RECTIFIERS
KS-15620
FERRORESONANT TYPE
OPERATING METHODS

CONTENTS PAGE

1. GENERAL 1
2. LIST OF TOOLS AND TEST APPARATUS . 4
3. OPERATION 9
3.01 Preparing to Start 9
3.02 Starting 10
3.03 Stopping 10
4. ROUTINE CHECKS 10
5. TROUBLES 13
Trouble Chart 13

1. GENERAL

1.01 This section covers the operation of the KS-15620 L7, L8, L9, L11 through L17, ▶L21, L22, and L23◀ automatically regulated semiconductor-type rectifiers using ferroresonant control.

1.02 This section is reissued to add the KS-15620 L21, L22, and L23 rectifiers. This issue does not affect the Equipment Test List.

1.03 The rectifiers covered by this section are all of the full wave type. They are designed for operation from a single-phase, 60 Hz $\pm$0.1 Hz, 115- and 117-volt $\pm$10 percent ac power source and are rated as follows:

KS-15620 RECTIFIER LIST NO.	AT&TCO RATING *	POWER SERVICE VOLTS AC	DC OUTPUT-CONTINUOUS VOLTS	DC OUTPUT-CONTINUOUS AMPERES
7,8	MD	115	48	6.0
9	MD	115	48/55	2.0
11, 13, 15	MD	117	48	6.0
12, 14, 16	MD	117	48	2.0
17	STD	117	48	1.6
21	STD	115	48/55	2.0
22	STD	117	48	2.0
23	STD	117	48	6.0

* The abbreviations MD and STD signify Manufacture Discontinued and AT&TCO Standard, respectively.

1.04 ▶The KS-15620 L17, L21, L22, and L23 rectifiers are used to supply power to the following equipment:

L17—Traffic Measurement System No. 1A (J3B005A)

L21—No. 2 Telegraph Serviceboard (J70100AA-2)
No. 9B Telegraph Serviceboard
Data Observing Transmission Center

L22—Type 0 Carrier Terminals (J86454)
83B1, 83B2, and 83B3 Selective Calling System (J70125)
SS1 Selective Signalling System (J99252)
81D1 Teletypewriter System (J70095)
82B1 Teletypewriter Switching System (J70124)
E6 Repeater (J99253)

L23—Type 0 Carrier Terminals (J86454)
TJ Radio—Order Wire and Alarm Circuits
100A Operator Training Equipment.◀

1.05 All rectifiers have pin jacks for measuring the output voltage. On all list number rectifiers except L17, screw type terminals are provided for ac and dc connections. On rectifier L17, the ac input is supplied through a permanently attached cord, and the dc output is supplied through a Western Electric Company #285B jack.

Warning: 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.

1.06 The instructions in this section are based on Power Data Section 4.43, sheets ▶1◀, 5, 7, 8, ▶17◀, and 18 and KS-Specification KS-15620, Issue 14.

1.07 For more detailed information on the operation and maintenance of associated equipment or apparatus, refer to the appropriate Bell System Practices.

DESCRIPTION—KS-15620 L7 Rectifier (See Fig. 1)

1.08 Power is fed through an ac line filter to a transformer consisting of two coils, one linear or nonsaturable reactor L3 and one nonlinear or saturable reactor L4. The primary winding of L3 is in series with the primary winding of L4. Capacitors C1 and C2 are in parallel with L4. The core material used in the nonlinear reactor L4 has a reasonably rectangular hysteresis loop. This circuit is designed so that at every half cycle the nonlinear core is saturated and the reactance of the nonlinear core reduced to a low level. The linear core provides sufficient series impedance to prevent the input current from increasing to high values during saturation.

1.09 The current from capacitors C1 and C2 flows through the primary winding on the nonlinear core during the time that it is saturated, thereby discharging the capacitors. Because the primary winding sets up a flux in the same direction as the original flux, if the latter is decreasing, the current in the primary winding on the nonlinear core continues to flow in the same direction, recharging C1 and C2 in the opposite direction. The nonlinear core now comes out of saturation and the flux builds up in the opposite direction. The nonlinear core will saturate again at the end of this half cycle causing the capacitors to discharge, then recharge, and the process repeats.

1.10 Since the saturation flux for a given core is a fixed quantity, the net result is a constant volt-time area under the secondary voltage wave form. Because the period of oscillation is constant (as determined by the input frequency) and the volt-time area of the secondary voltage is fixed, the net result is a fixed voltage output for varying input voltages. Some compensation for load variations is provided by connecting the secondary winding of the nonlinear reactor L4 in series with a secondary winding of the linear reactor L3. As the load increases, the current in the input circuit increases and since the voltage induced in the secondary of the linear reactor L3 is proportional to the change in current, some degree of load regulation is accomplished.

1.11 The output voltage is fed to the bridge-type full-wave rectifier consisting of diodes CR1 through CR4. The output filter section consists of capacitor C4 and a double-tuned filter consisting of inductor L1 and capacitor C3 in parallel with inductor L2. The taps on inductor L1 are factory selected to obtain minimum output ripple. Bleeder resistor R1 maintains minimum load on the rectifier output. A filter unit is provided in the ac input to reduce any RF interference from feeding back through the ac line.

Description—KS-15620 L8, L9, L11 through L16, ◗L21, L22, L23◖ rectifiers (See Fig. 2 through 9, ◗11, 12, and 13◖)

1.12 Power is connected to the ferroresonant transformer T1 consisting of primary and secondary coils wound on separate sections of the core. A magnetic shunt is placed between these two sections so as to produce loose magnetic coupling between the primary and secondary windings. Due to the loose coupling, that portion of the core within the secondary winding may be driven into saturation with negligible effect on the primary winding.

1.13 The capacitor connected across the secondary winding on the saturable section of the core resonates with the effective reactance of the transformer at the input frequency. This reactance is nonlinear (varying instantaneously through each half cycle) and, consequently, the term resonance as used here differs somewhat from the meaning applied to linear circuits. One effect of this difference is the generation of nonsinusoidal waveforms. In this circuit, as in linear series resonant circuits, it is possible to develop voltages across the resonant elements greater than the applied voltage. This characteristic is used here to develop voltages in the secondary winding sufficient to produce saturation flux levels in the portion of the core under the secondary winding.

1.14 The core material used in transformer T1 has a reasonably rectangular hysteresis loop. The transformer is designed so that at every half cycle the secondary core is saturated, with the flux reversing at every half cycle. Since the saturation flux for a given core is a fixed quantity, the net result is a constant volt-time area under the secondary voltage waveform. Because the period of oscillation is constant (as determined by the input frequency) and the volt-time area of the secondary voltage is fixed, the net result is a fixed voltage output for varying input voltages.

1.15 The output voltage is fed to the rectifying element and filtered of its ac ripple to a relatively smooth direct current. The filter is formed by inductor L1 and capacitors as follows.

RECTIFIER LIST NO.	CAPACITOR
8	C2 through C7
9, 21	C1 and C2
11	C2 through C5
12 through 16, ◗22, 23◖	C2 and C3

1.16 The output voltage is unregulated for load current changes and an increase in load current will reduce the output voltage. Resistor R1 maintains a minimum load on the output of the rectifier and also discharges the filter capacitors when the rectifier is disconnected from input power and load.

1.17 On the L9 and ◗L21◖ rectifiers, the 48- and 55-volt taps on the transformer T1 permit the selection of 48- or 55-volt operation.

Description—KS-15620 L17 Rectifier (See Fig. 10)

1.18 Power is supplied through the ac input fuse F1 across the primary winding of transformer T1. The capacitor C1 is connected across the secondary winding of T1 to form a ferroresonant regulator. The effective capacitive reactance of the ferroresonant regulator tends to maintain a constant voltage across terminals 4 and 5 of T1 for varying input voltages. The voltage across terminals 4 and 5 of T1 will vary with input frequency fluctuation. The voltage varies approximately 1.5 percent for every 1 percent change in input frequency (60 Hz).

1.19 The output voltage is fed to a bridge-type full-wave rectifier consisting of diodes CR1 through CR4. The output filter, consisting of capacitors C2, C3 and inductor L1, reduces the ac ripple to a low value. The output voltage is unregulated for load current changes and an increase in load current reduces the output voltage. Output fuse F2 protects the rectifier against overload conditions. The bleeder resistor R1 maintains a minimum load on the rectifier output and also discharges the filter capacitors when the rectifier is disconnected from the input power and load.

1.20 The circuit components are mounted on an aluminum plate which fits into an ABS plastic case with a removable cover. The plastic case is provided with mounting feet, and a carrying handle. The rectifier will operate with the case cover closed. The rectifier unit is portable, weighing approximately 22 pounds and measures 16 1/8 inches long, 8 1/4 inches wide, and 8 1/4 inches high. The ac input voltage is supplied through a 3-wire, 10 feet long cord and plug. A power-on lamp DS1 is provided to indicate that the ac input voltage is available. The rectifier unit is equipped with a single conductor grounding cord, 12 feet long. The grounding cord is permanently connected to the rectifier chassis and is connected to the rectifier positive output terminal. The free end of the grounding cord is equipped with an insulated alligator clip (Mueller #27 or equivalent).

2. LIST OF TOOLS AND TEST APPARATUS

CODE OR SPEC NO. TOOLS	DESCRIPTION
—	3-Inch C Screwdriver

TEST APPARATUS

KS-14510	Volt-Ohm-Milliammeter
—	Ammeter, DC Model No. 281, Scale 1.5-3-30, Weston Electrical Instrument Corporation or the Replaced No. 280
—	Variable Resistance Load Capable of Carrying 6 Amperes at 60 Volts
—	Plug-WECo #310 or Equivalent (Required for load test of L17 rectifier)

TABLE A – OUTPUT REQUIREMENTS

LIST		VOLTS – DC	CURRENT – AMPERES
7, 8, 11, 13, 15, 23		45 to 50	0 to 6
9	48-Volt Tap	45 to 51	0 to 2
	55-Volt Tap	52 to 58	0 to 2
12, 14, 16, 22		45 to 51	0 to 2
17		45 to 51	0 to 1.6
21	48-Volt Tap	45 to 51	0 to 2
	55-Volt Tap	52 to 58	0 to 2

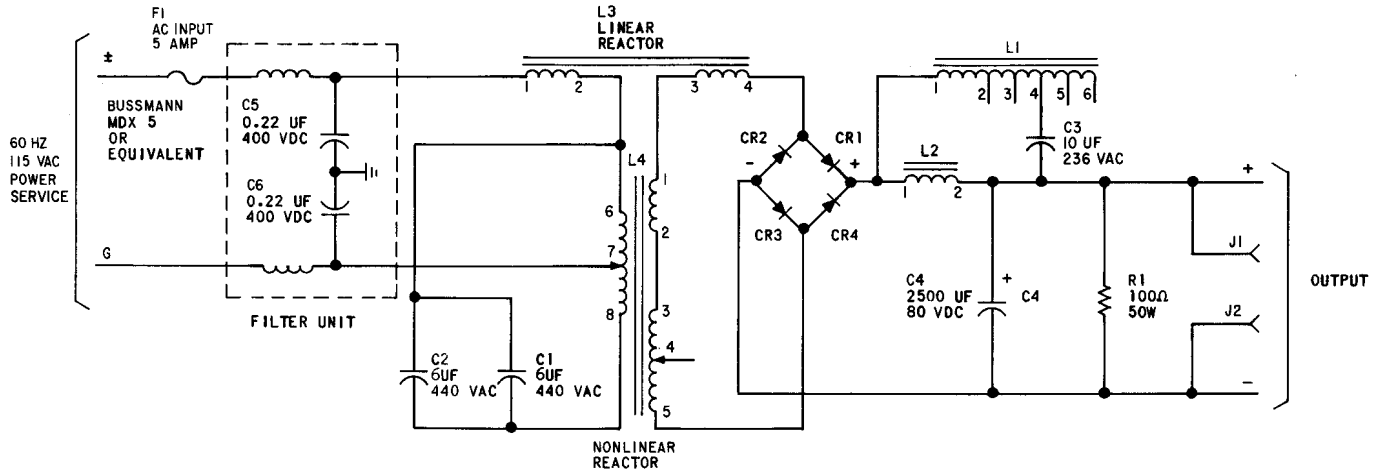


Fig. 1—KS-15620 L7 Rectifier

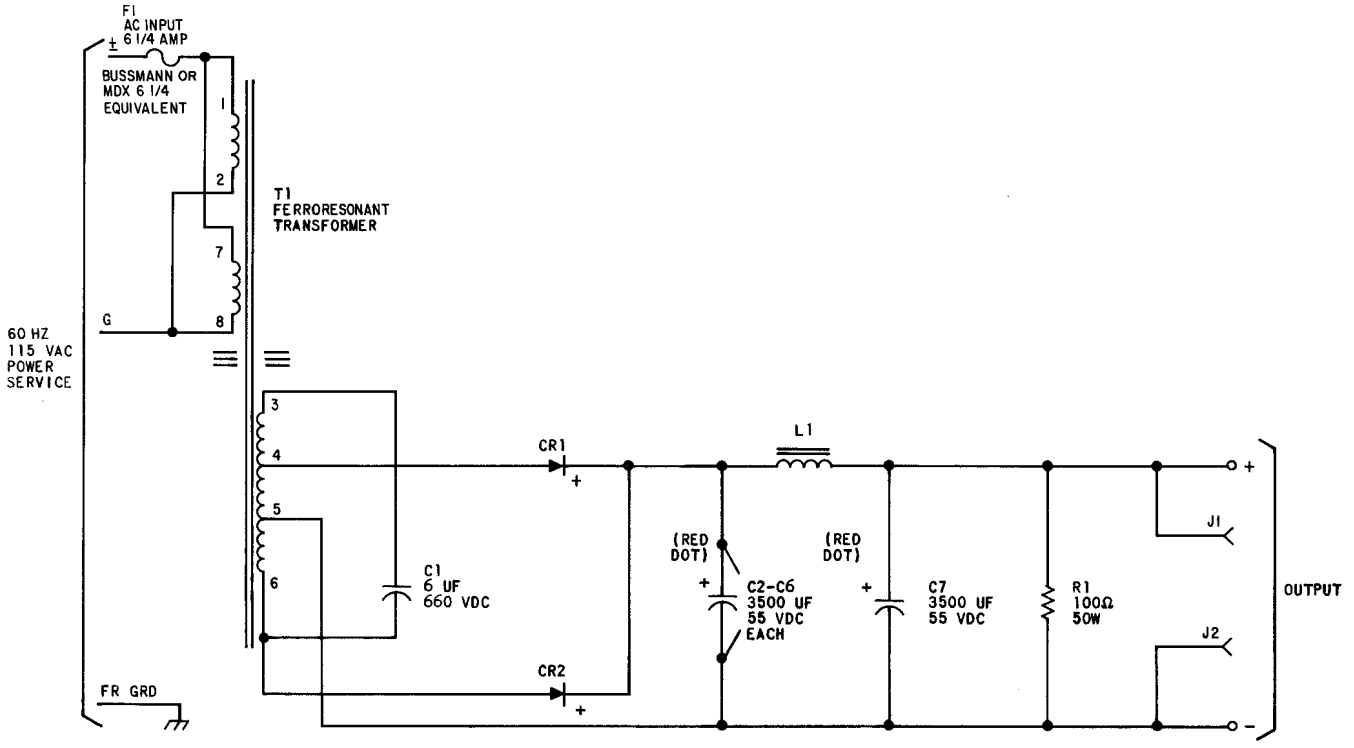


Fig. 2—KS-15620 L8 Rectifier

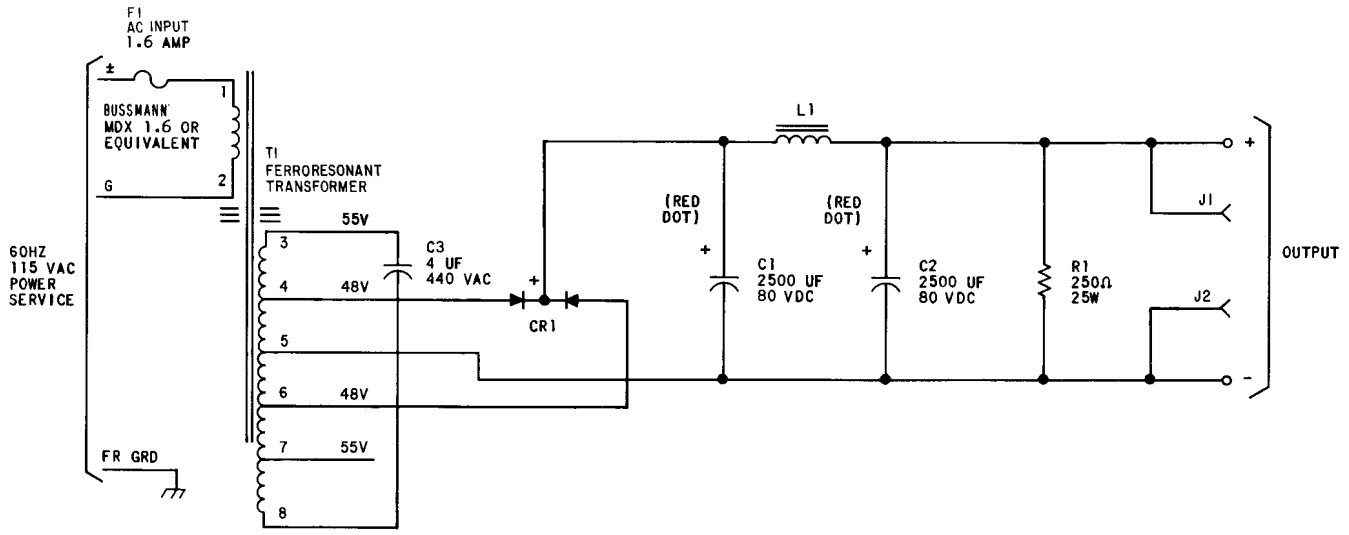


Fig. 3—KS-15620 L9 Rectifier

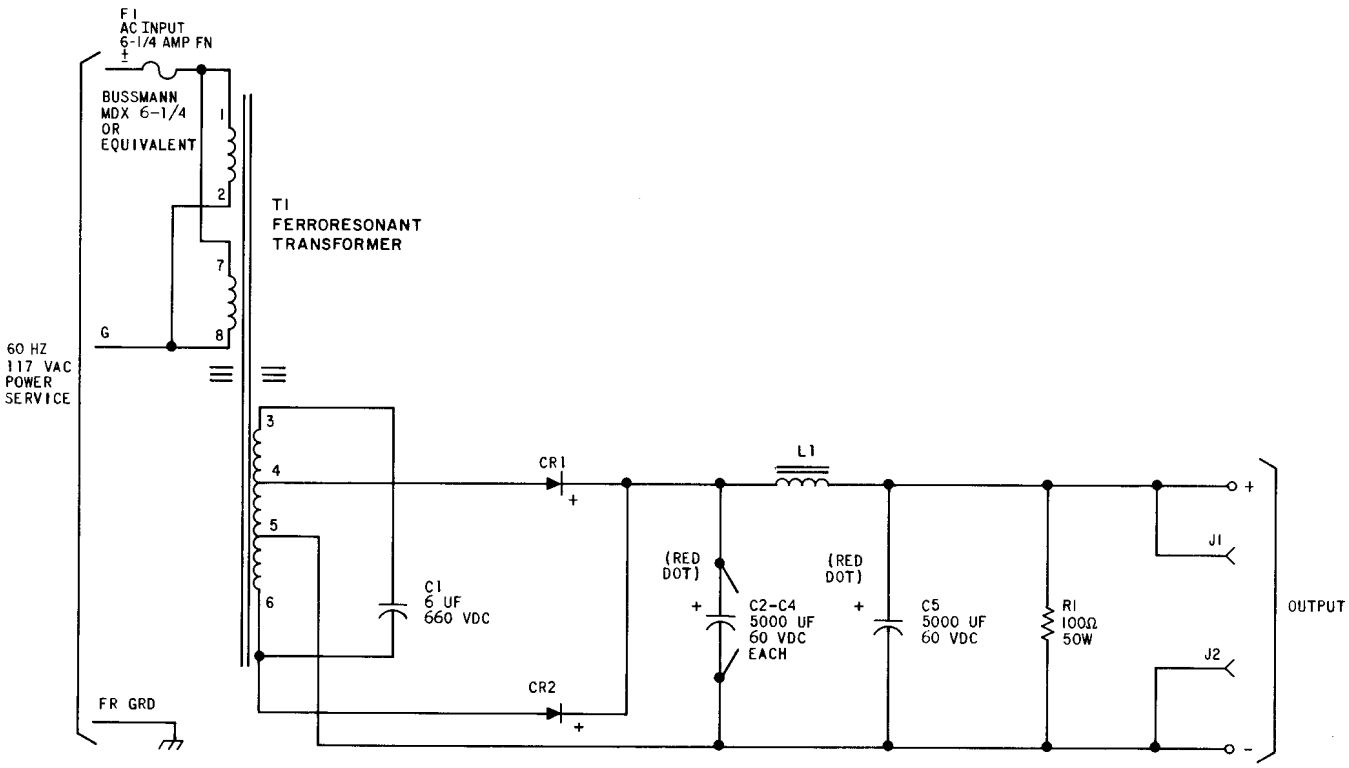


Fig. 4—KS-15620 L11 Rectifier

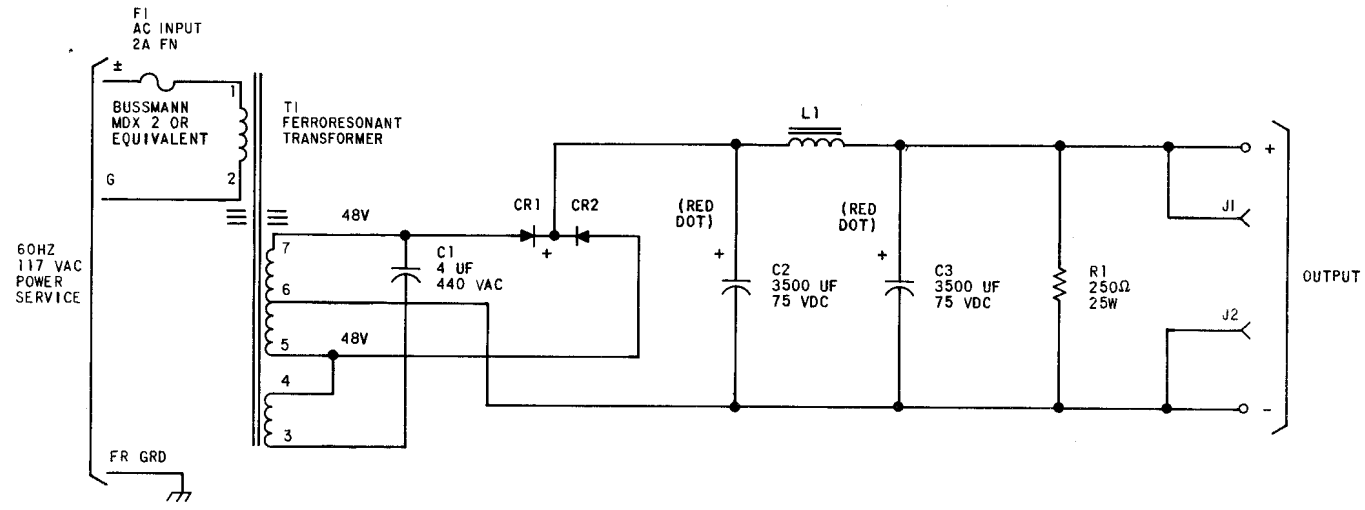


Fig. 5—KS-15620 L12 Rectifier

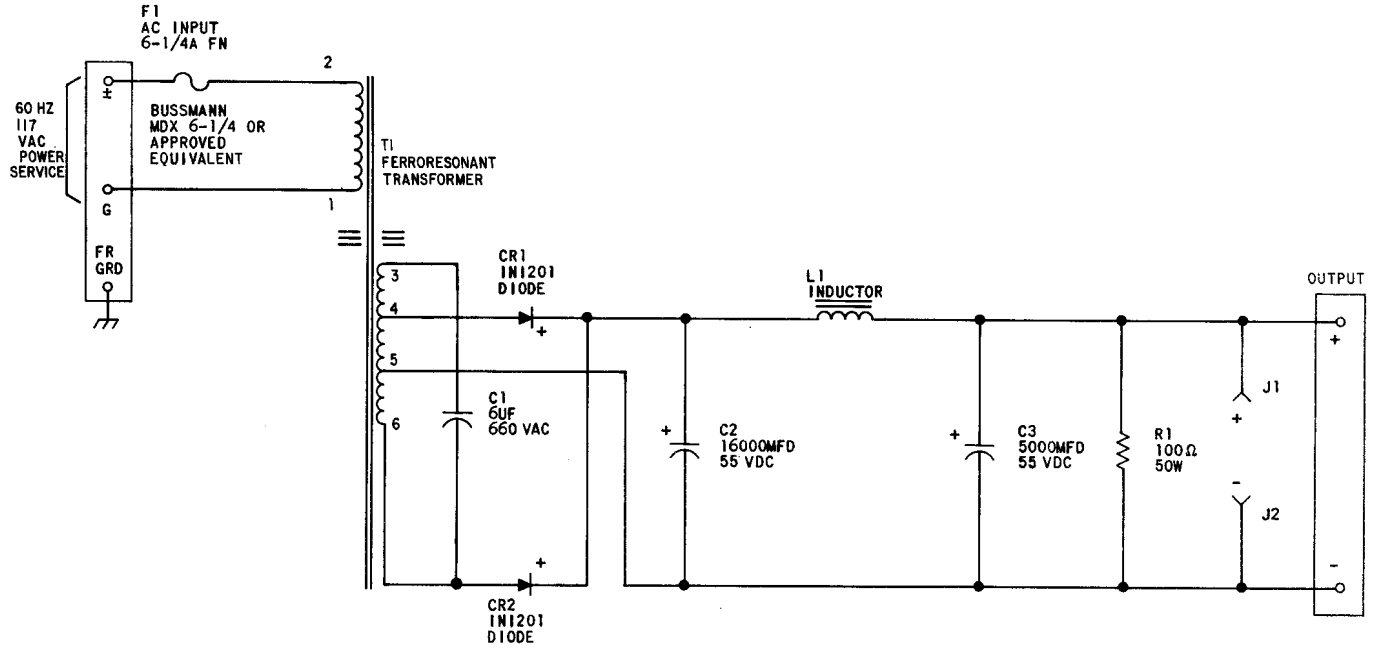


Fig. 6—KS-15620 L13 Rectifier

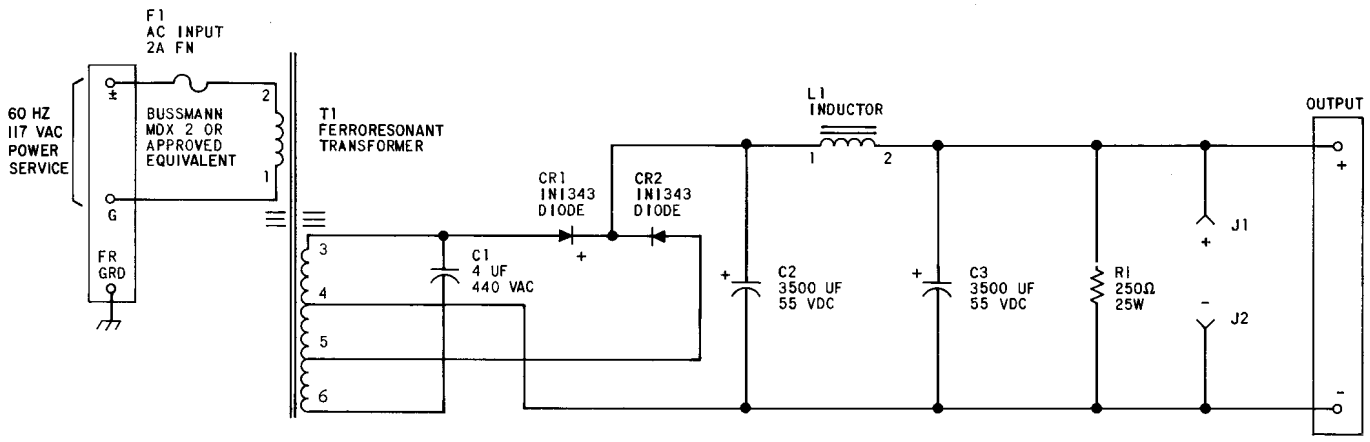


Fig. 7—KS-15620 L14 Rectifier

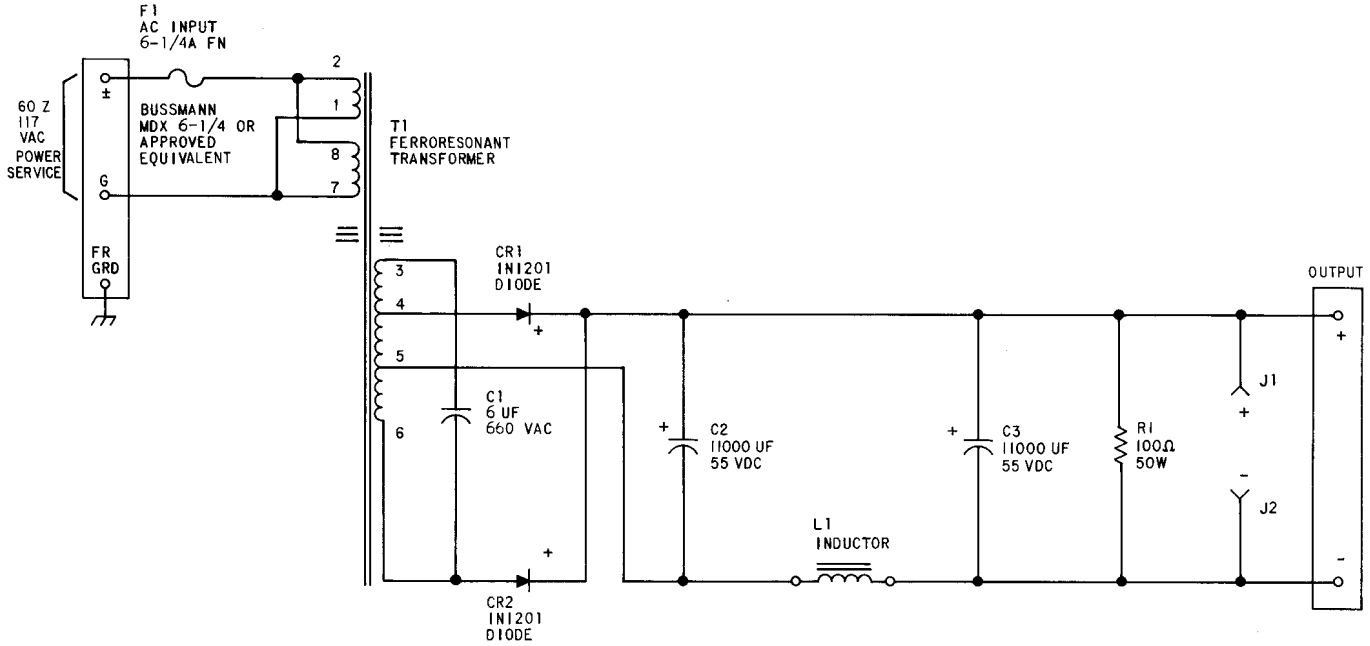


Fig. 8—KS-15620 L15 Rectifier

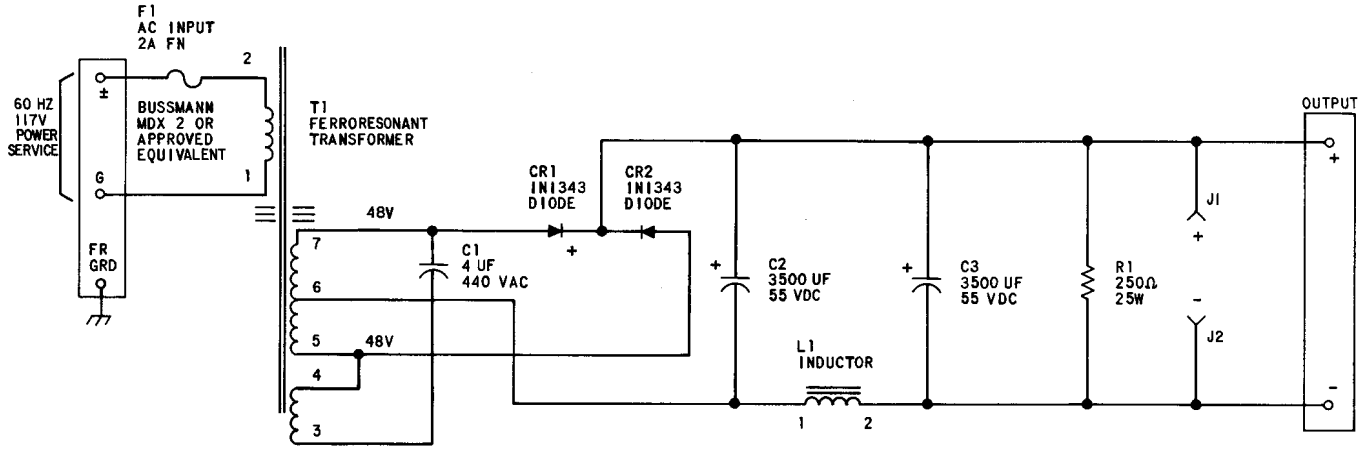


Fig. 9—KS-15620 L16 Rectifier

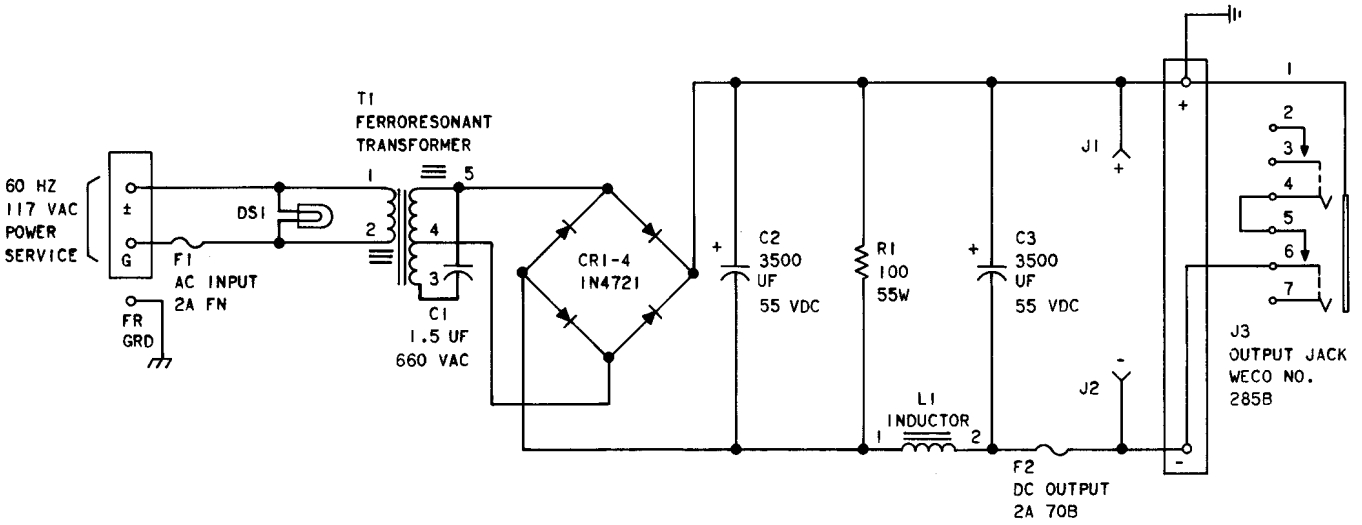


Fig. 10—KS-15620 L17 Rectifier

3. OPERATION

3.01 ***Preparing to Start:*** When preparing to put the rectifier in service, check the following.

(1) The proper size and type ac input fuse is available but ***not*** installed.

(2) All external connections are made in accordance with the schematic drawing covering the associated circuit of which the rectifier is a part.

(3) The associated equipment leads are connected to the rectifier output terminals. On rectifier L17, the associated equipment plug is connected in the rectifier output jack and the 70-type output fuse F2 is installed in the output fuse

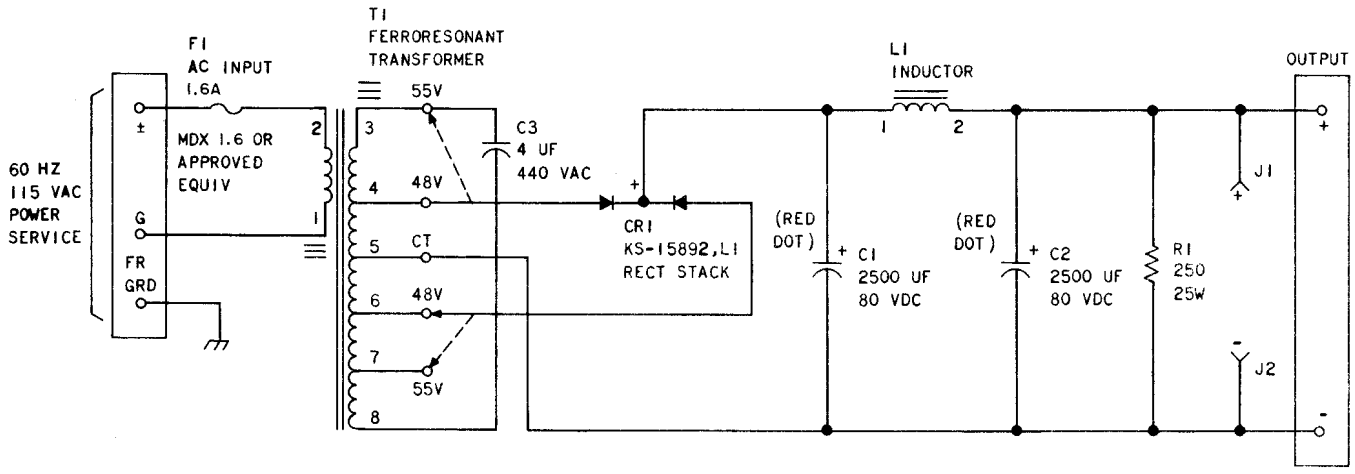


Fig. 11—KS-15620 L21 Rectifier

holder. The ground lead is connected to an approved ground.

(4) The ac input leads are connected to the rectifer input terminals. On rectifier L17, the ac cord is connected in the appropriate ac outlet.

3.02 ***Starting:*** To place the rectifier in service, proceed as follows.

(1) Insert the ac input fuse F1 in the associated fuse holder.

(2) Connect the KS-14510 volt-ohm-milliammeter, set on the 60 volts dc scale, to the (+) and (−) output test jacks.

Requirement: The KS-14510 meter indication should meet the output voltage requirement given in Table A.

3.03 ***Stopping:*** To stop the rectifier, remove the associated ac input fuse F1.

Caution: If the rectifier is removed from service for an extended period of time, the electrolytic capacitors should be connected to a source of direct current of suitable voltage and polarity as covered in 032-110-701.

4. ROUTINE CHECKS

4.01 Routine checks are intended to detect defects, and to guard against circuit failures which interfere with service. Perform the routine checks in accordance with the Equipment Test List, when the rectifier is initially started, and when the rectifier has been out of service for an extended period of time and is being returned to service. Checks other than those required by trouble conditions should be made during a period when they will not interfere with service.

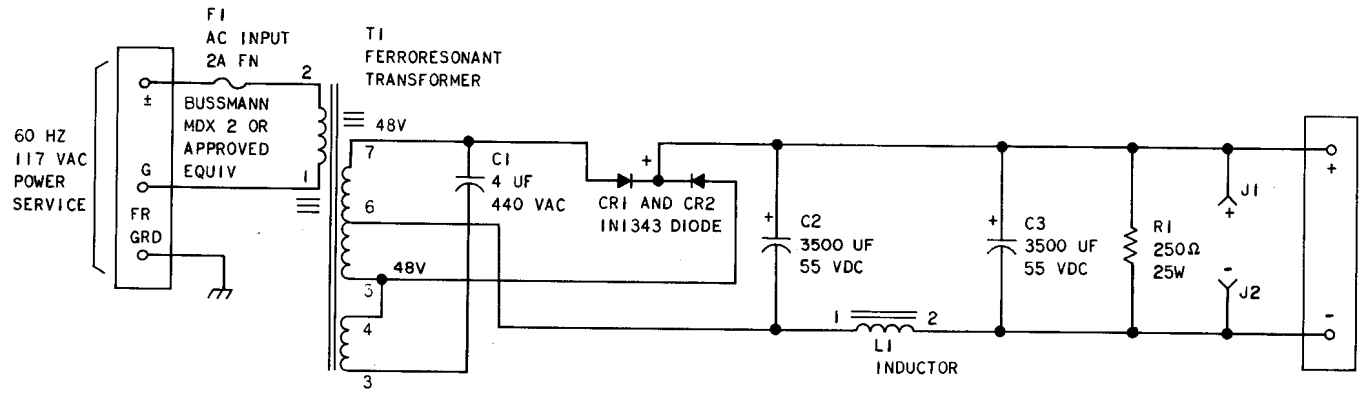
4.02 ***Clean Ventilating Passages:*** Keep the ventilating passages of the rectifier unobstructed to avoid excessive heating. The interior of the rectifier should be cleaned periodically while the rectifier is shut down. The cleaning procedure should be determined by local conditions.

4.03 ***Electrolytic Capacitors:*** Maintain electrolytic capacitors in accordance with Section 032-110-701.

4.04 ***Semiconductors:*** Maintain semiconductor devices in accordance with Section 032-173-301.

4.05 ***Output Voltage Check:*** Check the output voltage periodically under office load as follows.

(1) Connect the KS-14510 volt-ohm-milliammeter, set on the 60 volts dc scale, to the (+) and (−) test jacks.



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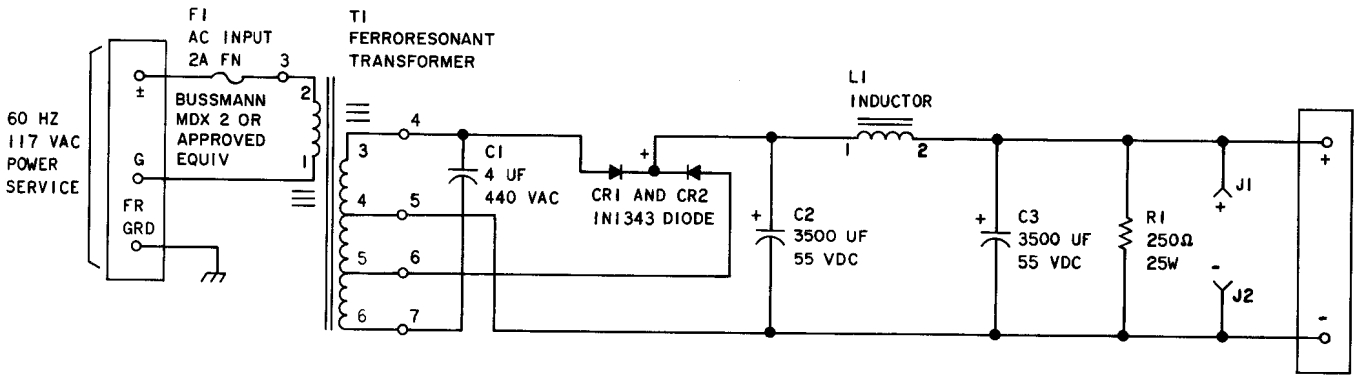

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Fig. 12—KS-15620 L22 Rectifiers

Requirement: The KS-14510 meter indication must be within the voltage range in Table A.

(2) Disconnect the KS-14510 meter from the (+) and (−) test jacks.

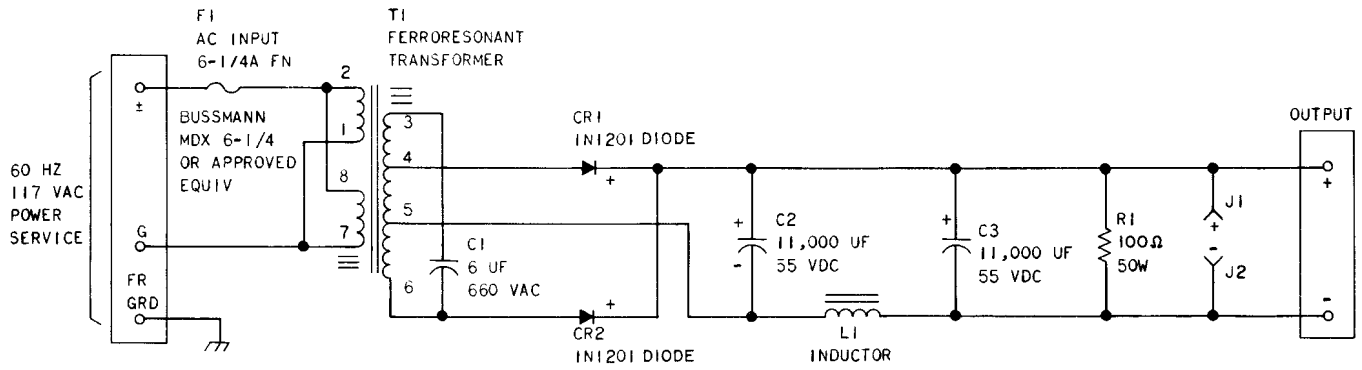
4.06 ***Test Load—Output Voltage Check:*** Check the output voltage under a variable test load as follows.

(1) Remove the associated ac input fuse.

(2) Disconnect the associated equipment leads from the rectifier output terminals. On rectifier L17, remove the associated equipment plug from the rectifier output jack.

(3) Connect an ammeter in series with the variable test load.

(4) Connect the test load and the series connected ammeter across the output terminals of the rectifier. On rectifier L17, the WECo #310 plug



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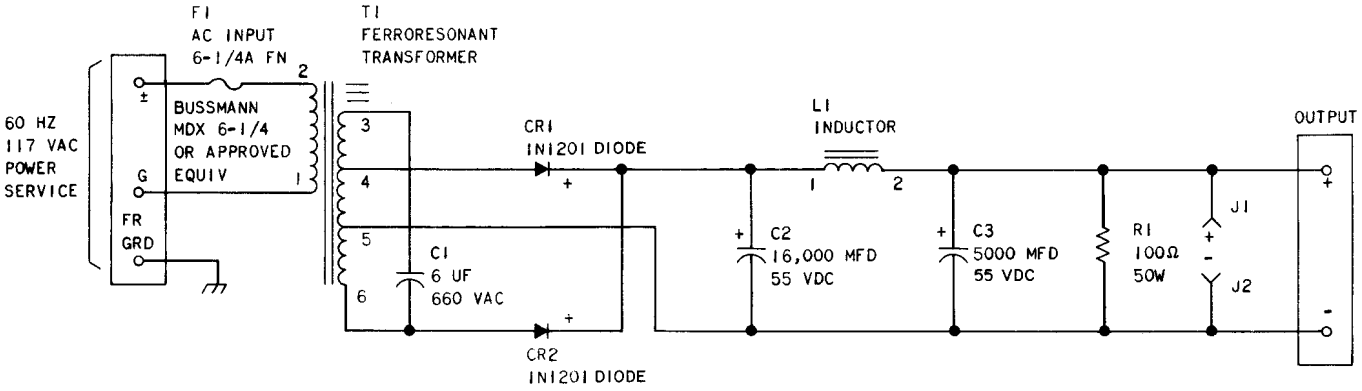

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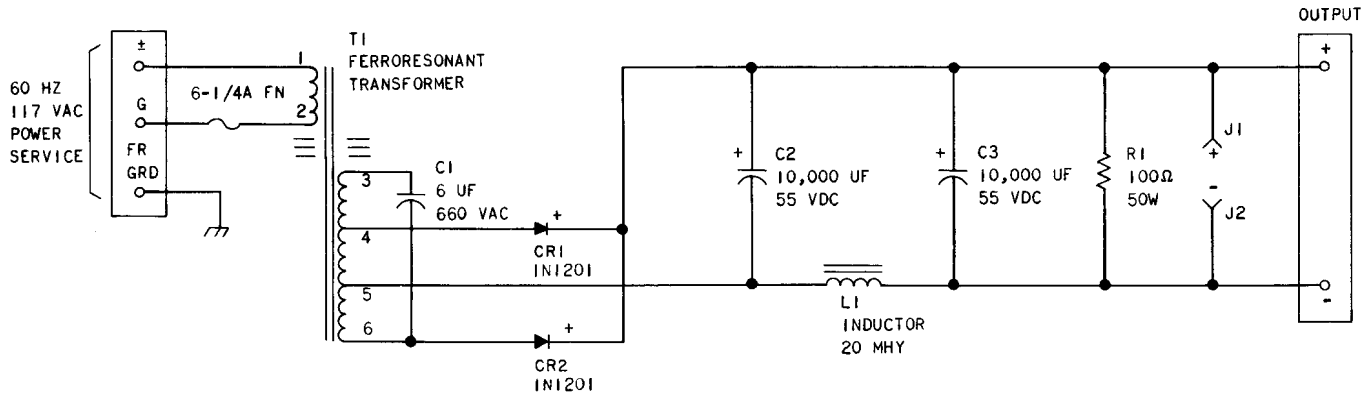

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Fig. 13—KS-15620 L23 Rectifiers

is used for output pick-up from the rectifier output jack (WECo #285B).

(5) Connect the KS-14510 volt-ohm-milliammeter, set on the 60 volts dc scale, to the (+) and (−) test jacks.

(6) Insert the ac input fuse in the associated fuse holder.

(7) Observe the rectifier output voltage while adjusting the test load from no load to full load.

Caution: Do not exceed the rectifier output current rating as given in Table A.

Requirement: The rectifier output voltage must meet the output voltage requirement in Table A.

(8) Operate the rectifier at full load capacity for at least 30 minutes.

(9) Repeat the no load to full load check in (7).

(10) Remove the associated ac input fuse.

(11) Disconnect the test load from the rectifier output terminals. On rectifier L17, remove the test load plug from the rectifier output jack.

(12) Disconnect the KS-14510 meter from the (+) and (−) test jacks.

(13) Connect the associated equipment leads that were disconnected in (2). On rectifier L17, reconnect the associated equipment plug in the rectifier output jack.

(14) To start the rectifier, insert the ac input fuse in the associated fuse holder.

5. TROUBLES

5.01 In general, the only items likely to become defective with use are the electrolytic capacitors and semiconductor diodes.

5.02 Any replacement of the L4 and L3 reactors on the L7 rectifier and of the T1 ferroresonant transformer on the L8, L9, L11, L12, L13, L14, L15, L16, L17, ◗L21, L22, or L23◖ rectifier should be made at the factory of the supplier. All other components can be replaced in the field. When replacement of the rectifying element is required, proceed as covered in 5.03.

5.03 ***Silicon and Germanium Rectifier Stacks and Diodes:*** Do not attempt to replace a diode in the stack assembly. When replacements are required, replace the entire stack. Do not combine stacks of different list numbers or different manufacturers. Do not attempt to replace any single diode. When replacements are required, replace all the diodes at the same time and do not combine diodes produced by different manufacturers.

Trouble Chart

5.04 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.
	Blown dc output fuse (L17).
Low dc output voltage	Low line voltage.
	High resistance at some connection in line circuit.
	Overload.
	Defective C3 capacitor (L9 and ◗L21◖)
	Defective C1 or C2 capacitor (L7).
	Defective C1 capacitor (L8, L11, L12, L13, L14, L15, L16, L17, ◗L22 and L23◖)
	Defective CR1 or CR2 rectifying elements (L8, L9, L11, L12, L13, L14, L15, L16, ◗L22 and L23◖)

TROUBLE	POSSIBLE CAUSE
	Defective CR1, CR2, CR3, or CR4 diode (L7 and L17).
High dc output voltage	Defective C3 capacitor (L9 and ◗L21◖)
	High line voltage.
	Defective C1 or C2 capacitor (L7).
	Defective C1 capacitor (L8, L11, L12, L13, L14, L15, L16, L17, ◗L22, and L23◖)
	Shorted filter inductor.
High ripple	Open filter capacitor.
	Shorted filter inductor.