Now, for something completely different, an issue devoted to the Dyna St-120 amplifier, both trouble shooting the stock unit (nobody out there seems to know how to properly fix one) and a do-it-yourself construction project - a power mos-fet power supply section for the St-120 (the same as we use in our complete MOS-FET 120B amplifier which interfaces nicely with the stock Dyna output circuits too).

The Dynaco St-120 was probably the most popular solid state amplifier ever in production with well over 100,000 units sold. It has also (from our experience of building and installing new circuits in thousands of them) probably had more improper and incompetent repair work performed on it than any other amplifier too. We get many calls from owners and from repair shops too, asking for St-120 parts and advice as how to fix them. Almost always, people ask for the wrong parts - parts we know do not normally fail, parts inadequate to make the repair, and a parts list that we know overlooks the real “trouble spots.” We know that many units are simply junked in despair after blowing up again and again after costly, but incompetent repairs, and this is not right. The unit can be made to run solidly if repaired properly and of course we would much rather see those “junkers” come here for our new circuits then being thrown away or becoming a permanent resident of the closet.

Because Dyna St-120 amplifiers tend to blow up a lot and seem to be so difficult to properly repair, there is one advantage to you, dear reader. They do tend to turn up cheap at garage sales and flea markets. More than one of my customers has found useful St-120 amplifiers for $10.00 and sent them here for new circuits. With the information that follows, you probably can make a $10.00 special into a pretty fair little power amplifier without sending it here.

At the end of this issue, I have printed the final version of the St-120 audio output schematic and parts list (the-stock circuit, not our mos-fet output circuit). Since the St-120 audio circuit was changed and, in general, improved many times in its long production life, it is very important that you compare your audio circuits to this schematic and update your unit to this schematic which is the most stable version. We will go through Dynaco's own audio circuit changes first.

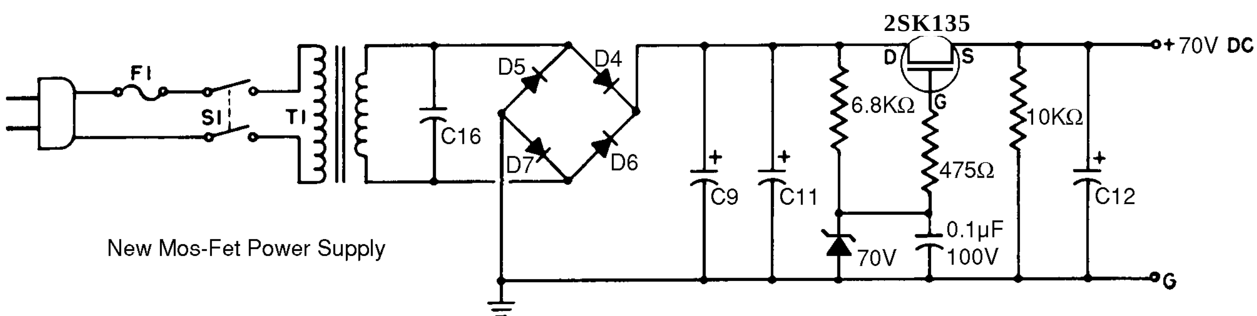
The earliest St-120 amplifiers did not have R27, R28, R29, C13, C14, C15, and the value of C6 was 50 µF at 10 volt (non-polar). These first units also used selected RCA 2N4347 output transistors in all applications. These were all factory wired units built in 1967. By the time the first kits were released, several changes had been made, changes you should make too if you still have an original version.

The first change was the addition of R27, a 0.47 ohm 2 watt emitter resistor to stabilize the outputs. Next R28 was added, a 3.3 ohm emitter resistor for Q4 for further stabilization. This can be added to old cards by making a couple of foil cuts and soldering the resistor to the foil side, and is necessary for stable operation. C14 (.001 µF) was added at this time to eliminate a turn-on "zip" sound. The output devices were changed to special select 2N3055 transistors (more about these later).

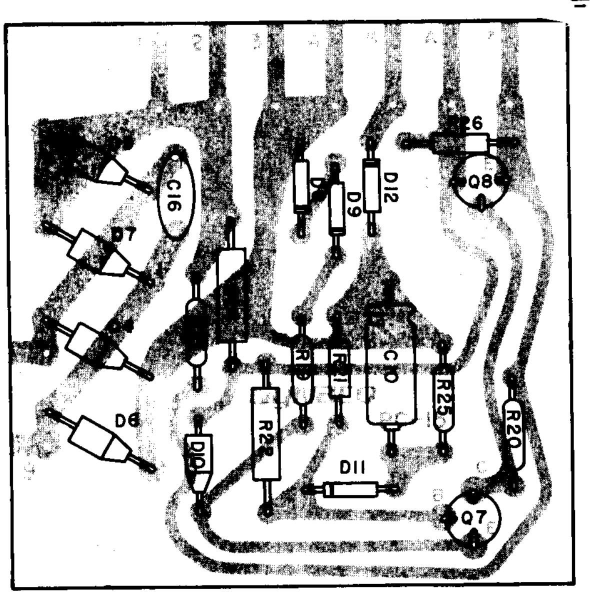
Much later in the production life of the amplifier (mid 1970s) further important changes were made. As the amplifier aged the front end became unstable (Q1-Q2 circuits). Many amplifiers turned into full power high speed oscillators and instantly blew-up for no good reason. The result was blown output transistors. Many times, after replacing the outputs, the amp simply blew up again! The oscillations occurred so fast, and so destructively, there was not time to measure the problem on an oscilloscope before the amp turned into slag again. The "cure" was a change in value of C13, and the addition of C15 to stabilize the front end. You must do this to your St-120 if you want reliable operation. C13 is changed from 27 pF to 68 pF. C15 (27 pF) is added. In addition, C1 was changed to a tantalum capacitor (5 µF 15 volt), and C6 was changed to a .47 µF 100 volt film capacitor. Make these changes to your amplifier too. The final production changes were the addition of R29 (1000 ohms) from each red to black output jack to provide a load for the output caps under open circuit operation, and the change of driver transistors from 2N5320 and 2N5322 types to a heavier TIP31 and TIP32 type. Making all of these changes will give you a much more reliable amplifier.

However, the problems really start when the amplifier fails. In general, the major problem is repairs made with inadequate (general purpose or too low a voltage rating) output transistors. Dynaco used special 2N3055 devices with a 90 volt rating. Standard 2N3055 outputs have a 60 volt rating and since the power supply puts out 72 volts, will fail quickly as they are overvoltaged! Standard replacements for the 2N3055 (HEP, ECG, SK, Tobisha, etc.) have even poorer specifications and are even less reliable in this circuit! Essentially, if a St-120 amplifier output stage fails, Q5, Q6, Q3, Q4, and D1 must all be replaced with parts meeting or exceeding Dyna's original specification for long term reliable service. A shorted output usually "kills" R27 too. Since it is very difficult to find high voltage 2N3055 output transistors, we find a useful replacement to be the much stronger Motorola 2N5630 output transistors, as used in the Dyna St-400 amplifier. In addition, Q3 can be replaced with the St-400 2N3440 and Q4 with the St-400 2N5416 predriver transistors for further durability improvements. Original Dynaco parts are available from Stereo Cost Cutters, Box 551, Dublin, Ohio 43017. Write them for their Dynaco parts catalogue.

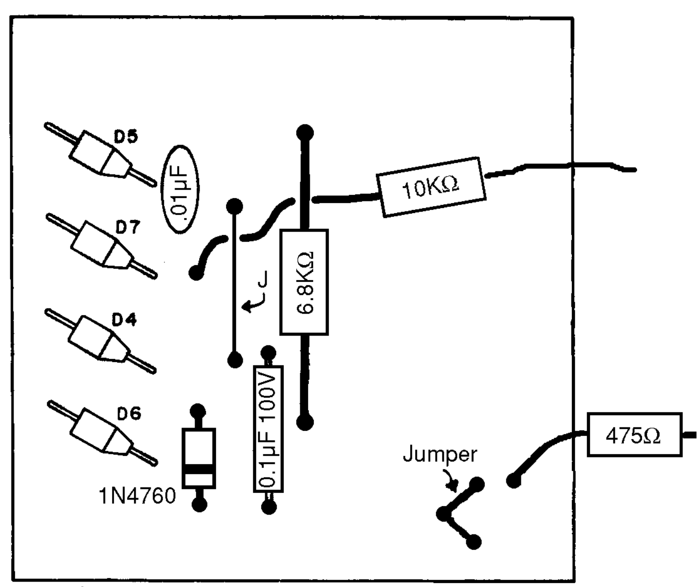
When one channel of a St-120 fails, this "overloads" the power supply (common to both channels) causing (hopefully) the power supply to "shut down" cutting power to both channels and with any luck at all, preventing further damage. Thus many people who think they have both channels out, in fact, do not. Only one channel has failed, causing the power supply, and thus the



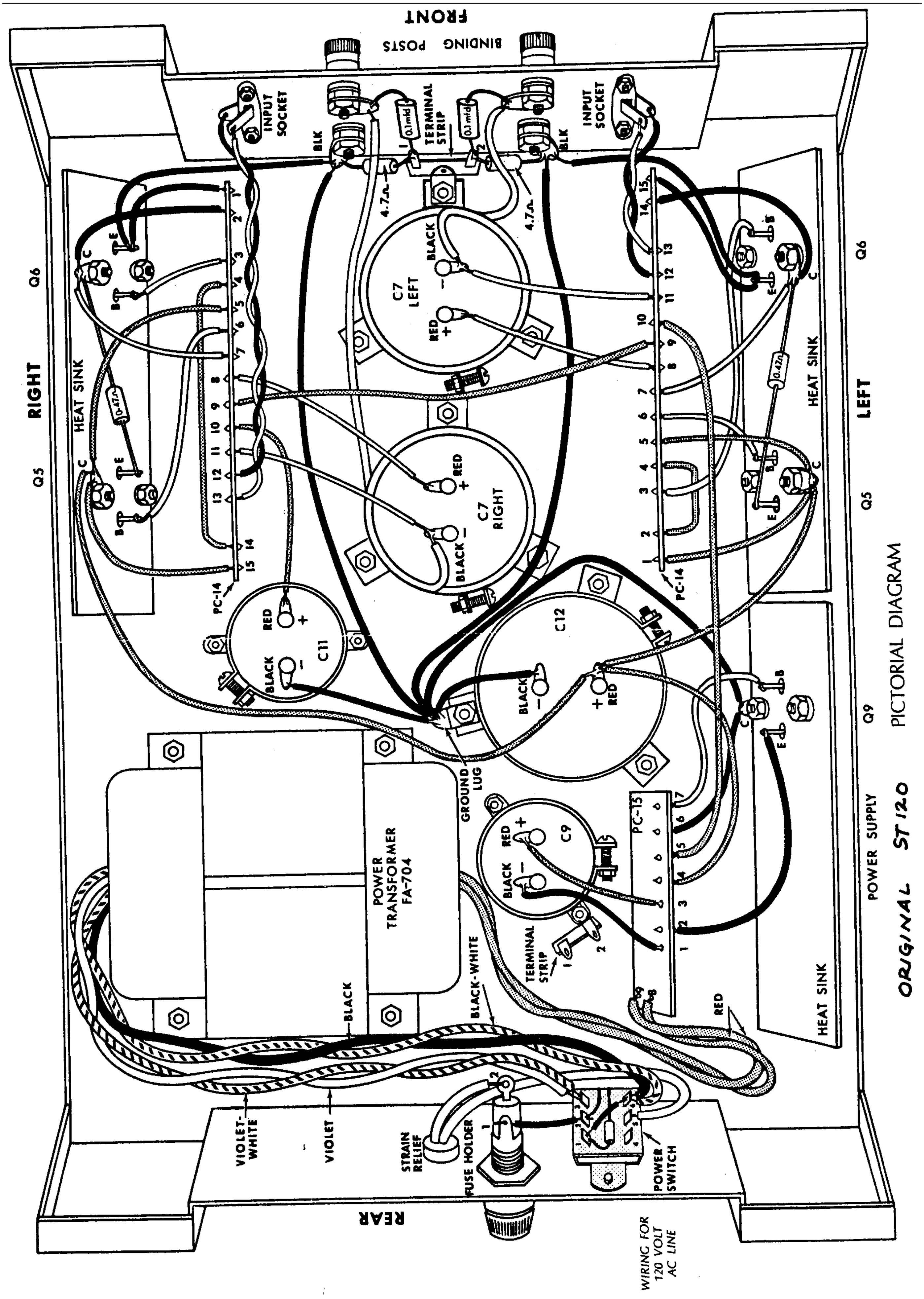
New Mos-Fet Power Supply

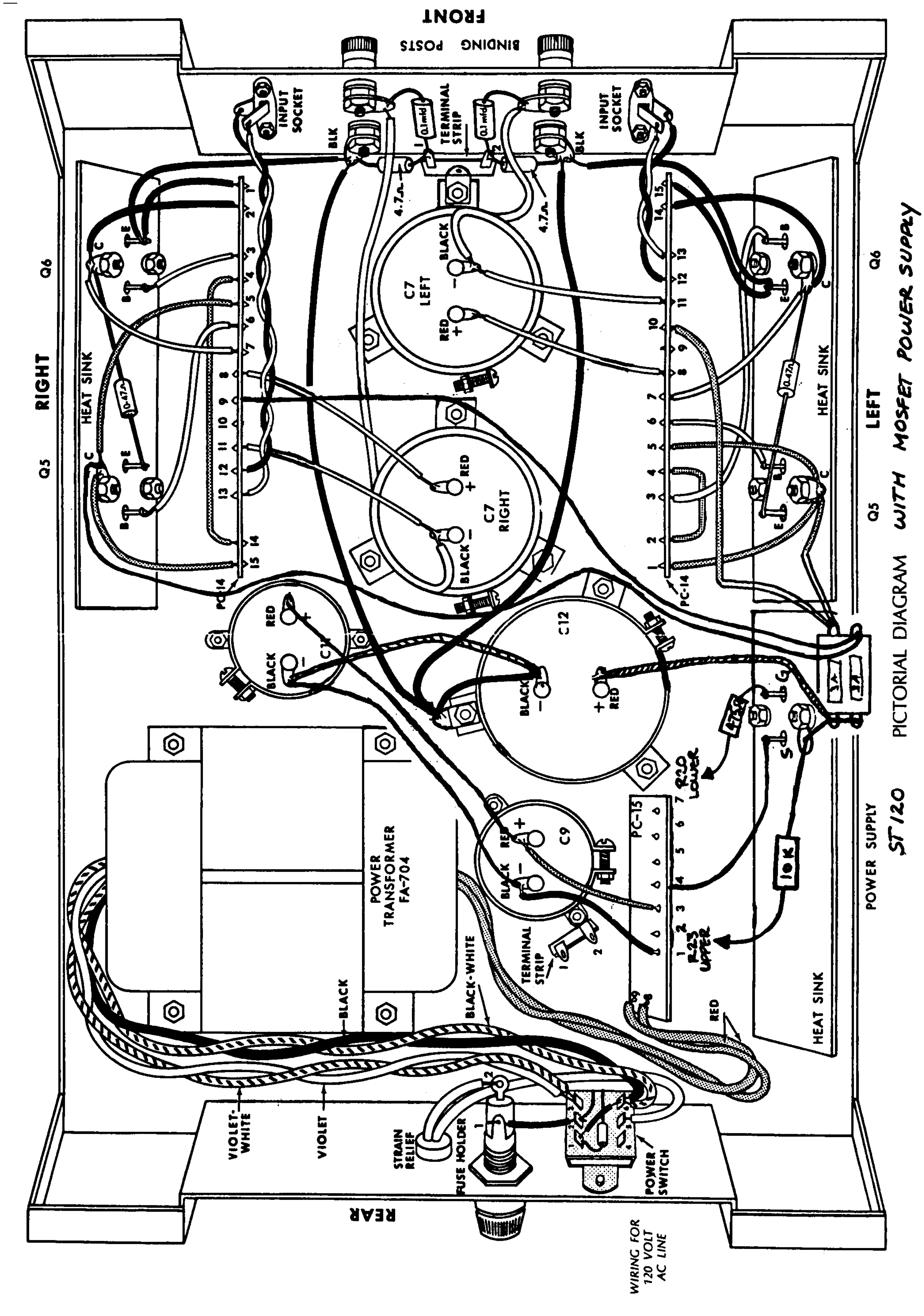


Original Power Supply Board PC-15

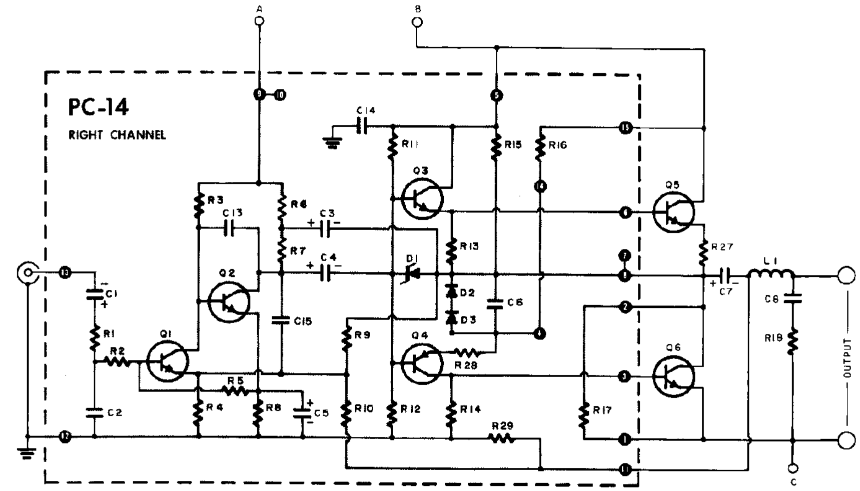


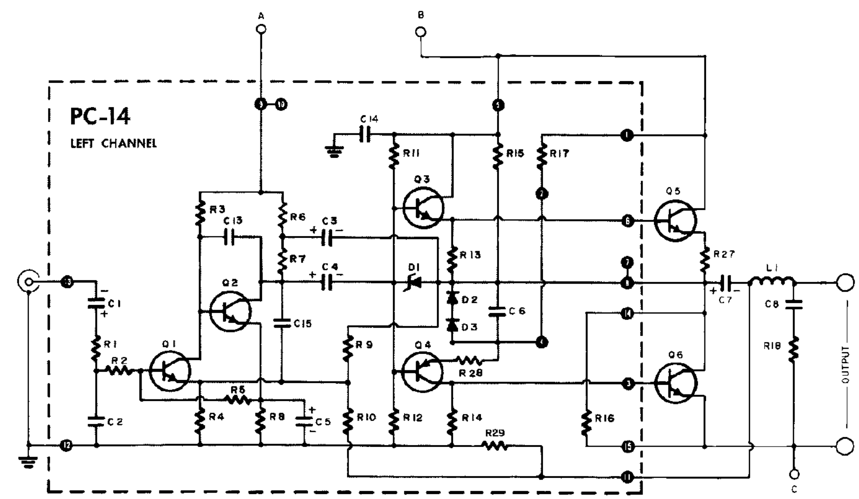
Revised Power Supply Board PC-15


FRONT
BINDING POSTS
INPUT SOCKET
BLK
TERMINAL STRIP
0.1 mfd
4.7Ω
RIGHT
LEFT
HEAT SINK
Q5
Q6
Q9
PC-14
PC-15
C7 LEFT
C7 RIGHT
C11
C12
C9
RED
BLACK
GROUND LUG
POWER TRANSFORMER FA-704
BLACK
BLACK-WHITE
VIOLET-WHITE
VIOLET
STRAIN RELIEF
FUSE HOLDER
POWER SWITCH
REAR
WIRING FOR 120 VOLT AC LINE
POWER SUPPLY
PICTORIAL DIAGRAM
ORIGINAL ST120



PICTORIAL DIAGRAM ST120 WITH MOSFET POWER SUPPLY





Original St-120 Schematic

COMPONENT VALUES

All resistors are ½ watt, 5% unless otherwise specified.

		PART #
R 1	4,700 ohms	113472
R 2	4,700 ohms	113472
R 3	30,000 ohms	113303
R 4	150 ohms	113151
R 5	100,000 ohms	113104
R 6	1,000 ohms	113102
R 7	1,500 ohms	113152
R 8	270 ohms	113271
R 9	4,700 ohms	113472
R10	3,900 ohms	113392
R11	10,000 ohms	113103
R12	10,000 ohms	113103
R13	100 ohms	103101
R14	100 ohms	103101
R15	4,700 ohms	113472
R16	300 ohms 7 watt, 5%	120301
R17	300 ohms 7 watt, 5%	120301
R18	4.7 ohms 1 watt, 10%	125040
R19	6,200 ohms	113622
R20	1,000 ohms, 10%	112102
R21	1,200 ohms	113122
R22	3,900 ohms 1 watt, 5%	116392
R23	1,000 ohms, 10%	112102
R24	4,700 ohms 1 watt, 10%	115472
R25	10,000 ohms	113103
R26	22,000 ohms, 10%	112223
R27	0.47 ohms 2 watt, 10%	128004
R28	3.3 ohms	113030
R29	1000 ohms, 10%	112102
C 1	5 mfd, tantalum	282505
C 2	150 pf mica	245151
C 3	250 mfd, 40v.	283267
C 4	35 mfd, 20v. non-polarized	283356
C 5	250 mfd, 16v.	283257
C 6	.47 mfd, 10v.	282505
C 7	3300 mfd, 50v.	283338
C 8	0.1 mfd, 100v.	264104
C 9	1000 mfd, 100v.	284108
C10	50 mfd, 25v.	283516
C11	500 mfd, 100v.	284507
C12	3300 mfd, 100v.	284338
C13	68 pf disc	237680
C14	0.01 mfd, 100v.	244104
C15	27 pf disc	244271
C16	.01 mfd, 1000 v.	228103

			PART #
Q 1	BC108A	130–180 Beta	572683
Q 2	2N5320	160–260 Beta, 90 V_{cer}, r = 5KΩ	572002
Q 3	TIP31C		577031
Q 4	TIP32C		567032
Q 5	2N3772	40–90 Beta @ 1 A, 100 V_{cer}, r = 100Ω	571844
Q 6	2N3772	60–90 Beta @ 1 A, 100 V_{cer}, r = 100Ω	571844
Q 7	2N4037	100–250 Beta, 90 V_{cer}, r = 5KΩ	564671
Q 8	2N5320	100–140 Beta, 90 V_{cer}, r = 5KΩ	574003
Q 9	2N4347	25–50 Beta @ 1 A, 110 V_{ceo}	574844

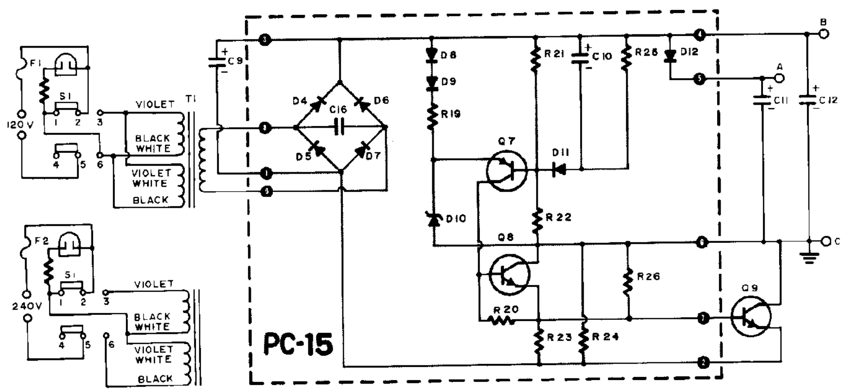
		PART #
D 1	zener diode, 5.1 volt, 5%, 400 mw.	540405
D 2	silicon diode, 0.8 volt drop @ 140 ma.	544015
D 3	silicon diode, 0.8 volt drop @ 140 ma.	544015
D 4	silicon diode, 3 amperes, 200 prv.	544322
D 5	silicon diode, 3 amperes, 200 prv.	544322
D 6	silicon diode, 3 amperes, 200 prv.	544322
D 7	silicon diode, 3 amperes, 200 prv.	544322
D 8	silicon diode, 1N4003	544012
D 9	silicon diode, 1N4003	544012
D10	zener diode, 58 volt, 2%, 1 watt	540158
D11	silicon diode, 1N4003	544012
D12	silicon diode, 1N4003	544012
T 1	Dynaco FA-704 power transformer	464001
S 1	DPDT lighted switch	334001
F 1	fuse 3 amp slo-blo	342030
F 2	fuse 1.5 amp slo-blo (alternate)	342015
L 1	74 inches of #16 insulated wire	319907

VOLTAGE TEST POINTS

Measured with VTVM, 120 or 240 volt 60 cycle AC line, 8 ohm load, shorted input. All voltages are DC unless specified AC.

Left PC-14		*Right PC-14*		*PC-15*	
#1	72	#1	0	#1	–21
#2	37	#2	36	#2	–21
#3	<0.5	#3	<0.5	#3	72
#4	37	#4	37	#4	72
#5	72	#5	72	#5	71
#6	36	#6	36	#6	0
#7	36	#7	36	#7	–20
#8	36	#8	36	#8	70 AC*
#9	71	#9	71	#9	70 AC*
#10	71	#10	71		
#11	0	#11	0		
#12	0	#12	0		
#13	0	#13	0		
#14	36	#14	37		
#15	0	#15	72		

*Measured between eyelets located on circuit board edge



other channel to shut off too. To trouble shoot, disconnect the B+ supply feed from first one, and then the other channel to find out which channel (with the other disconnected from and thus not loading down the power supply) still works. Many people have attempted and/or paid for two channel repairs when only one channel was defective.

The worst case problem is when one channel fails, and the user still attempts to drive the other channel. The protective circuits in the power supply will only hold up for a limited time before failing too. This causes the power supply transistor to blow, and the supply deregulates, going up from 72 to over 90 volts, thus overvoltaging the remaining good channel (and the still working parts in the defective channel) causing every transistor in the unit to melt, frazzling resistors and circuit foil too. For this, you get a plaque mounted on the wall, with the stuffed back half of a cat mounted on it (a catastrophe)!

If the power supply section fails, one of two things happens. The worst problem is described above, an overvoltage condition, with in excess of 90 volts DC at C12+, and probable major damage to the audio circuits. Sometimes the supply fails open, and the voltage at C12 will be near zero. A simpler failure (and quite common – especially in the summer when there is lots of power line transients) is a blown supply diode (one or more of D4, D5, D6, and/or D7) which will vaporize the line fuse but cause no further problems downstream, assuming the shorted diode(s) are located and replaced. Once in a while, the zener regulation diode (D10) will fail in a "low regulation voltage" mode. This will cause the supply output to drop to some lower voltage than the specified +72 volts. The cure for this simple problem is just to replace D10 with another 58 volt zener diode. The regulated power supply of the St-120 is a mess and nearly impossible to fix reliably at a rational cost. If any transistor goes, Q7, Q8, and Q9 must all be replaced with transistors of Dynaco specifications (matched together) and biasing resistor values must be "tweaked" to get things to work properly.

This is a design problem due to the inherent characteristics of bi-polar power transistors. The power supply must supply up to 6 amperes of regulated current at 72 volts. The power supply main series power transistor (Q9) has a beta (gain) of about 15. This means that to control 6 amperes of current, it must have up to 400 milliamps of current driving its base. The control reference is a zener diode (D10). It can only supply about 20 milliamps of current. Thus the current from D10 must be further amplified by Q7 and Q8 to provide enough current to supply the audio circuits. Thus we end up with a multistage amplifier in the supply regulator, which is inherently unstable. Thus it must be compensated (slowed down) to be stable and thus supplies, in effect, no current at all at high frequencies. Further circuits attempt to shut down and protect the supply in case of output failure, and other circuits try and provide a slow turn on to avoid thumps in the speakers. If all supply circuits are not exactly matched, it may not turn on, it may not regulate, it may turn on too fast, it may shut off too soon, or not at all. It is a real "bitch" to fix and make operate well. Thus, when we get a 120 in for repair only with a power supply problem, we never "fix" the original power supply, but simply install our own mos-fet power supply from the MOS- FET 120B amplifier which I shall now tell you how to do yourself.

The power mos-fet transistor we use (Hitachi 2SK133, 134, or 135) has nearly infinite current gain and can be controlled by a single zener diode. It has more current capacity than the transformer can deliver and can be protected by simple B+ fuses, it needs no "slow down" stabilization for the single stage circuit is inherently stable and thus has a bandwidth into the megahertz range and can supply current for high frequencies too. It cannot thermal run-a-way and requires no electronic protection. It is a simple circuit (six new electronic parts replacing the 17 original supply parts) and it will make your amplifier sound better.

The parts required are 1 Hitachi 2SK135 N channel mos-fet, 1 70 volt 1 watt zener diode, 1 .1 µF at 100 volt film capacitor, 1 475 ohm 1/2 watt resistor, 1 10,000 ohm 3 watt resistor, and 1 6,800 ohm 2 watt resistor. A dual fuse block containing two 3 ampere quick blow fuses is mounted on the power supply heat sink above the power mos-fet, and the audio circuits and power supply capacitors are rewired to interface with the new power supply. A .01 at 1000 volt capacitor is added across the diode bridge to suppress switching transients. We can supply a power supply parts kit (the parts described in this list) for $35.00 including shipping. "Hand holding" (if you screw it up) costs extra!

Anyway, assuming you have a St-120 that now has audio circuits in working order, here is how you install the new mos-fet power supply. (Refer to the print of the Dyna St-120 pictorial diagram supplied at the end of this article).

Unsolder all the wires to PC-15 eyelets 1 through 9, remove the black wire from Q9-C to the chassis ground lug, remove the two screws holding the power supply heatsink in the chassis (one in a rubber foot) and remove the power supply module from the chassis.

Unsolder and remove the red wires at each audio channel (PC-14) eyelets 9 and 10 and at the red (+) terminal of C11. Unsolder the red wires (three) at C12 red (+). The red wires from the left and right audio channel Q5-C will be reconnected later to the new fuseblock.

Remove the three long screws and spacers holding PC-15 to the heat sink and remove PC-15. Also remove Q9 from the heat sink but save the mounting hardware.

Clean the thermal compound from the heat sink assembly. You will need to make a trip to Radio Shack for a small tube of white thermal compound for mounting the new mos-fet power transistor and to sink the heatsink to the chassis upon reassembly.

Remove (unsolder) all the parts from PC-15 except the power supply diodes (D4, D5, D6, D7). If there is already a .01 µF at 1000 volt capacitor installed across eyelets 8 and 9 it can remain, if not, a new capacitor will later be installed.

Refer to the layout sketch of PC-15 (power supply circuit board). Now install the following new parts (all on the component side): A jumper wire connecting Q7 C, B, and E eyelets; a jumper wire in the R24 location; a new 6.8 K ohm resistor from the top hole of D8 to the bottom hole of R19; and a new .1 µF capacitor (104K) in the R22 location. Install a new 70 volt zener diode (1N4760) (banded end pointing down) in the D10 location. All connections are, of course, to be soldered. Add a .01 µF at 1000 volt capacitor (.01M) between the foil at eyelet 8 and 9 if one is not already installed (true in late model St-120 units only). Clear the solder from the following holes for reuse (use solder sucker or round wood toothpick): eyelets 1, 3, 4, 8, 9, the bottom hole of R20, and the top hole of R23. Inspect the PC-15 card very carefully to insure that no solder bridges (Lloyd's cousin) or foil breaks were made in removing the original parts or installing the new parts.

Now mount the new Hitachi 2SK135 output mos-fet transistor on the heatsink in the Q9 location. Coat the transistor mounting surface with thermal compound, slip the mica insulator on the leads, press it against the mounting surface, coat the insulator with thermal compound too and press this surface against the heatsink with the leads pointing through. Note the pins are offset and the transistor will only "line up" properly in one orientation (pins offset towards the top of the heatsink). Press a new shoulder washer into each mounting hole from the inside. Install two new #6 screws through the transistor. Fasten the bottom screw with a #6 lockwasher and nut firmly tightened, fasten the top screw with a #6 solder lug (pointing sideways directly towards the power switch end of the chassis) and another #6 nut, firmly tightened. It is very important that the transistor (and all mounting screws and the transistor pins) be isolated from the heatsink (no metal to metal contact). The original transistor was not isolated as it was a different circuit configuration.

Install the new fuseblock on the inside of the heatsink above the new transistor. It is fastened with one #6 screw through the top hole in the block from the inside, through the top free hole in the heatsink, and with a #6 lockwasher and nut on the outside of the heatsink, firmly tightened. It is located so the fuses will be parallel with the bottom of the chassis. Reinstall the rebuilt PC-15 card on the heatsink in its original location and orientation reusing the three original sets of long #6 screws and spacers.

Install a wire from the left (power switch end) side of the top fuse clip to the bottom fuse clip to the solder lug at the top #6 screw of the power mos-fet transistor (solder at the bottom fuse lug only at this time). Install the 10,000 ohm 2 watt resistor (brown, black, orange) from the mos-fet solder lug to the previously opened top hole of R23 on PC-15. The resistor will be placed between the PC card and the heatsink. Make sure a lead cannot touch the chassis, heatsink, or the mounting spacer for PC-15. Solder both ends. Install an insulated wire from the power mos-fet pin closest to PC-15 to eyelet 4 on PC-15 and solder both ends. Install the 475 ohm resistor (4750F) from the open bottom hole of R20 on PC-15 to the remaining mos-fet pin (furthest from PC-15). Locate the body of the resistor as close to the mos-fet pin as possible and keep the lead between the body and the mos-fet as short as possible.

Reinstall the power supply module in the chassis in its original location. It is easiest to first connect and solder the two red transformer leads to eyelets 8 and 9, then coat the heatsink mounting flange with thermal compound, and then fasten it in place with two sets of #6 hardware (including the original rubber foot on the corner mounting screw). Make sure the red leads cannot be "trapped" or pinched by the sink, chassis, or cover. Look also at this time at the other power transformer leads on the outside of the power transformer. Many times these are located so they can be "squashed" between the chassis and the inner cover flange when the cover is reinstalled. Correct this problem now if it exists.

Reconnect the black wire from C9 negative (-) lug to eyelet 1 on PC-15. Reconnect the red wire from C9 red (+) lug to eyelet 3 on PC-15. Connect an insulated wire from the top left new fuse lug (PC-15 side) to the red (+) lug of C12 (solder all connections). Connect a new insulated wire from C9 black (-) to C11 black (-). Eliminate the original wire from C11 black (-) to the chassis ground lug. Connect a new wire from C11 black (-) to C12 black (-). Connect a new wire from C9 red (+) to C11 red (+). Solder all connections. The power supply rebuild is now complete except for connecting it to the audio circuits and testing.

Connect an insulated wire from right channel Q5-C solder lug to the bottom right fuse lug (furthest from PC-15). The original red wire previously connected at C12 red (+) is probably too short and will need to be replaced with a new wire. Connect an insulated wire from right channel PC-14 eyelet 9 to the same lower right fuse lug on the power supply heatsink and solder all connections. Connect the red wire from left channel Q5-C solder lug to the top right fuse lug on the PC-15 heatsink. Connect an insulated wire from eyelet 9 on left channel PC-14 to this same right top fuse lug and solder all connections.

This completes the wiring. Now test the power supply operation before installing the two 3 ampere quick blow fuses connecting each channel's B+ supply to the new mos-fet regulated power supply. A DC voltmeter is required. With the 3 ampere slo-blo main chassis mount line fuse installed, but with both 3 ampere quick-blo B+ fuses not installed in the new dual fuseholder on the power supply heatsink, plug in the amplifier and turn it on. If the power supply is working properly, the DC voltage should read about +70 volts from C12 red (+) to ground with less than 10 millivolts of AC ripple. The DC voltage from C9 red (+) to ground should read about +90 volts DC with less than 2 volts AC ripple. The new power supply heatsink should not get hot (under any load) and the main line fuse should hold. If the fuse blows, or if any voltage is improper, unplug the amplifier and check your work for wiring errors and/or solder bridges and bad connections. If the voltage at C12 is low then probably the zener diode is defective. An immediate failure of the line fuse (splattered) indicates a shorted main diode (D4, D5, D6, or D7). You must achieve proper power supply operation before connecting the B+ fuses to avoid subsequent damage to the audio circuits.

Assuming that everything checks out, turn off the amplifier and let it set for 1/2 hour for the supply voltages to decay, then install the two 3 ampere quick-blo fuses in the new B+ fuseblock and try the amplifier again. All fuses should hold, the B+ voltages should remain the same as before. The DC voltage from C7 red (+) for each channel to ground should read about +35 volts DC (about one half the regulated power supply voltage). If these conditions are true, you may now reinstall the amplifier in your system and hear cleaner sound. Note that now each audio channel has an independent B+ fuse in series with its output transistors and an overload, output short, or audio channel failure will blow the associated B+ fuse, protecting the power supply and allowing the unaffected audio channel to continue normal operation.

The following are the necessary schematics, diagrams, and sketches for the mos-fet power supply conversion. Note that our mos-fet audio circuits may be added to your amplifier at any time, but not as a do-it-yourself kit. The audio circuits use complete new circuit boards and a very sophisticated layout and must be done at our shop. If you have successfully installed this mos-fet power supply yourself, you may deduct its parts cost ($35.00) from the full cost of the MOS-FET 120B rebuild if you send the amplifier to us for the new audio circuits.