KS-5669 RECTIFIER
OPERATING METHODS

1. GENERAL

1.01 This section covers the operation of regulated disc rectifier KS-5669, designed for use in floating or charging the battery for the mobile radio land receiver and rated 6.6 volts, 15 amperes. It is intended for operation on 105- to 125-volt, 60-cycle power service and will regulate the output to ±0.25 volt for constant load or to ±0.2 volt for constant input voltage with variations in load within the range of 1.5 to 15 amperes. The rectifier is suitable for use in room temperatures from -40F to +122F.

Caution: Voltages inside the rectifier case are over 150 volts to ground and between terminals. Do not allow a test pick to touch two metal parts at the same time or destructive and dangerous short circuits may occur. Disconnect a-c supply before working on rectifier except as necessary to make tests.

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

1.03 In this section the term capacitor is used for apparatus coded as either a capacitor or a condenser and the term resistor is used for apparatus coded as a resistor or a resistance.

1.04 The instructions are based on drawing SD-81027-01. For detailed description of the operation, see the corresponding circuit description.

1.05 The relay in the rectifier is assumed to be in adjustment in accordance with the circuit requirement table on the circuit drawing and the BSP section which applies.

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

1.07 List of Tools, Gauges, and Materials (Equivalents may be substituted if desired)

Screwdriver, cabinet 3"
Volt-ohm-milliammeter M9B

2. OPERATION

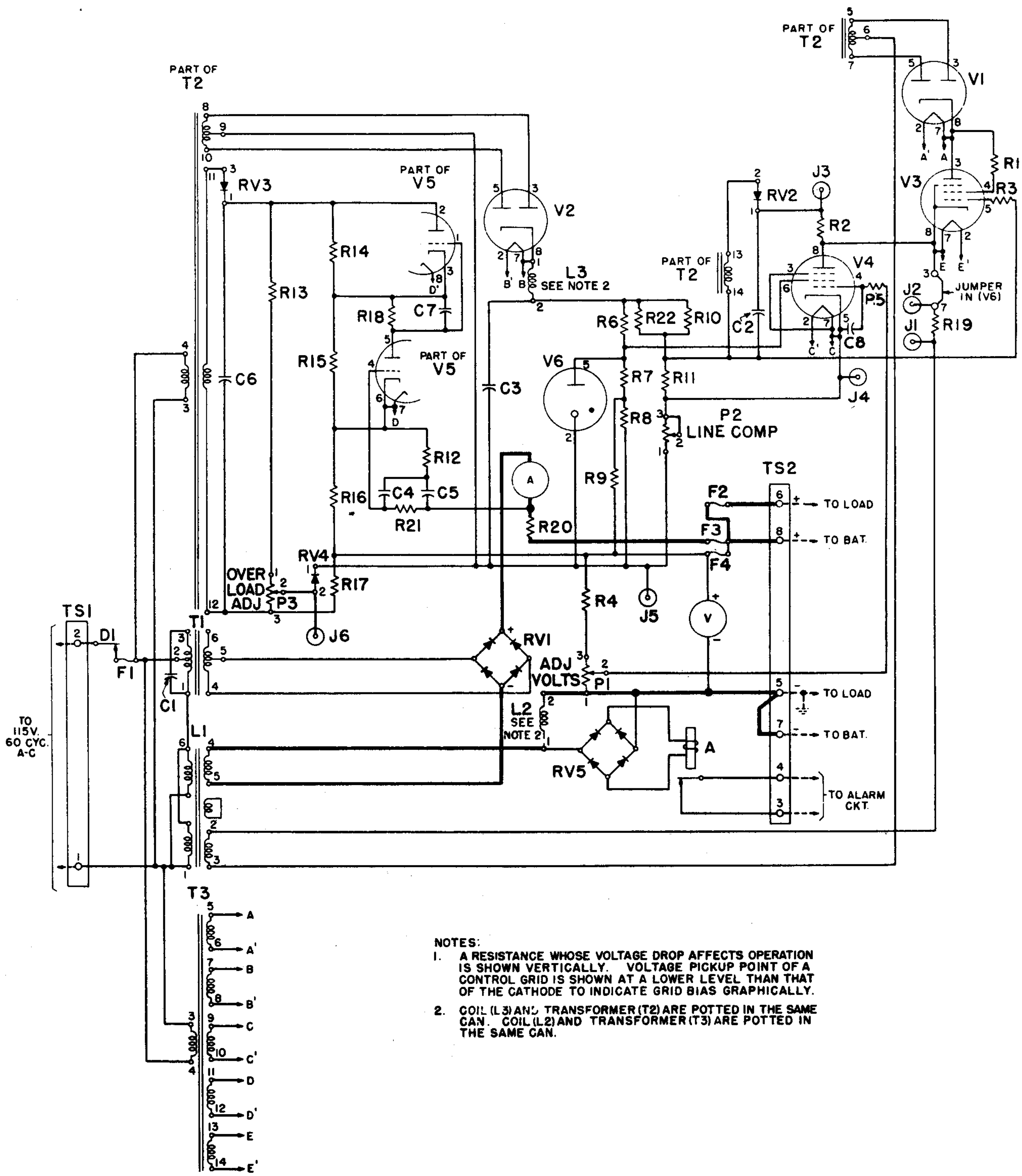
How The Rectifier Works

Fig. 1 - Functional Schematic based on SD-81027-01 Y Wiring
Fig. 2 - Functional Schematic based on SD-81027-01 X Wiring

2.01 The rectifier uses selenium discs as the rectifying element and uses a saturable reactor to control the voltage applied to the discs, thus securing regulation of the rectifier output. The saturation of the reactor is controlled by the rectifier output current and an electronic regulating circuit arranged to prevent overloading and to respond to changes in power service voltage as well as changes in output voltage.

2.02 Power is fed through the two a-c windings 1-6 of reactance L1 to the step down transformer T1 which delivers power to the disc assembly RV1 where the alternating current is rectified to d-c. The reactor has two d-c windings, one of which, 4-5, carries the rectifer output current and the other, 2-3, carries the saturating current from the regulating circuit. The reactor has lower a-c impedance as the iron core becomes more nearly saturated with increased direct current. This means the a-c voltage applied to the discs increases as the d-c in the reactor increases. Increasing load, therefore, tends to raise the a-c voltage enough to make up for internal losses in the rectifier due to increased load, thereby, tending to keep the d-c voltage constant. The saturating current in the regulating winding 2-3 changes as determined by the electronic regulating circuit in such a way as to hold the output voltage of the rectifier practically constant.

2.03 The electronic regulating circuit is designed to respond to (1) changes in output voltage, (2) changes in a-c line voltage and (3) changes in output current in excess of full load. In each case the proper effect is produced on amplifier tube V4 to cause a correction to maintain the output voltage constant. Any change which makes the grid 4 of tube V4 more negative with respect to its cathode decreases the current through R2 and therefore decreases the voltage drop across R2. The grid-to-



NOTES:

1. A RESISTANCE WHOSE VOLTAGE DROP AFFECTS OPERATION IS SHOWN VERTICALLY. VOLTAGE PICKUP POINT OF A CONTROL GRID IS SHOWN AT A LOWER LEVEL THAN THAT OF THE CATHODE TO INDICATE GRID BIAS GRAPHICALLY.
2. COIL (L3) AND TRANSFORMER (T2) ARE POTTED IN THE SAME CAN. COIL (L2) AND TRANSFORMER (T3) ARE POTTED IN THE SAME CAN.

Fig. 1 - Functional Schematic

cathode voltage od series tube V3 is the difference between the voltage across capacitor C2 and that across resistor R2, the voltage across C2 being the rectified voltage produced by winding 13-14 of T2 and varistor RV2.

2.04 Therefore, assuming no line voltage change at the moment, as the grid of V4 becomes more negative, the grid of V3 also becomes more negative and reduces the amount of current from rectifier tube V1 passing through V3 to the saturating winding 2-3. The reduced saturating current increases the impedance of L1 and reduces the voltage applied to the discs RV1 and therefore the rectifier output voltage. Making the grid of tube V4 more negative, therefore, decreases the rectifier output voltage and decreasing the grid bias of V4 increases the rectifier output voltage. The saturating current can be measured by measuring the voltage drop across 100-ohm resistor R19 at pin jacks J1 and J2, the current being 10 milliamperes for each volt drop.

2.05 Changes in output voltage produce changes in the current of the potentiometer circuit consisting of resistor R4 and potentiometer rheostat P1. Assuming that the power service is constant and that the rectifier output current is within its rating, changes in voltage across R4 and 3-2 of P1 produce the same change in grid-to-cathode voltage of V4. The cathode 5 connection to R4 is through P2, R8, and R9 all of which have voltage drops assumed to be constant. As the load increases, the voltage across R4 and 3-2 of P1 will tend to decrease. In other words, the grid bias on V4 will tend to decrease causing a sufficient increase in the voltage applied to the discs to restore the output voltage to normal as explained in 2.03 and 2.04.

2.06 Changes in power service voltage produce changes in the voltage taps 8-9-10 of transformer T2 which vary the current through tube V2. This circuit is from the 8 and 10 terminals of T2 through V2, choke coil L3, resistors R6, R7, and R8 in parallel with R10/R22, R11, and P2 to terminal 9 of T2. Assuming that the load is constant and within the current rating of the rectifier, an increase in line voltage increases the current through V2 and P2 resulting in an increase in voltage across P2 and, therefore, an increase in the grid bias of tube V4. As explained in 2.03 and 2.04, an increase in grid bias on V4 will tend to decrease the voltage applied to the discs and correct for the increase in line voltage. Rheostat P2 is adjusted and marked at the factory for line voltage compensation and should not require readjustment.

Overload for Rectifiers per Fig. 1

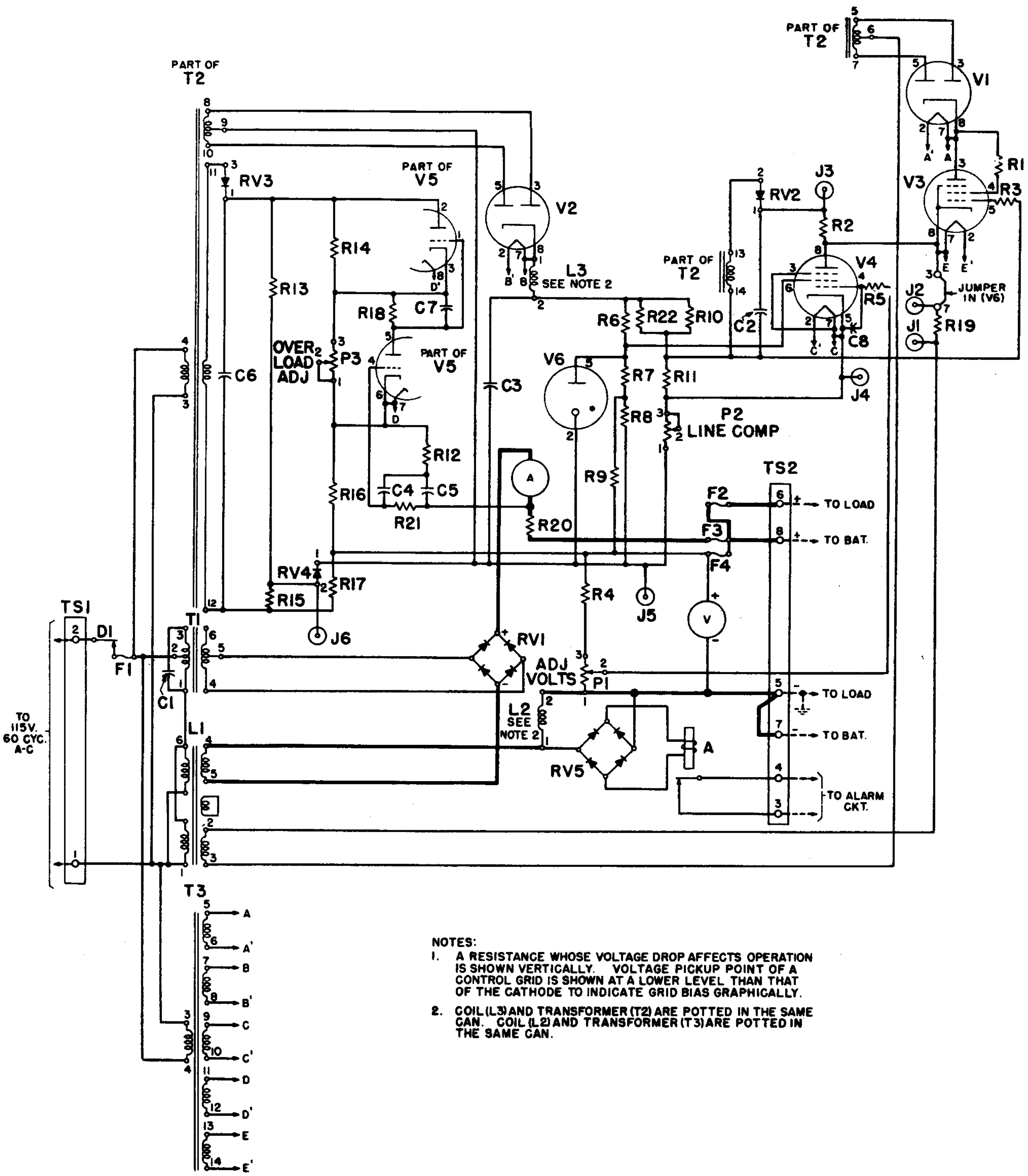
2.07 As the rectifier output increases, the voltage drop across R20 and fuse F3 increases, thus decreasing the grid 4 to cathode 6 voltage on tube V5, this grid bias being the difference in voltage drop across R16 and the drop across R20 and F3. Decreased grid bias 4-6 increases the current through R18, which increases the grid 1 to cathode 3 voltage, increasing the plate 2 to cathode 3 impedance. The plate voltage for each half of tube V5 comes from a potentiometer R14, R15, R16, and R17 in parallel with a second potentiometer R13 and potentiometer rheostat P3, both of which are bridged across the output of a rectifier consisting of winding 11-12 of T2 and varistor RV3, the output voltage being filtered and sustained by capacitor C6. As the plate-to-cathode 5-6 impedance of V5 decreases, the resistance of the combination of R15 and that part of the tube also decreases.

2.08 Similarly, as the plate-to-cathode 2-3 impedance of V5 increases, the resistance of the combination of R14 and that part of the tube also increases. A small decrease in grid bias 4-6, produced by an increase in load, effectively reduces the resistance across R15 and to a much greater degree increases the resistance across R14. This reduces the current through the resistors R15, R16, and R17. The reduced drop across R16 further decreases the grid bias 4-6 and tends to amplify the effect of an increased load.

2.09 The voltage drop across R17 therefore decreases as the load increases. The voltage drop across 2-3 of potentiometer P3 plus the voltage across R8 is in parallel with the voltage drop across R17 through the connection of resistor R9. Varistor RV4 in the connection between potentiometer P3 and resistor R8 permits flow of current only in one direction, that is, when the voltage 2-3 of P3 plus the voltage of R8 is greater than the voltage across R17. Except during periods of overload there is no current flow through resistor R9. The value of load current at which current begins to flow through R9 is adjustable by means of the OVERLOAD ADJ potentiometer P3. When current flows through R9, it causes a voltage drop across R9 which increases the grid bias on tube V4, decreasing the voltage applied to the discs RV1 as explained in 2.03 and 2.04 and preventing excessive output current.

Overload for Rectifiers per Fig. 2

2.1o As the rectifier output increases, the voltage drop across R20 and fuse F3 increases, thus decreasing the grid 4 to cathode 6 voltage on tube V5, this grid bias being the difference in voltage drop across R16 and the drop across R20 and F3. Decreased grid bias 4-6 increases the current through R18, which increases the grid 1 to cathode 3 voltage, increasing the plate 2 to cathode 3 impedance. The plate voltage for each half of



NOTES:

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2. COIL (L3) AND TRANSFORMER (T2) ARE POTTED IN THE SAME CAN. COIL (L2) AND TRANSFORMER (T3) ARE POTTED IN THE SAME CAN.

Fig. 2 - Functional Schematic

tube V5 comes from a potentiometer R14, P3, R16, and R17 in parallel with a second potentiometer R13 and R15, both of which are bridged across the output of a rectifier consisting of winding 11-12 of T2 and varistor RV3, the output voltage being filtered and sustained by capacitor C6. As the plate-to-cathode 5-6 impedance of V5 decreases, the resistance of the combination of P3 and that part of the tube also decreases.

2.11 Similarly, as the plate-to-cathode 2-3 impedance of V5 increases, the resistance of the combination of R14 and that part of the tube also increases. A small decrease in grid bias 4-6, produced by an increase in load, effectively, reduces the resistance across P3 and to a much greater degree increases the resistance across R14. This reduces the current through the resistors P3, R16, and R17. The reduced drop across R16 further decreases the grid bias 4-6 and tends to amplify the effect of an increased load. The voltage drop across R17 therefore decreases as the load increases.

2.12 The voltage drop across R15 plus the voltage across R8 is in parallel with the voltage drop across R17 through the connection of resistor R9. Varistor RV4, in the connection between R15 and R8, permits flow of current only in one direction, that is,when the voltage across R15 plus the voltage across R8 is greater than the voltage across R17. Except during periods of overload there is no current flow through resistor R9. The value of load current at which current begins to flow through R9 is adjustable by means of the OVERLOAD ADJ rheostat P3, the setting of which for a given load controls the current through R17 and therefore the voltage across R17. When current flows through R9, it causes a voltage drop across R9 which increases the grid bias on tube V4, decreasing the voltage applied to the discs RV1 as explained in 2.03 and 2.04 and preventing excessive output current.

2.13 An ammeter and a voltmeter are provided to indicate the load and voltage of the rectifier. Test pin jacks J1 to J6 furnish means for checking certain critical voltages and currents to assist in locating troubles which may develop in service.

2.14 The ripple voltage across choke coil L2 is rectified by varistor RV5 to energize relay A and is sufficient to hold relay A operated for all loads above about 1.5 amperes. Smaller output will be indicated by an alarm.

Preparing to Start Initially

2.15 Before putting the rectifier into service initially, check against the circuit drawing to be sure that:

(a) Correct tubes are in the sockets.

(b) Proper fuses F1, F2, F3, and F4 are in place.

(c) Rheostats ADJ VOLTS and OVERLOAD ADJ are turned completely counterclockwise.

(d) Rheostat P2 is at the marked position.

Initial Adjustments

2.16 After starting the rectifier by putting the input plug into the receptacle, allow the tubes to heat for approximately 30 seconds then gradually turn ADJ VOLTS rheostat clockwise. When the rectifier voltage exceeds the battery voltage, the ammeter will indicate the rectifier output current and this current will increase rather rapidly as the ADJ VOLTS rheostat is turned clockwise until the overload circuit begins to function. After this point is reached, further rotation of the ADJ VOLTS rheostat will not increase the current as rapidly. When the rheostat has reached the extreme clockwise position the output current should be limited to some value less than 15 amperes. If the current is 19 amperes or more, a different V5 tube should be tried. If difficulty is still experienced, notify the supervisor so that consideration may be given to the rectifier per rewiring option of SD-81027-01 which compensates for wider manufacturing variations in tube V5, no new equipment being required.

2.17 Turn OVERLOAD ADJ rheostat clockwise until the ammeter indicates a rectifier output current of 17 amperes. If voltmeter indicates less than 6.5 volts, allow batteries to charge slightly above this value so that when the ADJ VOLTS rheostat is turned counterclockwise, until the voltmeter indicates 6.5 volts, the ammeter indicates between 6 and 8 amperes. The above setting is approximately correct but may need a slight modification to make the voltmeter indicate 6.5 volts after the plant has been in service a few days and the batteries have reached a stable floating condition.

Routine Adjustments

2.18 For routine starting and stopping it is only necessary to insert the input plug into or remove it from the receptacle. Whenever, any tube is replaced, the initial adjustments should be rechecked.

3. ROUTINE CHECKS

3.01 Routine checks of the vacuum tubes can be made in a vacuum tybe tester to determine when a tube is poor and needs to be replaced to avoid possible future service reactions. For this purpose, refer to Section 100-640-101.

4. TROUBLES

4.01 The ADJ VOLTS rheostat P1, LINE COMP rheostat P2, and OVERLOAD ADJ rheostat P3 are all totally enclosed and should be replaced if defects develop in service.

Trouble Chart

4.02 Should any of the following troubles develop, it is suggested that the possible cause be checked in the order listed. If the trouble is not found, look for open connections.

Trouble	Possible Cause
No d-c current	Power failure. Blown input fuse F1. Cover switch not closing. Capacitor C1 short circuited. Blown output fuse F2, F3.
Low d-c current or voltage	ADJ VOLTS rheostat out of adjustment. Low line voltage. Failure of any vacuum tube V1 to V5. Shorted capacitor C3, C4, or C5.
High d-c current or voltage	OVERLOAD ADJ rheostat out of adjustment. High line voltage. Blown fuse F4. Voltage reference tube V6 aged. Capacitor C2 or C8 short-circuited.
Erratic d-c current or voltage	Loose connection at ADJ VOLTS rheostat.

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 secured, they may be useful in locating defective conditions.

5.02 High voltages are present within the rectifier and every precaution should be observed to avoid any contact with exposed metal parts or terminals when the rectifier is in operation.

Caution: When using any portable instrument, the leads should be connected at the instrument before making contact with the circuit to be tested. If connections are to be changed from one instrument range to another, the a-c should first be disconnected from the equipment being tested.

5.03 The readings given in the table are approximate and typical for a rectifier adjusted as indicated in 5.06. The readings are measured with an M9B meter which is provided with test leads. Connecting the M9B meter to observe readings does not appreaciably affect the rectifier output. The door switch does not disconnect both sides of the input power so that the terminals of the door switch and fuse, if provided, as well as the transformer primary terminals may be at voltage to ground. The time required for the output voltage to stabilize after the door switch is operated may be several minutes unless the load is temporarily disconnected while the door switch is released.

5.04 The M9B meter is provided with both test clip leads and test pick leads. Wherever, possible the test clip leads should be used in making connections to leave the maintenance man free to observe the meter and operate the door switch. When it is necessary to use a test pick lead, the door switch should be operated with some insulating material to avoid grounding one hand. This insulating material may be a stick 5 or 6 inches long with a depression in one end into which the switch plunger fits. The depression is to prevent the stick from accidentally slipping off of the switch plunger.

5.05 The procedure for making measurements is as follows:

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

(a) Unfasten and open the door of the rectifier, releasing the door switch, thereby disconnecting the a-c supply.

(b) Some readings using the jacks in the door of the rectifier may, of course, be made without opening the door for additional readings.

(c) Put the pin ends of the test leads in the meter jacks indicated in the table for the reading desired.

(d) Connect the test leads to the apparatus terminals shown in table.

(e) Operate the door switch keeping clear of other parts of the rectifier.

(f) When the output voltmeter has stabilized, observe the volts on M9B meter.

(g) Release the door switch.

(h) Remove the test leads from apparatus.

(i) Proceed to make any other measurements repeating items (c) to (h).

(j) Close doors and fasten it.

5.06 Table of Point-to-point Voltages

Rectifier adjusted to 6.6-volt, 7.5-ampere output with 115-volt, 60-cycle power supply.

Voltage Across	Measurements Made: From App.	From Term.	*To App.	*To Term.	M9B Meter: Jack	Toggle Switch	Reading Volts
C2	Jack	J3	T2	14	150	D-c	80
C3	L3	2	T2	9	300	D-c	220
C6	C6	Top	C6	Bottom	300	D-c	177
P2	Jack	J4	Jack	J5	15	D-c	0.6
R2	Jack	J3	Jack	J2	150	D-c	42
R2 & V4	Jack	J3	Jack	J4	300	D-c	152
R8	Junction	R7,R8,R9	Jack	J5	15	D-c	3.4
R19	Jack	J2	Jack	J1	3	D-c	1.9
RV1	RV1	+(R)	R11	-(B1)	15	D-c	7
RV4	Jack	J5	Jack	J6	15	D-c	0.5
V6	V6	5	V6	2	150	D-c	102
T1 Prim.	T1	1	T1	2	150	A-c	48
T1 Sec.	T1	4	T1	5	15	A-c	9.75
T2 Sec.	T2	5	T2	6	600**	A-c	392
T2 Sec.	T2	6	T2	7	600**	A-c	392
T2 Sec.	T2	8	T2	9	600**	A-c	365
T2 Sec.	T2	9	T2	10	600**	A-c	365
T2 Sec.	T2	11	T2	12	300	A-c	148
T2 Sec.	T2	13	T2	14	150	A-c	76
V1 Fil.	T3	5	T3	6	15	A-c	6.2
V2 Fil.	T3	7	T3	8	15	A-c	6.2
V3 Fil.	T3	13	T3	14	15	A-c	6.2
V4 Fil.	T3	9	T3	10	15	A-c	6.2
V5 Fil.	T3	11	T3	12	15	A-c	6.2

* "To Term" should be connected to -V jack of meter.

** Readings indicated for meter jack 600V may be observed using 300V jack with multiplier (D-176926 plug) plugged into the 300V jack if a 600V jack is not on the meter or 600,000 ohms may be connected in the lead from the 300V jack.

x The M9B meter has an accuracy of ±5 per cent on a-c and ±2 per cent on d-c.