

KS-20618 REGULATOR FOR SINGLE PHASE RECTIFIERS TEST PROCEDURES

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1. GENERAL

1.01 The KS-20618 regulator consists of four printed circuit boards and is intended for the control of dc output power and to provide alarm functions for rectifiers using thyristors or a triac-ferroresonant transformer combination. Its primary function is to regulate the output voltage of a rectifier at some preset level. In addition, the circuit provides current limiting and accepts control signals from the plant.

1.02 This issue does not affect the Equipment Test List.

1.03 The KS-20618 regulator is designed for use in rectifiers—such as the KS-20491, KS-20493, J87348, or J87349 rectifiers—to regulate respective output requirements. The KS-20618 regulator may be used wherever the capacity and regulation characteristics meet the specific requirement of equipment with which it will be associated.

1.04 The KS-20618 regulator operates from single-phase, 2-wire ac voltage, 57 to 63 Hertz. The variation from any ac input voltage is +5 and -10 percent. The output voltage regulation of a rectifier for combined line and load variation

is ± 0.5 percent steady state when the rectifier is designed to use the KS-20618 regulator.

1.05 Two of the four printed circuit boards in the KS-20618 regulator perform the functions for voltage and current control, the third contains the alarm and plant control functions, and the fourth board furnishes the power for the other three boards.

1.06 This issue of the section is based on the following drawing:

SD-82030-01, Issue 1

If this section is to be used with equipment or apparatus reflecting later issue(s) of the drawing(s), reference should be made to the SDs and CDs to determine the extent of the changes and the manner in which the section may be affected.

1.07 Refer to Section 032-173-301 for additional information for testing, replacing, and handling of circuit packs and semiconductor devices.

2. LIST OF TOOLS AND TEST APPARATUS

CODE OR SPEC NO.	DESCRIPTION
TOOLS	
—	3-Inch C Screwdriver
TEST APPARATUS	
—	Oscilloscope, Tektronix Model 545 with Dual Trace Vertical Preamplifier (or equivalent)
—	Digital multimeter, John Fluke Mfg. Co. Model 8100A AC and DC Volts (or equivalent)
KS-14510	Volt-Ohm-Milliammeter

3. OPERATION**A. General Description**

3.01 *KS-20618 L1 Pulse Circuit (CP1):* The List 1 circuit board, PULSE CIRCUIT, provides pulses for application to gates of thyristors or triacs at some time during the interval of 0 to 180 degrees of the ac sine wave being controlled and/or rectified. A second gate signal is provided during the interval of 180 to 360 degrees of the ac sine wave. The delay angle is controlled by a voltage signal from the VOLTAGE REGULATION AND CURRENT CIRCUIT (CP2). Pulses are generated in CP1 by a blocking oscillator which is controlled by the outputs of two voltage comparators, one for each half-cycle. The outputs of the comparator circuit depend on the relative magnitudes of an error signal from CP2 and the changes of the reference wave form which changes with supply voltage and load conditions.

3.02 *KS-20618 VOLTAGE REGULATION AND CURRENT CIRCUIT (CP2):* The List 2 circuit board, VOLTAGE REGULATION AND CURRENT CIRCUIT, compares the associated rectifier output voltage with a reference voltage which provides the PULSE CIRCUIT (CP1) with an error signal representing the polarity and magnitude of the difference. The CP2 also provides a circuit to limit the output current of the associated rectifier to an adjustable value between 50 percent and full load. A circuit is also provided which will limit the rate at which the rectifier will accept load when started. The circuit is design to work with either positive or negative output rectifiers by making simple wiring options in the external wiring to the circuit packs.

3.03 *KS-20618 L3 ALARM CIRCUITS (CP3):* The List 3 circuit board, ALARM CIRCUITS, provides circuits for controlling the associated rectifier from the plant circuit, sensing trouble conditions, and automatically shutting down the rectifier under alarm conditions.

3.04 *KS-20618 L4 DC POWER SUPPLY CIRCUIT (CP4):* The List 4 circuit board, DC POWER SUPPLY CIRCUIT, provides various dc voltages for Lists 1, 2, and 3 circuit boards. A voltage monitor circuit is provided to prevent the associated rectifier from operating unless power supply voltages are above a preset minimum.

B. Rectifier Operation

3.05 *Normal Operation:* Normally a rectifier circuit will remain energized and connected to the battery. In addition to manual starting and stopping, the rectifier may be stopped and restarted by signals from the power plant and will shut down automatically upon occurrence of certain trouble conditions.

Starting

3.06 In normal operation with the rectifier output terminals BAT and GRD connected to the battery, the power plant control connected to the rectifier, and the external rectifier POWER ON-POWER OFF switch in the OFF position, the ac line voltage is applied to the DC POWER SUPPLY CIRCUIT (CP4) through fuses. The DC POWER SUPPLY CIRCUIT (CP4) furnishes internal control power to the various control circuits. The voltage regulator circuit (CP2) is connected to the "RG" and "RB" remote sensing leads.

3.07 *To start the rectifier,* the rectifier POWER ON-POWER OFF switch is depressed and released. Provided the voltage monitor circuit on (CP4) senses that sufficient internal regulator voltage is available, the external ac input contactor operates to connect ac input power to the rectifier and the POWER ON lamp lights. Simultaneously, the regulator walk-in circuit is activated so the rectifier output current starts out low and increases linearly toward full load. After the walk-in cycle is complete, the walk-in circuit has no further effect on the current limiting circuit.

Normal Shutdown

3.08 *To shut down the rectifier,* the POWER ON-POWER OFF switch is depressed and released, and the POWER OFF lamp is lighted. In power plant operation, the power plant may shut down the rectifier by a ground signal on the plant "TR" lead, the ST1 relay is released, releasing the ac input contractor. The rectifier then restarts when the ground is removed from the plant "TR" lead.

Trouble Shutdowns

3.09 *Battery Voltage Shutdown:* If the battery voltage should exceed a maximum limit, the power plant will apply ground to the "HV" lead.

If, at that time, the rectifier is carrying 5 amperes or more of current, the rectifier is shut down and locked out. The RECT FAIL lamp lights and a ground signal is sent to the power plant circuit over the "RFA" lead.

3.10 Blown Charge Fuse: If a rectifier fault should occur to short the rectifier output terminals, the external CHARGE fuse will operate, blowing its associated alarm fuse. The rectifier will shut down and lock out. The RECT FAIL lamp will light and a ground signal is sent to the power plant circuit over the "RFA" lead.

3.11 Voltage Monitor Shutdown (CP4): If for any reason the +15 and/or -15 volt supplies in the DC POWER SUPPLY CIRCUIT (CP4) fall below a preset value (for instance, if the external ac input fuses should operate), the ST1 relay is released which releases the ac input contactor, shutting down the rectifier but not locking it out. When the voltage is restored, the rectifier will restart automatically.

3.12 Removal of Circuit Packs: Removal of either CP1, CP2, CP3, or CP4 circuit pack from its socket inhibits the start or shuts down the rectifier. Reinserting the circuit packs in their proper sockets restores normal operation.

Restart After Trouble Shutdown

3.13 If either of the trouble conditions in 3.09 or 3.10 should occur the rectifier is restarted after the trouble is corrected by operating the POWER ON-POWER OFF switch to the OFF position, then to the ON position.

C. Rectifier Testing

3.14 In order to perform tests and adjustments on the rectifier independently of the battery load, proceed as follows:

- (a) Disconnect the PLANT QUICK DISCONNECT connector.

- (b) Remove the charge alarm fuse and the CHARGE fuse from the output of the rectifier.

This prevents alarms from being sent to the plant while testing. The "RG" and "RB" leads are opened and the SNS relay is released, transferring the sensing for CP2 to the rectifier output terminals. The rectifier local SNS lamp lights. The output voltage may be set and current functions may be adjusted and tested independent of battery load.

4. TROUBLESHOOTING PROCEDURES

4.01 The troubleshooting procedures have been arranged (Fig. 1 through 10) to check the most probable cause of rectifier failure. The test procedure should start with a visual inspection, voltage measurements with the voltmeter, and finally tracing with an oscilloscope.

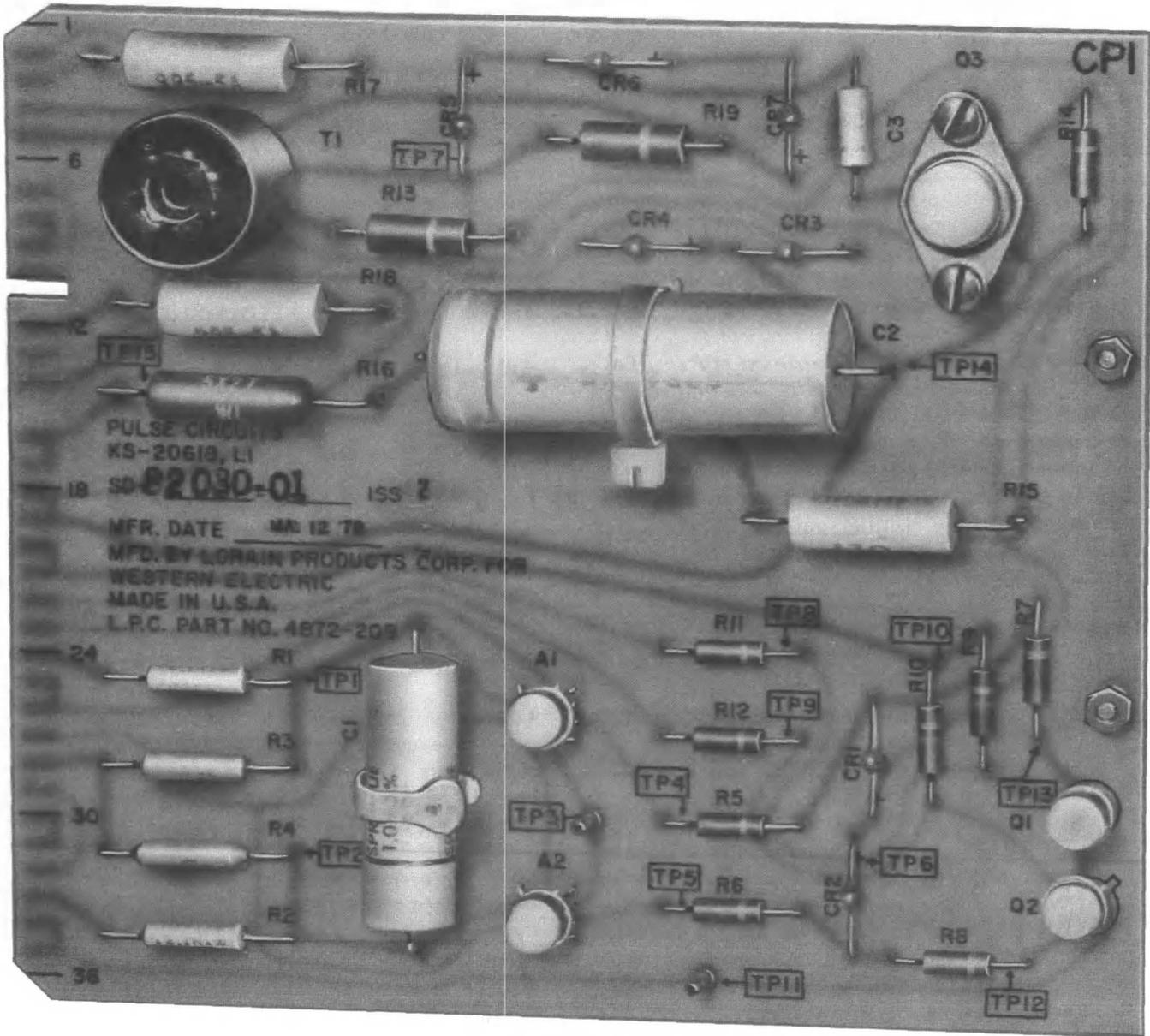
4.02 When signal tracing is necessary, select a properly grounded scope. Connect only one lead from the scope to the rectifier. Do not connect the ground lead of the oscilloscope to any part of the rectifier.

4.03 It is recommended that complete circuit boards be replaced rather than replacing components. Other associated circuit boards should be checked for possible damage before placing the rectifier back in service.

4.04 Reference should be made to the associated section for the rectifier. An analysis of the trouble indications will help determine which circuit pack should be checked. Reference should also be made to the associated rectifier SD and CD to assist in localizing trouble conditions.

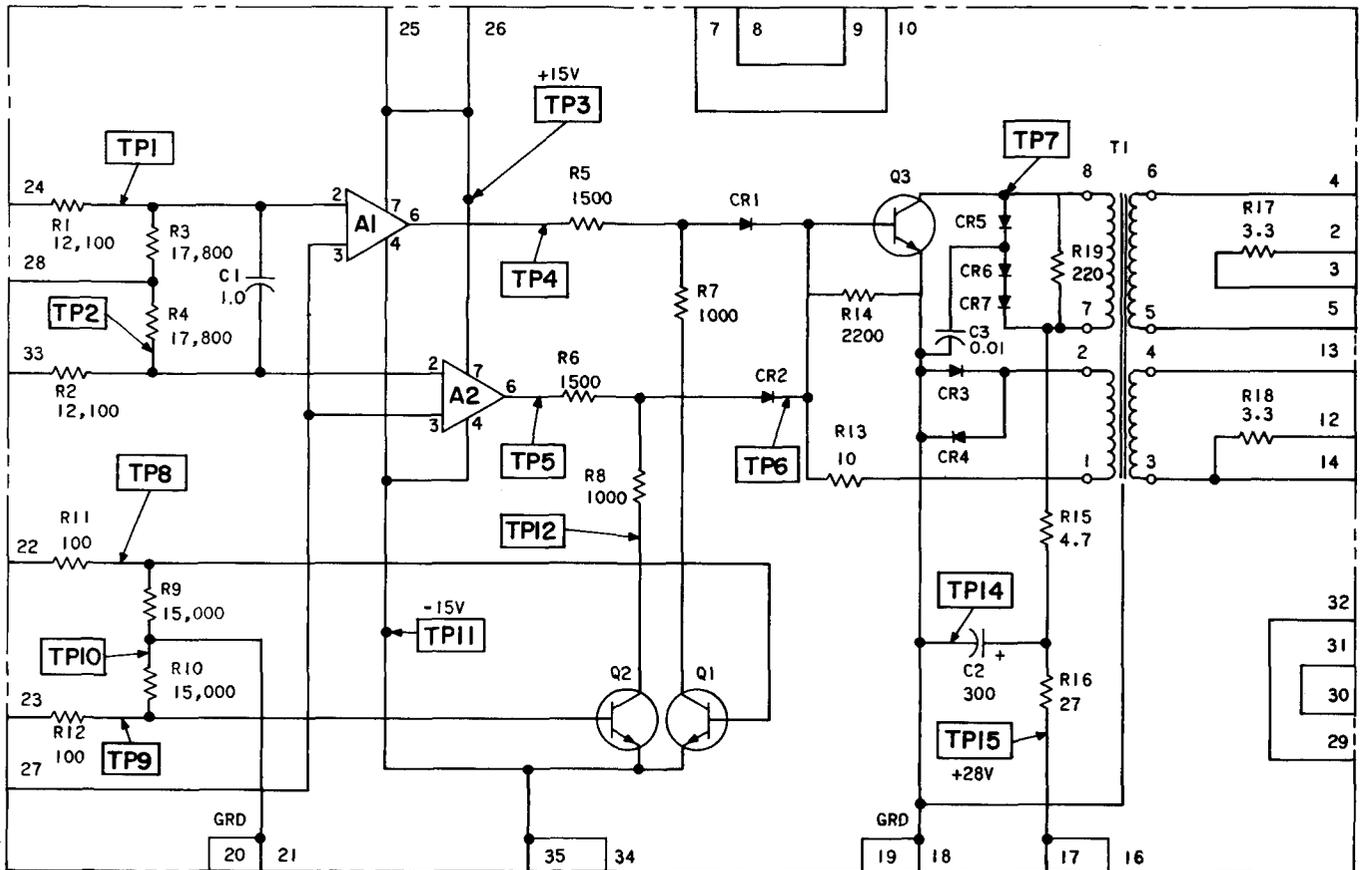


Before performing any tests or troubleshooting procedures, remove the rectifier from service as covered in C. RECTIFIER TESTING. This will prevent service reactions while performing tests on the rectifier.



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Fig. 1—KS-20618 L1 Pulse Circuits

**PRELIMINARY PROCEDURE:**

1. TURN OFF RECTIFIER.
2. REMOVE KS-20618, L1 CPI AND INSERT EXTENDER BOARD IN JCPI.
3. INSERT CPI INTO EXTENDER BOARD.

TESTING PROCEDURE:

1. TURN RECTIFIER ON.

CAUTION: TURN OFF RECTIFIER IMMEDIATELY IF OUTPUT VOLTAGE IS ABNORMALLY HIGH.

NOTE: IF THE OUTPUT VOLTAGE IS HIGH, THE POSSIBLE CAUSES ARE: DEFECTIVE TRANSISTOR Q3, SHORTED DIODE CR3 OR CR4, OR SHORTED CAPACITOR C1, C2, OR C3.

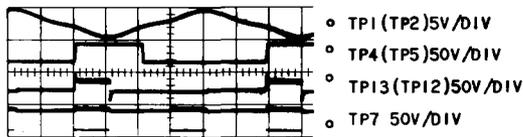
2. USING A DC OSCILLOSCOPE, SET AT APPROXIMATELY 3 MILLISECONDS PER DIVISION, CONNECT THE OSCILLOSCOPE TO THE TEST POINTS OR TERMINALS GIVEN IN FIG. 3, a THROUGH i. THE OPERATING CONDITION AND POSSIBLE CAUSES ARE GIVEN WITH EACH WAVEFORM.

NOTE: VOLTAGES SHOWN ARE TYPICAL WITH THE RECTIFIER AT 2 AMP LOAD.

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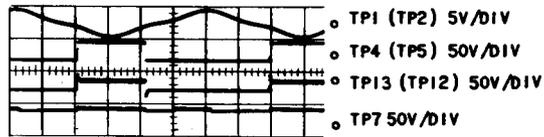
Fig. 2—Troubleshooting the KS-20618 L1 Pulse Circuits

SECTION 024-490-301



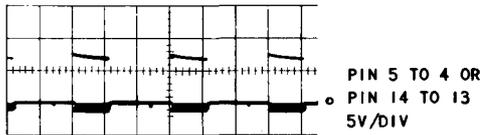
NORMAL OPERATION: (NOTE PHASE RELATIONSHIPS)
 TP1 (TP2) 5V(±1)
 TP4 (TP5) 24V(±4)
 TP13 (TP12) 15V(±1.5)
 TP7 27V (±3)

FIG. 3a



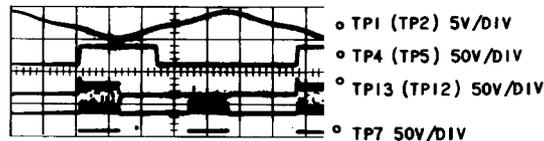
TROUBLE: PHASE AT TP7 AND TP13 (TP13) FOLLOWS TP4 (TP5)
POSSIBLE CAUSE: OPEN Q1 (Q2) OR SHORT BASE-EMITTER Q1 (Q2)

FIG. 3f



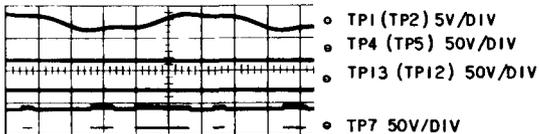
NORMAL GATE PULSES: 6.5V (±1)

FIG. 3b



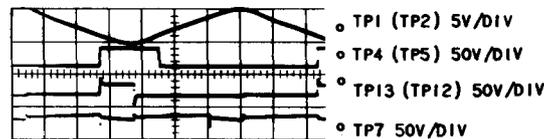
TROUBLE: HIGH AMPLITUDE REVERSE PULSES AT TP7
POSSIBLE CAUSE: OPEN CR3, CR4, CR5, CR6, OR CR7

FIG. 3g



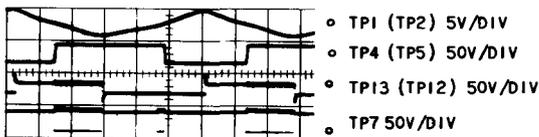
TROUBLE: NO SIGNAL AT TP4 (TP5)
POSSIBLE CAUSE: A1 (A2) DEFECTIVE

FIG. 3c



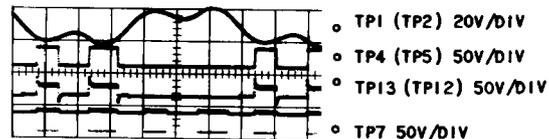
TROUBLE: Q3 WILL NOT OSCILLATE, THYRISTORS MAY MISFIRE
POSSIBLE CAUSE: OPEN FEEDBACK WINDING OF T1, TERM. 1 AND 2

FIG. 3h



TROUBLE: INCORRECT PHASE RELATIONSHIP BETWEEN TP4 (TP5) AND TP13 (TP12)
POSSIBLE CAUSE: SHORTED CR1 (CR2)

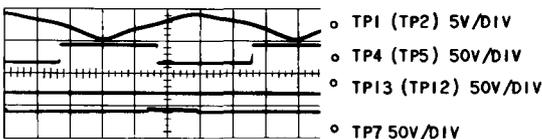
FIG. 3d



TROUBLE: INCORRECT WAVEFORM AT TP1 (TP2)
POSSIBLE CAUSE: OPEN C1

FIG. 3i

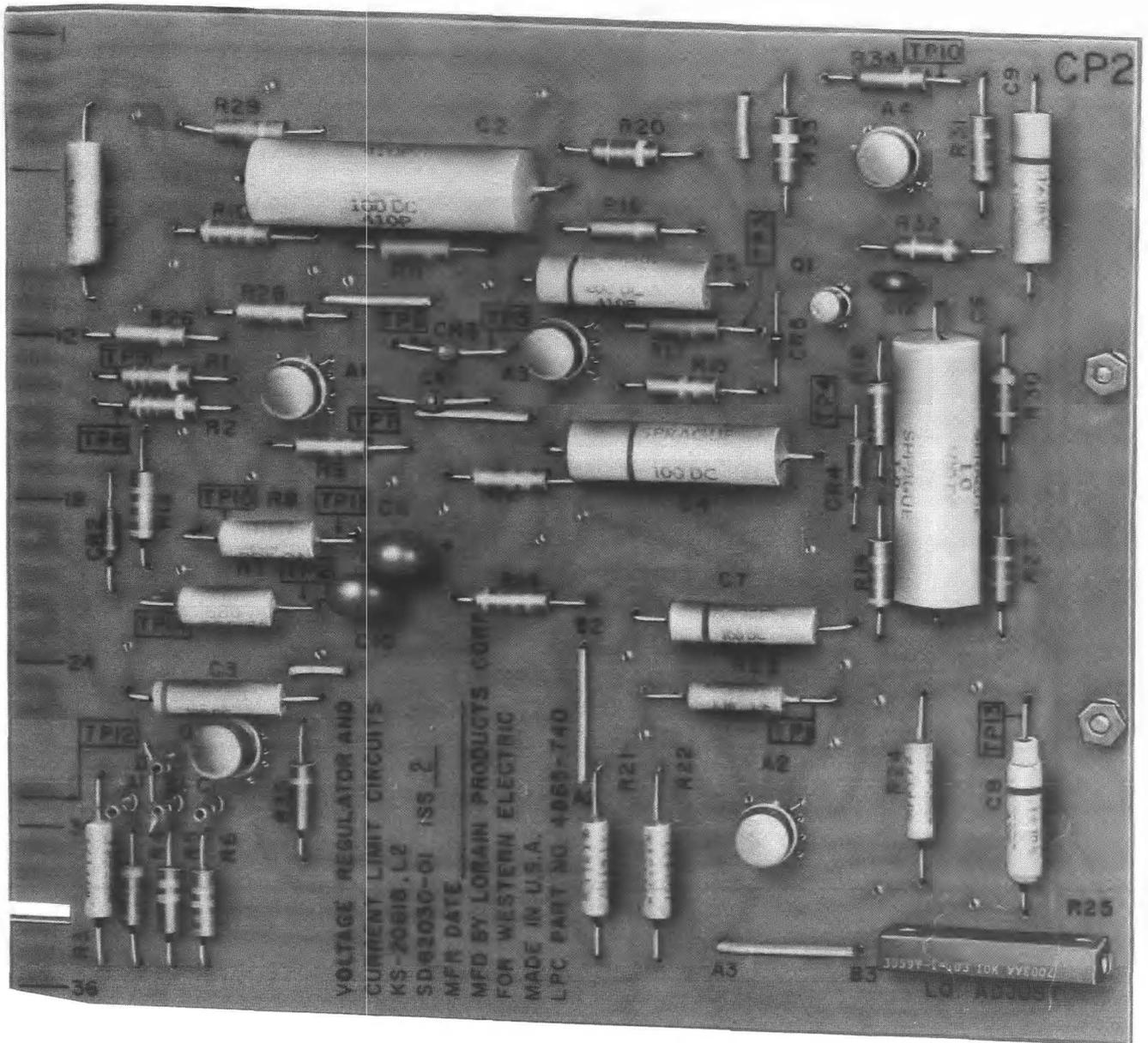
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TROUBLE: NO SIGNAL AT TP13 (TP12), HALF WAVE CONTROL
POSSIBLE CAUSE: SHORTED Q1 (Q2)

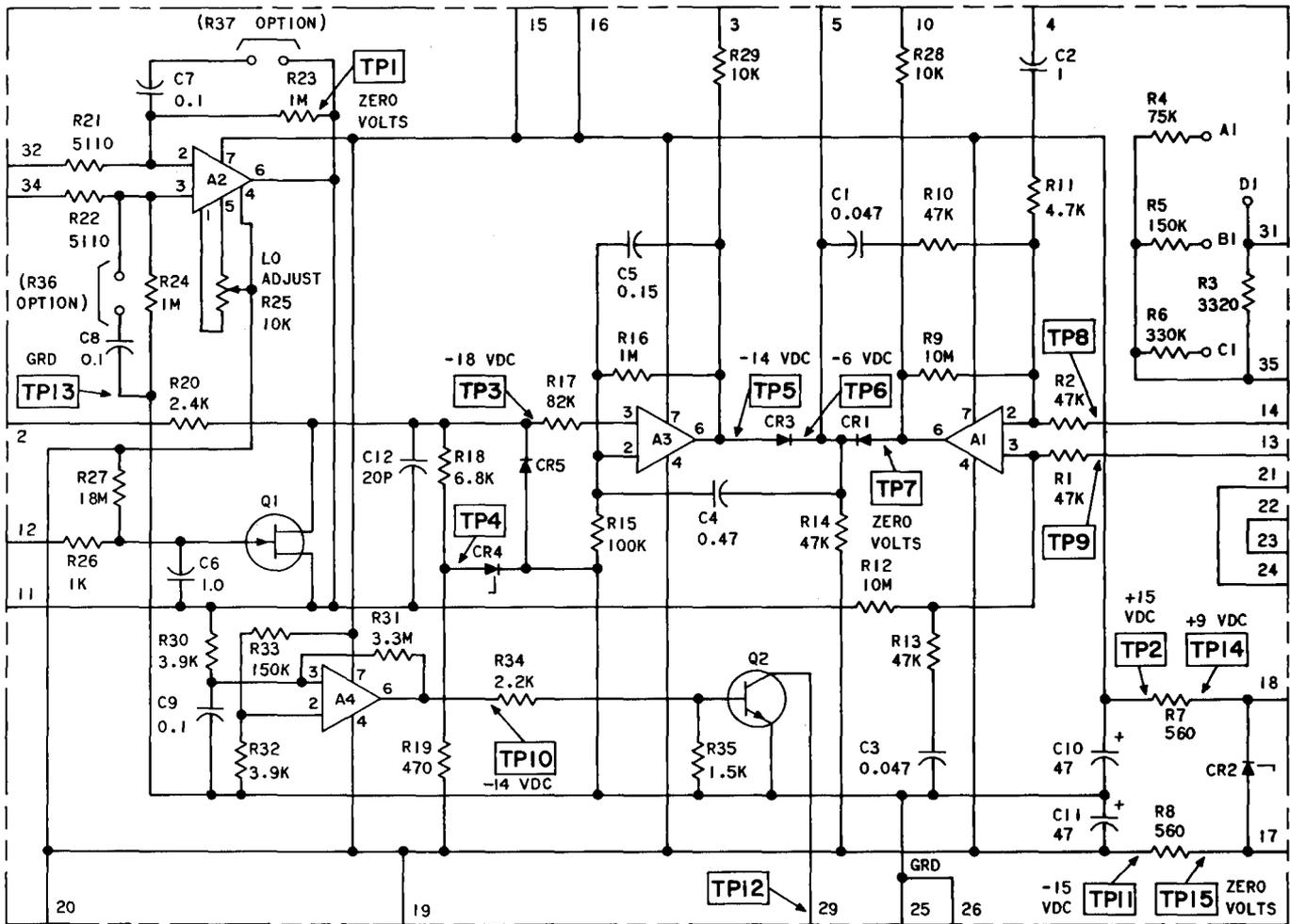
FIG. 3e

Fig. 3—KS-20618 Regulator—Waveforms for KS-20618 L1 Pulse Circuits CP1



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Fig. 4—KS-20618 L2 Voltage Regulator and Current Limit CP2

**PRELIMINARY PROCEDURE:**

1. TURN RECTIFIER OFF.
2. DISCONNECT LOAD FROM RECTIFIER.
3. REMOVE CP2 FROM JPC2.
4. INSTALL EXTENDER BOARD INTO JPC2.
5. INSTALL KNOWN GOOD CP2 INTO EXTENDER BOARD.
6. TURN RECTIFIER ON AND ADJUST FOR NORMAL BATTERY FLOAT VOLTAGE AT NO LOAD.

CAUTION: TURN OFF RECTIFIER IMMEDIATELY IF OUTPUT VOLTAGE IS ABNORMALLY HIGH.

7. SET CURRENT LIMIT FOR 60 AMPERES IN ACCORDANCE WITH ASSOCIATED RECTIFIER BSP.
8. TURN RECTIFIER OFF.
9. REMOVE THE KNOWN GOOD CP2 FROM JPC2.
10. INSTALL THE CP2 CARD TO BE TESTED INTO THE EXTENDER CARD.

TEST PROCEDURE:

NOTE: ALL TEST POINT VOLTAGES ARE WITH RESPECT TO GROUND AND UNLESS OUTPUT VOLTAGE IS ABNORMALLY HIGH, ALL TESTING IS DONE WITH THE RECTIFIER ON.

1. TURN RECTIFIER ON.

CAUTION: TURN OFF RECTIFIER IMMEDIATELY IF OUTPUT VOLTAGE IS ABNORMALLY HIGH.

2. CHECK EACH RECTIFIER TROUBLE INDICATION AT THE TOP OF THE CHART IN FIG. 6 TO DETERMINE THE TESTS TO BE MADE ON CP2.
3. WITH THE RECTIFIER ON, CONNECT THE VOLTMETER, SET TO THE CORRECT RANGE, BETWEEN THE TEST POINT GIVEN AND GROUND.

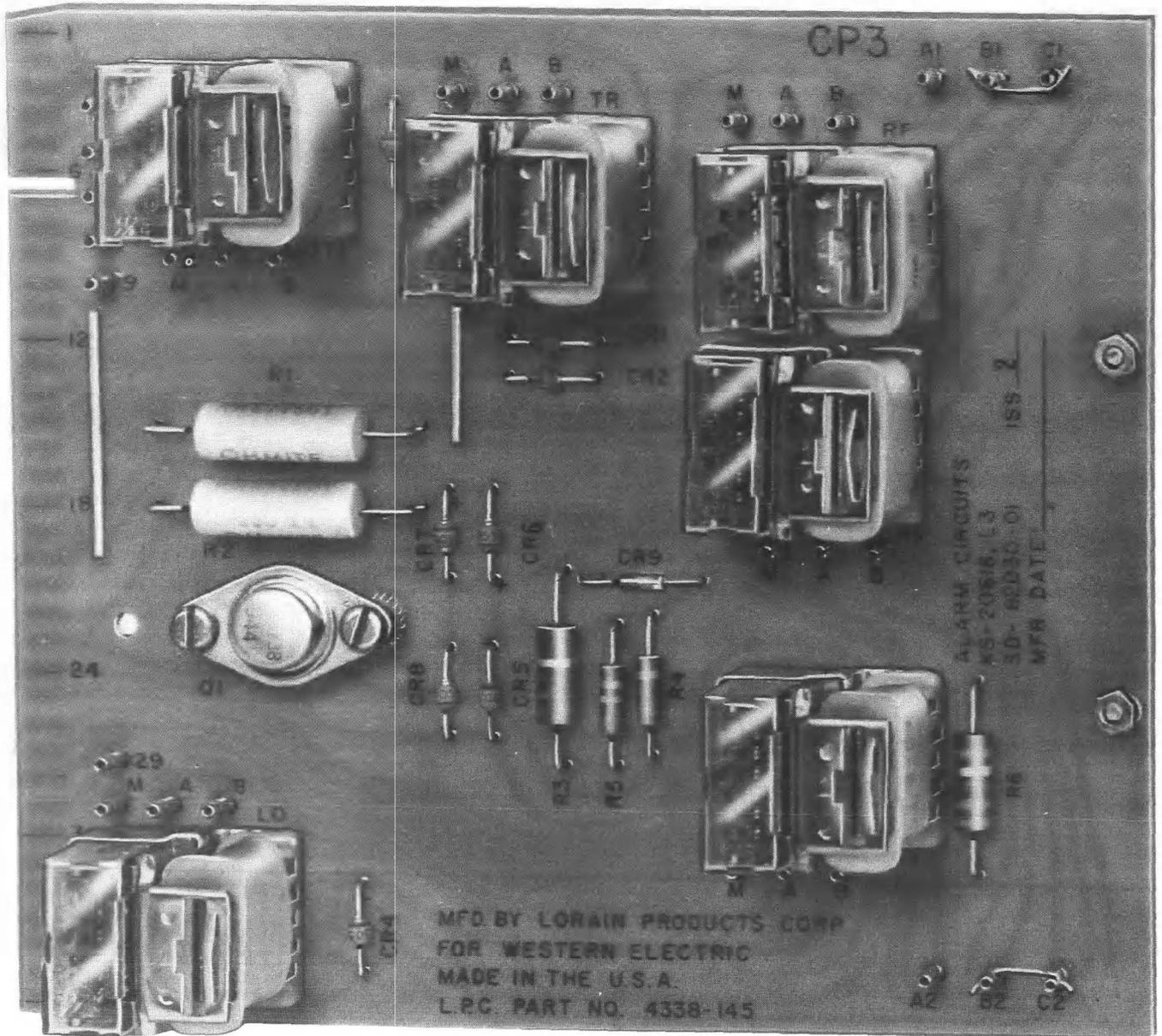
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Fig. 5—Troubleshooting the Voltage Regulator and Current Limit Circuits CP2

TROUBLE INDICATION CHART																
APPROXIMATE OUTPUT VOLTS	RECTIFIER INDICATION						CP2 INDICATION				CAUSE FOR INCORRECT INDICATION					
	NOTES	CURRENT LIMIT	CURRENT LIMIT ADJ.	SIMULATED CURRENT	WALK-IN	LO	TEST POINT	NORMAL INDICATION								
								ZERO LOAD	SIMULATED CUR ON AT 50% LOAD							
ZERO	RECTIFIER WILL NOT START.						TP2	+15 ±1.5 VDC		C10 SHORTED						
							TP11	-15 ±1.5 VDC		C11 SHORTED						
ABNORMALLY LOW	OUTPUT FULLY DEPRESSED.				NONE		TP3	-1.8 ±0.2 VDC	-1 ±0.4 VDC	A. Q1 SHORTED B. C12 SHORTED						
	NO REGULATION OUTPUT DROPS WITH LOAD.					NONE	TP14	+9 ±0.5 VDC		CR2 SHORTED						
							TP5	-12 ±2 VDC	-6 ±2 VDC	A3 DEFECTIVE						
	NO REGULATION OUTPUT DROPS WITH LOAD					NONE		TP1	0 ±0.05 VDC	+4 ±0.1 VDC	A2 DEFECTIVE					
								TP7	0 ±1 VDC		A1 DEFECTIVE					
	OUTPUT DROPS WITH LOAD OR SIMULATED CUR.				DECREASES OUTPUT			TP3	-1.8 ±0.2 VDC	-1 ±0.4 VDC	A. CR4 SHORTED B. CR5 SHORTED					
TP6								-0.5 ±1 VDC		C6 SHORTED						
OUTPUT AND REG ABNORMAL IN LOCAL SNS ONLY.							TP6	-0.5 ±1 VDC		C2 SHORTED						
NORMAL	REGULATION NORMAL						TP1	0±0.05 VDC	+4 ±0.1 VDC	A2 DEFECTIVE						
							TP5	-12 ±2 VDC	-6 ±2 VDC	A3 DEFECTIVE						
							TP6	-0.5 ±1 VDC		CR3 OPEN						
							TP5 (A3 HOT)	-12 ±2 VDC	-6 ±2 VDC	CR1 SHORTED						
							TP1	0 ±0.05 VDC	+4 ±0.1 VDC	C7 SHORTED						
										NONE		A. Q1 OPEN B. Q6 OPEN				
										ERRATIC		C12 OPEN				
										NO EFFECT AT TP1	NONE	NONE	TP1	0 ±0.05 VDC	+4 ±0.1 VDC	A2 DEFECTIVE
										NO EFFECT AT TP10		NONE	TP10	-12 ±2 VDC	+12 ±2 VDC	C9 SHORTENED
												NONE	TP10	-12 ±2 VDC	+12 ±2 VDC	A. A4 DEFECTIVE B. Q2 OPEN
												CONST	TP10	-12 ±2 VDC	+12 ±2 VDC	A4 DEFECTIVE
													TP12	+25 ±3 VDC	0.1 ±0.05 VDC	Q2 SHORTED
												NONE WITH LOAD, CONST WITH SIM. CUR.	TP1	0 ±0.05 VDC	+4 ±0.1 VDC	C8 SHORTED
								NORMAL	NARROW RANGE				TP4	-10 ±1 VDC		CR4 OPEN
													TP5	-12 ±2 VDC	-6 ±2 VDC	C5 OPEN
								OVERSHOOT AT SET PT.					TP6	-0.5 ±1 VDC		C4 OPEN
	OUTPUT DROPS WITH LOAD.				NORMAL	TP6	-0.5 ±1 VDC		C4 SHORTED C1 SHORTED							
	OSCILLATES ON REMOTE SNS.								C1 OPEN							
	OSCILLATES ON LOCAL SNS.								C2 OPEN							
ABNORMALLY HIGH	WALKS IN TO HIGH VOLTAGE DO NOT LEAVE POWER ON						TP6	-0.5 ±1 VDC		CR1 OPEN						
							TP7	0 ±1 VDC		A1 DEFECTIVE						
							TP14	+9 ±0.5 VDC		CR2 OPEN						

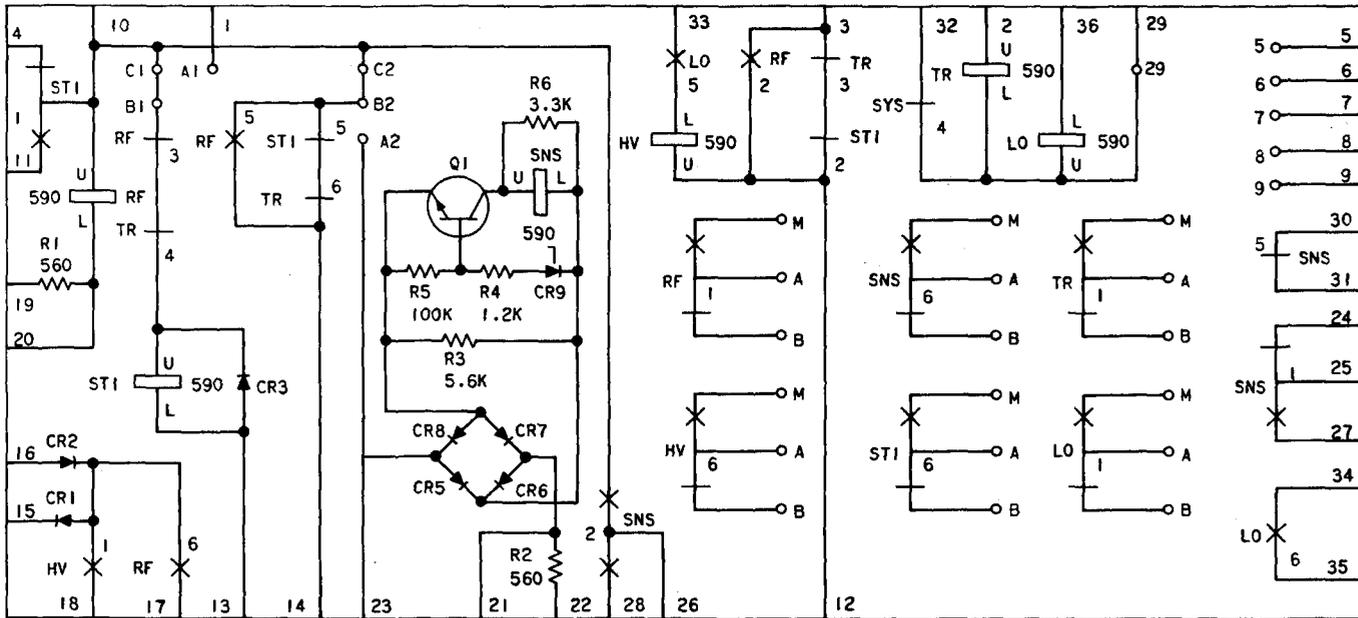
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Fig. 6—Trouble Indication Chart for the Voltage Regulator and Current Limit Circuit CP2



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Fig. 7—KS-20618 L3 Alarm Circuits CP3



PRELIMINARY PROCEDURE:

1. TURN RECTIFIER OFF. DISCONNECT AC INPUT POWER.
2. REMOVE ALARM CIRCUITS CP3 FROM JPC3.

NOTES: 1. ALL TESTING WILL BE DONE WITH CP3 REMOVED FROM THE RECTIFIER.

2. THE PREFERRED POWER SOURCE FOR THE TEST PROCEDURE IS A BENCH POWER SUPPLY OF 28-VOLTS DC, 5 AMPERES. HOWEVER, THE DC POWER SUPPLY CP4 IN THE RECTIFIER IS USED AS A POWER SOURCE IN THE TEST PROCEDURE.

TEST PROCEDURE:

- A. MAKE A VISUAL INSPECTION OF CP3 BOARD FOR BROKEN OR CRACKED COMPONENTS OR PRINTED LEADS.
 1. CHECK FOR JUMPER WIRE BETWEEN PIN B1 AND C1.
 2. CHECK FOR JUMPER WIRE BETWEEN PIN B2 AND C2.
- B. IF POWER SUPPLY CP4 IN THE RECTIFIER IS TO BE USED AS A POWER SOURCE, CONNECT TWO INSULATED CLIP CORDS TO THE -28 VOLT SUPPLY AT THE FILTER CAPACITOR, ONE TO PLUS SIDE (PIN 5 OF CP4) AND ONE TO MINUS SIDE (PIN 14 OF CP4).
 1. APPLY AC INPUT POWER TO THE INPUT CONTACTOR—RECTIFIER SHOULD BE OFF.
 2. USING THE VOLTMETER, CHECK -28 VOLT SUPPLY AT THE FILTER CAPACITOR.
 3. INSERT CP3 TO BE TESTED INTO CIRCUIT BOARD EXTENDER CARD—DO NOT INSERT CARDS INTO RECTIFIER.
 4. USING CLIP CORDS FROM THE -28 VOLT SUPPLY, FOLLOW THE TEST PROCEDURE IN TABLE 1.
- C. IF NO TROUBLE WAS DISCOVERED, USE AN OHMMETER TO CHECK THE FOLLOWING:
 1. RESISTANCE BETWEEN PIN 19 AND PIN 20 SHOULD BE 560 OHMS \pm 5%.
 2. RESISTANCE BETWEEN PIN 21 AND PIN 22 SHOULD BE 560 OHMS \pm 5%.
- D. USE AN OHMMETER TO CHECK THE FRONT TO BACK RATIO OF THE FOLLOWING:
 1. CR-2 CATHODE TO PIN 16.
 2. CR1-ANODE TO PIN 15.
 3. CR5, CR6, CR7 AND CR8-ANODE TO CATHODE.
- E. FOLLOW THE PROCEDURE IN TABLE 2. TO OPERATE THE RELAYS MANUALLY, PRESS DOWN ON THE ARMATURE AT THE TOP OF THE RELAY.

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Fig. 8—Troubleshooting the Alarm Circuit CP3

TABLE 1

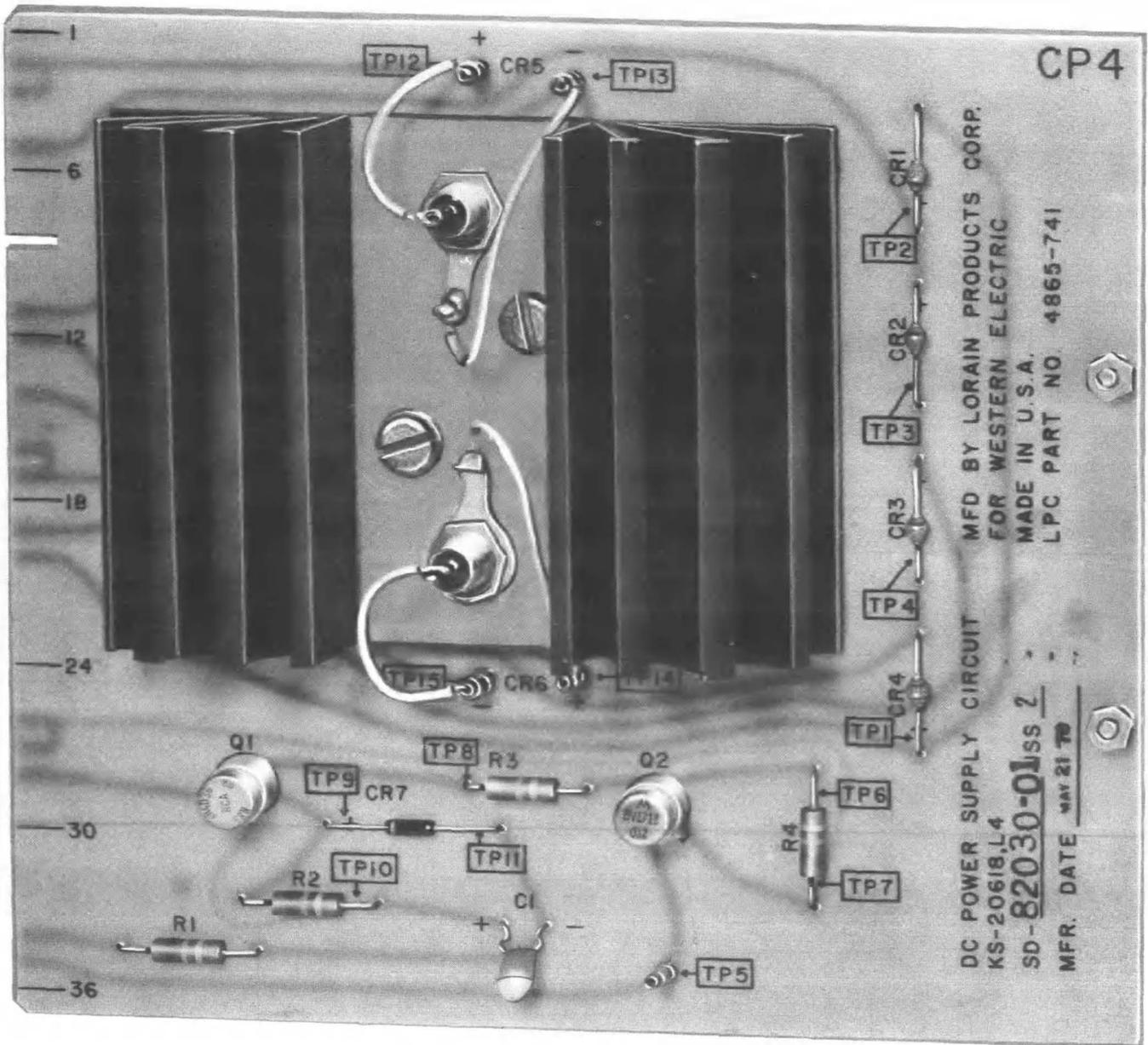
CONNECT CLIP CORDS:		NORMAL INDICATION	REASON FOR INCORRECT INDICATION
GROUND TO PIN	-28V TO PIN		
10	13	OPERATE STI	A. STI COIL DEFECTIVE B. CR3 SHORTED C. TR RELAY CONTACT 4 OPEN D. RF RELAY CONTACT 3 OPEN E. JUMPER B1 TO C1 OPEN
10	20	OPERATE RF	RF COIL DEFECTIVE
29	2	OPERATE TR	TR COIL DEFECTIVE
29	36	OPERATE LO	A. LO COIL DEFECTIVE B. CR4 SHORTED
29 AND 12	36 AND 33	OPERATE LO AND HV	A. HV COIL DEFECTIVE B. LO RELAY CONTACT 5 OPEN
21	23	OPERATE SNS	A. SNS COIL DEFECTIVE B. Q1 DEFECTIVE C. CR9 OPEN D. R3 OPEN E. R4 OPEN

TABLE 2

RELAY	NOTES	CONNECT OHMMETER:		NORMAL INDICATION		REASON FOR INCORRECT INDICATION
		PIN TO PIN		RELEASED	MANUALLY OPERATED	
STI		10	4	SHORT	OPEN	A. BENT, DIRTY OR CORRODED RELAY CONTACTS B. OPEN PRINTED CIRCUIT TRACES ON BOARD
		10	14	SHORT	OPEN	
		10	11	OPEN	SHORT	
		12	3	SHORT	OPEN	
TR	CONTACT 4 TESTED IN TABLE 1	12	3	SHORT	OPEN	
		10	14	SHORT	OPEN	
RF	CONTACT 3 TESTED	17	+CR2	OPEN	SHORT	
	MANUALLY OPERATE TR FOR THESE TESTS	3	12	OPEN	SHORT	
		10	14	OPEN	SHORT	
HV		18	+CR2	OPEN	SHORT	
SNS		10	26	SHORT	OPEN	
		24	25	SHORT	OPEN	
		30	31	SHORT	OPEN	
		32	29	SHORT	OPEN	
		26	28	OPEN	SHORT	
		25	27	OPEN	SHORT	
LO	CONTACT 5 TESTED	34	35	OPEN	SHORT	

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Fig. 8—Troubleshooting the Alarm Circuit CP3 (cont)



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Fig. 9—KS-20618 L4 DC Power Supply Circuit

