ST-70 Driver Mod

Manual

(revision d)

Designed by:

Alan Kimmel

Ron Welborne

Another ST-70 Driver Mod?

NO! Not just another ST-70 driver mod. This circuit, designed for us by Alan Kimmel, uses a triode first stage operated in the ideal constant-current mode. This and other features enable this ST-70 to deliver “REAL MUSIC”. In fact, in all my years of modification experience, this is the best ST-70 mod I have ever heard! It beats all others hands-down and now this circuit is available to you at a great price.

Why modify the ST-70? The Dynaco ST-70 is probably the most popular tube amp ever built. However, by today’s standards its sonic performance is somewhat mediocre. Its bass response is loose and the top-end lacks the detail required to make it a real contender. These deficiencies can be attributed to its less than adequate power supply filter capacitance and its simple but ineffective driver circuit.

There are alot of ST-70 driver board mods out there but most have taken a classical approach to solving this amplifier’s deficiencies. Alan Kimmel’s ST-70 modification incorporates an advanced constant-current technique using a 6U8A tube to operate the 5751 triode voltage gain stage in the most linear manner possible. In addition, the output of the 5751 is optimally coupled to the rest of the circuit and this coupling is such that the 5751 sees virtually no capacitance and no loading at all. The amount of negative feedback is modest, and is taken from the 8 ohm output tap which is more effective than taking it from the 16 ohm tap, as most do. This circuitry results in a superior level of detail in both the midrange and top-end. Next, the output tubes’ bias supply is regulated resulting in a constant bias point with minimum drift. And finally, over 500uF of capacitance is added to the main power supply circuit resulting in a much tighter bass response and lower distortion throughout the frequency spectrum. High quality parts are used throughout the design which is conveniently mounted on two circuit boards that fit snuggly inside the existing chassis.

ST-70 DESIGN FEATURES

The ST-70 driver mod features: a “main” printed circuit board consisting of the 5751/6U8A peripheral driver circuitry and the additional power supply filter capacitance (>500uF); a second bias-supply printed circuit board which includes the bias rectifier, filter caps, a zener diode regulator circuit and the bias adjustment potentiometers; and finally, a new aluminum mounting plate, with black anodized finish, is supplied which attaches to the top of the ST-70 chassis to support the rectifier and driver circuit tube sockets (with this design, there are no exposed components or circuit traces on top of the chassis). The existing output circuitry is retained.

The existing power supply filter capacitor is removed and no longer used. In place of the original capacitor are five 100uF filter caps plus high quality polypropylene film bypass capacitors. The original filter inductor is retained in our design. These inductors are notorious for failing, leaking and in general making a mess of the interior chassis space, however we have sources for new inductors so give us a call if you need to replace yours.

A high-pass and low-pass filter network is designed into the front-end of the driver circuit. These filters provide stability and offer much more reliable operation over the life of the amplifier. The high-pass circuit provides a low frequency roll-off at approximately 10Hz.

The original “Mono/Stereo” slide switch is converted to a mute function which allows you to connect and disconnect interconnect cables without turning off the amplifier.

A significant amount of point-to-point wiring still remains within the ST-70 chassis and therefore it is recommended that this kit only be attempted by individuals possessing a thorough understanding of tube circuits and having a moderate level of kit building experience.

The following instructions are for installing the complete Welborne Labs ST-70 modification kit in an existing chassis. If you have purchased only the circuit boards and are tailoring this mod to your own specifications or are building an ST-70 from scratch, use these instructions as a guide or as needed. These instructions are far from being ‘in-depth’ and it is recommended that you have in your possession a copy of the original Dyna ST-70 schematic or are very familiar with its layout and circuitry.

TOOLS REQUIRED FOR DISASSEMBLY AND ASSEMBLY

The following items will be required, or are recommended, to successfully assemble this kit:

Soldering Iron
Solder
Solder Wick or Solder-Removing Device
Drill
Pliers
Wire Strippers
Hex Driver
Screw Drivers
Volt/Ohm Meter
Schematic of Original Dyna Circuit May be Helpful

DISASSEMBLY INSTRUCTIONS

We recommend that you follow this disassembly sequence. As you disassemble the amplifier, place all of the old components and hardware in a container and keep them until you have completed this modification.

1) Remove tubes.

2) Remove bottom cover.

3) Remove existing filter capacitor can from chassis. For the present time, be careful to leave existing hookup wire intact and all leads left as long as possible.

4) Remove original driver circuit board.

5) Remove feedback leads from 16 ohm tap of output terminals.

6) Remove AC filament leads to driver board. Leave filament leads to the output tubes intact unless you are planning to replace them with new wire (recommended).

7) Remove rectifier tube socket. Leave lead lengths intact as much as possible. We are just replacing this socket with a new one and will be rewiring the new socket like the original.

8) If you are going to retain the existing bias circuitry, skip this step, otherwise remove all output tube bias circuitry (pots, capacitors, rectifier diode, resistors, etc.). Disconnect the transformer from the bias rectifier but leave the original transformer lead (red/black) that attaches to the bias rectifier diode intact and as long as possible.

9) Disconnect all input wiring (signal and ground) to the RCA input jacks. Replace jacks if desired (recommended).

10) Remove coupling capacitors (0.1uf caps) between the driver circuit and output stages. Remove resistor network (270k resistors) from the output stages (these will be replaced with better quality components).

11) If the power supply filter choke is in good shape (ie. not burnt or leaking) we recommend that you leave it in the ampli fier. If you choose to remove it, replace it with a 10-50 ohm 10 watt resistor. This is necessary as the specification sheet for the 5AR4 rectifier tube implies that no more than 50-60uf of capacitance be directly across its output. If the choke is removed from the circuit, the full 500uf of power supply capacitance will be across the tube, which is not good.

12) Output terminals should be replaced or at least thoroughly cleaned.

This completes the disassembly phase of the ST-70 mod. If you plan on replacing any of the remaining original wire (recommended because it is old) or replacing the output transformers, tube sockets, etc., now is the time to do it.

While all circuitry is removed, now is also a good time to clean the chassis, inside and outside, and perform any cosmetic surgery that you may have planned, ie. polishing or re-chroming, painting, lettering, etc.

ASSEMBLY INSTRUCTIONS

We recommend that you follow this assembly sequence. Refer to figures 1 through 9 as you follow the assembly instructions.

MOUNTING PLATE AND TUBE SOCKET INSTALLATION

1) Install the external mounting plate to the chassis using the supplied black socket head cap screws. The mounting plate lays flush on top of the chassis surface without the use of washers or standoffs. If desired, washers or standoffs may be used between the plate and chassis which will allow a little better air flow through the chassis. Mounting the plate to the chassis will more than likely require that you drill at least a couple of new holes in the existing chassis. The plate has six mounting holes and it is recommended that you use all of them to secure the plate to the chassis. Refer to figure 1.

2) Turn the chassis upside down and position the unstuffed main circuit board inside the chassis (foil side of circuit board facing down) as shown in figure 2. Measure and mark the position of the circuit board's four mounting holes on the chassis using a pen or marker. Once again it is required to drill new mounting holes in the chassis for the main circuit board. After drilling holes, place the circuit board to the side for later use.

3) Mount the four (4) 9-pin tube sockets and one (1) 8-pin tube socket to the mounting plate. Secure with the supplied screws.

4) Re-connect the leads to the 8-pin rectifier tube socket.

5) Install filament leads (white 18ga. Teflon-coated wire) to the four (4) 9-pin tube sockets. The filament voltage can be taken from the output tube sockets of each channel (left and right). Be sure to twist the filament leads tightly as this will help to reduce stray electrical noise. Route the filament leads around the outer perimeter of the chassis as close to the chassis wall as possible and away from input signal conductors. Refer to figure 2.

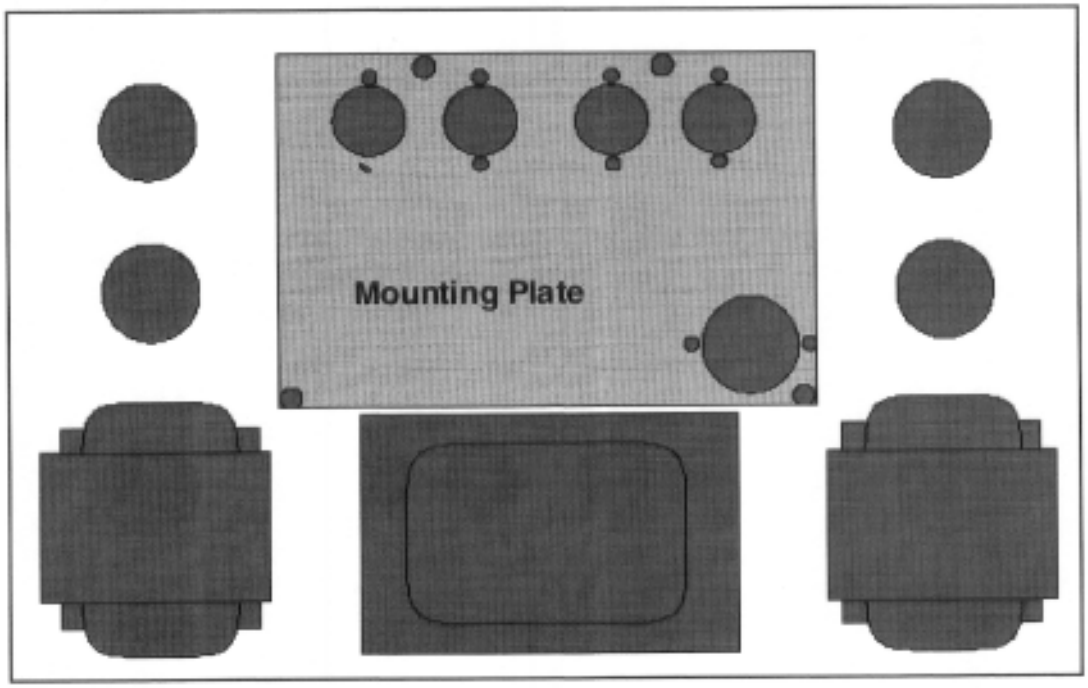


Figure 1. Top View of Chassis

ASSEMBLY INSTRUCTIONS

BIAS CIRCUIT BOARD ASSEMBLY AND INSTALLATION

1) Stuff the bias circuit board per the stuffing guide of figure 3. Double-check to insure the electrolytic capacitors and zener diodes are installed with the correct polarity. Solder approximately 12 inches of red 18 ga. hookup wire (supplied with kit) to the left channel bias output (H) and approximately 6 inches of red wire to the right channel output (I). Solder about 10 inches of black 18 ga. hookup wire to the ground pad (Gnd) of the bias board.

3) Solder the red/black colored transformer bias lead (J) to the bias circuit board.

4) Position bias circuit board in chassis. Secure with existing transformer nuts.

5) Solder left (H) and right (I) bias output leads to the bias resistor network at the output tubes. Refers to figure 3 and 4.

6) Solder the bias circuit ground lead to a terminal lug on the terminal strip located on the left side of chassis.

This completes the installation of the bias circuit board. The bias adjustment will be performed later-on in the 'Power-up and Test' section.

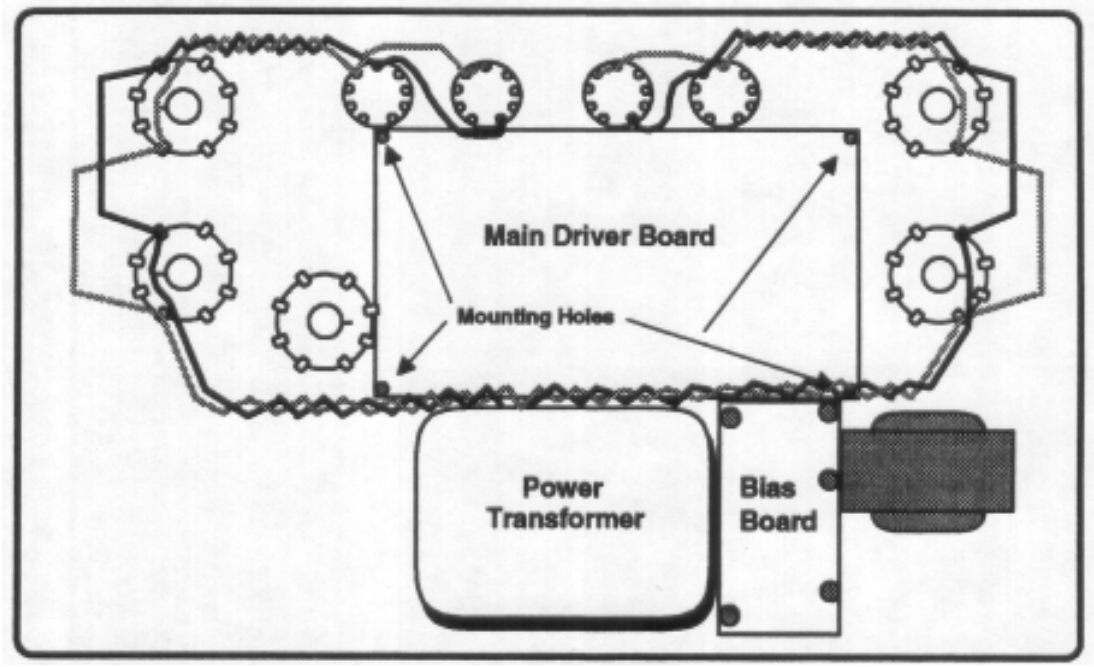


Figure 2. Chassis Layout

BIAS CIRCUIT BOARD ASSEMBLY AND INSTALLATION (cont'd)

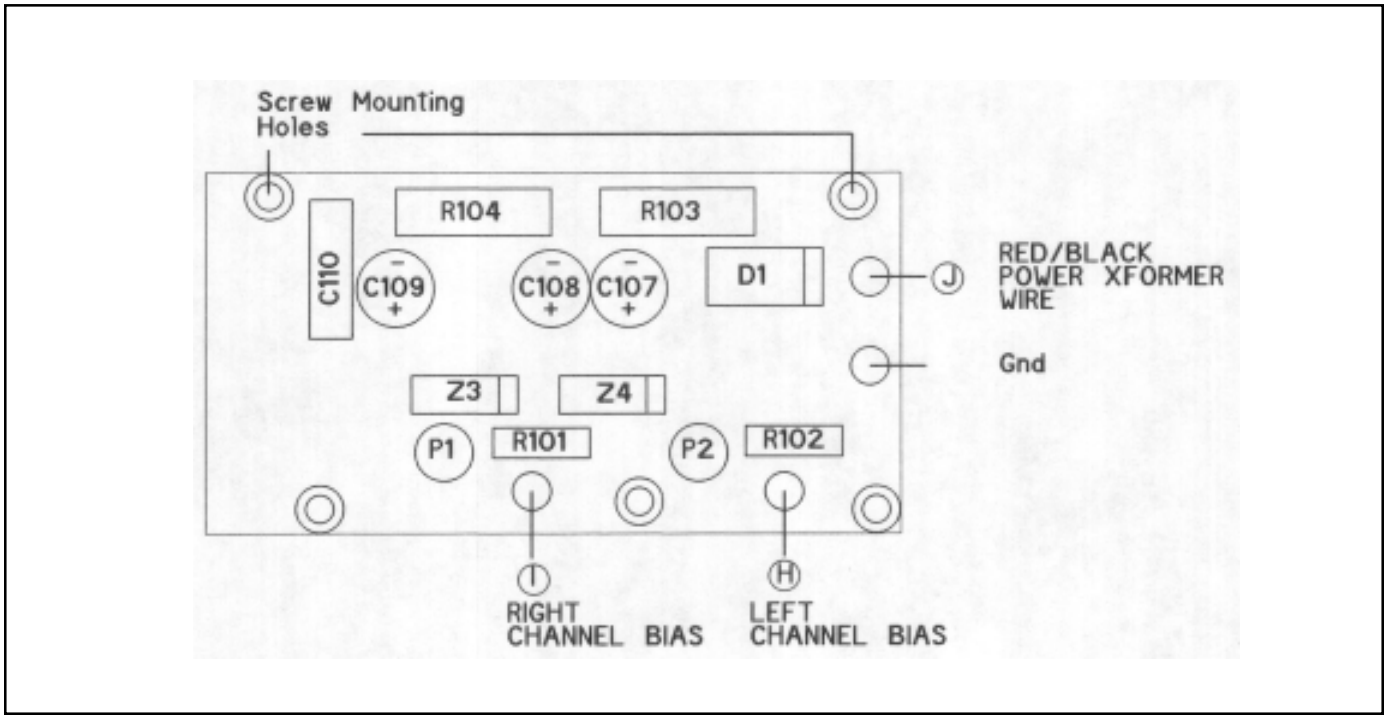


Figure 3. Bias Board Stuffing Guide

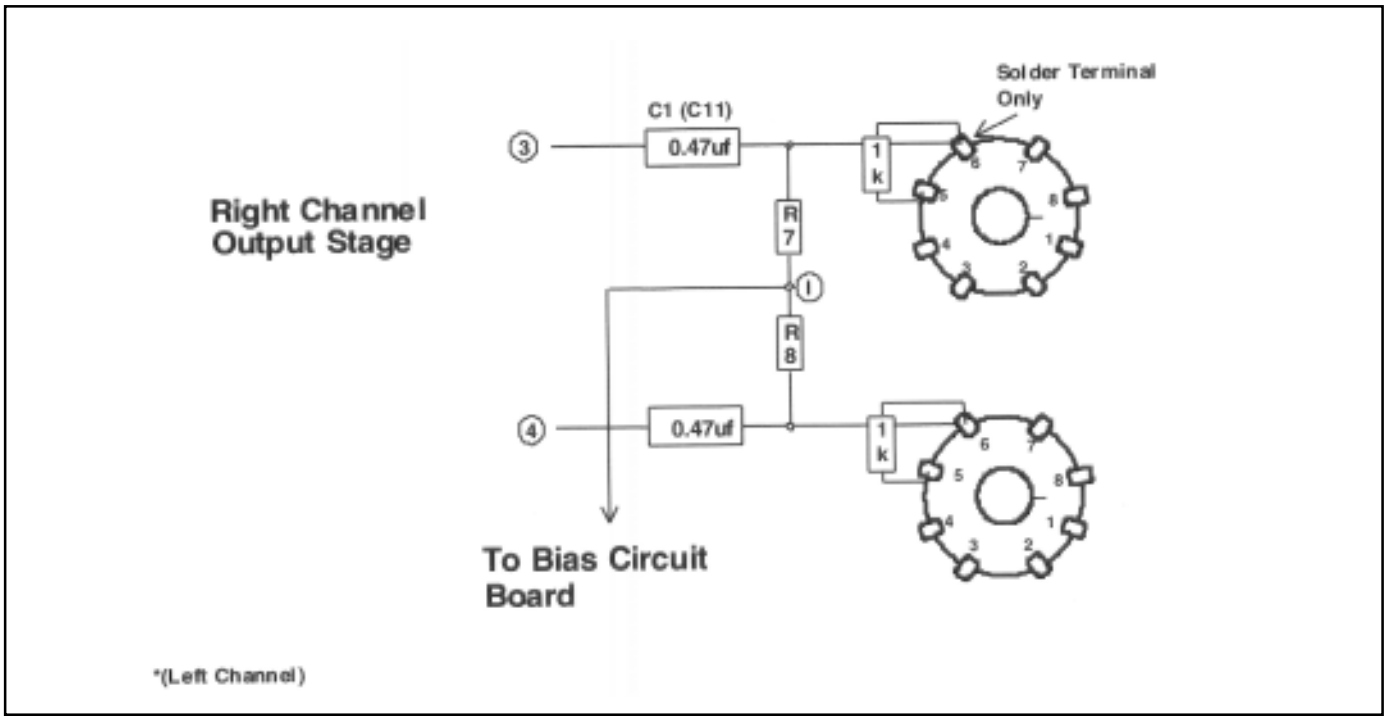
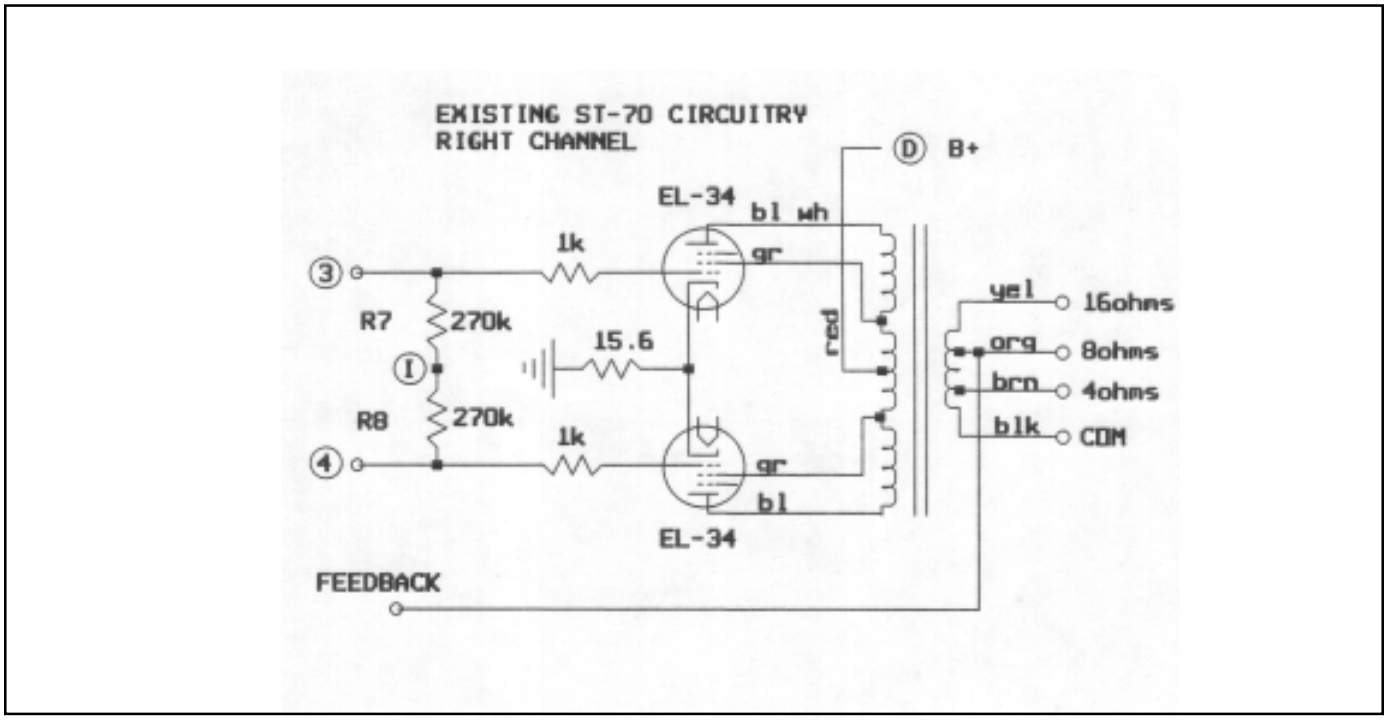


Figure 4. Bias Network

BIAS CIRCUIT BOARD ASSEMBLY AND INSTALLATION (cont'd)



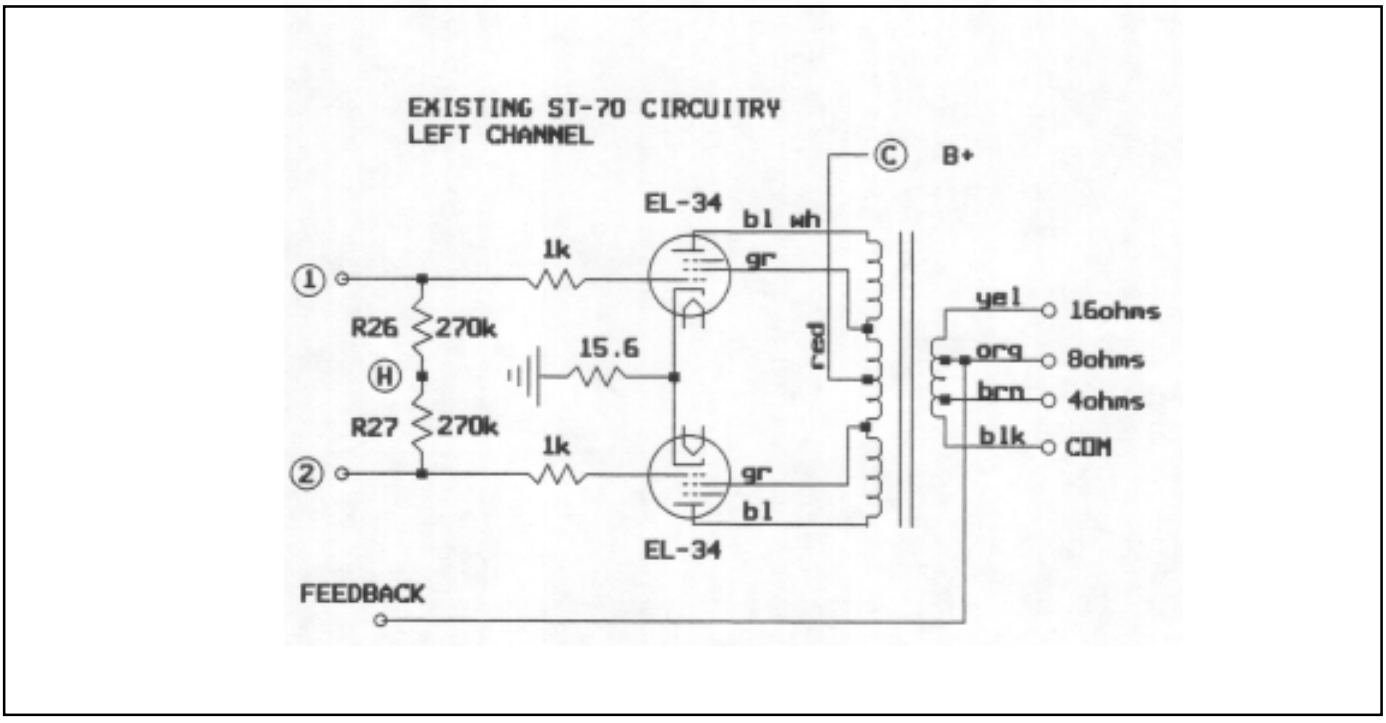


Figure 5. Output Circuitry and Bias Network

ASSEMBLY INSTRUCTIONS

MAIN CIRCUIT BOARD ASSEMBLY AND INSTALLATION

1) Begin by stuffing the main circuit board with its components. Refer to the stuffing guide of figure 6. It is usually easier to stuff the small low profile components first (ie. resistors and diodes) and then the larger high profile capacitors. Be sure to note polarity of the electrolytic capacitors. There are two (2) jumper wires located on the circuit board and designated as 'J'. Teflon coated Wonder wire has been included to be used as jumper wires. An additional jumper wire is necessary between the two points marked 'G' on the board. Wonder wire or 18 ga. Teflon can be used here.

2) Once the circuit board is stuffed with all of its components, the wiring can be installed. All leads originating from the main circuit board need to be inserted and soldered now as it will be difficult to add wires once the circuit board is mounted in the chassis and you have begun to connect them to other points in the circuit. Kimber Kable Teflon coated OFC hookup wire has been included for signal path wiring.

3) All leads going to the driver tubes should be cut to a length of approximately 6 to 8 inches. You might want to choose one color of wire for all leads going to the 5751 tubes and one color for the 6U8As or some other method of coding which suits your needs.

4) Approximately 12 inches of wire should be cut for the feedback leads. Once again the Kimber Kable wire can be used here and we have had good sonic results by twisting a few of the leads together in a braid.

5) Two ground leads of approximately 6 inches should be cut and installed in the positions marked 'Gnd' located between C8 and R13, and C16 and R32. 24 ga. is good here and these leads will go to the rca input jacks.

6) Cut and install one black 18 ga. ground lead of approximately 10 inches in one of the two pads marked 'Gnd' and located on either side of C104. Only one ground pad and lead are necessary, the other pad is not used.

7) Cut and install two red 18 ga. leads approximately 12 inches in length at positions marked 'E' and 'F'.

8) Cut and install two leads of Kimber Kable in the mute switch pads. These leads may be left out if you are omitting the mute switch.

9) Install one lead of the input Kimber Kaps to the main board.

This completes the main circuit board stuffing phase.

10) Before installing the main circuit board, install the required pin-to-pin jumper wires on the 5751 9-pin tube sockets. These jumpers run between pins 1 & 6, 2 & 7, and 3 & 8.

11) Install the grid resistors on the 9-pin tube sockets. Keep the leads as short as possible on these resistors. Solder one end of the resistors to the tube socket with the resistor positioned in a vertical orientation. Make a small loop or short pigtail on the opposite end of the resistor.

12) If you haven't already done so, install the coupling capacitors (Kimber Kaps) C1, C2, C11, and C12. The capacitor lead which connects to the main circuit board should be kept very short (as though you were mounting it on the circuit board). For the moment, leave the opposite ends long.

13) Make all power supply connections to the main circuit board. This step may be somewhat awkward as the existing leads from the transformer and choke will be short. Lengthen these if necessary to ease installation. Install the B+ leads, Choke leads, Rectifier leads and Filament leads. Refer to figures 6 and 7 for assembly.

ASSEMBLY INSTRUCTIONS

MAIN CIRCUIT BOARD ASSEMBLY AND INSTALLATION

14) Attach the main circuit board to chassis using the supplied screws and 1/4 inch standoffs. Once again this step will be awkward at best.

Once the circuit board is secured, the final assembly steps can begin. Refer to figure 9 for positioning and wiring.

15) Route and connect feedback leads to the 8 ohm taps of the output terminals.

16) Cut coupling capacitor leads to correct length, install Teflon sleaving and connect to output stage. Refer to figures 4, 6 and 9.

17) Connect red leads from points 'E' and 'F' to pin 6 of left and right 6U8A tubes.

18) Connect all remaining leads to the driver tubes. Refer to figure 6.

19) Connect all ground leads.

The layout and connection of all ground wires is very important. Refer to figure 8. Proper use of star grounding will minimize hum and prevent the insertion of ground loops.

20) Only one connection to chassis is made in the amplifier. Choose a point that is as close to the input signal as possible. We used the body of the mute switch which is connected to the chassis. Isolate all other chassis connections (this should be confirmed by using an ohm meter).

21) Referring to figure 8, there are two star grounds inside the chassis. One is a 'signal' star and the other a 'power ' star. The 'signal' star is located at the point where the chassis connection is made, and all of the input and output signal grounds are made here. The 'power' star is located at the terminal strip and all of the power supply grounds are here. One 18 ga. lead connects the two stars. Make sure that you do not use one of the lugs on the terminal strip which is tied to the chassis.

This completes the assembly and installation phase of the ST-70 mod. Now is a good time to go back and double-check and triple-check all of your wiring.

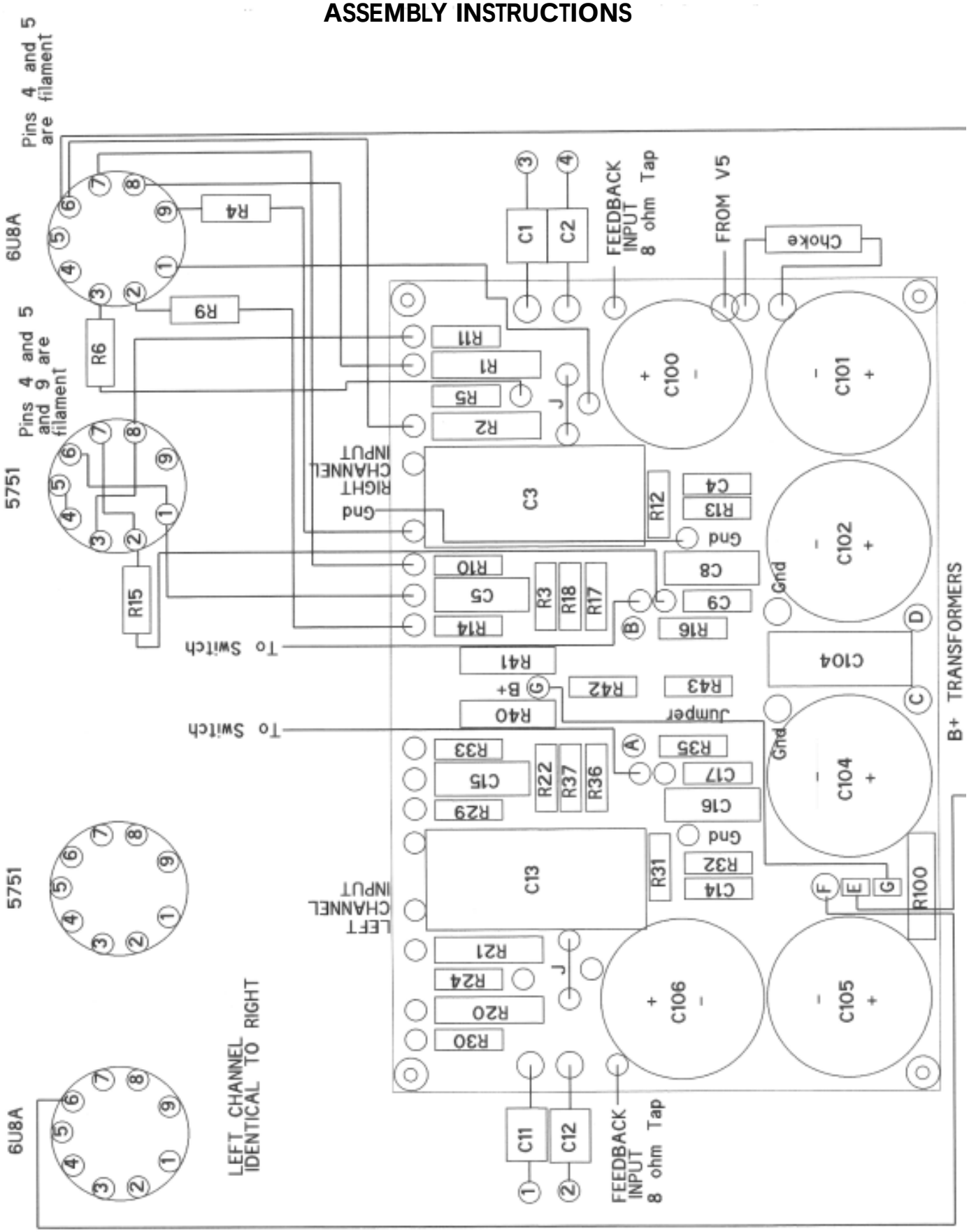


Figure 6. Main Circuit Board Assembly and Installation Guide

Figure 7. ST-70 Power Supply Schematic

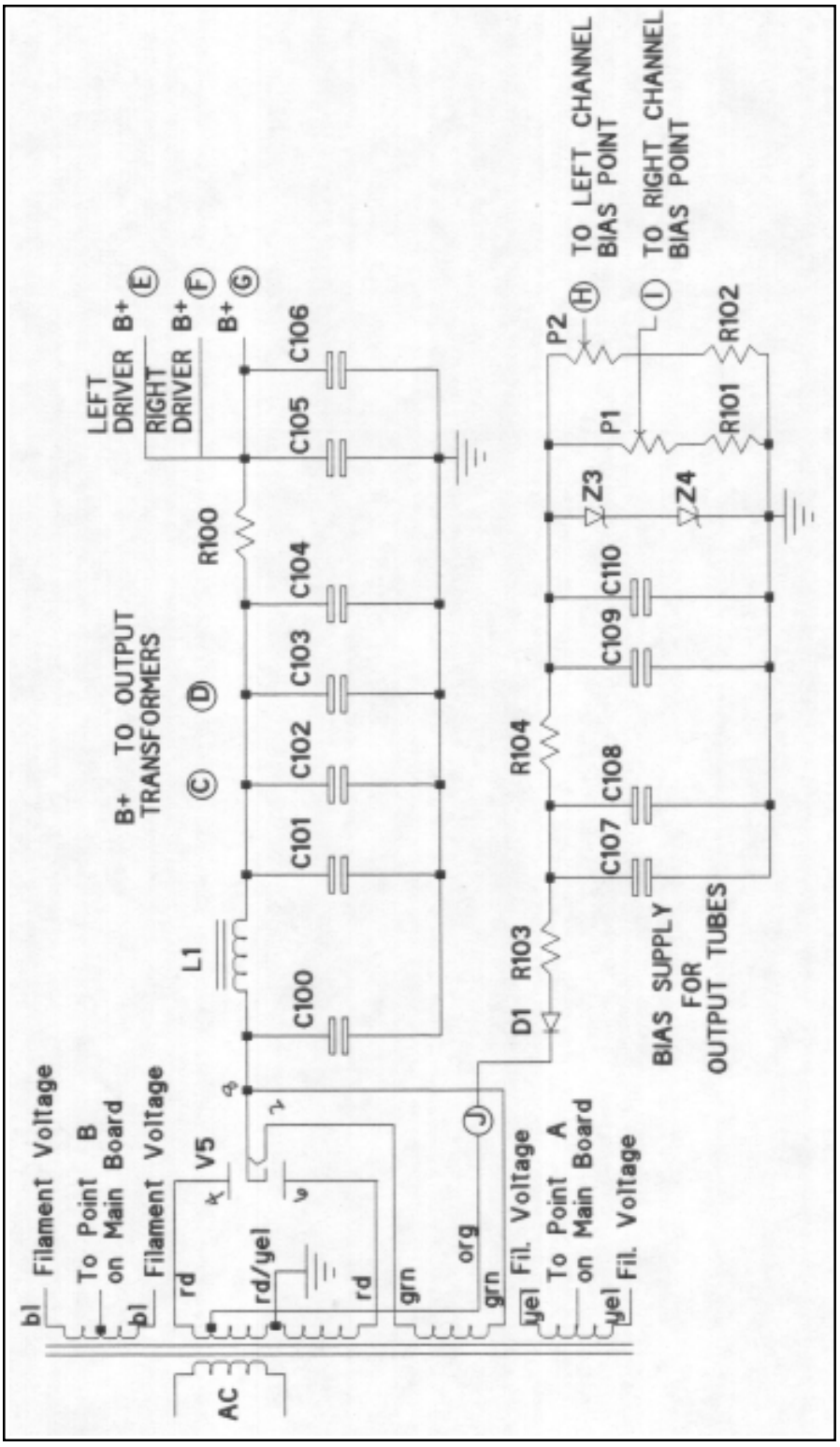


Figure 8. Grounding Diagram

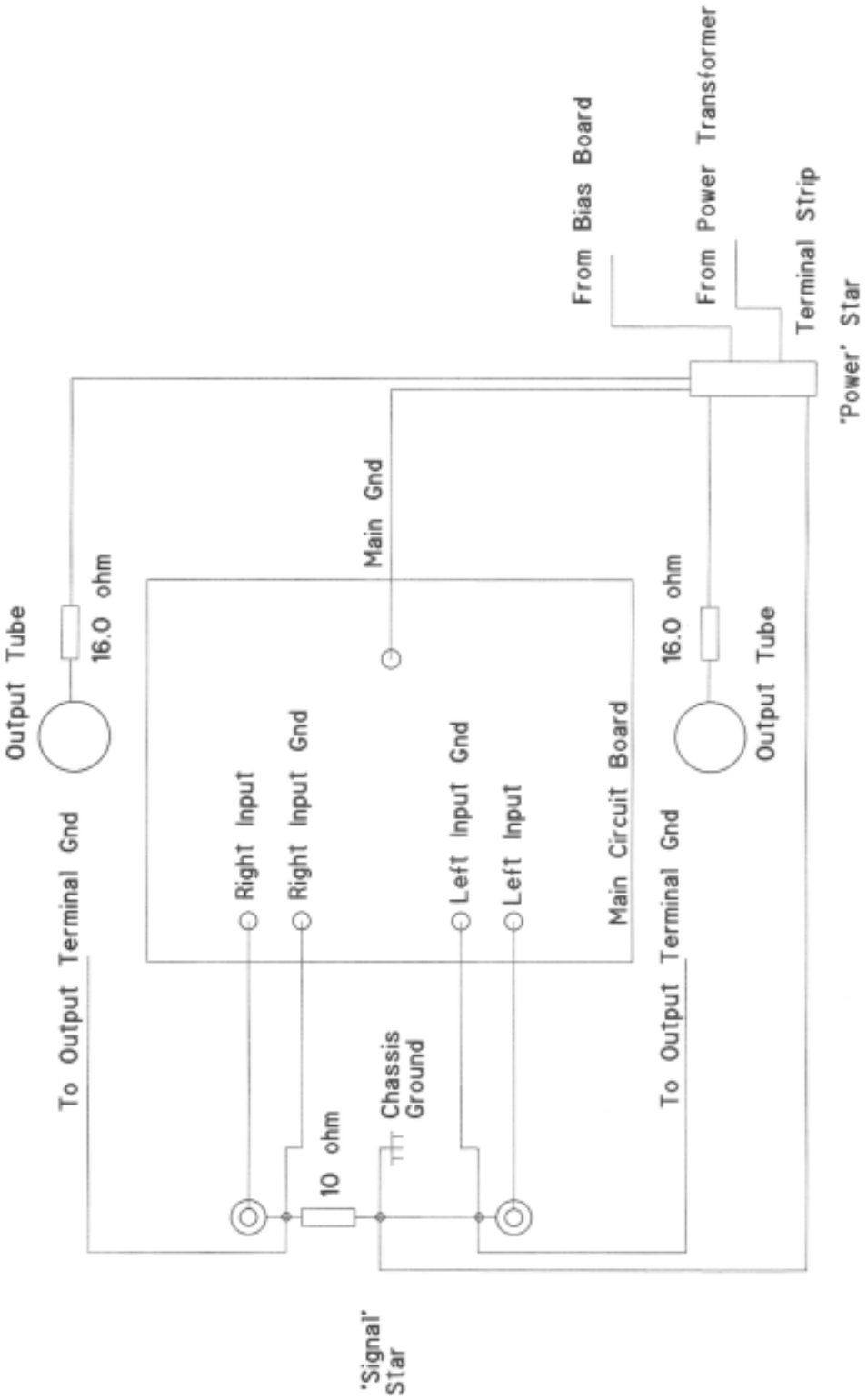
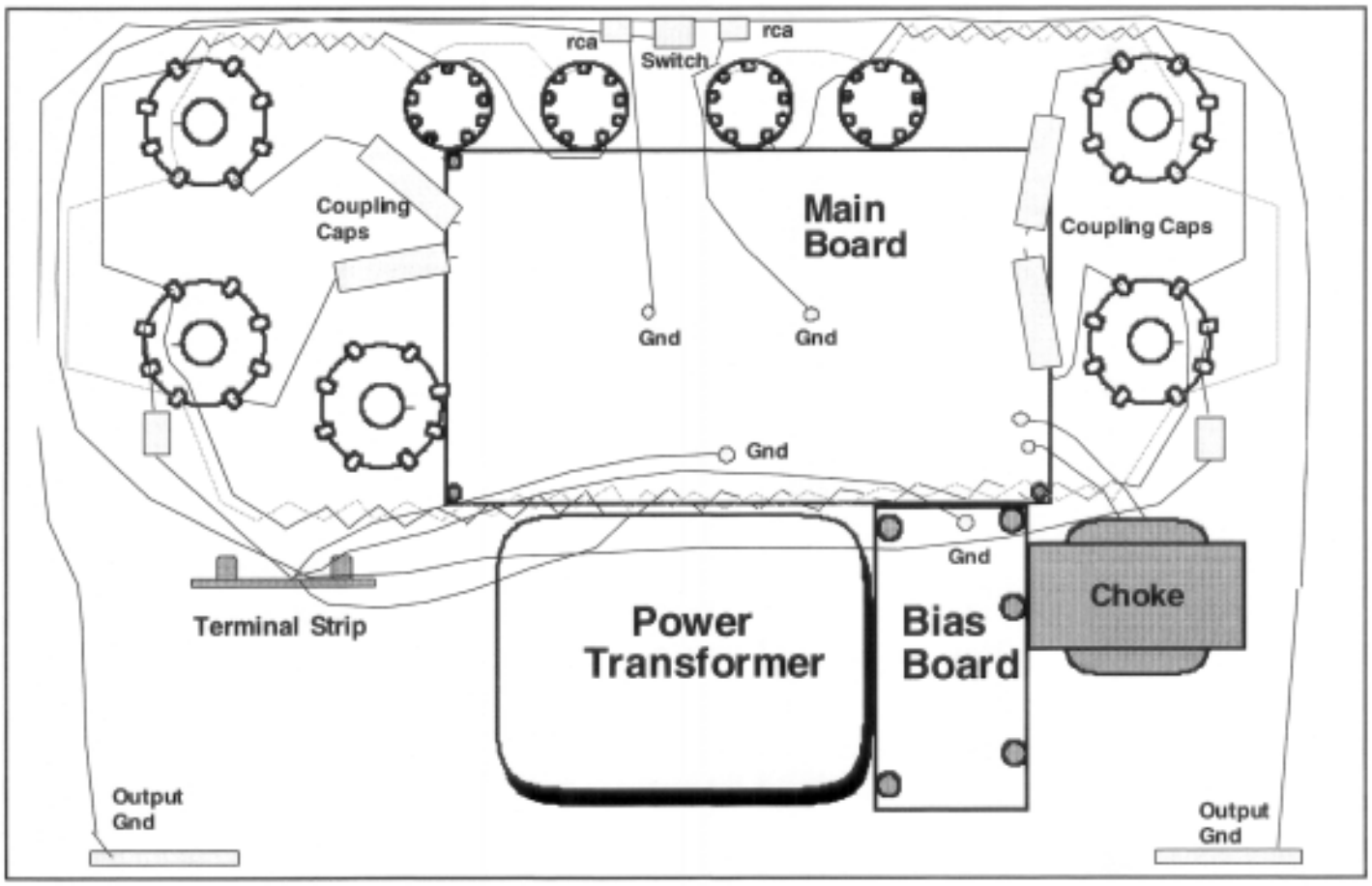


Figure 9. Wiring and Installation Guide Depicts Ground Connections



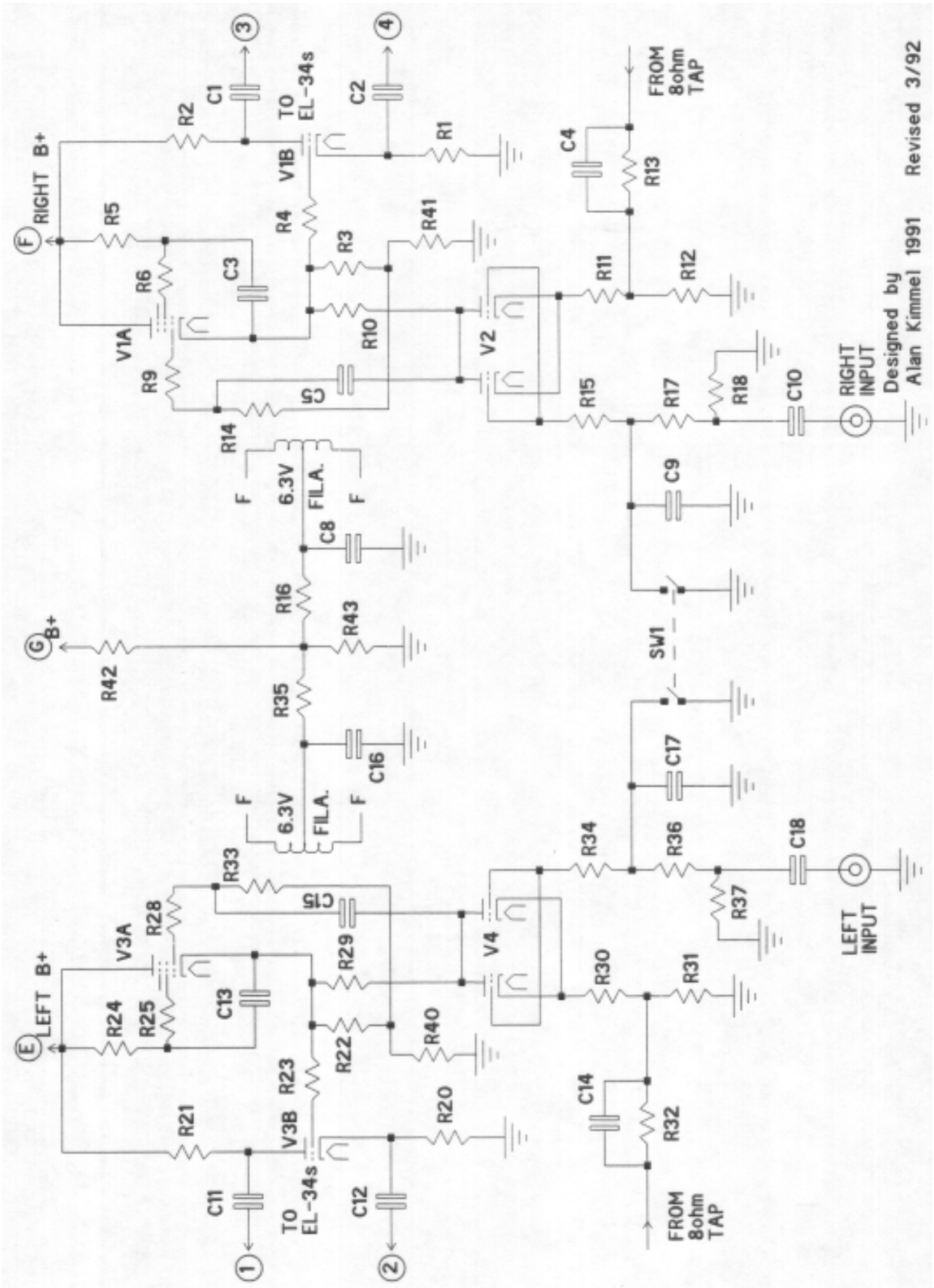


Figure 10. ST-70 Modification Schematic

ST-70 DRIVER BOARD PARTS LIST

R1,R2,R20,R21	33 Kohm	2 watt metal oxide resistor
R3,R22	2.2 Kohm	1/2 watt 1% metal film resistor
R4,R6,R9,R15, R23,R25,R28,R34	150 ohm	1/2 watt 1% metal film resistor (Caddock)
R5,R24	300 Kohm	1/2 watt 1% metal film resistor
R7,R8,R26,R27	270 Kohm	1/2 watt 1% metal film resistor (located off circuit board)
R10,R29	15 Kohm	1/2 watt 1% metal film resistor (Caddock)
R13,R32	5.6 Kohm	1/2 watt 1% metal film resistor
R14,R33	2.2 Mohm	1/2 watt 1% metal film resistor
R16,R35	330 Kohm	1/2 watt 1% metal film resistor
R17,R36	10 Kohm	1/2 watt 1% metal film resistor (Caddock)
R18,R37	150 Kohm	1/2 watt 1% metal film resistor
R40, R41	150 Kohm	2 watt metal oxide resistor
R42	330 Kohm	1/2 watt 1% metal film resistor
R43	100 Kohm	1/2 watt 1% metal film resistor
R100	680 ohm	2 watt metal oxide resistor
R11,R30	510 ohm	1/2 watt 1% metal film resistor
R12,R31	100 ohm	1/2 watt 1% metal film resistor
C1,C2,C11,C12	.47 uf/425V	Polypropylene capacitor (Kimber Kap)
C3,C13	.47 uf/630V	Polypropylene capacitor (WIMA)
C4,C14	100pf/630V	Polypropylene capacitor (Siemens)
C5,C15	0.1uf/250V	Polypropylene capacitor (WIMA)
C8,C16	0.1uf/250V	Polypropylene capacitor (WIMA)
C9,C17	68pf/630V	Polypropylene capacitor (Siemens)
C10,C18	0.1uf/630V	Polypropylene capacitor (Kimber Kap)
C100	47 uf/450V	Electrolytic capacitor (Panasonic)
C101,C102,C103,C105,C106	100 uf/450V	Electrolytic capacitor (Panasonic)
C104	0.1uf/630V	Polypropylene capacitor (WIMA)
V1,V3	6U8A	Triode/Pentode tube
V2,V4	5751	Twin Triode tube
PCB1		Driver Board printed circuit board

ST-70 BIAS BOARD PARTS LIST

R101,R102	10 Kohm	1/2 watt 1% metal film resistor
R103	200 ohm	2 watt metal oxide resistor
R104	330 ohm	2 watt metal oxide resistor
C107,C108,C109	100uf/63V	Electrolytic capacitor (Panasonic)
C110	0.1uf/250V	Polypropylene capacitor (WIMA)
P1,P2	10 Kohm	Cermet trimpot (Bourns)
Z3,Z4	1N5357B	20 volt 5 watt zener diode
D1	1N5408	1000Volt 3Amp diode
PCB2		Bias Circuit printed circuit board

ST-70 MISCELLANEOUS PARTS

PL1	5" x 7" Aluminum mounting plate
TS1,TS2,TS3,TS4	9 Pin chassis-mount tube sockets
TS5	8 Pin chassis-mount tube socket
Miscellaneous	Hardware (screws, nuts, standoffs, etc.)
	Wonder wire, Teflon-coated Hookup wire

POWER-UP AND TEST INSTRUCTIONS

Power-up Sequence

1) It is recommended that you connect the amplifier to a dummy load or old set of speakers during the power-up proce dure. Use the mute switch to short the amplifier's inputs. Amplifier must have tubes installed to power-up and test operation.

2) If you own or have access to a variable ac transformer, use it to slowly increase the ac voltage during power-up. Monitor the B+ as you increase the ac voltage. At full ac you should measure approximately 420 Vdc ± 10V. If you do not have access to variable transformer, use a voltmeter to measure the B+ voltage as you power-up the amplifier. If the B+ does not show signs of increasing, immediately turn off the power.

3) If the B+ comes up OK, and you are connected to a set of speakers, you can flip the mute switch and listen for excessive noise, oscillations or hum.

4) Adjust bias to approximately 1.5 volts. (1.4 to 1.6 is fine). Bias is measured from the 15.6 ohm resistors to gnd.

5) If all measurements checkout OK, you can apply a signal to the input.

Troubleshooting

Problem: Low or no B+	Check the rectifier tube. Check the polarity of all electrolytic capacitors.
Problem: No Sound	Check to make sure the mute switch is off or properly connected. Are the tubes glowing? Are your speakers properly connected?
Problem: Excessive Hum	Possible ground loop in circuit or chassis may not be grounded. Check all ground wiring. Check filament voltages and wiring. Check all tubes.
Problem: Outputs will not Bias	Check all connections in bias network surrounding the output tubes. Check to see if voltage is reaching and leaving the bias circuitry on the bias circuit board. There should be approximately -65 volts dc on the anode side of the rectifier diode. Try swapping output tubes. Check the output tubes on a tester if possible, if they are not closely matched, you may have trouble biasing them.

If you have difficulty troubleshooting your equipment, give us a call. We will be glad to help you get your equipment running. Please keep in mind that it can be somewhat difficult to troubleshoot equipment over the telephone and it can also be very expensive. A letter might be more appropriate, but in either case it will help if you have taken the time to write down as many symptoms as possible and also take and record some voltage measurements at key nodes in the circuit.

If all else fails, you can send your amplifier to us, however this should be your last resort. We have built an tested this amplifier and it works and therefore we have to assume that if your amplifier does not work, it is probably something you did wrong during assembly. We charge a flat rate of $35 per hour for repairs and you will be charged unless it is found to be an error in our design or assembly instructions that caused your amplifier to not function.

FINAL NOTES

No doubt many of you will look at this mod and see many more improvements that can be made. We will now suggest a few improvements ourselves and also identify some pitfalls to watch out for if you do make some additional mods once our circuit is in place.

If you are considering solid state rectification for the B+ you must understand that the voltage will increase considerably. Our power supply filtering circuit has very little margin as the filter capacitors are only rated at 450 volts. Solid state rectification of the existing power transformer secondary will result in too high of a voltage.

One source of improvement would be solid state rectification of the B+ voltage followed by a voltage regulation stage that drops the voltage back down to a usable level.

Regulation of the filament voltage will probably offer only marginal improvement, if any. Filament regulation is better suited for preamps.

Some of you may be considering adding even more filter capacitance to the power supply. You must be careful when you proceed down this path as too much capacitance will begin to overload the power transformer resulting in a distorted ac waveform. If you want to use more capacitance, I recommend replacing the original power transformer with one having double the current capacity.

While on the subject of power, it has been brought to our attention that some marginal 5AR4s can cause a considerable voltage surge at turn on that could possibly destroy our input filter capacitor. We suggest that you always use tubes obtained from reliable sources and tested if possible.

Other improvements: We have not used the most exotic components available in this design. We have not done so in order to keep the price of this kit affordable. All of the components we use are of very high quality and have been proven throughout the years. You may have a preference of different resistors, capacitors and wire. This is fine and is why we offer just the circuit boards for those of you wishing to source your own components.

We recommend matched output tubes, they will be easier to keep balanced as the tubes age.

We suggest replacing the RCA jacks with new ones. You can mount them in the existing mounting slot or use the original wholes allotted for the preamp power output or balance adjustment. We also recommend replacing the output terminals with either new ones or binding posts. Most original output terminals will be very oxidized and difficult to adequately clean.

If you have purchased our ST-70 mod kit, we hope you enjoy your new amplifier and we welcome your comments and would also like to hear of your results from any additional improvements you have made to our circuit. For those of you contemplating this purchase, we think you will be pleased with our mod. We feel it is the most musical ST-70 we have ever heard and we have listened to just about all of them in our 15 years in this hobby.