

KS-15135 RECTIFIER
AUTOMATICALLY REGULATED — METALLIC TYPE
24 VOLTS, 6 AMPERES
OPERATING METHODS

1. GENERAL

1.01 This section covers the operation of a regulated vacuum tube rectifier which is designed to operate from 115- or 230-volt ± 10 per cent, 50- or 60-cycle, ac power service and to deliver 24 volts dc with automatic regulation to ± 1 volt from 0- to 6-ampere load. The rectifiers are suitable for use in ambient temperatures from -40°F to 122°F (-40°C to 50°C).

1.02 This rectifier was originally intended for use in C3 radio telephone terminals.

Caution: Voltages inside the rectifier case are approximately 1000 volts between some terminals. Avoid all contact with terminals. Do not allow a test pick to touch two metal parts at the same time as destructive and dangerous short circuits may occur. Disconnect all fuses before working on rectifier except as necessary to make tests.

1.03 Routine checks should be made during a period when they will cause the least service reaction.

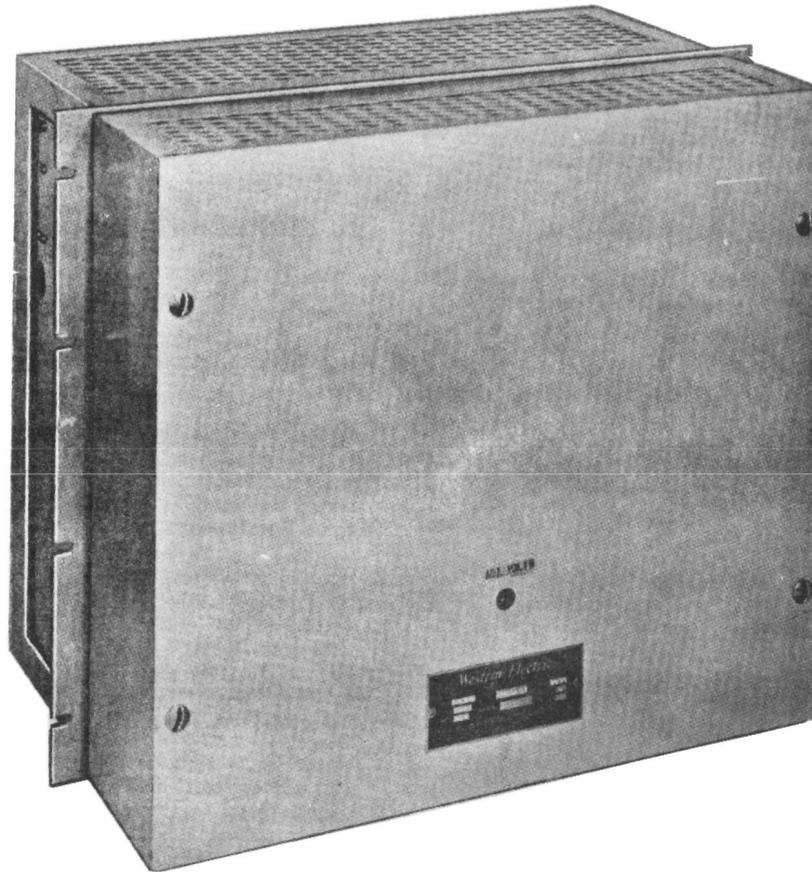


Fig. 1 - Front View

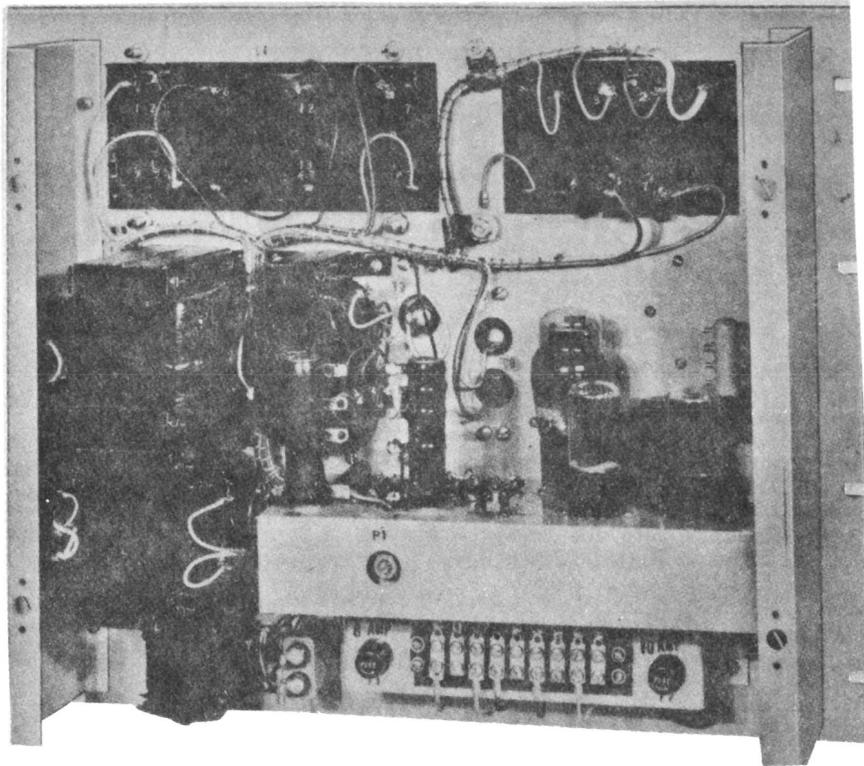


Fig. 2 - Front View - Cover Removed

1.04 It is essential that the metallic rectifier stacks be kept clean to prevent excessive heating. If either stack fails, replace both stacks. Do not combine stacks from different manufacturers.

1.05 Information in this section is arranged under the following headings:

1. GENERAL
2. OPERATION
 - 2.01 How the Rectifier Works
 - 2.08 Preparing to Start Initially
 - 2.09 Initial Adjustments
3. ROUTINE CHECKS AND ADJUSTMENTS
4. TROUBLES
5. POINT-TO-POINT VOLTAGES

1.06 List of Tools and Test Apparatus
(Equivalents may be substituted)

Tools

Screwdriver, cabinet, 3 inch

Test Apparatus

Resistor, 500 watt, 2 ohms for 115-volt ac service or 8 ohms for 230-volt ac service

Switch, knife, 10 amperes

Volt-ohm-milliammeter, KS-14510

2. OPERATION

Description

2.01 The rectifying element consists of two stacks of twelve selenium cells each, connected in a full-wave circuit.

2.02 Regulating Circuit: The ac input voltage to the transformer, which supplies the rectifier, is varied by a saturable reactor connected in series with this transformer across the power supply and functioning under the control of an electronic-type voltage regulator circuit. Voltage changes in the dc output, due to changes in load or in the ac input voltage, are amplified by the electronic equipment and applied to the control grid of a series tube; the output of which is connected to a dc winding on the saturable reactor. Changes in the amount of exciting current supplied to the dc winding of the saturable reactor cause inverse changes in the impedance of its ac winding to control the amount of line voltage supplied to the metallic rectifier transformer; thus maintaining the dc output voltage at its regulated value.

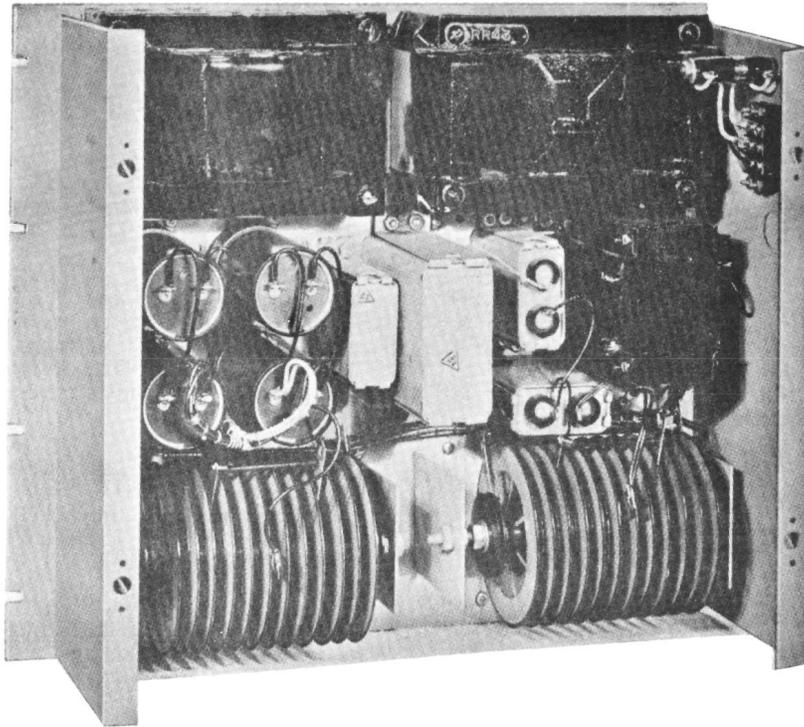


Fig. 3 - Rear View

2.03 The dc output voltage from the rectifier is adjustable from 20- to 26-volts using potentiometer P1 which has a slotted shaft appearing on the front of the rectifier. Turn CW to raise the voltage.

2.04 Fluctuations in line voltage are suppressed by potentiometer P2. This control is factory-adjusted and is located under the front cover. A locknut is provided on this control to prevent accidental disturbance of the setting.

2.05 A 2-stage, choke-capacitor filter connected between the selenium stacks and the output terminals, suppresses the voltage ripple.

2.06 Two fuses, one in the main ac lead and the other in the ac supply to the selenium stacks, provide protection from overloads and short circuits. The fuses are located under the front cover.

Voltage Regulation

2.07 The rectifier will operate from either 50 or 60 cycles, 115 or 230 volts by selecting the proper taps on the T1 and T2 transformers and the L1 saturable reactor.

(a) Voltage regulation is obtained by varying the magnetic saturation of saturable reactor L1. This coil has an

ac winding in series with the primary winding of transformer T1 and a dc winding in which the current is automatically regulated by the electronic control circuit. A decreased current in the dc winding 11-12 decreases the flux and reduces the saturation of reactor L1. This increases the impedance and the voltage drop in windings 1-3 and 6-8, thus decreasing the voltage applied to transformer T1 primary winding to lower the output and thus the voltage from the metallic rectifier.

(b) The bias on tube V1 is the difference between a part of the output voltage from the metallic rectifier (as determined by resistor R2 and the setting of P1) and the constant voltage drop in resistor R12. The drop through R11 is negligible and the effect of the drop through P2 is discussed in (c). An increase in the output voltage will produce an increase in the bias on tube V1 and reduce its plate current. Changes in tube V1 plate current cause voltage drop changes in resistors R5 and in parallel resistors R8 and R16 (which are in opposition to the bias developed by RV2). The difference in voltage is used to control the bias on tube V2. When current through tube V1 is reduced, the bias on tube V2 is increased and its plate current reduced. The plate-cathode circuit of tube V2 is in series with winding 11-12 of saturable reactor L1 and rectifier

tube V3, and when the current through V2 and L1 is decreased, the impedance of the coil increases, the ac voltage drop across windings 1-3 and 6-8 increases, reducing the ac input voltage to transformer T1 and, consequently, the output voltage of the rectifier. A decrease in the output voltage would have caused the regulating circuit to function in the opposite direction to raise the output.

(c) To compensate for fluctuations in the line voltage, adjustable potentiometer P2 is connected in the negative side of the regulating circuit between the reference voltage circuit and the cathode of tube V1. Its affect is to increase the bias on tube V1 whenever the line voltage rises, thus decreasing the current in the saturable reactor to maintain a constant voltage across transformer T1. When the line voltage decreases, the compensation functions in the opposite direction to maintain constant output voltage.

(d) RV1-1 and RV1-2 are metallic rectifier stacks employing selenium cells as the rectifying means. Together, they constitute a full-wave rectifier designated RV1 with the output filtered by inductors L2 and L3 and capacitors C2, C3, C4, and C5. Resistor R14 is a fixed load for rectifier RV1. Taps 6 and 9 on transformer T1 are provided to increase the voltage on the rectifier stacks to compensate for their aging. Rectifier stack RV2 is half-wave with its output filtered by capacitor C6 to supply bias voltage.

(e) Output from rectifier tube V4 is filtered by inductor L4 and capacitor C9. RT1 is a thermistor which, in conjunction with resistor R15, maintains a constant voltage across the terminals of the two in series and across resistors R10 and R12. Resistor R15 is provided with taps to permit the proper amount of resistance to be selected to match the value stamped on RT1. Resistors R6 and R7 serve as ballast and reduce the voltage applied to RT1. Resistors R15 and R7 are provided with taps which are adjusted to limit the current through RT1 to 25 ± 2 milliamperes at the time of manufacture. Resistors R8 and R16 in parallel, R9, and R13 are connected across the filtered output voltage of tube V4 as a voltage-divider circuit supplying the plate and the screen of tube V1.

(f) Resistor R3 is a grid current limiter. Resistor R4 and capacitors C8 and C7 serve to filter the grid of V1 and to dampen its response to rapid changes in voltage. Resistor R1 supplies the screen voltage to tube V2. Filament current for all the tubes is supplied by transformer T3.

Preparing to Start Initially

2.08 When putting the rectifier into service initially, check to see that:

(a) The ac input leads are connected to terminals 10 and 11 on terminal strip TS2 with the ground lead on terminal 10.

(b) For 115-volt ac power the leads from terminals 3 and 8 on saturable reactor L1 are connected to terminals 3 and 1, respectively, on terminal strip TS1. On terminal strip TS1, terminals 1 and 3 are strapped to terminals 8 and 4, respectively.

(c) For 230-volt ac power, the leads from terminals 3 and 8 on saturable reactor L1 are connected to terminal 2 on terminal strip TS1. On terminal strip TS1, terminals 1 and 3 are strapped to terminals 9 and 5, respectively.

(d) For 60-cycle ac power, the lead from capacitor C1 is connected to terminal 6 on terminal strip TS1.

(e) For 50-cycle ac power, the lead from capacitor C1 is connected to terminal 7 on terminal strip TS1.

(f) The output leads are connected to terminal strip TS3 with the positive or ground lead connected to terminal 12. The negative leads connect to terminals 13 and 14, terminal 13 furnishing a quiet output from a 2-stage filter and terminal 14 furnishing an output from a one-stage filter.

(g) The proper electron tubes are firmly placed in their sockets.

(h) The proper fuses are installed.

Initial Adjustments

2.09 Connect the portable voltmeter to terminals 12 and 13 on terminal strip TS3 with the positive lead on terminal 12. Adjust potentiometer P1 to obtain the desired voltage at full load. Check that this voltage does not change more than ± 1 volt at no load.

2.10 Potentiometer P2 is adjusted at the factory for optimum suppression of line voltage variations and generally this adjustment should be satisfactory. If a check on this adjustment is desired, proceed as follows:

(a) Disconnect ac power from the rectifier. Remove fuse F1 and connect a switch in parallel with a resistor across the fuse posts, (approximately 8 ohms for 230-volt service and 2 ohms for 115-volt service). Reconnect power.

(b) With full load on rectifier, open and close the switch several times noting dc output voltage for each position of the switch. Loosen the locknut and set potentiometer P2 with screwdriver at setting giving smallest variation in output voltage for the two positions of the switch, resetting potentiometer P1 after each change of potentiometer P2.

(c) Tighten locknut on potentiometer P2. With power off, replace the fuse and remove the switch and resistor. Restore power.

3. ROUTINE CHECKS AND ADJUSTMENTS

3.01 This rectifier is automatically regulated and should require no day-to-day adjustment. The output voltage should be checked periodically, however, and readjusted, if necessary, as the metallic rectifier stacks may age over a period of time and change the voltage slightly.

4. TROUBLES

4.01 The items most likely to require eventual replacement are electronic tubes and electrolytic capacitors. Make sure that the ac input power is disconnected when removing or replacing electron tubes.

4.02 If transformer T2 or inductor L4 are replaced, potentiometer P2 may require readjustment.

4.03 If the output voltage regulation from no load to full load is not within limits, check the electron tubes in any available tube tester and replace any defective tube. If a tube tester is not available, put in all new tubes to check the circuit and then try the old tubes one at a time to see which is defective. After installing new tubes, a readjustment of potentiometer P1 may be required to reset the voltage.

4.04 If the output voltage cannot be adjusted with potentiometer P1 and all of the electron tubes and metallic rectifiers are good, check the voltage drop across resistors R10 and R12. If this voltage is not between 43 and 60 volts, replace thermistor RT1. Note the resistance value stamped on the new RT1. Select the proper tap on resistor R15 that will make its resistance approximately equal to the RT1 value. Insert a portable milliammeter in series with RT1 and adjust the current through RT1 to 25 ± 2 milliamperes by means of the taps on resistors R6 or R7 as required. Remove the milliammeter and reconnect RT1.

Trouble Chart

4.05 Should any of the following troubles develop, it is suggested that the possible cause be checked in the order given. If the trouble is not found, look for loose or open connections or short circuits due to foreign matter lying across wiring terminals. If a check of the possible causes listed below or the use of the point-to-point voltage table does not lead to the location of the trouble, it is advisable to make resistance measurements with the circuit completely de-energized, comparing the measured values with the values shown in Fig. 4.

<u>Trouble</u>	<u>Possible Cause</u>
No output voltage	Blown fuse F1 or F2 (shorted capacitors C2 to C5) Failure or disconnection of the ac power supply Main control switch may be open Open or loose lead inside rectifier Defective rectifier stacks
Low output voltage	Improper setting of voltage adjuster P1 or compensator P2 Low ac input voltage Defective rectifier stacks Overload (Load on terminal 13 plus L4 not to exceed 6 amp) Poor connection on ac lead Aged or defective tubes. Try new V3 or V4 first
High output voltage	Improper setting of voltage adjuster P1 or compensator P2 Open in thermistor RT1 Open in any grid circuit
Erratic output voltage	Loose connection in wiring Poor contact of arm in P1 or P2 Insulation leakage in L1 (replace L1)

5. POINT-TO-POINT VOLTAGES

5.01 As long as the rectifier operates satisfactorily, point-to-point voltage values are not needed and are not operating requirements to be checked in routine. In case the rectifier output cannot be obtained, they may be useful in locating defective conditions.

5.02 High voltages are present within the rectifier case and every precaution should be observed to avoid any contact with exposed metal parts or terminals when the rectifier is in operation, or when not in operation, but connected to the line.

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Caution: When using any portable instrument, the leads should be carefully examined to make sure the insulation is undamaged. The leads should be connected at the instrument before making contact with the circuit to be tested.

Caution: The readings shown in the following table are for a typical rectifier in good working condition. A defect in a rectifier may leave a high voltage charge on a capacitor and other parts of the circuit with the power off. A defective rectifier with the power connected may have quite different voltages than those shown. Therefore, it may be desirable to use a higher voltage range in the voltmeter until readings indicate the proper range to use for the defective condition.

5.03 The readings given in the table are approximate and typical of a rectifier unit adjusted as indicated. They are made with the KS-14150 voltmeter which is accurate to ± 5 per cent on alternating current and to ± 2 per cent on direct current. It will not seriously affect the output of the rectifier unit when connected for making the readings.

5.04 Voltages given are typical for a regulated load of 6 amperes at 24 volts dc and 115-volt power service. Some voltages vary not only with input voltage and load but also with different apparatus such as tubes and capacitors.

AC Voltages

<u>Reading</u>	<u>Connect AC Terminals of Voltmeter to Terminal</u>	<u>Typical AC Volts</u>
AC input voltage on L1	1 and 3 on TS1	58
AC input voltage on T1	10 and TS2 and 3 on TS1	71
V1 filament	9 and 10 on T3	6.4
V2 filament	7 and 8 on T3	6.3
V3 filament	3 and 4 on T3	5
V4 filament	5 and 6 on T3	5
Plate supply to V4	9 and 11 on T2	980
AC supply to RV2	7 and 8 on T2	57
Plate supply to V3	4 and 6 on T2	800
Supply to RV1	6 and 9 on T1	40

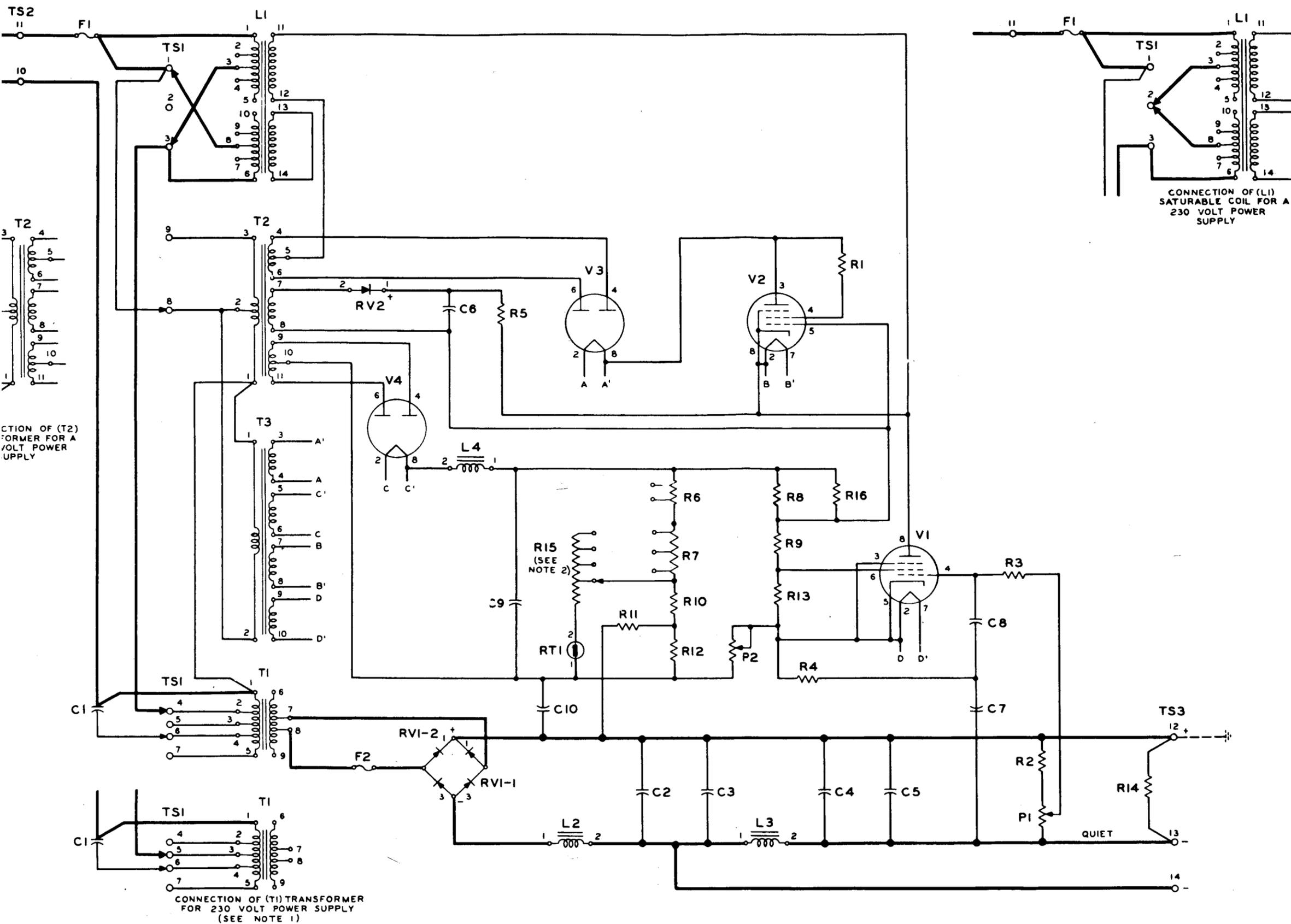
DC Voltages

<u>Reading</u>	<u>Connect + Terminal of Voltmeter to Terminal</u>	<u>Connect - Terminal of Voltmeter to Terminal</u>	<u>20,000 ohms per volt Typical DC Volts</u>
Winding 11-12 on L1	11 on L1	12 on L1	46
V3 output	3 on T3	12 on L1 or 5 on T2	330
RV2 output	Common strap between RV2 and R5	8 on T2	77
Supply to V1 Plate	11 on L1	Common strap between R13 and R4	150
Voltage across R15 and RT1	Wired tap on R15	1 on RT1	50*

*See voltage value marked on TR1 thermistor (range 43 to 60 volts).

<u>Reading</u>	<u>Connect + Terminal of Voltmeter to Terminal</u>	<u>Connect - Terminal of Voltmeter to Terminal</u>	<u>20,000 ohms per volt Typical DC Volts</u>
Bias on V1	Common strap between R13 and R4	Common strap between C8 and R3	0.75
Bias on V2	7 on T3	8 on T2	26.0
RV1 output (unfiltered)	12 on TS3	1 on L2	27
RV1 output (1st stage filter)	12 on TS3	14 on TS3	25

Attached: Fig. 4



CONNECTION OF (T2) FORMER FOR A 100 VOLT POWER SUPPLY

CONNECTION OF (T1) TRANSFORMER FOR 230 VOLT POWER SUPPLY (SEE NOTE 1)

CONNECTION OF (L1) SATURABLE COIL FOR A 230 VOLT POWER SUPPLY

- NOTES:
1. FOR A 60" POWER SUPPLY CONNECT THE (C1) CAPACITOR LEAD TO TERMINAL "6" ON TERMINAL BOARD (TS1) AS SHOWN. FOR A 50" POWER SUPPLY CONNECT THIS LEAD INSTEAD TO TERMINAL "7" ON THIS BOARD.
 2. SELECT THE TAP THAT WILL MAKE THE RESISTANCE OF (R15) EQUAL TO THE VALUE STAMPED ON (RT1).
 3. A RESISTOR WHOSE VOLTAGE DROP AFFECTS OPERATION IS SHOWN VERTICALLY.

RESISTORS	RESISTANCE IN OHMS
P1 (VAR)	100,000
P2 (VAR)	1,000
R1	47
R2	10,000
R3	100,000
R4	5,600
R5	100,000
R6 (TAPPED)	13,000 (7000, 10,000)
R7 (TAPPED)	3,000 (1500, 2400, 2700)
R8	68,000
R9	6,800
R10	150,000
R11	330,000
R12	1,000.00
R13	12,000
R14	75
R15	700
R16	68,000

FUSES	
F1	8 AMP
F2	10 AMP

TUBES	
V1	6AC7
V2	6L6 G/GA
V3	5Y3 GT/G
V4	5Y3 GT/G

FIG. 4 - FUNCTIONAL SCHEMATIC

FIG. 4

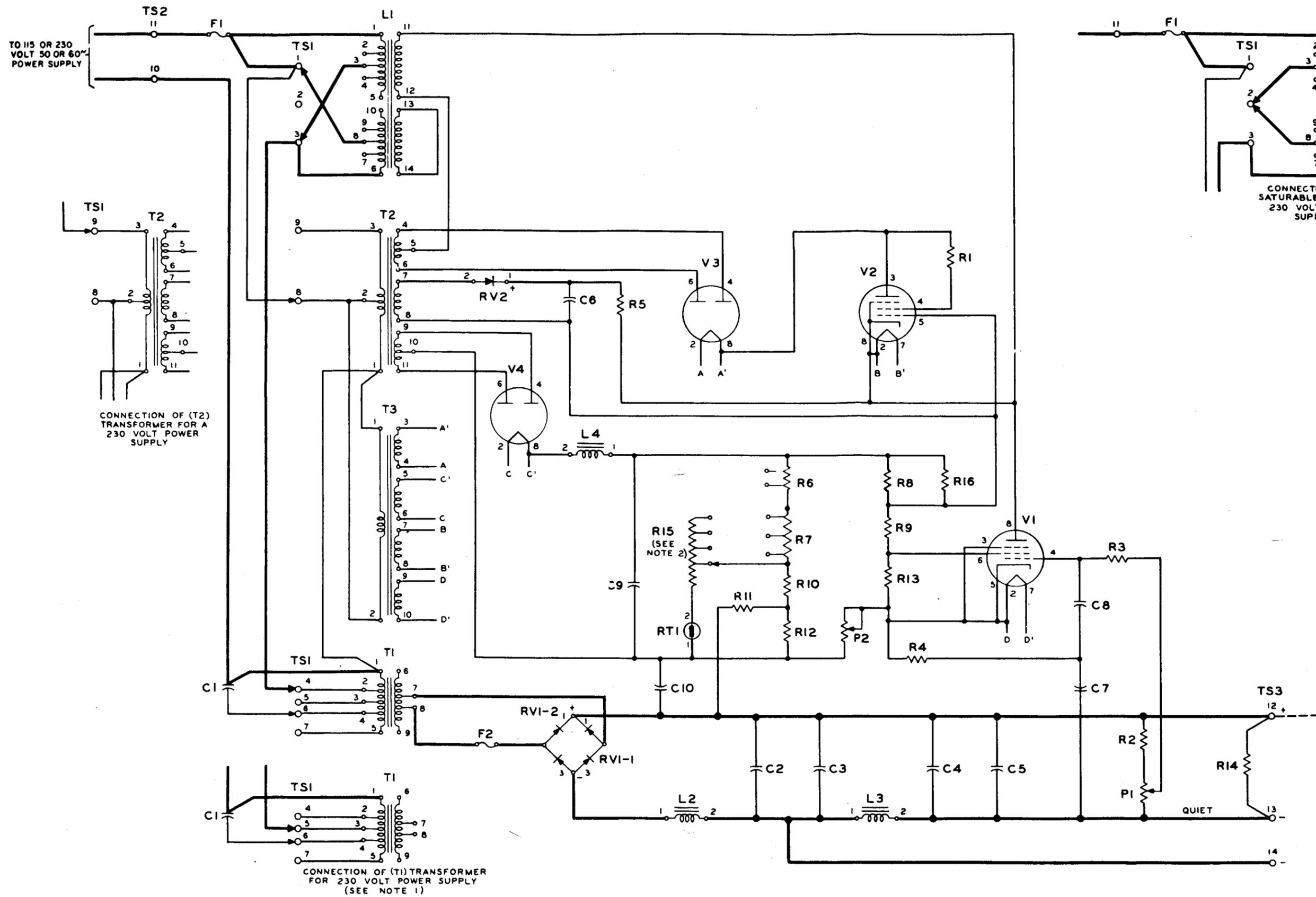


FIG. 4 - FUNCTIONAL SCHEMATIC