

Dear Customer,

Thank you for your interest in our **Harley Benton GA 15 Ultimate Mod Kit!**

Successfully implementing the modifications described in this manual will transform your GA-15 from an ugly duckling among guitar amplifiers into the metaphorical swan – 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 are described on our webpage (<https://cosmicampworks.com/harley-benton-ga15-guitar-amplifier-the-ultimate-mod/>). In the current manual, they have been re-arranged in order of increasing complexity. So, before diving into the deep, there is still some room for learning by doing. 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. Don't forget to listen to the sonic changes along the way! The manual starts out with some pretty straightforward tweaks:

1. **Adding a grid leak resistor to V2A (oddly, the first preamp tube is numbered V2 in the schematic (p.9, p.27) and on the circuit board; p.10),** to make sure the correct bias is maintained at all times.
2. **Replacing the cathode bias resistors of V2A and V2B (p.10),** for higher gain and a warmer sound.
3. **Replacing the cathode bypass capacitor of V2B (p.11).** This will allow more bass frequencies to pass through the tube, resulting in a fuller, less boxy sound.

Then there is a slightly more involved mod:

4. **Installing a gain control between the V2A and V2B (p.11).** In the stock GA15, R4 and R5 together form a voltage divider with an output voltage of only 1.66% of the input - a total waste of gain. As we're aiming to replace the active op-amp-based tonestack with a purely tube-based tonestack, we're going to need every bit of gain available. Therefore, the stock voltage divider is replaced here by a 500k gain potmeter. With its gain set to the max, it allows 100% of the signal from V2A to reach the grid of V2B (and with less than maximum gain, it works as a variable voltage divider). With a very strong input signal at V2A, V2B might even get overdriven - perfectly fine if that is what you want, but a clean signal should still be an option - dialing back the gain is the solution then. So, the primary goal of the added gain control is being able to dial in maximum clean headroom, rather than obtaining a crunchy, distorted sound (with maximum gain, you'll probably just get a slight crunch at best). Dialing in more gain will also make your tone harmonically richer and fatter, even before getting distorted. Less gain results in a somewhat more jangly tone.

The most challenging mods (some of which are optional):

5. **Assembling and installing a James tonestack and volume control on the back of three potmeters (p.13).** This enables creating a purely tube-based signal path (no op-amps), with a 2-band passive EQ (treble and bass). Due to the low insertion loss of the James tonestack, no additional tubes are needed to boost the signal. Wiring the tonestack may be quite challenging!
6. **Wiring a DC power supply for the preamp heater filaments and rearrange 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.
7. **Install a presence and negative feedback control - optional (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.
8. **Rerouting the wiring for the power tube heater supply - optional (p.25).** This is an optional mod; very likely, mod 6 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.

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.

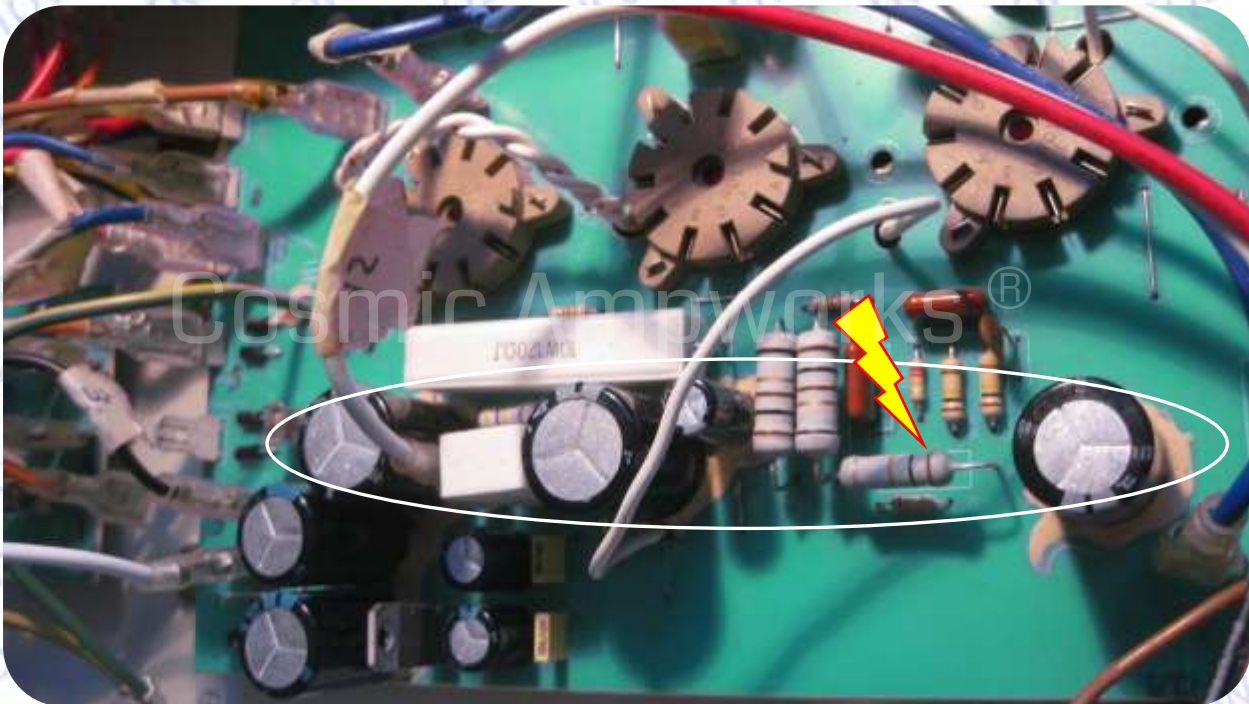


Figure 2. Filter capacitors and most parts of the HT (High Tension) section of the Harley Benton GA15 printed circuit board (seen from the back of the chassis).

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.

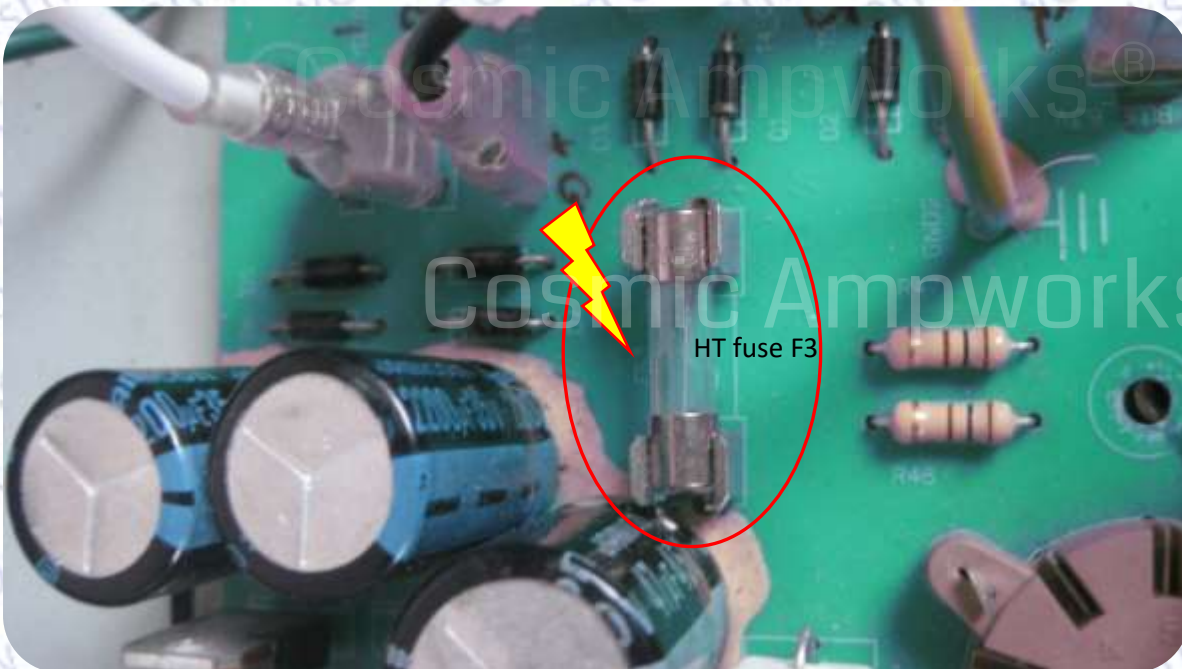


Figure 4. The HT fuse F3 (**DON'T TOUCH IT!**) is a good place to check for remaining high voltages after switching off and disconnecting the amp. Hang the black (negative) multimeter probe in one of the cage nuts (as described in the text), so that you only need to use one hand. With that hand, hold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

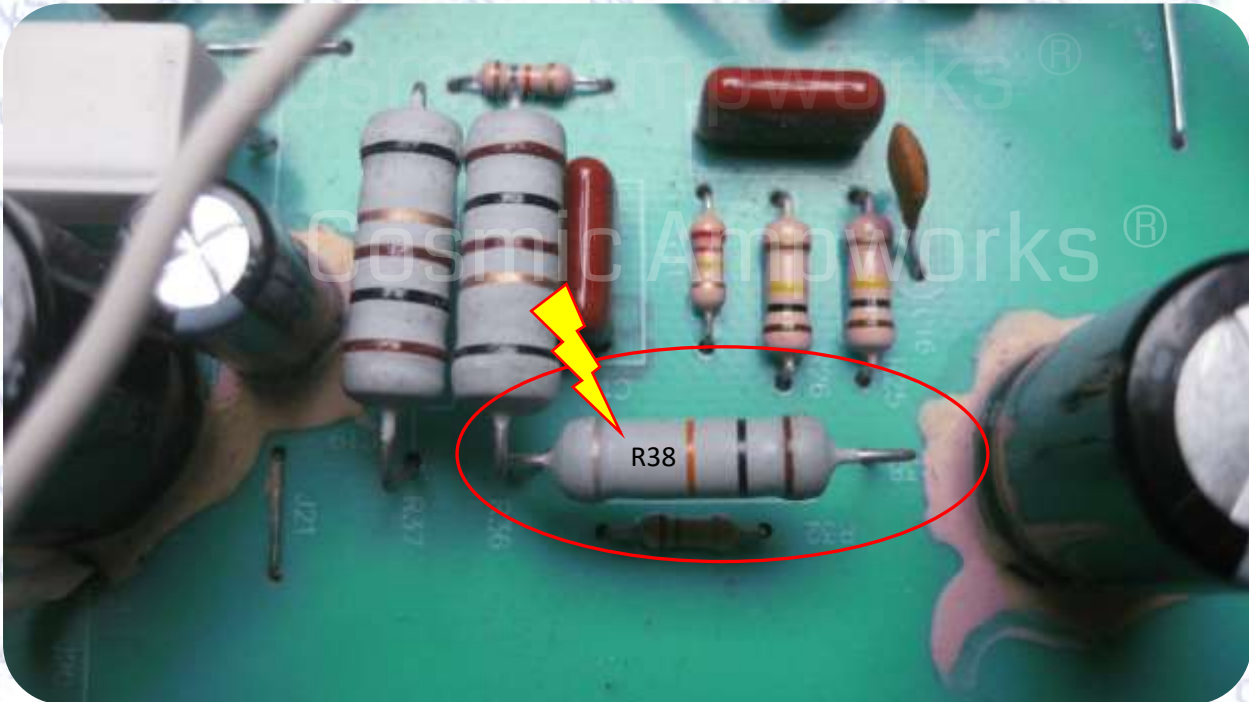


Figure 5 R38 (the voltage dropping resistor for the preamp tubes- **DON'T TOUCH IT!**) is a good place to check for remaining high voltages after switching off and disconnecting the amp. Hang the black (negative) multimeter probe in one of the cage nuts (as described in the text), so that you only need 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://robobinette.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 (for heater wiring; 0.6 m);
6. Double stranded speaker wire (for audio signals; 1 m);
7. Heatsink (for voltage regulator);
8. Dab of thermal grease;
9. Crocodile clip;
10. Potmeters: 500k (A) - 500k (B) - 1M (A - 2x);
 - Additional potmeters for optional presence mod: 1M(B) - 5k (B)
11. Resistors: 1M (2x) - 1.5k (2x) - 180k - 100k - 10k (1x)
 - Additional resistors for optional presence mod: 120k - 10k (1x)
12. Capacitors: 22u (radial) - 3.3n (0.0033uF) - 4.7n (0.0047uF) - 330p - 470p;
 - Additional capacitors for optional presence mod: 0.1u (1x)
13. 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).

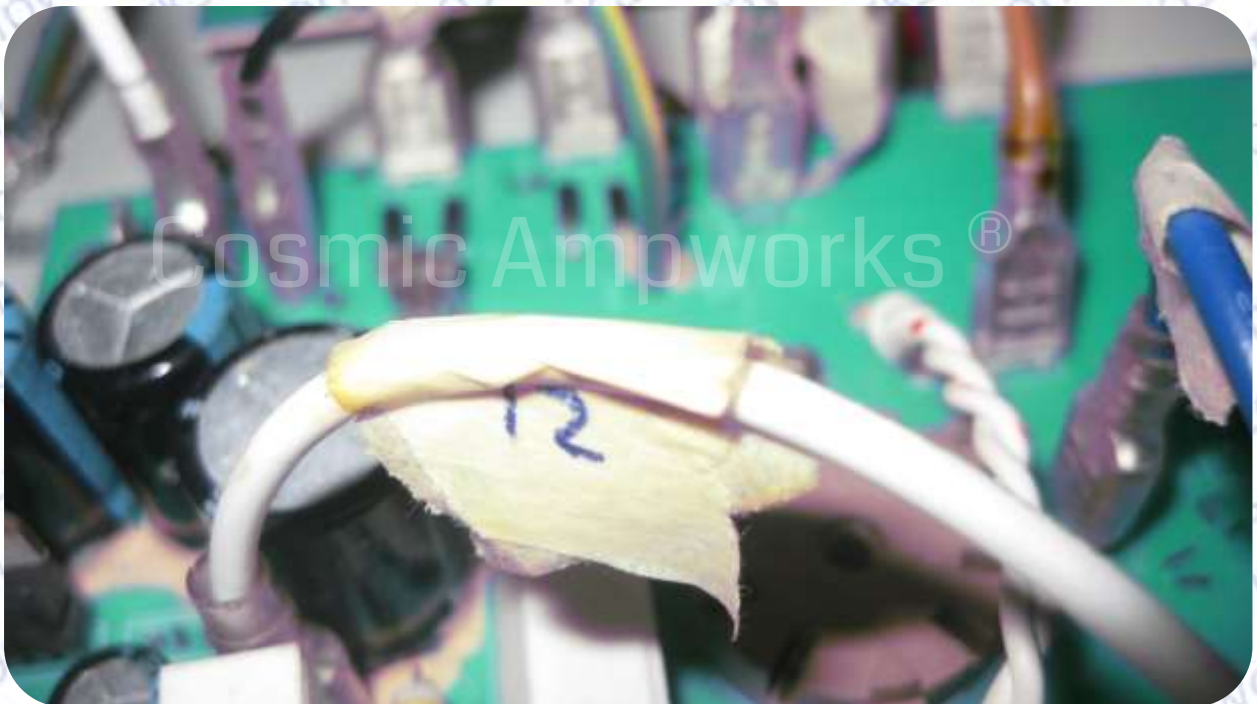


Figure 6. Label the wires with little pieces of masking tape before disconnecting the spade connectors, to make sure you put them back in the correct locations later on. NOTE: I used my own numbering and just wrote those numbers on the circuit board with a permanent marker.

8. Carefully disconnect all spade connectors, 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 potmeters by loosening the little screw in the back and then pulling them from the potmeter shaft. Then remove the potmeter washers and unscrew the retaining nuts.
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

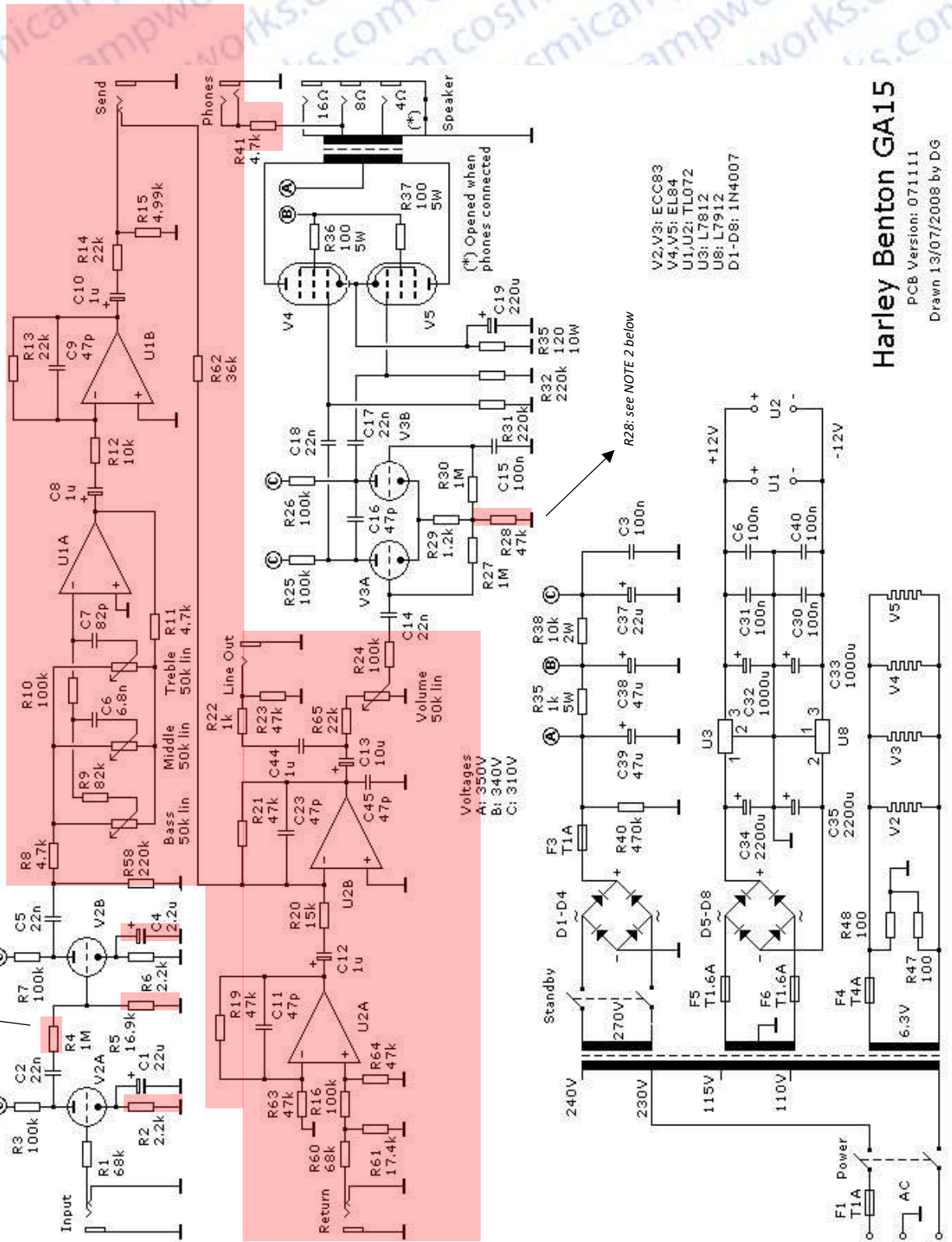
Heat up the soldering iron and keep de-soldering wire and needle nose pliers handy. **Preferably wear safety goggles:** when applying some force to a component that suddenly comes loose, the soldering iron or a blob of molten solder may suddenly jump towards your face.

A lot of parts will have to be removed, particularly those that are part of the op-amp tonestack and effects loop; we're going to replace the tonestack, remove the effects loop and remove the ICs. The power supply that was originally used for the ICs will be used to power the preamp tube heater filaments with DC, to reduce hum.

Figure 7 shows the schematic of the stock Harley Benton. 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 mods 1.-4. (see p.2), namely R2, R4, R5, R6 and C4. Then start with implementing those mods only.

For Mods 5 (passive EQ and purely tube-based signal path) and 6 (wiring a DC power supply for the preamp heater filaments and rearrange the heater wiring), all parts inside the red fields (Figure 7) need to be removed. From experience; leaving them in place may affect sound quality and even result in fuzz-like background sounds. So, take note of each component's number 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 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.



Harley Benton GA15

PCB Version: 071111
 Drawn 13/07/2008 by DG

Figure 7 Schematic of the Harley Benton GA15 (credits of original schematic: DG, 2008). Parts that are to be removed for "the Ultimate Mod" are in the red fields. **NOTE 1:** 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 mods 1.-4. (Section 1, p.2), namely **R2, R4, R5, R6 and C4**. Then start with implementing those mods only. **NOTE 2:** Removing R28 is only required for installing the (optional) presence control.

6. Installing new components (wear safety goggles!)

1. Solder a 1M grid leak resistor across the connections of the input jack (Figure 8).



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

2. Mount (solder) two 1.5k resistors in place of R2 and R6 (Figure 9).

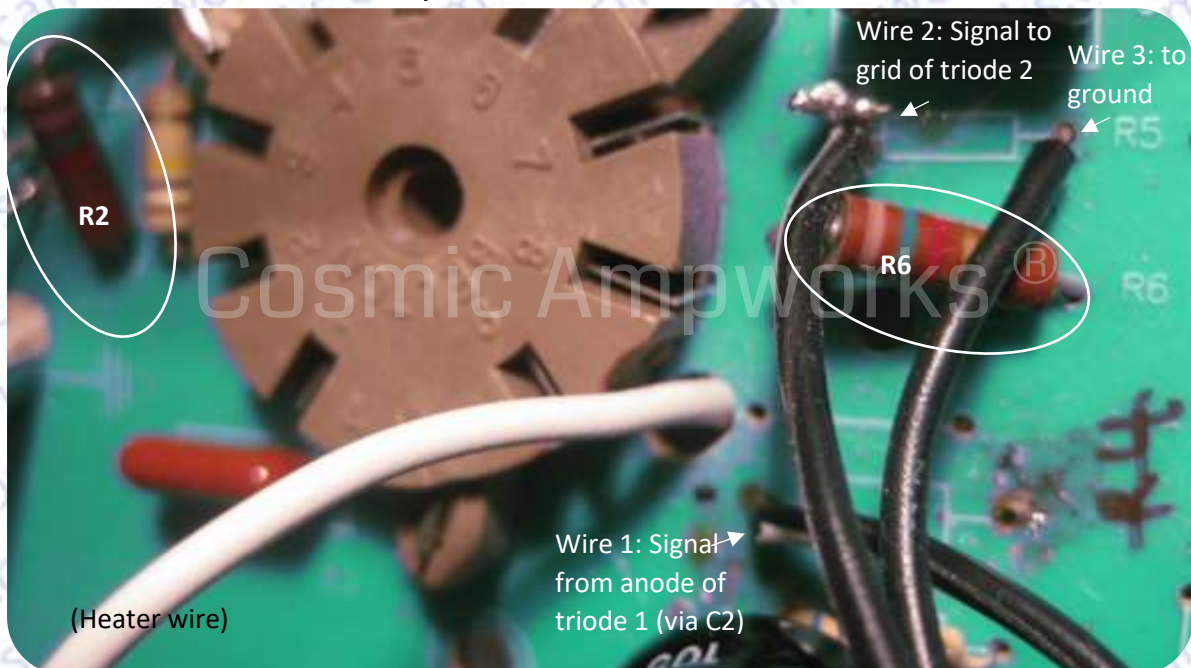


Figure 9. Two **1.5k resistors** are to be installed in place of **R2 and R6**, setting the bias of the first preamp tube to a more normal value than the stock GA15, which is biased very cold). For now, ignore Wires 1,2 and 3 – these connect to the gain pot (see point 4 in this section, p.11). Also ignore the white, rerouted heater wire (see point 6, p.16).

3. Solder a 22uF 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 vertical dash in the little round symbol on the circuit board (Figure 10).



Figure 10. A 22 μ F replacement for C4 has been installed here. Make sure to insert the negative pin (minus symbols on capacitor label) on the side of the vertical dash in the little round symbol on the circuit board. Part of the replaced R2 (1.5k) is also visible.

4. Install a gain control (500k potmeter, B = linear taper):

- First cut two pieces of the included double-stranded wire at lengths of about 15cm each.
- Split one of them into two single strands. Take one of them and remove about 5mm of insulation on both ends. Pry one end through the **rear**¹ hole of the removed R4 (Figure 9, "Wire 1") and solder it (to the underside of the board). Solder the other end of the wire to the **left**² lug of the potmeter (see Fig 11).
- Take the other (double-stranded) piece of wire. On one end, remove a couple of millimeters of insulation from both strands and them into the two holes of R5 (Figure 9, "Wire 2" and "Wire 3". On the other end of the wire, solder strand that runs from the *rear hole* of R5 (closest to the tube socket) to the center (wiper) lug of the potmeter (Figure 11). Solder the end that runs from the *front hole* of R5 to the righthand potmeter lug (Figure 11).
- Mount a local feedback (1M) feedback resistor underneath the board, by soldering one leg in the rear hole of R8 and soldering the other leg to the rear hole of R5 (closest to the tube socket - on the upside of the board, you just also soldered the wire there that runs to the wiper of the gain pot).

¹ With "rear" in this manual, the side that is **closest to or facing the rear of the chassis** is meant. With "front", the side that is **closest to the front or facing the front of the chassis** is intended.

² If reference is made to e.g. the "left-hand" or "right-hand potmeter lug" in this manual, then that applies to the situation where the potmeter shaft is facing the user and the lugs are upward facing - as in Figure 9.



Figure 11. Connect the gain pot by soldering the input (Wire 1 in Figure 9) to the left lug, ground (Wire 3 in Figure 9) to the right lug and the output (Wire 2 in Figure 9) to the center (wiper) lug. NOTE: If reference is made to e.g. the left-hand or right-hand potmeter lug in this manual, then that applies to the situation where the shaft is facing the user and the lugs are on top - as in Figure 11.



Figure 12. Mount a local feedback (1M) feedback resistor underneath the board, by soldering one leg in the rear hole of R8 and soldering the other leg to the rear hole of R5 (closest to the tube socket - on the upside of the board, you just also soldered the wire there that runs to the wiper of the gain pot). Also visible are a hole drilled for rerouting the preamp heater wire and another one that was drilled for a previous version of the mod - please ignore.

5. Assembling a James tonestack and volume control on the back of three potmeters and installing it.

- a. Solder a point-to-point James tonestack on the back of two potmeters (Figures 13, 14). First connect the two pots with R2 (180k); the appropriate distance (i.e. the distance between the mounting holes in the front of the chassis) can then be set and maintained. The component values are:
 - i. Treble pot: 500k (A); Bass pot: 1M (A)
 - ii. R1 = 100k; R2 = 180k; R3 = 10k
 - iii. C1 = 330p; C2 = 470p; C3 = 4.7n; C4 = 3.3n
- b. Cut two lengths of single-stranded wire of some 7cm each. Connect one side of the one wire to the junction of R3 and C4 and one side of the other wire to the center lug of the treble pot.

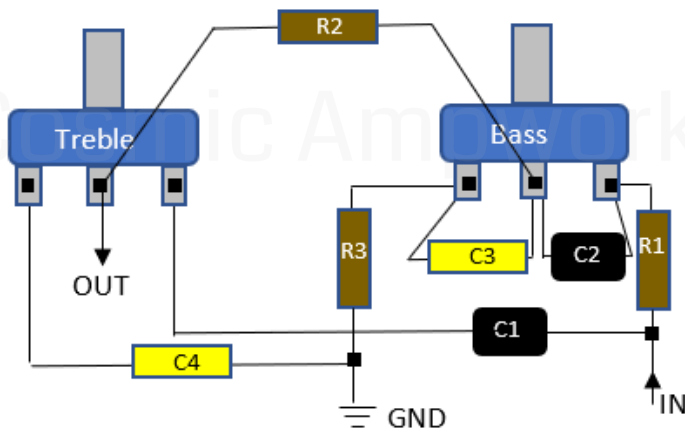


Figure 13. Layout of a James tonestack on the back of two potmeters. Soldering lugs are pointing upwards (as in Figure 14 below).

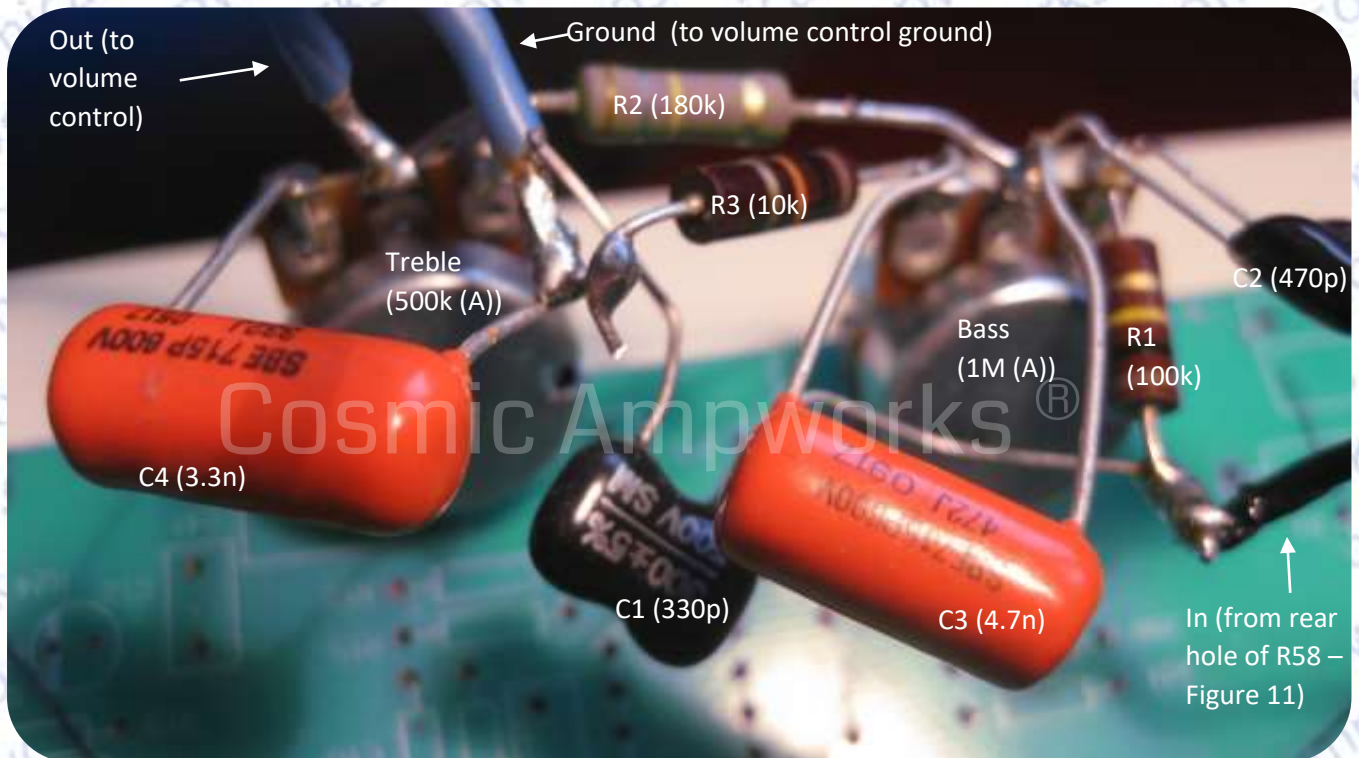


Figure 14. James tonestack for the GA15 (NOTE: "orange drop" capacitors used here, instead of yellow "mustard" caps). As this is only a 2-dimensional picture, parts may seem connected that are not; for soldering best rely on Figure 13. Also refer to Figure 15.

c. Connect the volume control (1M, A = audio taper) to the tonestack:

- i. Solder the wire from the center (wiper) lug of the tonestack treble pot to the left lug of the volume pot (*NOTE: seen from the back, as in Figure 15, it's the right lug*).
- ii. Connect the ground wire from the tonestack (from the junction of R3 [10k] and C4 [3.3n] of the tonestack; Figures 13-15) to the right lug of the volume pot (*NOTE: it's the left lug if seen from the back, as in Figure 15*). **Before soldering**, also connect a short piece of some 5 cm of wire to that lug. Then solder.
- iii. Solder some 4 cm of single stranded wire to center lug of the volume pot.

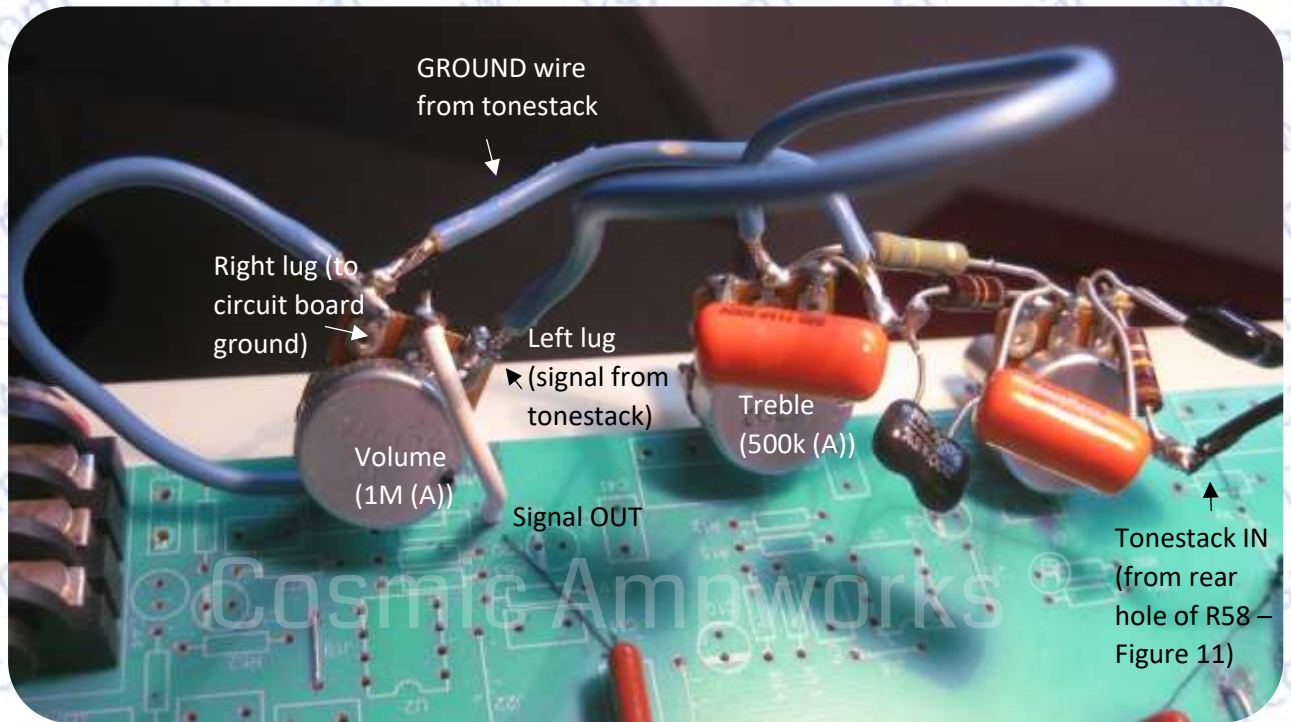


Figure 15. Tonestack and volume control assembly.

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

- i. Cut a length of about 15 cm of speaker wire, separate the two strands and solder one strand to the rear hole of the removed R58 (Figure 16 - "wire to tonestack").
- ii. Solder the other end of the wire to the tonestack "IN", at the junction of C1 (330p) and R1 (100k) of the tonestack; see Figures 16, 17 and 18.
- iii. Solder the ground wire from the volume pot (left lug, see Figure 17) to the leftmost hole (seen from the front of the circuit board) of VR1, the original volume control (Figure 17).
- iv. Solder the signal ("OUT") wire from the center wiper of the volume control to the left hole of the removed R24 (Figure 15, "signal out").



Figure 16. Solder a length of some 15 cm of wire 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 - optional - presence control and modified phase inverter, see further down).

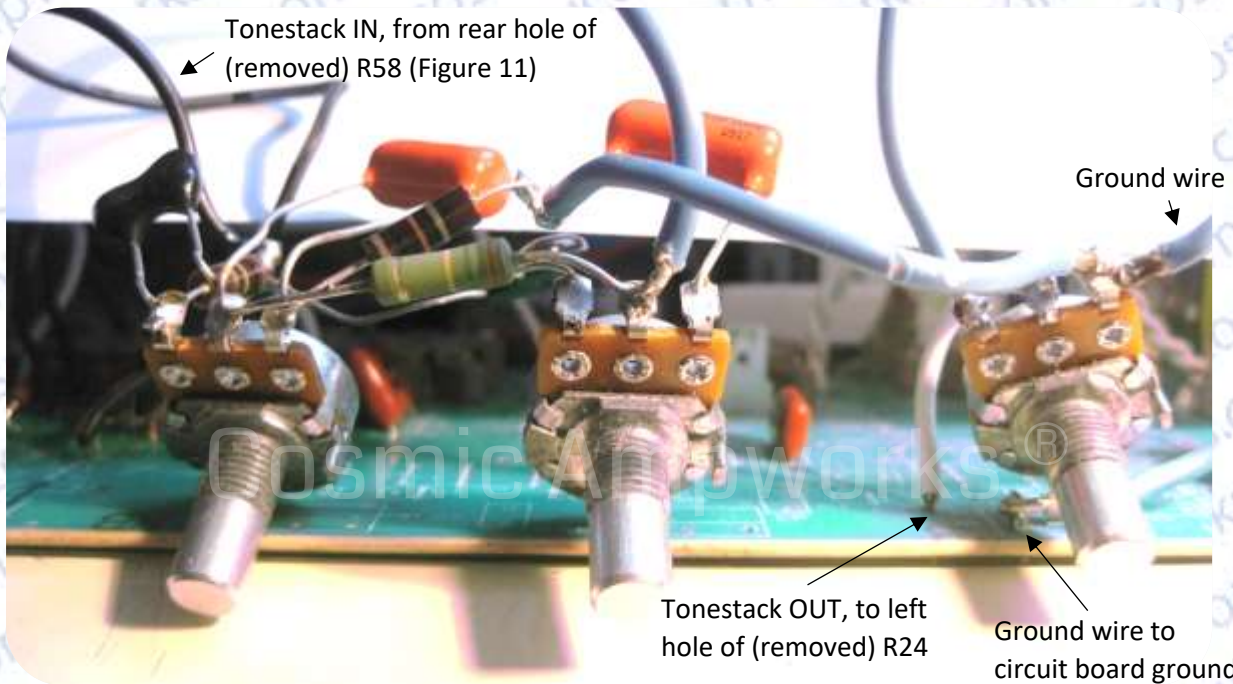
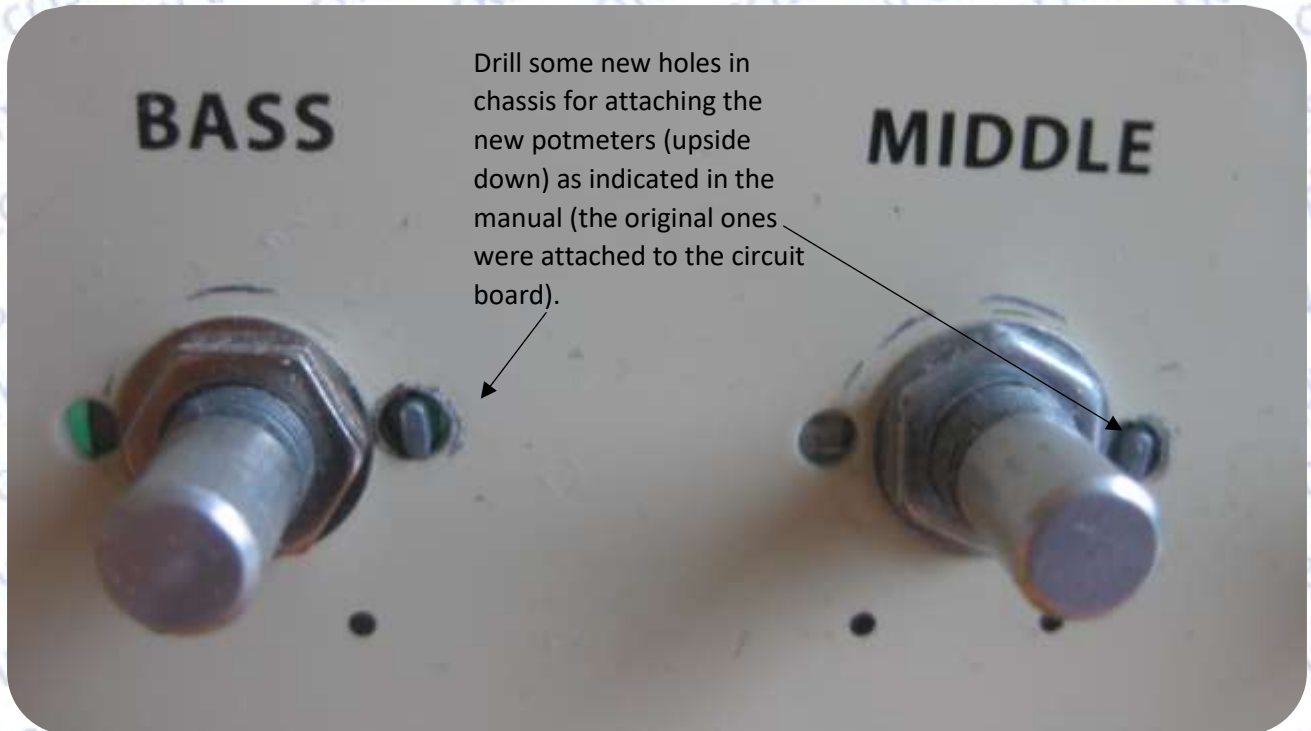


Figure 17. The tonestack (the left two potmeters) and volume control (right pot) assembly has 3 connection points to the circuit board: SIGNAL IN (from rear hole of the removed R58 - Figure 11), SIGNAL OUT (the left hole of the removed R24 - this Figure) and GROUND (the leftmost hole of the removed original volume pot VR5).



For attaching the potmeters of the new tonestack, gain and volume controls to the chassis as indicated in this manual, some extra holes need to be drilled in the chassis; (Figure above)

6. Wire a DC power supply for the preamp heater filaments.

- a. Carefully de-solder and remove the L7912³ 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*.

³ 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. It supplies -12 V DC, it supplies +12 V DC. See point 6.j.ii.

- 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.



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.

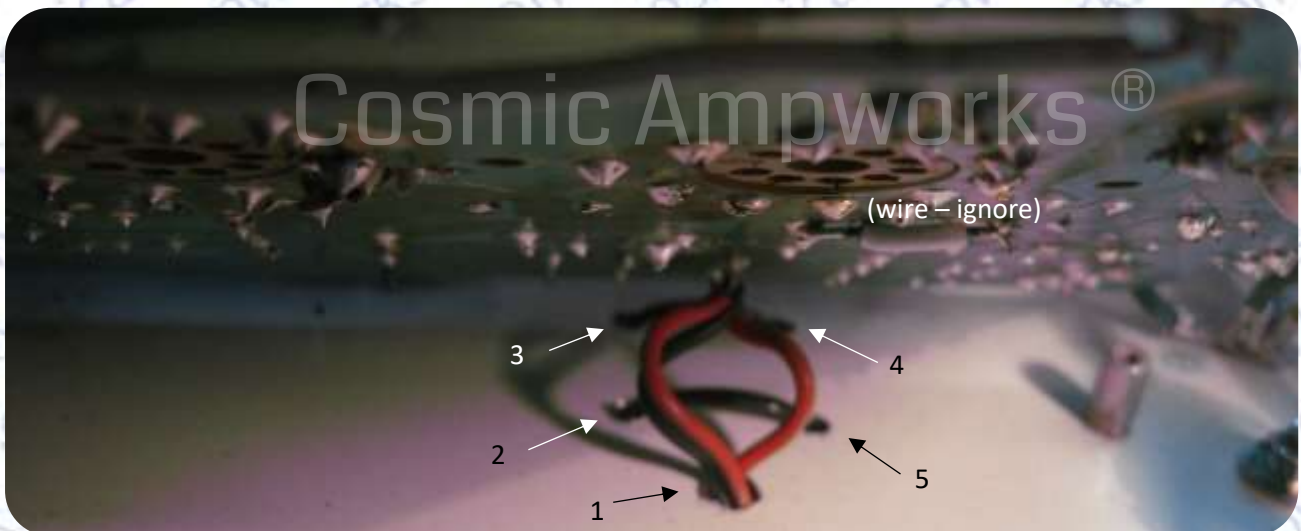


Figure 20. Drill five holes in the bottom of the chassis for attaching the heat sink that cools voltage regulator L7912 (viewed from inside the chassis). Hole no. 1 needs be wide enough to accommodate the 3 wires connecting to L7912 - smoothen its edges with a file. The other holes should be wide enough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

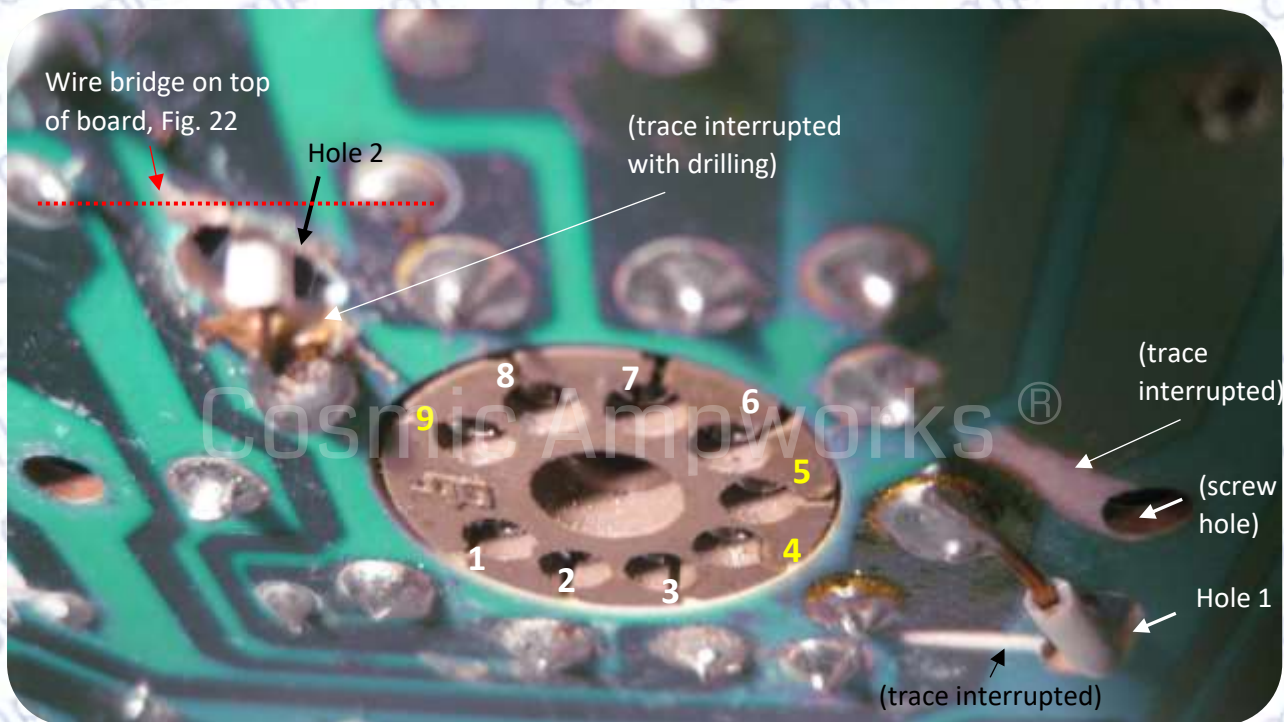


Figure 21. Drill two holes near the second preamp tube: hole 1 right next to the tube socket connections to pins 4 and 5 (Figures 23 and 24); the location is not particularly critical. Drill hole 2 just above the tube socket solder connections of pin 9, but make sure not to accidentally drill through 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.

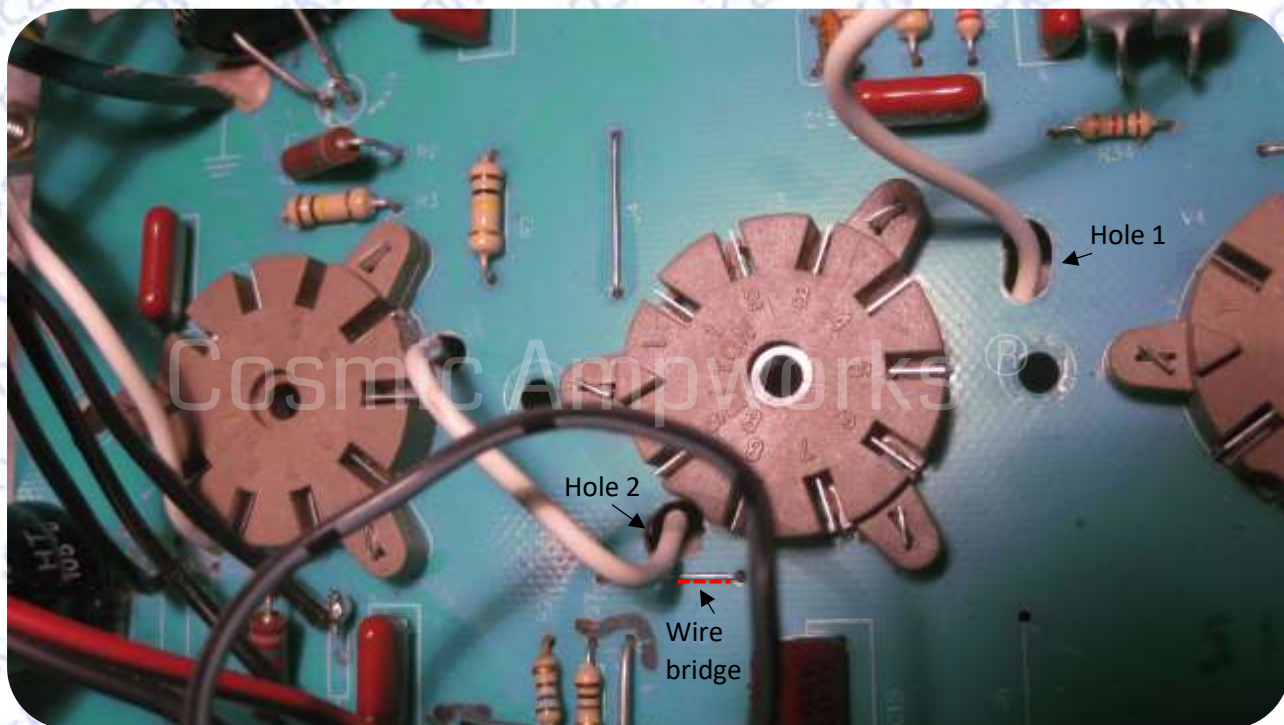


Figure 22 Drill two holes near the second preamp tube: hole 1 right next to the tube socket connections to pins 4 and 5 (Figures 23 and 24); the location is not particularly critical. Drill hole 2 just above the tube socket solder connections of pin 9, but make sure not to accidentally drill through the wire bridge! Drilling is best done from the underside of the board.

- j. Run a 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 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 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.

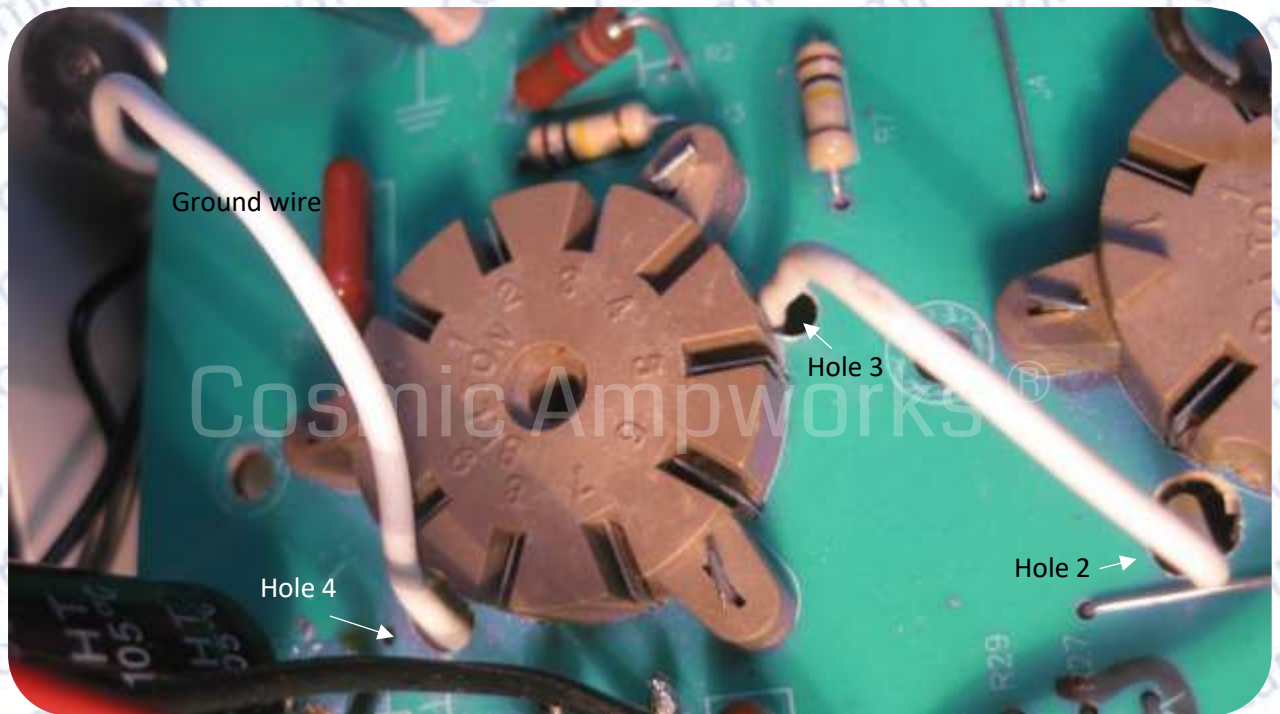


Figure 24. Drill two holes near the first preamp tube: Drill hole 3 right next to the tube socket solder connections of pins 4 and 5; the location is not particularly critical, but make sure not to damage the trace running from pin 6 of the tube (anode) to R7 (load resistor). Drill hole 4 just above the tube socket solder connections of pin 9.

7. **Optional:** install a presence and negative feedback control (5k and 1M potmeters, B = linear tapers) and modify the phase inverter:

- a. Mount the included 10k 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). 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). 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 27).
- 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 28), 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 28); solder the other end to the front leg of C15 (Figure 28; 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!

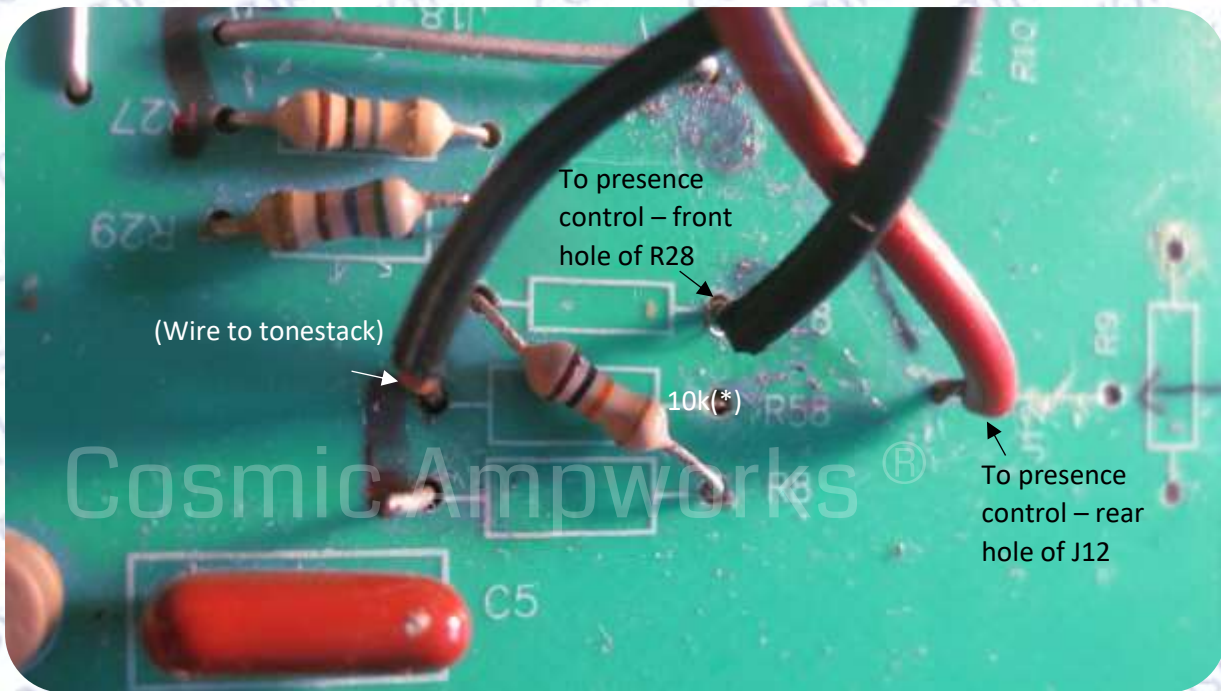


Figure 25 The tail resistor R28 of the phase inverter is replaced by mounting the included 10k resistor diagonally to the circuit board, with one leg in the rear hole of (the removed) R28 and the other leg in the front hole of R8. Presence wire are soldered to the front hole of R28 (ground) and the rear hole of (removed) wire bridge J12. Also visible is a wire that runs to the new tonestack – to be discussed further down.

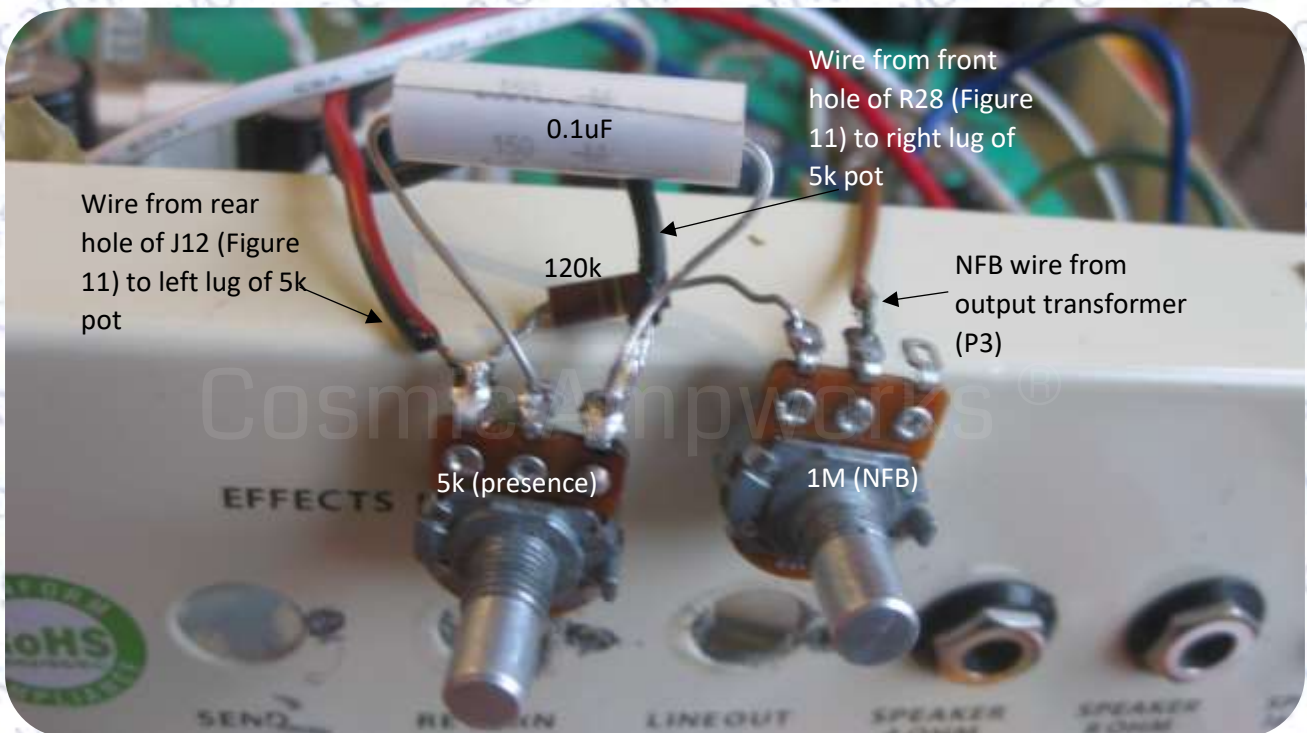


Figure 26. Connect the presence and negative feedback (NFB) controls: solder the wire that runs from the rear hole of J12 to the left lug of the 5k potmeter. Solder the other strand to the right lug. Solder the legs of the 0.1uF capacitor to the right and center (wiper) lugs of the 5k potmeter. Solder 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 Send/Return/Lineout jacks used to be. The run a wire from the center tap of the 1M potmeter to P3 (Figure 27), on the left rear of the board.



Figure 27. 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).

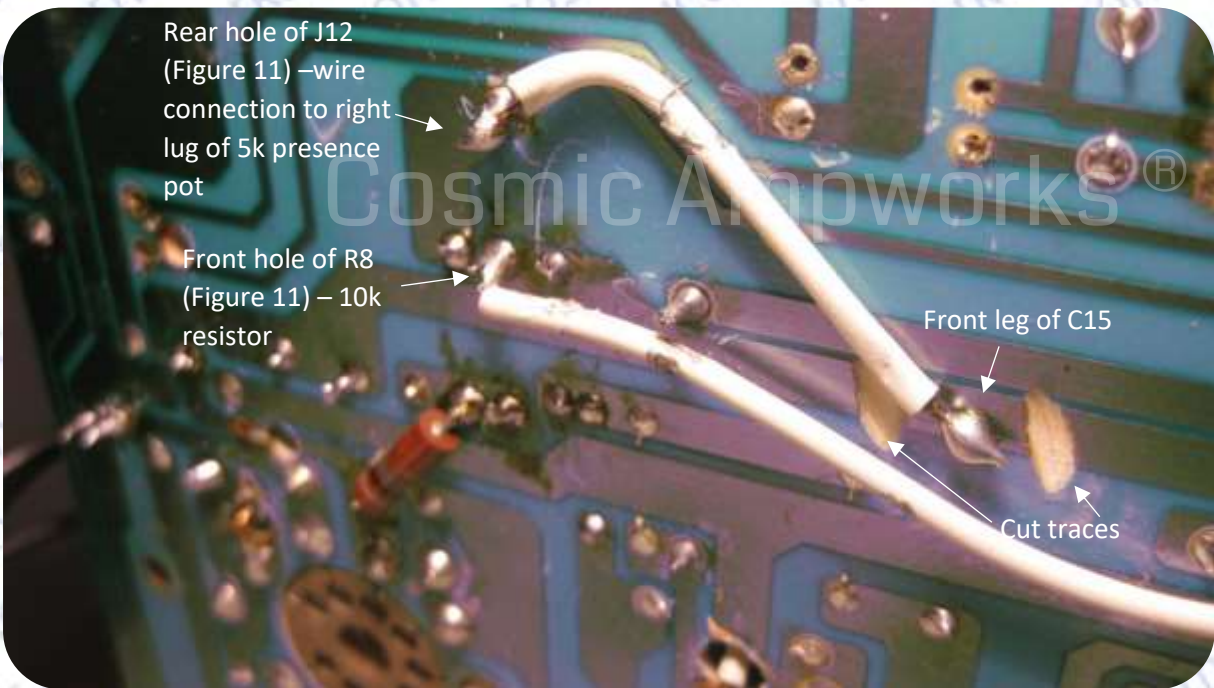


Figure 28. Interrupt the PCB traces on either side of the front leg of C15 (Figure 14). Cut a length of single stranded wire about of 4.5 cm. Underneath the board, solder one end of it into the rear hole of J12; solder the other end to the front leg of C15 (also underneath the board). Be careful not 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 29. 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).

8. **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.
- First cut the two circuit board traces that conduct 6.3 V AC to the power tube heaters (Figure 30) with a Dremel tool with grinding attachment, with a rotary drill or with a simple file.
 - Then, drill three holes in the circuit board:
 - Drill holes 1 and 2 close to the spade connectors that connect the board to the 6.3V DC power supply (Figures 30, 31)
 - Drill hole 3 close to the 2nd power tube, near the circuit board screw hole (Figures 30, 31)
 - Twist two lengths of single stranded wire (Figure 31). 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!

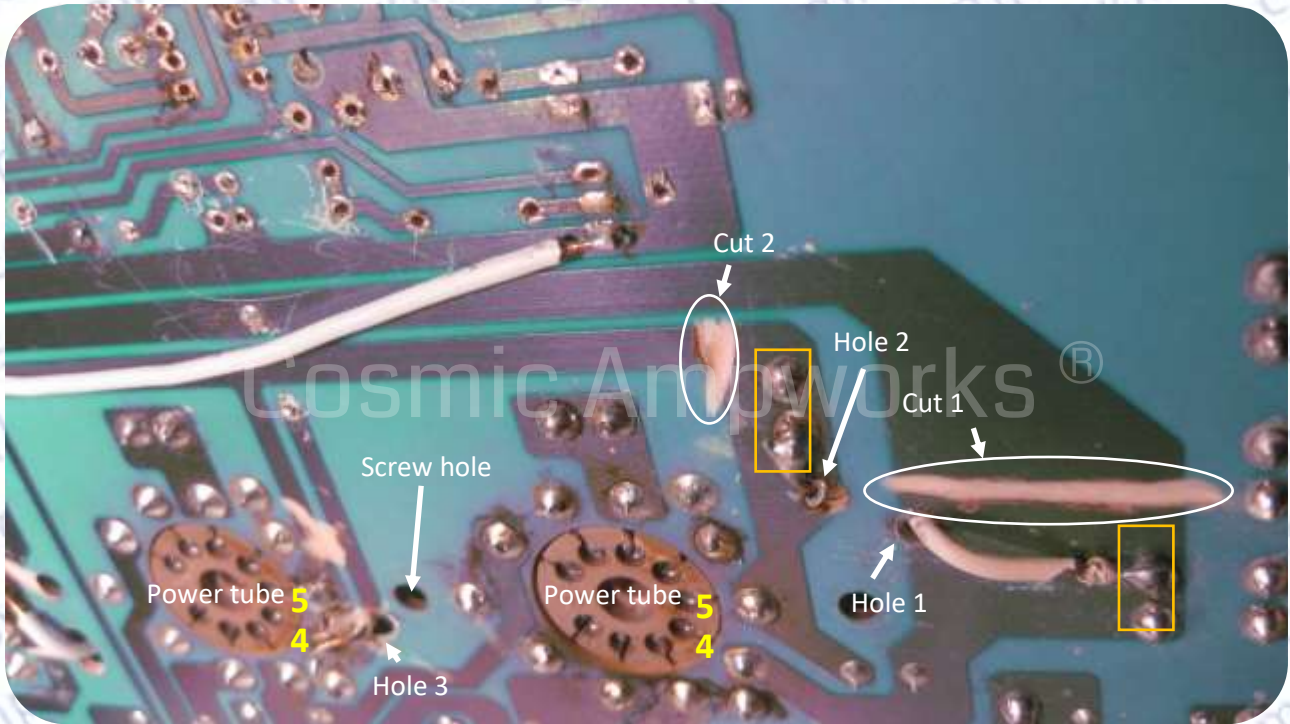


Figure 30. Cut the circuit board traces that conduct electricity to the power tube heaters (cuts encircled). Then drill three holes for the new heater supply wiring (6.3 V spade connectors marked with orange rectangles). Tube heaters are connected to tube pins 4 and 5.



Figure 31. 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 the same for pins no 5. If using wires of identical color, use a marker to distinguish them.

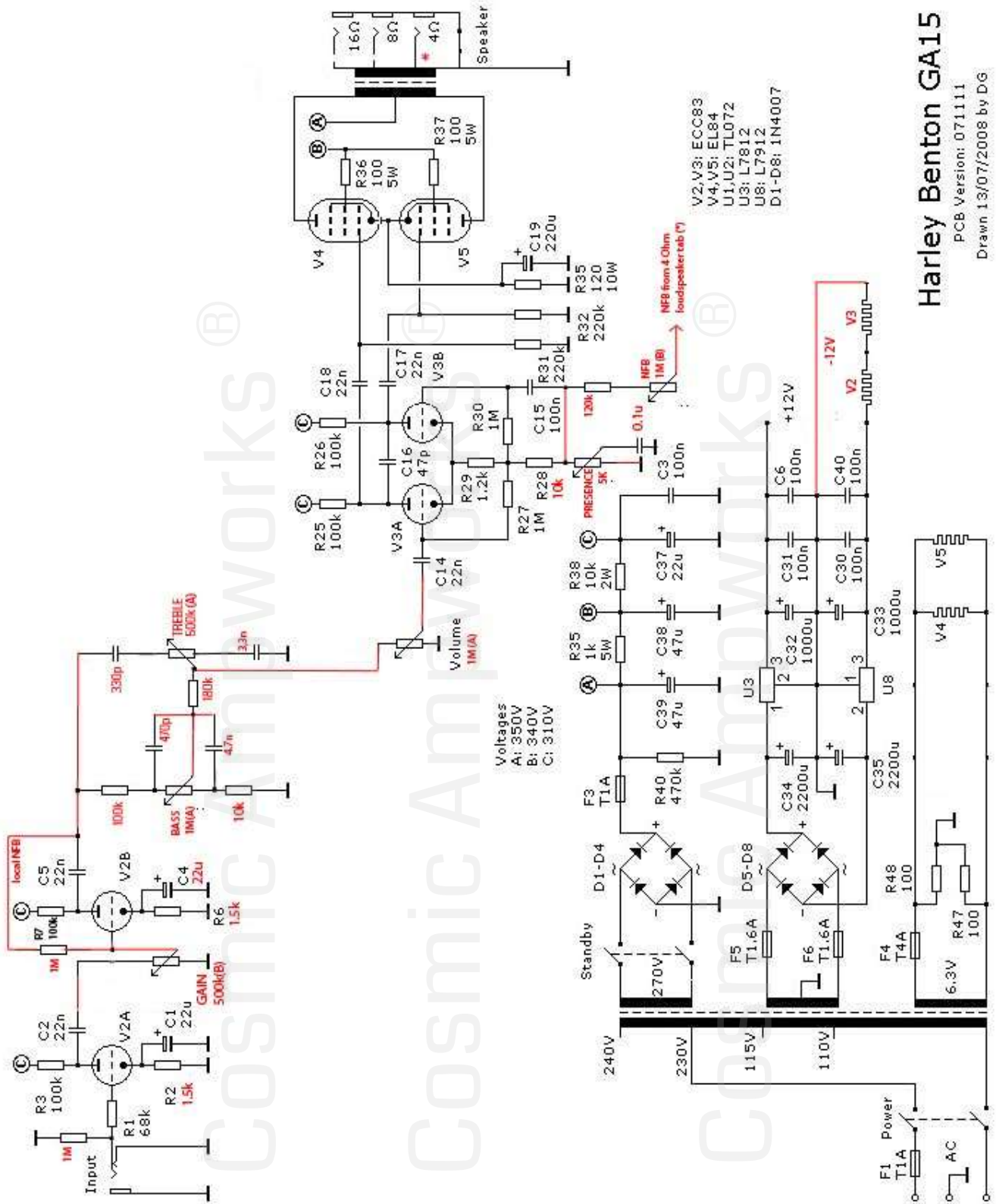


Figure 32 A last look at the circuit board.

...and that's a wrap! Hopefully, modifying your amp has yielded satisfactory results and some agreeable hours! Please don't hesitate to provide comments or feedback via <https://cosmicampworks.com/contact/>

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# Harley Benton GA15

PCB Version: 071111  
 Drawn 13/07/2008 by DG

Figure 33 Schematic of the modified Harley Benton GA15