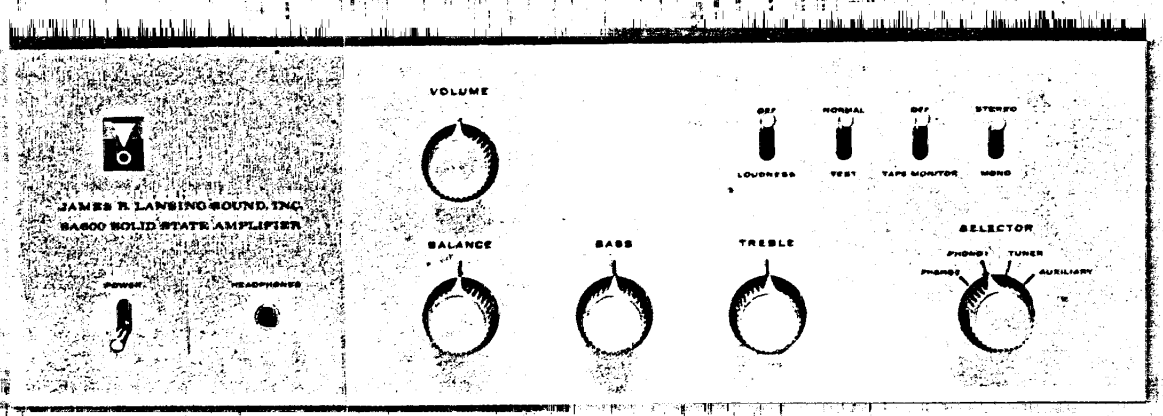
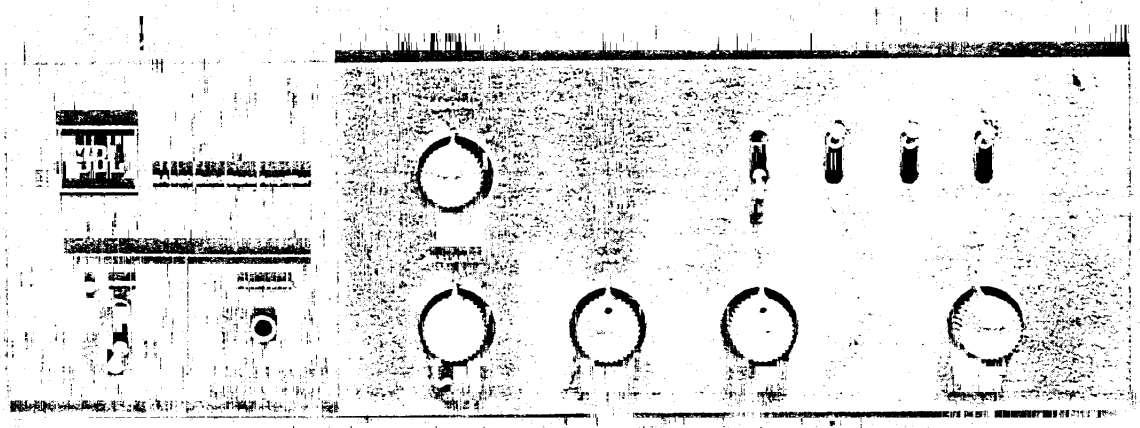


SA600
SA660
SERVICE MANUAL
REPLACEMENT PARTS



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MODELS SA600 AND SA660

DESCRIPTION OF OPERATING CONTROLS AND CONNECTIONS

1.1 FUNCTIONS OF FRONT PANEL CONTROLS

1.1.1 POWER SWITCH - This controls not only the amplifier but any other units which are plugged into the two black switched outlets on the bottom panel. A third, white outlet is not affected by the power switch.

1.1.2 HEADPHONE JACK - Any standard stereo headset can be plugged into this jack for private listening. When headphones are plugged in, the loudspeakers are muted. The signal level at the headphone jack is sufficient to give satisfactory results with any 8-16 ohm phones, and with sensitive units of higher impedance as well. The test has no effect on the headphone operation.

1.1.3 VOLUME CONTROL - The volume of both stereo channels is adjusted simultaneously and identically by volume control.

1.1.4 BALANCE CONTROL - The balance control adjusts the relative volume between the right and left channels. Turning the knob clockwise emphasis the sound from the right hand speaker. Turning the knob counterclockwise shifts the emphasis to the left hand speaker.

1.1.5 BASS CONTROL - When the control pointer is centered on the vertical line, the low frequency response curve of the SA600 is flat. Operation of this control adjusts response in both channels.

NOTE: The JBL SA660 incorporates concentric tone control potentiometers which permit independent adjustment of bass and treble response for each channel.

1.1.6 TREBLE CONTROL - When the control pointer is centered on the vertical line, high frequency response of the SA600 is flat. Response of both channels is simultaneously adjusted with this control.

1.1.7 SELECTOR - The rotary switch selects any one of four program sources that may be connected to the SA600, and has been designed to be as quiet as possible. There are almost no audible transients generated when switching from one input to another, so long as shorting plugs are inserted in unused inputs. All inputs other than that selected are automatically grounded to avoid annoying cross talk between program sources. Tape play input is selected by the tape monitor switch.

1.1.8 LOUDNESS SWITCH - With loudness switched off, the volume control adjusts only sound intensity. With the loudness switch set in its down position emphasis is placed on bass tones at decreased volume.

1.1.9 TEST/NORMAL SWITCH - The test switch is a special JBL feature used to balance the two stereo channels. The A-B connects the speaker to reproduce the difference between channels. When a monophonic source is used, and both channels are balanced, essentially no output should be heard from the speakers.

1.1.10 TAPE MONITOR SWITCH - When using a tape machine having separate record and playback heads with its own electronics for recording and playback, the Tape Monitor Switch allows immediate comparison between source and recording. When the Tape Monitor Switch is off, the SA600 operates normally and whatever program you hear is the same program being fed to the tape recorder. When the switch is thrown down to the TAPE MONITOR the same program source continues to feed to the recorder, but the loudspeakers (or headphones) now pick up the signal from the tape recorder playback head.

1.1.11 STEREO/MONO SWITCH - This switch connects the two preamplifier channels in parallel providing monophonic reproduction when placed in the MONO position. If only monophonic operation is desired, do not connect both amplifier outputs in parallel. Such a connection will result in output transistor failure.

1.2 INPUT PANEL CONNECTIONS (See figure 1-1).

NOTE

Do not use shorting plugs in the "out to Recorder" jacks or the unit becomes inoperative, although no actual damage will occur. It is desirable to place shorting plugs in all unused inputs to avoid clicks or transients when switching between inputs.

All connections in the top row are channel A (left loudspeaker). All connections in the bottom row are channel B (right loudspeaker).

1.2.1 UNSWITCHED AC OUTLET - The white AC receptacle is always connected to the AC power line and can be used for turntable, record player or tape recorder.

1.2.2 SWITCHED OUTLETS - Any devices plugged into the two black outlets are switched on and off with the SA600.

1.2.3 OUT TO RECORDER - Cables from these jacks connect to the "line" or high level inputs of the tape recorder.

1.2.4 TAPE PLAY - These jacks connect to the outputs from any tape machine with its own built-in preamplifier. The Tap Play inputs are selected by the Tape Monitor switch rather than the rotary SELECTOR switch.

1.2.5 AUXILIARY - This is an all-purpose input which can be connected to any program source which has a signal level of 0.25 or more.

1.2.6 TUNER - Requires an input of 0.25 volts.

1.2.7 MAGNETIC PHONO - 1. This input accepts any low-level pickup requiring standard RIAA equalization. The sensitivity of the Phono 1 input is controlled by a 3-position switch on the bottom panel. With this switch set in the "LOW" position, maximum sensitivity, 4 millivolts of signal are required to drive the SA600 to its full rated output.

1.2.8 MAGNETIC PHONO - 2. This input is not affected by the bottom panel balance control and should be used as a second phono channel.

1.2.9 CHASSIS GROUND - A spring loaded terminal is located to the right of the MAGNETIC PHONO 2 jacks. This terminal is used to make a ground connection to a record changer or turntable which has a separate ground wire.

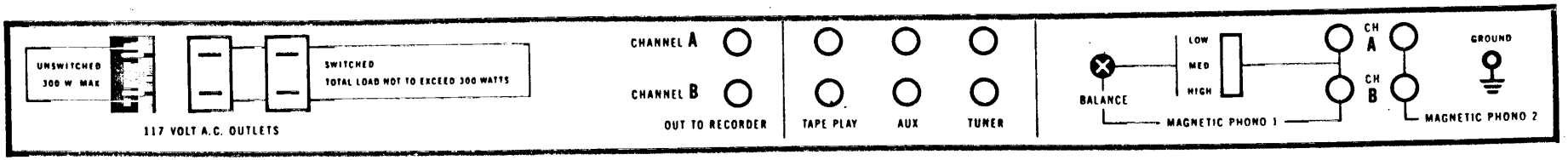


Figure 1-1 INPUT PANEL

1.3 INPUT PANEL CONTROLS

1.3.1 BALANCE CONTROL - This is a separate "trim" balance control for the magnetic phono 1. inputs. Nearly every magnetic phono cartridge has a slightly different output for each channel. This second balance control eliminates the need to adjust the front panel control when playing records.

1.3.2 PHONO CARTRIDGE MATCHING SWITCH - By correctly matching the operating characteristics for the SA600 to the output level of a phonograph cartridge, signal to noise ratio and dynamic range can be significantly improved. If a cartridge has a low output signal, set the switch to "low". If a cartridge has a high signal level, set the switch to "high". It is important to remember that the phono cartridge matching switch operates both phono inputs 1 and 2.

1.4 BACK PANEL CONNECTIONS

1.4.1 CHANNEL A TRANSDUCER TERMINALS - The red terminal connect to the red (or +) loudspeaker terminal, and the black terminal connects to the black (or COM) loudspeaker terminal. The left-hand loudspeaker system should be connected to the channel "A" terminals.

1.4.2 CHANNEL B TRANSDUCER TERMINALS - The wires from the right-hand loudspeaker system connect to these terminals, as discussed in Channel "A" loudspeaker connections.

CAUTION

Do not connect the two channels in parallel or to the outputs of another amplifier. If a signal is fed back into the output terminals, transistors can be damaged. This means that you must not connect the speaker output to another amplifier and that two sets of output terminals must not be tied together. For monophonic reproduction through a single system, simply use one set of outputs. No increase in output power can be obtained by attempting to parallel the amplifier outputs. The unused output terminals can be left disconnected without danger.

1.4.3 FUSE - For 110-120 volt operation, a 2 amp. slo-blo fuse is required. For 220-240 volt AC lines, a one amp. slo-blo fuse should be used. The AC outlets on the bottom panel are not fused.

SECTION II

PERFORMANCE SPECIFICATIONS

2.1 INTRODUCTION

The specifications which follow are measured with both channels operating simultaneously into 8-ohm loads. AC line voltage is held at 117 volts, 50/60 cycles or 234 volts 50/60 cycles depending on transformer connections. During normal use, the performance of the SA600 is not appreciably affected by line voltage fluctuations between 110 and 120 volts.

2.2 TEST POINTS

Power amplifier test points are provided for checking the performance of the power amplifier section only. Signal connections between the preamplifier and the power amplifier are made with standard phono pin plugs and jacks. These are accessible after removing the top cover. To test the power amplifier remove the pin plugs from the jacks and connect the desired external oscillator or other signal source. Approximately one volt of signal is required at this point for full power output. It should be noted that the only front panel function which remains operative are the POWER SWITCH, TEST/NORMAL SWITCH, and HEADPHONE JACK.

2.3 PERFORMANCE SPECIFICATIONS SA600 AND SA660

POWER OUTPUT	Any frequency from 10 cps to 30,000 cps.
SA600	80 watts continous RMS power, 40 watts per channel.
SA660	120 watts continous RMS power, 60 watts per channel.
FREQUENCY RESPONSE	From high level inputs - ± 0.75 db 20 to 20,000 cps, ± 1.5 db 10 to 130,000 cps. Power amplifier only (measured at test point provided) ± 0.25 db 20 to 20,000cps. ± 1.5 db 3 to 200,000 cps.

HARMONIC DISTORTION	From high level inputs - less than 0.2 percent from 20 to 20,000 cps at Rated Output. 0.1 percent from 20 to 20,000 cps at one watt. Power amplifier only, less than Rated Output.
SA600	80 watts Rated Output
SA660	120 watts Rated Output
INTERMODULATION DISTORTION	From high level inputs - less than 0.2 percent at 80 Rated Outputs watts or any lower level, 0.07 percent at one watt (IHF Standard - 60 and 7,000 cps, 4:1 ratio) Power amplifier only, less than 0.15 percent at Rated Output or any level less Rated Outputs.
SA600	80 watts Rated Output
SA660	120 watts Rated Output
SENSITIVITY	Signal required for rated output: Phono input at 1,000 cps reference 4, 8 or 16 millivolts into 47,000 ohms, switch selected. High level inputs 0.25 volts into 35,000 ohms.
MAXIMUM PHONO LEVEL	250 millivolts at 1,000 cps with less than 0.1 percent harmonic distortion.
HUM AND NOISE	Through both preamplifier and power amplifier: Low level inputs (1,000 ohm termination) - 72 db below rated output, equivalent to one microvolt at input terminals or 80 db below 10 millivolts. These specifications are measured with the phono switch set at LOW, giving rated output with 4 millivolts signal. With switch set at MED or HIGH, noise is further reduced to 75 db or 78 db below rated output, respectively. High level inputs - 85 db below rated output.
BASS CONTROL	± 18 db at 20 cps minim m range.
SA600	Ganged controls simultaneously adjusts both channels.
SA660	Concentric controls permit independent response adjustment.

DAMPING FACTOR	Generator impedance at output terminals:
SA600	0.35 ohms, equivalent to a damping factor of 23 when connected to an 8 ohm load.
SA660	0.25 ohms, equivalent to a damping factor of 32 when connected to an 8 ohm load.
STABILITY	The power amplifier of the SA600 and SA660 utilizes the exclusive JBL T-Circuit (patent pending). It is completely stable when connected to any loudspeaker system or even to a capacitive load. Specified distortion and stability without oscillation are maintained through extreme variations in output load, whether resistive, capacitive or inductive. Moreover, AC line surges do not affect the amplifier stability.
SHORT CIRCUIT PROTECTION	Protection is absolute when the amplifier channels are not connected in parallel or to the outputs of another amplifier. Otherwise, the amplifier cannot be damaged by accidental or intentional short open circuit at the output terminals, or by any degree of impedance mismatch.
TRANSISTORS	
SA600	36 silicon transistors plus 19 silicon diodes.
SA660	37 silicon transistors plus 23 silicon diodes.
POWER AMPLIFIER CIRCUIT	The JBL T-Circuit (patent pending) is an analog computer-type operational DC amplifier ... the most nearly perfect amplifying circuit ever developed. All stages are direct coupled, including the output stage so that accurate control of the loudspeaker is maintained to DC. In the JBL T-Circuit, there are no audio transformers of any kind, no coupling capacitors, no reactive components to affect the response of the stability of the circuit in any way.

TREBLE CONTROL	±15 db at 20,000 cps minimum range.
SA600	Ganged controls simultaneously adjusts both channels.
SA660	Concentric controls permit independent response adjustment.
VOLUME CONTROL	Volume control tracking to be within 2 db over 50 db attenuation range.
TRANSIENT RESPONSE	Rise time measured at high level inputs is 2.5 microseconds from 10% - 90% of square wave signal at peak power output or any lower level power. Power amplifier only 2.0 microseconds at peak power or any lower power level. Response to such square wave signals is free from detectable overshoot or ringing, as observed on an oscilliscope.
SA600	Power rating 160 watts peak power.
SA660	Power rating 240 watts peak power.
OVERLOAD	Less than 1/10 of one cycle to recover from 100 percent single cycle overload at any frequency from 20 to 20,000 cps.
OUTPUT IMPEDANCE	8 ohms rated impedance, 4 to 16 ohms nominal impedance. When driving a 16 ohm load, the amplifier meets all published specifications except that power output is reduced. When driving a 4 ohm load, the amplifier produces increased output power for brief periods of time. Prolonged operation at more than 40 watts per channel, however, will trigger the built-in automatic overload devices.
SA600	4 ohms - 130 watts, 8 ohms - 80 watts, 16 ohms - 64 watts.
SA660	4 ohms - 180 watts, 8 ohms - 120 watts, 16 ohms - 80 watts.

2.4 MEASUREMENT TECHNIQUES

Most of the commonly available instruments used in testing audio amplifiers have higher distortion and/or noise than the SA600 or SA660 generates. In order of preference we recommend for the audio oscillator a Radrord Low Distortion Oscillator or a Hewlett Packard Model H20-220 C.D. Use of a Hewlett Packard Model 333A Harmonic Distortion Analyzer is preferred and for ease of making IM Distortion measurements we recommend the Audio Instrument Company Model 168 Analyzer. Because the residual distortion, hum and noise of the SA600 is so low, the measuring techniques recommended below should be used.

2.4.1 TESTING HIGH LEVEL INPUTS

2.4.1.1 TOTAL HARMONIC DISTORTION - (Figure 2-1)

1. Connect the oscillator to either the AUX or TUNER input jack with a standard shielded cable.

2. Connect the harmonic distortion analyzer and an 8 ohm non-inductive load resistor to the red and black output terminals of the SA600.

3. Both the oscillator and the distortion analyzer should be "floated" or isolated from the power line grounding system. This can be done by using a two-blade power plug adaptor which disconnects the instruments power cable ground pin. If the Hewlett Packard oscillator is used, the output terminal ground strap should be disconnected so that the output is floated from the instruments chassis ground. Do not connect a common ground between the oscillator and analyzer.

HARMONIC DISTORTION TEST

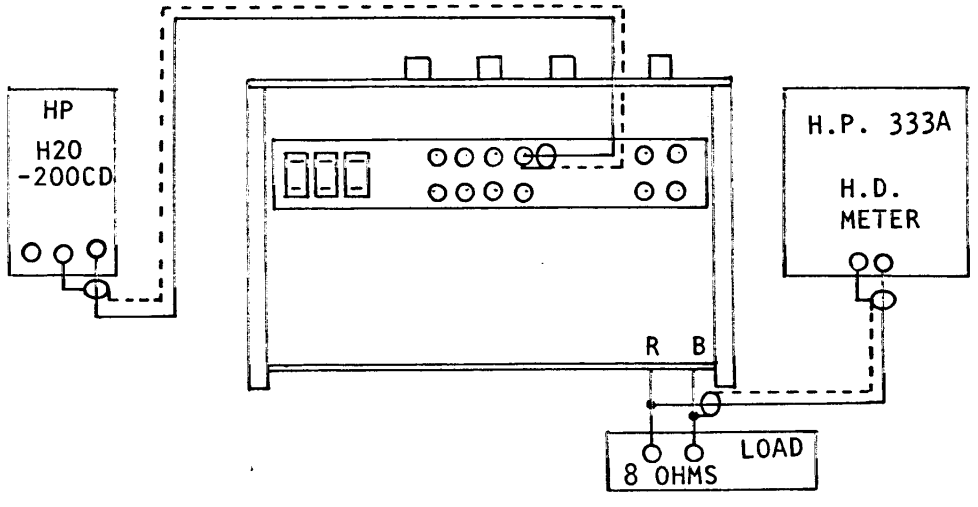


Figure 2-1 HARMONIC DISTORTION TEST CONNECTIONS

2.4.1.2 INTERMODULATION DISTORTION - (Figure 2-2)

1. Connect the "Oscillator Out" terminals of the intermodulation analyzer to either the AUX or TUNER with a standard shielded cable.
2. Connect the non-inductive 8 ohm load resistor to the red and black output terminals of the SA600.
3. Connect the hot "Analyzer Input" terminal to the red output terminal of the SA600. Make no connection between the analyzer ground terminal and the black output terminal of the SA600. This precaution avoids the ground loop that would be completed through the analyzer common input-output connection.

I.M.DISTORTION TEST

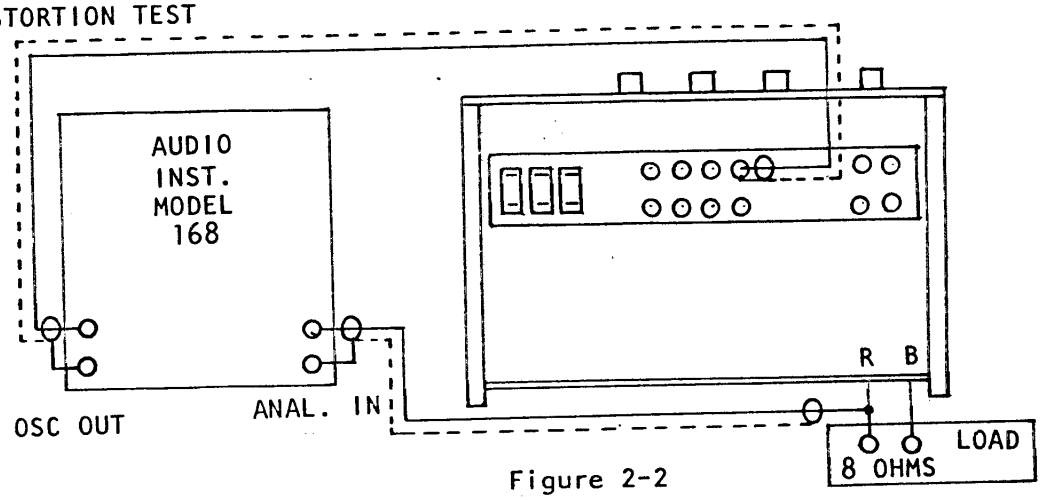


Figure 2-2

2.4.1.3 HUM AND NOISE - (Fig 2-3)

1. Connect an AC vacuum tube voltmeter to the red and black output terminals of the SA600.
2. Terminate the desired high level input (AUX or TUNER) with a phono plug containing a 1000 ohm resistor. The resistor should have short leads to the phono plug and should be shielded by the plug body.
3. Select the correct input with the SA600 SOURCE switch, turn the volume control to maximum and measure the noise output on the VTVM. Express the noise reading in decibels below full output (17.9 volts across the 8 ohms is 40 watts).

NOISE TEST

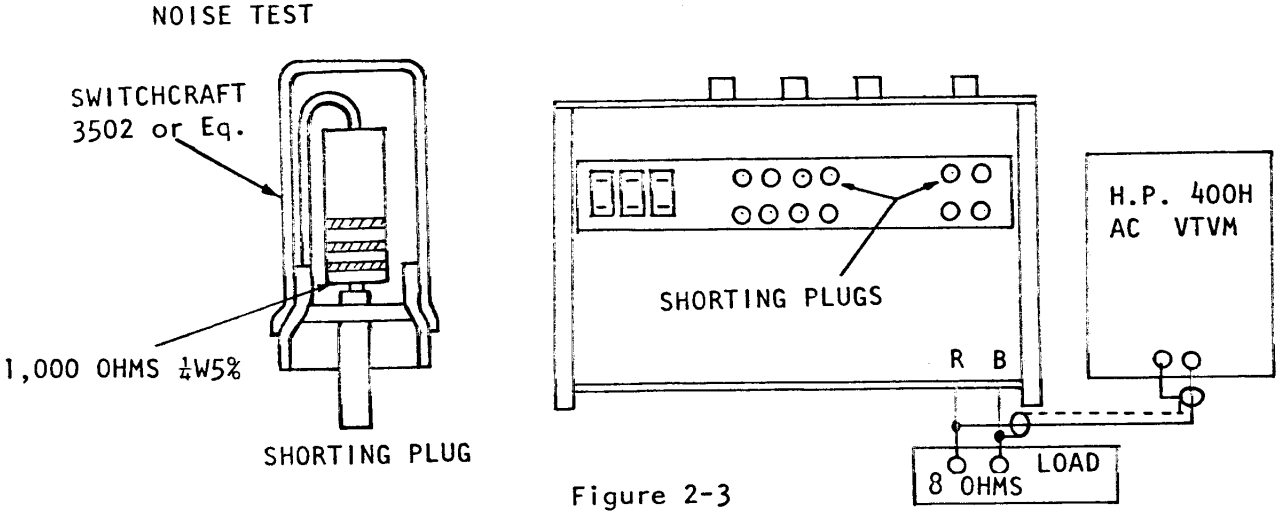


Figure 2-3

2.4.2 TESTING LOW LEVEL INPUTS

2.4.2.1 DISTORTION -

1. Use a floating oscillator and analyzer as described in the High Level Distortion measuring procedure.
2. The amplifier should be tested with only one channel driven to avoid ground loops which would mask the actual distortion and noise.

2.4.2.2 HUM AND NOISE -

1. Terminate the phono input jack with 1000 ohm resistor as noted previously.
2. Set the SOURCE switch at PHONO.
3. Turn the volume control all the way up and measure the noise output with a VTVM. The reading may be expressed as decibels below full output or as "microvolts referred to the input". To obtain the latter figure, the output noise reading must be divided by the gain of the SA600 at 1000 Hz. The nominal gain of the amplifier at this frequency is 4000. The exact gain can be obtained by feeding a one millivolt signal at 1000 Hz into the phono input and then measuring the output with a VTVM.

2.4.2.3 INTERMODULATION DISTORTION -

The SMPTE measurement techniques specifies that a 4-1 ratio exists between low and high frequency response. The RIAA equalization used to compensate for magnetic phono cartridge and recording characteristics prevents accurate interpretation of any measurement made under SMPTE test conditions.

SECTION III

THEORY OF OPERATION

3.1 OVERALL CIRCUIT

The SA600 Solid State Amplifier consists of three major functional sections. These are: The two-channel preamplifier contained on a single, large circuit board, the two separate power amplifiers on identical circuit boards, and the power supply.

Each preamplifier has five inputs any one of four are selected by the SELECTOR SWITCH. The main output of each preamplifier is coupled to a power amplifier. An auxiliary preamplifier output is available at the "OUT TO RECORDER JACK". A separate "TAPE PLAY" input is provided, bypassing the selector switch and "OUT TO RECORDER" jack.

The two power amplifier circuit boards share a cast heat sink with common power supply. The channel A power amplifier is on the top and the channel B is underneath.

The power supply uses silicon diodes and provides +23 volts dc regulated for the preamplifier and six balanced plus and minus supply levels to the power amplifiers. The power supply common return is chassis ground.

These circuits are explained next in greater detail.

3.2 POWER AMPLIFIER DETAILS

Since each power amplifier channel is identical to the other the following description applies to both.

The power amplifier stages are entirely direct coupled and have a direct-coupled feed-back loop around the entire amplifier. Basically, the circuit consists of a cascaded complementary symmetry emitter followers connected as a dc amplifier driven by two direct coupled differential amplifiers.

3.2.1 OUTPUT T-CIRCUIT - The unique output circuit is called the Locanthi amplifier named after the designer.

Figure 3-1 is a schematic diagram of the Locanthi three-stage cascaded complementary symmetry emitter-follower output circuit, hereafter referred to as a T-Circuit. (Because of its NPN-PNP symmetry, the configuration has the general appearance of the T-Network).

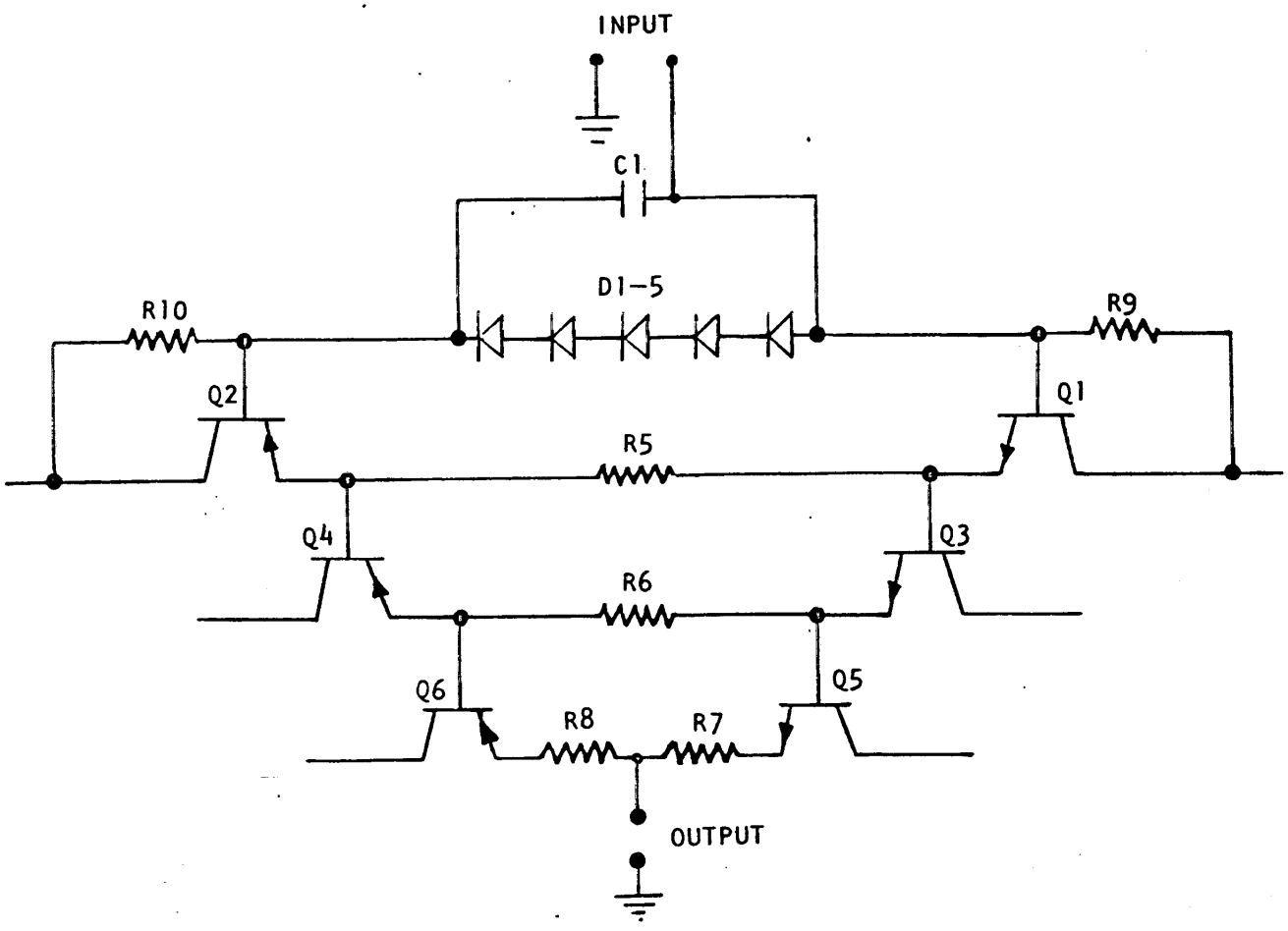


Figure 3-1 BASIC "T" CIRCUIT

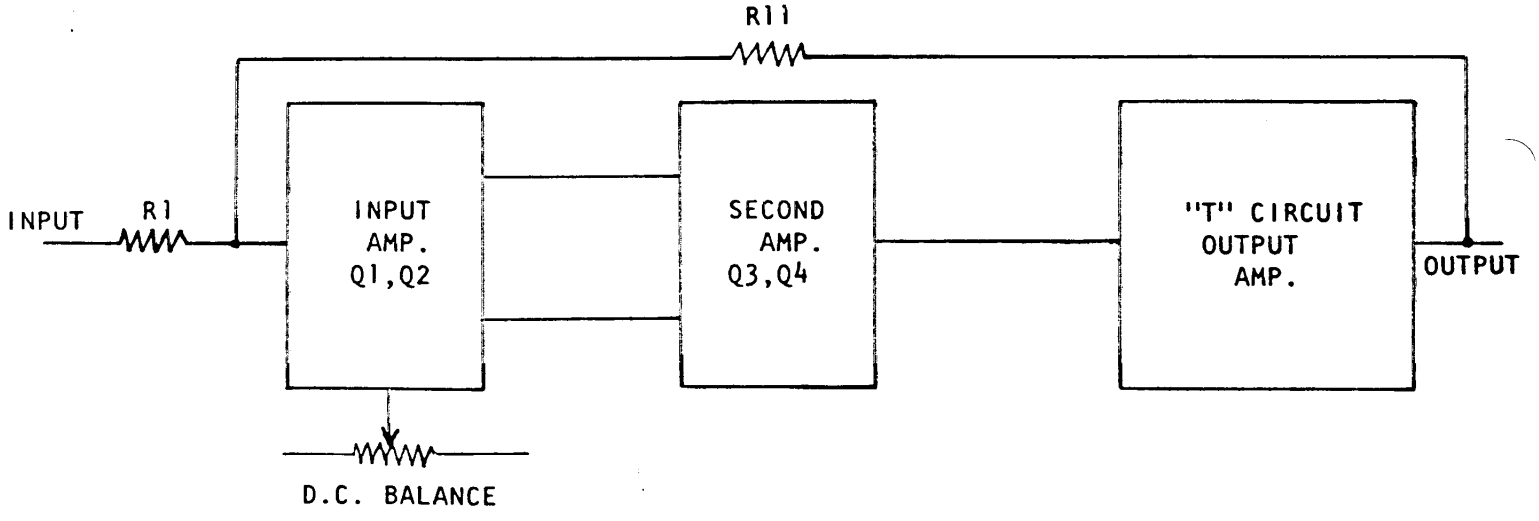


Figure 3-2 POWER AMPLIFIER BLOCK DIAGRAM

3.2.1.1 WHY EMITTER FOLLOWERS ARE USED -

Before describing the special advantages of this particular design, perhaps it should be explained why the complementary symmetry emitter-followers were chosen.

First, a look at the negative side of the picture. Of all three possible configurations for a transistor output circuit, the emitter-follower places the most difficult demand upon the preceding driver stage.

Moreover, the base-to-emitter capacitance of most transistors is quite large, and varies with the output current of the transistor. At high frequencies, this non-linear input capacitance presented by emitter-follower to its driver stage results in another limitation on performance. The high-frequency distortion produced by this effect can be severe, particularly with germanium output transistors.

Third, the power gain of an emitter-follower is relatively low, approximately a factor of ten lower than that of either of the other two possible output circuit configurations. Fourth, since the voltage gain of the output stage is only about 0.92, the driver must supply more voltage than appears across the load impedance.

These disadvantages are overbalanced by the emitter-follower's advantages as a low distortion voltage-following amplifier of very wide bandwidth. But most important the inherently high linearity provides low distortion. The instaneous output voltage at maximum output current is down only 4 percent; and it can be shown that this produces a total harmonic distortion of only 1.5 percent, before feedback is applied.

3.2.1.2 THERMAL STABILITY - The output transistors (Q5 and Q6 in figure 3-1) are connected directly to a high current power supply of about ± 37.5 V potential. Each base of the output circuit has a path allowing the collector-to-base leakage current to flow through its opposite driver-stage emitter. It can be seen that suitable collector-to-base leakage current paths are provided for all of the transistors.

3.2.1.3 PURPOSE OF THE BIAS DIODE ASSEMBLY - A bias supply consisting of diodes D1 through D5 provides the necessary bias for the six cascaded emitter-followers. The bias supply operates at a low current level and dissipates very little signal power. Thermal tracking is provided by mounting the reference diodes directly into the heat sink.

The transistors are biased so that with no signal they all draw a small amount of idling current. A positive signal from the input stage causes the output transistor Q5 to conduct as necessary to deliver power to the load, and Q6 is driven to cutoff. Since half of the T-Circuit is essentially cut off when the other half is conducting, it is, in a sense, a Class B amplifier. But because the no-signal "on" currents for each of the pair-stages are adjustable independently, any crossover problems can be avoided.

3.2.1.4 THE CASCADED STAGES - Each of the driver stages has a lower beta cut-off frequency than the preceding one, so that the overall frequency limitation of the basic T-circuit is determined almost entirely by Q5 and Q6. In practice the bandwidth of the overall T-circuit is greater than 100K Hz. This gives more than two octaves above and below the audible frequency range of 20 to 20,000 Hz; thus, the classic textbook rules regarding reduction of distortion and noise with negative feedback apply. A feedback factor of 50 reduces the distortion of the output circuit alone by that factor. This is true for frequencies up to 20K Hz. and essentially down to DC.

The load impedance at the amplifier output is multiplied by a factor of about 100,000 and is reflected back to the input of the T-circuit, and with an input driver collector load resistance of about 5,000 ohms, the DC stability factor is of the order of 20. There are no thermal runaway problems.

The ratio between reflected load impedance and input collector load is advantageous in another way as well. A typical 8-ohm load is reflected back to the input as about 800,000 ohms. Since the source impedance is only 5,000 ohms, the resulting 160:1 ratio swamps out any effects propagated back due to the beta nonlinearities of Q5 and Q6.

It should be noted that it is necessary to provide successively higher collector supply voltages going backward from the output transistors to take care of the saturation voltage drops of the preceding drivers. Supply for Q5 and Q6 is roughly ± 37.5 V, for Q3 and Q4 ± 42.1 V, for Q1 and Q2 ± 46.8 V.

3.2.1.5 OUTPUT LIMITATION - The output transistors Q5 and Q6 have a very high DC power dissipation capability as compared to that normally found in transistorized audio amplifiers. The transistors used are rated for DC dissipation of 150 watts each, so that there is no need for exotic high-speed electronic current limiting devices. All that is required is a simple thermal breaker (CB101) that opens in one tenth to sixty seconds depending on the magnitude of the overload.

3.2.2 DRIVING STAGE - Figure 3-2 shows the complete amplifier (one stereo channel) and the low-level driving stage. The latter is a two-stage differential DC amplifier having a voltage gain of 1200. The frequency response of the driving stage is far greater than 100K Hz, so that the single factor limiting the frequency response of the complete amplifier is still Q5 and Q6. The closed loop gain of the complete amplifier is essentially R11/R1, or approximately 25. The feedback factor, therefore, is about 50.

3.3 PREAMPLIFIER DETAILS

The preamplifier circuit board contains two separate, identical channels. Channel A consists of all components numbered in the 100 series (for example Q101). Channel B is 200 series. The following description of Channel A also applies to Channel B when the component designations are read, for example, as R201 instead of R101.

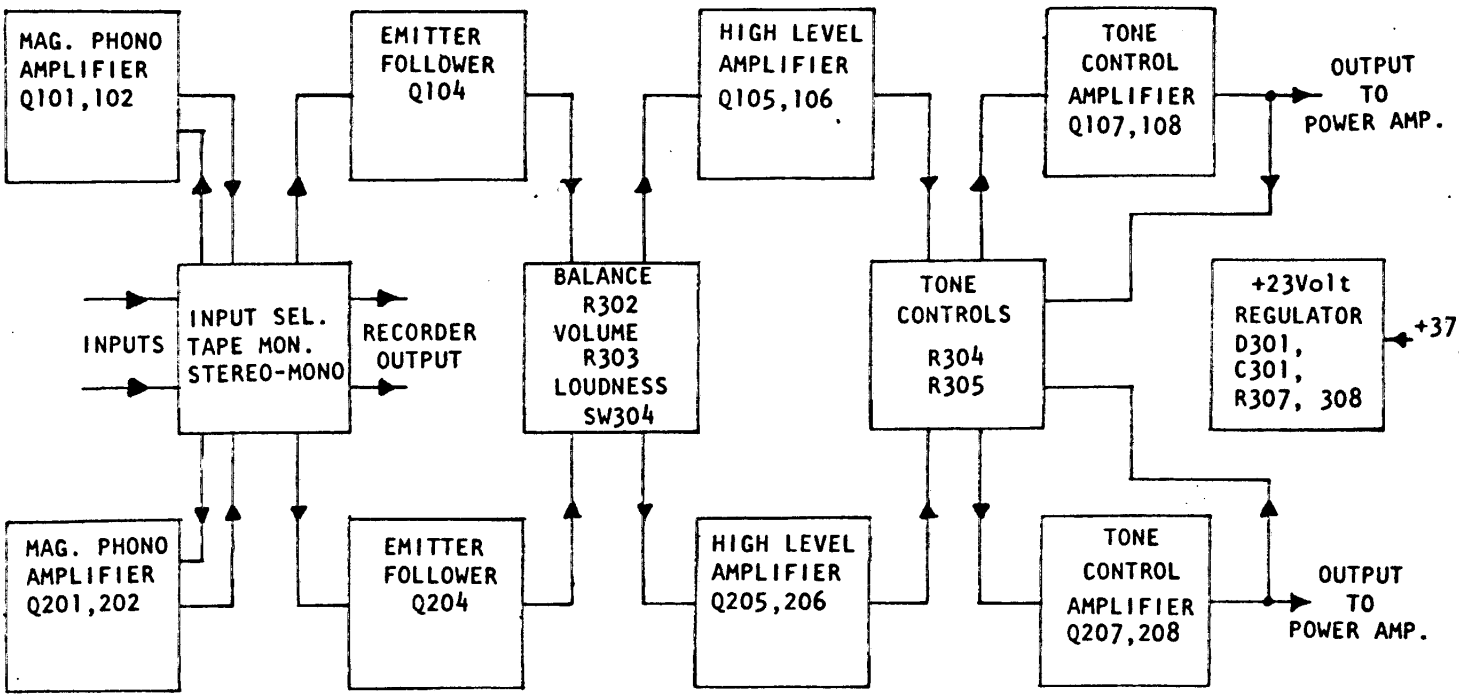


Figure 3-3 PREAMPLIFIER BLOCK DIAGRAM

In the HIGH switch position, the preamplifier accepts the output of high-level magnetic cartridges. At maximum VOLUME setting, the input sensitivity is 16 millivolts; the preamplifier will not be overloaded with levels up to 100 millivolts. In the LOW switch position, a signal level of 4 millivolts will produce full amplifier output. In both Q101 and Q102, the amount of DC degeneration is greater than AC degeneration, because the emitter load resistance is split. For example, Q102 has a total DC emitter load resistance of R118 + R119 = 1.3K. But its AC load is only 180 ohms, through AC bypass capacitor C105.

NOTE

The split-resistance emitter load is used in a number of preamplifier stages. When troubleshooting stages, an open bypass capacitor produces a common sympton: the AC gain has dropped to the DC gain value.

The output of the phono preamplifier is taken from the emittter of the emitter-follower Q103 (NPN) and AC coupled through C109, through the SELECTOR switch, and through the TAPE MONITOR SWITCH (OFF position) to the next amplifier stage Q104. The output at the emitter of Q103 is also applied as negative feedback back to the emitter of Q101 through the network R116, R117, C106 and C107. This network has a DC resistance of 280K ohms (which sets the overall preamplifier gain at 44), but has lower reactance at high frequencies. The resultant low-boost response of the phono preamplifier compensates for the typical magnetic pickup response curve. (figure 3-4)

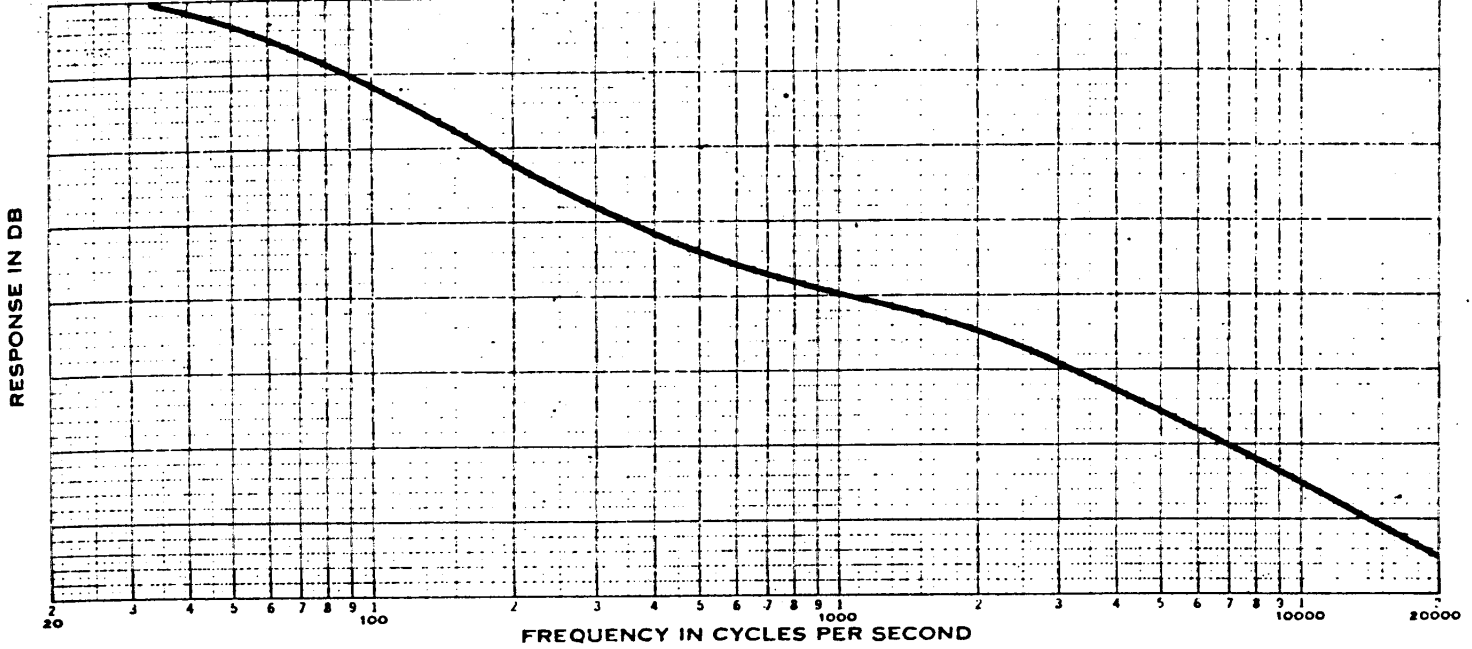


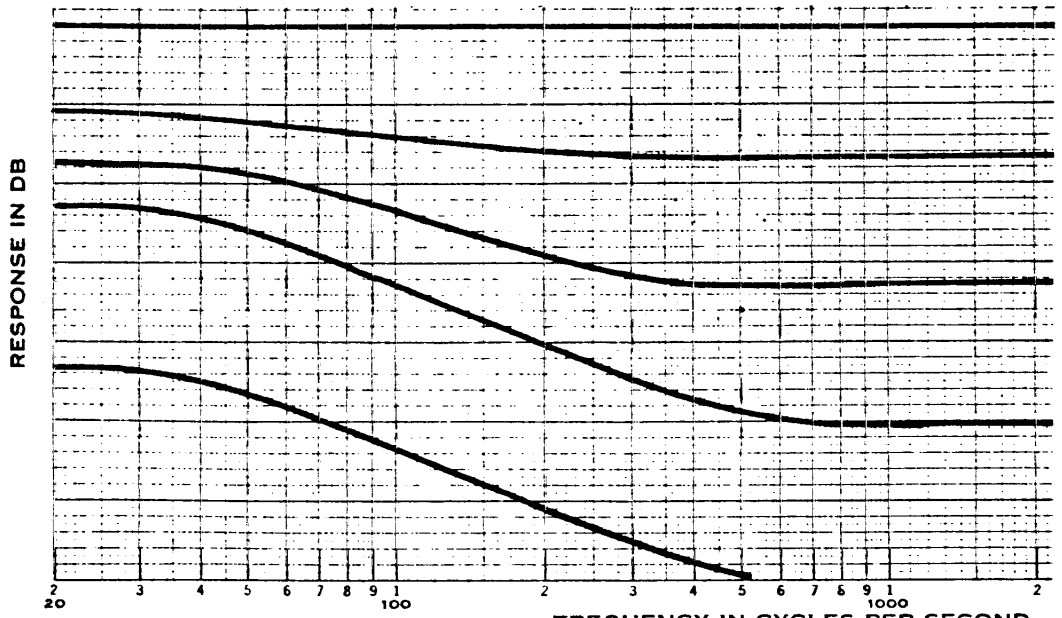
Figure 3-4 MAGNETIC PHONO EQUALIZATION

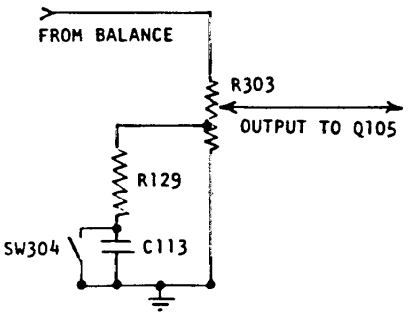
3.3.2 EMITTER FOLLOWER STAGE Q104 - Transistor Q104 (NPN) receives its input from either of the two sources: (1) direct from the TAPE PLAY, TUNER or AUX. JACKS, or (2) output of the mono preamplifier, Q103. In either case, the nominal input level is 250 millivolts. The Q104 emitter output has a DC load of 3.6K ohms (R128). The AC load is 10K ohms (BALANCE potentiometer, R302). The emitter follower effectively isolates the BALANCE potentiometer from the input.

3.3.3 BALANCE, LOUDNESS AND VOLUME CONTROLS - The channel A BALANCE control R128 is an attenuator control which is ganged with the channel B BALANCE control R228. When the BALANCE setting is changed, the percentage resistance increases on one potentiometer and decreased on the other, attenuating one channel. The wiper of R128 is connected to the VOLUME potentiometer R303. Both the BALANCE and VOLUME potentiometers are dual-section. The two volume control sections are matched at the factory to within 2 db tracking.

Loudness compensation is achieved by tapping the VOLUME CONTROL and shunting higher frequencies to ground, as shown in the simplified schematic, figure 3-5.

Figure 3-5 LOUDNESS COMPENSATION





When the LOUDNESS switch SW204 is ON, capacitor C113 is placed in series with resistor R129. This causes the higher frequencies only to be bypassed to ground. As shown in the diagram, most of the low frequencies are allowed to flow through the bottom terminal of the VOLUME control to ground. So, the wiper of the VOLUME control picks off more lows when it is set below the tap point. The curves in figure 3-4 show how the response varies for different VOLUME control settings. Beyond the 50 percent setting, the response is flat. Notice that the amount of high frequency de-emphasis levels off at the very high frequencies. This is the shelf level and is due to resistor R129 which prevents the high frequencies from being completely shorted to ground.

3.3.4 INTERSTAGE AMPLIFIER - Transistors Q105 (NPN) and Q106 (PNP) are direct-coupled, common emitter amplifiers which raise the audio level to 1 volt required by the power amplifier. Q107, 108 are used in feedback amplifier which has a gain of 1 when the controls are set flat. Negative feedback through R137 limits the AC gain of Q105 and Q106 to approximately 5. The AC gain is 5 because this is the ratio of the feedback voltage divider, R137/R133 = 5. The collector output of Q106 is coupled through C117 to the tone control section.

3.3.5 BASS AND TREBLE CONTROLS - The BASS and TREBLE controls vary the frequency at which boost or cut begins. For lowest possible distortion, tone control equalization is achieved by feedback rather than passive networks. Figure 3-6 shows the equivalent circuit of the tone control network and amplifier.

Transistors Q107 and Q108 comprise the tone control amplifier. The output (emitter of Q108) is fed back to the input (base of the Q107) through the tone control network and is summed with the audio from stage Q106. As shown in figure 3-5, the BASS control varies the frequency at which the low boost or cut begins. the slope of the equalization curve is relatively constant. The TREBLE control varies the amount of high boost or cut rather than frequency. Outputs of Q108 is applied to the power amplifier and has a nominal level of 1 volt RMS for maximum power output.

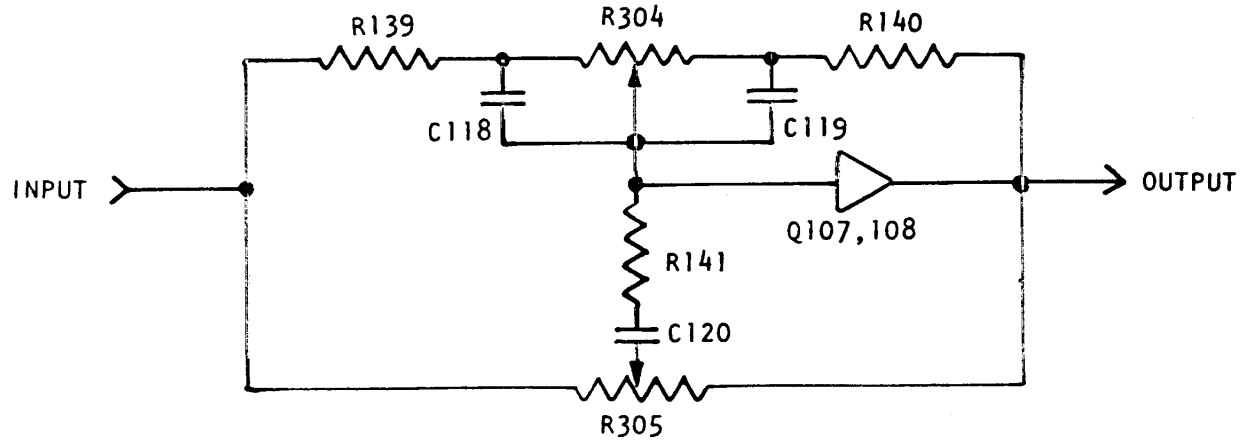


Figure 3-6A TONE CONTROL BLOCK DIAGRAM

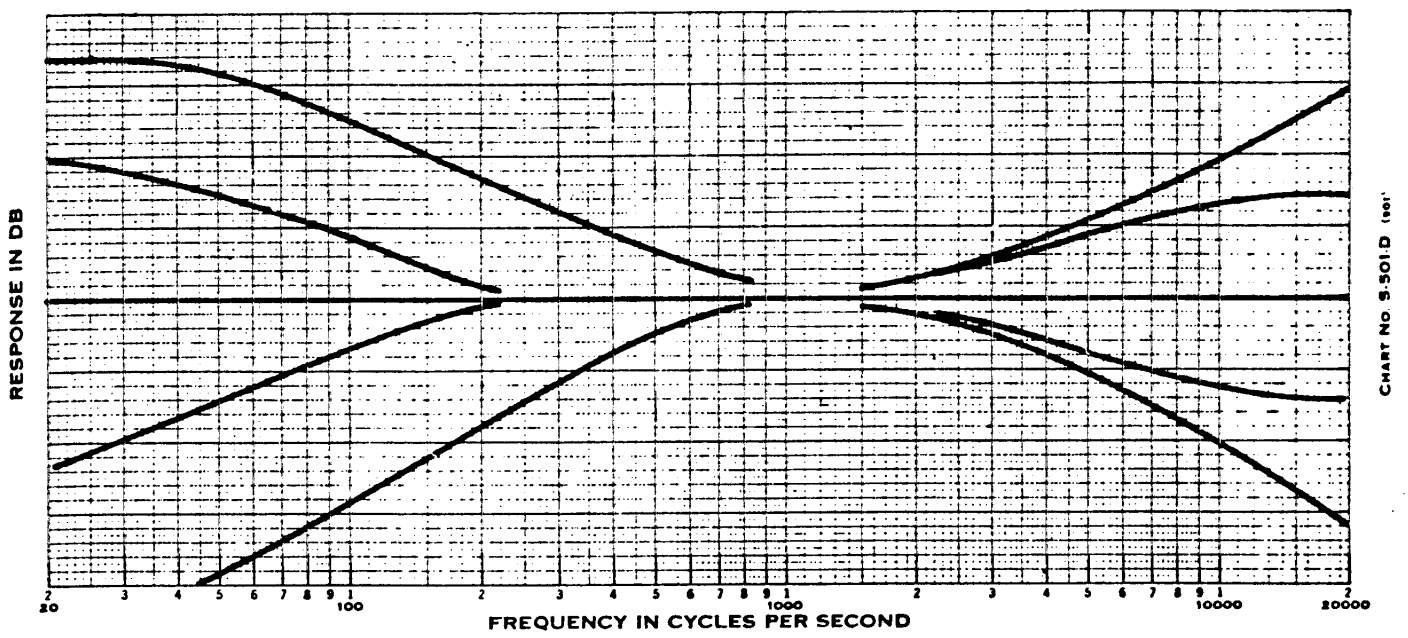


Figure 3-6B TONE CONTROL CURVES

3.4 POWER SUPPLY

The SA600 Power Supply consists of 8 silicon diodes, power transformer, zener diode and associated filter capacitors.

A high current supply provides +37.5 and -37.5 voltages which operate the output transistors. D101 through D104 are used as a bridge rectifier while filtering is accomplished by C101 through C104. Small capacitors C111 and C112 provide a low impedance path for high frequency currents developed in the output stage. Common reference is obtained by connecting the secondary winding centertap to chassis ground.

The +23 volt supply is obtained from the +37.5 volt supply. Resistors R307 and R308 in conjunction with zener diode D301 provide a regulated output.

Additional operating voltages of +42.1 and +46.8 are obtained by a separate winding on the power transformer. D105, D106, C105, C106 and C107 are a voltage doubler which provide these two voltages. The doubler supply, or boost voltages, are referenced to the +37.5 volt supply maintaining a fixed reference to the output stage supply.

Negative boost voltages are derived from D108, 109 and capacitors C108, 109 and 110 are referenced to the -37.5 volt supply.

Operating voltages for the input amplifiers are obtained from the ± 46.8 volt supplies. Since all voltages are referenced to the main supplies, AC supply voltage changes are reflected equally in both + and - supplies and balanced out through the power amplifier.

3.5 DIFFERENCES BETWEEN SA600 and SA660

Paragraph 3.2.1.4

Power supply voltages in the SA660 are ± 41.5 V, ± 46.5 V, ± 52.0

Paragraph 3.2.1.5

OVERLOAD DIODES - The higher operating voltages and peak currents resulting from the increased power capabilities of the SA660 require the use of an overload protective circuit. This requirement is fulfilled by two silicon diodes, D6 and D7.

A simplified circuit is illustrated in figure 3-7. In use, the base emitter voltage drops "T" circuit transistors remains nearly constant providing the output capabilities are not exceeded. As the devices are driven toward saturation the base emitter drops rapidly increase.

During the positive peaks which exceed the amplifiers capability, D6 conducts shunting the drive signal around the output. On negative peaks D7 provides a similar function.

It can readily be seen that during overload operation, the diodes will limit drive current to maintain the output "T" circuit within its dissipation and peak current capabilities.

Refering to the complete schematic diagram figure 5-4, the diodes are apparently cross-connected, with the negative protective diode connected to the positive amplifier and positive diode connected to the negative amplifier. This connection is due entirely to the D.C. bias requirments which establish the signal threshold for protection.

When it is considered that the reference diode is an AC short circuit but maintains a 3.5 volt DC drop it is then apparent that the diodes are in effect connected to the same point.

Figure 3-3

Add Q301 in +23 volt regulator. Change +37.5 volt supply to 41.5 volts.

Paragraph 3.3.4

Ratio of $\frac{R137}{R133}$ = 6.5 Hence interstage gain is now 6.5

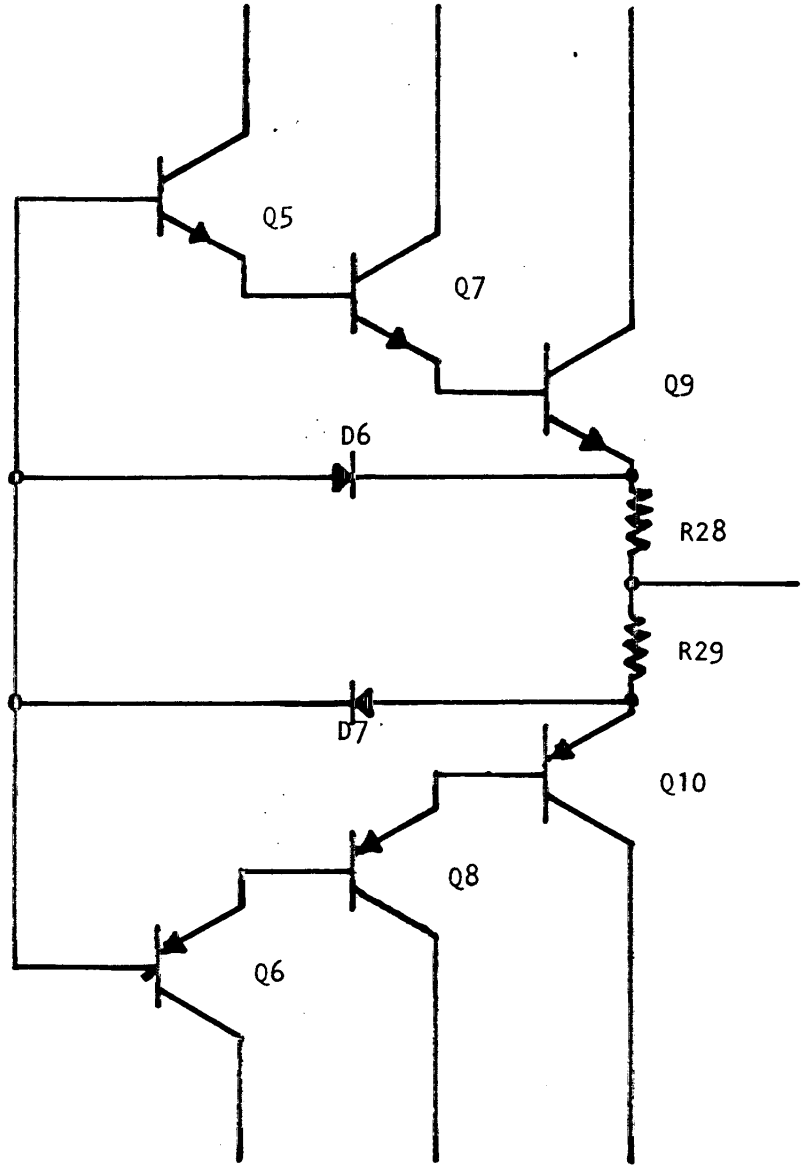


Figure 3-7 SIMPLIFIED SA660 OUTPUT AMPLIFIER

SECTION IV

TROUBLESHOOTING

4.1 SYSTEM TROUBLESHOOTING

Often, amplifier problems reported by the owner of an elaborate stereo system can be traced to factors outside the amplifier. Unlike the vacuum tube amplifiers, the SA600 is normally not subject to gradual deterioration or intermittent hum and noise problems. In fact, the solid state circuits have proven so reliable that the entire stereo setup should be checked before bringing the amplifier into the shop. Table 4-1 gives some hints for troubleshooting the system.

4.2 AMPLIFIER DISASSEMBLY

After isolating any amplifier malfunction to either the preamplifier circuit board, a power amplifier, or the power supply, disassemble the unit as explained below.

TOP COVER REMOVAL

Step 1. Using a Phillips Head screwdriver, remove six metal screws which secure the top of the cabinet.

Step 2. Lift the top by prying up with fingernails. Do not pry cover off with any tool which might mar the finish.

PREAMPLIFIER AND FRONT PANEL REMOVAL

Step 3. Using a Phillips Head screwdriver, remove four black screws which secure the front panel to the sides of the cabinet.

Step 4. Remove five screws which secure the rear of the preamplifier circuit board to the cabinet base. (One of five screws is shorter and is used to secure two black ground wires to the chassis ground).

CAUTION

FOR TEST, A JUMPER MUST BE INSTALLED TO PROVIDE A GROUND RETURN FROM THE INPUT JACK STRIP TO THE BLACK LEADS.

To do this, carefully rotate the preamplifier/panel assembly to gain access to the underside. Do not attempt to lift the assembly out of the cabinet ... the attaching leads are not long enough.

Step 6. Place a strip of cardboard or wooden stick under the preamplifier/panel assembly to prevent circuit components from touching the chassis. The unit may be plugged in for testing. Component locations are shown in figures 4-2, 4-3, 4-4.

Step 7. Using a Phillips Head screwdriver remove the 10-32 machine screws which secure the power section heat sink casting to the cabinet. Two screws are on the underside of the cabinet. For the two screws which secure the heat sink to the side brackets, a long shank screwdriver is recommended.

Step 8. Lift the entire power section out and rotate it so that the electrolytic capacitor can point downward. Then lower the power section down into the cabinet. Alternatively, the power section and the preamplifier/panel assembly can both be placed on wooden sticks laid across the top of the cabinet.

NOTE

Early production units use four screws from the side brackets to the heat sink and none on the underside.

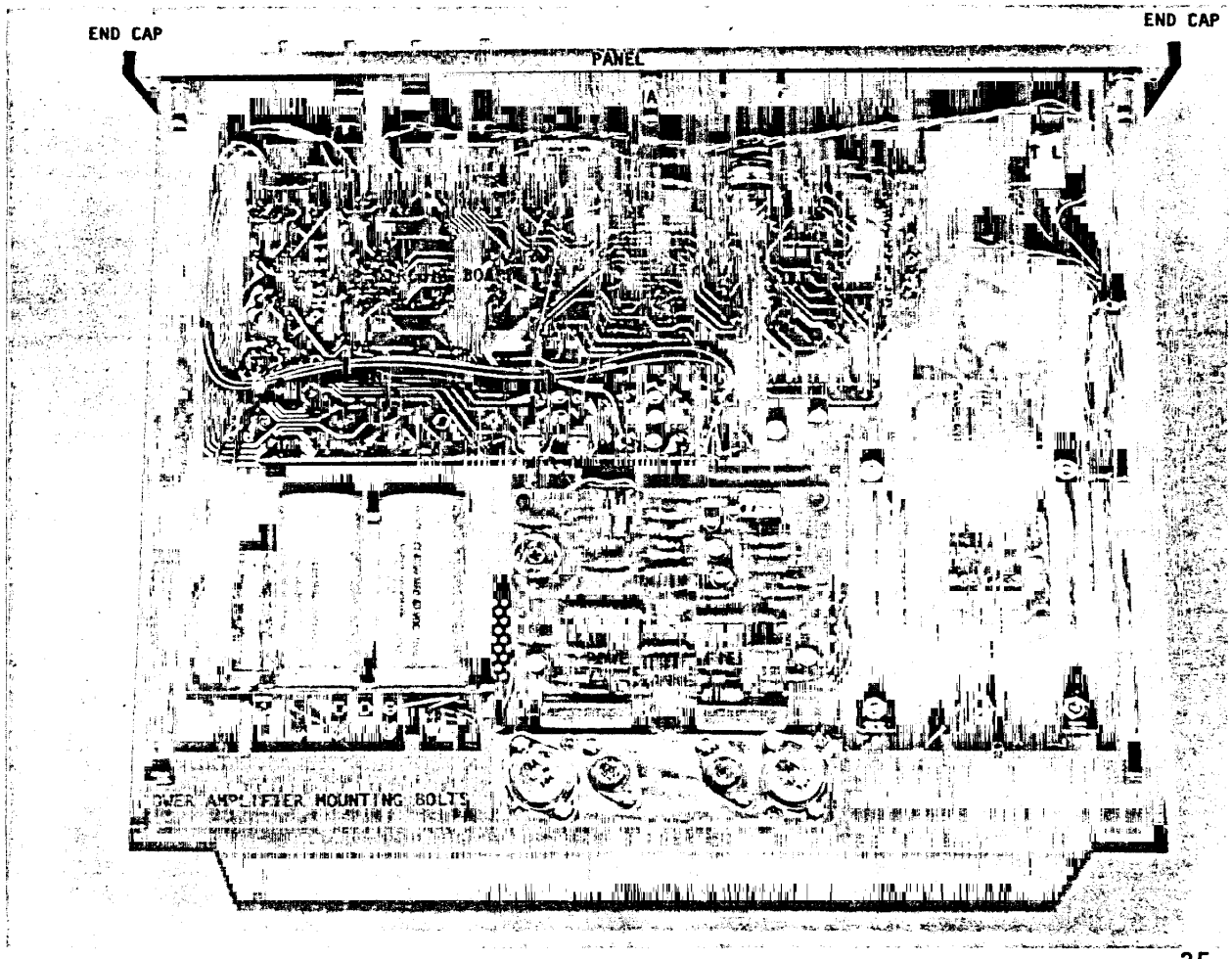


Figure 4-1 TOP VIEW

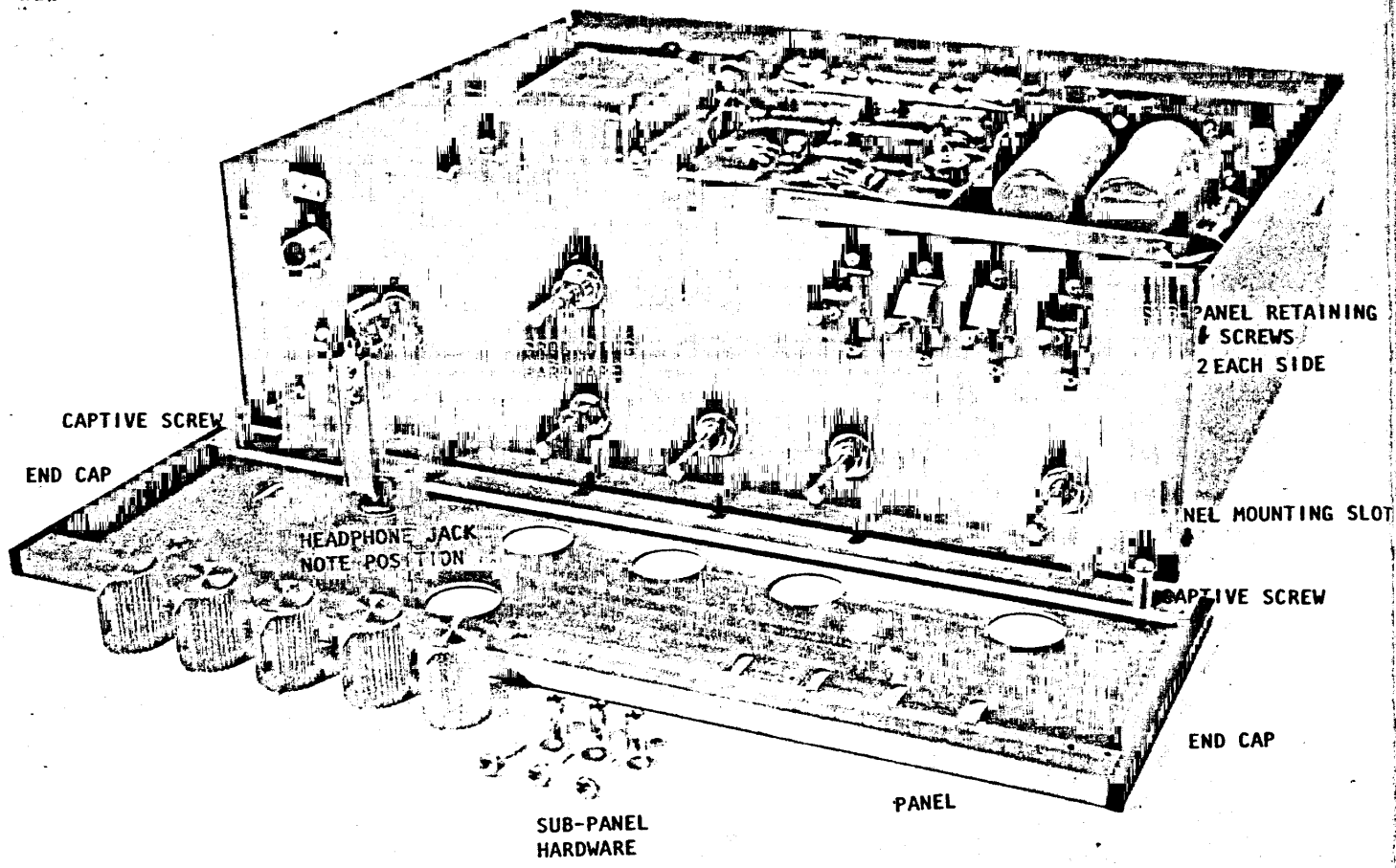


Figure 4-2 FRONT PANEL

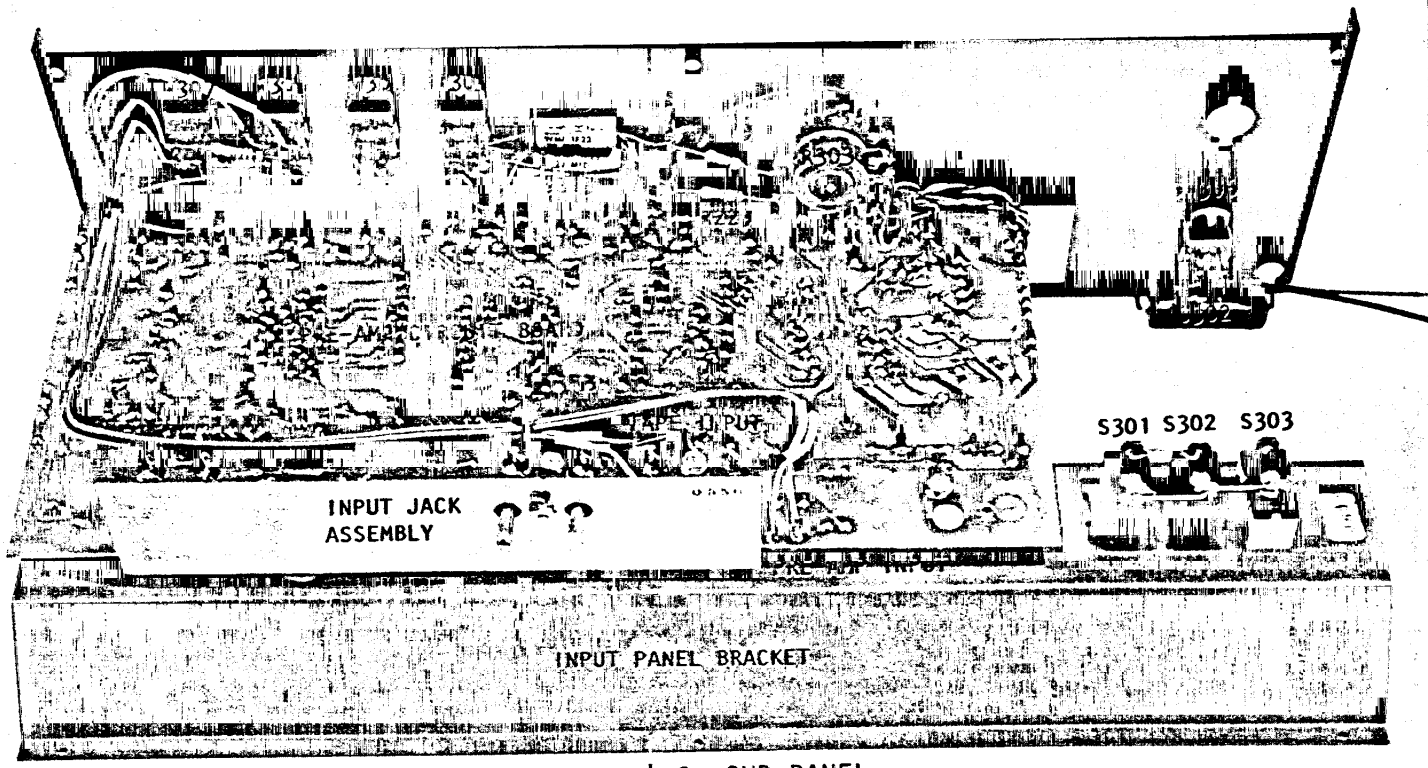


Figure 4-3 SUB PANEL

POWER SUPPLY REMOVAL

Step 9. Most of the power supply components are located on the filter/rectifier sub-chassis. To remove this sub-chassis for servicing, remove four screws which secure it to the heat sink casting (figure 4-4). A standoff bushing is used under each screw -- be sure to re-install correctly before turning on the power.

Step 10. Rotate the filter/rectifier to position the receifier diodes and wiring for testing. Figure 4-7, indicates filter/rectifier components.

DRIVER CIRDUIT BOARD REMOVAL

NOTE: Most service operations can be performed without removing the circuit board.

Step 11. Remove the four power transistors (two #6 Phillips Head screws each).

Step 12. Remove the four #6 Phillips countersunk screws which secure the power amplifier circuit board to the heat sink.

Step 13. Pull the amplifier board slowly to withdraw the bias assembly. Components locations are shown in figure 4-8.

CAUTION

BE CAREFUL TO NOT BREAK THE BIAS DIODE CONNECTIONS. SEE FIGURE 4-11.

FRONT PANEL REMOVAL

Step 14. If any of the panel controls must be replaced, it will be necessary to remove the front panel (figure 4-9). First remove the five knobs and then extract three 6-32 Phillips #6 screws across the top. Lift panel up to release then withdraw the panel.

4.3 DETAILED TROUBLESHOOTING

The most likely troubles and their remedies are listed in tables 4-2 and 4-3. Table 4-2 is for channel A of the preamplifier and table 4-3 is for channel A of the power amplifier and for the power supply. The tables apply to channel B if the component designation series are changed. For example, Q101 in channel A becomes Q201 for channel B of the preamplifier. For the power amplifier, Q1 in channel A becomes Q51 in channel B.

When the amplifier in question does not pass an audio test signal, one good technique is to measure all of the transistor DC voltages. Refer to tables 4-4 and 4-5 and compare each base, emitter, and collector voltage with that given. Although the voltage between emitter and collector can be slightly different from that given, the base-to-emitter voltage should <u>always</u> be 0.6 volts for nearly any silicon transistor type.

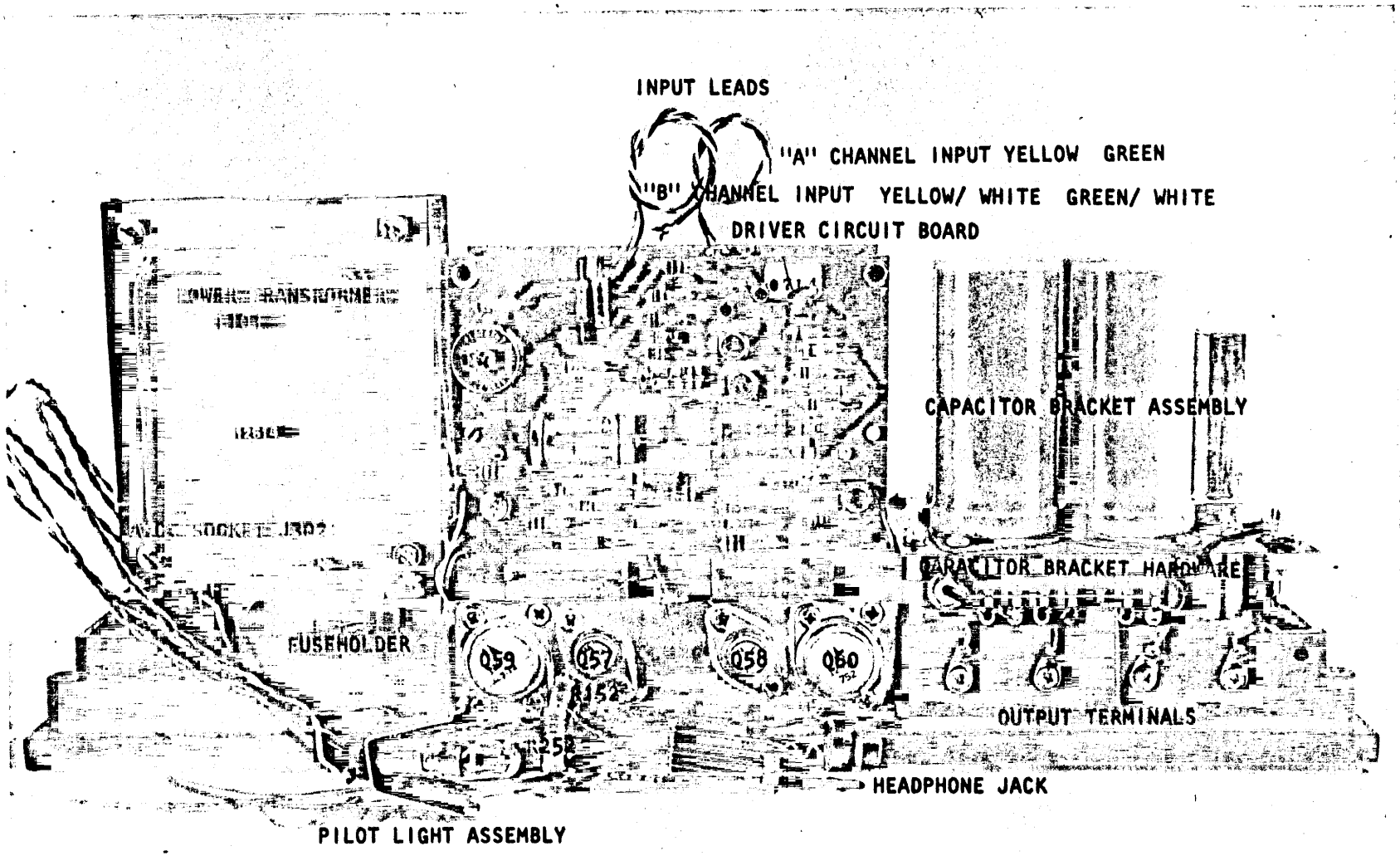


Figure 4-4 POWER AMPLIFIER

TABLE 4-1. BASIC STEREO SYSTEM TROUBLESHOOTING

TROUBLE SYMPTOM	REMEDIES
A. Entire amplifier dead. No pilot light.	1. Check fuse. 2. Line cord. 3. Check wiring of power switch and power transformer.
B. No Stereo effect (Stereo/ MONO Switch set to Stereo)	1. Turn BALANCE control to either extreme. If one channel is not operating, refer to C, below. 2. If both channels are operating, check for defective input wiring, cartridge, multiplex tuner, or tape deck. 3. If program source is at fault, look for wrong stylus pressure, improper multiplex FM tuning, or tape head misallignment.
C. No Output	1. Check the shorting plugs are not in the "out to recorder jacks". 2. Check for improper input or output connections. 3. Set STEREO/MONO switch to MONO. If the signal is reproduced by remaining channel, high level inputs the trouble lies between Q104 and Q108 of the preamplifier or in the power amplifier. Low level inputs only check Q101, Q102 and Q103. 4. Temporarily interchange the red and green wires from the preamplifier outputs to the power amplifier input jacks. If signal gets through, trouble is located in one power amplifier. Refer to table 4-3 for power amplifier troubleshooting.
D. Hum in System	1. Check interconnecting cable for proper shield bonding to plugs. 2. Connect a No. 18 ground wire between the amplifier GROUND post and the system tape deck or turntable motor frame. 3. Check for ripple in amplifier power supply due to faulty electrolytic filter capacitor. 4. If hum still exists in a complex system installation, connect the system GROUND to a true earth ground, such as a cold water pipe.

TABLE 4-2. BASIC STEREO SYSTEM TROUBLESHOOTING

TROUBLE SYMPTOM	REMEDIES
A. Apparent low gain	1. Check gain from magnetic PHONO input jack to OUT TO RECORDER JACK. Normal gain @ 1K Hz. should be: LOW ----------44 MED ----------22 HIGH --------11 2. Check gain from TAPE PLAY input jack to power amplifier input jack. Normal gain should be 5. Gain on the SA660 should be 6.5. 3. Check gain from power amplifier input jack to TRANSDUCER TERMINALS output. Normal gain shoul be 24.
B. Noise in both channels	1. Noisy power supply to preamplifiers. Check C30 and D301.
C. Noise in one channel	1. If noise increases with VOLUME setting, but sho decrease at loudness tap at and max. rotation transistor Q105 may be defective. Check Q105.
D. Noise as VOLUME or BALANCE control is rotated.	1. Faulty ground path between potentiometer shaft and housing. Check for proper shaft grounding washer.
E. Low gain on high level inputs.	1. Check Q104, 105, 106 and associated components.
F. Insufficient BASS or TREBLE boost.	1. Check components and transistors Q106, Q107.
G. Hum (MAGNETIC PHONO input only)	1. Faulty ground between jack and ground strip. (re-swage input jacks)
H. Objectional transients as input SELECTOR is rotated.	1. No shorting plugs. Install shorting plugs in unused inputs (except OUT TO RECORDER jack).
I. Preamplifier oscillates	1. Clean preamplifier circuit board, foil side, at selector switch with alcohol.

TABLE 4-3. POWER SECTION TROUBLESHOOTING

TROUBLE SYMPTOM	
A. Fuse blows	1. Output transistor shorted, one or both channels. Check Q9 and Q10. Determine if load has DC resistance of 2 ohms or more. 2. Rectifier shorted. Check D101-104. 3. Bias diode assembly open. Check D1-D5. 4. Filter capacitor shorted. Check C101-C105, C111, C112. 5. If 33 ohm resistors R29, 30 are damaged. Replace output transistors.
B. DC residual at output. (TRANSDUCER TERMINALS)	1. ± 0.1 V is normal. 2. Zero adjustment incorrect. Adjust R9. 3. Leaky or shorted transistors. Check Q1,Q2. 4. Open or shorted transistors. Check Q5-Q10.
C. Clipping below rated power.	1. Check power supply voltages, especially boost supplies, both positive and negative.
D. Circuit breaker operates at low level.	1. Replace breaker.
E. Oscillation	1. Check HEADPHONE jack orientation. Frame must be toward top of SA600. 2. Check lead routing to HEADPHONE jack. 3. Check installation for lead dress.
F. R 13 10 ohm 1 watt resistor burned.	1. Amplifier has oscillated or been operated at high power above 50K Hz.

4.3.1 R. F. INTERFERENCE

There are no firm rules which can be applied to reduce or eliminate R. F. Interference in a music system.

A major problem can be shielding of signal carrying leads. It is recommended that all shielded cables use quality braided shield, an excellent material for such cables is RG/59 coxial cable. Record changers may have an unshielded muting switch which allows R. F. pickup. Thic can be shielded with heavy duty aluminum foil. Shielded leads should be twisted together to avoid forming ground loops for radio frequencies. Experience indicates that spiral wound shields are effective for audio frequencies but allow considerable R. F. Pick-up.

Use of a small resistor connected in series with the hot input leads and located at the amplifier inputs will reduce R. F. Interference. Typical value for magnetic phono inputs is 470 ohms. This value resistor has been incorporated in the SA600's with serial 3400 or above. Schematic reference R101, 102, 201, 202. Increasing the resistor value will increase the R. F. Attenuation but will also degrade the signal to noise ratio.

Interference may also be coupled through loudspeaker leads into the amplifier. To determine if this is the case, disconnect the speaker leads and using a very short lead, place a speaker near the amplifier and note if the interference still exists. If a short lead removes the interference construct and connect the network as illustrated in figure 4-5. Note that the black output terminal is hot ground; ground connection should be made directly to the terminal provided in the bottom panel, (input panel).

R. F. Interference can also be introduced through the power line and use of a heavy duty power line filter may alleviate the problem. Connecting leads between the SA600 and filter should be as short as possible.

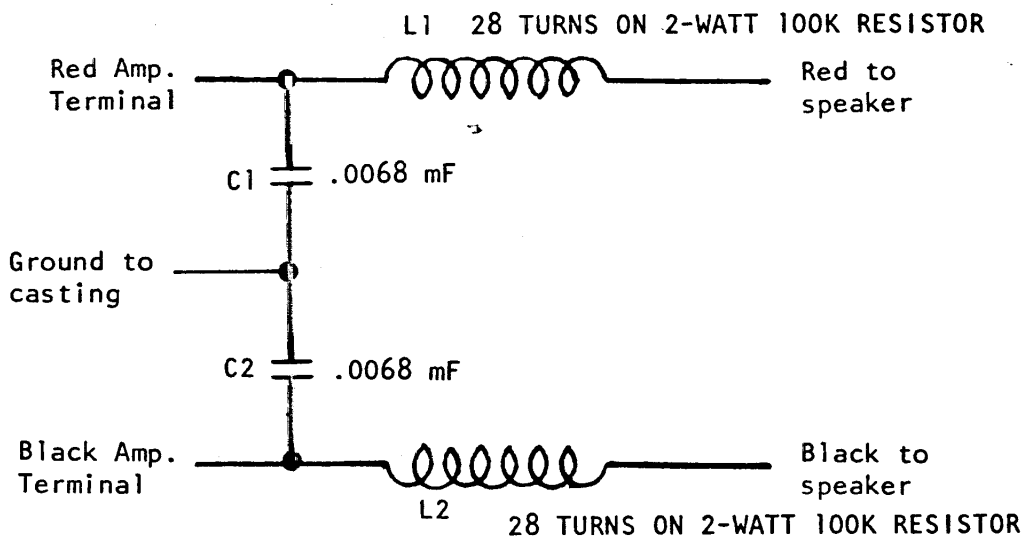


Figure 4-5 OUTPUT STAGE R. F. FILTER

TABLE 4-4 PREAMPLIFIER DC TEST VOLTAGES

COMMON TO BOTH SA600 and SA660

CHANNEL A			
TRANSISTOR	EMITTER	BASE	COLLECTOR
Q101	6.4	6.9*	20.5
Q102	21.4	20.5	11.0
Q103	10.5	11.0	B+
Q104	12.3	12.8*	B+
Q105	9.5	10.0*	15.0
Q106	15.5	15.0	10.5
Q107	1.9	2.4*	13.0
Q108	12.5	13.0	B+

CHANNEL B			
TRANSISTOR	EMITTER	BASE	COLLECTOR
Q201	6.4	6.9*	20.5
Q202	21.4	20.5	11.0
Q203	10.5	11.0	B+
Q204	12.3	12.8*	B+
Q205	9.5	10.0*	15.0
Q206	15.5	15.0	10.5
Q207	1.9	2.4*	13.0
Q208	12.5	13.0	B+

* = High impedance (erroneous measurements with 20,000 ohms/volt meter)

B+ = Supply voltage = +23.0 V ±5%

All voltages measured with 100,000 ohm/volt meter

TABLE 4-5. DRIVER AND SA600 POWER AMPLIFIER DC TEST VOLTAGES

CHANNEL A			
TRANSISTOR	EMITTER	BASE	COLLECTOR
Q1	+1.25	+0.75	-40.0
Q2	+1.25	+0.75	-40.1
Q3		-40.0	GND
Q4		-40.1	-1.75
Q5	+1.2	+1.75	+46.8
Q6	-1.2	-1.75	-46.8
Q7	+0.51		+42.1
Q8	-0.51		-42.1
Q9		+0.51	+37.5
Q10		-0.51	-37.5

CONDITIONS: +Vcc1 = +46.8

-Vcc1 = -46.8

CHANNEL B			
TRANSISTOR	EMITTER	BASE	COLLECTOR
Q51	+1.25	+0.75	-40.0
Q52	+1.25	+0.75	-40.1
Q53		-40.0	GND
Q54		-40.1	-1.75
Q55	+1.2	+1.75	+46.8
Q56	-1.2	-1.75	-46.8
Q57	+0.51		+42.1
Q58	-0.51		-42.1
Q59		+0.51	+37.5
Q60		-0.51	-37.5

CONDITIONS: +Vcc2 = +42.1 +Vcc3 = +37

-Vcc2 = -42.1 -Vcc3 = -37

TABLE 4-5 SA660 DRIVER AND POWER AMPLIFIER DC TEST VOLTAGES

CHANNEL A			
TRANSISTOR	EMITTER	BASE	COLLECTOR
Q1	1.25	0.75	-44
Q2	1.25	0.75	-44
Q3		-44	0
Q4		-44	-1.75
Q5	1.2	1.75	52
Q6	-1.2	-1.75	-52
Q7	0.51	1.2	46.5
Q8	-0.51	-1.2	-46.5
Q9		0.51	41.5
Q10		-0.51	-41.5

	CHANNEL B		
TRANSISTOR	EMITTER	BASE	COLLECTOR
Q51	1.25	0.75	-44
Q52	1.25	0.75	-44
Q53		-44	0
Q54		-44	-1.75
Q55	1.2	1.75	52
Q56	-1.2	-1.75	-52
Q57	0.51	1.2	46.5
Q58	-0.51	-1.2	-46.5
Q59		-0.51	41.5
Q60		-0.51	-41.5

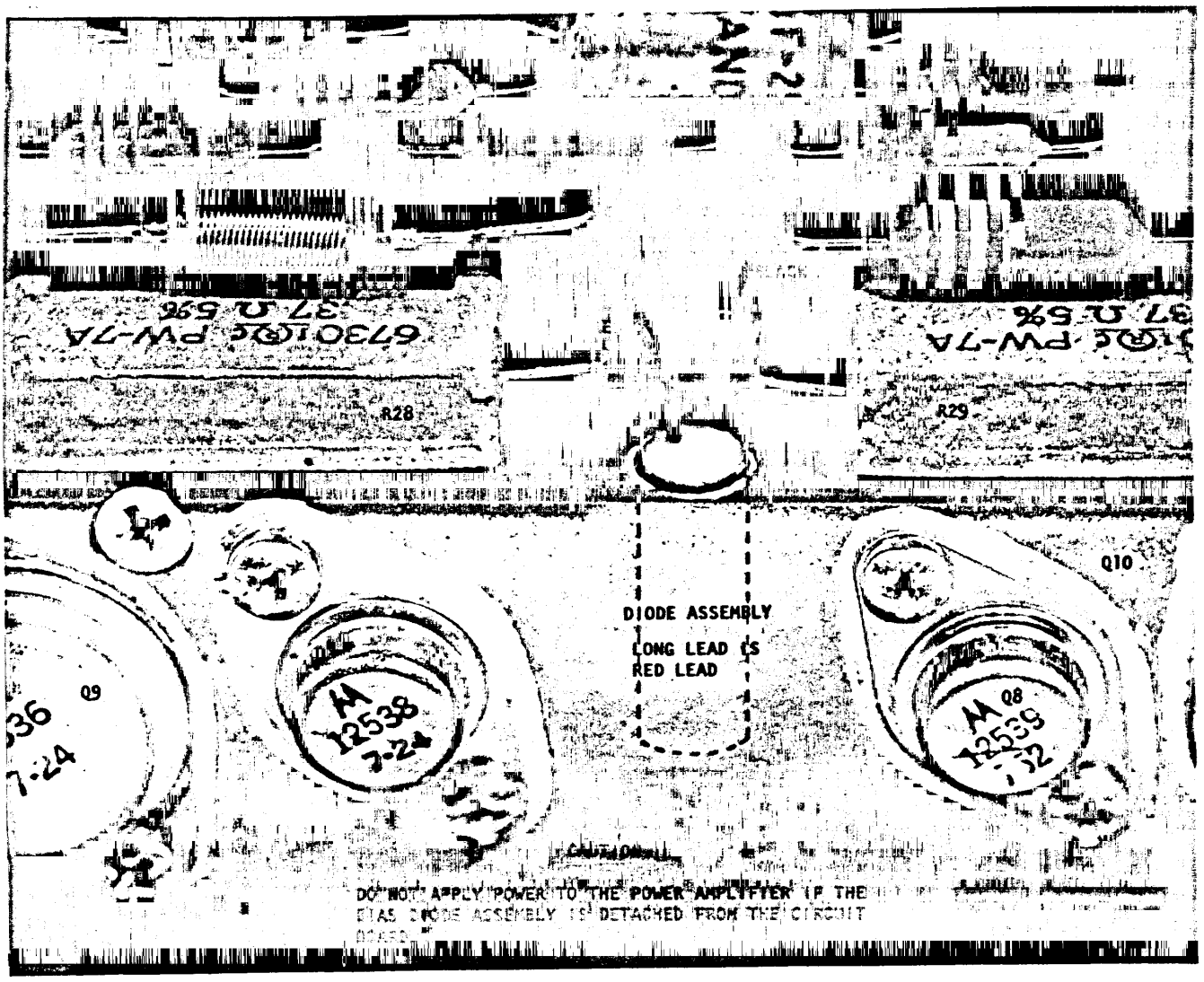


Figure 4-7 BIAS DIODE INSTALLATION

4.5.3 ZENER DIODE INSTALLATION

If the zener diode D301 is replaced, it must be mounted exactly as shown in figure 4-8. (Omit for SA660)

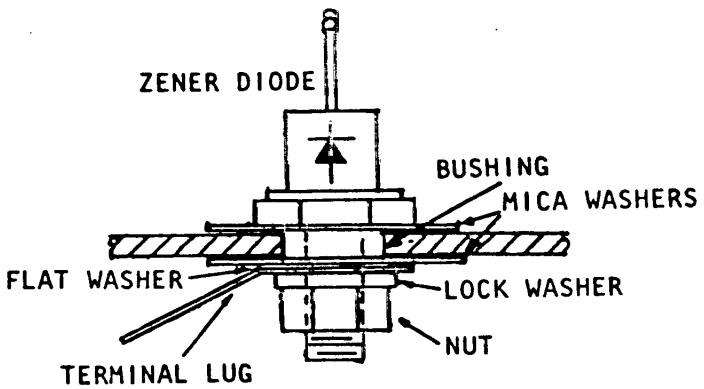


Figure 4-8 ZENER DIODE INSTALLATION

4.5 REPAIR PRECAUTIONS

Some special care must be taken when replacing components. These precautions are outlined below.

4.5.1 TRANSISTOR GREASE

The white silicone grease under each of the power transistors is necessary to assure heat flow from the transistor to the heat sink. If the grease is accidentia wiped away, Dow Corning No. 340 must be applied. See figure 4-6.

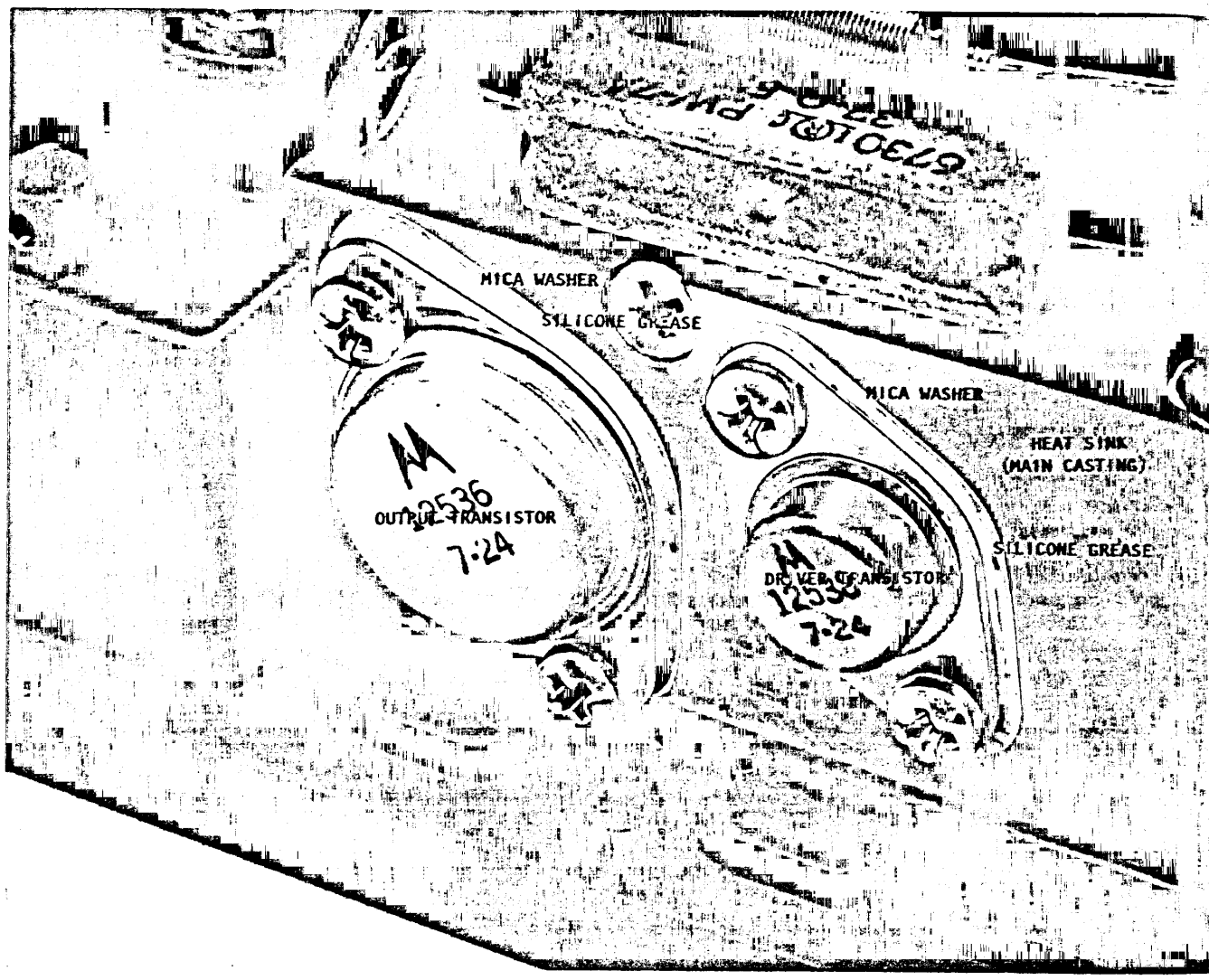


Figure 4-6 TRANSISTOR INSTALLATION

4.5.2 BIAS DIODE REMOVAL AND INSTALLATION

The power amplifier bias diode assembly (figure 4-7) is designed to slide out of the heat sink when the power amplifier card is removed. The diode assembly is greased for good thermal contact but may be tight fitting. Be very careful to not break the connection.

4.5.4 REPLACEMENT OF RESISTORS AND CAPACITORS

Resistors and capacitors on the circuit boards must be replaced as shown in figure 4-13. The technique is as follows:

Step 1. When a components is suspected, clip one of the leads at midpoint to remove it from the circuit.

Step 2. Check the component.

Step 3. If faulty, clip the other component lead at midpoint.

Step 4. Loop the new component leads over the old stub and solder.

CAUTION

DO NOT APPLY HEAT DIRECTLY TO THE PRINTED CIRCUIT BOARD. THIS MAY CAUSE CIRCUIT FOIL TO LIFT FROM THE BOARD.

4.6 POWER LINE VOLTAGE CHANGE

The power transformer supplied in the model SA600 and SA660 has two primary windings which can be connected either in series or in parallel, depending on the voltage of the AC power line. (Figure 4-9)

Remove the top panel for access to the power transformer. Make sure that the unit is not plugged into the AC line. Then gently pull out the primary wires which are tucked into the space between the transformer and the back panel.

Connections are made with "wire nuts". The appropriate wires are lightly twiste together, and a wire nut then screwed onto the connection. After the proper connections have been made as shown in the diagram below, the wires should again be tucked into the space between the transformer frame and the back panel of the power amplifier.

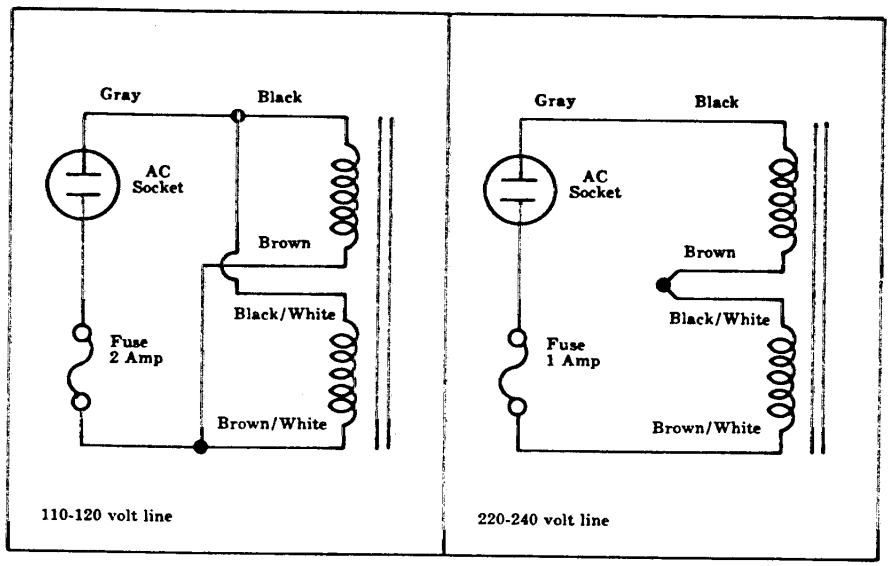


Figure 4-9 LINE VOLTAGE CHANGE

INITIAL PRODUCTION

SA600's used Epoxy transistors as Q1 and Q2; driver circuit board. These units should be revised to the current schematics to insure greatest reliability. Complete componentskits for retrofit are available from JBL upon request. Order must be accompanied by serial number of unit.

Following are changes to be accomplished:

1. POWER AMPLIFIER

REFERENCE	ORIGINAL	CHANGE TO
C1, C51	6.4 MFD	2.0 MFD
C7, C57	180 pF	75 pF
NONE	10K	SHORT OUT
R20, R70	NOT USED	82 OHMS
C3, C53	NOT USED	1500 pF
NONE	JUMPER R9 WIPER TO R9, R18 JUNCTION	
Q1, Q2	12547	12888
Q51, Q52		

2. PREAMPLIFIER

REFERENCE	ORIGINAL	CHANGE TO
C102, C202	20 MFD	25 MFD
C105, C205	500 MFD	35 MFD
C110, C210	6.4 MFD	1.0 MFD
R151, R251	100K OHM	20K OHM
C302	NONE	.047 MFD

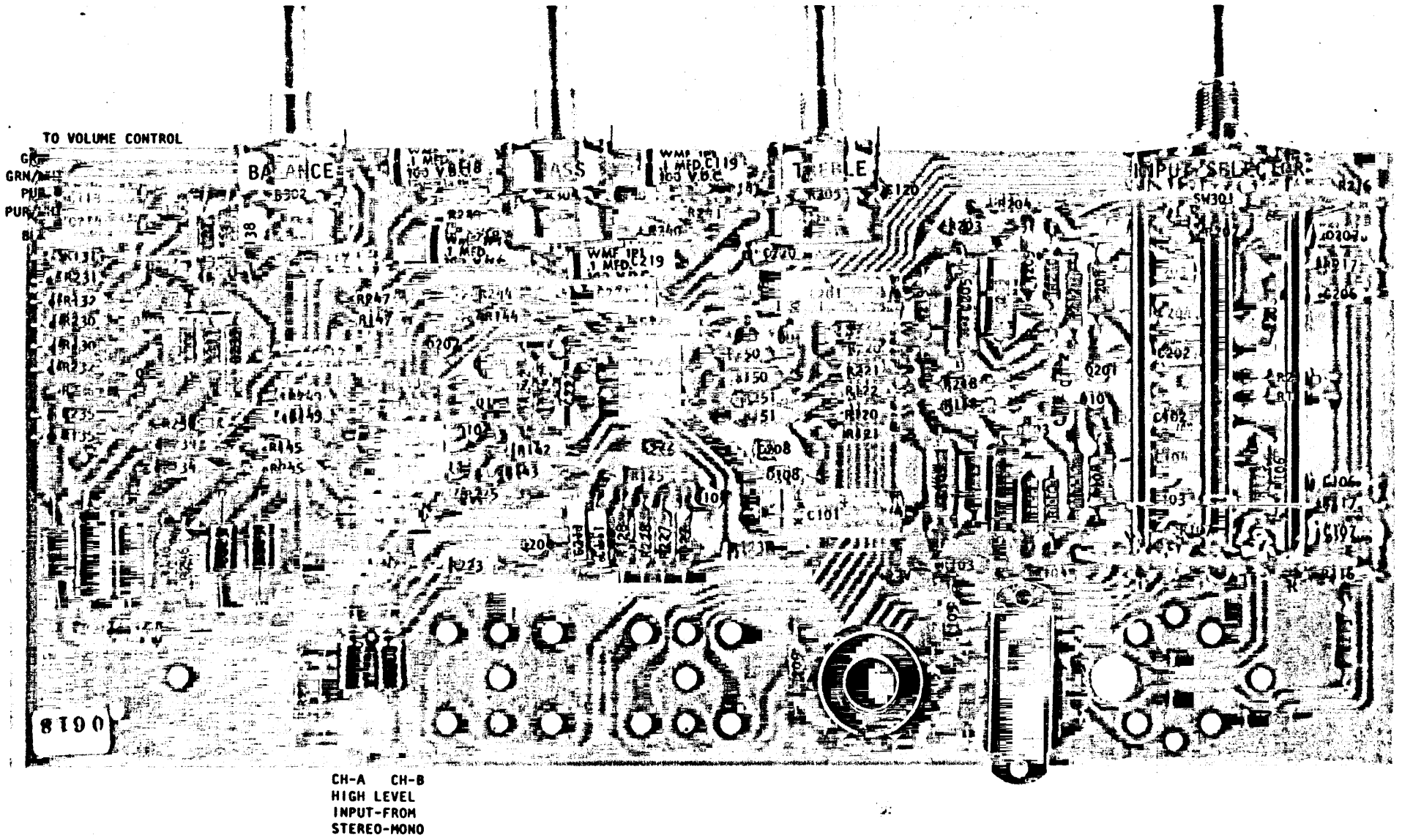


Figure 4-10 PREAMPLIFIER CIRCUIT BOARD

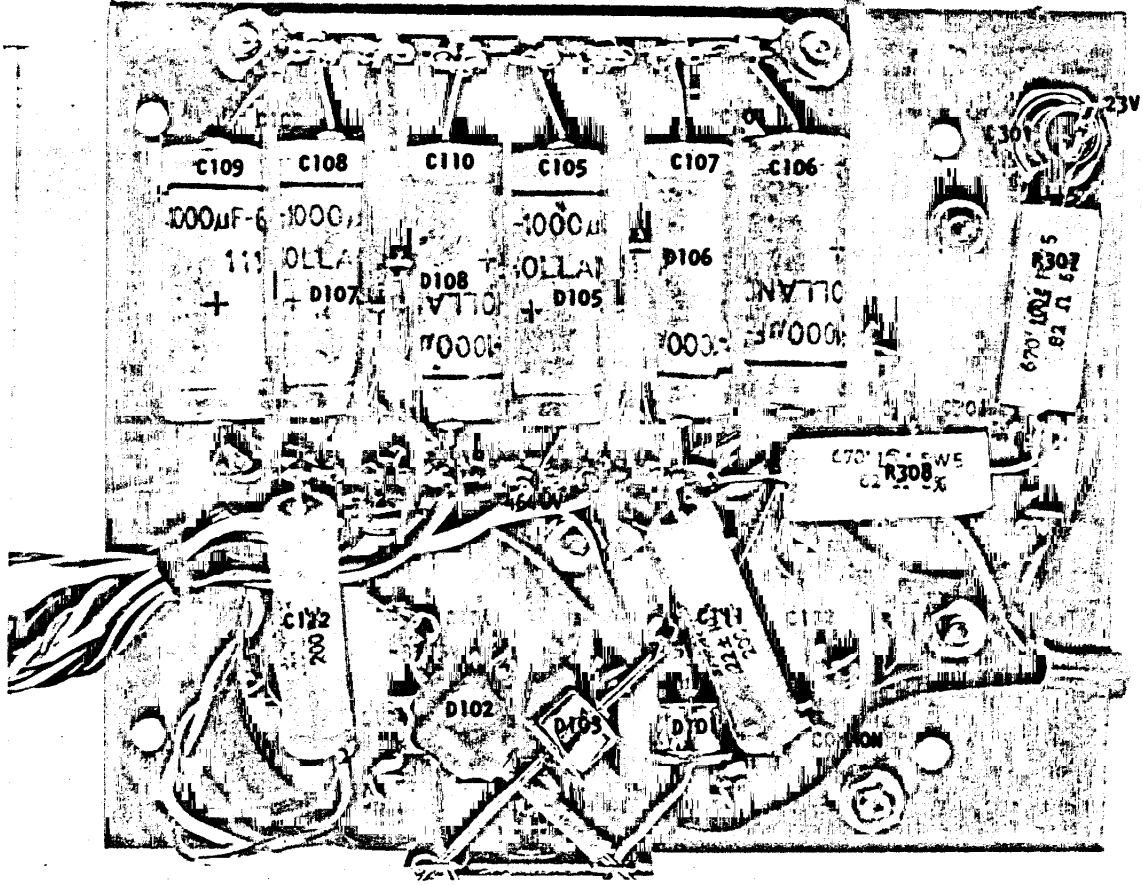


Figure 4-11 SA600 CAPACITOR BRACKET

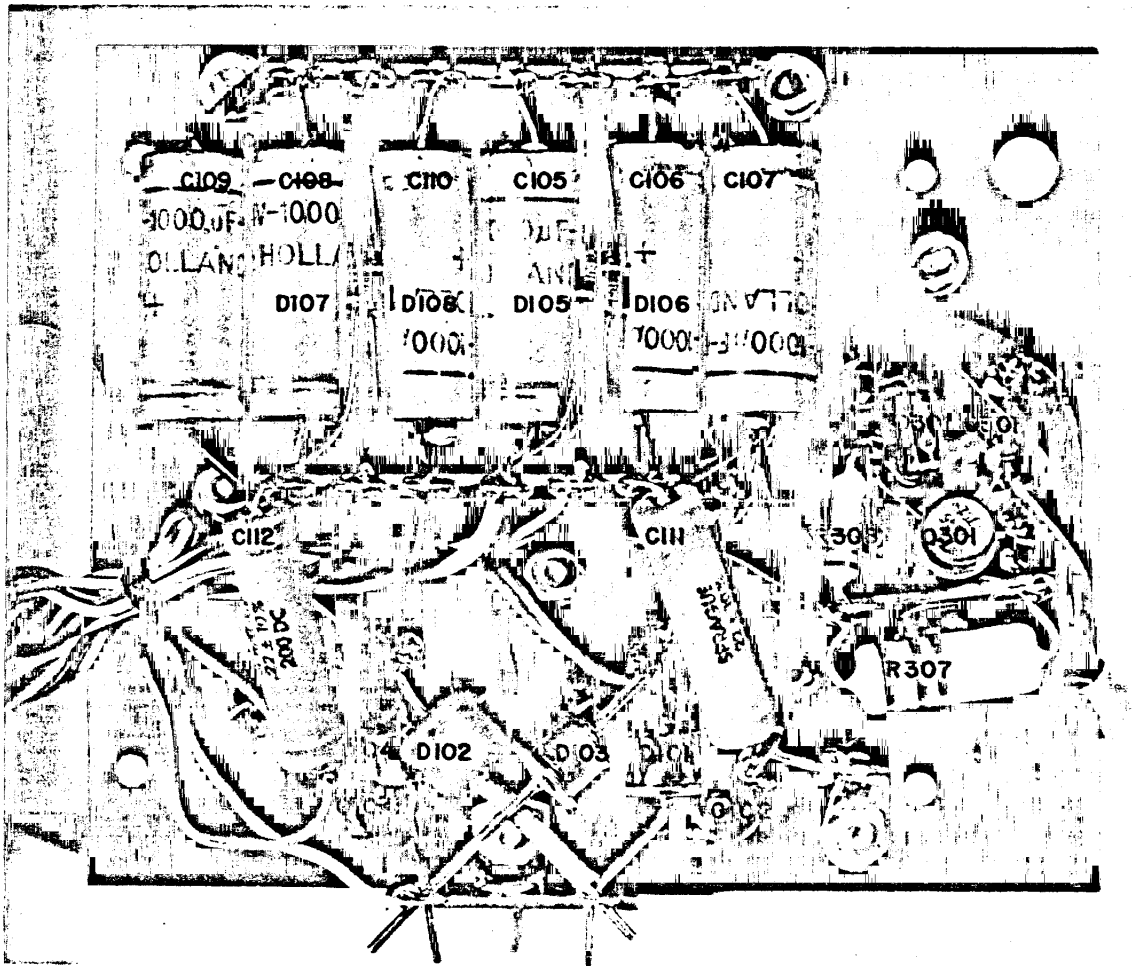


Figure 4-12 SA660 CAPACITOR BRACKET

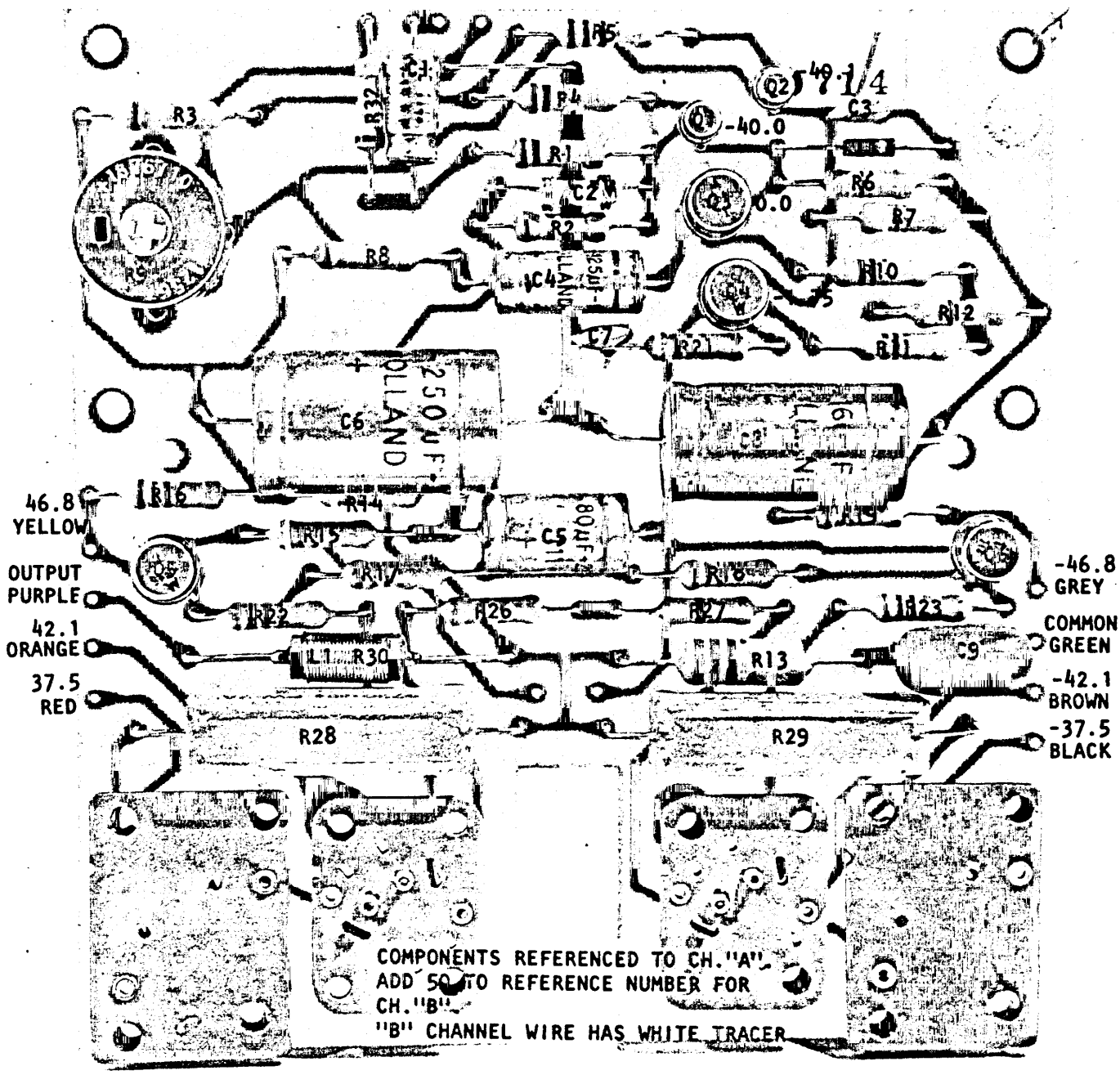


Figure 4-13 DRIVER CIRCUIT BOARD

NOTE: SA660 ONLY PROTECTIVE DIODES ARE CONNECTED BETWEEN EMITTER ENDS OF R28,29 AND DIODE ASSEMBLY TERMINALS.

SECTION V

REPLACEMENT PARTS AND SCHEMATICS

5.1 REPLACEMENT PARTS

Replacement parts for the SA600 Solid State Amplifier are listed in the following pages. It is recommended that only JBL replacement parts be used in this high-quality amplifier.

5.1.1 RESISTORS

All resistors are the deposited carbon film type. Any failures should be replaced with the same type. *Ordinary molded composition carbon resistors must not be used except for R101, 201, 102 or 202 on the preamplifier or R20 R70 on the preamplifier. Replacements are available directly from JBL.

5.1.2 CAPACITORS

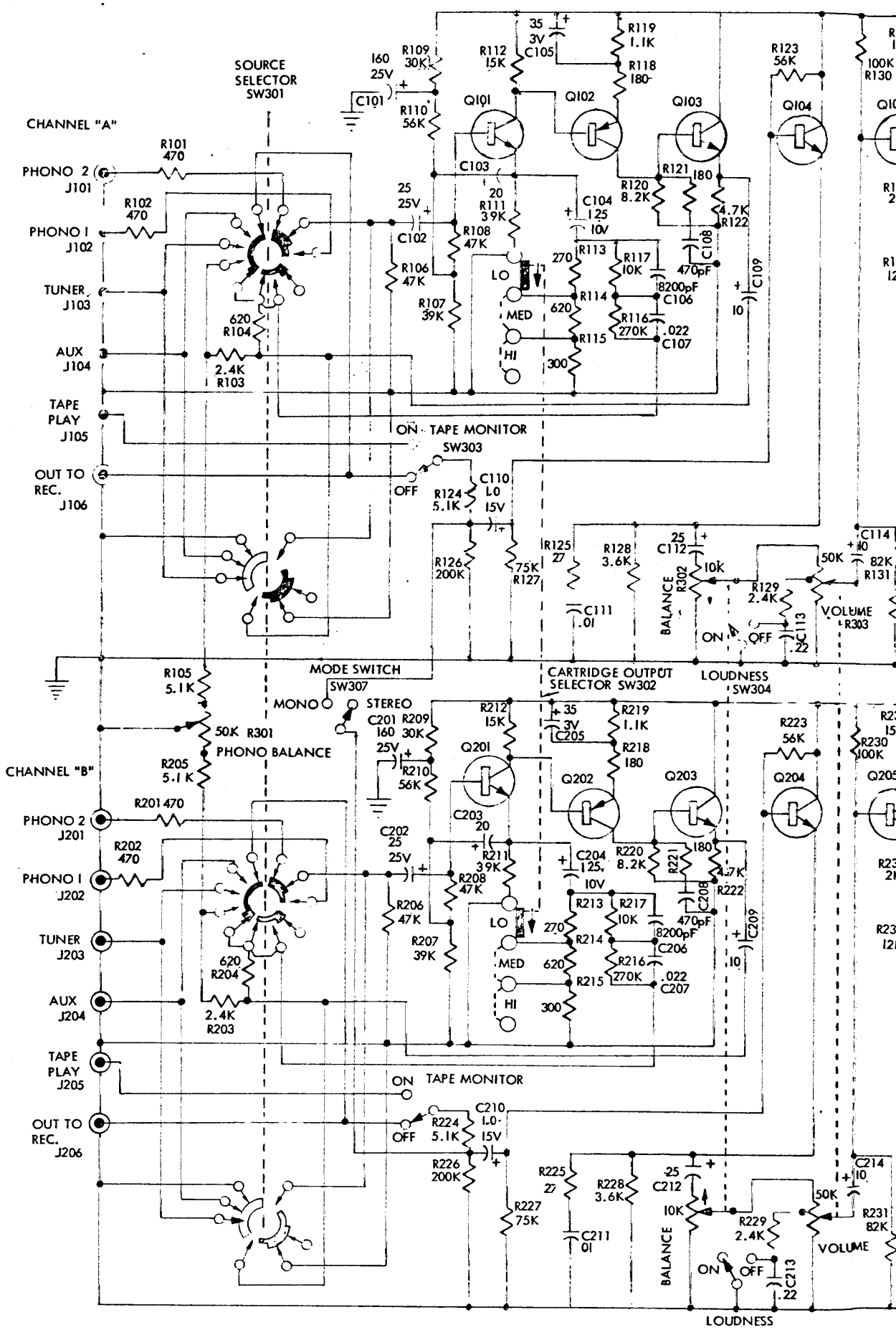
Most of the electrolytic capacitors used in the SA600 are specially made. Replacements should be ordered directly from JBL by part number or reference number. Under no circumstances should inferior-rated electrolytics be substituted. Lower capacities in any circuit will impair performance. Lower working voltage ratings will cause premature failure. Capacitors have been selected for low noise specifications.

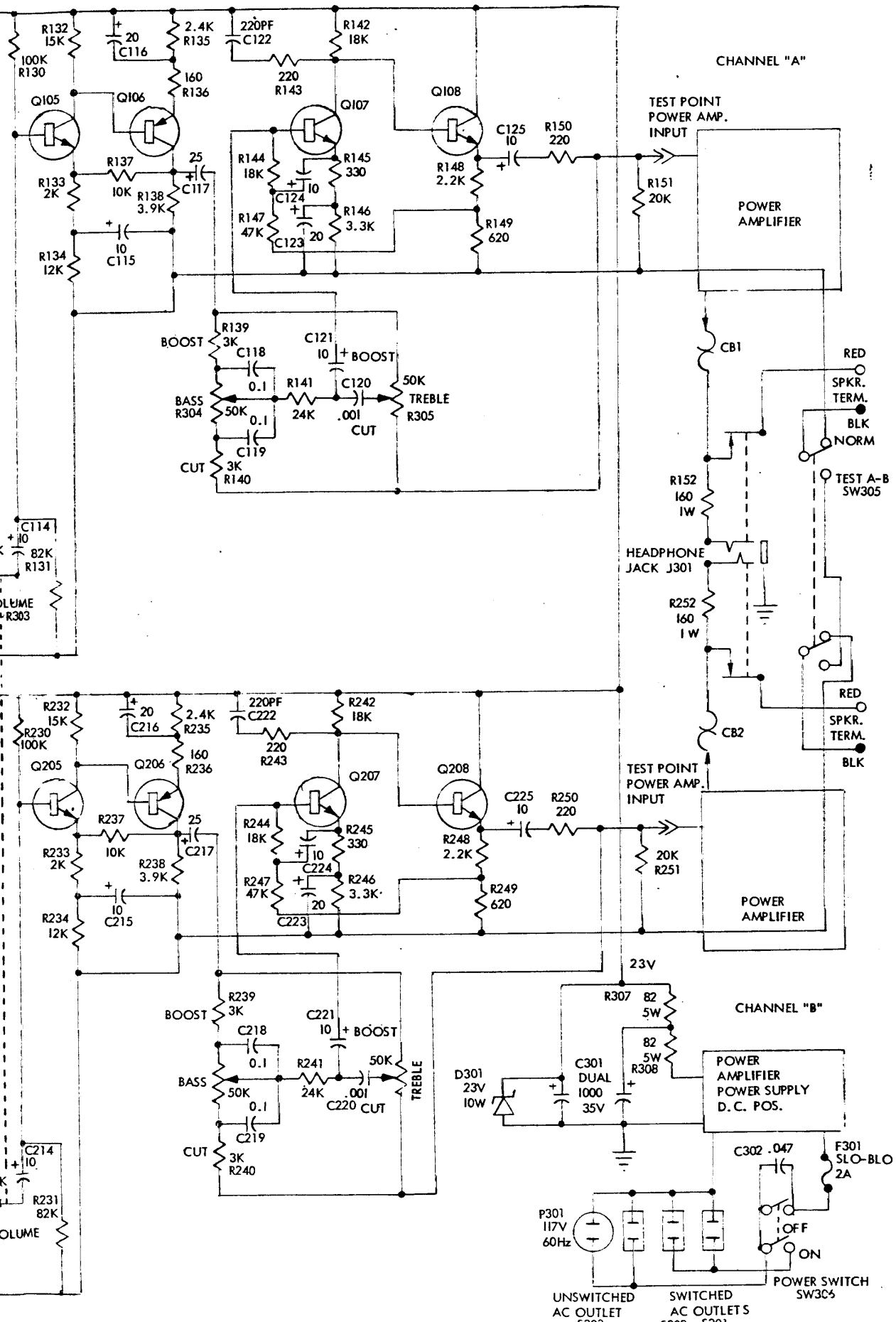
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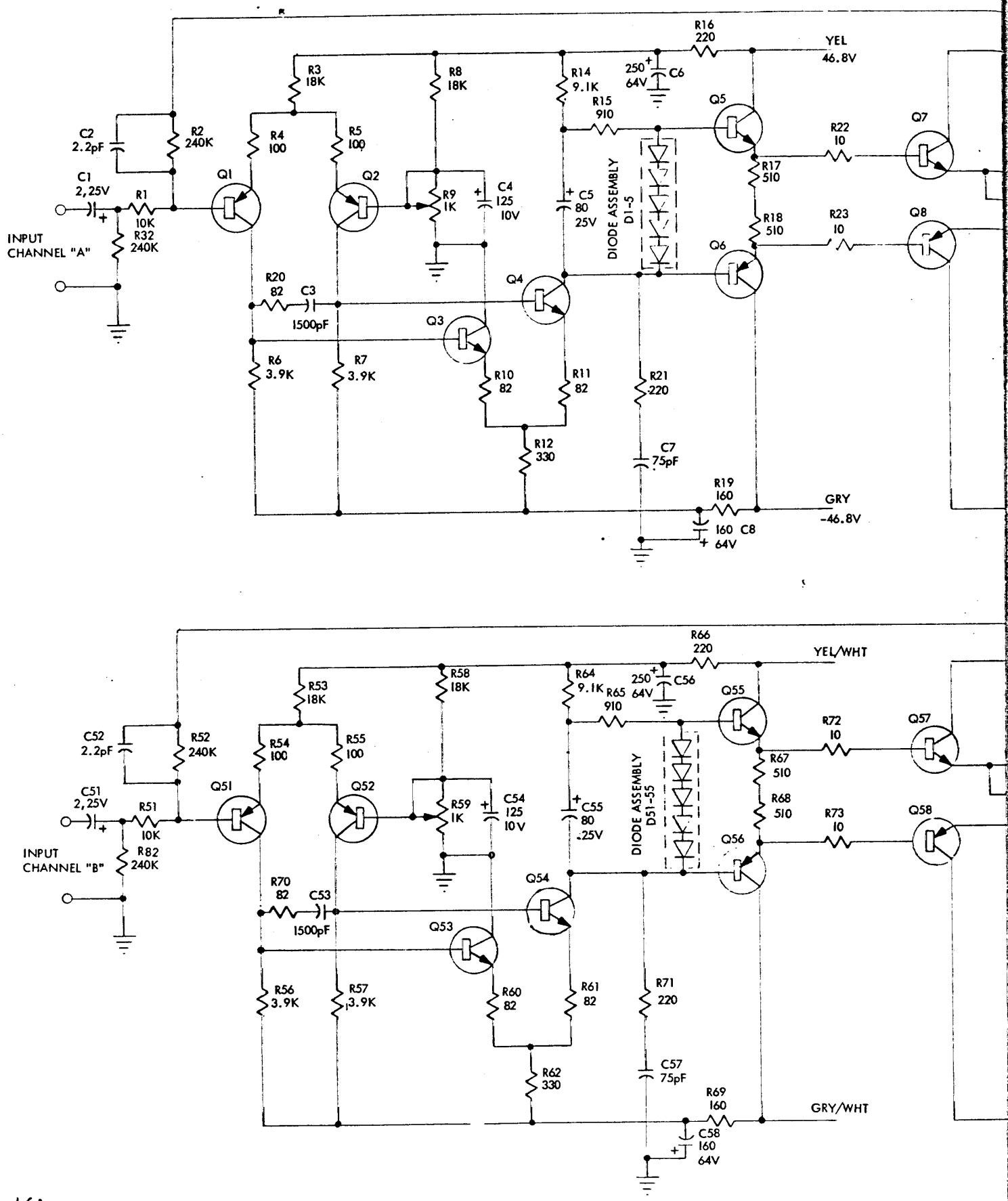
* Technicians who are familiar with professional or military dc amplifiers will remember that carbon resistors can be more noisy and have a greater resistance change with temperature.

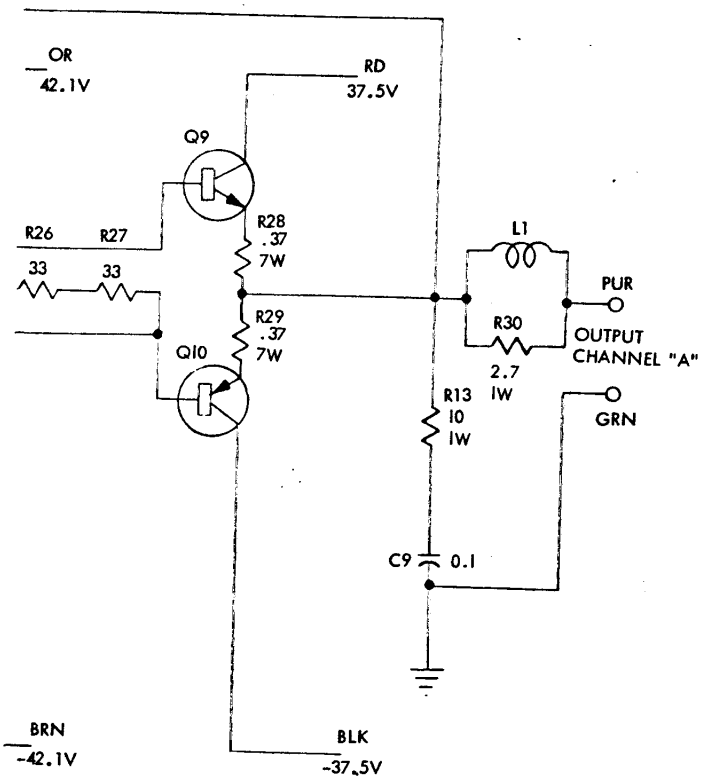
5.1.3 TRANSISTORS

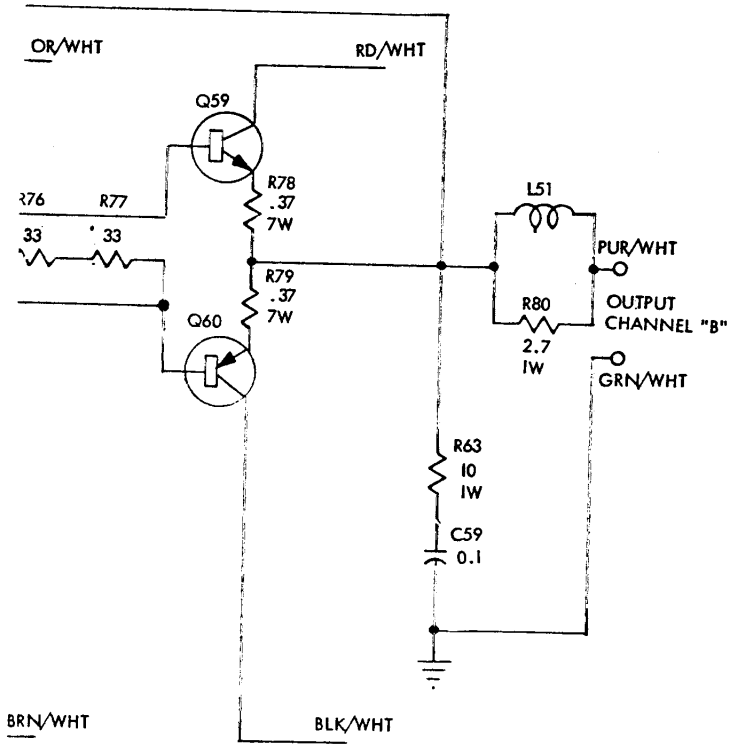
All transistors are selected for current gain, low noise, and other important characteristics. Experience has shown that the current gain from one transistor to the next in any production batch varies so much that sometimes one will not work well in the circuit. For this reason, all transistors carry special part numbers and must be ordered from JBL. Specify the reference number Q101 etc. where the transistor is used.

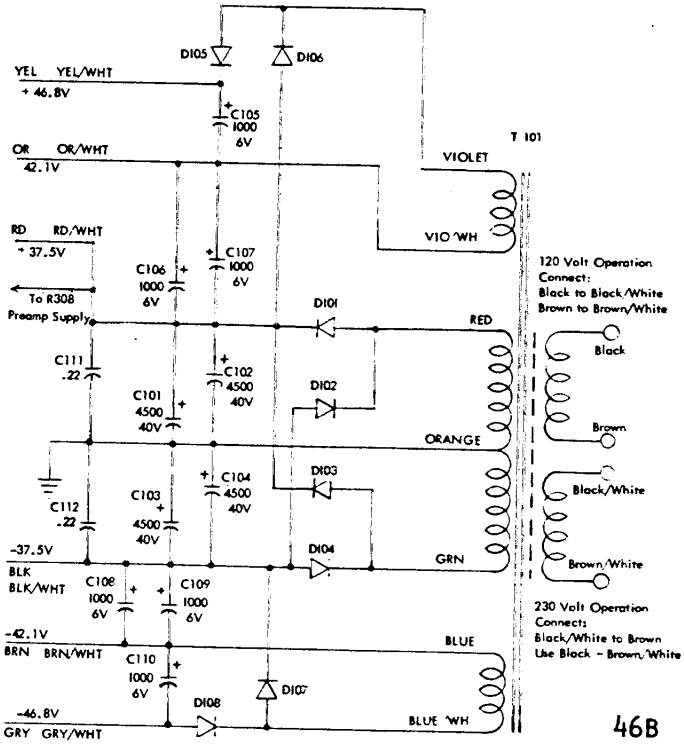

SOURCE SELECTOR SW301
CHANNEL "A"
PHONO 2 J101
PHONO 1 J102
TUNER J103
AUX J104
TAPE PLAY J105
OUT TO REC. J106
R101 470
R102 470
620 R104
2.4K R103
C101 160 25V
R109 30K
R110 56K
Q101
Q102
Q103
35 3V C105
R112 15K
R119 1.1K
R118 180
C103 25 25V
C102 25 25V
R108 47K
R106 47K
R107 39K
R111 39K
C104 125 10V
R113 270
R114 620
R115 300
R117 10K
R116 270K
C106 8200pF
C107 .022
C108 470pF
R120 8.2K
R121 180
R122 4.7K
C109 10
LO
MED
HI
ON TAPE MONITOR
SW303
OFF
C110 LO 15V
R124 5.1K
R126 200K
R127 75K
R125 27
R128 3.6K
C111 .01
C112 25 10K
BALANCE R302
R129 2.4K
50K VOLUME R303
C113 .22
ON OFF
C114 10
82K R131
R123 56K
Q104
100K R130
MODE SWITCH SW307
MONO
STEREO
CARTRIDGE OUTPUT SELECTOR SW302
LOUDNESS SW304
R105 5.1K
50K R301 PHONO BALANCE
R205 5.1K
CHANNEL "B"
PHONO 2 J201
PHONO 1 J202
TUNER J203
AUX J204
TAPE PLAY J205
OUT TO REC. J206
R201 470
R202 470
620 R204
2.4K R203
C201 160 25V
R209 30K
R210 56K
Q201
Q202
Q203
35 3V C205
R212 15K
R219 1.1K
R218 180
C202 25 25V
C203 20
R211 39K
R208 47K
R206 47K
R207 39K
C204 125 10V
R213 270
R214 620
R215 300
R217 10K
R216 270K
C206 8200pF
C207 .022
C208 470pF
R220 8.2K
R221 180
R222 4.7K
C209 10
LO
MED
HI
ON TAPE MONITOR
OFF
C210 1.0 15V
R224 5.1K
R226 200K
R227 75K
R225 27
R228 3.6K
C211 01
C212 25 10K
BALANCE
R229 2.4K
50K VOLUME
C213 .22
ON OFF
C214 10
82K R231
R223 56K
Q204
100K R230
LOUDNESS

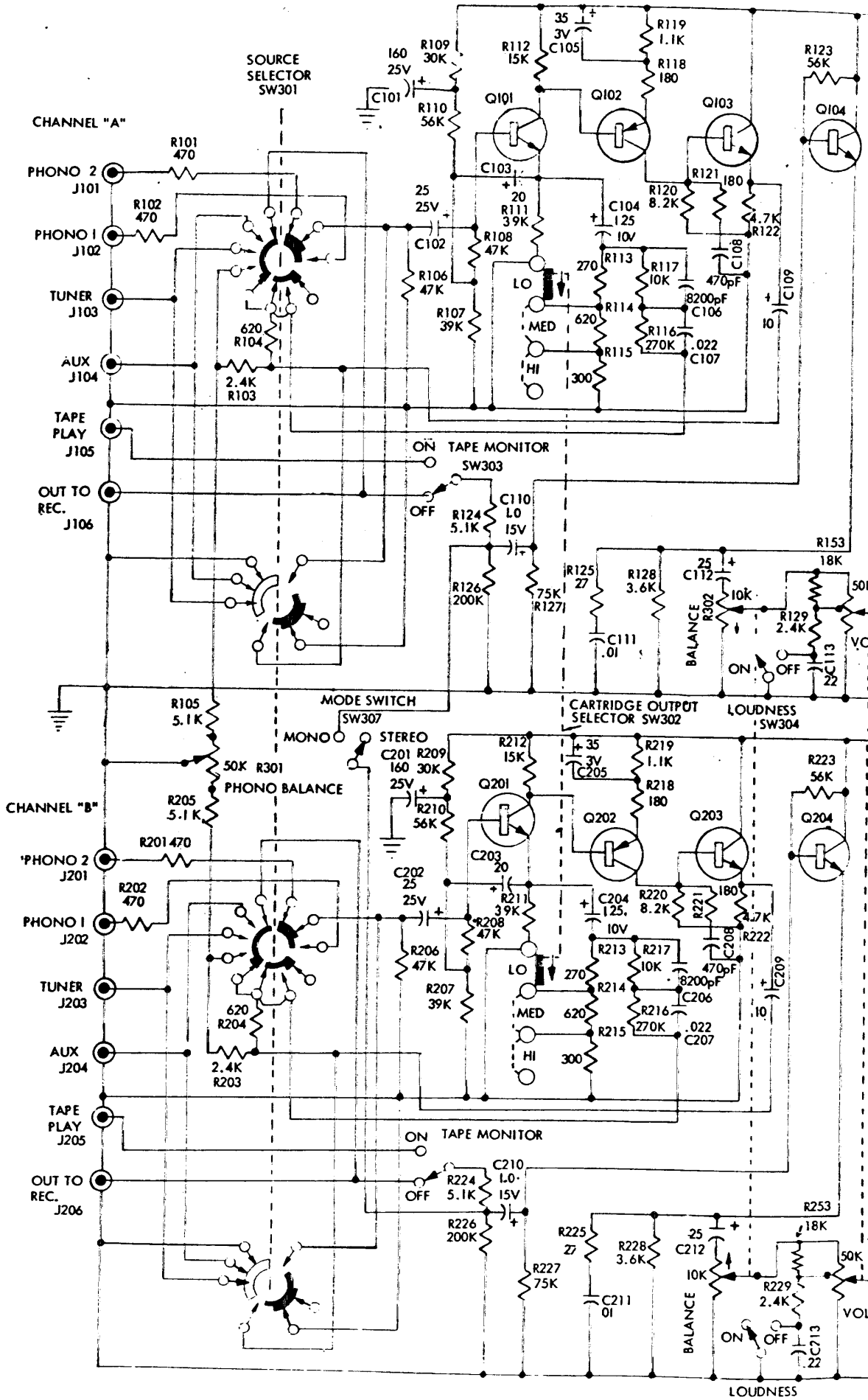

CHANNEL "A"
R132 15K
100K R130
20 C116
2.4K R135
220PF C122
R142 18K
220 R143
160 R136
Q105
Q106
Q107
Q108
TEST POINT POWER AMP. INPUT
C125 10
R150 220
R137 10K
25 C117
R133 2K
R138 3.9K
R144 18K
R145 330
10 C124
R147 47K
R146 3.3K
C123 20
R148 2.2K
R149 620
R151 20K
POWER AMPLIFIER
10 C115
R134 12K
R139 3K
BOOST
C118 0.1
C121 10
BOOST
BASS R304 50K
0.1 C119
CUT 3K R140
R141 24K
C120 .001 CUT
50K TREBLE R305
CB1
RED SPKR. TERM.
BLK NORM
TEST A-B SW305
R152 160 1W
HEADPHONE JACK J301
R252 160 1W
C114 10
82K R131
OLUME R303
RED SPKR. TERM.
BLK
CB2
R232 15K
R230 100K
20 C216
2.4K R235
220PF C222
R242 18K
220 R243
160 R236
Q205
Q206
Q207
Q208
TEST POINT POWER AMP. INPUT
C225 10
R250 220
R237 10K
25 C217
R233 2K
R238 3.9K
R244 18K
R245 330
10 C224
R247 47K
R246 3.3K
C223 20
R248 2.2K
R249 620
20K R251
POWER AMPLIFIER
10 C215
R234 12K
23V
R307 82 5W
CHANNEL "B"
R239 3K
BOOST
C218 0.1
C221 10
BOOST
BASS 50K
0.1 C219
CUT 3K R240
R241 24K
C220 .001 CUT
50K TREBLE
82 5W R308
D301 23V 10W
C301 DUAL 1000 35V
POWER AMPLIFIER POWER SUPPLY D.C. POS.
C214 10
R231 82K
OLUME
C302 .047
F301 SLO-BLO 2A
P301 117V 60Hz
OFF
ON
POWER SWITCH SW306
UNSWITCHED AC OUTLET
SWITCHED AC OUTLETS

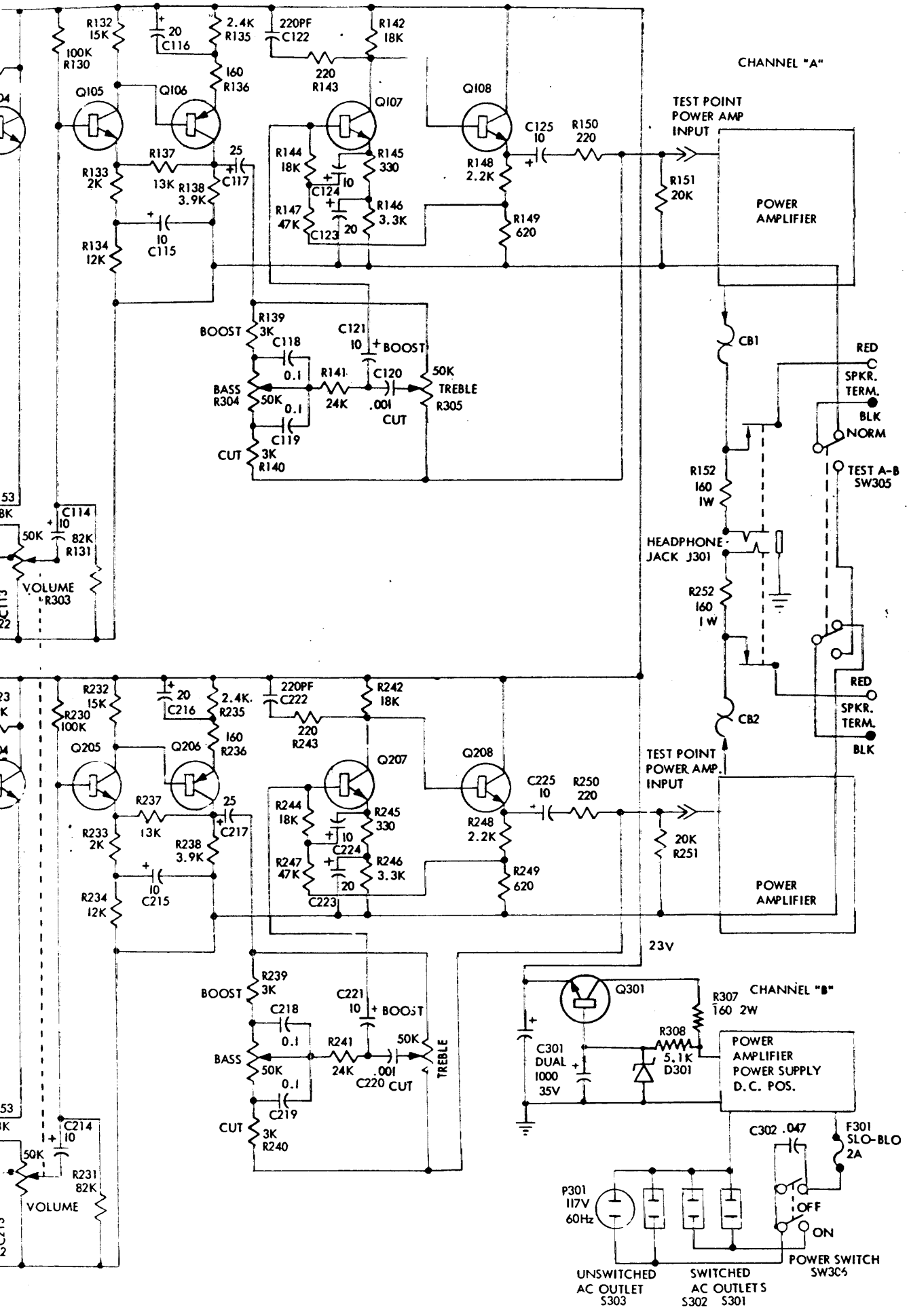

R16
220
YEL
46.8V
R3
18K
R8
18K
R14
9.1K
250
64V
C6
R15
910
Q5
Q7
C2
2.2pF
R2
240K
R4
100
R5
100
R22
10
C1
2,25V
R1
10K
R32
240K
Q1
Q2
R9
1K
C4
125
10V
C5
80
25V
DIODE ASSEMBLY
D1-5
R17
510
R18
510
R23
10
Q8
Q6
INPUT
CHANNEL "A"
R20
82
C3
1500pF
Q4
Q3
R6
3.9K
R7
3.9K
R10
82
R11
82
R21
220
R12
330
C7
75pF
R19
160
GRY
-46.8V
160
64V
C8
R66
220
YEL/WHT
R58
18K
R53
18K
R64
9.1K
250
64V
C56
R65
910
Q55
Q57
C52
2.2pF
R52
240K
R54
100
R55
100
R72
10
R67
510
C51
2,25V
R51
10K
Q51
Q52
R59
1K
C54
125
10V
C55
80
25V
DIODE ASSEMBLY
D51-55
R68
510
R73
10
Q58
Q56
INPUT
CHANNEL "B"
R82
240K
R70
82
C53
1500pF
Q54
Q53
R56
3.9K
R57
3.9K
R60
82
R61
82
R71
220
R62
330
C57
75pF
R69
160
GRY/WHT
C58
160
64V

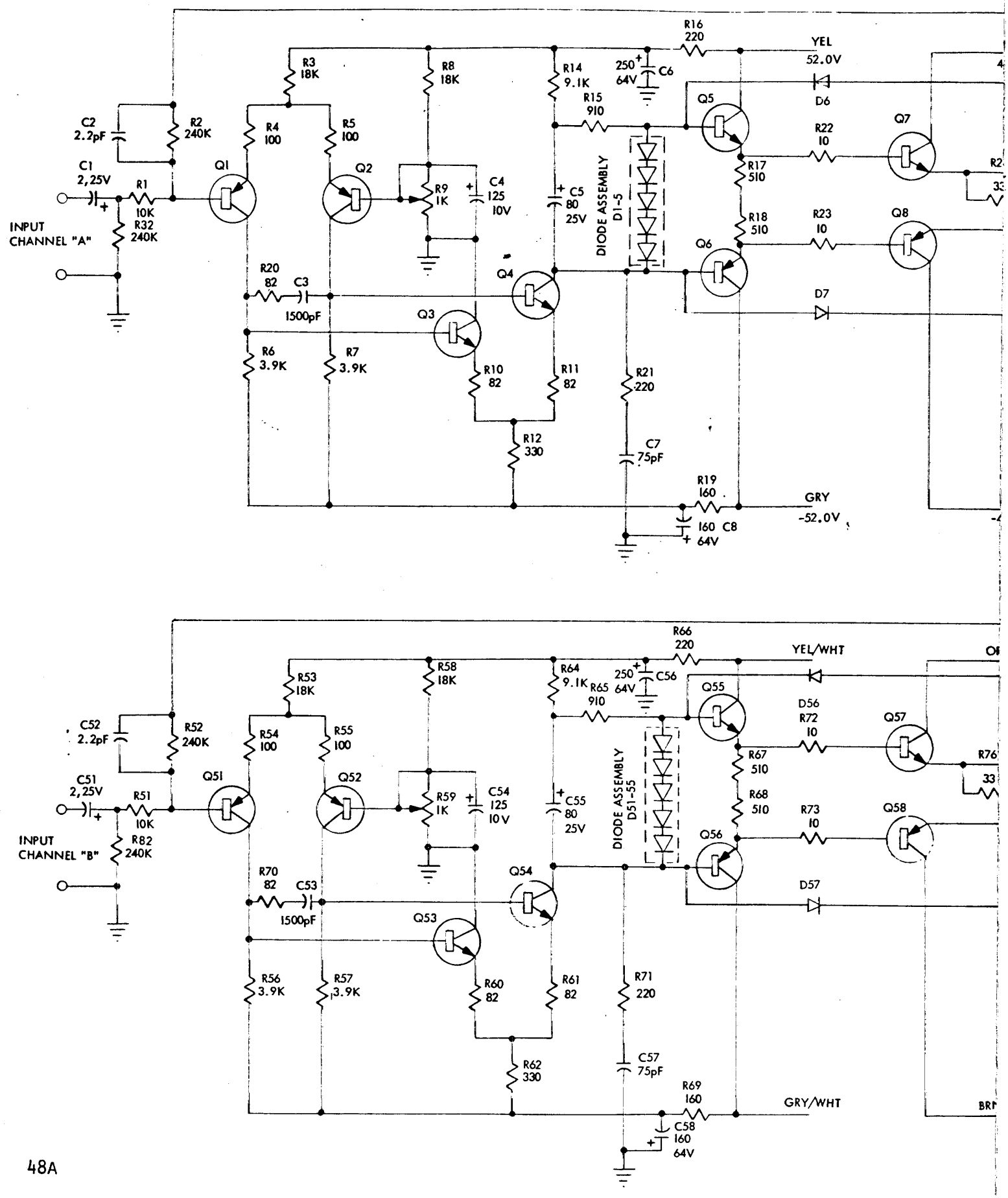

OR
42.1V
RD
37.5V
Q9
R26
R27
33
33
R28
.37
7W
R29
.37
7W
Q10
L1
PUR
R30
2.7
1W
OUTPUT
CHANNEL "A"
R13
10
1W
GRN
C9
0.1
BRN
-42.1V
BLK
-37.5V

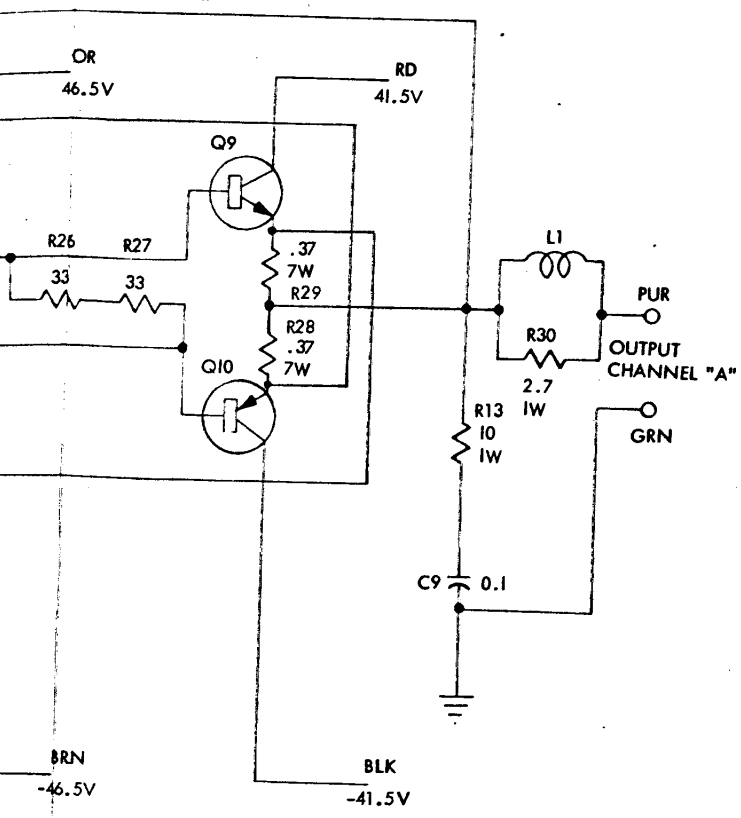

OR/WHT
RD/WHT
Q59
R76
R77
33
33
R78
.37
7W
R79
.37
7W
Q60
L51
PUR/WHT
R80
2.7
1W
OUTPUT
CHANNEL "B"
GRN/WHT
R63
10
1W
C59
0.1
BRN/WHT
BLK/WHT

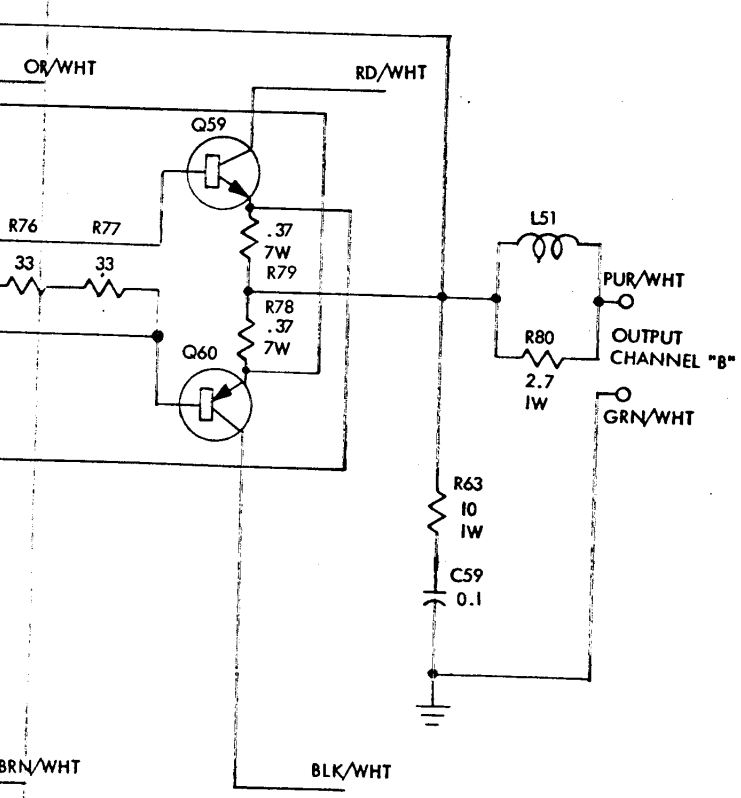

D105
D106
YEL
YEL/WHT
+ 46.8V
C105
1000
6V
T 101
OR
OR/WHT
42.1V
VIOLET
VIO/WH
RD
RD/WHT
+ 37.5V
To R308
Preamp Supply
C106
1000
6V
C107
1000
6V
D101
RED
C111
.22
C102
4500
40V
D102
C101
4500
40V
ORANGE
C112
.22
C103
4500
40V
C104
4500
40V
D103
-37.5V
BLK
BLK/WHT
D104
GRN
C108
1000
6V
C109
1000
6V
-42.1V
BRN
BRN/WHT
BLUE
C110
1000
6V
D108
D107
-46.8V
GRY
GRY/WHT
BLUE WH
120 Volt Operation
Connect:
Black to Black/White
Brown to Brown/White
Black
Brown
Black/White
Brown/White
230 Volt Operation
Connect:
Black/White to Brown
Use Black - Brown/White

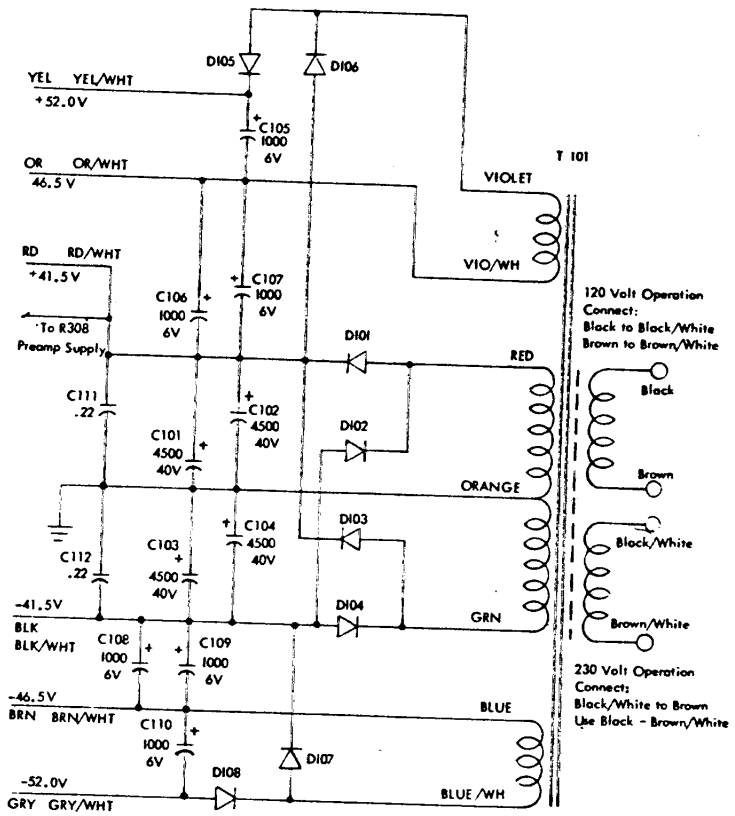

SOURCE SELECTOR SW301
CHANNEL "A"
PHONO 2 J101
PHONO 1 J102
TUNER J103
AUX J104
TAPE PLAY J105
OUT TO REC. J106
R101 470
R102 470
620 R104
2.4K R103
160 25V C101
R109 30K
R110 56K
35 3V C105
R112 15K
R119 1.1K
R118 180
Q101
Q102
Q103
Q104
R123 56K
C103 20
25 25V C102
R111 39K
R108 47K
R106 47K
R107 39K
C104 125 10V
R120 8.2K
R121 180
4.7K R122
C108 470pF
C109 10
R113 270
R117 10K
8200pF C106
R114 620
R116 270K
.022 C107
R115 300
LO
MED
HI
ON TAPE MONITOR SW303
OFF
R124 5.1K
C110 LO 15V
R126 200K
75K R127
R125 27
R128 3.6K
C111 .01
25 C112
10K R302
BALANCE
R129 2.4K
C113 22
R153 18K
ON OFF
MODE SWITCH SW307
MONO
STEREO
R105 5.1K
50K R301 PHONO BALANCE
R205 5.1K
CHANNEL "B"
PHONO 2 J201
PHONO 1 J202
TUNER J203
AUX J204
TAPE PLAY J205
OUT TO REC. J206
R201 470
R202 470
620 R204
2.4K R203
C201 160 25V
R209 30K
R210 56K
R212 15K
C205 35 3V
R219 1.1K
R218 180
Q201
Q202
Q203
Q204
R223 56K
C202 25 25V
C203 20
R211 39K
R208 47K
R206 47K
R207 39K
C204 125 10V
R220 8.2K
R221 180
4.7K R222
C208 470pF
C209 10
R213 270
R217 10K
8200pF C206
R214 620
R216 270K
.022 C207
R215 300
CARTRIDGE OUTPUT SELECTOR SW302
LOUDNESS SW304
ON TAPE MONITOR
OFF
C210 LO 15V
R224 5.1K
R226 200K
R227 75K
R225 27
R228 3.6K
C211 01
R253 18K
25 C212
10K
BALANCE
R229 2.4K
C213 22
50K
ON OFF
LOUDNESS


CHANNEL "A"
R132 15K
100K R130
20 C116
2.4K R135
220PF C122
R142 18K
160 R136
220 R143
Q105
Q106
Q107
Q108
TEST POINT POWER AMP INPUT
C125 10
R150 220
R137
13K
R138 3.9K
25 C117
R133 2K
R144 18K
R145 330
C124 10
R147 47K
C123 20
R146 3.3K
R148 2.2K
R149 620
R151 20K
POWER AMPLIFIER
R134 12K
10 C115
BOOST
R139 3K
C118
0.1
C121 10
BOOST
R141 24K
C120 .001
CUT
50K TREBLE R305
BASS R304 50K
0.1 C119
CUT 3K R140
CB1
RED SPKR. TERM.
BLK
NORM
TEST A-B SW305
R152 160 1W
HEADPHONE JACK J301
R252 160 1W
RED SPKR. TERM.
BLK
CB2
C114 10
50K
82K R131
VOLUME R303
CHANNEL "B"
R232 15K
R230 100K
20 C216
2.4K R235
220PF C222
R242 18K
160 R236
220 R243
Q205
Q206
Q207
Q208
TEST POINT POWER AMP. INPUT
C225 10
R250 220
R237
13K
R238 3.9K
25 C217
R233 2K
R244 18K
R245 330
C224 10
R247 47K
C223 20
R246 3.3K
R248 2.2K
R249 620
20K R251
POWER AMPLIFIER
R234 12K
10 C215
23V
BOOST
R239 3K
C218
0.1
C221 10
BOOST
R241 24K
C220 .001
CUT
50K TREBLE
BASS 50K
0.1 C219
CUT 3K R240
Q301
R307 160 2W
CHANNEL "B"
R308 5.1K
D301
C301 DUAL 1000 35V
POWER AMPLIFIER POWER SUPPLY D.C. POS.
C214 10
50K
R231 82K
VOLUME
C302 .047
F301 SLO-BLO 2A
P301 117V 60Hz
OFF
ON
POWER SWITCH SW305
UNSWITCHED AC OUTLET S303
SWITCHED AC OUTLETS S302 S301


R16
220
YEL
52.0V
R3
18K
R8
18K
R14
9.1K
250
64V
C6
R15
910
D6
C2
2.2pF
R2
240K
R4
100
R5
100
Q5
Q7
R22
10
C1
2,25V
R1
10K
Q1
Q2
R9
1K
C4
125
10V
C5
80
25V
DIODE ASSEMBLY
D1-5
R17
510
R18
510
R23
10
Q8
INPUT
CHANNEL "A"
R32
240K
Q6
R20
82
C3
1500pF
Q4
D7
Q3
R6
3.9K
R7
3.9K
R10
82
R11
82
R21
220
R12
330
C7
75pF
R19
160
GRY
-52.0V
160
64V
C8
R66
220
YEL/WHT
R53
18K
R58
18K
R64
9.1K
R65
910
250
64V
C56
C52
2.2pF
R52
240K
R54
100
R55
100
Q55
D56
R72
10
Q57
R67
510
R68
510
C51
2,25V
R51
10K
Q51
Q52
R59
1K
C54
125
10V
C55
80
25V
DIODE ASSEMBLY
D51-55
R73
10
Q58
INPUT
CHANNEL "B"
R82
240K
Q56
R70
82
C53
1500pF
Q54
D57
Q53
R56
3.9K
R57
3.9K
R60
82
R61
82
R71
220
R62
330
C57
75pF
R69
160
GRY/WHT
C58
160
64V







POWER SUPPLY SECTION

PREAMPLIFIER CIRCUIT BOARD

REFERENCE NUMBER	DESCRIPTION	PART NUMBER	USER NET
Q 101, 103, 104 107, 108, 109 203, 205, 207 208	Transistor, NPN	12593	2.30
Q 102, 106 202, 206	Transistor, PNP	12594	2.30
C 101, 201	Capacitor, 160 mF 25V	12800	1.44
C 102, 202	Capacitor, 25 mF 25V	12610	1.20
C 103, 116, 123 203, 216, 223	Capacitor, 20 mF 16V	12459	.87
C 104, 204	Capacitor, 125 mF 10V	12461	1.35
C 105, 205	Capacitor, 35 mF 3 V	12856	1.08
C 106, 206	Capacitor, 8200 pF	12662	.33
C 107, 207	Capacitor, 0.022 mF	12010	.36
C 108, 208	Capacitor, 470 pF	10840	.22
C 109, 209 114, 214 115, 215	Capacitor, 10 mF 25V	12462	.90
C 110, 210	Capacitor, 1 mF 15V	12851	.87
C 111, 211	Capacitor, .01 mF	12663	.24
C 112, 117 212, 217	Capacitor, 25 mF 25V	11397	1.20
C 118, 218 119, 219	Capacitor, 0.1 mF	11405	.54
C 120, 220	Capacitor, 1000 pF	11404	.24
C 121, 221 124, 224 125, 225	Capacitor, 10 mF 25V	12642	.90
C 122, 222	Capacitor, 220 pF	12464	.22

PREAMPLIFIER CIRCUIT BOARD

Note: Asterisks indicate component value change in SA660.

REFERENCE NUMBER	DESCRIPTION	PART NUMBER	USER NET
R 101, 201 102, 202	Resistor, 470 Ohm ½W 5%	13238	.30
R 103, 203 135, 235	Resistor, 2400 Ohm ½W 5%	10160	.30
R 104, 204 114, 214 149, 249	Resistor, 620 Ohm ½W 5%	10075	.30
R 105, 205	Resistor, 5100 Ohm ½W 5%	11461	.30
R 106, 206 108, 208 147, 247	Resistor, 47K OHm ½W 5%	12260	.30
R 107, 207 111, 211	Resistor, 39K Ohm ½W 5%	11613	.30
R 109, 209	Resistor, 30K Ohm ½W 5%	12484	.30
R 110, 210 123, 223	Resistor, 56K Ohm ½W 5%	11930	.30
R 112, 212	Resistor, 15K Ohm ½W 5%	11046	.30
R 113, 213	Resistor, 270 Ohm ½W 5%	11508	.30
R 115, 215	Resistor, 300 Ohm ½W 5%	12013	.30
R 116, 216	Resistor, 270K Ohm ½W 5%	11469	.30
R 117, 217 137, 237*	Resistor, 10K Ohm ½W 5%	11464	.30
R 118, 218 121, 221	Resistor, 180 Ohm ½W 5%	11457	.30
R 119, 219	Resistor, 1100 Ohm ½W 5%	10949	.30
R 120, 220	Resistor, 8200 Ohm ½W 5%	11993	.30
R 122, 222	Resistor, 4700 Ohm ½W 5%	11174	.30
R 125, 225	Resistor, 27 Ohm ½W 5%	12552	.30

PREAMPLIFIER CIRCUIT BOARD

REFERENCE NUMBER	DESCRIPTION	PART NUMBER	USER NET
R 126, 226	Resistor, 200K Ohm ½W 5%	12488	$ .30
R 127, 227	Resistor, 75K Ohm ½W 5%	10842	.30
R 128, 228	Resistor, 3600 Ohm ½W 5%	10942	.30
R 130, 230	Resistor, 100K Ohm ½W 5%	10072	.30
R 131, 231	Resistor, 82K Ohm ½W 5%	12598	.30
R 133, 233	Resistor, 2000 Ohm ½W 5%	12014	.30
R 134, 234	Resistor, 12K Ohm ½W 5%	10077	.30
R 136, 236	Resistor, 160 Ohm ½W 5%	11456	.30
R 138, 238	Resistor, 3900 Ohm ½W 5%	12486	.30
R 139, 239 140, 240	Resistor, 3000 Ohm ½W 5%	11460	.30
R 141, 241	Resistor, 24K Ohm ½W 5%	10989	.30
R 142, 242	Resistor, 18K Ohm ½W 5%	11466	.30
R 143, 243 150, 250	Resistor, 220 Ohm ½W 5%	10076	.30
R 145, 245	Resistor, 330 Ohm ½W 5%	10082	.30
R 146, 246	Resistor, 3300 Ohm ½W 5%	12623	.30
R 148, 248	Resistor, 2200 Ohm ½W 5%	10943	.30
R 151, 251	Resistor, 20K Ohm ½W 5%	10073	.30
R 152, 252	Resistor, 160 Ohm 1W 5%	12659	.30
SA660	Component value change		
*R 137, 237	Resistor, 13K Ohm ½W 5%	11465	.30
R 301	Potentiometer, 50K Ohm Phono Balance	12479	2.25
R 302	Potentiometer, 10K Ohm Balance	12312	6.60
	SUB-PANEL ASSEMBLY		
R 303	Potentiometer, 50K Ohm Volume	13313	7.80
R 304, 305*	Potentiometer, 50K Ohm Tone Control	12311	5.70

R 124, 224	Resistor, 5100 Ohm ½W 5%	11461	.30
R129, 229	Resistor, 2400 Ohm ½W 5%	10160	.30
C113, 213	Capacitor, 0.22 mF 100V	11606	.60
C 302	Capacitor, 0.047 mF 600V	11941	.36
S 301	Switch, Selector	12565	12.00
S 302	Switch, Phono level	11452	.72
S 303, 304, 305 306, 207	Mode, Test, Loudness, Tape Monitor, AC Switch Assy		3.33
	Input Jack Plate Assembly	12619	10.50
	Phone Jack	11364	3.60
	AC Receptacle - Black	12585	.54
	AC Receptacle - White	12608	.54
	Ground Terminal	10244	.30
SA660 ..... R 304, 305	Component value change Potentiometer, Dual Section, 50K Ohm	13296	5.70
R 153, 253	Resistor, 18K Ohm ½W 5%	11466	.30
C 1, 51	Capacitor, 2.0 mF 25V	11401	.81
C 2, 52	Capacitor, 2.2 pF	12798	.22
C 3, 53	Capacitor, 1500 pF 10%	12863	.22
C 4, 54	Capacitor, 125 mF 10V	12461	1.35
C 5, 55	Capacitor, 80 mF 25V	10906	.75

DRIVER CIRCUIT BOARD

C 6, 56	Capacitor, 250 mF 64 V	12671	2.18
C 7, 57	Capacitor, 75 pF	12889	.22
C 8, 58	Capacitor, 160 mF 64 V	12597	1.40
C 9, 59	Capacitor, 0.1 mF 200V	10114	.58
L 1, 51 R 30, 80	Choke	12530	.60
R 1, 51	Resistor, 10K Ohm ½W 5%	11464	.30
R 2, 52 32, 82	Resistor, 240K Ohm ½W 5%	12563	.30
R 3, 53	Resistor, 18K ohm ½W 5%	11466	.30

R 4, 54 5, 55	Resistor, 100 Ohm ½W 5%	11507	.30
R 6, 56 7, 57	Resistor, 3900 Ohm ½W 5%	12486	.30
R 9, 59	Potentiometer, 1000 Ohm Wirewound	12567	1.10
R 10, 11, 60 20, 61, 70	Resistor, 82 Ohm ½W 5%	11455	.30
R 12, 62	Resistor, 330 Ohm ½W 5%	10082	.30
R 13, 63	Resistor 10 Ohm 1W 5%	10081	.54
R 14, 64	Resistor, 9.1K Ohm ½W 5%	12558	.30
R 15, 65	Resistor 910 Ohm ½W 5%	12564	.30
R 16, 21 61, 71	Resistor, 220 Ohm ½W 5%	10076	.30
R 17, 67 18, 68	Resistor, 510 Ohm ½W 5%	11459	.30
R 19, 69	Resistor, 160 Ohm ½W 5%	11456	.30

DRIVER CIRCUIT BOARD

R26, 27 76, 77	Resistor, 33 Ohm ½W 5%	11454	.52
R28, 29 78, 79	Resistor, 0.37 Ohm 7W	12596	.52
*Q 1, 51 2, 52	Transistor, PNP 1st. Diff. Amp.	12888	7.80
*Q 3, 53 4, 54 5, 55	Transistor, NPN 2nd Diff Pre-Driver	12546	5.40
*Q 6, 56	Transistor, PNP Pre-Driver	12545	19.80
D 1-5, 51-55	Diode Assembly	10896	10.50
*Q 10, 60	Transistor, PNP Power	12537	22.27
*Q 9, 59	Transistor, NPN Power	12536	7.27
*Q 8, 58	Transistor, PNP Driver	12539	4.80
*Q 7, 57	Transistor, NPN Driver	12538	3.15
*Q 6, 56 7, 57	Diode	10909	.67

* SA660 ..... Transistor compliment

Q 1, 51 2, 52	Transistor	13297	8.60
Q 3, 53 4, 54 5, 55	Transistor,	13314	5.40
Q 6, 56	Transistor	13315	19.80
Q 7, 57	Transistor	13300	3.15
Q 8, 58	Transistor	13301	4.80
Q 9, 59	Transistor	13298	7.27
Q 10, 60	Transistor	13299	22.27
	CAPACITOR BRACKET		
C 101, 102 103, 104	Capacitor, 4500 mF 40V	12430	8.90
C 105, 106, 107 108, 109, 110	Capacitor, 1000 mF 6V	12590	1.35
C 111, 112	Capacitor, 0.22 mF 200V	12853	.60
D 101, 102 103, 104	Diode Rectifier High Current	12550	.90
D 105, 106 107, 108	Diode Rectifier Boost Supply	10909	.67
* D 301	Diode Zener 23V	12686	11.35
C 301	Capacitor, 1000-1000 mF	12480	3.75
* R 307, 308	Resistor, 82 Ohm 5W	12687	.52
	Terminal Strip, 7 Terminal	10907	.15
	Terminal Strip, 6 Terminal	10239	.10
	Wafer, Capacitor Mounting	10030	.20
* T101	Power Transformer	12614	30.60
* SA660	Component Value Changes		
CB 101, 201	Circuit Breaker	13176	2.25
	Terminal Strip, 6 Terminal	10239	.10
D 301	Diode Zener	13309	2.70
Q 301	Transistor	13310	3.15
R 307	Resistor, 160 Ohm 2W	13295	.36

R 308	Resistor, 5100 Ohm ½W 5%	11461	.30
	Fuse 2 amp. Domestic	12612	.30
	Binding Post Red	10243	.30
	Binding Post Black	10244	.30
	Insulating Washer	10817	.10
* T 101	Power Transformer	13278	33.00

FRONT PANEL ASSEMBLY

Front Panel	12470	15.00
Knob	12285	3.00
*Knob Front	13311	1.00
*Knob Rear	13312	2.00
Bottom Cover	12453	15.00
Top Cover	12500	6.45
Pilot Light #1820	12473	.48
Mounting Foot	11600	.15
Panel, End Cap	12305	2.40

* SA660 Parts

Specify color and model number when ordering panels and covers.