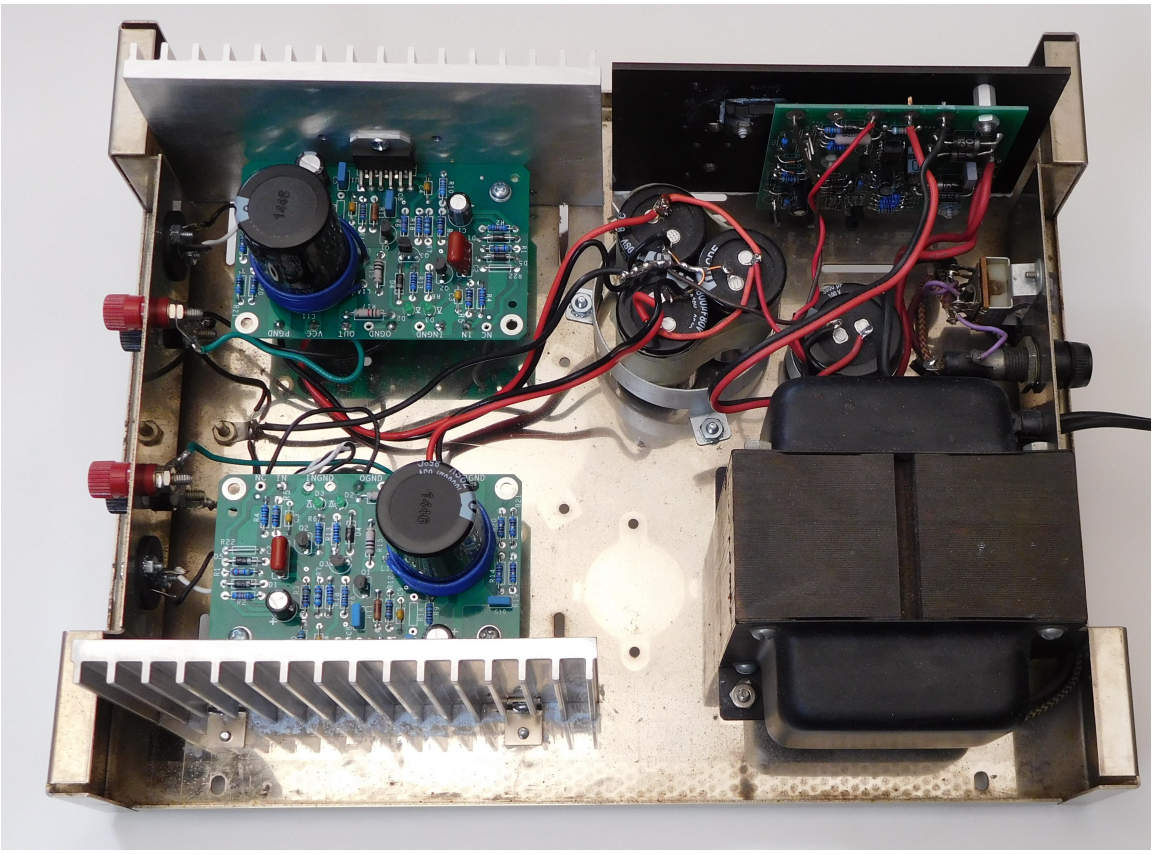
# DYNACO STEREO 120
# COMPLETE REBUILD KIT




Revision 1p09
December 7, 2018

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# Section 1: About this Manual

This manual gives you all the information you need to completely rebuild your Dynaco Stereo 120 Solid State Power Amplifier using UpdateMyDynaco replacement module kits and components. You will:

- Replace all the old electrolytic capacitors
- Replace the power supply regulator board
- Replace the amplifier modules
- Increase the energy available from the power supply while improving its regulation and reducing its noise
- Reduce the distortion in the amplifier channels
- Make your Stereo 120 sound better than new!

The only part of your Stereo 120 that really needs to work is the power transformer, line cord, fuse-holder, and power switch.

## *Who Should Attempt this Project?*

You can rebuild your Dynaco Stereo 120 if you can:

1. solder (using normal rosin core solder and a soldering iron).
2. use simple hand tools like screwdrivers, wire cutters, and pliers.
3. read and follow directions.

It helps if you:

1. know a bit about electronics, or
2. have a friend who knows a bit about electronics
3. can get to YouTube to watch videos about the assembly process

## *Tools You'll Need*

You'll need the following tools to update your Stereo 120:

1. flat blade screwdriver for #6 screws
2. Phillips screwdriver (#2)
3. pliers or nut drivers suitable for #6 hardware (5/16" nut driver or hex wrench)
4. needle nose pliers (helpful, but not strictly necessary)
5. pencil type soldering iron of 25 to 50 Watts (no huge honking soldering guns or blowtorches)
6. wire cutters and strippers

7. multi-meter (strongly recommended to cross-check resistor values against color codes)
8. magnifying glass, to verify identification codes on small components

## *Project Overview*

The project consists of the following steps:

1. Removing the old amplifier modules (circuit board and heat-sink).
2. Removing the old power supply module.
3. Removing the old electrolytic capacitors.
4. Cleaning up the chassis.
5. Building the new power supply module.
6. Installing and wiring the new capacitors and checking out the new power supply.
7. Building the new amplifier modules.
8. Connecting everything together.
9. Checking everything out.
10. Listening to great sounding music!

## *Important Safety Notes*

By purchasing this kit, you have agreed to hold AkitikA, LLC harmless for any injuries you may receive in its assembly and/or use. To prevent injuries:

- Wear safety glasses when soldering to prevent eye injuries.
- Always unplug the power before working on the amplifier.
- Large capacitors hold lots of energy for a long time. Before you put your hands into the amplifier:
    - Pull the AC plug!
    - Wait 1 full minute for the capacitors to discharge!
- Remove jewelry and rings from your hands and wrists, or anything that might dangle into the amplifier.
- If working in the amplifier, keep one hand in your pocket, especially if you're near the power supply or power supply wires. This can prevent serious shocks.
- Build with a buddy nearby. If you've ignored all the previous advice, they can dial 911 or get you to the hospital.

## *About Components*

We reserve the right to make design/or component changes at any time without prior notification.

## *Recommended Solder*

The kit must be assembled with 60/40 Rosin Core solder. The recommended diameter is 0.032 inches. Among many such sources of solder, I have used

- Kester 24-6337-8800 50 Activated Rosin Cored Wire Solder Roll, 245 No-Clean, 63/37 Alloy, 0.031" Diameter. This is a 1 pound roll of solder. No-clean means that it leaves the minimum possible residue on the PCB.

- MG Chemicals 60/40 Rosin Core Leaded Solder, 0.032" Diameter, 0.6 oz Pocket Pack

# Section 2: Removing the Modules and Caps

## *Opening the Amplifier*

1. ***Make sure the amplifier is unplugged. If it was recently powered allow the amp to sit for one full minute before proceeding.***
2. Remove the four screws along the outside edge of the bottom that hold the cover in place (see Figure 1).

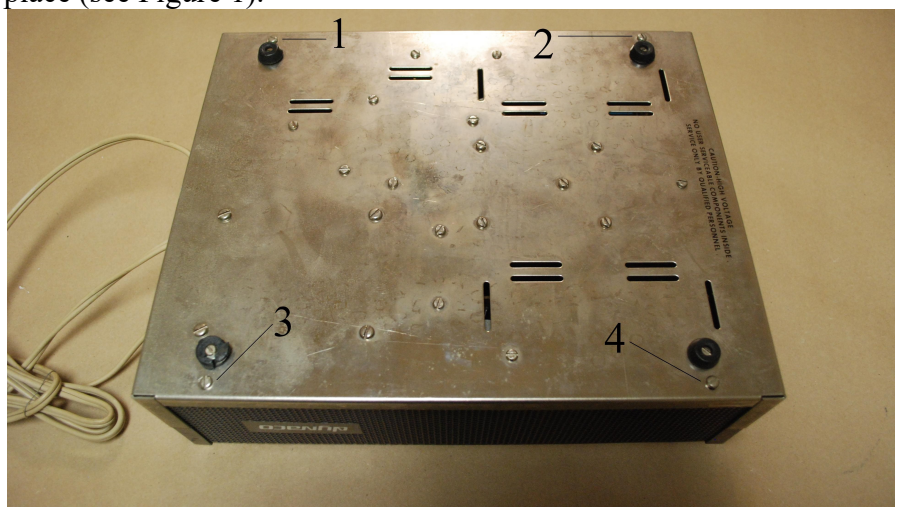



**Figure 1-Location of the four screws that hold the cover to the base**

3. Holding both the top and bottom of the amplifier, flip it over.
4. Lift the perforated metal top off of the amplifier.

## *Remove the old amplifier modules*

The following discussion refers to Figure 2.

We'll keep this simple. The amplifier modules (PC-14's and the associated heat sinks) are held in by two sets of 6-32 screws and nuts that go through the foot of the heatsink and into the chassis. Remove those two screws from each amplifier module. Then:

1. Cut all the wires that hold the amplifier modules into the chassis. You can use the X's in Figure 2 for hints on where to cut the amplifier module wires.
2. Lift out the two amplifier modules.
3. Set the module asides. We will not re-use any part of either amplifier module.
4. Save only the mounting screws for later re-use.

## *Remove the Capacitors*

### C7 RIGHT

1. Remove the 3 sets of #6 hardware that hold C7 RIGHT to the bottom of the chassis.

2. Unroll one foot of the wire that's wrapped around C7 RIGHT and connects to the RIGHT RED Binding post.
3. Cut this wire near C7 RIGHT so that about 1 foot of wire remains connected to the RIGHT RED Binding post.

### C7 LEFT

4. Remove the 3 sets of #6 hardware that hold C7 LEFT to the bottom of the chassis.
5. Unroll one foot of the wire that's wrapped around C7 LEFT and connects to the LEFT RED Binding post.
6. Cut this wire near C7 LEFT so that about 1 foot of wire remains connected to the LEFT RED Binding post.

### C9, C11, and C12

You'll now remove C9, C11, and C12. Disconnect the wires as needed to make them easy to remove.

1. Remove the 3 sets of #6 hardware that hold C9 to the bottom of the chassis.
    a. If you are re-building your Stereo 120 for 120 Volt operation, you can remove the two-terminal terminal strip held until one of the C9 mounting screws. You can also save it to re-install later, along with the new C9, although it will have no wires connected if you've configured your Stereo 120 for 120 Volt operation.
    b. If you are re-building your Stereo 120 for 240-volt operation, you'll find that there are transformer wires connected to those terminals. In this case you'll need to keep those wires and terminals.
2. Remove the 3 sets of #6 hardware that hold C11 to the bottom of the chassis.
3. Remove the 3 sets of #6 hardware that hold C12 to the bottom of the chassis.
4. Loosen the mounting clamp hardware for C9 and remove C9 from its clamp.
5. Loosen the mounting clamp hardware for C12 and remove C12 from its clamp.
6. Neither C11 nor its mounting clamp will be re-used in the re-build.

### Removing the Output Zobel Networks

Refer to Figure 2 as you:

1. Clip the lead of the 0.1 µF capacitor that connects to the RIGHT RED binding post, near the RIGHT RED Binding post.
2. Clip the lead of the 4.7 Ohm resistor that connects to the RIGHT BLACK binding post, near the RIGHT BLACK binding post.
3. Clip the lead of the 0.1 µF capacitor that connects to the LEFT RED binding post, near the LEFT RED Binding post.
4. Clip the lead of the 4.7 Ohm resistor that connects to the LEFT BLACK binding post, near the LEFT BLACK binding post.
5. Remove the terminal strip and the two attached resistors and capacitors.

### Making the Speaker Binding Posts User Friendly

The speaker binding posts have holes for the speaker wire. These holes should be oriented from side to side, not up and down, to allow easy connection of the speaker wires. If your binding posts are already correctly oriented, skip this step. If not, here's the

procedure that should be applied to whichever of the 4 binding posts don't have the correct orientation:

1. Loosen the binding post (red or black plastic part) until you can see the hole in the mounting stud.
2. Loosen and remove the nut that holds the speaker connection wires. Remove the speaker wire lugs, noting their locations so that they may be correctly returned.
3. Loosen the remaining nut just enough to be able to spin the binding post to the correct orientation. Keep the binding post from turning as you tighten it with a nail (or stout toothpick) through the wire hole.
4. Replace the solder lugs with the speaker connection wires.
5. Replace and tighten the nuts that hold those lugs in place.

## Remove the Ground Lug and Wires

1. Remove the nut and bolt that hold the ground lug to the chassis. It is located between C12 and the transformer. Cut the wires near the lug. See Figure 3.

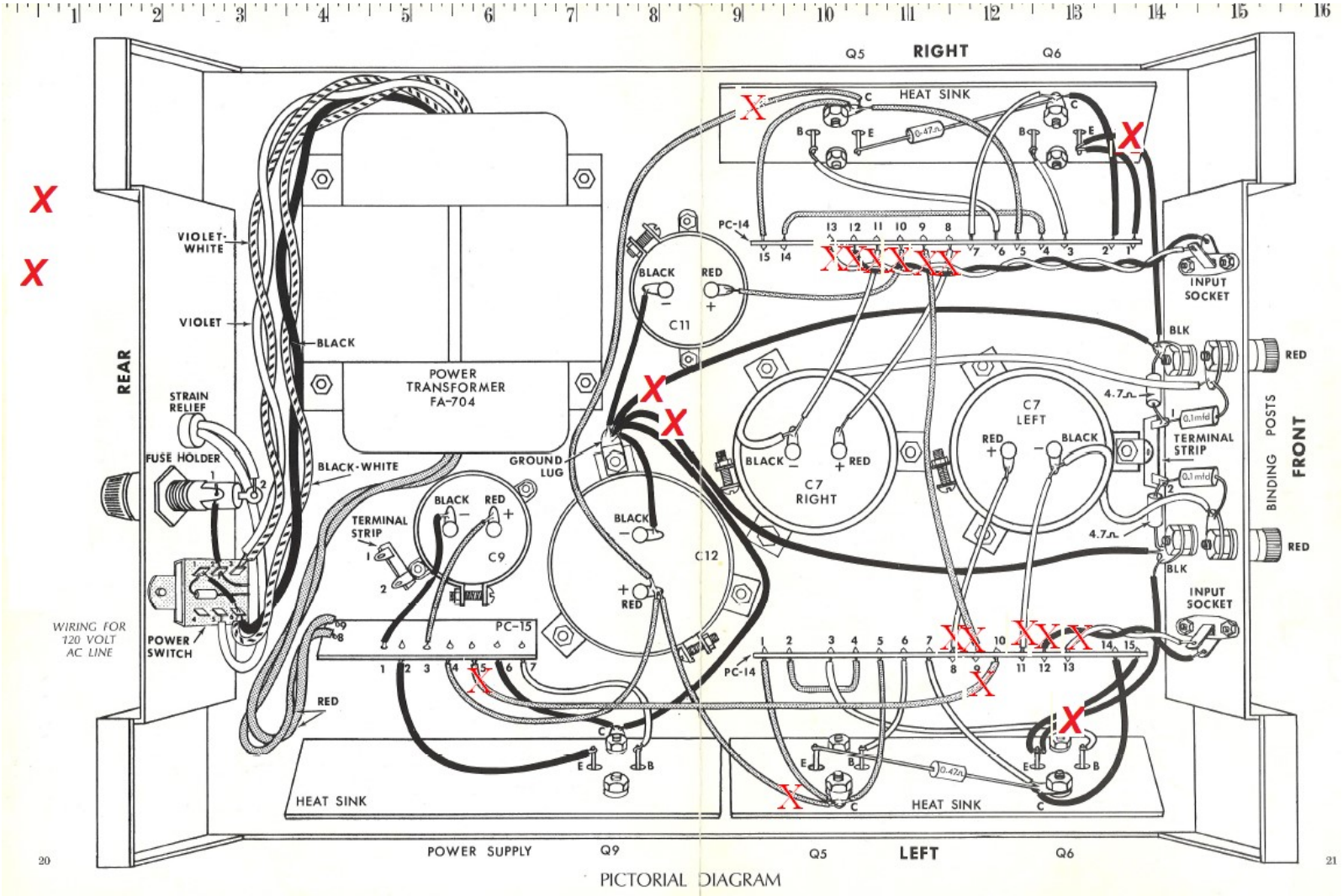



**Figure 2-Component Identification, and where to cut**

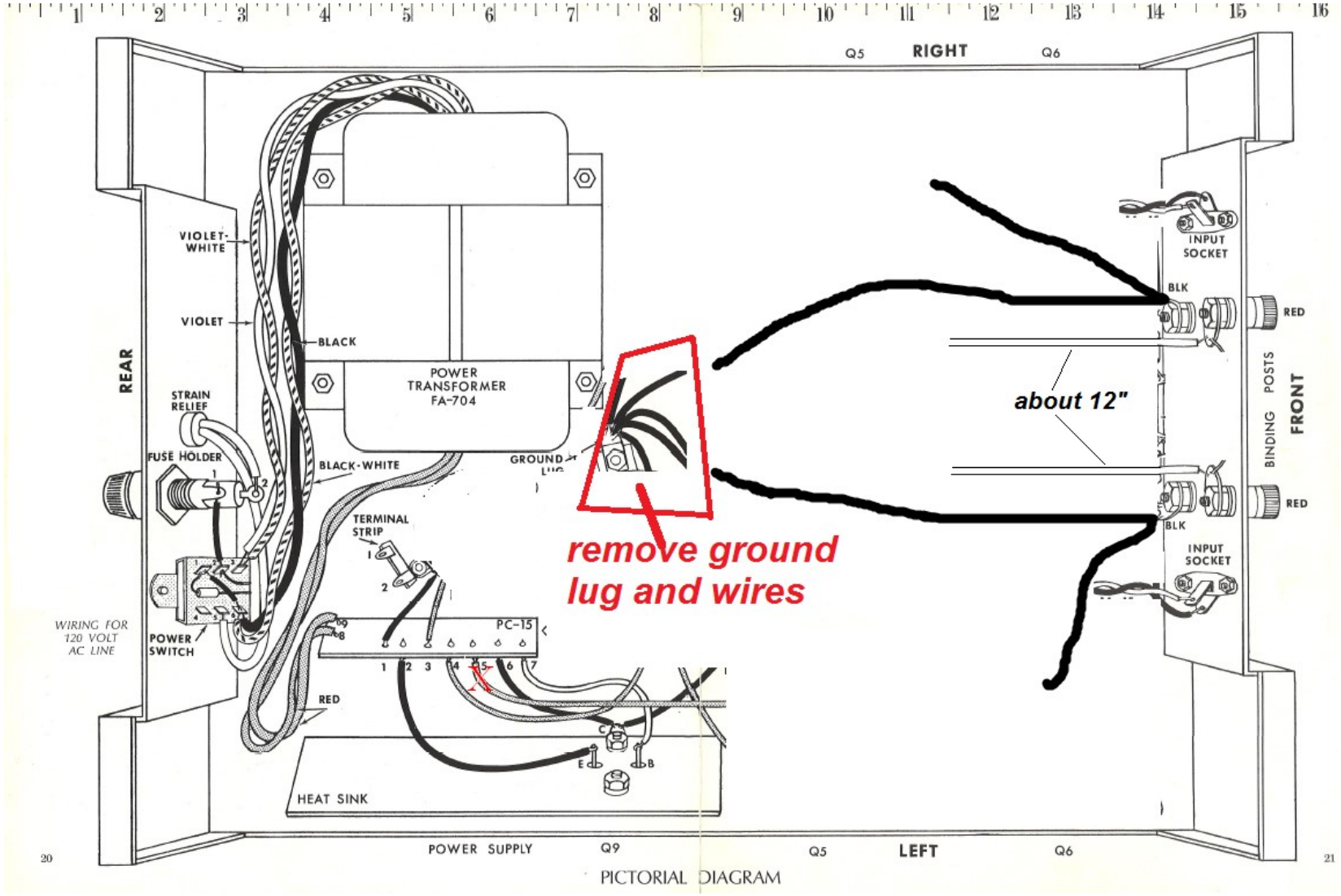



**Figure 3-Amp modules removed**

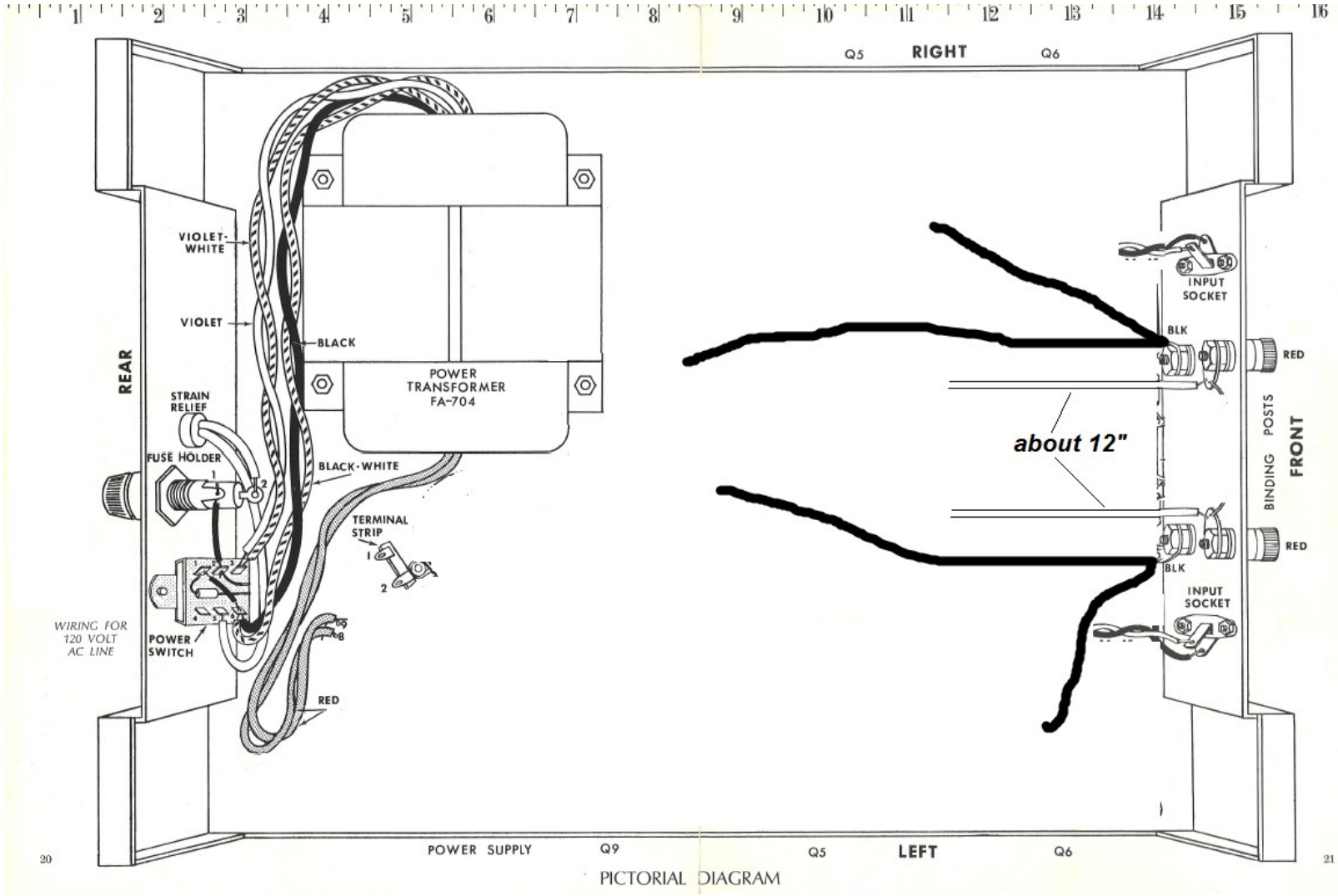



**Figure 4-Amp and Power Supply Modules Removed**

# Section 3: Removing the Stereo 120 Power Supply

Please refer to Figure 3 and Figure 4. After you've completed the previous section, only the power supply (PC-15 and the related heatsink) remains in the chassis. Our goal here is to remove the power supply, leave the transformer wires long, and harvest the *power-supply* heat-sink for re-use.

1. Remove the two screws that hold the power supply heatsink to the bottom of the chassis.
2. De-solder the two red wires that run from the power transformer to eyelets 8 and 9 of the power supply PCB. If this is awkward, you could cut the wires quite close to the regulator PCB. Still, try to leave these wires as long as possible.
3. Cut the rest of the wires that hold the power supply PCB to the chassis, cutting them close to the PCB.
4. Disassemble the PCB from the heat-sink.
5. Remove the large power transistor from the heat-sink. Cut whatever wires join the large power transistor to the PCB to facilitate its removal.
    a. Remove the mica washer. You may have to peel it off. Sometime the easiest way is to scrape it off carefully with a single-edged razor.
    b. Clean up and remove the old white thermal compound using isopropyl alcohol and paper towels. The 90% version works better than the usual 70% stuff. *Be careful, the combination of paper towels and isopropyl alcohol is quite flammable!*
6. Save the power supply heatsink and the chassis mounting hardware for later use.

## Clean up the chassis

Remove the rest of the wires and hardware until your amp looks like Figure 4. As shown, all the wiring from the power cord through to the secondary wiring of the transformer will remain intact. The only other wires that will be hanging on are:

1. 12 inch pieces of white wire, on attached to each red speaker binding posts.
2. 4 black wires, two on each black binding post.
3. Twisted pairs hanging onto the RCA jacks.

This is the perfect time to clean up the chassis. Use whatever combinations of cleaners and metal polishes you feel comfortable using. At this point, some people will strip the rest of the parts off the chassis, and run the chassis through the dishwasher before multiple rounds of metal polish.

There's a youtube that details a hard-core version of the cleaning and stripping process:

https://www.youtube.com/watch?v=o8jEKVTDoBU

Note that some of the details will differ, but it should give you a general idea of the process, especially if your plan is to take things to the nth degree.

It's up to you how much of a project you'd like to make of the cleanup. When you're finished with your chosen amount of cleanup, then turn the page, and we'll start re-building your Stereo 120.

# Section 4: Assembling and Testing the Power Supply

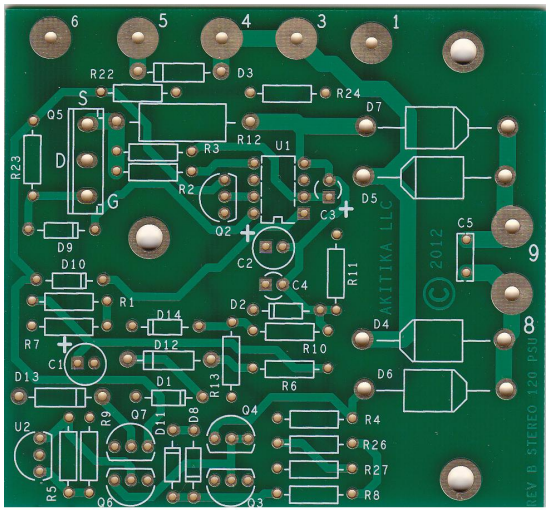



**Figure 5-Power supply bare PCB**

This section details the process of building the power supply circuit board. We start with an overview on this page. The specifics you need to start building begin on the next page.

In general, you'll start with the components that lay closest to the board, working your way towards the taller components. You will:

1. Empty the contents of the PSUG envelope into a flat soup bowl. This keeps the parts from getting lost, and makes them easy to find.
2. Install the resistors
3. Install the diodes
4. Install the capacitors
5. Install the transistors
6. Install the integrated circuits.
7. DO NOT INSTALL THE LARGE PASS TRANSISTOR (Q5) AT THIS TIME!

## *Component Order*

You'll notice that the component designations in the directions don't go exactly in order. We have grouped them so that all components with the same value appear together. This makes assembly easier. You'll find in the parts kit that similar parts, e.g. 3 1K resistors, are typically (though not always) taped together.

## *Install the Resistors*

In general, you install the resistors by placing the body on silk screen side of the board, and the leads through the indicated holes. Bend the leads over on the back of the board to keep the resistors from falling out until your solder them in place. Try to bend the leads in a direction that won't lead to solder bridges between traces that should remain disconnected.

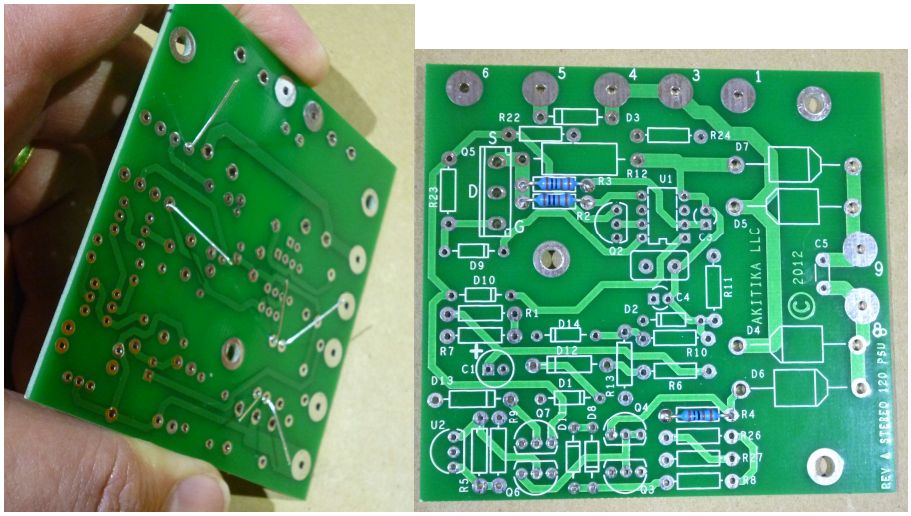



**Figure 6-Installing resistors**

We recommend the following procedure:

1. Insert all the resistors of the same value, e.g. R2, R3, and R4.
2. Bend the leads as described above.
3. Solder the leads on the back of the board.
4. Clip the leads.

Track your progress by placing a check-mark in the done column as you install each resistor. Check resistor values with a meter, or by reading the color code[1]. Orient the resistor with the fat brown band on the right, then you can read both the Color Code column and the resistor from left to right.

| ¼ Watt, 1% resistors | | | |
|---|---|---|---|
| Designation | Value | Color code | Done? (✓) |
| R2 | 1K | Brown, Black, Black, Brown, Brown | |
| R3 | 1K | Brown, Black, Black, Brown, Brown | |
| R4 | 1K | Brown, Black, Black, Brown, Brown | |
| R6 | 10K | Brown, Black, Black, Red, Brown | |
| R26 | 10K | Brown, Black, Black, Red, Brown | |
| R27 | 10K | Brown, Black, Black, Red, Brown | |
| R8 | 20K | Red, Black, Black, Red, Brown | |
| R9 | 20K | Red, Black, Black, Red, Brown | |
| R1 | 15K | Brown, Green, Black, Red, Brown | |
| R5 | 140K | Brown, Yellow, Black, Orange, Brown | |
| R7 | 5K76 | Green, Violet, Blue Brown, Brown | |
| R10 | 26K1 | Red, Blue, Brown, Red, Brown | |
| R11 | 3K01 | Orange, Black, Brown, Brown, Brown | |
| R13 | 3.01 Meg | Orange, Black, Brown, Yellow, Brown | |
| R22 | 165K | Brown, Blue, Green, Orange, Brown | |
| R23 | 100 | Brown, Black, Black, Black, Brown | |
| R24 | 95K3 | White, Green, Orange, Red, Brown | |

[1] See "Resistor Color Code" on page 24 to see how to read resistor color codes.

| 2 Watt, 5% resistor | | | |
|---|---|---|---|
| Designation | Value | Marking | Done? (✓) |
| R12 | 0.1 | 0.1 | |

## *Install the Diodes*

Now install the diodes. Be careful to observe the polarity markings on the diodes. You'll notice that one end of the diodes has a band. Match the banded end of the diode with the banded end of the silk screen.

| Designation | Type, Package | Description | Done? (✓) |
|---|---|---|---|
| D1 | BZX55B33, DO-35 | 33 Volt 2% zener diode | |
| D14 | BZX55B33, DO-35 | 33 Volt 2% zener diode | |
| D2 | BZX79-B10, DO-35 | 10 Volt 2% zener diode | |
| D8 | 1N4148, DO-35 | 0.2 A, 100 PIV, switching diode | |
| D9 | 1N4148, DO-35 | 0.2 A, 100 PIV, switching diode | |
| D10 | 1N4148, DO-35 | 0.2 A, 100 PIV, switching diode | |
| D11 | 1N4148, DO-35 | 0.2 A, 100 PIV, switching diode | |
| D3 | 1N4004, DO-41 | 1A, 400 PIV, rectifier diode | |
| D12 | 1N4004, DO-41 | 1A, 400 PIV, rectifier diode | |
| D13 | 1N4004, DO-41 | 1A, 400 PIV, rectifier diode | |
| D4 | 1N5404, DO-201AD | 3A, 400 PIV, rectifier diode | |
| D5 | 1N5404, DO-201AD | 3A, 400 PIV, rectifier diode | |
| D6 | 1N5404, DO-201AD | 3A, 400 PIV, rectifier diode | |
| D7 | 1N5404, DO-201AD | 3A, 400 PIV, rectifier diode | |

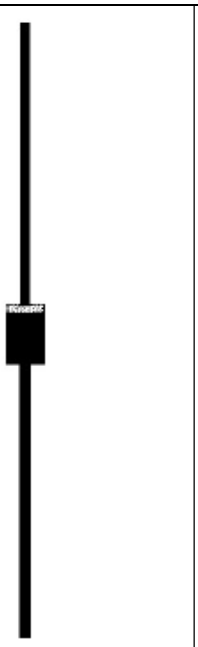
### Identifying the glass body diodes

The glass body diodes have the following identifying marks. If your vision is like mine, you may need good light and a magnifying glass.

- 1N4148, D8-D11, has the number 48 visible
- BZX55B33B, D1 and D14, has the number 33 visible
- BZX79-B10, D2, has the number 10 visible

Also, typically when these diodes are packed, you can preliminarily identify the types because:

- The 4 1N4148 diodes will typically be taped together
- The 2 BZX55B33B diodes will typically be taped together
- The 1 BZX79-B10 diode will be by itself

| | | |
|---|---|---|
|  |  |  |
| D4-D7, DO-201AD opaque black plastic package | D3, D12, D13, DO-41, opaque black plastic package | D1, D1, D8-D11, D14, DO-35 glass package |

## *Install the Capacitors*

Now install the capacitors:

| Designation | Value | Description | Done? (✓) |
|---|---|---|---|
| C1 | 10 µF | 100V electrolytic (polarized), cylindrical shape | |
| C2 | 10 µF | 100V electrolytic (polarized), cylindrical shape | |
| C3 | 100 nF | 50V, Z5U, +/- 20%, marked 104 | |
| C4 | 100 nF | 50V, Z5U, +/- 20%, marked 104 | |
| C5 | 10 nF | 400V, film, 20%, box shaped | |
| C6[2] | 1 µF | 100 Volt, film cap, box shaped, marked 1µ0K100 | |

Notes:

1. C1 is polarized, showing a minus sign (-) on the negative end of the capacitor. Make sure that the minus sign faces away from the plus sign (+) marked on the silk screen for C1.
2. C2 is also polarized.

[2] C6 is only present if your PSUG kit is Rev03, which has the Rev D PCB. Earlier kits do not have C6. You can find more information by downloading the latest PSUG Manual from the web-site.

## *Install the Transistors*

Spread the outside leads a bit to make it easier to insert them into the board. Do not install Q5 now. It will be installed later.

| *Orient the transistor so its body shape matches the silk-screen outline. Leave the top of the transistor about ½" off the board! The lead length prevents stress on the body and keeps the transistor safe from too much heat during the soldering operation.* | | | |
|---|---|---|---|
| Designation | Type | Description | Done? (✓) |
| Q2 | 2N3904, TO-92 | 60 V NPN bipolar transistor | |
| Q3 | 2N3904, TO-92 | 60 V NPN bipolar transistor | |
| Q4 | 2N3904, TO-92 | 60 V NPN bipolar transistor | |
| Q6 | 2N5401, TO-92 | 150 V PNP bipolar transistor | |
| Q7 | 2N5401, TO-92 | 150 V PNP bipolar transistor | |

*Don't confuse U2 and Q2. They have the same shape, but operate very differently. Get a loupe, and a light, and make sure you haven't put one or the other in the wrong place!*

## *Install the Integrated Circuits*

Install the integrated circuits.

| *Orient U1 so that pin 1 on the chip matches pin 1 on the silk screen.*<br>*Orient U2 to match the silk screen outline.* | | | |
|---|---|---|---|
| Designation | Type | Description | Done? (✓) |
| U1 | LM258 or LM358 | 8 Pin DIP | |
| U2 | TL431, TO-92 | Programmable shunt regulator | |

## *Final Inspection of the Circuit Board*

After you've taken a break, look over your completed circuit board one more time. Looking on the component side, double check:

1. polarity (banded end) of diodes matching the banded end on the silk screen.
2. polarity of C1 (minus sign away from the indicated plus sign on the silk screen).
3. polarity of C2 (per the indicated drawing).

If you get one of these polarities wrong, there is a good chance that the power supply won't work, or there will be damage when you power it up.

Look at the solder side of the board. Make sure that:

1. All component leads are soldered (it's easy to forget one or two, and that will cause either unreliable operation, or no operation at all!)
2. There are no solder bridges between pads which should be isolated. Solder bridges may stop the amplifier from working correctly.

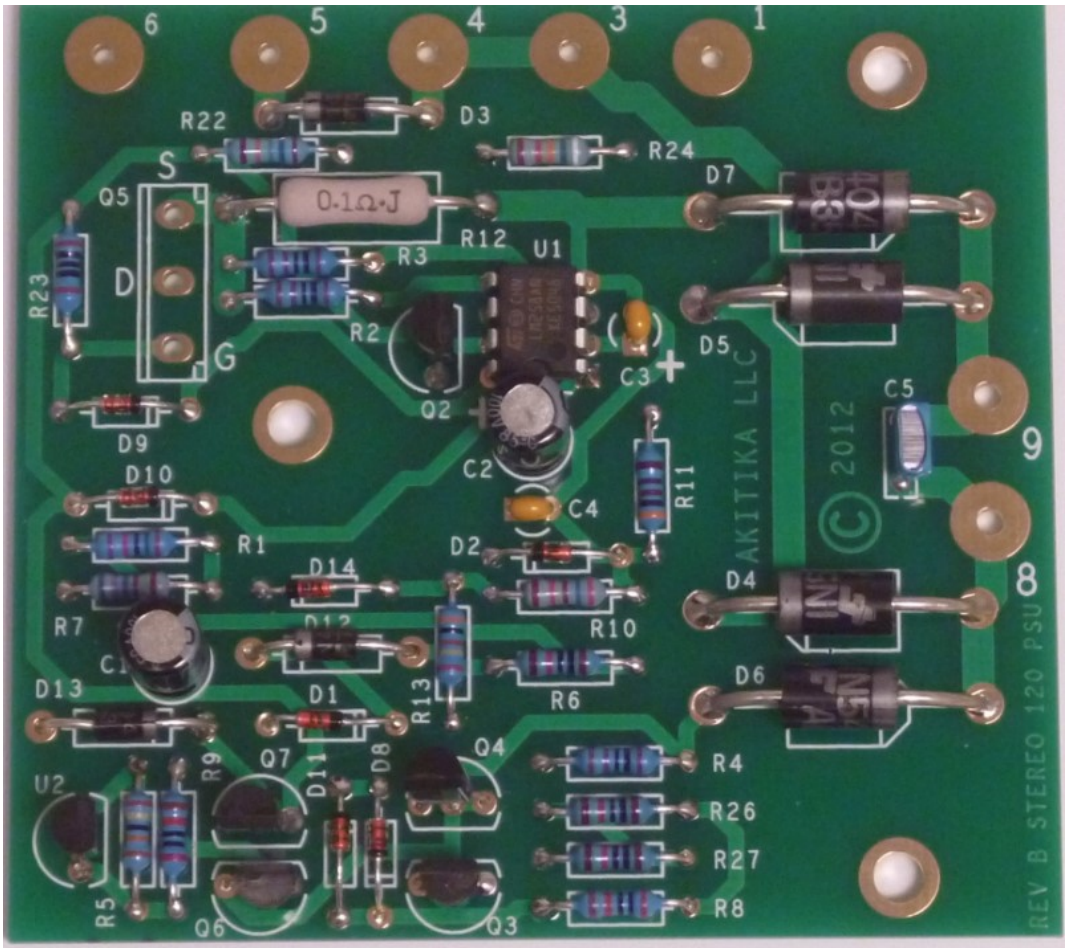



**Figure 7-Completed Circuit Board (to this point)**

## *Final Assembly*

Attach three standoffs to the heat sink as shown in Figure 8 using 6-32x3/8" SEM screws.

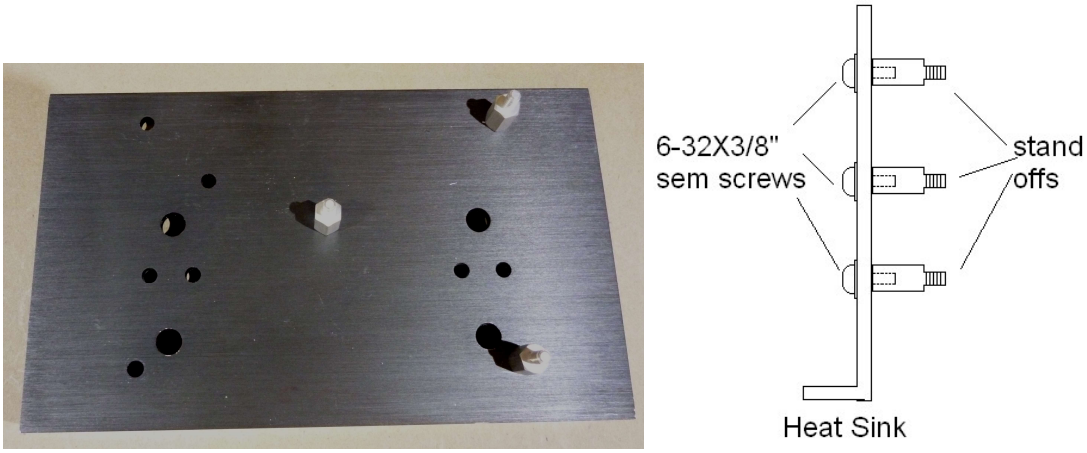



**Figure 8-Installing the stand-offs. Picture on left shows location, picture on right shows side view of assembly detail**

Form the leads of Q5 as shown in Figure 9.

| | | |
|---|---|---|
| Q5 | IRFP250N, TO-247 | N-Ch MOSFET, 200 V @ 30 A |

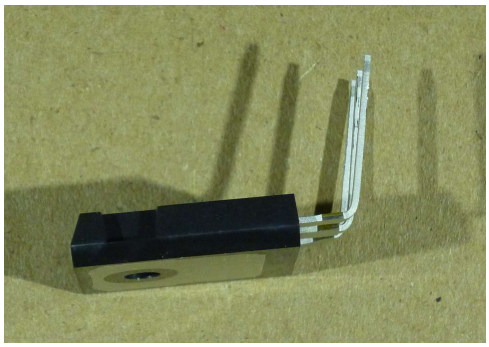


**Figure 9-forming Q5's leads**

Smear a thin film of heat sink compound to the metal tab side of Q5 as shown in Figure 10.

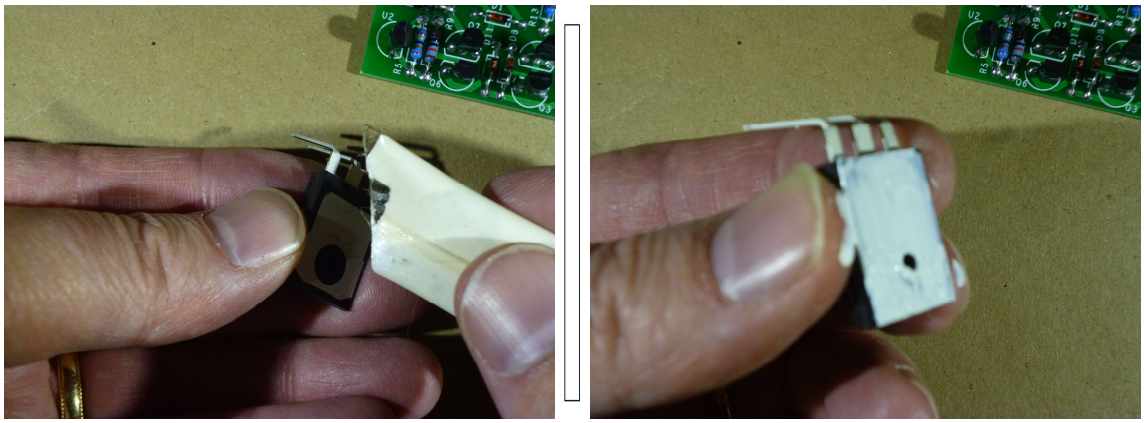


**Figure 10-Apply heat sink compound to metal tab side of Q5**

Use a 6-32x1/2" SEM screw and a 6-32 PEM nut to fasten Q5 to the heatsink as shown in Figure 11. For now, leave the screw and nut a bit loose.

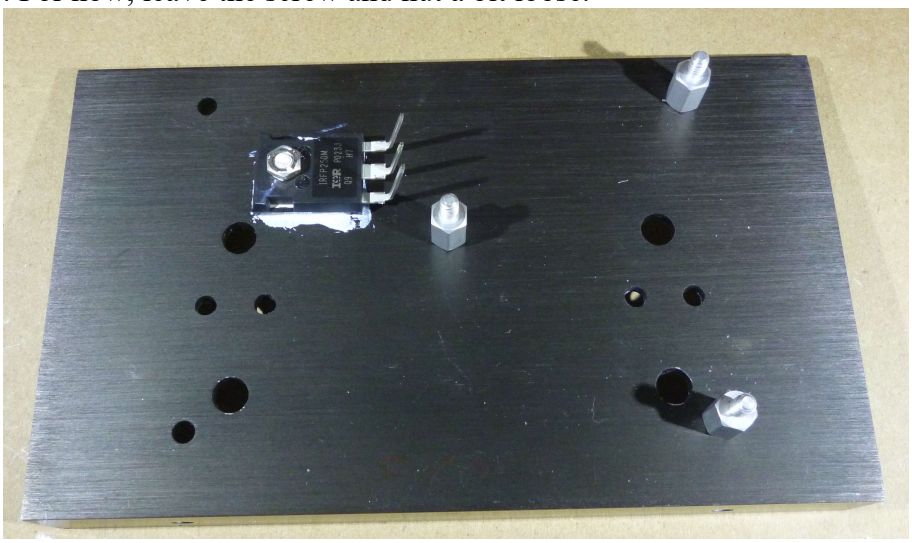


**Figure 11-fasten Q5 to the heat sink as shown**

Fit the assembled circuit board over the leads of Q5, passing the three leads through the holes marked S, G, and D. Wiggle the board so the threaded parts of the standoffs engage the mounting holes on the PC board.

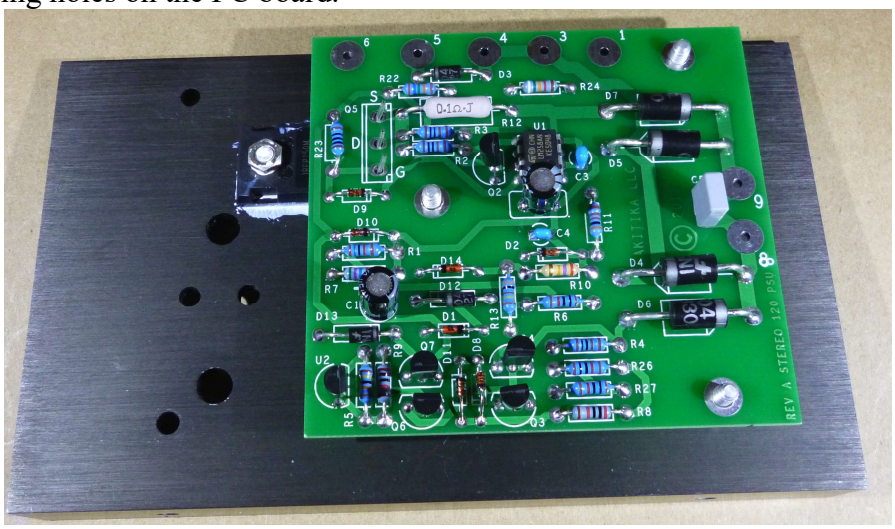


**Figure 12-installing the PC board on the heat sink**

Install and tighten the 3 PEM nuts that hold the PCB to the standoffs. Tighten the screw that holds Q5 to the heat sink. Wiggle it a bit and form its leads to make sure that it lies flat along the heat sink. Solder the source, drain, and gate leads of Q5. Clip the leads about $^{1}/_{8}$ to ¼ inch above the PCB.

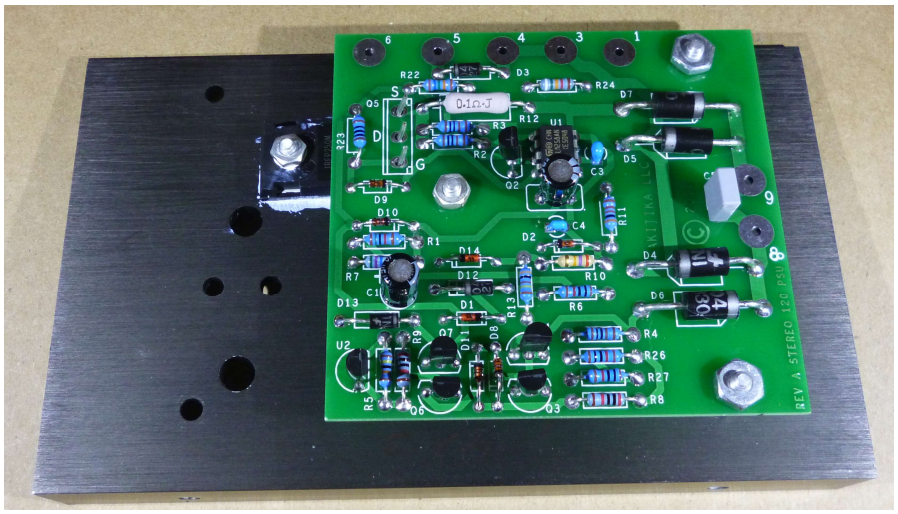


**Figure 13-install and tighten the nuts**

Examine the chassis where the heat sink was installed. If there is old thermal compound present, remove it with Isopropyl alcohol and a paper towel.

| |
|---|
| *Be careful...Isopropyl alcohol and paper towels are a potentially flammable combination*! |

## *Installing the Completed Power Supply and New Capacitors*

In this section, you'll complete installation of the power supply and test the power supply by itself. That limits collateral damage in the case of assembly errors or component problems.

## Installing C9

1. Install C9's replacement, a 3900 µF 100 Volt capacitor, into the bracket that previously held the old C9 (1000 µF 100 Volts). Use the same screw that previously held the capacitor snugly in the clamp. Use the same screws and hardware to fasten the clamp to the chassis. Refer to Figure 2 for the preferred orientation of the plus and negative terminals of C9. You'll find a Red-Blue twisted pair made from 18 AWG solid wire. *Note: Depending upon the vintage of your Stereo 120, you may find it necessary to wind a few turns of electrical tape around the bottom of the new C9 to build up the diameter to fit the old clamp snugly.*
2. Cut a 5 ½" length of the Red-Blue twisted pair, and strip about ¼" from the 4 ends.
    - Solder the blue wire from C9's negative terminal to eyelet 1 of the PCB.
    - Solder the red wire from C9's positive terminal to eyelet 3 of the PCB. ***Double check the last two connections to make sure the polarity is correct!***

Install the 6-32 hardware and foot that hold the power supply heat sink in place. Tighten the hardware finger tight for now.

## Build the C12 Dynamite Capacitor

1. You'll replace C12, a single 2.5" diameter capacitor with three 30 mm diameter capacitors, as shown in Figure 14.

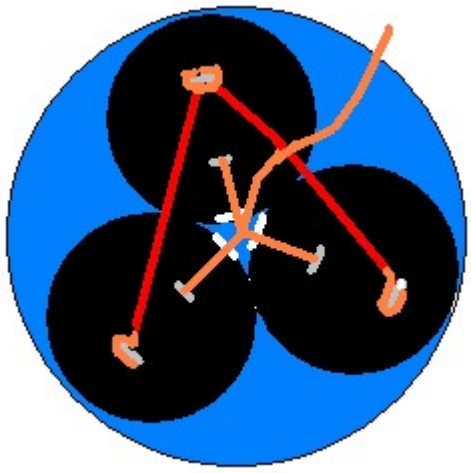


**Figure 14-3 30 mm diameter capacitors take the space of one 2.5" diameter capacitor**

2. Orient the three capacitors with the ***negative*** leads in the center of the grouping.
3. Place a piece of masking tape around the outside of the three capacitors to hold them together. This will make it easier to install the ground and positive wire harnesses.
4. Construct the ground harness for the caps:
    a. Remove 4" of insulation from the supplied 20 AWG wire.
    b. Cut the resulting bare wire into two 2" long pieces.
    c. Twist and shape the wires as shown in Figure 15.

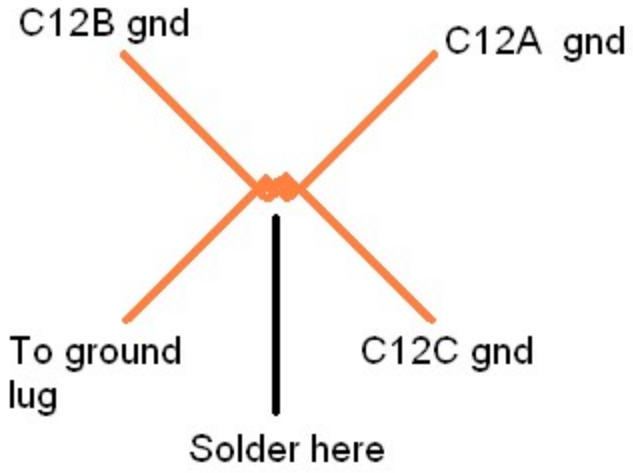



**Figure 15-Ground Harness Configuration**

5. Solder the center section as indicated. Place the soldered portion of the jumper in the center of the dynamite capacitor configuration. Hook the ends of three of the four wires to the three negative terminals of the capacitors. Solder the wires to the negative terminals.
6. Form the remaining wire upward, away from the caps. You'll attach it to the amplifier ground connections in a later step.
7. Prepare the Positive Wire Harness as follows (see Figure 14):
    a. Cut two pieces of red 20 AWG wire, each to a length of 2 ½".
    b. Remove ¼" of insulation from the ends of the wires (4 places).
    c. Form the bare ends into hooks. Crimp the hooks around the positive terminals of the capacitor as shown in Figure 14. Solder the connections, making sure to leave room for additional wires added in later steps.

## Installing the New C12 Dynamite Capacitor Configuration

Now it's time to install the new capacitor arrangement and reconnect the wires. Use Figure 16 to guide the re-wiring of the C12 replacement capacitor.

1. Fit the new dynamite capacitor configuration into the original C12 mounting clamp.
2. When the orientation agrees with Figure 16, snug up the capacitor clamp band. Do not over-tighten it.
3. Remove the masking tape that held the capacitor configuration together.
4. Locate the shorter piece of 18 AWG stranded red/black pair (zip cord). Cut a 5" length, then strip ¼" from the four ends. Tightly twist and tin the four ends.
5. Solder the red wire from C12's positive bus to eyelet 4 of the PCB.
6. Solder the black wire from C12's ground bus to eyelet 6 of the PCB. Place the C12 end of this wire close to the end of the ground wire tail that connects to the capacitor grounds.
7. Inspect your work carefully. Make sure that there is no possible way for wires connected to the positive and negative terminals of the new C12 configuration to come into contact.

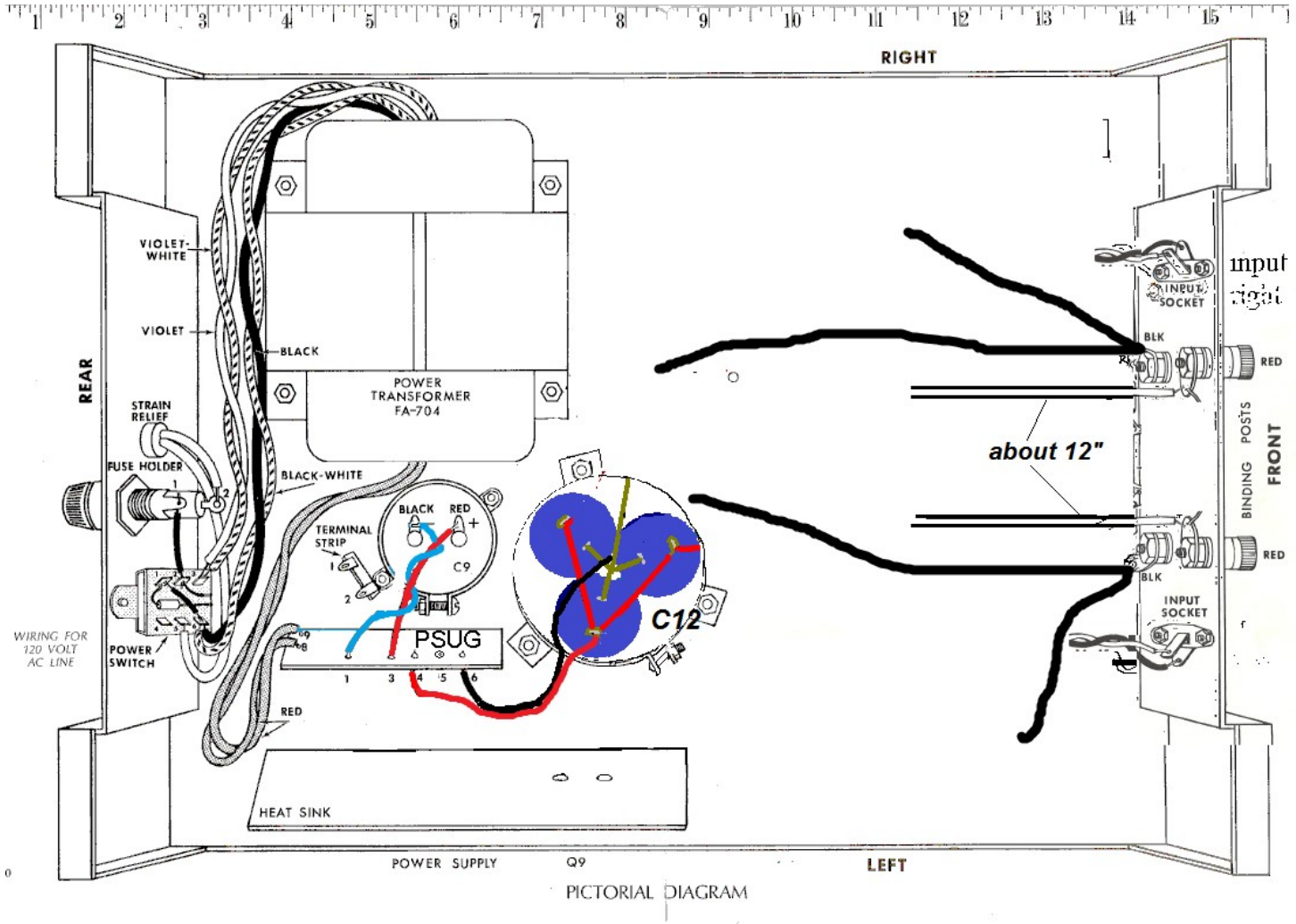



**Figure 16-Power Supply Installation completed**

### Connect the Transformer to the Power Supply

Make sure that the AC power cord is not plugged in.

Here are the wiring steps:

1. Place the power supply heatsink and PCB assembly roughly in position in the amplifier. Don't install the mounting screws that hold the assembly to the chassis.
2. Twist the two transformer red wires together to minimize hum.
3. Solder one red wire from the transformer to eyelet 8 of the PCB.
4. Solder the other red wire from the transformer to eyelet 9 of the PCB.
5. Now, tighten the screws that go through the foot of the heatsink, holding the power supply heatsink and PCB assembly in place.

### Test the Power Supply

Before you begin, make sure to compare your assembly to Figure 16. Double check the polarity of capacitors C9 and C12.

Make sure that the AC power cord is not plugged in. Turn the power switch on. Now, standing well away from the chassis, plug in the AC power cord. There may be a small "bong" sound when you plug the amplifier in, and perhaps a small arc at the wall socket, but there should be no smoke or drama coming from the amplifier chassis.

If after a minute everything seems calm, measure the output voltage. A DC voltmeter connected across C12 should show 72+/-2 volts. If this is the case, unplug the power cord and go on. If the output voltage is wrong, stop and check your work. Please heed the warnings below:

*If the voltage across C12 is out of tolerance, pull the plug and STOP!*

- *Anything outside of the range of 69-75 Volts is considered bad!*
- *More than 76 volts could be hazardous to your amplifier modules!*
- *More than 84 volts will be fatal to your amplifier modules!!!*
- *If you don't have a DC voltmeter...GET ONE! This is not the time to play amplifier roulette!*

## Section 5: Assembling the Amplifier Circuit Boards

This section details the process of building the amplifier module circuit boards. We start with an overview on this page. There are two amplifier modules, one each for the right and left channels. You'll build the first channel, then go back to this page to build the second channel.

Begin by carefully emptying the contents of *one* of the envelopes marked "GT-101 Amplifier Module" into a broad soup bowl, as shown in Figure 17.

In general, you'll start with the components that lay closest to the board, working your way toward the taller components. You will:

1. Install the resistors
2. Install the small capacitors
3. Install the diodes
4. Install the LEDs
5. Install the medium size capacitors
6. Install the transistors
7. Install the big capacitor
8. Wind and install the output inductor.
9. Install the LM3886.

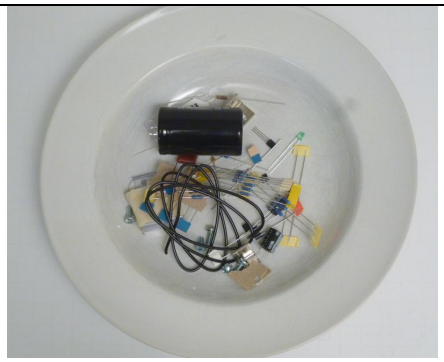


**Figure 17-Empty the amplifier components into a soup bowl**

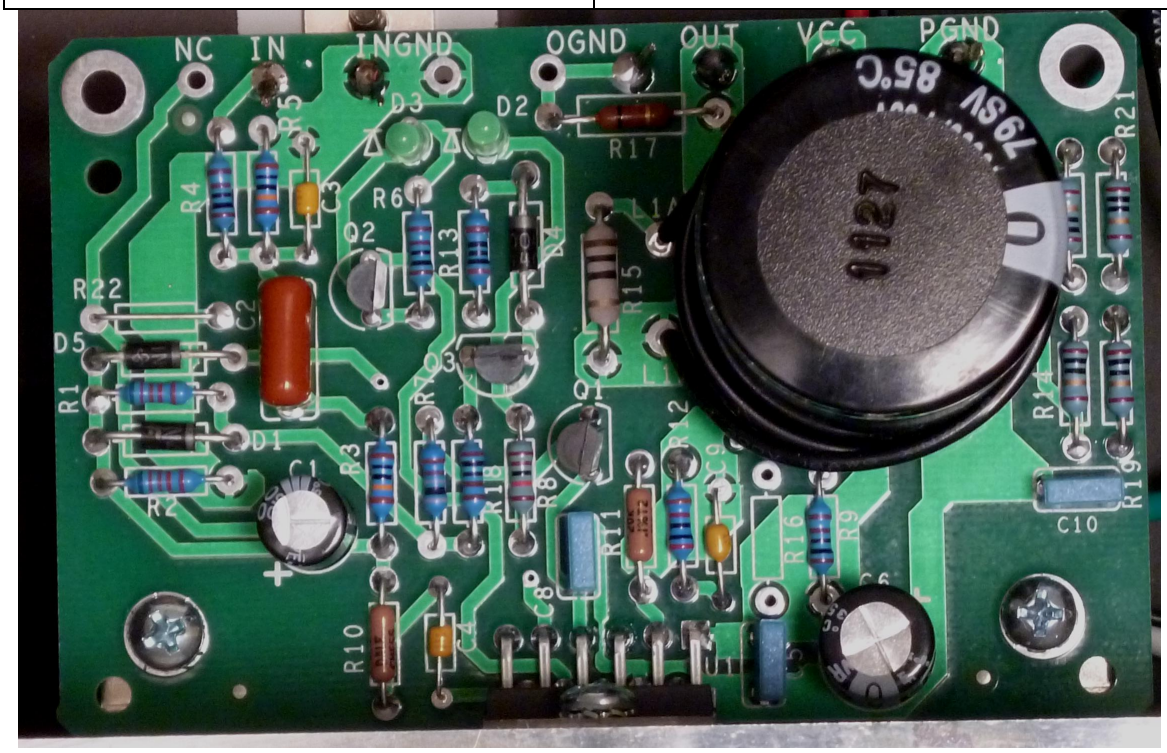



**Figure 18-Closeup of Completed Amplifier board (your big cap may look a bit different)**

## *Install the Resistors*

In general, you install the resistors by placing the body on the silk screen side of the board, and the leads through the indicated holes. Bend the leads over on the back of the board to keep the resistors from falling out until your solder them in place. Try to bend the leads in a direction that won't lead to solder bridges between traces that should remain disconnected.

We recommend the following procedure:

5. Insert all the resistors of the same value, e.g. R14, R19, R20, and R21.
6. Bend the leads as described above.
7. Solder the leads on the back of the board.
8. clip the leads.

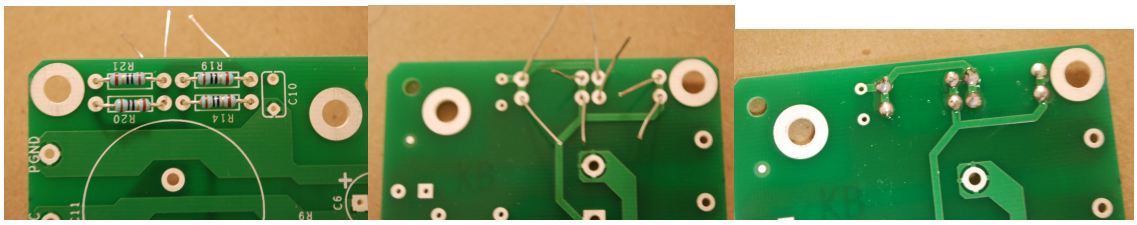



**Figure 19-First four resistors are installed, leads bent on the back side, soldered, then clipped.**

*When you have completed this section, there will only be one empty resistor slot, R16, a no-load, which will remain empty.*

Keep track of your progress by placing a check-mark in the done column as every resistor is installed. The resistor values can be checked with a meter, or by reading the color code[3]. Orient the resistor with the fat brown band on the right, then you can read both the Color Code column and the resistor from left to right.

*You will build two identical channels. We've provided two Done columns, Done1 for the first channel you build, and Done2 for the second channel. We recommend that you build the channels one at a time, completing the first channel, then returning to this point to build the second channel.*

| Designation | Value | Color Code | Done 1 | Done 2 |
|---|---|---|---|---|
| R14 | 10 | Brown, Black, Black, Gold, Brown | | |
| R19 | 10 | Brown, Black, Black, Gold, Brown | | |
| R20 | 10 | Brown, Black, Black, Gold, Brown | | |
| R21 | 10 | Brown, Black, Black, Gold, Brown | | |
| R13 | 100 | Brown, Black, Black, Black, Brown | | |
| R1 | 46K4 | Yellow, Blue, Yellow, Red, Brown | | |
| R2 | 51K1 | Green, Brown, Brown, Red, Brown | | |
| R3 | 100K | Brown, Black, Black, Orange, Brown | | |
| R5 | 100K | Brown, Black, Black, Orange, Brown | | |
| R7 | 9K09 | White, Black, White, Brown, Brown | | |
| R8 | 11K | Brown, Brown, Black, Red, Brown | | |
| R12 | 20K | Red, Black, Black, Red, Brown | | |
| R4 | 1K | Brown, Black, Black, Brown, Brown | | |
| R6 | 1K | Brown, Black, Black, Brown, Brown | | |
| R9 | 1K | Brown, Black, Black, Brown, Brown | | |
| R18 | 1K | Brown, Black, Black, Brown, Brown | | |
| R10 | 1K, 0.1% | Brown, Black, Black, Brown, Violet; In some kits, the resistor may have the numbers: 1K 0.1% on a brown body | | |
| R11 | 20K, 0.1% | Red, Black, Black, Red, Violet In some kits, the resistor may have the numbers: 20K 0.1% on a brown body. | | |

[3] See "Resistor Color Code" on page 32 to see how to read resistor color codes.

| | | | | |
|---|---|---|---|---|
| R17 | 1K (1 Watt) 5% | Brown, Black, Red, Gold (there are less stripes on a 5% resistor)[4] | | |
| R15 | 10 (1 Watt) 5% | Brown, Black, Black, Gold (there are less stripes on a 5% resistor). This resistor has a larger body. | | |
| R16 | | This Location Remains Empty | | |
| R22 | 0 Ohms | Use one of the cut resistor leads from a previous step to span the R22 mounting holes, making a 0 Ohm resistor. | | |
| Note: R8 and R18 are near each other on the board. Be careful not to mix them up! | | | | |

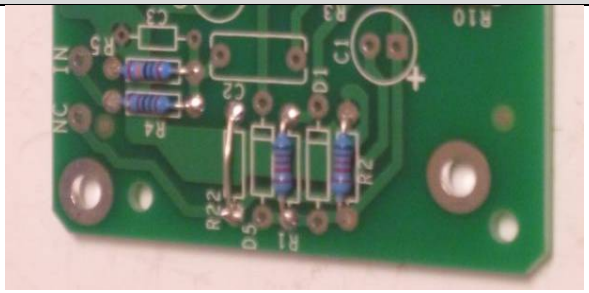



**Figure 20-Zero Ohm R22 installation detail**

## *Install the Small Capacitors and the Diodes*

Now we'll install the following small capacitors:

| Designation | Value | Marking | Done 1 | Done 2 |
|---|---|---|---|---|
| C3 | 220 pF | 221 | | |
| C4 | 220 pF | 221 | | |
| C9 | 47 pF | 470 (some may be marked 47J) | | |

Here's what these three caps look like (not to scale):

Next we install diodes D1, D4 and D5.

| *Be careful! Diodes have a polarity. Make sure the band on the diode aligns with the banded end of the silk screen!* | | | | |
|---|---|---|---|---|
| Designation | Value | Marking | Done1 | Done2 |
| D1 | 1N4004 | 4004 | | |
| D4 | 1N4004 | 4004 | | |
| D5 | 1N4004 | 4004 | | |

Here's what the diodes look like (not to scale):

Next we install LEDs D2 and D3 (Light Emitting Diodes – the green light from these LEDs will be of medium brightness, and thus visible in a normally lit room.

[4] The resistor body of this "1 Watt" resistor seems small to me, but the manufacturer's data sheet swears that it's a 1 Watt resistor. In most cases, it will be called on to dissipate considerably less.

| *Be careful! Light Emitting Diodes have a polarity, also! Read carefully to make sure you're putting the diodes in the right way! The cathode of the LED is indicated by a bar (negative sign) molded into the package. On some packages, there is no bar, but seen from the top, the circular outline with have a flat side. That flat side is the cathode. Finally, if the leads are uncut, the shorter of the two leads will be the cathode.* | | | | |
|---|---|---|---|---|
| Designation | Value | Marking | Done1 | Done2 |
| D2 | T1 style | none | | |
| D3 | T1 style | none | | |

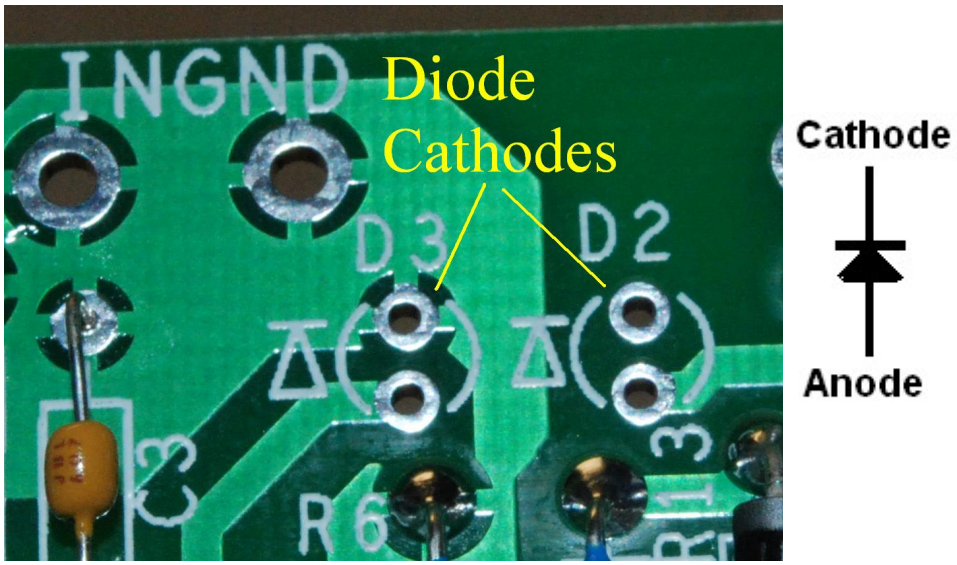



**Figure 21-showing LED cathode orientation**

## *Last Capacitors and the Transistors*

Now, the medium tall polarized electrolytic capacitors:

| *C1 and C6 are polarized. Make sure the negative sign on the capacitors faces away from the positive sign on the silk screen!* | | | | |
|---|---|---|---|---|
| Designation | Value | Marking | Done 1 | Done 2 |
| C1 | 100 µF, 50 V | 100 µF, 50 V, and minus sign for polarity | | |
| C6 | 47 µF, 100 V | 47 µF, 100 V, and minus sign for polarity | | |

And the non-polarized capacitors:

| Designation | Value | Marking | Done 1 | Done 2 |
|---|---|---|---|---|
| C2 | 1 µF, 63 V or 100V | 105K, 63 V or 100V (pillow shaped mylar capacitor) | | |
| C5 | 0.1 µF, 100V | µ1J100, small blue box shape | | |
| C8 | 0.1 µF, 100V | µ1J100, small blue box shape | | |
| C10 | 0.1 µF, 100V | µ1J100, small blue box shape | | |

Install the transistors. Spread the outside leads a bit to make it easier to insert them into the board.

| *Orient the transistor so its body shape matches the silk-screen outline. Leave the top of the transistor about ½" off the board! The lead length prevents stress on the body and keeps the transistor safe from too much heat during the soldering operation.* | | | | |
|---|---|---|---|---|
| Designation | Value | Marking | Done 1 | Done 2 |
| Q1 | 2N5551, NPN | 2N5551 | | |
| Q2 | 2N5551, NPN | 2N5551 | | |
| Q3 | 2N5551, NPN | 2N5551 | | |

Now install the speaker coupling capacitor:

| *Watch the polarity! Make sure the minus sign faces away from the plus sign on the silk screen. That puts the minus side of the cap along the outer edge of the circuit board.* | | | | |
|---|---|---|---|---|
| Designation | Value | Marking | Done 1 | Done 2 |
| C11 | 3300 µF 63V | 3300 µF, 63 WVDC | | |
| C11 will be 10000 µF @ 63V if you have purchased the 10KµF upgrade. The 10 KµF upgrade produces a bit more bass with lower distortion. | | | | |

The speaker coupling capacitor will either snap or push into place. Verify once more that you have polarity correct, and then solder both speaker terminals to the circuit board. This will probably take more heat, time, and solder than anything you have soldered up to now.

## *Winding the Output Inductor*

This step takes just a bit of finesse, but if you've come this far, you have nothing to worry about. If you're a bit frazzled, take a break before proceeding.

There...feel better? OK, let's go. Just follow these steps, ***measuring the wire length carefully if you want to succeed the on first shot***.

1. Locate the 30" piece of 18 AWG solid wire supplied in each amplifier envelope. The color may well vary from kit to kit. Straighten it out in preparation for a precise measurement. Hint: An easy way to straighten the wire is to essentially play "tug-of-war" with the wire. Two people, and two pairs of pliers works well. One person, a bench vise, and a pair of pliers also works well. The wire will actually lengthen a little as you tug it. Don't stretch it more than about ¼".
2. Cut a 24 3/8" length of the straightened 18 AWG solid wire. The length supplied with be about 30", so you'll have to carefully measure and cut the wire.
3. Strip back 3/8" of insulation from both ends of the wire. Be careful not to nick the conductors.
4. From the component side, place one stripped end of the wire into the L1A terminal. Route it around the output capacitor as shown in (see Figure 22) Solder the wire into the L1A hole.
5. Wind 6 turns of wire, closely spaced, so it looks like Figure 23. When you get to the end of the coil, fold the end across the existing turns, toward the L1B hole.
6. Pull the end of the wire through the L1B hole, and solder it on the back of the board.

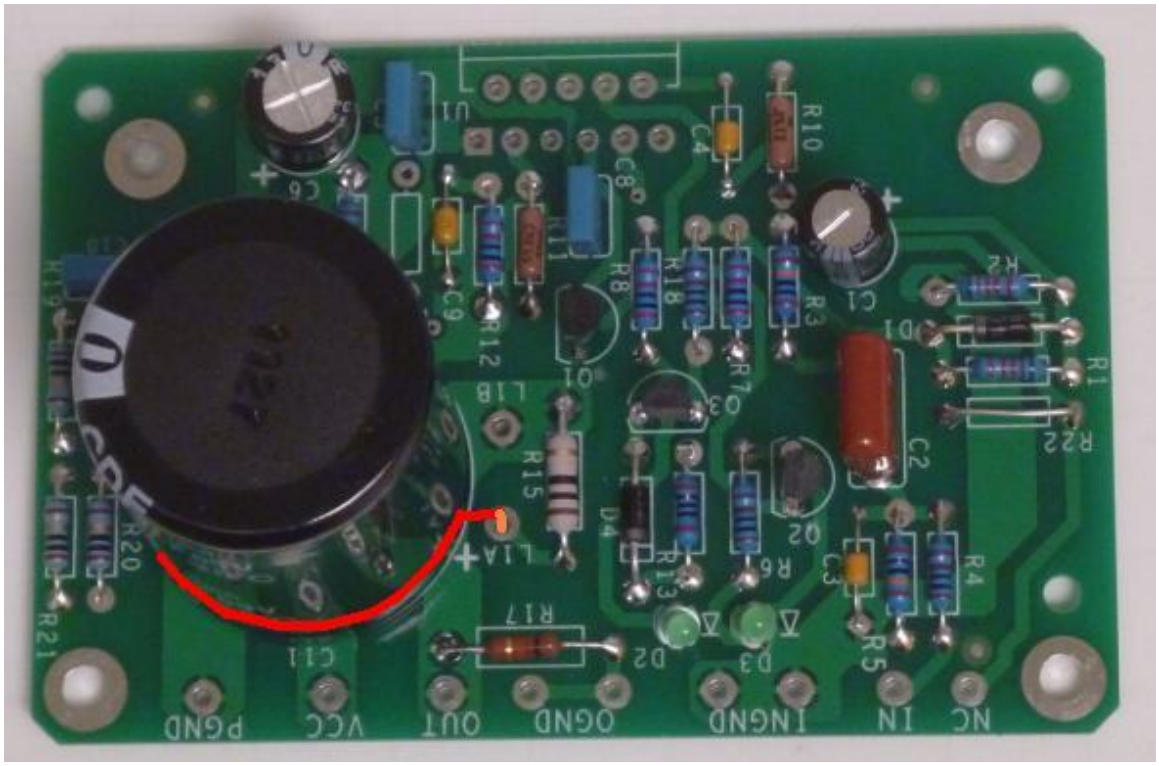



**Figure 22-Starting to wind the output inductor**

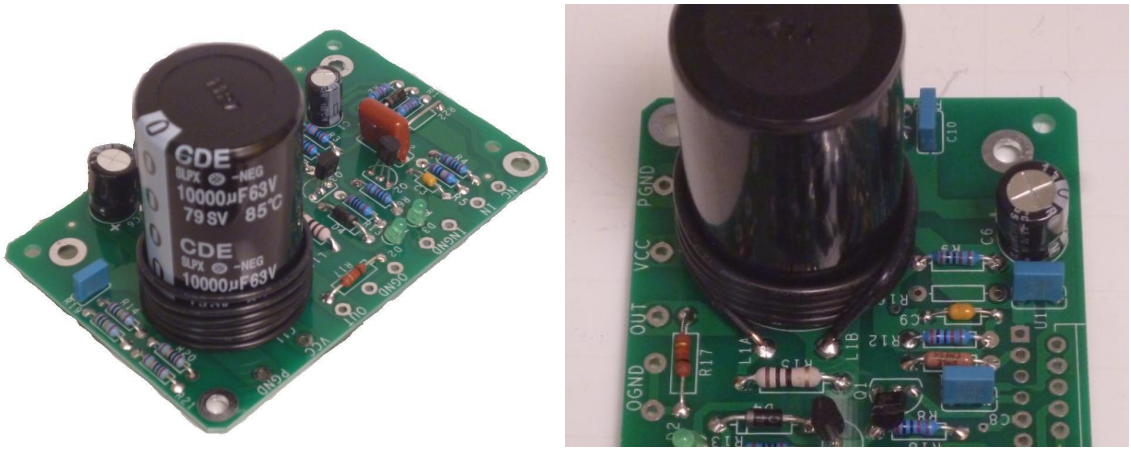



**Figure 23-finishing step for the output inductor**

## *Final Amplifier Module Assembly and LM3886 Installation*

### Mounting the PCB to the Super-duper Heatsinks

These are the last steps in building the circuit. Refer to Figure 24. You'll first mount the PCB to the heatsink, then install the LM3886.

1. Fasten the brackets to the PCB using 6-32x1/4" screws.
2. Square up the PCB/bracket assembly to the heat sink. Use the #6-32x3/8" screws to fasten the brackets to the heat sink. Note that the hole in the bracket that adjoins the heatsink is a clearance hole.

3. Cut a corner of the thermal compound packet. If you use it appropriately, that's enough to do everything you need. Place a line of thermal compound onto the back of the LM3886. Use your finger to smear the line into a thin film covering on the back of the LM3886. Save the rest of the thermal compound for other steps in the assembly.
4. Insert the LM3886 into the PCB and against the heat sink using a 6-32x3/8" screw (Figure 24).
5. Make sure that the LM3886 leads sit evenly above the board. There should be some daylight between the bottom row of pins and the board (Figure 25), and the pins should protrude evenly on the solder side.
6. When the LM3886 looks square tighten all the screws, especially the screw that holds the LM3886 to the heat sink. Both the tab and heat sink are metal, so you can tighten it firmly.
7. Solder just the corner pins, and recheck the assembly for squareness and pin protrusion.
8. When everything looks good, solder the rest of the LM3886 pins.
9. Use 6-32x3/8" screws to attach the two mounting foot brackets to the cleared spaces on the finned side of the heat sink. Note that the screw passes through a clearance hole in the bracket. The remaining bracket hole is tapped to accept a 6-32 screw that will be installed at a later step.
10. Repeat the process to build the amplifier module for the second channel.

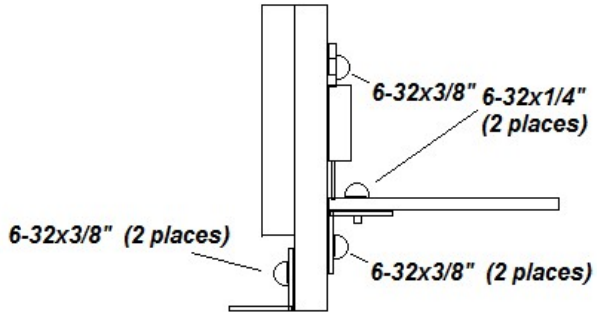



**Figure 24-Assembling the circuit board to the super duper heat sink**


**Figure 25-The LM3886 sits up off the board to avoid shorts between the front and back rows of pins. The body should be at right angles to the circuit board**

*Carefully inspect your soldering. Make sure that all pins of the LM3886 are soldered, and that there are no solder bridges between pins. Inspect the board from both the top and the bottom!*

### *Final Inspection of the Circuit Board*

After you've taken a break, look over your completed circuit board(s) one more time. Looking on the component side, double check:

1. polarity (banded end) of D1 and D4 matching the banded end on the silk screen.
2. polarity (flat end, or molded bar end) of LEDS D2 and D3, placed toward the outside edge of the board.
3. polarity of C1 (minus sign away from the indicated plus sign on the silk screen).
4. polarity of C6 (minus sign away from the indicated plus sign on the silk screen).
5. polarity of C11 (minus sign close to the edge of the board).

If you get one of these polarities wrong, there is a good chance that the amplifier won't work, or there will be damage when you power it up.

Look at the solder side of the board. Make sure that:

1. All component leads are soldered (it's easy to forget one or two, and that will cause either unreliable operation, or no operation at all!)
2. There are no solder bridges between pads which should be isolated. Solder bridges may stop the amplifier from working correctly.

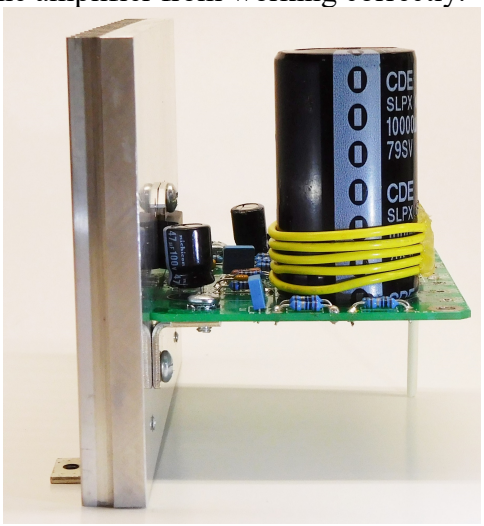



**Figure 26-completed amplifier module mounted on the heatsink**

## Section 5: Wiring in the Updated Amplifier Modules

This section gives the steps needed to wire the new modules into your old amplifier. Here's the plan:

1. Revise the grounding system
2. Connect the power
3. Complete the grounding system
4. Replace the left and right channel input wiring.
5. Connect all the wires to the amplifier modules.
6. Fasten the amplifier modules in place.

## *Revise the Grounding System*

We're revising the grounding system for two reasons. First, after a number of years, some of the connections may need to be refreshed to make good contact. Second, these changes can reduce the hum to very low levels. Please refer to Figure 27.

Use one of the supplied #6 lugs to create the new grounding arrangement. Make the following three connections to the lug prior to installing it into the chassis.

1. Connect the short black wire from the left black binding post.
2. Connect the short black wire from the right black binding post.
3. Cut a piece of the supplied 18 AWG stranded black wire to run from the lug to the ground connection of C12.

Solder all three wires to the lug, then use a recovered 6-32 nut and bolt to fasten the lug to the chassis as shown in Figure 27. The two remaining black wires that connect to the binding posts will be used in a later step.

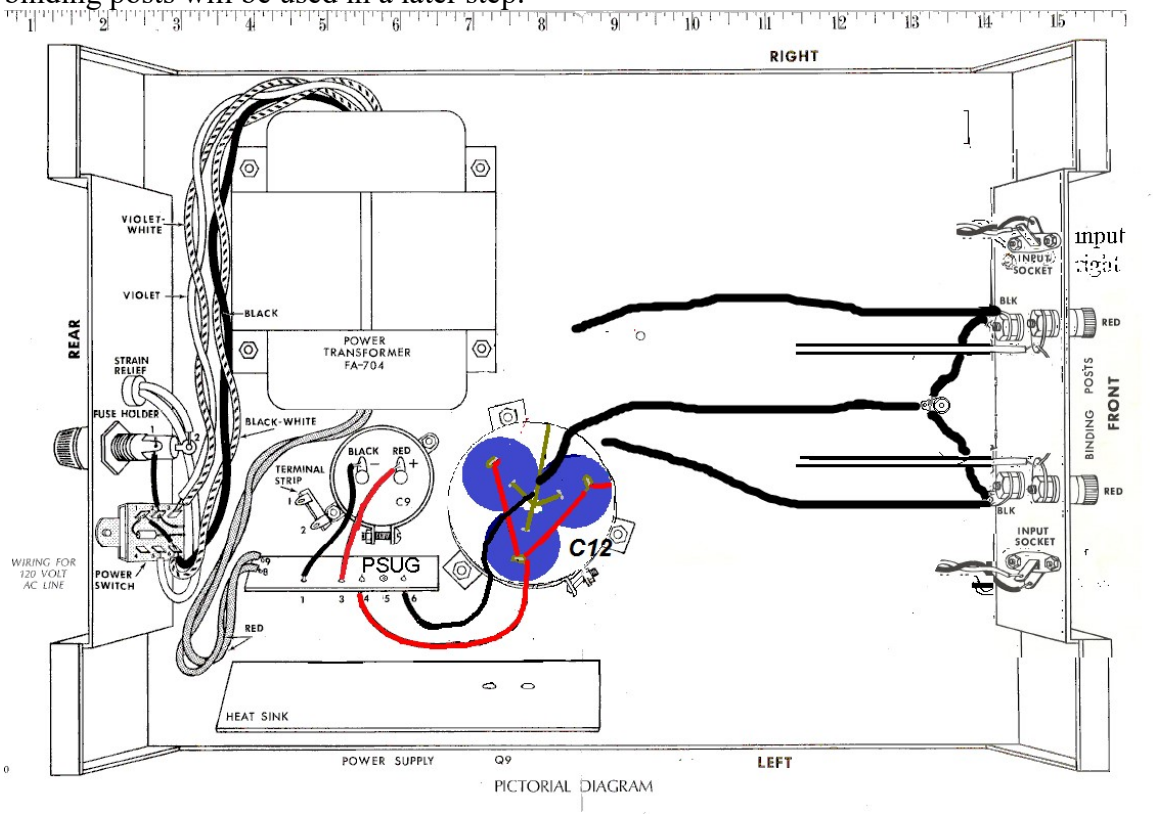



**Figure 27-Rewiring Half the Grounds**

## *Revise the Power System*

Please refer to Figure 28.

*Warning: Do not connect power to the amplifier modules unless you are sure that the power supply output voltage is less than 76 Volts!*

1. Cut the supplied 24" length of red-black wire into two 12" lengths.
2. For the first 12" piece, remove 1/4" of insulation from the red and black wires at one end.
3. Repeat this for the second 12" piece of red and black wire.

4. Wrap the red wire of the first red-black wire around one of the C12 terminals as shown in Figure 28.
5. Wrap the red wire of the second red-black wire around the other of the C12 terminals as shown in Figure 28.
6. Wrap the black wire of the first red-black wire around the bare wire that connects to C12's negative terminal, closest to the already-connected ground wire from the Power Supply.
7. Wrap the black wire of the second red-black wire around the bare wire that connects to C12's negative terminal, next to the previous wire.
8. Solder all the connections to C12. Note that these connections may require more heat and solder than the typical connection.

## *Wiring the Inputs*

*Note: These directions assume that you are using the original, non-isolated RCA jacks. These jacks make a ground connection to the chassis. If you are using isolated RCA jacks, or if your RCA jacks are original jacks held in with rivets and the rivets are loose, then you must add the two wires shown in* Figure 30.

1. Right Channel – Remove the old wires from the input connector.
    a. Take one black-white twisted pair and cut it to a 4" length[5].
    b. Strip ¼" of insulation off both sides of the two wires.
2. Connect the black/white twisted pair to the right channel input jack.
    a. Solder the black wire to the shorter terminal (ground).
    b. Solder the white wire to the longer terminal
3. Left Channel – Remove the old wires from the input connector.
    a. Cut the second black-white twisted pair to a 5.5" length.
    b. Strip ¼" of insulation off both sides of the two wires.
4. Connect the black/white twisted pair to the Left channel input jack.
    a. Black wire to the shorter terminal (ground)
    b. White wire to the longer terminal

[5] This may seem a bit long to you, but lets you position the modules for inspection or re-work without unsoldering the input wires. Feel free to make these wires shorter once you are comfortable with the amplifier's performance.

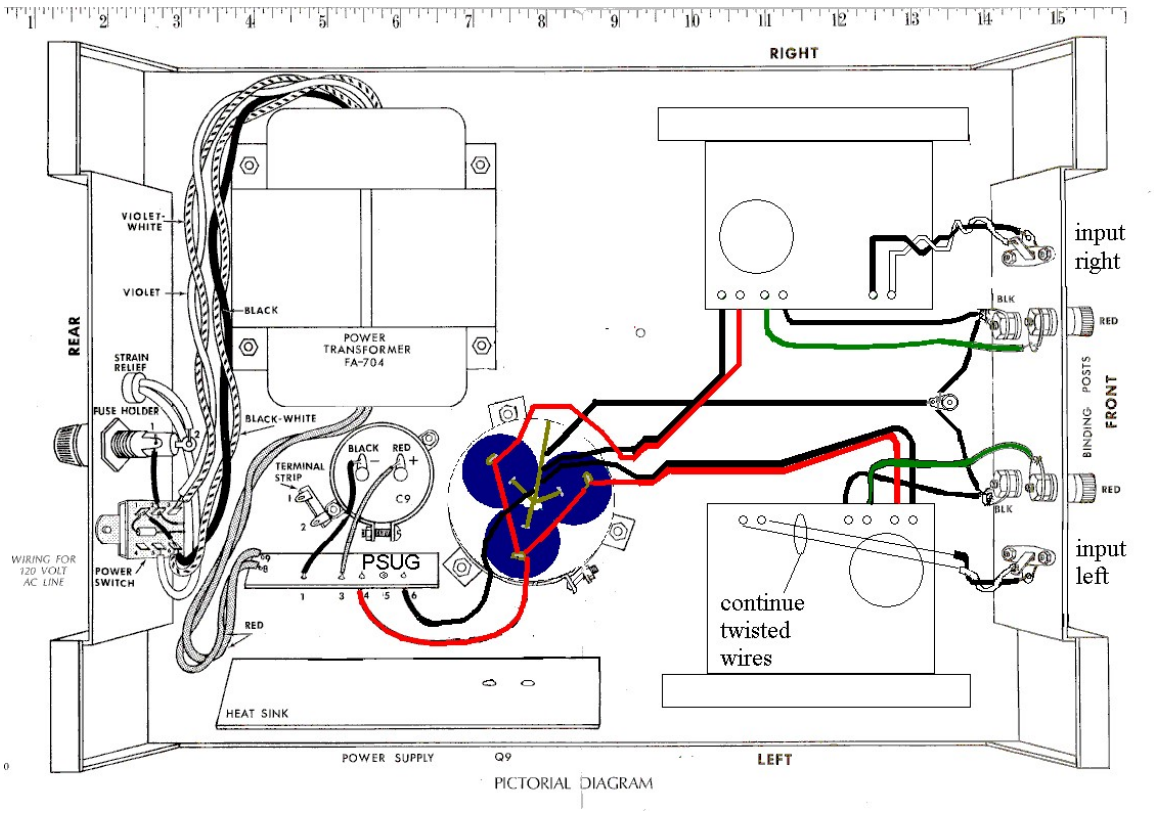



**Figure 28-completed wiring**

## *Wiring the Outputs*

Both red speaker output terminals should have 16 AWG white wires still connected. (For clarity, this is shown in green in Figure 28.)

1. Form the left channel wire toward the place where the left channel amplifier module will sit.
2. Form the right channel wire toward the place where the right channel amplifier module will sit.

## *Connecting the Left Channel Amplifier Module*

1. Set the left channel amplifier board and heat sink assembly in place. Don't mount it to the chassis yet. Note that the new PCB should face the center of the amplifier chassis.
2. Select one red-black pair connected to C12 to power the left channel board:
    a. From the solder side of the board, insert the left channel red wire through the left channel VCC eyelet and solder it on the component side.
    b. From the solder side of the board, insert the left channel black wire through the left channel PGND eyelet and solder it on the component side.
3. For the black and white twisted pair that brings signal to the left channel board:
    a. From the component side of the board, insert the left channel black wire through the left channel INGND eyelet and solder it on the solder side.
    b. From the component side of the board, insert the left channel white wire through the left channel INPUT eyelet and solder it on the solder side.

4. Dress the remaining black wire coming from the left channel black speaker binding post to one of the OGND terminals of the left channel amplifier. Cut it to length and remove ¼" of insulation. Insert it into the OGND terminal from the solder side of the board, and solder it on the component side of the board.
5. Dress the white wire from the left channel red speaker binding post to the OUT eyelet of the left channel amplifier. Remove ¼" of insulation, and insert the wire from the solder side. Solder on the component side.
6. Check your work. The following eyelets on the PCB should each have a wire:
    a. VCC (red wire of the red-black pair)
    b. PGND (black wire of the red-black pair)
    c. IGND (black wire of the black-white twisted pair)
    d. INPUT (white wire of the black-white twisted pair)
    e. OGND (black wire from the left channel black speaker binding post)
    f. OUTPUT (wire from the left channel red speaker binding post).
7. Make sure that the bottom lip of the heat sink is clean, and also the place where it mounts to the chassis. Place a line of thermal compound along the bottom of the short part of the heat sink. Smear it into a thin film using a finger.
8. Mount the heat sink to the chassis using salvaged 6-32x1/2" hardware. Remember that the outside mounting screw also carries a mounting foot.

## *Connecting the Right Channel Amplifier Module*

1. Set the right channel amplifier board and heat sink assembly in place. Don't mount it to the chassis yet. Note that the new PCB should face the center of the amplifier chassis.
2. Select one red-black pair connected to C12 to power the right channel board:
    a. From the solder side of the board, insert the right channel red wire through the right channel VCC eyelet and solder it on the component side.
    b. From the solder side of the board, insert the right channel black wire through the right channel PGND eyelet and solder it on the component side.
3. For the black and white twisted pair that brings signal to the right channel board:
    a. From the component side of the board, insert the right channel black wire through the right channel INGND eyelet and solder it on the solder side.
    b. From the component side of the board, insert the right channel white wire through the right channel INPUT eyelet and solder it on the solder side.
4. Dress the remaining black wire coming from the right channel black speaker binding post to one of the OGND terminals of the right channel amplifier. Cut it to length and remove ¼" of insulation. Insert it into the OGND terminal from the solder side of the board, and solder it on the component side of the board.
5. Dress the white wire from the right channel red speaker binding post to the OUT eyelet of the right channel amplifier. Remove ¼" of insulation, and insert the wire from the solder side. Solder on the component side.
6. Check your work. The following eyelets on the PCB should each have a wire:
    a. VCC (red wire of the red-black pair)
    b. PGND (black wire of the red-black pair)
    c. IGND (black wire of the black-white twisted pair)

d. INPUT (white wire of the black-white twisted pair)
e. OGND (black wire from the right channel black speaker binding post)
f. OUTPUT (wire from the right channel red speaker binding post).

7. Make sure that the bottom lip of the heat sink is clean, and also the place where it mounts to the chassis. Place a line of thermal compound along the bottom of the short part of the heat sink. Smear it into a thin film using a finger.
8. Mount the heat sink to the chassis using salvaged 6-32x1/2" hardware. Remember that the outside mounting screw also carries a mounting foot.

# Section 6: Testing the Completed Amplifier

It's best to test the completed amplifier one step at a time. In that manner, if you have something wrong, you may damage the amplifier module, but you won't damage your speakers.

## *Test #1*

1. Disconnect signal inputs and speakers from the amplifier.
2. Turn the power switch off.
3. Plug in the amplifier.
4. Turn the power switch on.
5. Observe the amplifier for a minute.
    a. It will make a "bong" sound when you turn on the power switch, but after that about all you should hear is a soft humming sound from the power transformer.
    b. Watch for smoke. There should be no smoke. If you see smoke, turn off the amplifier immediately, take a few deep breaths, and refer to the troubleshooting section.
    c. Feel the heat-sinks. There should be no appreciable heating.
6. In a normally lit room, you should see that both pairs of LEDs are on.

If this all goes well, (no smoke or excess heating) leave the power on and move on to Test #2.

## *Test #2*

1. If you have a DC voltmeter, check the voltage on the speaker outputs.
    a. Left channel red to black binding post should show a DC voltage of less than 100 mV if the amp has been on for about 1 minute[6]. The longer the amp is on, the lower the DC output voltage will be.
    b. Repeat this test for the Right channel speaker binding posts.

If this result is ok, go on to test 3. If this result is not correct (e.g. speaker binding posts have a few volts of DC after the amp has been on for more than 1 minute), then re-check:

- Polarity of C11 (the large 10,000 uF 63V capacitors on the power amplifier PCB's)
- R17 is installed and has the correct value (1000 Ohms)

[6] The DC voltage will drop to very nearly zero in 15 seconds if a speaker is connected.

- That one of the OGND terminals has a ground wire installed.

## *Test #3*

1. Hook speakers up to the binding posts. There may be a very soft click as you hook up the speaker.
2. The speakers should be rather quiet at this point, perhaps with barely audible hiss or hum if you place your ear near sensitive speakers. Any more noise than this probably indicates either an assembly error or a power supply problem.

## *Test #4*

1. Turn off the amplifier power.
2. Connect your preamp output to the power amplifier input.
3. Turn down the preamp volume.
4. Turn on the amplifier power. You may hear a soft click or thump from your speakers.
5. After about 15 seconds, turn up the preamp volume to the desired listening level, and enjoy your amplifier.

The amplifier has special slow turn-on features that avoid pops and clicks in the speakers at turn-on without the need for relays. The DC bias voltages in the amplifier will thus take 30 seconds or so to reach steady state. During that time, you may hear some distortion. Don’t worry, it will clear up perfectly in 30 seconds unless you are over-driving the amp, or something is wrong. Think of it like a tube amp...it takes 30 seconds to warm up.

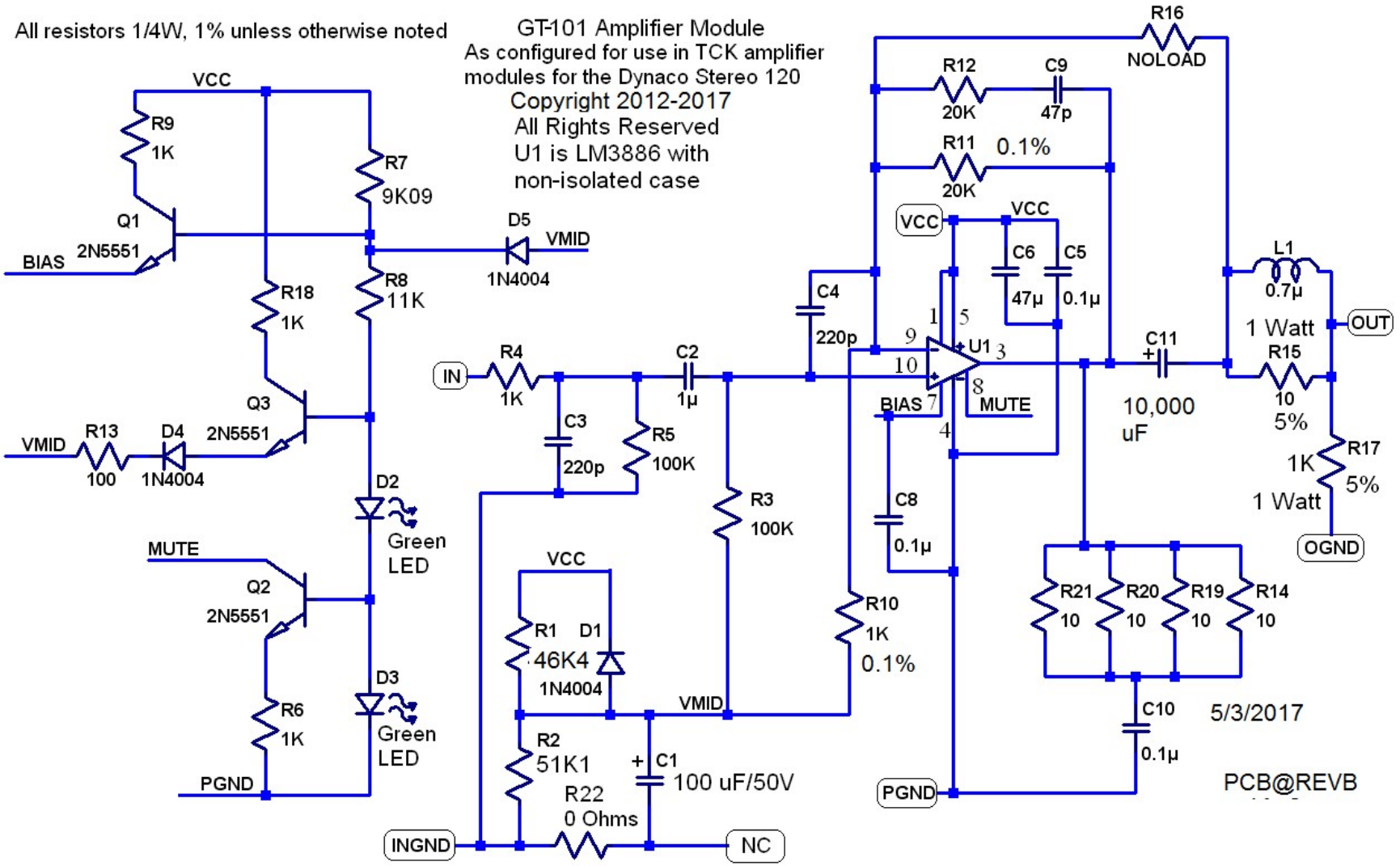



**Figure 29-Schematic of amplifier module**

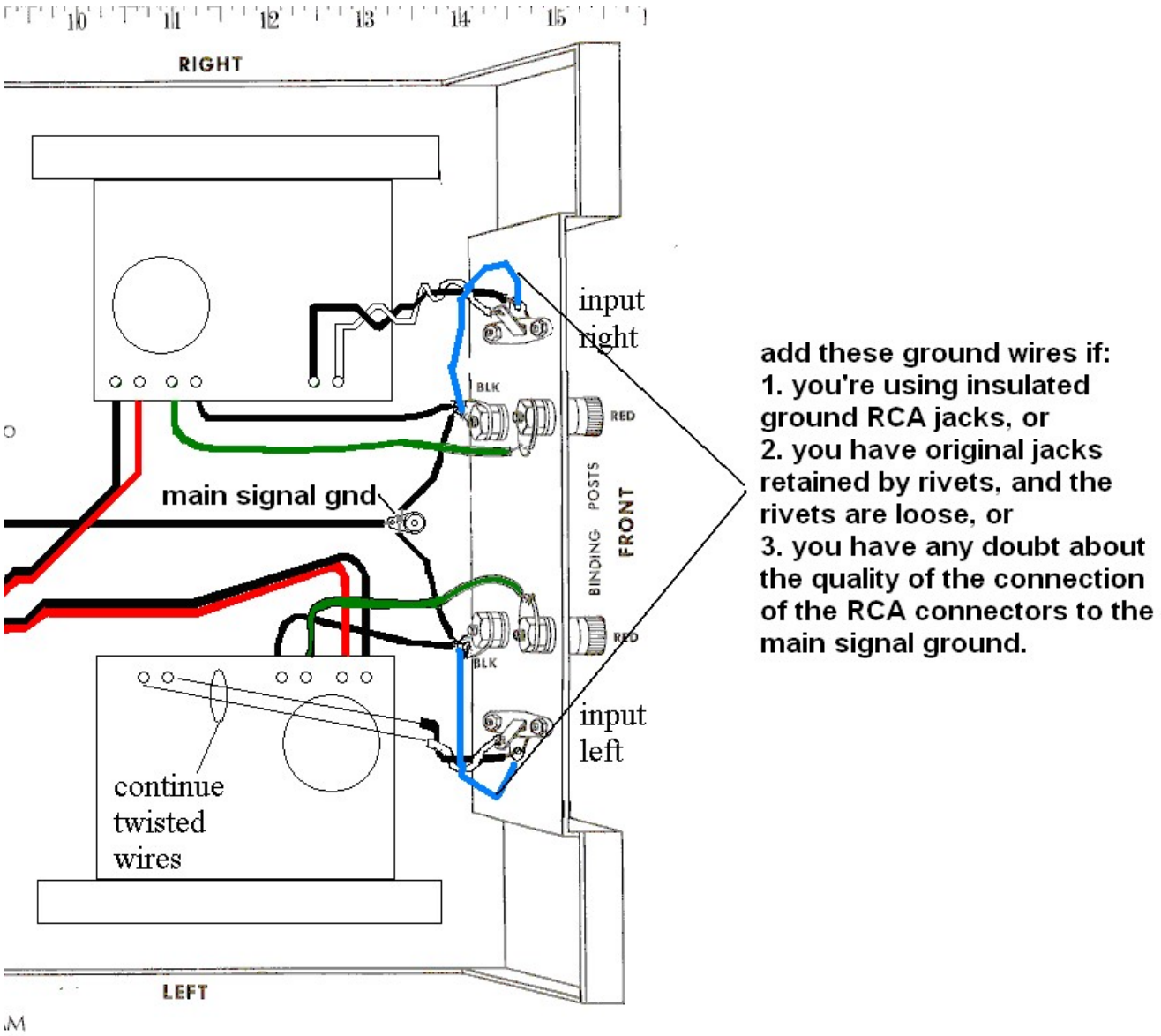



**Figure 30-Optional Input Ground Wires are shown in blue**

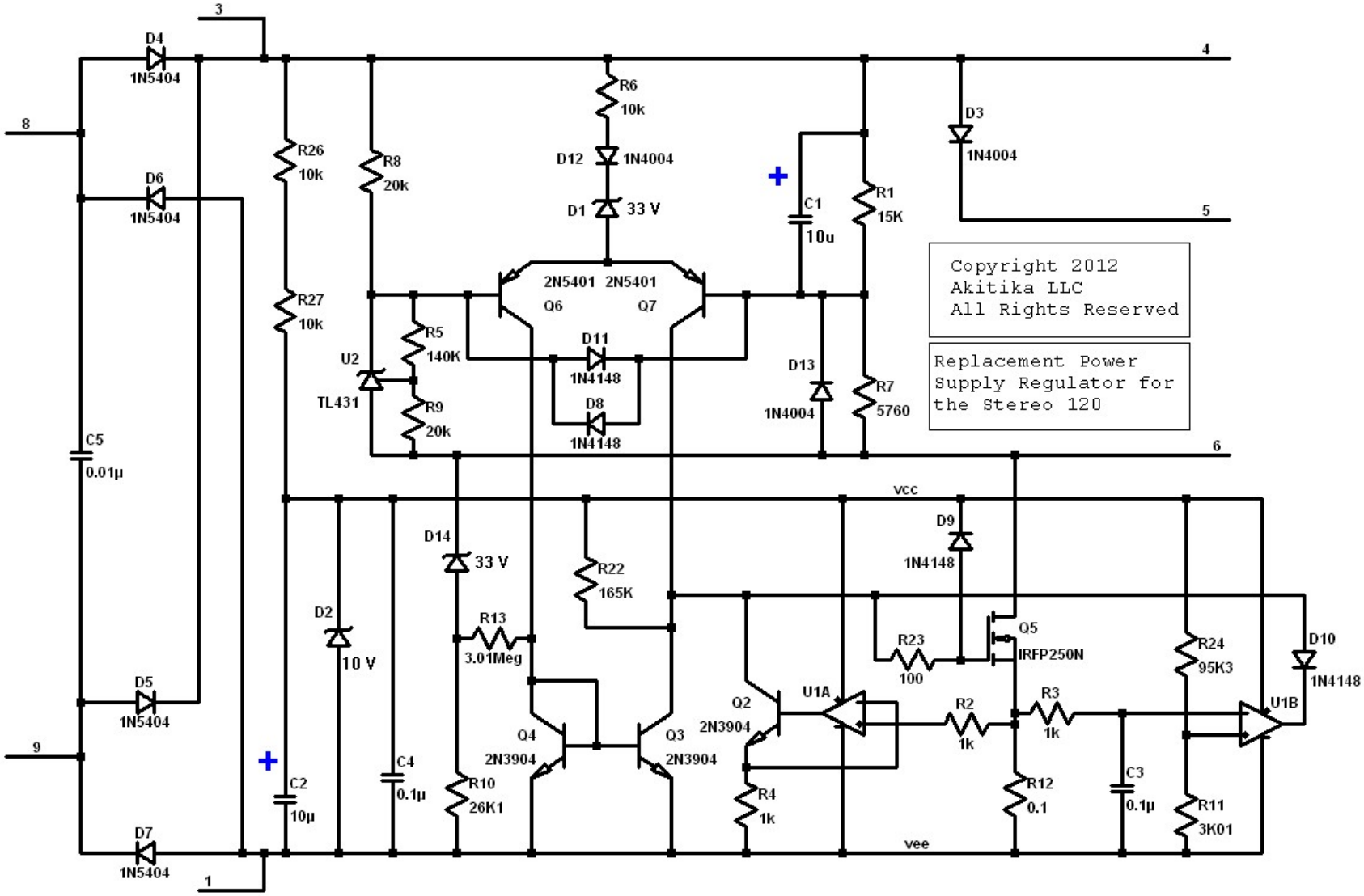



**Figure 31-Power Supply Schematic**

## *Resistor Color Code*

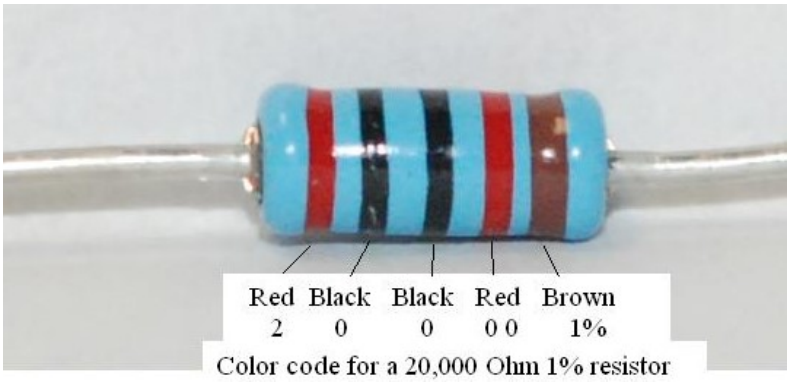



**Figure 32-demonstrating the resistor color code**

Here's an extreme close-up of a ¼ W metal film 20K (20,000) Ohm resistor, designated by the standard resistor color code.

The colors map to numbers:

| Color | Number |
|---|---|
| Black | 0 |
| Brown | 1 |
| Red | 2 |
| Orange | 3 |
| Yellow | 4 |
| Green | 5 |
| Blue | 6 |
| Violet | 7 |
| Gray | 8 |
| White | 9 |

The color band positions have the following meaning (5-band, 1 % resistors):

| Position | Meaning |
|---|---|
| 1 | Left-most Digit (e.g. most significant) |
| 2 | Next digit to the right |
| 3 | Next digit to the right. |
| 4 | Number of zeros that follow the three digits, unless:<br>• Band 4 is gold => multiply by 0.1<br>• Band 4 is silver=> multiply by 0.01 |
| 5 | Tolerance:<br>• Violet (purple) =>0.1%<br>• Brown =>1%<br>• Red => 2%<br>• Gold=> 5%<br>• Silver=>10%<br>• No band=>20% |