RECTIFIERS
KS-15620 L1, L2, L3, L6, AND L10
OPERATING METHODS

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1. GENERAL

1.01 This section covers the operation of KS-15620 L1, 2, 3, 6, and 10 automatically regulated semiconductor-type rectifiers using saturable reactor control.

1.02 This section is reissued to change the title, to add description of operation and functional schematic for the KS-15620L10 rectifier, and to omit KS-15620L7, L8, and L9 rectifiers now covered in Section 169-682-302.

1.03 The rectifiers covered by this section are all of the full-wave type. They are designed for single-phase, 60-cycle, 115-volt ac power source and are rated as follows.

KS-15620 RECTIFIER LIST NO.	POWER SERVICE VOLTS AC	DC OUTPUT-CONTINUOUS VOLTS	DC OUTPUT-CONTINUOUS AMPERES
1	115	48/55	1.75
2,10	115	48/55	2.00 ←
3	115	48	3.50
6	115	48	4.00

All rectifiers have pin jacks to facilitate measuring the output voltage. Screw-type terminals are provided for the ac and dc connections.

> ***Caution:** Avoid all contact with terminals, as high voltages are present. Do not allow a test pick to touch two metal parts at the same time, as destructive and dangerous short circuits may occur. Remove the fuse in the rectifier or disconnect the ac power before working on the rectifier.*

1.04 Keeping the ventilating passages and rectifier cells clean is especially important to avoid excessive heating.

1.05 Routine checks are intended to detect defects, particularly in frequently operated parts of the equipment, and, insofar as possible, to guard against circuit failures which interfere with service. Checks and adjustments other than those required by trouble conditions should be made during a period when they will not interfere with service.

1.06 For more detailed information on the operation and maintenance of individual equipment or apparatus, refer to the appropriate Bell System Practice.

2. LIST OF TOOLS, GAUGES, AND TEST APPARATUS

CODE OR SPEC NO.	DESCRIPTION
TOOLS	
—	3-Inch C Screwdriver (or the replaced 3-inch cabinet screwdriver)
GAUGES	
KS-14510L1	Volt-Ohm-Milliammeter
—	Ammeter, DC, Model No. 281 Scale 1.5-3-30, Weston Electrical Instrument Corporation, or the replaced No. 280

CODE OR SPEC NO.	DESCRIPTION
TEST APPARATUS	
—	Variable Resistance Load Capable of Carrying 4 Amperes at 60 Volts

3. OPERATION

Description of Operation

KS-15620 L1 and 3 Rectifiers (see Fig. 1 and 3 — functional schematics)

3.01 Power is connected to the primary winding of the T1 transformer. The output of the T1 transformer is fed to the RV1 rectifying element through the load windings of the L2 saturable reactor. The voltage which is applied to the RV1 rectifying element and the L1 reactor will vary according to the degree of saturation of the core of the L2 reactor. (The means of controlling this saturation will be explained later.) As the saturation of the core of the L2 reactor increases, the voltage drop across its load windings decreases, thereby increasing the voltage applied to the RV1 rectifying element. This increases the output voltage of the rectifier.

3.02 The saturation of the core of the L2 reactor is controlled by the direct current through the shunt and series control windings. The voltage at no load is controlled by the adjustment of the R2 rheostat. Increasing the current in the shunt control winding of the L2 reactor increases the saturation in its core, thereby decreasing the impedance of its load windings. This allows a greater voltage to be applied to the RV1 rectifying element, which increases the output voltage of the rectifier. Conversely, reducing the current in the shunt control winding of the L2 reactor will decrease the output voltage of the rectifier.

3.03 The series control winding of the L2 reactor is used to compensate for resistance drop in the rectifier as the load increases from no load to full load. The S1 tap switch is provided to adjust the amount of compensation needed to keep the output voltage constant throughout the entire load range. Increasing the number of active turns on the series control winding of the L2 reactor will increase the voltage applied to the RV1 rectifying element when load is being supplied by the rectifier. The R1 rheostat serves as a bleeder resistance for the power supply and is factory adjusted.

3.04 In the case of list 1 rectifier, a 2-section filter is formed by the L3 and L4 inductors and the C1, C2, and C3 capacitors. The 48- and 55-volt taps permit the selection of 48- or 55-volt operation.

3.05 In the case of list 3 rectifier, a 2-section filter is formed by the L3 and L4 inductors and the C1, C2, C3, and C4 capacitors.

KS-15620 L2 and L6 Rectifiers (see Fig. 2 and 4 — functional schematics)

3.06 Power is connected to the primary winding of the T or T1 transformer and saturable reactance L2 transformer. The output of the T or T1 transformers is fed to the A1 or CR1 and CR2 rectifying elements, respectively and the load windings of the L1 saturable reactor. The current which flows through the A1 or CR1 and CR2 rectifying elements will vary according to the degree of saturation of the core of the L1 reactor. (The means of controlling this saturation will be explained later.) As the saturation of the core of the L1 reactor increases, the impedance of its load windings decreases, thereby increasing the current flowing through the A1 or CR1 and CR2 rectifying elements. This increases the output voltage of the rectifier.

3.07 The saturation of the core of the L1 reactor is controlled by the direct current through the shunt and series control windings. The voltage is controlled by the adjustment of the R2 potentiometer. Increasing the current in the reference control winding of the L1 reactor in one direction increases the saturation of the core of the L1 reactor, thereby decreasing the impedance of the load windings of the L1 reactor. This allows a greater current to flow through the A1 rectifying element of the list 2 rectifier or the CR1 and CR2 rectifying elements of the list 6 rectifier which increases the output voltage of the rectifier. Reversing the current in the reference control winding of the L1 reactor will decrease the output voltage of the rectifier. The direction of current flow in the reference winding is determined by the balance of voltages in the voltage regulating circuit. The voltage drop across a section of the R2 potentiometer and the R3 resistor oppose the voltage drop across the R4 resistor; the higher voltage determines the direction of current flow in the reference control winding. Any change in the output voltage of the rectifier changes the drop across the R2, R3, and the change in current through the shunt control winding is such as to cause the output voltage of the rectifier to change in the opposite direction. Thus, a constant output voltage is achieved.

3.08 The series control winding of the L1 reactor is used to compensate for resistance drop in the rectifier as the load increases from no load to full load. Because the reference voltage is lower than the output voltage, additional compounding is obtained by the use of the L3 filter reactor connected in series with the load. The voltage drop across the filter reactor is a small fraction of the total output voltage but is a relatively large fraction of the reference voltage, so that with increasing load current, a rising output-voltage characteristic may be obtained. The 1000-ohm resistor, bridged across the reference rectifier terminals, provides a path for the flow of reverse current through winding 3-4 of L1.

3.09 In the case of list 2 rectifier, the L2 transformer and the C3 capacitor combination make up a ferroresonant system such that the voltage at terminals 4 and 6 of the L2 transformer is essentially constant over the specified line voltage range. The voltage in the winding 6-7 of the T transformer provides a voltage proportional to the line voltage. The sum of these two voltages is applied to the A2 rectifying element. The dc voltage across the R4 resistor is the reference voltage referred to in 3.08. A filter is formed by the L3 reactor and the C1 and C2 capacitors. The 48- and 55-volt taps on the T transformer permit the selection of 48- or 55-volt operation.

3.10 In the case of list 6 rectifier, the L2 transformer and the C5 capacitor combination make up a ferroresonant system such that the voltage at terminals 4 and 6 of the L2 transformer is essentially constant over the specified line voltage range. The voltage in winding 6-7 of the T1 transformer provides a voltage proportional to the line voltage. The sum of these two voltages is applied to the CR3 rectifying element. The dc voltage across the R4 resistor is the reference voltage referred to in 3.08. A filter is formed by the L3 reactor and the C1, C2, C3, and C4 capacitors.

KS-15620 L10 Rectifier (see Fig. 5 — functional schematic)

3.11 Power is connected to the primary winding of the T1 transformer and the primary winding of the T2 ferroresonant reactor in series with the C4 capacitor. The output of the T1 transformer is fed to the CR1 rectifying element through the load windings of the L1 saturable reactor and the L3 shunt inductor. Under light load conditions, the sum of the magnetizing forces created by the windings is small. Therefore the impedance of the L1 saturable reactor is relatively high, reducing the voltage applied to the CR1 rectifying element. When the core of the L1 saturable reactor is saturated by the current flowing through its windings, the impedance of the L1 saturable reactor is low, thus increasing the voltage supplied to the CR1 rectifying element. The L3 shunt inductor provides a preload for the L1 saturable reactor and aids in the balancing of currents in the load windings of the L1 saturable reactor.

3.12 The reference circuit consists of the C4 capacitor in series with the primary winding of T2 reactor. The secondary winding of the T2 reactor is connected through the CR2 and CR3 rectifying elements to an isolated winding of the T1 transformer. The reference voltage supplied by this circuit at the terminals of the R4 resistor causes the dc current in the reference control winding of the L1 saturable reactor to vary; this tends to compensate for ac input line voltage variation. The R4 resistor acts as a preload on the reference voltage. The reference voltage is compared with the output voltage through the reference control winding of the L1 saturable reactor.

3.13 Load current passing through the series control winding of the L1 saturable reactor provides sufficient magnetization in the core of the L1 saturable reactor to overcome most of the losses encountered in the T1 transformer, L1 saturable reactor, CR1 rectifying element and wiring. The output voltage is controlled by the adjustment of the R2 potentiometer. This allows the output voltage to be set at a voltage above or below the reference voltage.

3.14 In controlling the impedance of the L1 saturable reactor, the current through the reference control winding can be in either direction depending on whether the output voltage is above or below the desired output voltage. The impedance of the L1 saturable reactor will decrease if the output voltage is low and increase if the output voltage is high. Thus an essentially constant output voltage is achieved.

3.15 A filter is formed by the input C1 and C2 capacitors, the L2 filter choke, and an output C3 capacitor. The 48- and 55-volt taps on the T1 transformer permit the selection of 48- or 55-volt operation.

Preparing To Start Initially

3.16 When preparing to put the rectifier into service initially, check that:

(a) The proper size and type ac supply fuse has been provided in the rectifier.

(b) The 48- or 55-volt tap on list 1 and 2, rectifiers is on the proper terminal.

(c) The tap switch on lists 1 and 3 is set near the midposition.

(d) The R2 potentiometer on lists 2, 6, and 10 is near its midposition.

Initial Adjustments

3.17 After the checks suggested in 3.16 are completed, connect the voltmeter to the + and − test jacks and connect an ammeter in series with the test load across the output terminals of the rectifier. Insert the ac fuse and note the output voltage with the test load adjusted for the rated output current. The R2 potentiometer (lists 2, 6, and 10 only) must be adjusted to bring the output voltage to the desired full-load value. The list 1 and 3 rectifiers have a tap switch to adjust the full-load voltage. Allow the rectifier to operate at full load for at least 30 minutes and then repeat the full-load checks. Readjust if necessary.

(a) With the list 1 rectifier connected for 48 volts and adjusted at 115 volts ac input for 48 ±1 volts and 1.75 amperes, the output voltage shall remain within the limits of 45 and 50 volts for any load between no load and 1.75 amperes, and with any input voltage between 105 and 125 volts, 60 cycles.

(b) With the list 1 rectifier connected for 55 volts and adjusted at 115 volts ac input for 55 ±1 volts and 1.75 amperes, the output voltage shall remain within the limits of 52 and 57 volts for any load between no load and 1.75 amperes, and with any input voltage between 105 and 125 volts, 60 cycles.

(c) With the list 2 or 10 rectifier connected for 48 volts and adjusted at 115 volts ac input for 48 ±1 volts and 2 amperes, the output voltage shall remain within the limits of 45 and 50 volts for any load between no load and 2 amperes, and with any input voltage between 105 and 125 volts, 60 cycles.

(d) With the list 2 or 10 rectifier connected for 55 volts and adjusted at 115 volts ac input for 55 ±1 volts and 2 amperes, the output voltage shall remain within the limits of 52 and 57 volts for any load between no load and 2 amperes, and with any input voltage between 105 and 125 volts, 60 cycles.

(e) With the list 3 rectifier adjusted at 115 volts ac input for 48 ±1 volts and 3.5 amperes, the output voltage shall remain within the limits of 45 and 50 volts for any load between no load and 3.5 amperes, and with any input voltage between 105 and 125 volts, 60 cycles.

(f) With the list 6 rectifier adjusted at nominal input of 115 volts ac for an output of 48 ±1 volts at 4.0 amperes, the output voltage shall remain within the limits of 45 and 50 volts for any load between no load and 4.0 amperes and with any input voltage between 105 and 125 volts ac, 60 cycles.

Routine Adjustments (normal operation)

3.18 The rectifier has no disconnecting switches and is connected to both ac power and the load when the associated fuse is in place. If it is necessary to take a rectifier out of service, remove load, then remove the ac fuse. To restart, replace the ac fuse.

4. ROUTINE CHECKS

4.01 The following should be performed.

(a) The output voltage and load current should be checked periodically to be sure that they are correct under office load.

(b) Electrolytic capacitors should be maintained in accordance with Section 032-110-701.

5. TROUBLES

5.01 The only items likely to become defective with use are the electrolytic capacitors and semiconductor stacks or diodes.

5.02 The rectifying element of the list 1, 2, 3, or 6 rectifier will age with use, and after a period of years may require readjustment of the R2 potentiometer on the lists 2, 6, and 10 or the← tap switch on the lists 1 and 3. Any replacements of rectifying elements, inductors, or transformers in the list 1 and 3 rectifiers should be made at the factory of the supplier. The R1 and R2 resistors in the list 1 and 3 rectifiers should not be readjusted in the field. All other components can be replaced in the field.

5.03 The R2 potentiometer on the lists 2, 6, and← 10 requires no maintenance. If operation indicates a defective sliding contact, use screwdriver to turn it back and forth a few times to clean the surfaces. If the potentiometer becomes defective, replace it. When replacement of the rectifying element of the list 6 and 10 rectifiers is required, proceed as covered in 5.04 and 5.05.

5.04 ***KS-15620 L6 Rectifier:*** Selenium rectifier cells may fail due to aging, which is an increase in the resistance of the cells. The replacement of only the defective stack in the rectifying element that consists of more than one stack may result in an unbalanced condition in the rectifying element. To avoid unbalance, replace stacks as follows.

(a) When replacing a defective stack or stacks in a multiple stack element, replace all other stacks in the element that have been in service 2 years or longer.

(b) Do not combine stacks of different list numbers or different manufacturers.

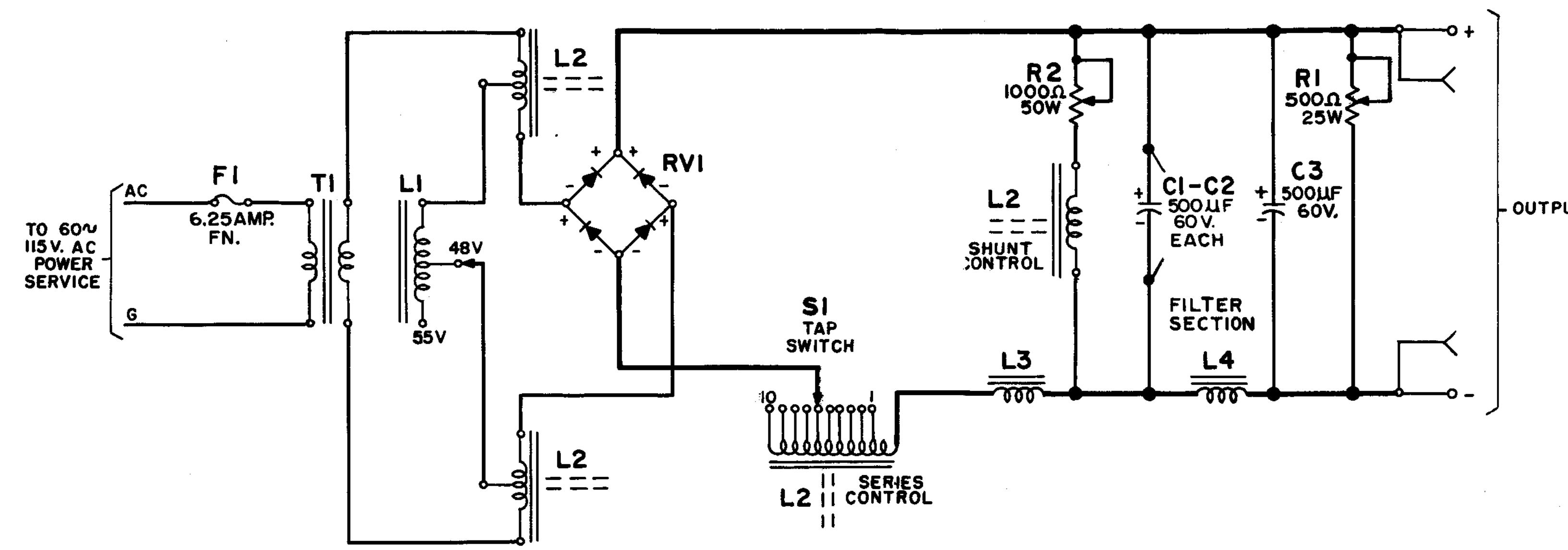
(c) Never attempt to replace part of the rectifier cells in a stack or bolt assembly. Always replace the entire stack.

5.05 ***KS-15620L10 Rectifier:*** Do not attempt to replace a diode in the germanium stack assembly. When replacements are required, replace the entire stack. Do not attempt to replace any single germanium diode. When replacements are required, replace all diodes at the same time and do not combine diodes produced by different manufacturers.

Trouble Chart

5.06 Should any of the following troubles develop, it is suggested that the possible causes be checked. If the trouble is not found, look for open or loose connections or short circuits due to foreign material lying across wiring terminals.

TROUBLE	POSSIBLE CAUSE
No dc output voltage	Failure or disconnection of the input power
	Blown ac supply fuse
	Shorted capacitors or resistors
Low dc output voltage	Tap switch out of position (lists 1 and 3)
	R2 potentiometer out of adjustment (lists 2, 6, and 10) ←
	Low line voltage
	Aged rectifying elements (lists 1, 2, 3, and 6)
	High resistance at some connection in line circuit
	Overload
	Defective CR2 or CR3 rectifier diode (list 10)
	Defective section of CR1 rectifier stack (list 10)
High dc output voltage	Tap switch out of position (lists 1 and 3)
	R2 potentiometer out of adjustment (lists 2, 6, and 10) ←
	High line voltage
	Shorted filter inductor
High ripple voltage	Open capacitor
	Shorted filter inductor



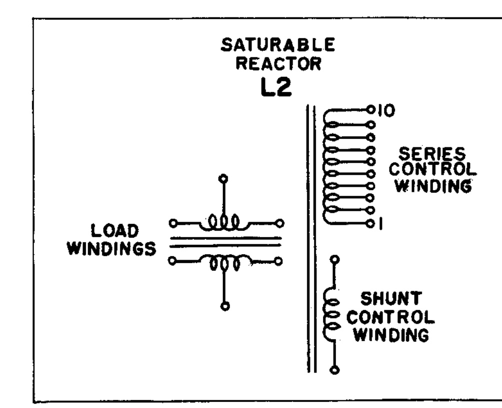


Fig. 1 — Functional Schematic KS-15620 L1 Rectifier

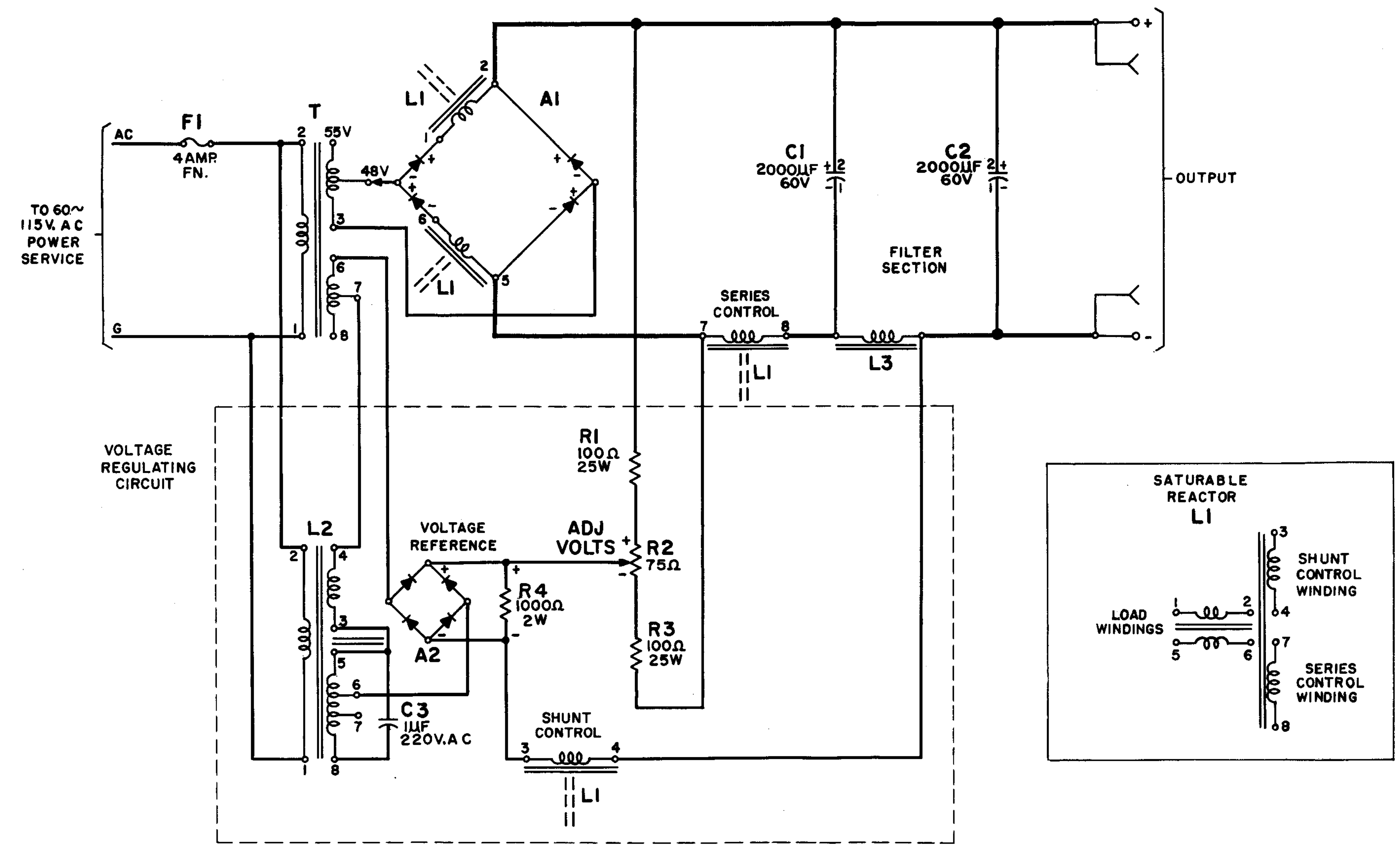
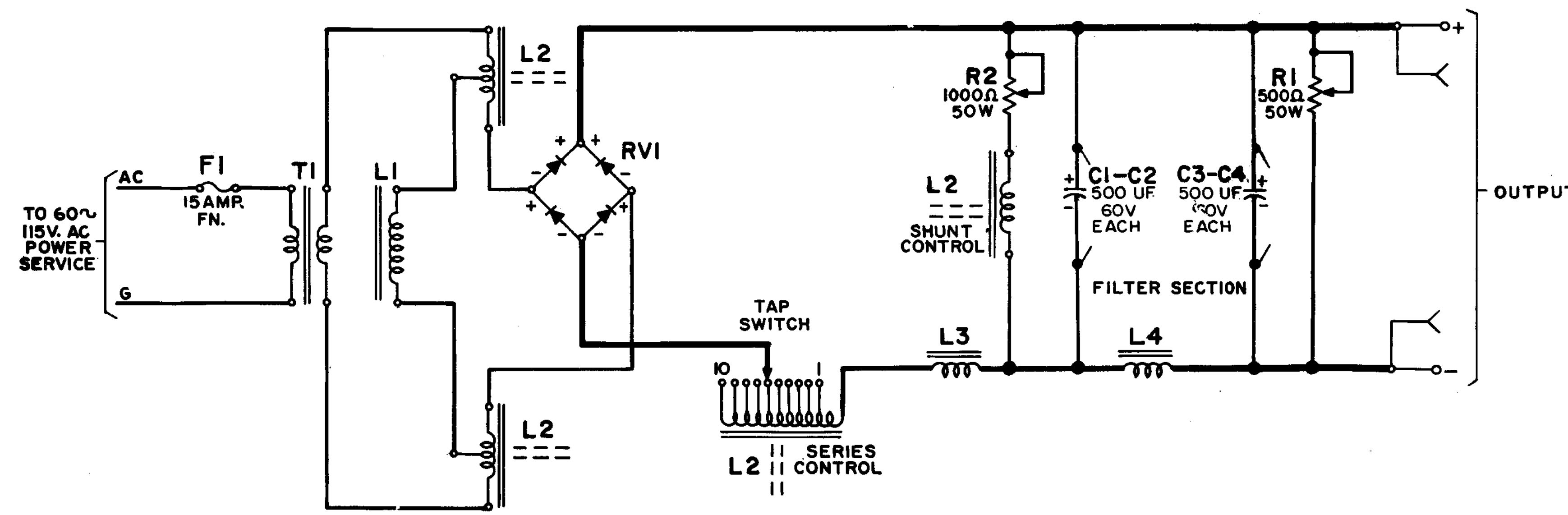


Fig. 2 — Functional Schematic KS-15620 L2 Rectifier



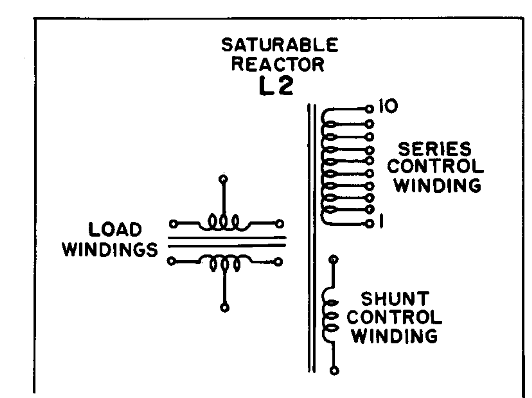


Fig. 3 — Functional Schematic KS-15620 L3 Rectifier

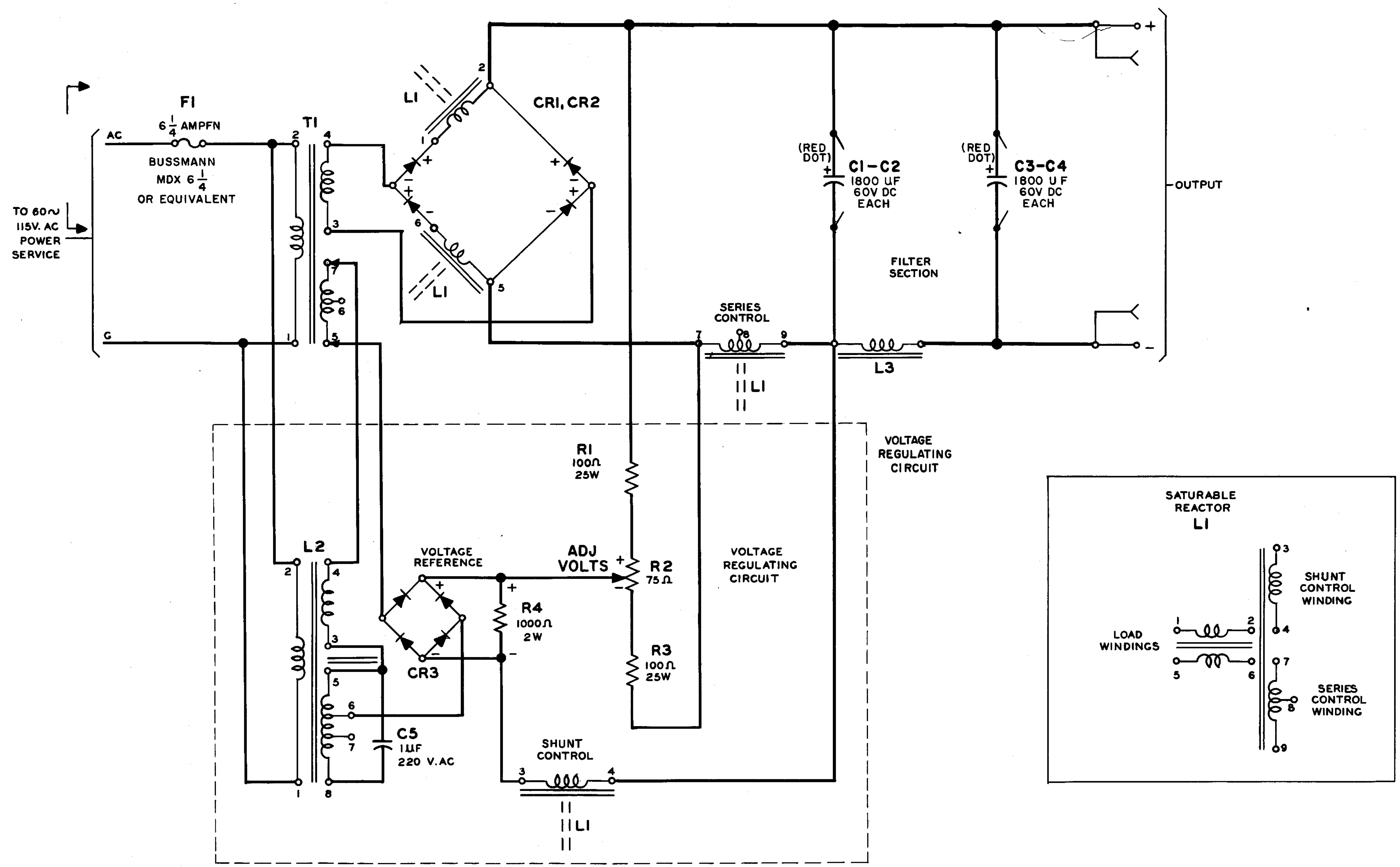
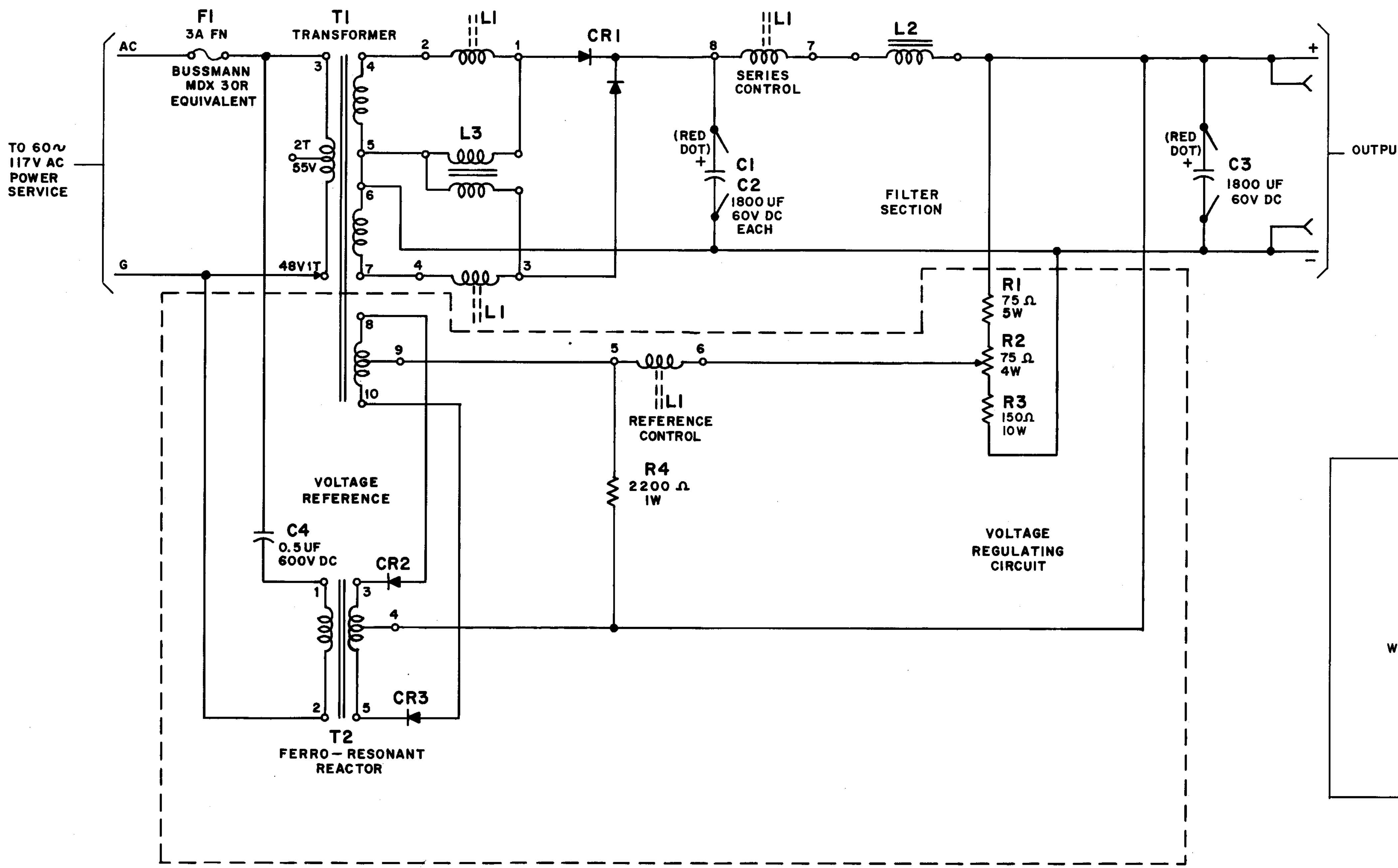


Fig. 4 — Functional Schematic KS-15620 L6 Rectifier



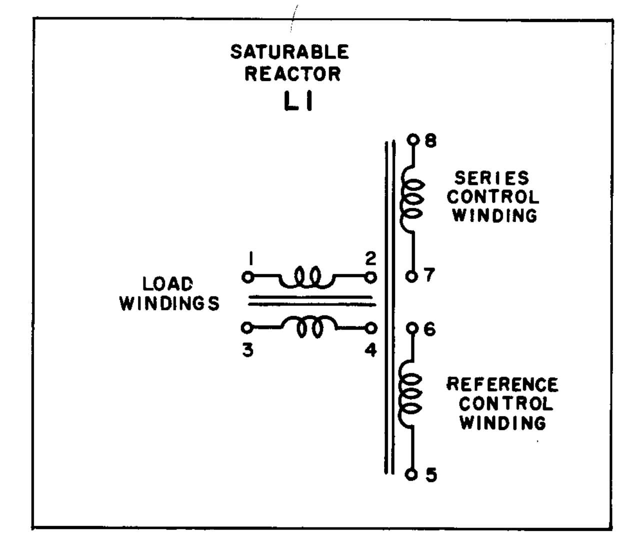


Fig. 5 — Functional Schematic KS-15620 L10 Rectifier