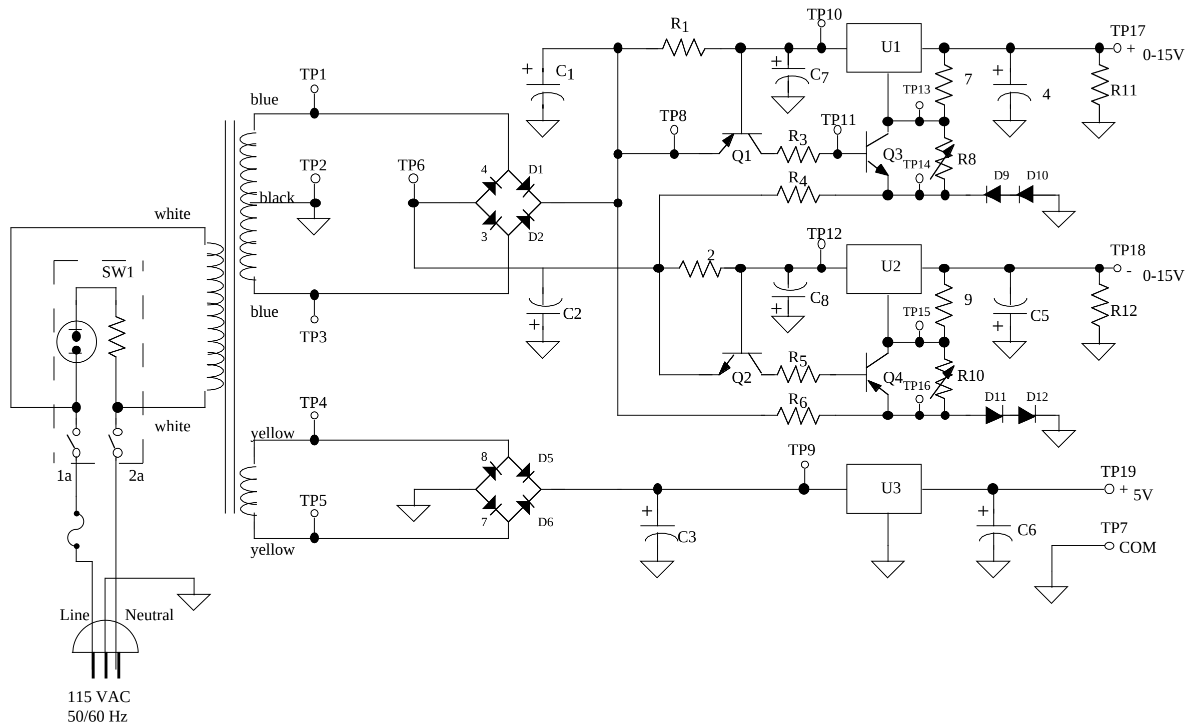
# SCHEMATIC OF GRAYMARK 808 POWERED BREADBOARD




D1 1N5399
D2 1N5399
D3 1N5399
D4 1N5399
D5 1N5399
D6 1N5399
D7 1N5399
D8 1N5399
D9 1N4148
D10 1N4148
D11 1N4148
D12 1N4148

Q1 9015 transistor
Q2 9014 npn transistor
Q3 9014 npn transistor
Q4 9015 transistor

U1 LM317 voltage regulator
U2 LM337 voltage regulator
U3 LM309 voltage regulator

R1 1Ω, 1 watt
R2 1Ω, 1 watt
R3 6.8KΩ, 1/4-watt
R4 2.2kΩ, 1/4- watt
R5 6.8KΩ, 1/4-watt
R6 2.2kΩ, 1/4- watt
R7 340Ω, 1/4-watt
R8 5kΩ potentiometer
R9 340Ω, 1/4-watt
R10 5kΩ potentiometer
R11 1.5kΩ, 1/4-watt
R12 1.5kΩ, 1/4- watt

C1 1000µf
C2 1000 µf
C3 4700 µf
C4 10µf
C5 10µf
C6 10µf
C7 10µf
C8 10 µf

NOTE: If you have to replace any of your transistors the 9015 in the kits can be replaced by either the 2N2907 or 2N3906 or almost any other pnp small signal transistor. The 9014 can be replaced by either the 2N2222 or 2N3904 or almost any other npn transistor. The 1N5399 diodes can be replaced by almost any power diode. The diodes in the 1N400X (i.e., 1N4001, 1N4002, etc.) family are readily available and acceptable substitutes. The 1N4148 diodes can be replaced by any common switching diode such as a 1N914.

## TESTING COMPONENTS

One of the most common problems encountered in building the Graymark 808 power supply kits is a defective component.

You should check all the resistors for correct values (use a DMM set to measure ohms) before you solder them into your circuit. Last year, we found several resistors which were open, i.e., their resistance was infinite, which were hard to find in the soldered circuit board.

Diodes and transistors can be readily checked in or out of circuit as described below. Diodes are readily checked with an ohmmeter. Using an ohmmeter measure the resistance of the diode, then reverse the test leads and repeat the measurement. The diode should have a high resistance in one direction, and a low resistance in the other direction. If it does not then the diode is probably defective and should be replaced.

A transistor is much more difficult to test and requires some explanation. The basic transistor you are using in the Graymark kit has three terminals, as shown in Fig. 1.

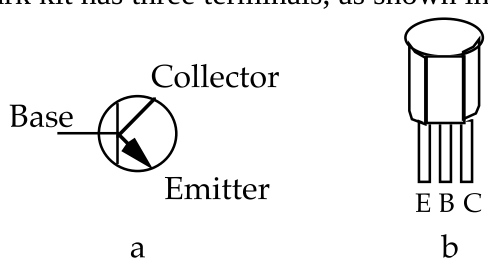
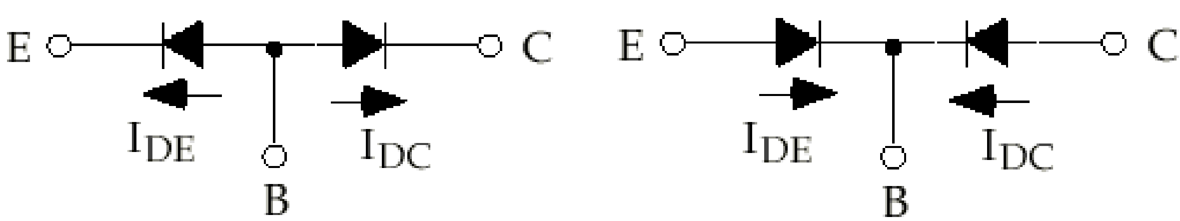



Fig. 1. a. Transistor circuit diagram; b. Transistor pinout.

As shown in Fig. 1.b, when the flat face is facing you and the terminals are on the bottom, the terminal on the left is the emitter (E), the center terminal is the base (B), and the right hand terminal is the collector (C). For many purposes, including simple testing, the transistor can be modeled as back to back diode. See Figure 2. There are two general methods of testing transistors: (1) out of circuit using an ohmmeter, and (2) in a powered circuit using a voltmeter.




(a) npn transistor (b) pnp transistor

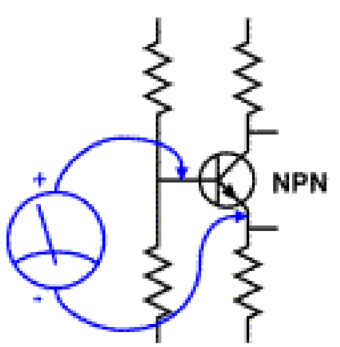
Figure 2 Simplified large signal (a) npn and (b) pnp transistor models

A good bipolar transistor exhibits diode-like behavior between the base and emitter connections, and also between the base and collector connections as shown in Figure 2.. To test a transistor out of circuit measure the resistance between the base and emitter with an ohmmeter, then switch the test leads and measure the resistance again. One polarity should indicate a low resistance and the other should indicate a very high resistance. Measure the base-collector diode in the same way, reversing the leads for the second measurement. Again one polarity should indicate high, and the other low resistance. Both diodes connections in a transistor must be tested.  If either diode connection is defective, the transistor is probably defective and should be replaced.

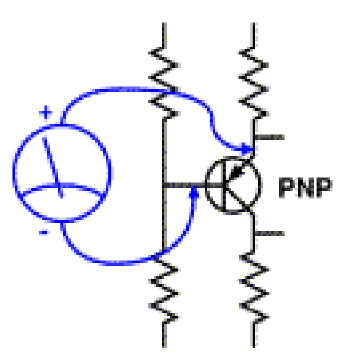
There are two methods of testing a transistor in a circuit with the circuit power turned on.

With the exception of saturated logic circuits, the base-emitter diode is always forward biased in a correctly operating bipolar transistor circuit. (In saturated switching circuits, the transistor is sometimes turned on hard, sometimes turned off)

<u>Make this measurement with the circuit's power turned on.</u> With your voltmeter set on a low voltage range (say 2V full scale), measure the voltage between the base and the emitter of the suspect transistor. For a silicon transistor, you should see 0.5 to 0.7 volts. If you don't see the forward bias voltage of the base-emitter diode, then the device is damaged or the bias circuit is faulty.  The diagrams below show the polarities of these voltages for NPN and PNP devices, respectively.  When testing transistors in circuit the voltage polarity is not usually the problem.  As long as you measure a base-emitter voltage reasonably close to 0.5 to 0.7 volts the transistor is probably fine.




(a) Base should be positive with respect to emitter in functional npn transistor




(b) Base should be negative with respect to emitter in functional pnp transistor

Figure 4 - Testing transistors in circuit using base emitter voltage measurements

There is a second test you can make of a transistor in a powered circuit.  In a properly operating linear transistor amplifier, the collector current will be nearly the same as the emitter current. To be precise: emitter current = collector current + base current. (The base current should be a small fraction of the total.)  <u>Make this measurement with the circuit power turned on.</u> With your voltmeter set on a medium range, (perhaps 20V full scale) measure the voltage <u>across the emitter resistor</u>. In the circuit of Figure 4, you would measure the voltage across R3. As an example, lets assume that you measure 10 Volts. If so, according to Ohm's Law, there must be 1mA flowing through R3. ( I = E/R )

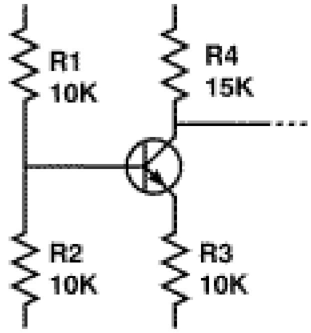



Figure 4 - Voltage measurements of a typical npn transistor circuit

According to our emitter vs. collector current approximation, there should also be about 1mA of collector current. Using Ohms Law, we calculate that there should be 15 Volts across R4. ( E = I*R ) If the voltage across R4 is too high or too low, there is more or less collector current than we expected. However, this test is more difficult to interpret than the previous one. If the voltage is not what was expected there is probably something wrong with this device (very low beta, for example). However, there could also be some other circuit path where significant current is flowing (into or out of the next stage, for example). This is not a definitive test.

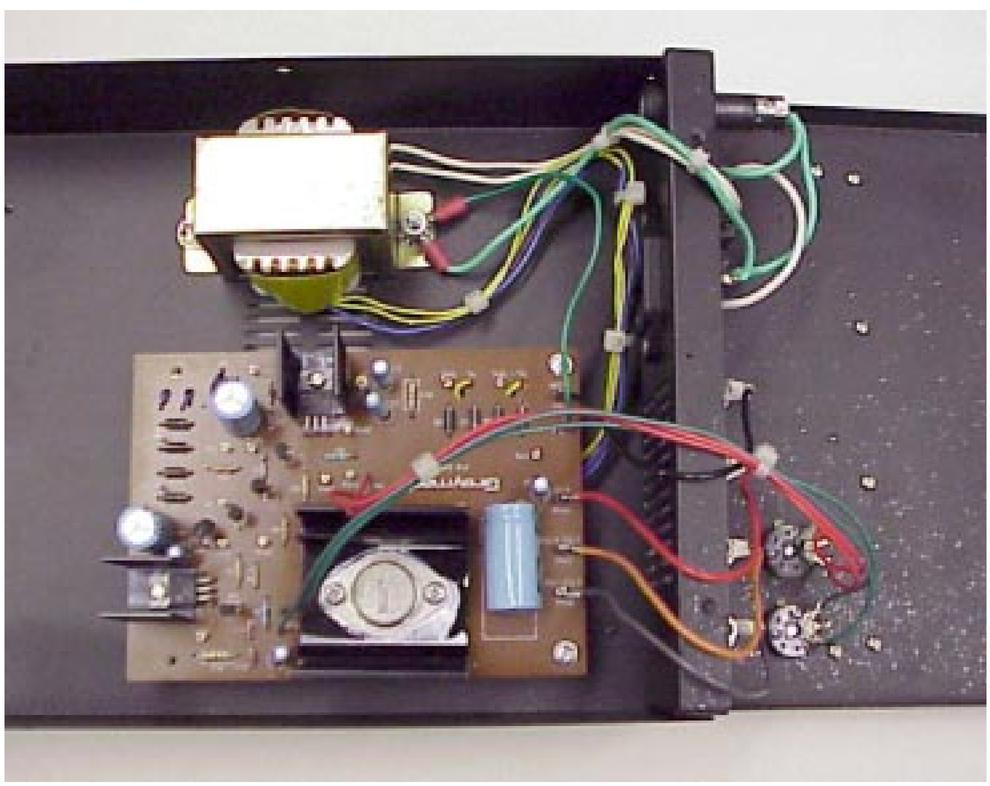
We have measured the following voltages in a fully operational Graymark 808 power supply. As long as your measured voltage is near these that part of the circuit is probably working.

| Test Point | Voltage (DC) | | Test Point | Voltage (DC) |
|---|---|---|---|---|
| TP1 | | | TP11 | -0.88 |
| TP2 | | | TP12 | -29.5 |
| TP3 | | | TP13 | 13.11 |
| TP4 | | | TP14 | -1.45 |
| TP5 | | | TP15 | -15.27 |
| TP6 | -29.1 | | TP16 | 1.4 |
| TP7 | | | TP17 | 14.36 |
| TP8 | 29.4 | | TP18 | -16.54 |
| TP9 | | | | |
| TP10 | 29.4 | | | |
| | | | | |

# Comments about assembling your Graymark power supply.

A top view of the breadboard is shown to the right and your final working power supply will look exactly like this. However, the interior photos are much more useful in planning your construction..

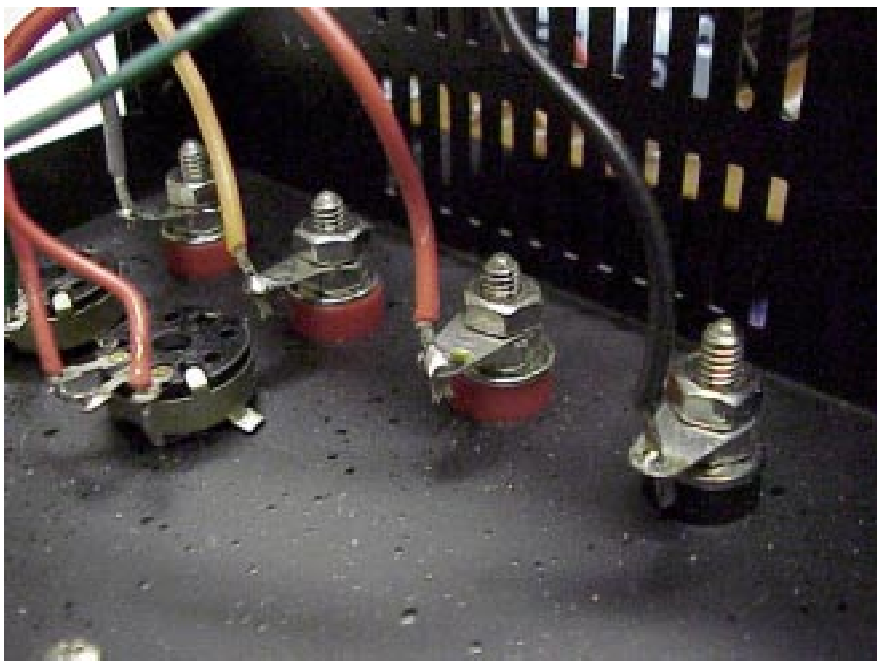

The figure below shows the inside of the Graymark. What this picture shows (which your Graymark manual does not) is the layout of the wiring. Notice that I carefully tied some of the wires together to make the inside neater and paid careful attention to the length of the wires so none of them are excessively long for their intended connection.



This is a closeup of the power wiring to the AC connector, fuse holder, and switch. This wiring follows the color convention given in the Graymark manual. Technically, the wiring from the AC connector to the fuseholder and then to the switch should be black, not green; but you were not given appropriate black wires in your kit. In AC wiring, black indicates a "hot" or "line" wire

and "green" indicates ground. In general, green should never be used for a wire carrying AC power.

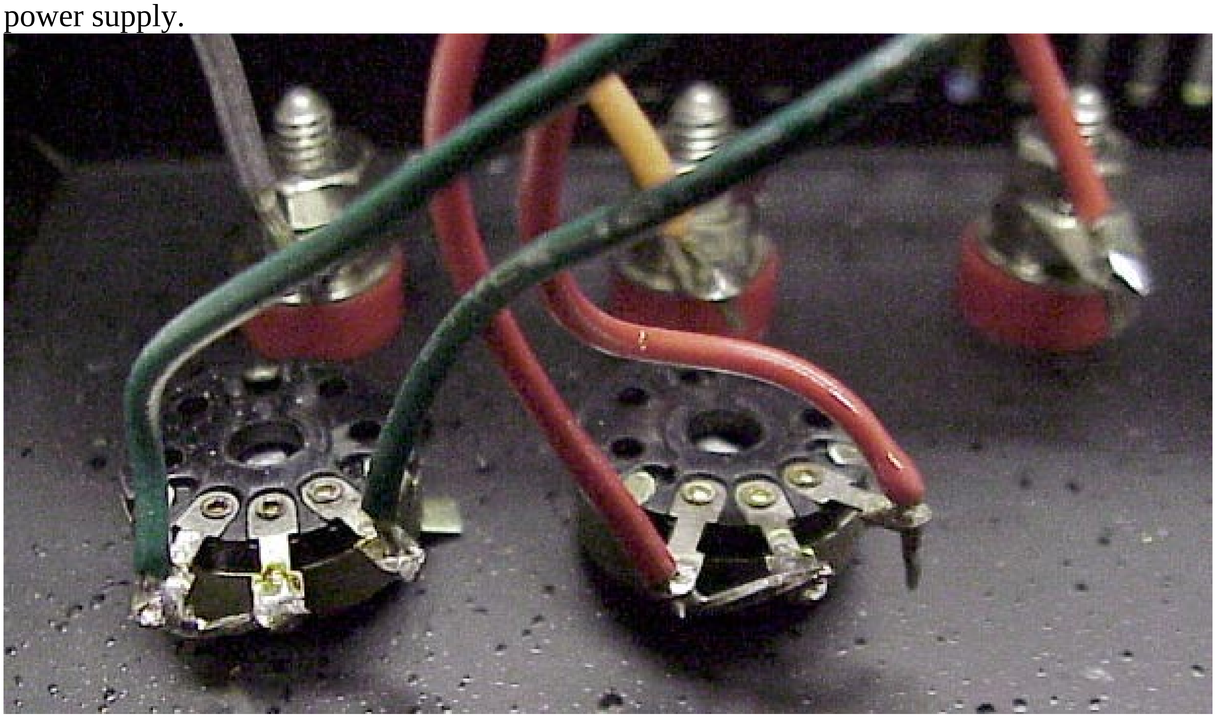
Pay careful attention that the binding posts are assembled with no metal parts touching the metal power supply case. Metal parts of the binding posts touching the case can cause the fuse to blow in the assembled power supply; however, it can also manifest itself as a low output voltage and very hot voltage regulators.



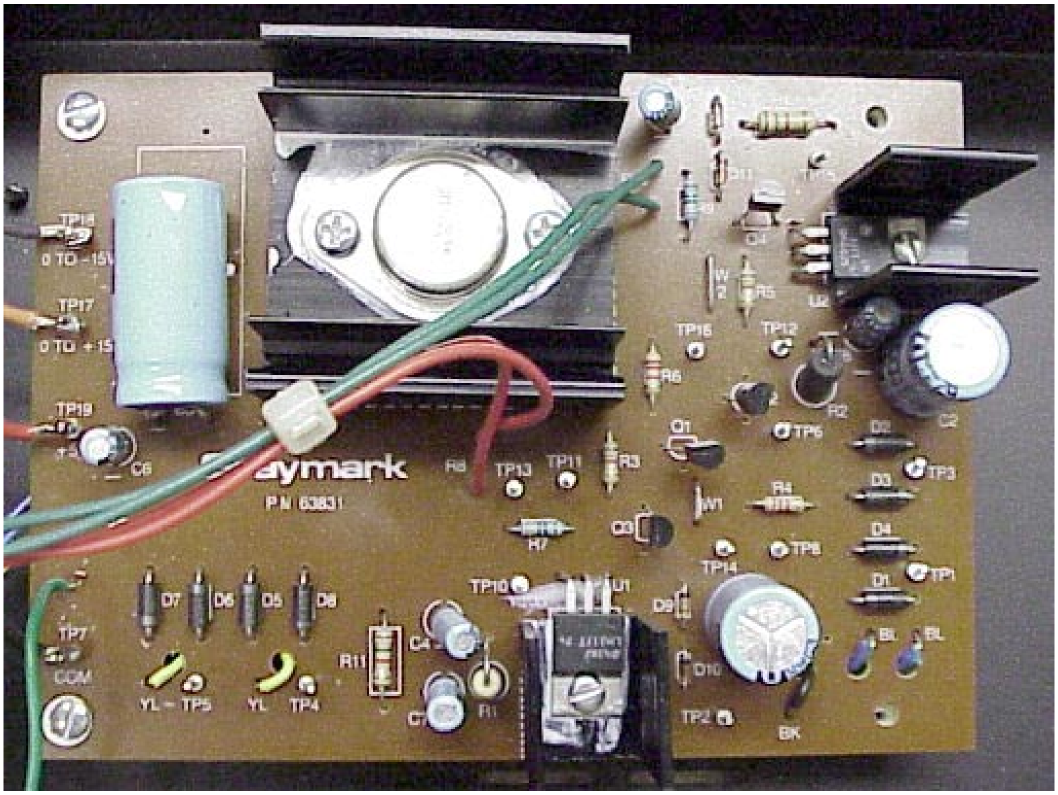
(a) Top view of binding post (b) Bottom view of binding post

Each metal washer is insulated from the metal case by plastic. If you are concerned about your assembly check that they are electrically isolated from the case using an ohmmeter BEFORE you solder to them.

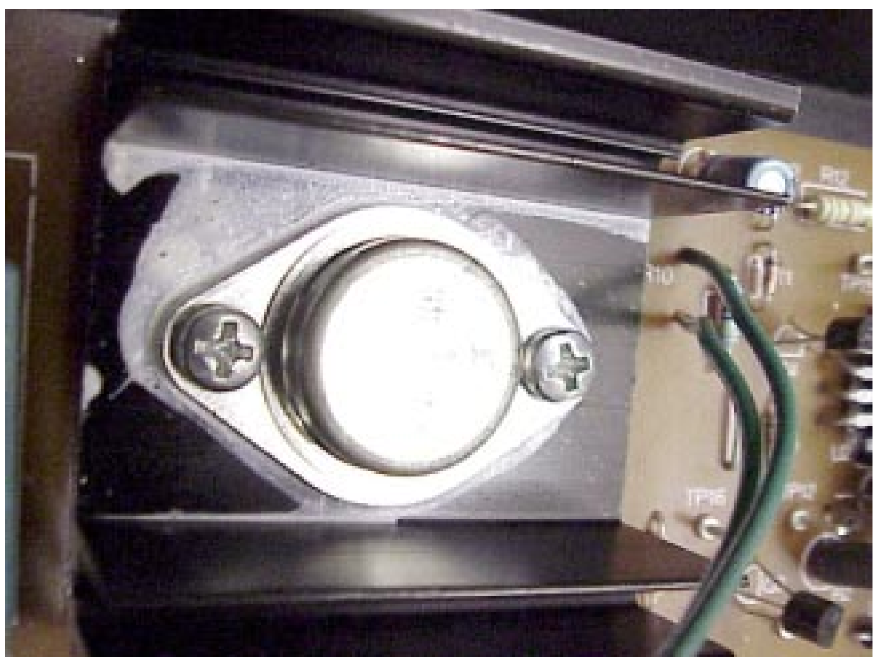
You should also be very careful that none of the wires soldered to the binding posts or potentiometers touch the metal case. These can also cause blown fuses in your assembled power supply.



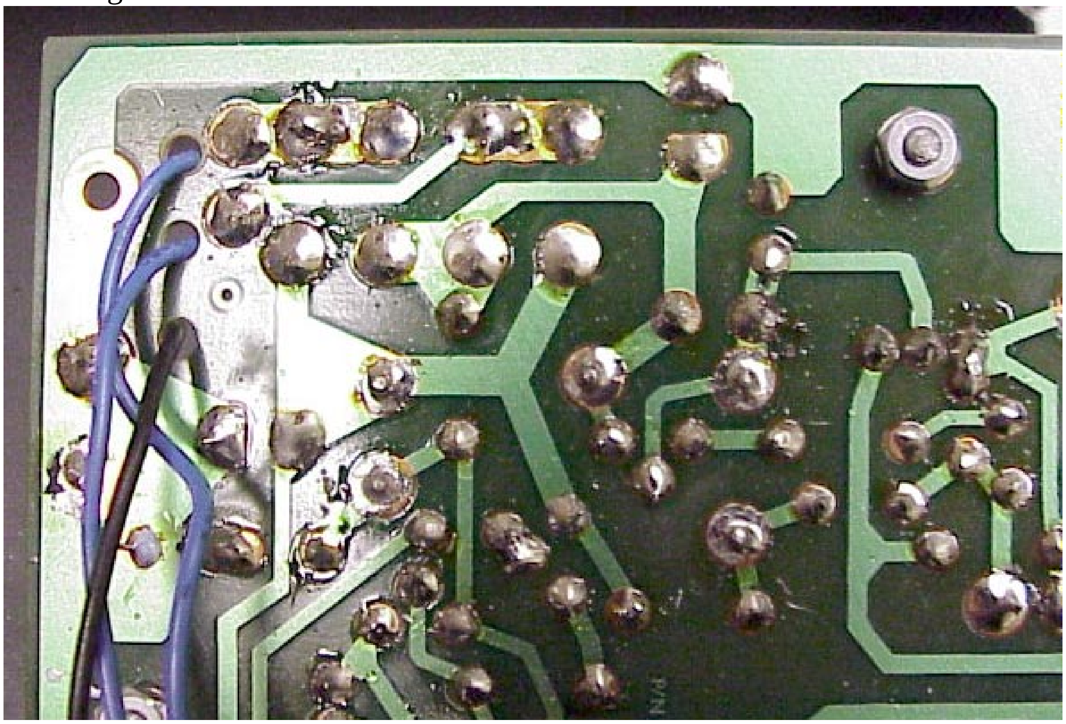
This picture shows the completely assembled printer circuit board.



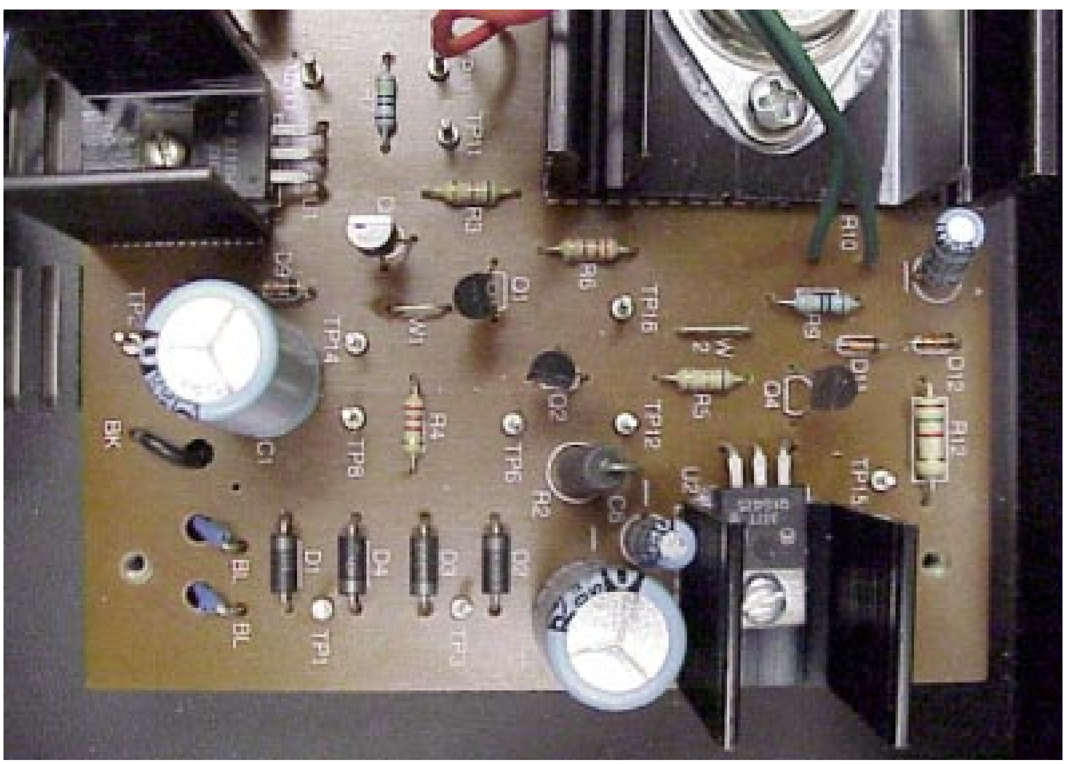

Notice that I have not used an excessive amount of heat sink compound on any of the voltage regulators. This shows well in this closeup photo.



Soldering should be neat and clean.  The bottom of your circuit board should approximate the soldering shown below.



And just to help you in your wiring and testing I have also included closeups of the "stuffed" printer circuit board shown below.




We hope this will help you wire a successful, working Graymark with no problems.