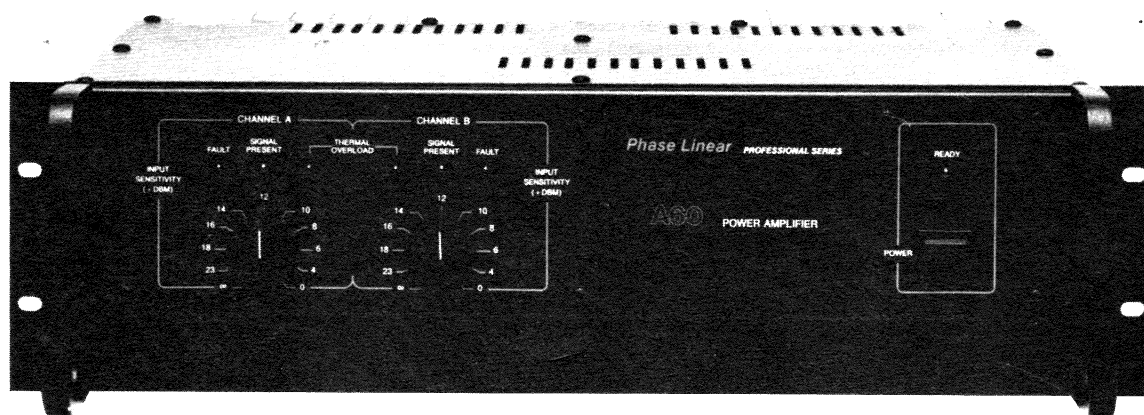


A60 POWER AMPLIFIER

SERVICE MANUAL



Phase Linear PROFESSIONAL SERIES

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**CAUTION: THIS MANUAL IS INTENDED FOR USE ONLY BY QUALIFIED
SERVICE PERSONNEL. HAZARDOUS VOLTAGES MAY BE
ENCOUNTERED IN THE SERVICING OF THE A60 AMPLIFIER. USE
EXTREME CAUTION AND READ ALL INSTRUCTIONS CAREFULLY.**

Phase Linear Service Department
20121 48th Ave. West
Lynnwood, WA 98036

Tel. (206) 774-8848
(206) 774-3571

prepared 10-81

1-0. SPECIFICATIONS

ELECTRICAL PERFORMANCE

POWER OUTPUT

225 watts output power minimum RMS per channel both channels driven into 8 ohms with no more than .05% total harmonic distortion (20-20kHz).

350 watts RMS per channel into 4 ohms

650 watts RMS mono mode into 8 ohms

FREQUENCY RESPONSE

11Hz to 190kHz +0, -1dB

INTERMODULATION DISTORTION

(60Hz: 7kHz @ 4:1)

Less than .005% at rated power into 8 ohms

Less than .005% at rated power into 4 ohms

SIGNAL-TO-NOISE RATIO

100dB (IHF A Weighted)

DAMPING FACTOR: 330:1 @ 1,000 Hz

INPUT IMPEDANCE: Balanced – 20k ohms, each leg to ground. Unbalanced – 20k ohms.

INPUT SENSITIVITY

.775 VRMS (0dBm) at maximum level for 120 watts output. 1.0 VRMS for 225 watts output.

SPEAKER IMPEDANCE

No less than 4 ohms in stereo

No less than 8 ohms in mono

SLEW RATE

100 volts per microsecond

RISE TIME

Less than 1.0 microsecond

PHASE SHIFT

0° at 20Hz

-3.1° at 20kHz

PROTECTION:

Output transistor protection: Electronic limiters together with power supply fuses prevent excursions into unsafe operating areas, regardless of load impedance.

Speaker Protection: This amplifier does not provide speaker protection from very high power levels. The user must make sure that all speakers to be connected to this amplifier can safely handle a minimum of 225 watts.

Separate fusing of speakers is highly recommended. An electronically activated relay disconnects the amplifier's output from the speakers:

1. For approximately five seconds after turn-on.
2. Immediately after turn-off.
3. In the presence of DC output voltage or high level subsonic signals.

GENERAL

POWER REQUIREMENTS:

- a. 120 VAC $\pm 10\%$, 50/60Hz (USA & selected export markets)
- b. 240 VAC $\pm 10\%$, 50/60 Hz (General export models)

POWER CONSUMPTION: 960 watts (maximum)

LINE CORD: Three-conductor, grounded, removable type.

MECHANICAL

UNIT:

Dimensions: 19"w × 5¼"h × 13¾"d (rack
depth)
(48.3cm × 13.3cm × 34.9cm)
(Standard EIA rack-mountable)

Weight: 45 lbs. (20.4 kgs)

SHIPPING:

Dimensions: 22½"w × 11"h × 21½"d
(57.2cm × 27.9cm × 54.6cm)

Weight: 52 lbs. (23.6 kgs)

Specifications are subject to change without
notice due to design improvements.

2-0. PANEL FUNCTIONS

FRONT PANEL DESCRIPTION

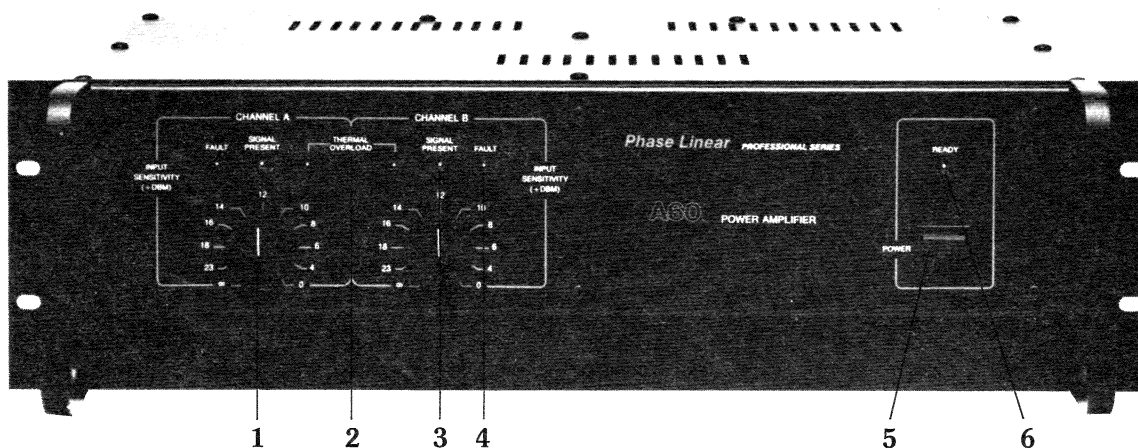


Illustration 1

- 1. INPUT SENSITIVITY CONTROL:** Stepped attenuators for each channel allow the input sensitivity of the A60 to be matched for optimum performance to any source input. These attenuators are calibrated in "dBm" required at the input for 120w output (not full power – see OPERATING INSTRUCTIONS). For example, when the attenuator is set at 0 dBm, an output from the mixing board or electronic crossover of .775 volts will result in 120w output.
- 2. THERMAL OVERLOAD INDICATOR:** This red LED will light any time the temperature of the heatsink exceeds its thermal limit. All incoming signals will be muted during the overload condition (as long as the overload indicator is lit) allowing the amplifier to cool. When the amplifier has cooled sufficiently full gain will be restored and the overload indicator will extinguish.
- 3. SIGNAL PRESENT:** A green LED which lights whenever audio signals are present at the amplifier's output.
- 4. FAULT INDICATOR:** The red LED fault indicators will light up whenever the amplifier is clipping, current limiting, the supply fuse is blown, or for any reason the output of the amplifier does not precisely follow the input. Refer to OPERATING INSTRUCTIONS section for further details.
- 5. POWER SWITCH:** Allows independent switching of the amplifier.
- 6. READY INDICATOR:** This green LED will light up approximately five (5) seconds after the power switch is turned on to indicate that the output relay is closed and the amplifier is ready for operation.

REAR PANEL DESCRIPTION

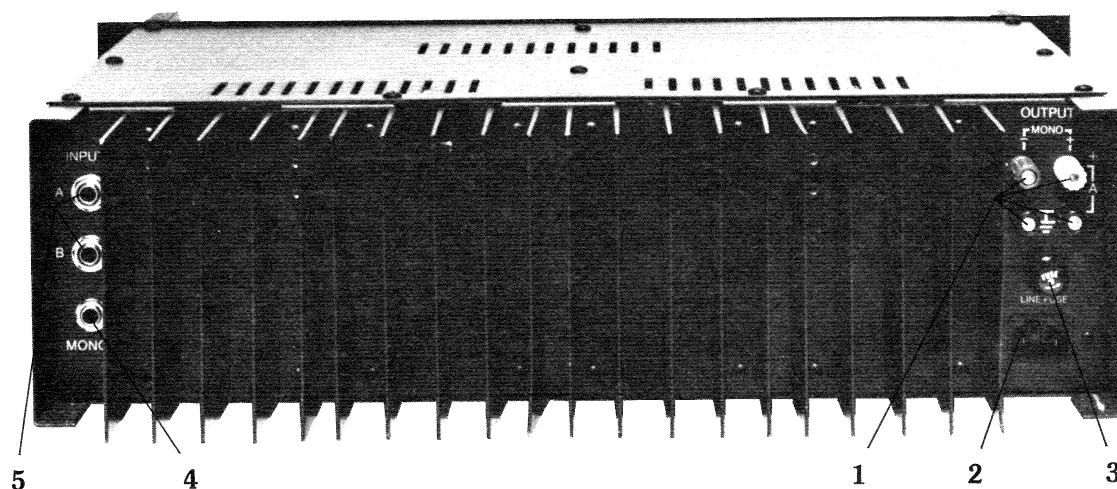


Illustration 2

1. **OUTPUT TERMINALS:** For stereo operation, connect each speaker line so that the plus terminal of the speaker is connected to the positive terminal of the amplifier (red, white) and the common or ground of the speaker is connected to the black or ground terminal of the amplifier. For mono (bridged) operation, connect the plus terminal of the speaker to Channel A positive terminal (white) and the common or ground terminal of the speaker to the positive (red) terminal of Channel B.
2. **POWER CORD:** Power is supplied to the A60 via the detachable line cord supplied with the amplifier. The line cord is of the three conductor variety, the third prong being a safety ground. (CAUTION: Do not cut the third grounding prong from the plug.)
3. **LINE FUSE:** Fuseholder for the primary fuse of the transformer; required to ensure the transformer does not exceed its safe operating limits.
4. **MONO (Bridged) INPUT:** Inserting an input plug into the MONO input *automatically* places the amplifier in its bridged mode. (See Mono Operation in the TECHNICAL INFORMATION section for further details.)
5. **STEREO INPUT:** These inputs will accept standard 1/4" phone plugs carrying line level balanced *or* unbalanced signals. Plugging in a *stereo* phone jack allows balanced operation, while plugging in a *mono* phone jack *automatically* switches the system to unbalanced operation.

3-0. INSTALLATION

POWER CONNECTION

Power is supplied to the A60 via the detachable line cord supplied with the unit. The line cord is of the three conductor variety, the third prong being a safety ground. The AC voltage source should be capable of supplying at least 10 amps to the amplifier to insure proper transient power capability. If an extension cord is required, be sure to use the heavy-duty variety (16 gauge or larger) and keep the length short to prevent power loss. **CAUTION:** Be sure the amplifier is plugged into the proper power source. Operation of a 120 volt version on a 240 volt line will cause certain damage. For voltage conversion, refer to service manual or contact an authorized dealer or the factory.

GROUNDING

Input and output grounds are internally connected to the chassis of the A60 in such a fashion (inputs grounded; outputs floating) to minimize the possible ground loops that result in hum when units are rack mounted. Grounding of the power amplifier to the preceding line level components is accomplished through the shielded input cable. No further grounding of the A60 should be necessary.

VENTILATION

The A60 Power Amplifier requires a generous supply of cooling air to dissipate the relatively large amounts of heat generated by any high power amplifier. The amplifier must be installed allowing unrestricted ventilation with adequate clearance for the heatsinks to breathe. In rack installations involving several high power amplifiers or other equipment which restricts normal convection air flow through the rack,

forced air ventilation must be provided by the installation of an exhaust fan in the rack to provide a minimum of 60 cubic feet per minute air exchange to avoid overheating of all the equipment in the rack.

INPUT/OUTPUT CONNECTIONS

Stereo Operation: To connect the input of the A60 to a line source, such as a mixer or electronic crossover, always use shielded wire with 1/4" phone plugs – ground being applied to the sleeve and positive signal connected to the tip and negative signal connected to the ring for balanced or positive to the tip only for unbalanced operation. The inputs to the A60 are either balanced or unbalanced high impedance (20k ohms). For balanced systems use *stereo* phone jacks and for unbalanced systems use *mono* phone jacks. The switching is done automatically.

Low impedance speaker wires should be connected between the A60 and the speakers. Due to the high output capability of the A60 the speakers should be fused. Please refer to the section entitled Speaker Fusing. A large wire gauge is necessary to handle the potentially high output current of the amplifier and not reduce the damping factor significantly. Sixteen-gauge wire or larger is recommended for this purpose.

Care should be taken to insure all speaker connections are made properly. Dual banana plugs are recommended to minimize the chance of short circuiting the output of the amplifier.

CAUTION: NEVER CONNECT THE OUTPUTS OF THE TWO CHANNELS TOGETHER OR WITH ANOTHER AMPLIFIER'S OUTPUT AS THIS WILL LEAD TO POSSIBLE AMPLIFIER DAMAGE. BE CERTAIN THAT THE POWER IS OFF WHEN HOOKING UP ANY SPEAKERS TO THE AMPLIFIER.

Correct phasing of the speakers should be maintained when connecting them to the amplifier. If the speakers are connected out of phase, sound cancellations will occur at some frequencies. Proper phasing can be assured by connecting the "Hot" and "Common" terminals of the amplifier to the corresponding terminals on the speakers.

Mono (Bridged) Operation: The mono or bridged mode of the A60 allows the amplifier to deliver 650 watts power capability into a single speaker load of 8 ohms connected across the hot terminals of Channel A and B. Should mono operations be desired, one cable carrying the desired audio should be connected to the mono input which will *automatically place the amplifier in the bridged mode*. The input sensitivity is then controlled for both halves of the mono output signal by *Channel A level control only*. The mono speaker is connected between the plus terminal of Channel A, and the plus terminal of Channel B. *Do not make any connection to the minus or ground terminals when the A60 is in mono operation.* Note: If the speakers are connected in the normal stereo configuration and signal is improperly applied to the Channel A or B inputs and not the mono input, no damage will occur but the silence will be obvious.

SPEAKER FUSING

The fuses in the amplifier are primarily to protect the amplifier. The speakers connected to the amplifier should be fused, especially in the case of compression drivers. No matter how much care is taken in the design of a good sound reinforcement system, accidents can occur due to feedback, microphones dropping to the floor or connecting cables being torn loose by drug crazed throngs. All of these can cause system overdrives which may destroy expensive drivers unless precautions are taken during installation. Determine from the speaker manufacturer the correct protection fuse for your specific model. Install a fuse socket in the speaker line where it will be easily accessible. If the fuse opens repeatedly, it indicates that the desired listening level is not safely obtainable with the present speaker system. **DO NOT OVERFUSE.**

If fusing information is not available from the manufacturer or if the speaker system is a home-built type, the following equation is recommended for determining the correct speaker protection fuse:

$$I = \sqrt{\frac{P}{4R}}$$

where I is the current rating of the fuse in amperes, P is the maximum *peak* power handling capability in watts, and R is the value of the speaker impedance in ohms. For example, an 8 ohm speaker capable of handling 125 watts of peak power should be protected with a 2 amp fast acting fuse.

4-0. OPERATING INSTRUCTIONS

INITIAL USE

Before turning the A60 on for the first time, double check to see that all connections are made according to the "Installation" section. The A60 may be switched on by means of the Power switch located on the front panel. The "fault" lights may flash very briefly as the power comes on, however they should not remain on. Power on indication is provided by the green "Ready" LED which will illuminate only after the five second period has elapsed during which the amplifier's output relay is open. If, at any time while the amplifier is being operated the output relay should open, the ready light will extinguish to indicate the amplifier's refusal to pass nastiness on to the speakers.

INPUT SENSITIVITY CONTROLS

The input attenuators are calibrated in dBm – 0dBm being the most sensitive position. At this fully clockwise position, an input level of .775 VRMS (0dBm) will result in an output voltage of 31 VRMS. This is the voltage required to produce 120 watts in an 8 ohm load. The counter-clockwise positions of the attenuators reduce the input sensitivity by the indicated amounts.

This calibration philosophy allows for equal SPL level at the speakers, regardless of which Phase Linear Amplifier is used. The Phase Linear Model A30 is taken as the standard where 0dBm yields 120 watts output. Likewise, 0dBm in Model A60 will produce 120 watts output. The difference in the A60 is an additional 3dB of power headroom above this level. The advantage offered is that all Phase

Linear amplifiers can be set at the same spot and will produce equal power output for the same input voltages.

SIGNAL PRESENT

The Signal Present LED's monitor the output of each amplifier, lighting whenever there is audio present. Input signals greater than approximately –32dBm (19mV) will light the LED's. Each channel is monitored independently.

FAULT INDICATORS

The Channel A and B fault indicators will illuminate for the duration of any of the following conditions:

1. Clipping
2. Current limiting
3. Blown power supply fuses
4. Slew Rate limiting
5. Anytime the output of the amplifier does not precisely follow the input.

THERMAL OVERLOAD INDICATOR

The thermal overload light will illuminate anytime the temperature of the heatsink exceeds its thermal limit. All incoming signals will be muted during the overload condition allowing the amplifier to cool, and the thermal overload indicator will serve to verify this condition.

READY INDICATOR

The Ready light will illuminate anytime the speaker relay is closed indicating the amplifier's willingness to faithfully serve in the quest for elevated sound pressure levels.

AMPLIFIER FUSING

The A60 contains internal "melt-down" only fuses which are not easily replaceable and provide two important functions: 1. These fuses will only blow in case of definite failure which, by definition, requires servicing before the fuses can be replaced. This protects internal components from further damage possible from a catastrophic output failure. 2. Separate fusing of Channel A and B provides a means of disconnecting one channel from the power supply in the event of a failure so that the remaining channel may still be used until repairs can be made to the faulty channel.

OPERATING CHARACTERISTICS

When operating at or near maximum power output, the amplifier will be warm to the touch. This is quite normal, and will not cause damage. The output transistors in the amplifier are rated to run at a maximum temperature of 150°C (302°F). They will never get that warm due to thermal safeguards employed internally. To keep the amplifier within its safe operating temperature, proper ventilation must be maintained and speaker impedance limits observed. (4 ohms or greater in stereo and 8 ohms or greater in bridged mode.)

5-0. TECHNICAL INFORMATION

CIRCUIT DESCRIPTIONS

The Phase Linear A60 consists of two independent direct-coupled analog power amplifiers combined to form one stereo unit capable of very high power output, with extremely low distortion and noise. Refer to the schematic diagram and following description for a brief explanation of the technical aspects of this amplifier.

The low-level input section employs a wide-band FET input differential control amplifier. This amplifier performs all of the linearizing functions required to correct for the small irregularities found in a high gain, high current power amplifier. The input signal applied to this stage is processed and modified to obtain the properly processed input signal for the first stage of voltage amplification.

The voltage amplifier (Q5 & Q7) between the control amplifier and the current amplifiers is a common base type, performing both level shifting and voltage gain to supply the proper level and drive currents for the final stage of voltage gain.

Transistors Q6 and Q8 provide the final voltage and current gain necessary to drive the four pairs of paralleled output transistors.

R12, R20, C1 and C3 provide level and frequency scaling of the negative feedback which is applied to the inverting port of the control amplifier to set the overall system gain and closed loop frequency response of the amplifier. This negative feedback also reduces any open loop nonlinearities, which may exist, to virtually unmeasurable amounts.

The speaker relay is driven by the series combination of Q14 and Q15 and is pulled low to its "on" state only when there is no DC voltage present on the bases of either Q13 or Q14. Any AC appearing on the input to this circuit is shunted to ground by either C13 or C14. The series combination of R56 and C14 provide the approximately 5 second turn-on delay of the relay system when power is first applied to the unit. D11 and D12 in conjunction with filter capacitor C21 provide power to this circuit.

The inverter which is used to drive Channel B during mono operations is comprised of two operational amplifiers, one of which is a unity gain non-inverting buffer which drives an inverting amplifier from a constant impedance which delivers the proper polarity for bridged operation.

MODULE REPLACEMENT

The Phase Linear A60 was designed with ease of service as a prime design consideration. The amplifier is modular which lends itself to replacement of a damaged channel, however only qualified technicians should attempt such repair. Phase Linear Corporation and its authorized warranty stations have the personnel and equipment to repair the A60. However, replacement modules are available from the factory and replacement involves only four screws. If module replacement is attempted great care must be exercised in the process to ensure every connection is properly made prior to reapplying power.

MONO OPERATION

Operating a stereo amplifier in the mono mode (sometimes known as bridging or strapping) is achieved by inverting the signal polarity of one channel and connecting the speaker load from the hot side of one channel to the hot side of the other. The result, then, is that when one channel is driven to a certain amplitude, the other channel is driven to the exact same level, but the polarity is reversed. This exactly doubles the voltage applied to the loudspeaker for any given input. Since the power applied to

the load $= \frac{E^2}{R}$, then it follows that $\frac{(2E)^2}{R} =$ four times the power in that load

For example, assume the output voltage of the

A60 = 36 VRMS then $\frac{(36)^2}{8} = \frac{1296}{8}$ or 162 watts.

If we double the voltage we then have $\frac{(72)^2}{8}$ or $\frac{5184}{8} = 648$ watts. As you can see from this example, a speaker of less than 8 ohms would be asking the amplifier for an enormous amount of power. For this reason, *do not operate the A60 in mono mode for speakers of less than 8 ohms (nominal).*

Of course all of this power does not come free of charge. When driving a load in the mono mode, each channel of the amplifier is actually driving only one half of the total load impedance.

Therefore thermal loading on the heatsinks will be greater due to higher current flow in the output devices. (When the two channels each drive the load from different ends and at opposite polarity, there is an effective ground placed at the center of the load, thus one half of the impedance is seen by each channel.)

6-0. SCHEMATIC AND ASSEMBLY DIAGRAMS

CONTENTS:

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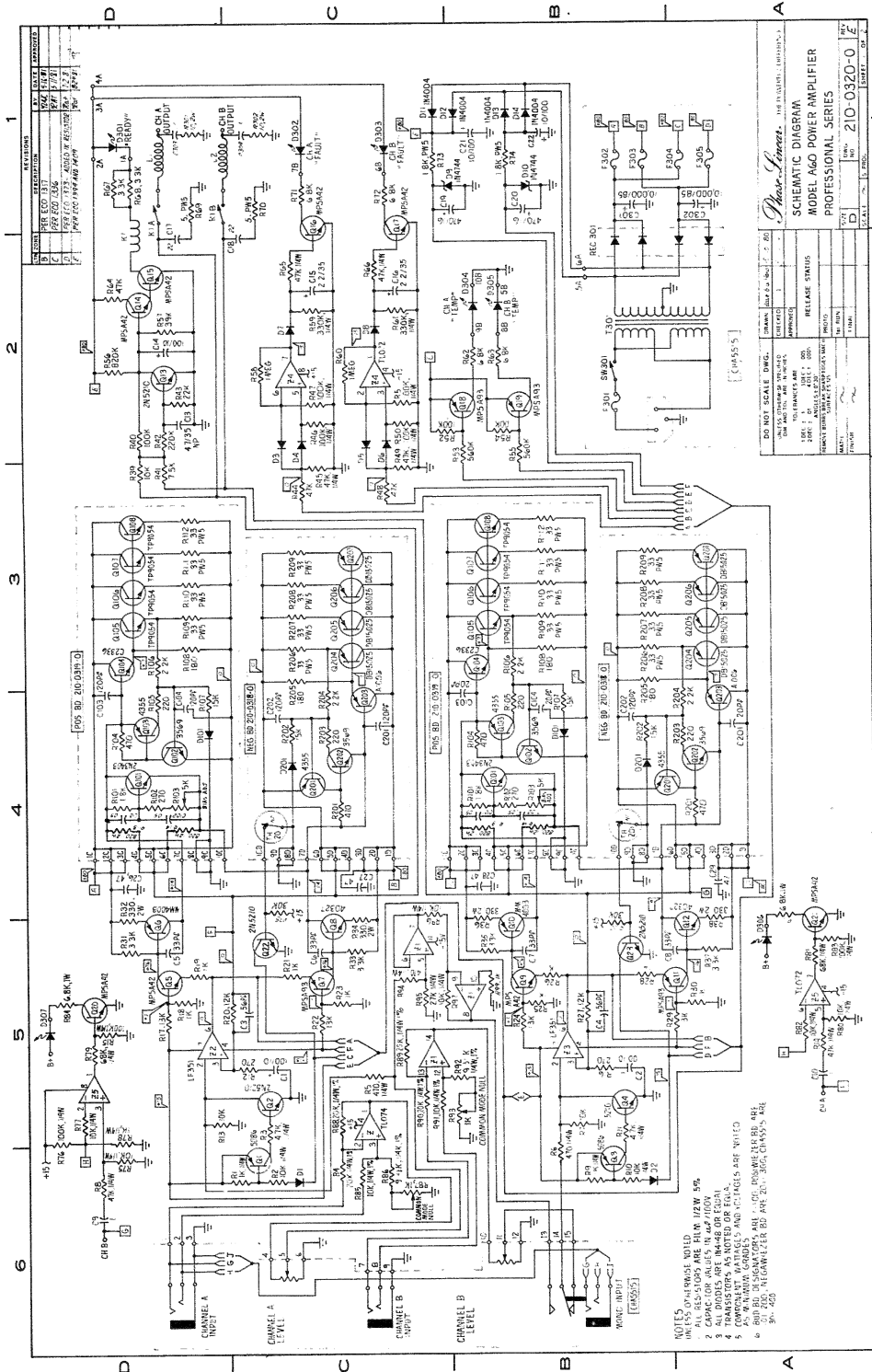


Fig. 6-1a. Schematic Diagram, Model A60

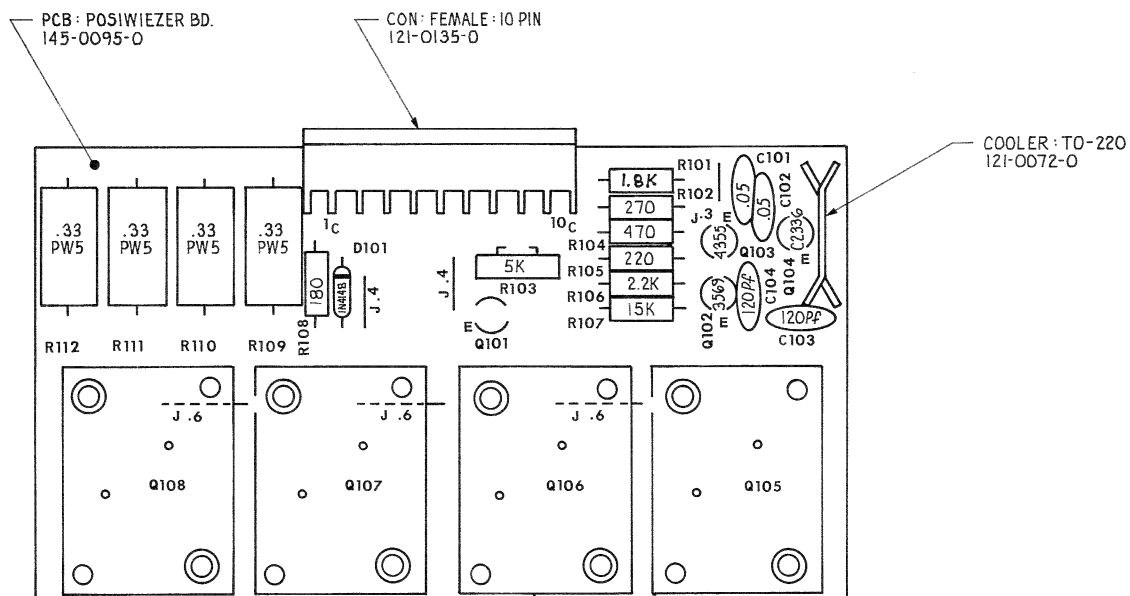


Fig. 6-2a. Assembly Diagram, Pos. Module

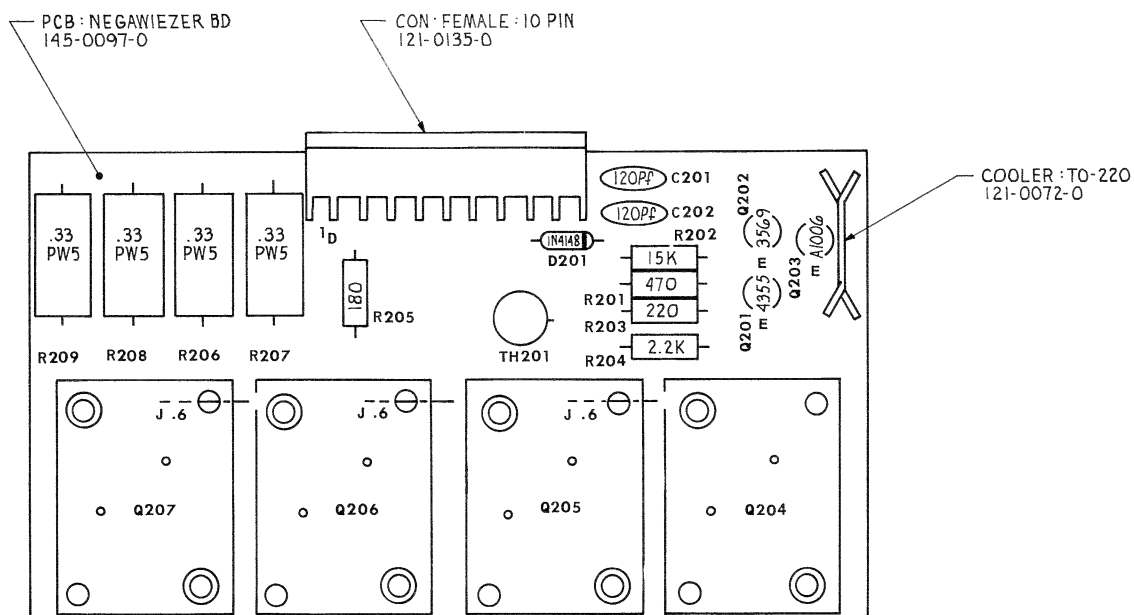


Fig. 6-2b. Assembly Diagram, Neg. Module

SOCKET: PCB: T0-3
121-0071-0 (4 PLACES)

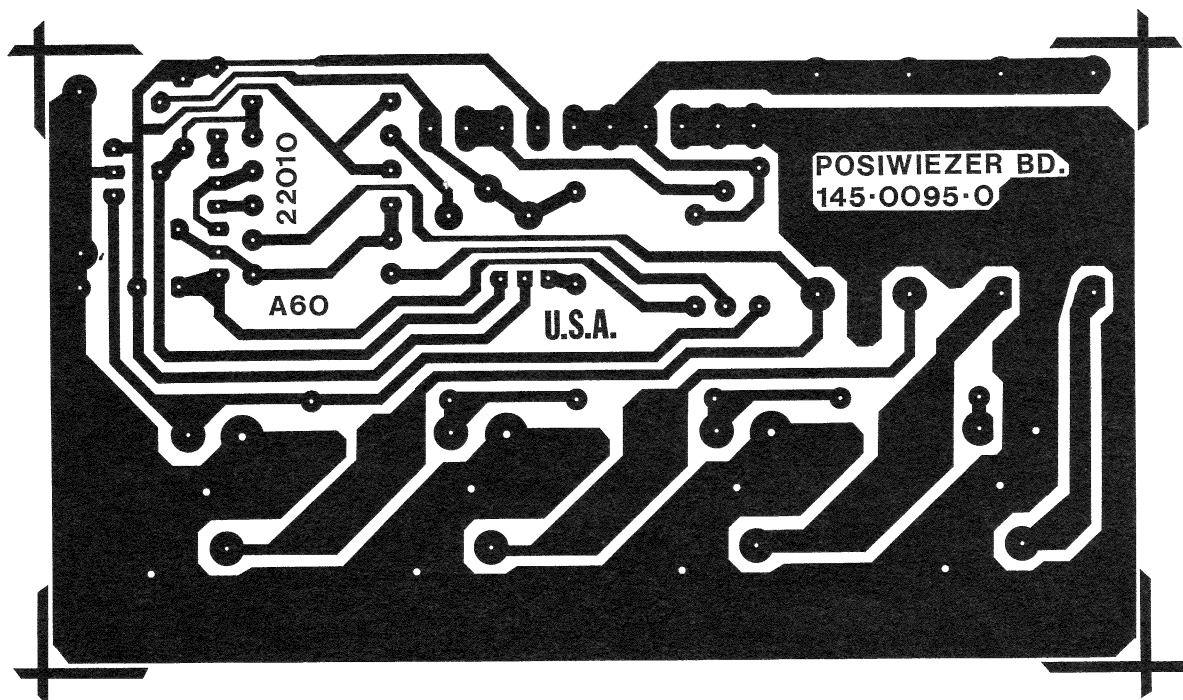


Fig. 6-2c. Foil Pattern, Pos. Module

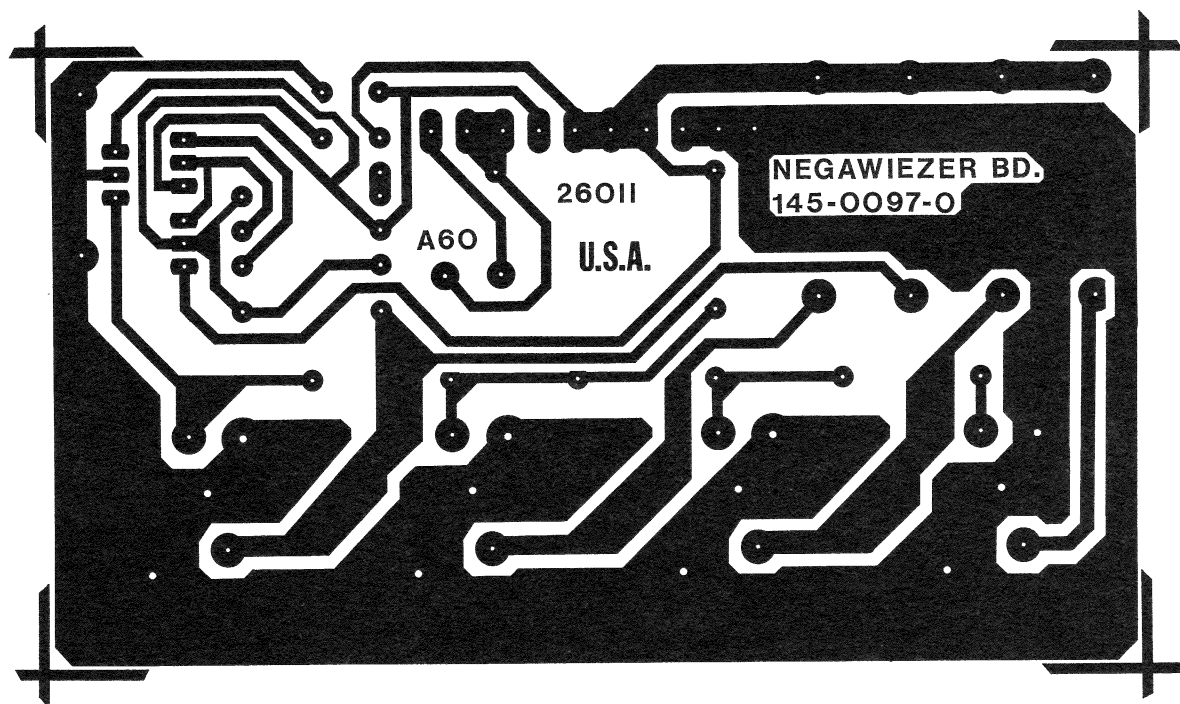


Fig. 6-2d. Foil Pattern, Neg. Module

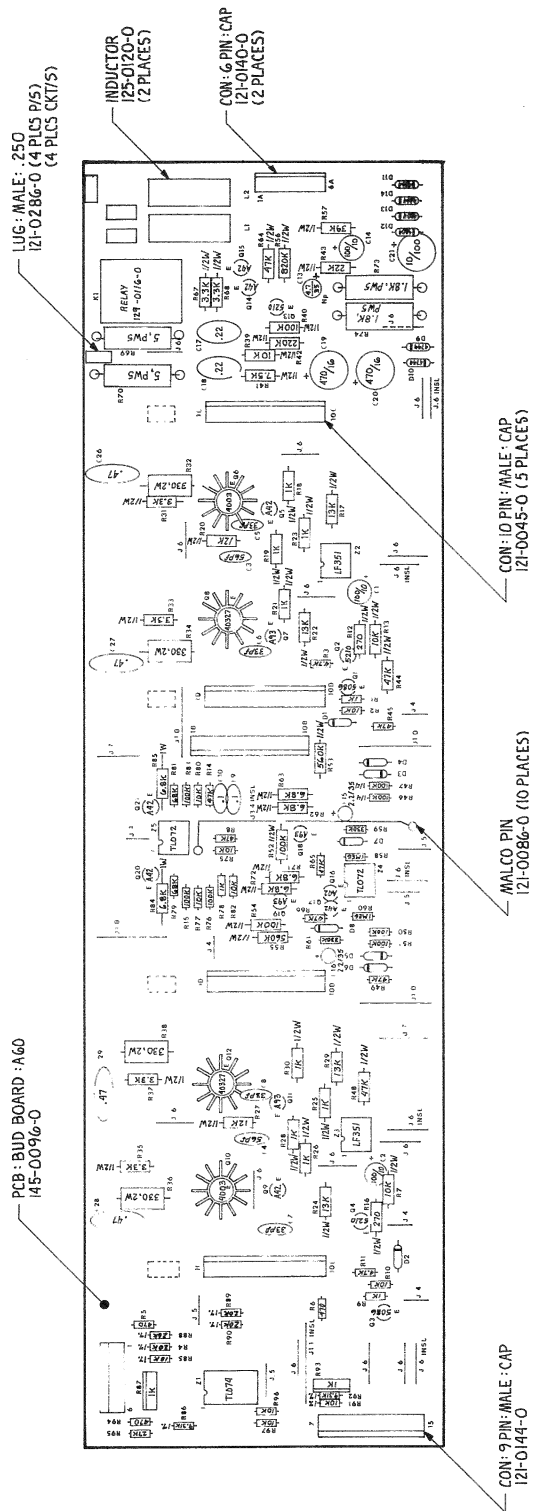


Fig. 6-3a. Assembly Diagram, Mother PCB

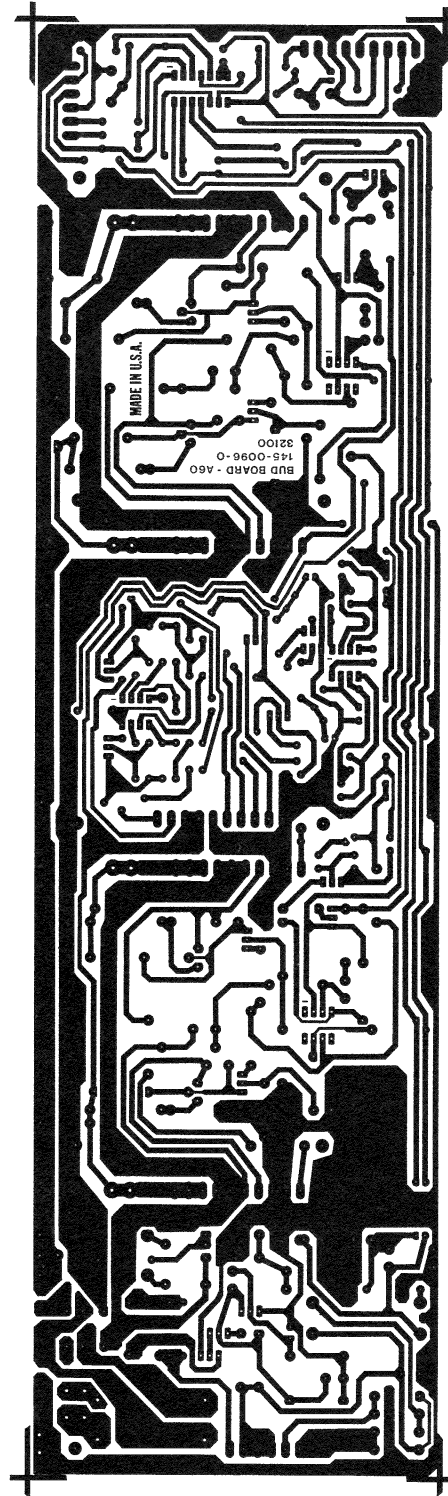


Fig. 6-3b. Foil Pattern, Mother PCB

7-0. TEST PROCEDURE

CONTENTS:

- 7-1. Power Supply
- 7-2. Energizing the Unit
- 7-3. Output Signal without Load
- 7-4. Output Signal with 8 ohm Test Load
- 7-5. Distortion
- 7-6. Offset Voltage
- 7-7. Protection Circuit Test
- 7-8. Output Relay Test (DC and Subsonics)
- 7-9. Balanced Line and Bridge Mode (Mono) Test

NECESSARY TEST EQUIPMENT:

Ultra-low distortion audio signal generator
VOM or DMM
Dual-trace oscilloscope
THD analyzer
250 watt 8 ohm load resistor
Variable line transformer (VARIAC)

7-1. POWER SUPPLY

Before plugging in the A60 AC line cord check the line fuse on the back of the chassis. Verify AGC10A (1¼", 10A, fast-blo) fuse for the AC line. For 220-240 volt operation verify AGC5 fuse.

CAUTION!! SAFETY CRITICAL COMPONENT. REPLACE FUSES ONLY WITH SAME TYPE AND RATING. REMPLACER UNIQUEMENT PAR UN FUSIBLE DE MENE TYPE AT CALIBRATION.

NOTE: If the fuse is discovered blown do not energize the unit, even after replacing the blown fuse. Follow the procedure in TROUBLESHOOTING, Section 8-1 to properly energize the unit without causing possible further damage to the unit's output stage.

7-2. ENERGIZING THE UNIT

- 1) Plug the line cord into a variable line transformer (VARIAC) and slowly turn it up to 117 VAC (or 220-240 VAC as required). If a VARIAC is not available, plug the line cord directly into a working AC outlet of proper line voltage. Verify that the READY indicator illuminates after approximately 5 seconds.

7-3. OUTPUT SIGNAL WITHOUT A LOAD

- 1) Monitor channel A output with the scope and AC voltmeter. DO NOT Connect any other load to the outputs at this time.
- 2) Drive channel input with a 2 kHz sine wave signal until the output wave form is well into clipping. Verify that the clipping is symmetrical. Verify operation of signal present and fault (clipping) LEDs.
- 3) Repeat steps 1 and 2 for channel B.

7-4. OUTPUT SIGNAL WITH 8 OHM TEST LOAD

- 1) Connect an 8 ohm/250 watt load resistor to channel A output terminals and monitor channel A output.
- 2) Apply a 2 kHz signal to channel A input and verify at least 42 volts RMS output before clipping.
- 3) Repeat the above at 20 Hz, 200 Hz and 20 kHz for both channels.

7-5. DISTORTION

- 1) Monitor channel A output with a THD analyzer.
- 2) With an 8 ohm load also connected to channel A output, drive channel A to an output of 42 volts RMS and verify a THD plus noise of 0.05% or less.
- 3) Repeat this procedure with channel B.
- 4) Use this same procedure to verify IM distortion of 0.005% or less.

NOTE: It may be necessary to use the LPF in the THD analyzer if so equipped.

7-6. OFFSET VOLTAGE

- 1) Measure across the output terminals of each channel for presence of DC voltage and verify ± 10 mv or less with no input connected to the amplifier.

7-7. PROTECTION CIRCUIT TEST

- 1) Drive channel A with a 200 Hz signal to an output level of 42 volts RMS.
- 2) Short the output terminals of channel A together with a jumper wire for 1 to 4 seconds. Remove the jumper and verify that the amplifier resumes normal operation.
- 3) Repeat this test for channel B.

7-8. OUTPUT RELAY TEST (DC AND SUBSONIC)

- 1) Drive channel A into clipping with a 1-10 Hz signal (with or without a load) and verify that the output signal is removed almost immediately. This should be accompanied by a distinct clicking sound as the output relay opens.

- 2) Turn down or remove the input signal and verify that normal operation resumes in 2-4 seconds.
- 3) Repeat this procedure with channel B.

7-9. BALANCED LINE AND BRIDGE MODE (MONO) TEST

- 1) Drive channel A with a suitable low impedance balanced line source.
- 2) Verify a gain increase of +6 dB over unbalanced gain.
NOTE: Phase Linear uses the sleeve-ground, ring-minus (-) and tip-plus (+) standard connection for balanced operation.
- 3) Repeat this procedure with channel B.
- 4) Monitor the MONO output (red and white output terminal connections) with scope and AC voltmeter and with 8 ohm test load.

NOTE: Be sure to lift all test equipment chassis grounds to prevent the output from being shorted to chassis ground and to prevent damage to test equipment. Do not connect any load to the MONO output terminals less than 8 ohms to prevent damage to the output stage.

- 5) Drive the MONO input with a 2 kHz sine wave and verify at least 72 volts RMS output before clipping.

NOTE: Mono mode input sensitivity is controlled by the Channel A volume pot.

8-0. TROUBLESHOOTING AND ALIGNMENT

CONTENTS:

- 8-1. Power Supply Malfunction
 - a. Blown line fuse
 - b. Blown supply fuse(s)
 - c. Checking for shorted output transistors
 - d. Isolating the defective output transistors
 - e. Output transistor current sharing test
- 8-2. Output Malfunction-No Load Connected
 - a. No output, one or both channels
 - b. Asymmetrical waveform clipping
 - c. Truncated or asymmetrical waveform output
 - d. Waveform oscillations
 - e. Excessive current draw when turning up variable line transformer (VARIAC)
- 8-3. Output Malfunction into a Test Load
 - a. Unit delivers less than rated output
 - b. Asymmetrical clipping or truncated waveform
- 8-4. Excessive Distortion/Bias Adjustment
 - a. Bias adjustment
 - b. Unit overheats
 - c. Excessive THD
- 8.5 Excessive Offset Voltage
- 8.6 Protection Circuit Malfunction
 - a. Supply fuses open during protection circuit test
- 8-7. Output Relay Malfunction
 - a. Output relay will not open with subsonic or DC signal
 - b. Output relay opens prematurely or intermittently
 - c. Output relay will not close after unit is energized

- 8-8. Balanced Line and Bridge Mode (Mono) Malfunction
 - a. Balanced line CMRR adjustment
 - b. No balanced line output
 - c. No bridge mode (mono) output
- 8-9. Front panel indicator malfunction
 - a. No signal present LEDs
 - b. No fault (clipping) LEDs
 - c. No ready LED
 - d. No thermal overload LED

NOTE: Most transistors and diodes in the model A60 can be checked in circuit using an ohmmeter on the Rx1 or 2k scale. With the A60 line cord connected from the AC line source measure the forward-biased junction and verify a reading of 400-700 ohms typically on a DVM for a good device. Actual readings on good devices will vary from meter to meter, and some meters do not have sufficient test voltages to turn on a semiconductor junction. Nevertheless, the shorted or open device is usually revealed quickly using this in-circuit method.

CAUTION: Before making any measurements internal to the A60, unless otherwise specified, be sure that the line cord is unplugged and the power supply capacitors are discharged. The A60 filter capacitors hold a charge for a long time so it is important that they are fully discharged by shorting a low value (5-25 ohms) with at least a 5 watt rating from the fuse block terminals to ground after the unit is unplugged.

Use extreme caution when taking any measurements internal to the A60 with the power on—hazardous voltages are present. Only qualified personnel with properly insulated and protected equipment should attempt servicing of the A60 with the power on.

8-1. POWER SUPPLY MALFUNCTION

a. Blown line fuse.

- 1) Disconnect positive and negative wires from the bridge rectifier and measure for shorted diodes in the bridge.
- 2) Measure for shorted power transformer.
- 3) Disconnect wiring at the power supply filter capacitors and measure for shorted capacitor(s).

b. Blown supply fuse(s).

If any of the supply fuses are found blown there is a high probability that one or more of the output transistors is defective, especially if the blown fuse(s) appear vaporized black or silver indicating a large current surge.

CAUTION: Do not replace fuse(s) and energize the unit at this time since this may cause further damage to the output stage. First perform the following test to check for defective output transistors:

c. Checking for shorted output transistors.

- 1) Be sure that the AC line cord of the A60 is unplugged, then follow the necessary disassembly steps in Section 9-0.
- 2) The output transistors can be checked as follows: For the NPN output transistors (MJ15024 or TP9054) place the negative probe of an ohmmeter on the collector bus of the output transistors. Touch the positive probe to any one of the output emitters in that bank. If any one of the output transistors in that bank are shorted the meter will display a very low reading, usually

less than one ohm. If none of the outputs are shorted the meter will display a typical reading for a forward biased junction, usually 400-700 ohms depending on the meter used.

- 3) The above applies equally to the PNP (MJ15025 or DB15025) output transistors except that the positive probe is now placed on the collector bus and the negative probe is touched to any of the emitters in that bank.

d. Isolating defective output transistors.

- 1) To isolate the defective output(s) in a bank which indicates a short switch the ohmmeter to the lowest scale (Rx1 or Rx200). Touch the proper probe (negative for NPN, positive for PNP) to the collector bus as in 8-1c above and touch the other probe to any output transistor emitter lead in that bank. One reading will be significantly lower (about 0.6 ohm) than the other, which indicates that the lower reading output is shorted.
- 2) Remove the defective output transistor(s) and check each one individually as verification that it is indeed shorted. Replace the defective output transistor(s) and repeat the above procedure until no short is indicated.

NOTE: Whenever any output transistor has been replaced it is necessary to perform the following step to verify proper and equal current sharing of all output transistors.

e. Output transistor current sharing test.

This test is necessary to verify that all output transistors are operating properly by equally sharing current. Although the amplifier will probably meet all specifications without all outputs operational, increased loading of the remaining outputs will result in a significant reduction in reliability.

- 1) With an 8 ohm test load resistor connected to the output terminals of channel A, drive the channel A input with a 200 Hz sine wave signal to obtain 42 volts RMS output.
- 2) Turn down the variac to about 75-80 volts. Monitoring the output signal on an oscilloscope will reveal a waveform which is clipping very hard.
- 3) Using a DC voltmeter measure the voltage drop across the emitter resistors in each bank. Verify that there is less than a 20% variation in voltage drops across each resistor.
- 4) Replace any output transistor whose emitter resistor voltage drop varies more than $\pm 10\%$ from the average reading in that bank. Before replacing, however, measure the emitter resistor to insure that it is not defective.

8-2. OUTPUT MALFUNCTION—NO LOAD CONNECTED

a. No output, one or both channels.

- 1) Check for blown supply fuse(s) or line fuse. Refer to Section 8-1a or 8-1b.
- 2) With power off, check all transistors and diodes in circuit as described in Section 8-0 Note on testing semiconductors.

- 3) Drive the inputs with a 1 volt signal at 2 kHz. Energize the unit and check for signal at pins 1 and 14 of Z1 and pin 6 of Z2 and Z3. If any of these ICs has latched up to the supply ($\pm 15\text{v}$), replace the respective IC. If signal is present at the output of Z1 but not present at the input of Z2 and 3 then check the thermal overload attenuator circuit comprised of Q1-4 and Q22 and Q23 which shunts input signal to ground under thermal overload conditions.

- 4) Isolate the protection circuit as outlined in Section 8-2c and re-test.
- 5) Check for loose, worn, or dirty input jacks.

b. Asymmetrical waveform clipping.

- 1) Verify matched power supply plus and minus voltage readings at the power supply filter capacitors ($\pm 80\text{ VDC}$). There should be no more than 2 volts difference between the two readings.
- 2) Possible defective driver Q104 or Q203.
- 3) Isolate the protection circuit as outlined in Section 8-2c and re-test.

c. Truncated or asymmetrical waveform output.

- 1) Possible defective protection circuit. Remove Q102, Q103, Q201, Q202 and re-test. Also check diodes D101 and D201.
- 2) Possible defective output driver Q104 or Q203.
- 3) Possible defective voltage gain stage Q6, 8, 10, 12.
- 4) Possible defective level shifter stage Q5, 7, 9, 11.

d. Waveform oscillations.

- 1) Check output poles (RC network C17/R69, C303/R301, C18/R70, C304/R302).
- 2) Increase value of driver "slow-down" caps C103, 201 to a maximum of 270 pf.
- 3) Replace input ICs Z1, 2, 3.
- 4) Check all grounding points for weak or broken solder joints.

8-3. OUTPUT MALFUNCTION INTO A TEST LOAD

a. Unit delivers less than rated output.

- 1) Check for line or VARIAC sag.
Voltage at the line plug must be at least 117 VAC while delivering full output.

b. Asymmetrical clipping or truncated waveform.

- 1) Possible defective protection circuit.
See Section 8-2c.
- 2) Possible defective driver Q104, Q203.
- 3) Possible defective voltage gain stage Q6, 8, 10, 12.
- 4) Possible defective level shifter stage Q5, 7, 9, 11.
- 5) Possible open output transistor Q105-108 or Q204-207.
- 6) Possible open output emitter resistors R109-112 or R206-209.

- 2) Set the bias trim pot R103 to obtain .3-.4 VDC across R108 or R205.
- 3) Increase the value of R102 to 470 ohms if bias cannot be set low enough.

b. Unit overheats.

- 1) Check with customer to verify that the load impedance being driven is not less than 4 ohms per channel, or less than 8 ohms in the bridged (mono) mode.
- 2) Check to insure that there is sufficient area for air circulation around the heatsinks during normal operation.
- 3) If the unit develops excessive heatsink temperatures while at idle or during low power usage then the following steps should be taken.
- 4) Adjust bias per Section 8-4.
- 5) Check for possible waveform oscillations. See Section 8-2c.

c. Excessive THD.

- 1) Excessive crossover distortion —possible shorted bias transistor Q101.
- 2) Possible defective protection circuit parts. See Section 8-2c.
- 3) Possible THD analyzer interface problem. Activate the high filter and re-test. Check test bench grounding for possible ground loops. Ground the analyzer directly to the output ground; not to the scope or load.

8-4. EXCESSIVE DISTORTION/BIAS ADJUSTMENT

a. Bias Adjustment.

- 1) Remove all input and output connections, then measure the DC voltage drop across R108 or R205 with the unit powered up but cold.

8-5. EXCESSIVE OFFSET VOLTAGE

- a. Excessive offset voltage
 - 1) Check for correct op-amp supply on Z1, 2, 3 (± 15 VDC).
 - 2) Replace Z2 or Z3.
 - 3) Replace C1 or C2.
 - 4) Possible open front end transistor Q5-8.

8-6. PROTECTION CIRCUIT MALFUNCTION

- a. Supply fuses open when amplifier output terminals are shorted.
 - 1) Check Q102, 103, Q201, 202, D101, 102 and associated resistors.
 - 2) Possible open Q105 or Q204. Check for equal current sharing per Section 8-1e.

8-7. OUTPUT RELAY MALFUNCTION

- a. Output relay will not open with subsonic or DC input.
 - 1) Check Q13-15.
 - 2) Possible bad C13 or C14.
- b. Output relay opens prematurely or intermittently.
 - 1) Possible intermittent DC offset. See Section 8-5.
 - 2) Check Q13-15 and C13 & 14.
 - 3) Possible bad relay.
- c. Output relay will not close after unit is energized.
 - 1) Possible DC latch up. Check for excessive DC on input terminals of relay. If excessive offset is present see Section 8-5, 8-2 and 8-3.
 - 2) Check Q13-15 and C13 & 14.

8-8. BALANCED LINE AND BRIDGE MODE (MONO) MALFUNCTION

- a. Balanced line CMRR adjustment.
 - 1) Drive the inputs with a suitable common mode source while adjusting common null pots (R87, 93) for minimum output. CMRR should be at least 60 dB.
- b. No balanced line output.
 - 1) Be sure customer is using the sleeve-ground, ring-minus, tip-plus standard balanced line connection.
 - 2) Check Z1.
 - 3) Check input jacks.
- c. No bridge mode (mono) output.
 - 1) Be sure customer is using the mono input jack, the Channel A volume pot and has the load connected to the two hot (red and white) output terminals. See installations on page 7.
 - 2) Check Z1.
 - 3) Check mono input jack.

8-9. FRONT PANEL INDICATOR

MALFUNCTION

a. No signal present LED.

- 1) Check Z5, Q20 & 21, LED D306 & 307.

b. No fault (clipping) LED.

- 1) Check Z4, Q16 & 17, D308 and LED D302 & 303.

c. No ready LED.

- 1) Check for blown supply fuses. See Section 8-1.
- 2) Check for excessive offset voltage. See Section 8-5.
- 3) Check output relay circuit. See Section 8-7.
- 4) Check LED D301.

d. No thermal overload LED.

- 1) Check thermal switch TH201.

NOTE: The first 100 or so A60s used a normally open thermal switch. Later units used a normally closed switch with the addition of inverter transistor Q22.

- 2) Check Q22, Q18 & 19 and LED D304 & 305.
- 3) Check thermal overload shunt circuit Q1-4, D1 & 2.

9-0. DISASSEMBLY

CONTENTS:

- 9-1. Output Module Replacement
- 9-2. Mother PCB (Bud Board) Access and Removal
- 9-3. Transformer Tray Removal
- 9-4. Front Panel Removal
- 9-5. Sub-Front Panel, Rack Handle & Volume Pot Removal

9-1. OUTPUT MODULE REPLACEMENT

- 1) Remove top cover (10 screws), inspect and replace any open power supply fuses (AGC 10 or suitable 1¼", 10A, fast-blo fuse).
- 2) Remove the defective output module(s) by removing the four module screws and pulling the module straight back.
NOTE: The positive output modules (Posiwiezer) are the outer pair, the negative output modules (Negawiezer) are the inner pair.
- 3) Insert the replacement module(s) while being careful to properly align the molex connector and chassis mounted card guides. Install module screws.
- 4) Apply AC power and verify normal operation, see Section 7-0 for test procedure.

IMPORTANT NOTE: If the A60 fails in any way (no output, fault LED on, distortion...) after applying AC power then there may be a problem on the mother board. Proceed to Section 8-0 for TROUBLESHOOTING information or contact the Phase Linear Factory Service Dept. (206-774-8848) or your nearest Phase Linear Professional Products dealer for assistance.

9-2. MOTHER PCB (Bud Board) ACCESS AND REMOVAL

- 1) Remove all 4 modules per Section 9-1.
- 2) Loosen rear rail by removing two screws on each side of the rear rail (Fig. 9-2a), and screws on the bottom (Fig. 9-2b).
- 3) Disconnect the input molex connectors (Fig. 9-2c) and output spade lugs and molex connector (Fig. 9-2d).
- 4) Pull the rear rail back past the chassis sides.

NOTE: There is one ground wire soldered to the input jack ground bias which prevents complete removal of the rear rail.

- 5) Squeeze the locking standoffs (9 standoffs) with a pair of pliers while prying the mother PCB away from the transformer tray (Fig. 9-2e).
- 6) Remove the power supply wire cable ties to allow sufficient clearance for troubleshooting on the foil side of the mother PCB. Proceed to step 7 for mother PCB removal.
- 7) Disconnect the power supply spade lugs (Fig. 9-2f) and the molex connector at the center of the mother PCB (Fig. 9-2e).
- 8) De-solder 2 white and/or 1 green wire on foil side of mother board as applicable.
- 9) Remove the mother PCB (Fig. 9-2g).
- 10) Refit new mother PCB by reversing the above steps.

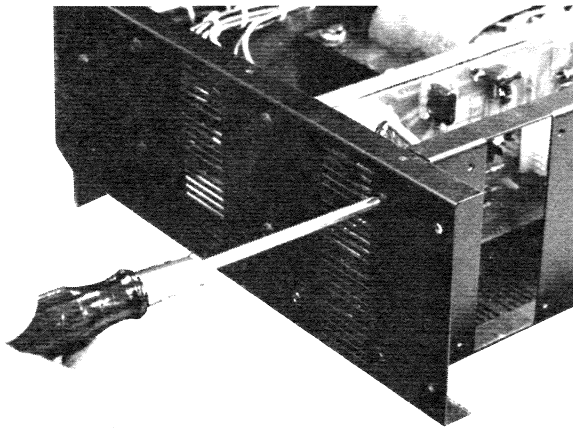


Fig. 9-2a.

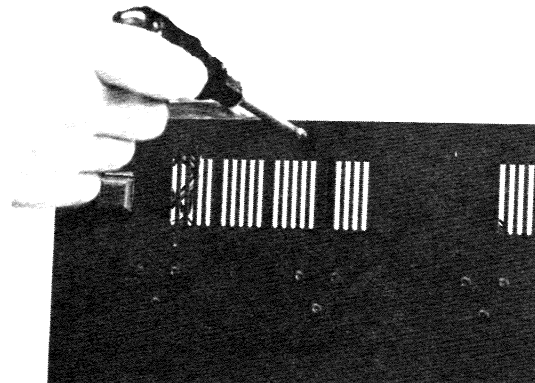


Fig. 9-2b.

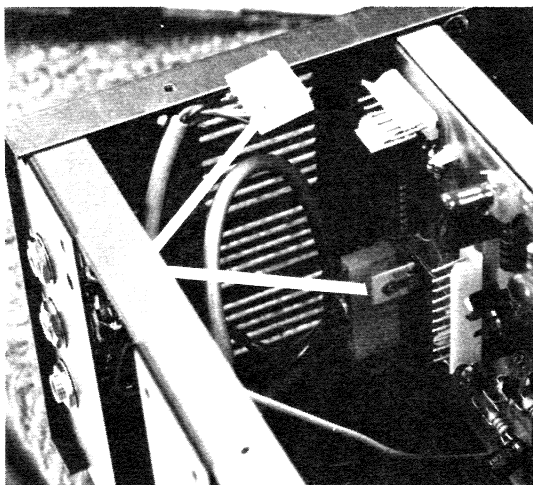


Fig. 9-2c.

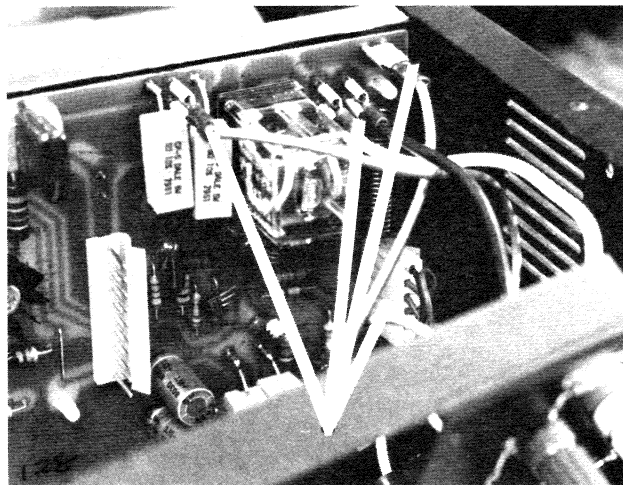


Fig. 9-2d.

Fig. 9-2e.

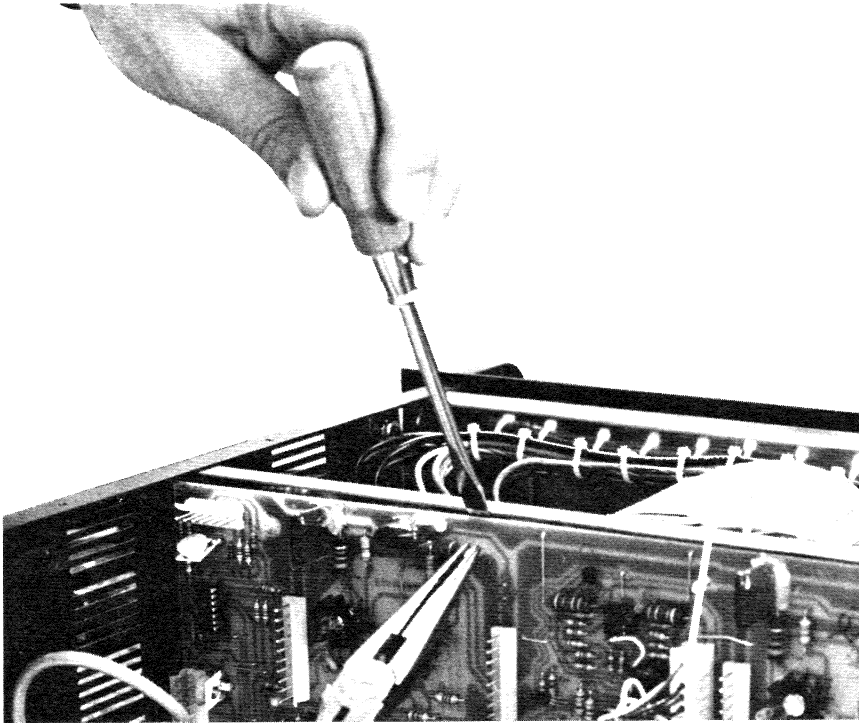


Fig. 9-2f.

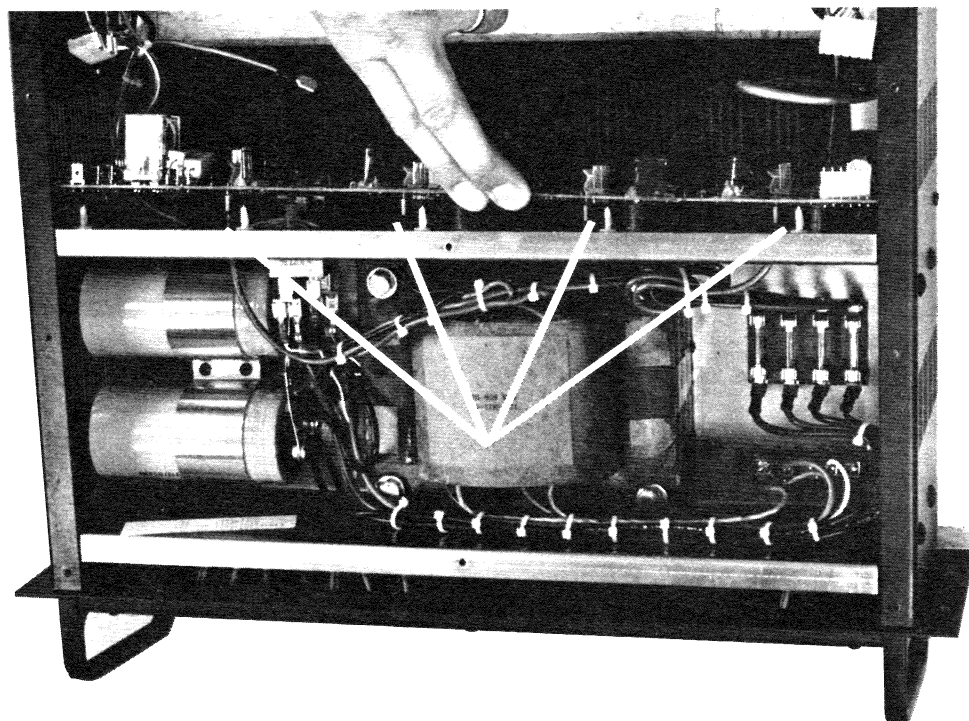
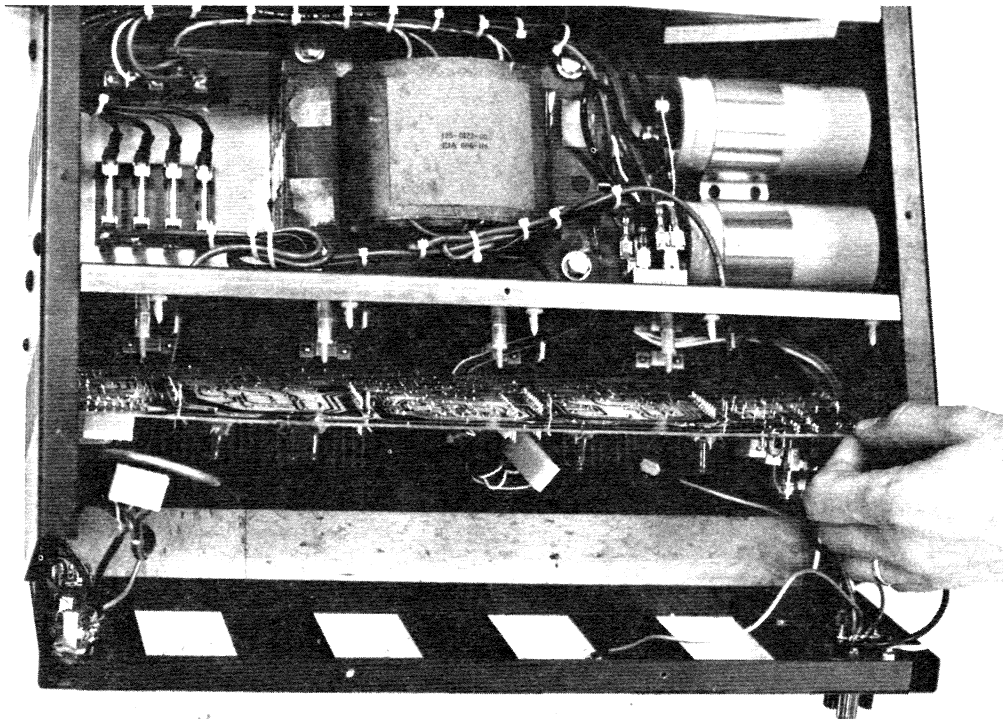


Fig. 9-2g.



9-3. TRANSFORMER TRAY REMOVAL

- 1) Remove output modules and mother PCB per Section 9-1 and 9-2.
- 2) Remove four screws on each end of the transformer tray.
- 3) Disconnect the POWER switch spade lugs and remove the READY LED.
NOTE: LED Removal and placement. Pry off the LED bezel retaining ring from the back side of the front panel (some LED rings—PL#121-0287—may be heat glued but this should present no problem) with a small blade screwdriver. Push the LED out of the bezel (PL#121-0255) from the front side of the front panel and then push out the bezel from the back side of the front panel.
- 4) The transformer tray can now be removed for access to the transformer bolts, etc.

- 5) Refit transformer tray by reversing the above steps.

9-4. FRONT PANEL REMOVAL

- 1) Remove the two input sensitivity knobs by pulling straight off.
- 2) Remove the six 7/64" front panel allen screws.
- 3) Disconnect the POWER switch spade lugs and remove all indicator LEDs (see Section 9-3.3 note on LED removal).
- 4) Push out the POWER switch from the back side of the front panel.
- 5) Re-fit front panel by reversing the above steps while making sure all indicator LEDs are firmly seated.

9-5. SUB-FRONT PANEL, RACK HANDLE & VOLUME POT REMOVAL

NOTE: The A60 is assembled from the back to front. It will therefore be necessary to entirely disassemble the A60 for access to sub-front, rack handle and volume pots.

- 1) Remove output modules and mother board per Section 9-1 and 9-2.
Complete transformer tray removal is unnecessary so proceed through step 9-3.2 only. Slide the transformer tray back as far as the wiring harness will allow (about 2"). Remove front panel per Section 9-4. Proceed through step 9-4.2 if complete front panel removal is unnecessary.
- 2) Remove the rack handle screws with a 3/16" allen wrench (Fig. 9-5c). The bottom handle screws require a long (8-10") allen wrench or complete removal of the transformer tray if a long allen wrench is unavailable.
- 3) Remove the input sensitivity pot shaft nuts with an 11mm nut driver.
- 4) Sub-front panel replacement will require complete removal of the front panel per Section 9-4 and removal of the front panel support bracket pop rivets.
- 5) Re-fit part by reversing the above steps.

10-0. LINE VOLTAGE SELECTION

The model A60 is equipped with a dual primary power transformer which can be wired for either 110-120 VAC or 220-240 VAC, 50/60 50/60 Hz line voltage operation.

The unit can be wired for either line voltage operation by changing the spade lug connections on the power transformer primary wires as per the following diagram:

After wiring the unit for selected line voltage operation the line fuse must be changed accordingly:

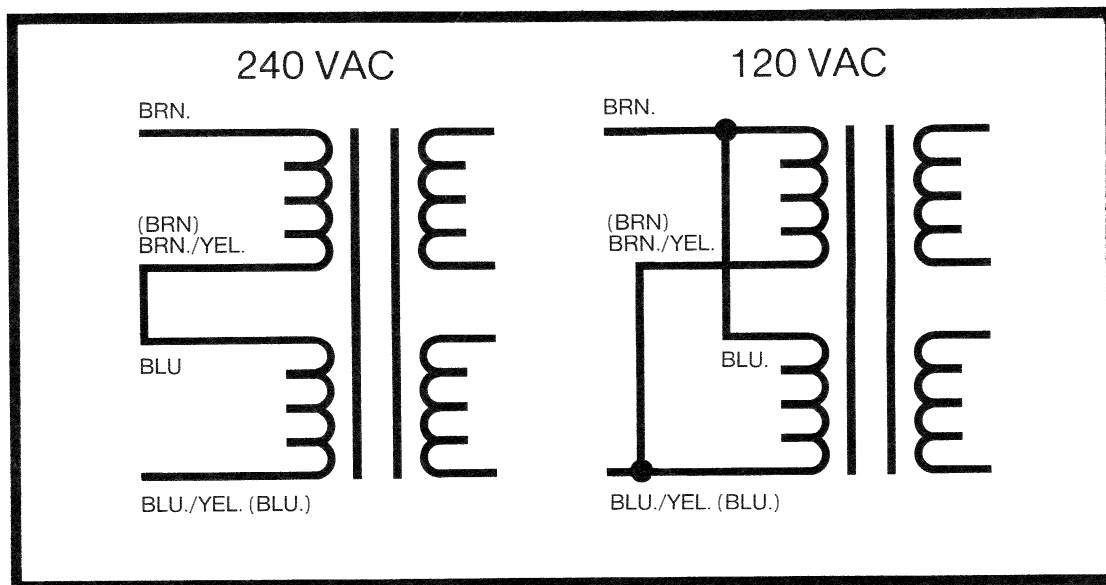
FOR 110-120 VAC operation use only ACG10 or 3AG 10A.

FOR 220-240 VAC operation use only ACG5 fast-blow or 3AG 5A fast-blow type fuse.

CAUTION!! SAFETY CRITICAL COMPONENT; REPLACE FUSES ONLY WITH THE SAME TYPE AND RATING.

ATTENTION!! REMPLACER UNIQUEMENT PAR US FUSIBLE DE MEME TYPE AT CALIBRATION.

It is not necessary to replace the supply fuses with a different value. No other changes or alterations are necessary for line voltage conversion.



11-0. PARTS LIST — A60

TRANSISTORS:

TP9054/MJ15024	126-0073
DB15025/MJ15025	126-0123
2SD555	126-0068
2SB600	126-0069
2SA1006	126-0094
2SC2336	126-0095
40327	126-0007
MM4003	126-0006
2N3403	126-0018
MPS A93	126-0028
MPS A42	126-0052
4355	126-0045
3569	126-0044
2N5210	126-0127
Insulator: TO-3	121-0015

INTEGRATED CIRCUITS:

LF351	126-0114
TL074	126-0074
TL072	126-0116

DIODES:

Bridge rect: 25A/200V	126-0001
1N4148	126-0002
1N4004	126-0003
1N4744 (15V)	126-0064
LED: red	126-0125
LED: green	126-0126
LED bezel	121-0255
LED bezel ring	121-0287

NOTE: For sources of semiconductors see the manufacturer's trademark on the device package.

CAPACITORS:

10,000 85v:lytic	127-0181
470/16v:lytic:rad	127-0125
100/16v:lytic:ax	127-0022
10/100v:lytic:ax	127-0093
100/6.3v:lytic:rad	127-0033
5/35:lytic:ax	127-0037
2.2/50:lytic:rad	127-0119
.47/100v:mylar	127-0014
.1/100v:mylar	127-0015
.01/100v:mylar	127-0063
.05/25v:disc	127-0007
.0027/150v:disc	127-0049
120pf/100v:disc	127-0020
100pf/100v:disc	127-0088
56pf/100v:disc	127-0044
33pf/100v:disc	127-0002

RESISTORS:

6.8k/1w	128-0802
1.8k/5w	128-0372
330/2w	128-0379
10/2w	128-0381
.33/5w	128-0344

SWITCHES:

Power	129-0151
Thermal:N/O	129-0203
Thermal:N/C	129-0116
Relay:HL2P:48v	129-0116

POTENTIOMETERS:

5k trim:multi turn	129-0046
50kB:Input level	129-0153
1k trim:CMRR null	129-0073

TRANSFORMERS/INDICATORS:

Power transformer 125-0122
Coil:output 125-0127

PRINTED CIRCUIT BOARDS:

Output PCB:negative 210-0318
Output PCB:positive 210-0319
Mother PCB 210-0320

OUTPUT MODULES:

Output module:neg 210-0317
Output module:pos 210-0315

METALWORK:

Front panel 220-0135
Sub-front 141-0291
Chassis 141-0290
Rear rail 220-0137
Top cover 220-0133
Rack handle:5 in. 142-0073
Input control knob 142-0061
Transformer tray 141-0295
Heatsink 142-0083
Filter cap clamp 141-0184
Cover support bracket 141-0296

HARDWARE:

Handle bolt:3/16" allen 122-0150
Front panel bolt:7/64" allen 122-0146
Module screw:6-32x1/2 122-0004
Top/bottom cover screw 122-0123
Transformer bolt 122-0160

MISCELLANEOUS:

Fuse:3AB/10A 121-0253
Fuse:ACG/10A 121-0039
Fuseholder block 121-0284
Fuseholder:line 121-0298
Jack:1/4":input 121-0205
Jack:1/4":mono 121-0124
LED bezel 121-0255
LED bezl ring 121-0287
Binding post:white 121-0006
Binding post:red 121-0007
Binding post:black 121-0008
Line cord:18/3 121-0262
Line cord: receptacle 121-0252
Insulator:output xstr 121-0066
Barrier strip:5 term. 121-0317
Spade lug adapter 121-0318

12-0. SERVICE BULLETINS AND SUPPLEMENTS