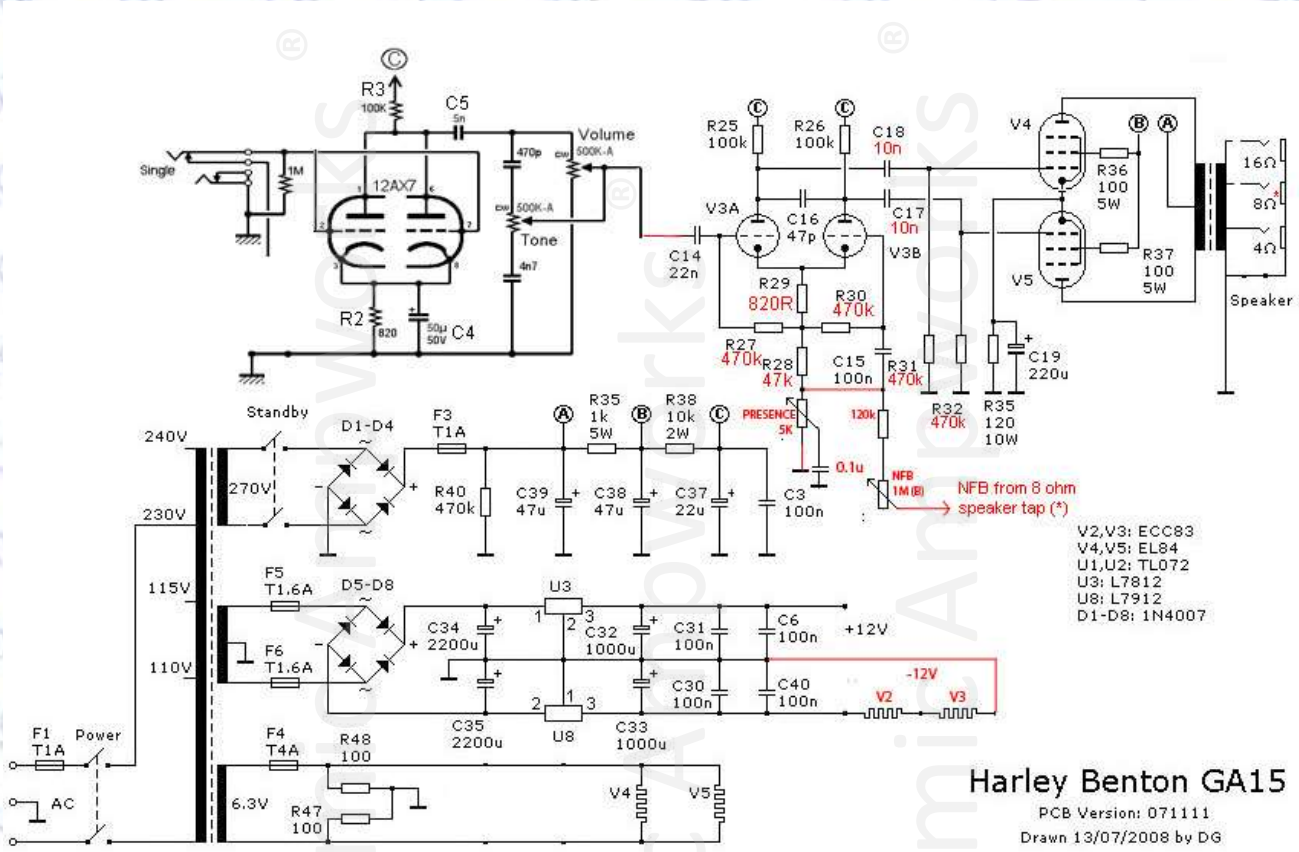

Figure 34 Schematic of the Harley Benton GA15 errr… GA18!