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Instruction / Manual

MODEL 313A

VOLTAGE CALIBRATOR



ELECTRONICS FOR INDUSTRY
INSTRUMENTS / COMPONENTS

JOHN FLUKE MFG. CO. INC.

P. O. Box 7428

Seattle 33, Washington

July 10, 1964

MODEL 313A

VOLTAGE CALIBRATOR

313A serial no. 283 and above.

MODEL 313A

ADDENDUM

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The reference designations on printed circuit board 313A-402 were not in accordance with the reference designations on the schematic diagram for 313A serial numbers 123 through 206.

The following list is a cross reference between the reference designations on the schematic diagram and those on the 313A-402 board.

VOLTAGE CONTROL RESISTORS CROSS REFERENCE LIST

Reference Designation on		Reference Designation on	
Schematic Diagram	Printed Circuit Board	Schematic Diagram	Printed Circuit Board
R201	R201	R216	R233
R202	R202	R217	R234
R203	R203	R218	R235
R204	R211	R219	R241
R205	R212	R220	R242
R206	R213	R221	R243
R207	R214	R222	R244
R208	R215	R223	R245
R209	R221	R224	R251
R210	R222	R225	R252
R211	R223	R226	R253
R212	R224	R227	R254
R213	R225	R228	R255
R214	R231	R229	R256
R215	R232		

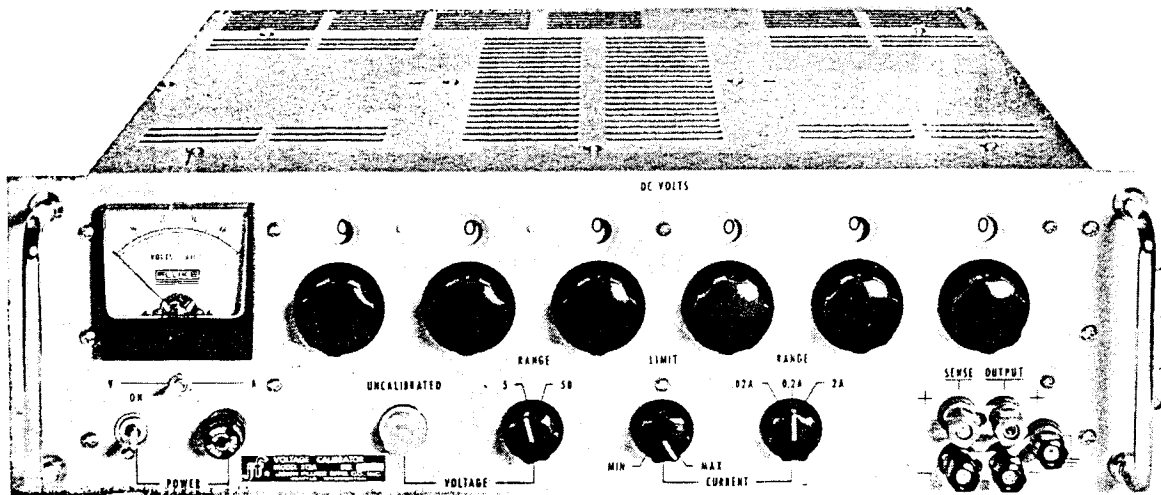
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SECTION I

INTRODUCTION AND SPECIFICATIONS

1-1. INTRODUCTION

a. The John Fluke Model 313A is a solid-state Voltage Calibrator having an output range of 0 to 50 volts and 0 to 2 amperes. The calibrator may be operated with either positive or negative output terminal grounded, or with both terminals isolated from ground by up to 500 volts. Provision is made for remotely controlling the output voltage. A current limiting circuit protects the external load by limiting the output current to any value between 2 milliamperes and 2.2 amperes.

b. The calibrator is not damaged by a continuous short circuit, and normal operation is restored when the overload is removed. A front panel warning light illuminates when the output current exceeds the pre-set maximum. External sensing terminals are provided for eliminating errors due to line drop in the connecting leads. The panel meter may be switched to monitor either voltage or current.

c. The main feedback loop, which controls the output voltage, contains a chopper-stabilized amplifier having more than 160 db of gain at DC. Sampling string resistors are precisely matched both for resistance accuracy and for temperature coefficient. An auxiliary feedback loop senses the voltage drop across the series regulating transistor, and controls a pre-regulator to maintain low power dissipation in the series element. The necessity for forced air cooling is thereby eliminated.

d. The voltage reference element is a specially processed and selected zener diode, which is supplied by a constant-current regulated source. The reference zener diode, and the current-regulating components, are enclosed in a temperature-controlled oven.

e. The Model 313A utilizes plug-in printed circuit boards for ease of calibration and maintenance. The chassis is tapped for standard rack slides, which should be used when the instrument is rack-mounted. All heat-producing elements are isolated from control circuitry to ensure stable operation at high ambient temperatures.

1-2. RECEIVING INSPECTION

This instrument has been thoroughly checked and tested before being shipped from the factory. Immediately after receiving the instrument, carefully inspect for damage which may have occurred in transit. If any damage is noted, follow the instructions outlined on the warranty page in the back of this manual.

1-3. SPECIFICATIONS

a. ELECTRICAL

OUTPUT VOLTAGE: 0 to 50 VDC; 0 to 5 VDC.

VOLTAGE CALIBRATION ACCURACY: $\pm 0.01\%$ or 100 uv, whichever is greater.

OUTPUT CURRENT: 0 to 2.0 amperes.

CURRENT LIMITING: Continuously variable from 2 milliamperes to 2.2 amperes in three ranges of 0.02, 0.2, and 2 amperes. An indicator lamp illuminates when current limiting begins.

INPUT POWER: 115/230 VAC $\pm 10\%$, 50-60 cps, single phase, approximately 300 VA maximum.

LINE REGULATION: 0.0005% or 50 uv (whichever is greater) for a 10% line change from nominal.

LOAD REGULATION: 0.0005% or 50 uv (whichever is greater) for a load change of 2 amperes.

METER: One meter to monitor either output voltage or current.

OUTPUT CONNECTORS: Front panel insulated binding posts on 3/4" centers; terminal strip on rear panel.

OUTPUT POLARITY: Either terminal may be grounded, or both terminals may be left floating up to 500V above ground.

OUTPUT IMPEDANCE: Less than 0.0001 ohm from DC to 100 cps; less than 0.001 ohm to 1 KC; and less than 0.2 ohms to 100 KC.

REMOTE PROGRAMMING: External rheostat connected to rear terminal strip (1000 ohms per volt on 50V range; 10,000 ohms per volt on 5V range).

REMOTE SENSING: Output voltage may be measured at load via front panel terminals or rear terminal strip.

RESOLUTION: 100 uv on 50V range; 10 uv on 5V range.

RIPPLE: Less than 50 microvolts RMS.

STABILITY: $\pm 0.002\%$ or 100 uv per hour; $\pm 0.0025\%$ or 100 uv per day; $\pm 0.005\%$ or 100 uv per month.

TEMPERATURE RANGE: 0°C to 55°C operating; -40°C to +60°C storage.

b. MECHANICAL

MOUNTING: Standard relay rack; rubber supports provided for bench use.

SIZE: 19" wide by 18" deep by 5-1/4" high.

WEIGHT: Approximately 50 lbs.

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SECTION II

OPERATING INSTRUCTIONS

2-1. CONTROLS, TERMINALS, AND INDICATORS

The location, reference designation, and functional description of external controls, terminals, and indicators of the Model 313A are given in Figure 2-1.

2-2. PREPARATION FOR USE

a. Before the instrument is first used, verify that the SENSE terminals are connected to the OUTPUT terminals at the front panel or rear terminal strip. Also verify that the jumper between terminals 6 and 7 on the rear terminal strip is in place.

b. Heat producing transistors in the 313A are mounted on heat sinks in the rear section of the chassis. Cooling air for these heat sinks enters through the lower perforated chassis cover and leaves through the top. Care must be exercised to ensure that the air flow is not restricted by covering the chassis perforations. The instrument is supplied with rubber supports which raise the chassis above the bench far enough to permit airflow. If the supports are removed, the chassis should be raised by other means to provide airflow.

c. The instrument is supplied for use on 115 volts or 230 volts, as requested. If it becomes desirable to change operation from one voltage to the other, refer to the instructions on the schematic diagram.

2-3. BASIC OPERATING SEQUENCE

a. Connect the instrument to a 115 VAC power source. If the instrument has been wired for 230 volt operation, connect to 230 VAC.

NOTE

This instrument is equipped with a 3-wire line cord. Connection to a properly wired outlet automatically connects the chassis of the instrument to earth ground. If the instrument is connected to a two-contact outlet, the green lead extending from the adapter should be connected to a good earth ground.

b. Connect +SENSE terminal to +OUTPUT terminal, and connect -SENSE terminal to -OUTPUT terminal. This is usually done with the shorting links provided on the

front panel terminals. When using the rear terminal strip for output connections, also use the rear terminal strip for sense connections. The output must be sensed at only one location: if not, the 313A may not be within specifications.

c. Set CURRENT RANGE switch to the range which will provide the required output current.

d. Set CURRENT LIMIT control to MAX.

e. Turn VOLTAGE RANGE switch to desired full scale range of 5 or 50 volts.

f. Set DC VOLTS decade controls to the desired output voltage.

g. Connect load to OUTPUT terminals.

h. Set POWER switch to ON.

j. Monitor output voltage or current by setting meter switch to V (voltage) or A (current) as desired.

2-4. REMOTE SENSING

a. If the connecting wires to the 313A are long or small in diameter, there may be an appreciable voltage drop between the load and the 313A. Figure 2-2 is a nomograph for determining the approximate voltage drop in the connecting leads. The graph is used as follows: using a straight edge, connect the current required by the load to the AWG size of wire to be used; read the voltage drop per conductor per foot. For example, if #12 wire leads, each one foot long, are used to connect a load requiring 2 amperes, the voltage drop in each wire is approximately 3.2 mv, or 6.4 mv total. At 50 volts output, 6.4 mv represents a voltage equal to 25 times the load regulation of the instrument. Remote sensing is provided on the 313A to counteract the effects of load line voltage drop and obtain instrument regulation at the load. Remote sensing is connected as follows.

b. Set POWER switch to off.

c. Remove connections between SENSE and OUTPUT terminals on the front or back panel of the instrument, whichever is being used.

d. Using twisted pair wire, connect SENSE terminals directly to points of load at which voltage is to be controlled. Be sure +SENSE terminal is connected to positive terminal of load and -SENSE terminal is connected to negative terminal of load.

e. Connect an electrolytic capacitor of at least 1000 uf, 75 volts rating, across the load.

f. Proceed with steps c through j of paragraph 2-3.

CONTROLS TERMINALS AND INDICATORS	LOCATION	REFERENCE DESIGNATION	FUNCTIONAL DESCRIPTION
POWER switch	Front Panel	S1	Applies AC line voltage to the primary of the power transformer.
Meter	Front Panel	M1	Indicates magnitude of output voltage or output current, depending on the position of the meter toggle switch.
Meter switch	Front Panel	S4	Selects either voltage measurement (V) or current measurement (A) for the meter.
DC VOLTS controls	Front Panel	S201, S202, S203, S204, S205, S206	Selects magnitude of output voltage. Recessed numbers above each control indicates magnitude of output voltage.
VOLTAGE UNCALIBRATED lamp	Front Panel	DS3	Illuminates when the maximum pre-set current is exceeded or closely approached. This indicates that the calibration of the DC VOLTS controls is no longer accurate.
VOLTAGE RANGE switch	Front Panel	S2	Selects maximum output voltage range of either 5 or 50 volts, and changes the meter circuitry accordingly.
CURRENT LIMIT control	Front Panel	R6	Varies current limit between 10% and 120% of the maximum current indicated by the CURRENT RANGE switch.
CURRENT RANGE control	Front Panel	S3	Selects maximum output current limiting range of 0.02, 0.2, or 2.0 amperes, and changes the meter range accordingly. Current will be limited when the maximum selected value is approached.
SENSE terminals	Front Panel		Provided for controlling the voltage at the load, thus eliminating error due to voltage drop in the connecting leads.
OUTPUT terminals	Front Panel		Provided for connecting the load to the 313A.
GROUND terminal	Front Panel		Provided for grounding either output terminal.
REFERENCE CALIBRATE adjustment	Rear Panel	R8	Allows adjustment of the internal reference voltage.
Terminal strip	Rear Panel		OUTPUT terminals (2 and 3), SENSE terminals (1 and 4), and ground terminal (5) are identical in function to the terminals previously described. REMOTE PROGRAMMING terminals (4, 7, and 8) are provided for connection to a remotely located voltage control element. REFERENCE MONITOR terminals (9 and 10) provide a 1.02 volt sample of the reference voltage for monitoring and adjustment.

Figure 2-1. FUNCTION OF CONTROLS, TERMINALS, AND INDICATORS

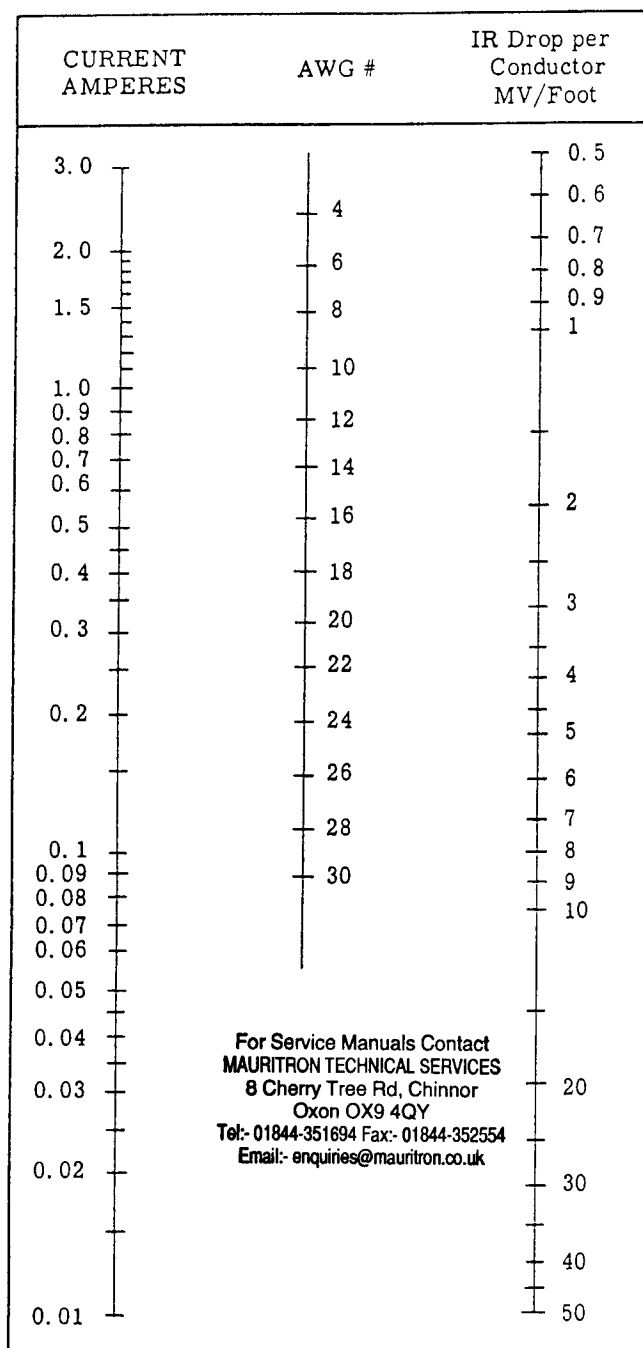


Figure 2-2. NOMOGRAPH OF VOLTAGE DROP
IN LOAD LEADS

2-5. REMOTE PROGRAMMING

The output voltage of the 313A can be controlled from a remote location, as follows:

- Set POWER switch to off.
- Remove the jumper between terminals 6 and 7 on the rear terminal strip.
- Using insulated, shielded, twisted pair wire, connect the remote programming resistor between terminals 4 and 7 of the rear terminal strip, and connect the shield of the wire to terminal 8. The remote programming resistor may be either fixed or variable,

but its resistance must be equal to the desired output voltage multiplied by 1000 ohms per volt for the 50 volt range, or 10,000 ohms per volt for the 5 volt range. If the resistor is fixed, it should have an accuracy of better than 0.01% in order to maintain the specified calibration accuracy of the 313A. If the leads to the programming resistor are long, it is desirable to subtract the resistance of the wires from the nominal value of any fixed resistor used for remote programming. An external capacitor of the approximate size and voltage rating of C201 must be connected across the programming resistor.

CAUTION

The shield of the wire used will be of the same potential as the + SENSE terminal, and must therefore be insulated to avoid accidental grounding. Care must be exercised to avoid an open circuit in the programming resistor network, as this would result in loss of regulation and possible damage to the instrument.

- Proceed with steps c through j of paragraph 2-3, except for step f. The DC VOLTS controls on the instrument panel will have no effect: voltage control is provided by the external resistor.

2-6. CURRENT LIMIT CONTROL

The current limit control is designed to protect the 313A and the load connected to it from damage which may be caused by excessive load current. The current limiting level may be set as follows:

- Set controls on the 313A as follows:

VOLTAGE RANGE	50
CURRENT RANGE	(as desired)
CURRENT LIMIT	MAX
DC VOLTS controls	04.000
Meter switch	A
POWER switch	ON

- Short the OUTPUT terminals and set the maximum output current limit by adjusting the CURRENT LIMIT control counter-clockwise until the meter indicates the desired current. Note that full-scale meter range always corresponds to the maximum current indicated by the CURRENT RANGE switch.

c. The maximum output current limit as set in the preceding step will limit the current to the indicated maximum in the event of a short circuit. Limiting will begin at approximately 2.5 milliamperes less than the set value in the 20 milliamperere range, 25 milliamperes less than the set value in the 200 milliamperere range, and 250 milliamperes less than the set value in the 2 ampere range. The VOLTAGE UNCALIBRATED warning lamp will illuminate just prior to the start of current limiting.

- Remove the short from the OUTPUT terminals.
- Proceed with steps e through j of paragraph 2-3.

amplifier is to alter the conduction of Q2 so that the difference between the two inputs of the amplifier is zero, which means both inputs are held at positive bus voltage. Since V_{ref} is constant, the current through R_f is also constant. Therefore, the output voltage is equal to the IR drop across R_f , and is directly proportional to the value of R_f . If desired, R_f may be external to the 313A, which provides remote programming. Also, one terminal of R_f and one terminal of the main differential amplifier may be connected directly to the load for remote sensing.

(2) The output voltage is controlled by Q2 and the main differential amplifier; however, the voltage into Q2, which is the charge on capacitor C1, is controlled by Q1201, a silicon controlled rectifier. CR1201 through CR1204 apply rectified, full wave pulses to the anode of Q1201. The conduction angle of Q1201 is controlled by the pulse generator, which is a unijunction transistor oscillator, to maintain the charge on C1 approximately 8 volts above the output voltage, so that approximately 8 volts appear across Q2. If a sudden current drain reduces the charge on C1, then amplifier A₁ causes the pulse generator to produce pulses at a higher frequency, which causes Q1201 to conduct earlier in the cycle, restoring the charge on C1. When a low output voltage is selected, Q1201 conducts later in the cycle, which reduces the charge on C1, thus reducing the dissipation of Q2. It should be noted that if the output voltage is suddenly turned to zero with a load connected to the instrument, then the approximate voltage of C1 would appear across Q2. Provision is made for rapidly discharging C1 when the output voltage is suddenly reduced, thus preventing damage to Q2. A description of this function is given in paragraph 3-2h.

(3) The 313A is provided with a control which will limit the output current to any value within the range of the instrument. The value of current limit is selected by R6. Transistor Q902 is normally in the non-conducting state. When the current begins to exceed the selected value, amplifier A₂ causes Q902 to begin to conduct. This by-passes part of the current from R_f , which reduces the output voltage. When Q902 is conducting, an increase in the voltage setting of the DC VOLTS controls will produce only a minor increase in the actual output voltage, because more of the control current will pass through Q902. Consequently, when the current-limiting portion of the circuit is in operation, the calibration accuracy of the DC VOLTS controls is no longer valid.

c. In order to provide a more detailed understanding of the 313A, the following paragraphs describe the operation of each portion of the circuit.

3-2. CIRCUIT DESCRIPTIONS

a. Master Voltage Reference (313A-401). The reference voltage is developed across CR1402. This zener diode is selected and aged to have a stability of 25 ppm per 1000 hours. Transistor Q1401 and diode CR1401 form a constant-current source, which provides current for the reference voltage diode and for the voltage monitor circuit. The 1.02 volt reference monitor voltage is developed by R111, which has a constant current of 1 milliamperes. R8 is a calibration adjustment to compensate for drift due to aging. CR1401, CR1402, Q1401, and R1401 are enclosed in a temperature-controlled oven to prevent any changes in the reference voltage which would otherwise be caused by changes in ambient

temperature. Resistors R116 and R117 are used to adjust current through the voltage control resistors.

b. Main Amplifier (313A-407). The error signal from the junction of R721 and the Voltage Control Resistor Assembly (313A-402) is applied to the input of the main differential amplifier. The base of Q703 is the input path for AC signals; the input path for DC signals is through the chopper amplifier into the base of Q702. (Operation of the chopper amplifier is discussed in the next paragraph.) Providing the separate input path for AC provides more rapid regulation of the output voltage. Q701 and Q708 are current sources for the two stages of the differential amplifier. Use of these current sources provides maximum gain from the differential amplifier. The compound connection of Q702 to Q704, and Q703 to Q705, provides high input impedance and minimizes temperature effects. Feedback capacitor C701 provides frequency compensation of the feedback loop. The output of the amplifier is from the collector of Q706. This signal is applied to the driver amplifier for further amplification.

c. Chopper Amplifier (313A-405). The chopper amplifier consists of three cascaded amplifiers. The input and output of this amplifier are synchronously chopped by a 60 cycle chopper. In this way, the chopper alternately samples the difference between the error signal and the +SENSE voltage. The filtered output of the chopper is applied to one input of the differential amplifier.

d. Driver Amplifier (313A-411). The error signal from the differential amplifier is applied to Q1105 and Q1104, which provide additional amplification of the error signal. Q1103 is a common-base amplifier which provides additional voltage gain. The signal is then applied to the parallel transistors Q1102 and Q1108, which control the series passing transistor. The conduction of the series passing transistor varies according to the load. Q1101 provides a constant current for the collector of Q1103. If the output voltage is suddenly reduced, the voltage drop across Q2 will increase due to the stored charge on C1. If the voltage drop across Q2 exceeds the voltage of the zener diode CR815, then a positive voltage will be applied to the base of Q1106, causing Q1106 to conduct. This causes Q1107 to conduct heavily through R9, thus discharging C1.

e. SCR Firing Circuit (313A-408). CR801 through CR804 comprise a full wave bridge rectifier which supplies a pulsating DC voltage to the SCR firing circuit. CR805 clips this pulsating waveform and delivers the resultant to the unijunction oscillator. The unijunction transistor Q802 will conduct whenever the emitter voltage exceeds the base-to-base voltage by a fixed ratio. C802 and R802 in parallel with Q803 form an R-C charging circuit which determines the emitter voltage of Q802. When the voltage of C802 exceeds the emitter-to-base voltage of Q802, Q802 will conduct, and an output pulse will appear across R803. This pulse is amplified by Q804 and applied through T801 to the gate of Q1201. The charging time of C802 may be varied by controlling the collector current of Q803. Any difference in voltage drop across CR815 and Q2 is detected by Q803, which controls the firing time of Q1201 to reduce the voltage difference to zero.

f. SCR Bridge Assembly (313A-412). Lamps DS1 and DS2 limit the voltage applied to the bridge for protection of the semiconductors. CR1201 through CR1204 apply full-wave, rectified, unfiltered DC pulses to the

anode of Q1201. Q1201 conducts during a portion of each pulse, the angle at which conduction begins being determined by the timing of the pulse from the unijunction oscillator. When output power requirements are minimum, the unijunction pulse appears near the end of the rectifier conduction cycle: when output power requirements increase, the pulse appears earlier in the rectifier conduction cycle, thus maintaining a constant voltage drop across Q2.

g. Voltage Control (313A-402). The voltage control resistors are connected between one differential amplifier input terminal and the -SENSE terminal. The junction of the voltage control string with the differential amplifier and master voltage reference is maintained at positive bus potential by the differential amplifier and series passing transistor. The current through the voltage control string is constant at 1 milliampere on the 50 volt range and 0.1 milliampere on the 5.0 volt range. Since the output voltage is equal to the IR drop across the voltage control string, the stability and accuracy of the resistors used is very important, particularly in the higher resistance values. For this reason, special Fluke wirewound resistors are used which have been matched for resistance accuracy and temperature coefficient and have been designed for excellent long term stability.

h. Overcurrent Limit/Indicator (313A-409). Q903 and Q904 form a differential amplifier, one input of which is fixed. Resistor R6 is used to set the limiting point by adjusting the bias of Q904. Q905 is the current source for the differential amplifier. R922, R923, and Therm-

istor R924 provide temperature compensation for the current source. When the pre-set value of current is being exceeded as sensed by the current shunts R1, R1001, or R1002, the output from the collector of Q904 turns on Q902, which diverts the sampling string current and reduces the output voltage. The collector of Q903 turns on Q901, which illuminates the VOLTAGE UNCALIBRATED lamp (DS3).

i. Voltmeter-Ammeter Circuit (313A-410). Switch S2 selects the correct value of series dropping resistor according to the selected voltage range. Switch S3 selects the correct value of meter shunt and current limiting shunt resistance according to the selected current range.

j. Auxiliary DC Voltage Supplies (313A-403 and 313A-404). CR301 through CR304, C301, C302, and R301 provide filtered, unregulated DC voltage. Q304 and Q305 form a differential amplifier. The base of Q305 is connected to zener diode CR307, which is the source of reference voltage. The base of Q304 is connected to a voltage divider which samples the output voltage. Any error in the output voltage results in an error signal from the collector of Q304, which is applied to the base of Q303. Since the current gain from the base of Q303 to the collector of Q302 is 1200 minimum, a small error signal causes an appreciable change in the conduction of Q302, which restores the output voltage to its initial value. The operation of the -15VDC supply (313A-404) is very similar to the operation of the +25VDC supply, except that the polarities are reversed.

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SECTION IV

MAINTENANCE

4-1. INTRODUCTION

Maintenance of the 313A Voltage Calibrator should consist primarily of occasional cleaning and calibration. Preventive maintenance is discussed in paragraph 4-2. A discussion of troubleshooting and a troubleshooting chart are presented in paragraph 4-3. Calibration procedures and the equipment necessary are presented in paragraph 4-4.

4-2. PREVENTIVE MAINTENANCE

Preventive maintenance consists primarily of occasional cleaning to remove dust. If desired, the instrument may be cleaned with a rag saturated with anhydrous denatured ethyl alcohol. The voltage control resistors are protected by a dust cover, which should not be removed if possible. Because of the high accuracy of the voltage control resistors (R201 through R229), they should not be touched, nor bent. Consequently, if one of the voltage control switches (S201 through S206) is suspected of faulty operation, the switch should be removed for inspection and/or replacement.

4-3. TROUBLESHOOTING

a. The 313A is provided with a test adapter which facilitates troubleshooting. The test adapter may be inserted between the printed circuit boards and the chassis connector. The test adapter provides voltage test points and current loops for monitoring current through the use of clip-on current probes. Using a milliammeter in a transistor circuit will change the bias of the transistor, and is not a satisfactory method of measurement.

b. When measuring voltages on the printed circuit boards, it is recommended that the major portion of the voltage probe be wrapped with insulating tape. This will reduce the possibility of damaging a transistor due to an accidental short-circuit to a high voltage component.

c. Transistors in the 313A are mounted to the circuit boards by use of transistor sockets. This is an aid to measuring voltages, as well as providing easy removal of the transistor for testing.

d. Figure 4-1 is a table of various failures and probable causes. Reference to Figure 4-1 will occasionally indicate the cause of a failure. Components may be located by referring to Section V. Figure 4-2 is a table of the pin voltages of the transistors in the 313A. Figure 4-2 may be used in conjunction with Figure 4-1, or in conjunction with the paragraphs which follow.

e. The following paragraphs are specific tests which can be performed to the 313A to facilitate troubleshoot-

ing and/or performance testing. It is recommended that the tests be performed in the given order. A list of equipment is given in Figure 4-3.

(1) Auxiliary Supply Voltages.

(a) Place the test adapter between printed circuit board (PCB) 313A-407 and the chassis connector.

(b) Set the POWER switch to ON.

(c) Connect the positive lead of the 821A to terminal U of the test adapter, and connect the negative lead of the 821A to the + SENSE terminal. The 821A should indicate $-15 (\pm 0.5)$ volts.

(d) Connect the positive lead of the 821A to terminal M of the test adapter. The 821A should indicate $+25 (\pm 0.5)$ volts.

(2) Chopper Output Voltage.

(a) Connect the positive lead of the 821A to terminal B of the test adapter, and connect the negative lead of the 821A to the + SENSE terminal. The 821A should indicate 2.5 volts minimum.

(b) Connect the positive lead of a DC power supply to the + OUTPUT terminal, and connect the negative lead of the power supply to the - OUTPUT terminal. Set the power supply to 10V output.

(c) Vary the external power supply voltage around the 10V level, and observe a change in the voltage indicated by the 821A of $-2.5V$ to $+2.5V$, minimum.

(3) Control Circuit Operation.

(a) Repeat step 4-3e (2) (b).

(b) Connect the positive lead of the 821A to terminal T of the test adapter, and connect the negative lead of the 821A to the + SENSE terminal.

(c) Adjust the voltage of the external power supply from 9V to 11V approximately, and observe that the 821A indicates a change in the same direction.

(4) Diode Check, Sense Terminals.

(a) Set POWER switch to the off position, and remove the shorting links between the SENSE and OUTPUT terminals.

(b) Connect the positive lead of the Simpson 270 to the + OUTPUT terminal, and connect the negative lead of the Simpson 270 to the + SENSE terminal. The Simpson should indicate between 5 ohms and 25 ohms. Reverse the leads and observe a resistance greater than 1,000 ohms.

(c) Connect the positive lead of the Simpson 270 to the - SENSE terminal, and connect the negative lead to the - OUTPUT terminal. The Simpson should indicate between 5 ohms and 25 ohms. Reverse the leads and observe a resistance greater than 1,000 ohms.

SYMPTOM	PROBABLE CAUSE	REMEDY
No output.	Blown power fuse.	Check fuse F1 and replace if necessary.
Constant percentage error in output voltage.	Improper calibration. Change in reference voltage. Leaky C201.	Re-calibrate according to paragraph 4-4. Check 1.02V reference voltage at terminals 9 and 10 on rear terminal strip. Test and replace if necessary.
Percentage error over part of voltage range.	Defective wirewound resistor in one of the voltage selector switches.	Set output voltage to maximum and decrease one position at a time until the error disappears. The defective resistor will be found at the last switch position in which the error was noted.
Output erratic over part of range.	Same as percentage error part of range. Defective voltage selector switch (S201 through S206).	Carefully replace switch.
Output voltage suddenly rises above selected value.	Shorted Q2, Q1101, Q1102, or Q1108. Open sample resistor or switch.	Test and replace if necessary. Remove jumper between terminals 6 and 7 on rear terminal strip, and connect an ohmmeter between terminals 4 and 6. Measure the resistance of the sampling string and compare to the schematic diagram.
Loss of control.	Open R723.	Test and replace if necessary.
Poor line regulation.	Incorrect voltage from auxiliary supplies. Change in reference voltage.	Measure output voltage of auxiliary -15V, -20V, and +25V supplies. Repair if necessary. Check reference voltage at terminals 9 and 10 on rear terminal strip.
Poor load regulation.	Defective component on 313A-405 board. Incorrect SENSE connections.	Check and repair as necessary. Check connections of SENSE leads to the load.
Oscillation in output.	Incorrect adjustment of R1116. Defective component of 313A-407 board. Oscillation in auxiliary supplies.	Refer to paragraph 4-4g. Test and repair as necessary. Test and repair if necessary.

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Figure 4-1. TROUBLESHOOTING CHART (sheet 1 of 2)

SYMPTOM	PROBABLE CAUSE	REMEDY
Excessive drift.	Auxiliary +25V supply voltage too high.	Test and repair as necessary.
	Defective Q1401, CR1401, or CR1402.	Test and replace if necessary.
Excessive ripple.	Excessive ripple in auxiliary supplies.	Test and repair auxiliary supplies.
	Defective component on 313A-407 board.	Test and repair as necessary.
Fuse blows repeatedly.	Shorted C6 or C7.	Test and replace if necessary.
	Shorted Q1106, Q1107, or CR1206.	Test and replace if necessary.
	Defective relay K1.	Test and replace if necessary.

Figure 4-1. TROUBLESHOOTING CHART (sheet 2 of 2)

(5) Operation of Crowbar Circuit.

(a) Connect the negative lead of the Simpson 270 to terminal E of the 313A-411 printed circuit board. Connect the positive lead to terminal A of the 313A-411 printed circuit board. Set the Simpson to the 50V range.

(b) Set the POWER switch to ON.

(c) Set the DC VOLTS controls to 49.99910.

(d) Observe that the Simpson deflects briefly at each position as the DC VOLTS controls are reduced in steps of 10 volts.

(6) Absence of Transients.

(a) Connect the oscilloscope to the OUTPUT terminals. Set oscilloscope sweep speed to 0.5 sec/cm, and set vertical sensitivity to 0.5 V/cm, with DC coupling.

(b) Set DC VOLTS controls to zero.

(c) Alternately set the POWER switch to ON and off. Transients indicated by the oscilloscope should not exceed ± 1 volt.

(7) Operation of Current Range and Current Limit.

(a) Set CURRENT RANGE to .02A.

(b) Set the meter range switch to A.

(c) Set the DC VOLTS controls to 000000.

(d) Connect a resistor of 8.2K, 10%, 1W across the OUTPUT terminals.

(e) Set CURRENT LIMIT to mid-range.

(f) Set the DC VOLTS controls so that the panel meter indicates 5 milliamperes (approximately 41 volts).

(g) Reduce the CURRENT LIMIT control until the UNCALIBRATED lamp illuminates.

(h) Parallel the 8.2K resistor with a 100 ohm, 10%, 1/2W resistor. The panel meter should indicate 7.5 milliamperes or less. Remove both resistors.

(i) Set the CURRENT RANGE control to 0.2A.

(j) Set DC VOLTS controls to 000000.

(k) Connect a 2.2K, 10%, 2W resistor across the OUTPUT terminals.

(l) Set the CURRENT LIMIT control to mid-range.

(m) Set the DC VOLTS controls so that the panel meter indicates 20 milliamperes, (approximately 44 volts).

(n) Reduce the CURRENT LIMIT control until the UNCALIBRATED lamp illuminates.

(o) Parallel the 2.2K resistor with a resistor of 100 ohms, 10%, 1/2W. The panel meter should indicate less than 35 milliamperes. Remove both resistors.

(p) Set the CURRENT RANGE to 2A.

(q) Set the DC VOLTS controls to 000000.

(r) Connect two 470 ohm, 10%, 2W resistors in parallel across the OUTPUT terminals.

(s) Set the CURRENT LIMIT control to mid-range.

(t) Set the DC VOLTS controls so that the panel meter indicates 200 milliamperes (approximately 47 volts).

(u) Reduce the CURRENT LIMIT control until the UNCALIBRATED lamp illuminates.

(v) Parallel the two 470 ohm resistors with a 10 ohm, 10%, 2W resistor. The panel meter should indicate less than 350 milliamperes.

(w) Remove the three resistors and set the POWER switch to off.

(8) 500 Volt Isolation.

(a) Connect a one megohm resistor to the negative terminal of the 407D DC Power Supply. Connect the resistor to the 313A chassis ground terminal. Connect the positive power supply terminal to the 313A -OUTPUT terminal.

(b) Using the line cord adapters furnished with the 313A and the 821A, isolate the chassis of both instruments from line ground.

(c) Remove the shorting links from the 313A.

(d) Connect the 821A voltmeter across the one megohm resistor.

(e) Set the DC VOLTS controls to 50V.

TRANSISTOR	V _E	V _B	V _C	TRANSISTOR	V _E	V _B	V _C
Q2	-10.4	-10.5	-20.5	Q707	15.0	14.6	0.6
Q301	41.8	41.5	27.0	Q708	19.0	18.5	15.0
Q302	25.5	26.0	42.5	B ₁	B ₂	E	
Q303	26.0	26.8	42.5	Q802	-64.0	-70.0	-64.5
Q304	8.8	9.5	27.0	Q803	-53.5	-53.1	-64.5
Q305	9.0	9.8	25.5	Q804	-69.2	-69.0	-51.0
Q401	-25.4	-25.2	-16.0	Q901	-42.0	-43.8	+79.0
Q402	-26.0	-25.8	-16.0	Q902	-41.0	-41.5	0.0
Q403	-16.5	-16.0	-25.5	Q903	-41.4	-41.0	-43.8
Q404	-9.6	-10.0	-16.0	Q904	-40.8	-41.0	-40.8
Q405	-9.2	-9.5	-26.0	Q905	-36.2	-36.3	-40.5
Q501	0.2	1.0	17.0	Q1101	-49.6	-49.1	-41.4
Q502	17.0	16.5	0.2	Q1102	-10.4	-10.7	-20.5
Q503	0.2	0.8	14.5	Q1103	+0.2	0.0	-10.8
Q504	14.8	14.5	0.2	Q1104	10.2	10.1	0.2
Q505	7.0	7.1	17.8	Q1105	0.2	0.7	10.2
Q701	-5.0	-4.5	-1.0	Q1106	-20.6	-20.8	-0.1
Q702	-1.0	-0.1	+15.0	Q1107	-0.2	-0.1	-20.7
Q703	-0.8	-0.2	+15.0	Q1108	-10.5	-10.8	-20.6
Q704	15.0	14.8	-0.8	Q1201	0.0	0.0	A
Q705	15.0	14.5	-0.8				+68.0
Q706	15.0	14.6	0.6				

This chart is to be used under the following conditions:

- Output voltage set to 40V.
- No load connected to the instrument.
- Output polarity: negative (+ grounded).
- All measurements made with VTVM from chassis ground to specified terminal.
- These voltages may vary as much as 20% between instruments; however, the difference between V_E and V_B should be approximately as shown.

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Figure 4-2. TRANSISTOR VOLTAGE CHART.

- (f) Set the POWER switch to ON.
- (g) Turn on the 407D, and set to 500 volts output.
- (h) The 821A should indicate approximately zero volts.

NOTE

One hour warm-up is required before the following tests are performed.

- (9) Linearity Test.
 - (a) Connect the 821A to the 313A OUTPUT terminals.
 - (b) Set the 821A to 0 volts and 0.01 null range.
 - (c) Set DC VOLTS controls to 000000.
 - (d) Set the VOLTAGE RANGE switch to 49.99910.
 - (e) Set POWER switch to ON. Also apply power to the 821A.
 - (f) Simultaneously adjust the first DC VOLTS control and the 821A "A" control in ten-volt increments. The 821A should indicate the following voltages:

VOLTAGE POSITION	VOLTAGE MEASURED
10 volts	10 (± 0.001) volts
20 volts	20 (± 0.002) volts
40 volts	40 (± 0.004) volts

- (g) Set DC VOLTS controls to zero, and turn the 821A controls to zero.
- (h) Simultaneously adjust the second DC VOLTS control and the 821A "B" control in one-volt increments. The 821A should indicate the following voltages:

VOLTAGE POSITION	VOLTAGE MEASURED
1 volt	1 (± 0.0001) volts
2 volts	2 (± 0.0002) volts
4 volts	4 (± 0.0004) volts
6 volts	6 (± 0.0006) volts
8 volts	8 (± 0.0008) volts

- (i) Set the DC VOLTS controls to zero, and set the 821A controls to zero.

(10) Line Regulation.

- (a) Connect the 821A to the SENSE terminals.
- (b) Connect the resistor bank to the OUTPUT terminals.
- (c) Set the CURRENT RANGE control to 2A, and set CURRENT LIMIT control to MAX.
- (d) Set DC VOLTS controls to 49.9000 volts.
- (e) Connect the 313A to the line through the Variac, and adjust the Variac for 115 VAC output.
- (f) Adjust the resistor bank for 2 amps load current. Record the output voltage indicated on the 821A.
- (g) Reduce the Variac output voltage to 100 VAC. The 821A should indicate less than ± 0.00025 volts change from step (f).
- (h) Return the Variac to 115 VAC output. Record the voltage indicated by the 821A.
- (i) Increase the Variac to 130 VAC output voltage. The 821A should indicate less than ± 0.00025 volts change from step (h).
- (j) Disconnect the resistor bank from the OUTPUT terminals and repeat the measurements of steps (e) through (i).

(11) Load Regulation.

- (a) Connect the 821A to the SENSE terminals.
- (b) Set the Variac to 115 VAC output.
- (c) Connect the resistor bank to the OUTPUT terminals.
- (d) Set the DC VOLTS controls to 49.9000.
- (e) Set the POWER switch to ON, and adjust the resistor bank for 2 amperes load current.
- (f) Using the 0.001 volt null range on the 821A, measure the voltage across the SENSE terminals.
- (g) Alternately connect and disconnect the load by switching a 100K resistor in series with the load. The 821A should indicate less than ± 0.00025 volts change.
- (h) Repeat steps (e) through (g) with the DC VOLTS controls set to 4.99000. The 821A should indicate less than ± 0.00025 volts change.
- (i) Set the POWER switch to off, and remove the shorting links between the SENSE terminals and the OUTPUT terminals. Connect the SENSE terminals directly to the load terminals.
- (j) Connect the 821A to the load terminals.
- (k) Set the DC VOLTS controls to 49.9000.
- (l) Set the POWER switch to ON, and adjust the load current to 2 amperes.
- (m) Alternately connect and disconnect the load by switching a 100K resistor in series with the load. The 821A should indicate less than ± 0.00025 volts change.
- (n) Set POWER switch to off.

(12) Ripple.

- (a) Remove the shorting link between the OUTPUT terminal and the chassis ground terminal.
- (b) Connect the 313A as in Figure 4-6. All connecting leads must be coaxial cable.
- (c) Set the POWER switch to ON.
- (d) Set the DC VOLTS controls to 49.99910.
- (e) Adjust the resistor bank for a load current of 2 amperes.
- (f) Measured RMS ripple should be less than 0.00005 volts.
- (g) Set the POWER switch to off, and disconnect the resistance bank.
- (h) Set the POWER switch to ON.
- (i) Measured RMS ripple should be less than 0.00005 volts.

4-4. CALIBRATION

The calibration accuracy of the 313A should be checked every 30 days. Calibration should be accomplished in a draft-free area having an ambient temperature of $72 (\pm 3)^{\circ}\text{F}$. This will provide maximum accuracy under laboratory conditions. The equipment required for calibration is listed in Figure 4-4. The location of calibration adjustments is given in Figure 4-5. The test adapter used for calibration and/or troubleshooting is attached to the left side of the rear panel of the instrument.

a. PRELIMINARY CALIBRATION PROCEDURE.

- (1) Remove the top cover of the 313A.
- (2) Set POWER switch to ON and allow the 313A to warm to equilibrium temperature. Usually one hour of operation is adequate.
- (3) Refer to Figure 4-4 for a list of required calibration equipment: turn on all test equipment and allow to warm to equilibrium temperature.

RECOMMENDED EQUIPMENT	SPECIFICATIONS REQUIRED
Simpson #270, or equivalent Variable	Ohmmeter 100-to-130 VAC, 5 amps
Oscilloscope-Tektronics 543 with type L plug in, or equivalent	Minimum of 0.5 sec/cm sweep speed & 0.5 volts/cm vertical sensitivity
Resistors	8.2K, 10%, 1W 100Ω, 10%, 1W 2.2K, 10%, 2W 470Ω, 10%, 2W 10Ω, 10%, 2W 1K, 10%, 2W
Voltmeter, Fluke 821A, or equivalent	0.01% accuracy
Load resistor bank	2 amp capacity
True RMS voltmeter, Fluke 910A, or equivalent	Capability to measure non- sinusoidal waves
DC Power Supply, Fluke 407D, or equivalent	0 to 500 VDC
Preamplifier, AC to AC, Tektronix, type 123	Gain of approx- imately 20 db, less than 10 uv noise level battery powered.

Figure 4-3. EQUIPMENT REQUIRED FOR TROUBLESHOOTING

(4) Connect series combination of galvanometer and standard cell bank to standard cell terminals of the voltage reference divider.

(5) Adjust voltage reference divider for correct standard cell voltage.

(6) The following calibration steps are independent and may be performed in any desired order.

b. CURRENT LIMIT ADJUSTMENT

(1) Set 313A POWER switch to off and place test adapter between board 313A-409 and chassis connector.

(2) Set controls on the 313A as follows:

CURRENT RANGE	0.02A
CURRENT LIMIT	MIN
DC VOLTS	all zero
POWER	ON

(3) Connect differential voltmeter between terminals J and P of test adapter.

(4) Adjust R909 so that differential voltmeter indicates 0 (± 0.1) volts.

(5) Adjust R911 so that the VOLTAGE UNCALIBRATED lamp barely illuminates.

(6) Repeat steps "(4)" and "(5)" until both conditions occur simultaneously.

RECOMMENDED EQUIPMENT	SPECIFICATIONS REQUIRED
Saturated standard cell bank with an accuracy of $\pm 0.001\%$.	Must be capable of measuring 5 and 50 volts with an accura- cy of at least $\pm 0.003\%$.
Voltage reference divider having 5 and 50 volt termi- nals with an accuracy of $\pm 0.001\%$.	
Galvanometer suitable for use with voltage reference divider.	
Any Fluke Differential Voltmeter.	Must be capable of measuring 0, 1.02, 2.6, 15, and 25 volts with an accuracy of $\pm(0.05\% + 50 \text{ uv})$.
Tektronix type 543 oscillo- scope with type L plug-in unit.	Must have a 15 megacycle band- width and 5 mv/ cm vertical sensitivity.

Figure 4-4. CALIBRATION EQUIPMENT.

c. ADJUSTMENT OF -15 VOLT SUPPLY.

(1) Set 313A POWER switch to off and place test adapter between board 313A-404 and chassis connector.

(2) Set 313A POWER switch to ON.

(3) Connect differential voltmeter between terminals U and K of test adapter.

(4) Adjust R409 so that voltmeter indicates 15 (± 0.1) volts.

(5) The -15 volt auxiliary supply will require balancing if Q404, Q405, or any associated circuit component is replaced. Proceed as follows:

(a) Connect differential voltmeter between test points TP401 and TP402.

(b) Adjust R406 so that voltmeter indicates zero (± 0.005) volts.

d. ADJUSTMENT OF +25 VOLT SUPPLY.

(1) Set 313A POWER switch to off and insert test adapter between board 313A-403 and chassis connector.

(2) Set 313A POWER switch to ON.

(3) Connect differential voltmeter between terminals H and M of the test adapter.

(4) Adjust R309 so that voltmeter indicates 25 (± 0.1) volts.

(5) The +25 volt auxiliary supply will require balancing if Q304, Q305, or any associated circuit component is replaced. Proceed as follows:

(a) Set the 313A POWER switch to off and place test adapter between board 313A-403 and chassis connector.

(b) Set 313A POWER switch to ON.

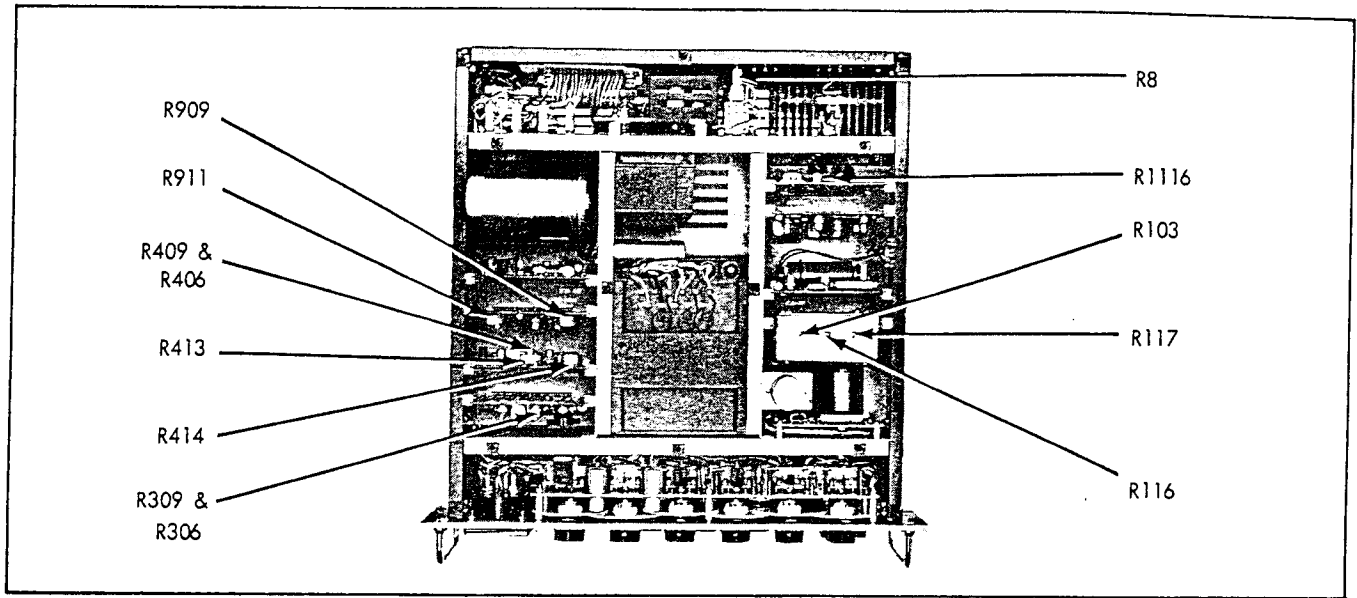


Figure 4-5. LOCATION OF CALIBRATION ADJUSTMENTS

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(c) Connect differential voltmeter between test points TP301 and TP302.

(d) Adjust R306 so that voltmeter indicates zero (± 0.005) volts.

e. ADJUSTMENT OF ZENER CURRENT.

(1) Set 313A POWER switch to off and insert test adapter between board 313A-401 and chassis connector.

(2) Connect differential voltmeter between terminals C and D of test adapter.

(3) Refer to the zener oven to determine which zener diode is used.

(4) Adjust R103 so that the voltmeter indicates 2.6 (± 0.01) volts when zener diode 313A-430 is used, and 2.1 (± 0.01) volts when zener diode 313A-431 is used.

f. ADJUSTMENT OF REFERENCE VOLTAGE.

(1) Set POWER switch to ON.

(2) Connect differential voltmeter to terminals 9 and 10 on the rear terminal strip.

(3) Adjust R8 (REFERENCE CALIBRATE control) so that voltmeter indicates 1.02 (± 0.00001) volts on the most sensitive voltmeter null range. On earlier models, R115 on board 313A-401 may also be adjusted if necessary.

g. ADJUSTMENT OF DRIVER FREQUENCY RESPONSE.

(1) Set 313A POWER switch to off and insert test adapter between board 313A-411 and chassis connector.

(2) Set the controls on the 313A as follows:

VOLTAGE RANGE	50
DC VOLTS	16.0000
POWER	ON

(3) Connect a 20-ohm load to the 313A OUTPUT terminals.

(4) Connect the oscilloscope to the 313A SENSE terminals.

(5) Adjust oscilloscope to trigger on the silicon controlled rectifier spike, and set sweep speed to 5 microseconds per centimeter.

(6) Set vertical sensitivity to 5 millivolts per centimeter with AC coupling.

(7) Adjust R1116 on board 313A-411 to obtain minimum amplitude of damped transient following silicon controlled rectifier spike; R1116 will normally be set for maximum resistance (fully CCW).

h. ZERO ADJUSTMENT.

(1) Set the VOLTAGE RANGE switch to 5V and all DC VOLTS controls to zero.

(2) Connect + OUTPUT terminal to chassis ground terminal.

(3) Connect differential voltmeter to OUTPUT terminals of 313A. Set voltmeter to zero.

(4) Adjust R413 on board 313A-404 for a null on the differential voltmeter.

(5) Set VOLTAGE RANGE control to 50V.

(6) Adjust R414 for a null on the differential voltmeter.

i. ADJUSTMENT OF 50 VOLT RANGE.

(1) Set 313A POWER switch to off and place test adapter between board 313A-401 and chassis connector.

(2) Set VOLTAGE RANGE switch to 50V and DC VOLTS controls to 49.99910 (50 volts).

(3) Connect 313A OUTPUT terminals to 50 volt terminals of voltage reference divider, and connect the galvanometer to the voltage divider.

(4) Set 313A POWER switch to ON.

(5) Adjust R117 to null galvanometer.

j. ADJUSTMENT OF 5 VOLT RANGE.

- (1) Set 313A POWER switch to off.
- (2) Set the VOLTAGE RANGE switch to 5 and set the DC VOLTS controls to 4.9999 $\overline{10}$ (5 volts).
- (3) Connect the 313A OUTPUT terminals to the 5 volt terminal of the reference divider. Connect galvanometer to voltage divider.
- (4) Set 313A POWER switch to ON.
- (5) Adjust R116 to null galvanometer.

NOTE

It may be necessary to adjust the 5 volt range approximately 2 millivolts high to compensate for the added resistance of the test adapter.

- (6) Replace board 313A-401 in the chassis connector and measure 5 volt and 50 volt output. Adjust R116 and R117 if necessary.

k. REFERENCE VOLTAGE MONITORING.

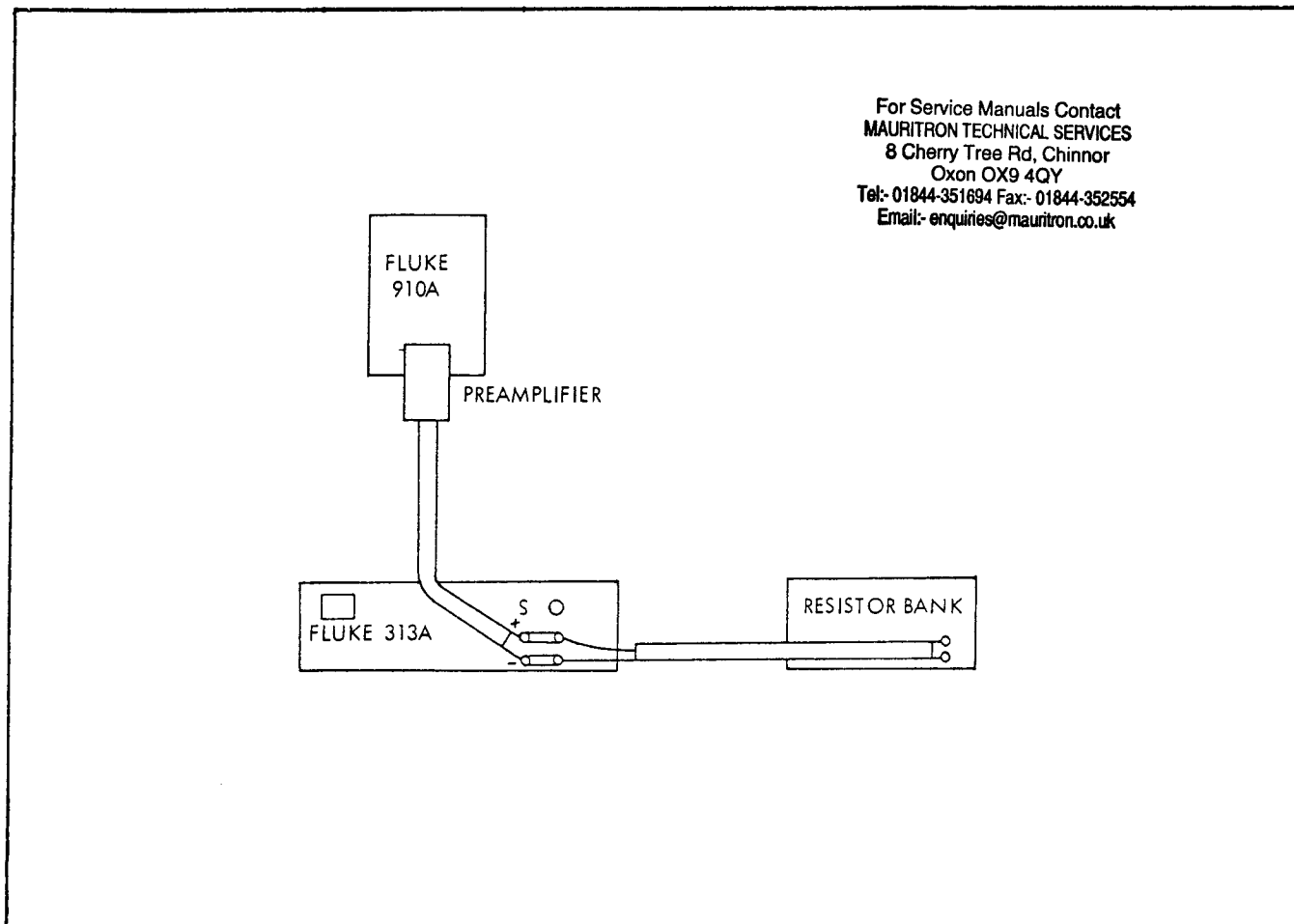
The REFERENCE CALIBRATE control, and terminals 9 and 10 of the rear terminal strip, are provided for monitoring and adjusting the internal reference voltage. This should be performed only when it is necessary to improve the 0.005% stability of the 313A. The REFERENCE CALIBRATE control and terminals 9 and 10 may be used regardless of the connections to the instrument or the position of the front panel controls.

(1) Connect a series combination of a Microvolt Potentiometer, such as the Fluke Model 831A, and a temperature-controlled standard cell between terminals 9 and 10 of the rear terminal strip.

(2) Null out voltage difference with the potentiometer.

(3) Monitor reference voltage of the 313A with the potentiometer. If the reference voltage changes by 5 parts per million, the output of the 313A will change by 5 parts per million.

The calibration of the instrument is complete.



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Figure 4-6. CONNECTIONS FOR RIPPLE MEASUREMENT

SECTION V

LIST OF REPLACEABLE PARTS

5-1. INTRODUCTION

The following list describes all normally replaceable parts of the Model 313A Voltage Calibrator. Parts are identified on the list and on corresponding illustrations by reference designations from the schematic diagram. Those parts (mechanical) which have no reference designation are identified on the illustrations by Fluke stock number.

5-2. HOW TO OBTAIN PARTS

a. Standard components have been used wherever possible, and can be obtained locally. All parts manufactured or altered by Fluke, and all parts for which Fluke controls the design, are identified by an asterisk

preceding the Fluke stock number. All structural parts and special parts should be ordered from your local Fluke representative or from the factory.

b. When ordering parts always include:

(1) Reference designation, description, and Fluke stock number.

(2) Instrument model and serial number.

c. When ordering the resistors mounted on the Sample Resistor Assembly, 125815 (313A-402), always include all of the markings on the old resistor. These resistors are grouped according to resistance tolerance and temperature coefficient, and the old markings are necessary to properly identify the resistor.

d. Most structural parts are not listed. To order these, give complete description, function, and location of part.

REFERENCE DESIGNATION	DESCRIPTION	FLUKE STOCK NO.	USE CODE
	Final Assembly (Rack Model) (See Figure 5-1)	*139261	
	Front Panel Assembly (See Figure 5-2)	*139287	
	Master Voltage Reference (See Figure 5-3)	*145003	
	Auxiliary Power Supply Assembly, +25V (See Figure 5-4)	*125823	
	Auxiliary Power Supply Assembly, -15V (See Figure 5-5)	*125831	
	Chopper Amplifier Assembly (See Figure 5-6)	*125849	
	Main Amplifier Assembly (See Figure 5-7)	*145011	
	SCR Firing Circuit Assembly (See Figure 5-8)	*125864	
	Overcurrent Limiter Assembly (See Figure 5-9)	*125872	
	Meter Shunt Assembly (See Figure 5-10)	*125880	
	Driver Assembly (See Figure 5-11)	*125898	
	Rectifier Assembly (See Figure 5-12)	*125906	
	Main Harness Assembly (Not illustrated)	*125914	E

REFERENCE DESIGNATION	DESCRIPTION	FLUKE STOCK NO.	USE CODE
	Test Adapter (Shown on Figure 5-1)	*125856	
	Reference Oven (See Figure 5-13)	*145029	
C1	Capacitor, electrolytic, 9500 uf -10/+75%, 75V	106971	
C2	Capacitor, ceramic, 0.05 uf -20/+80%, 500V	105676	
C3	Capacitor, electrolytic, 500 uf -10/+100%, 25V	105031	
C4	Capacitor, electrolytic, 500 uf -10/+75%, 100V	143149	
C6, C7	Capacitor, electrolytic, 150 uf -10/+100%, 150V	106914	
C10 thru C12	Capacitor, ceramic, 0.01 uf -20/+80%, 500V	105668	
C13 thru C15	Capacitor, ceramic, 0.05 uf -20/+80%, 500V (C13 not illustrated)	105676	
C16	Capacitor, ceramic, 0.01 uf -20/+80%, 500V, (not illustrated)	105668	
C17	Capacitor, plastic, 0.47 uf \pm 20%, 600V	105494	
C18	Capacitor, electrolytic, 100 uf -10/+100%, 25V	106518	HH
C19	Capacitor, ceramic, 0.005 uf, \pm 20%, 1000V	105650	MM
CR1	Diode, zener, 18V, 14ma	113365	J
CR6, CR7	Diode, silicon, 6 PIV, 100 ma Diode, silicon, 100 PIV, 1A	113308 116111	C D
CR8	Diode, silicon, 100 PIV, 1A	116111	K
CR9	Diode, silicon, 100 PIV, 1A	116111	P
DS1, DS2	Lamp, neon, type NE48	125971	
DS6	Lamp, incandescent, type 10C7	104539	
DS7	Lamp, neon, type NE2E	100347	O
K1	Relay, DPDT, 115 VAC 5A	106864	
L1	Choke, 75 mH	126086	
L2	Choke, RF, 100 uH, \pm 5%, 1/2W	111542	
Q2	Transistor, PNP, germanium, type 2N1546 Transistor, PNP, germanium, type 2N1556	117234 160663	F G
R1	Resistor, wirewound, 1.5 Ω \pm 1%, 50W	113498	
R4	Resistor, wirewound, 1K \pm 5%, 5W	113282	
R5	Resistor, wirewound, 2K \pm 5%, 5W	113506	
R7	Resistor, wirewound, 3.5K \pm 5%, 5W	113290	
R8	Resistor, variable, wirewound, 5 Ω \pm 10%, 2W Resistor, variable, wirewound, 10 Ω \pm 10%, 2W	113514 112995	C D

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REFERENCE DESIGNATION	DESCRIPTION	FLUKE STOCK NO.	USE CODE
R9	Resistor, wirewound, $150\Omega \pm 5\%$, 10W	112334	
R10	Resistor, wirewound, $20\Omega \pm 5\%$, 5W	113522	
R11	Resistor, composition, $8.2K \pm 10\%$, 2W	110072	
R12	Resistor, wirewound, $0.43\Omega \pm 5\%$, 10W	113548	
R13	Resistor, wirewound, $3.5K \pm 5\%$, 5W	113290	J
R16	Resistor, deposited carbon, (not illustrated) $195K \pm 1\%$, 1/2W	143529	Z
	Resistor, deposited carbon, $1M, \pm 1\%$, 1/2W	161075	E
	Resistor, deposited carbon, $196K \pm 1\%$, 1/2W	161513	Y
R17	Resistor, metal film, (not illustrated) $10\Omega \pm 1\%$, 1/2W	151043	D
	Resistor, metal film, $36.5\Omega \pm 1\%$, 1/2W	151027	E
R18	Resistor, deposited carbon, (not illustrated), $500K \pm 1\%$, 1/2W	107367	D
R20	Resistor, composition, $18\Omega \pm 10\%$, 1/2W	108811	P
R21	Resistor, composition, $2.4K \pm 5\%$, 1/2W	108902	P
T1	Transformer, power	*126078	

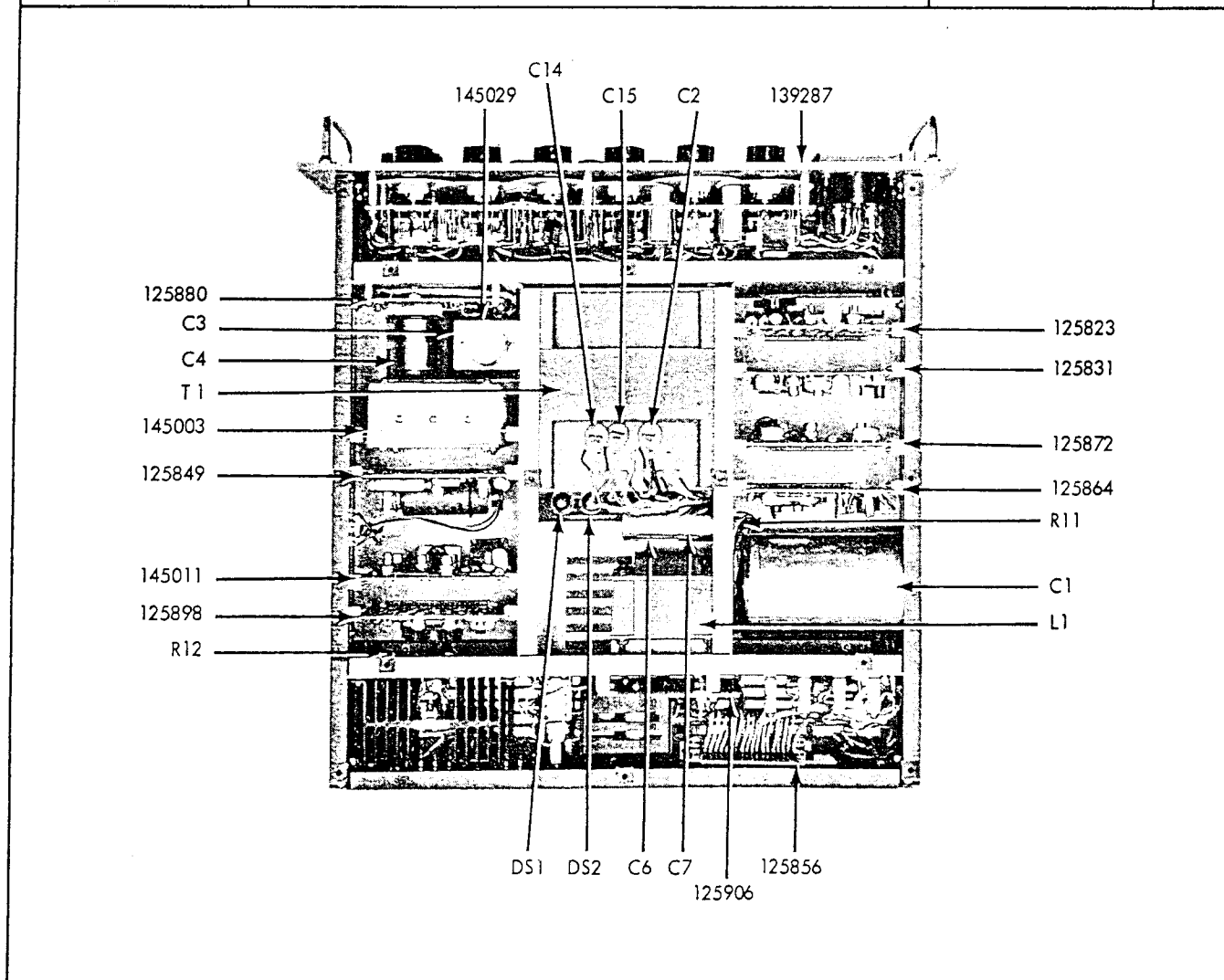
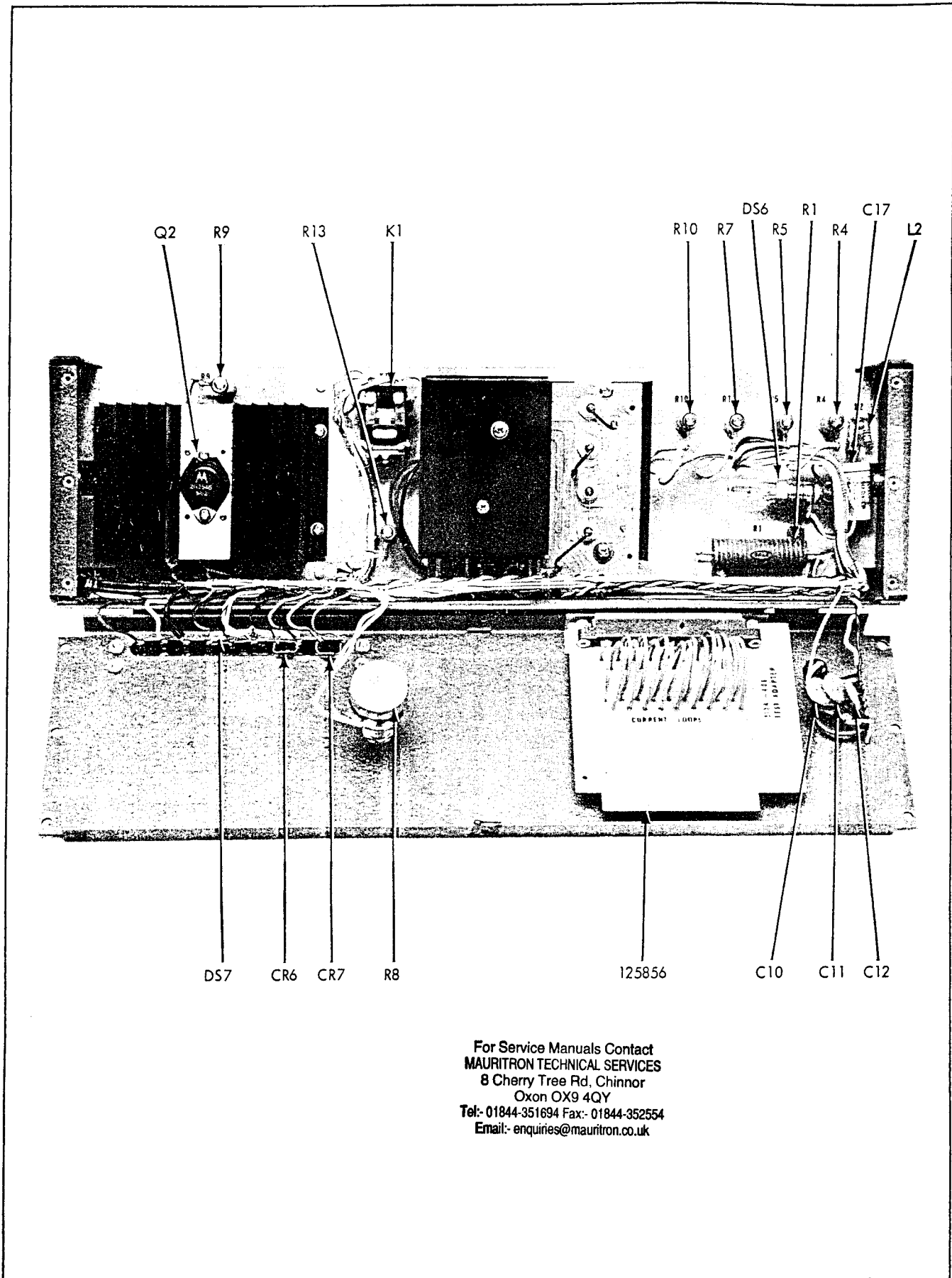


Figure 5-1. FINAL ASSEMBLY (sheet 1 of 2)



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Figure 5-1. FINAL ASSEMBLY (sheet 2 of 2)

REFERENCE DESIGNATION	DESCRIPTION	FLUKE STOCK NO.	USE CODE
	Front Panel Assembly Sample Resistor Assembly	*139287 *125815 (313A-402)	
C201	Capacitor, plastic, 2 uf $\pm 20\%$, 100V	106963	
R201	Resistor, wirewound, 10K $\pm 0.01\%$, 1/10W Resistor, wirewound, 10K $\pm 0.01\%$, 1/2W	*131821 *131664	F G
R202, R203	Resistor, wirewound, 20K $\pm 0.01\%$, 1/10W Resistor, wirewound, 20K $\pm 0.01\%$, 1/2W	*131813 *131680	F G
R204	Resistor, wirewound, 1K $\pm 0.01\%$, 1/10W Resistor, wirewound, 1K $\pm 0.01\%$, 1/2W	*131847 *131706	F G
R205 thru R208	Resistor, wirewound, 2K $\pm 0.01\%$, 1/10W Resistor, wirewound, 2K $\pm 0.01\%$, 1/2W	*131839 *131714	F G
R209	Resistor, wirewound, 100 Ω $\pm 0.015\%$, 1/10W	*155846	
R210 thru R213	Resistor, wirewound, 200 Ω $\pm 0.015\%$, 1/10W	*131656	
R214	Resistor, wirewound, 10 Ω $\pm 0.03\%$, 1/2W	*131775	
R215 thru R218	Resistor, wirewound, 20 Ω $\pm 0.03\%$, 1/2W Resistor, wirewound, 20 Ω $\pm 0.03\%$, 1/2W	*131763 *155887	F G
R219	Resistor, wirewound, 1 Ω $\pm 0.2\%$, 1/10W	*131888	
R220 thru R223	Resistor, wirewound, 2 Ω $\pm 0.2\%$, 1/10W	*131870	
R224	Resistor, wirewound, 0.096 Ω $\pm 1\%$, 1/10W	*131904	
R225 thru R229	Resistor, wirewound, 0.196 Ω $\pm 1\%$, 1/10W	*131896	
S201	Switch, rotary, 2 sections, 5 positions Switch, rotary, 2 sections, 5 positions	*126029 *154971	F G
S202 thru S205	Switch, rotary, 2 sections, 10 positions Switch, rotary, 2 sections, 10 positions	*126011 *154963	F G
S206	Switch, rotary, 2 sections, 11 positions Switch, rotary, 2 sections, 11 positions	*126003 *154955	F G
DS3	Lamp, neon, type NE51	101709	
DS201, DS202	Lamp, incandescent, 6.3V, type 47	102855	
M1	Meter, 1 ma, $\pm 1\%$	111500	
R6	Resistor, variable, wirewound, 10K $\pm 5\%$, 2W	113480	
S1	Switch, toggle, DPST, 6A, 125V	114835	

REFERENCE DESIGNATION	DESCRIPTION	FLUKE STOCK NO.	USE CODE
S2	Switch, rotary, 1 section, 2 position	125989	
S3	Switch, rotary, 1 section, 3 position	125997	
S4	Switch, toggle, DPDT, 5A, 115V	115113	
	Fuseholder	100107	
	Knob, 1-1/2 inch (not illustrated)	101121	II
	Knob, 1-1/4 inch (not illustrated)	188581	JJ
	Knob, 1 inch (not illustrated)	101287	II
	Knob, 1 inch (not illustrated)	188565	JJ
	Fuse, 3A, Fast-blowing (not illustrated)	109199	
	Binding post, black, (not illustrated)	142984	
	Binding post, red, (not illustrated)	142976	

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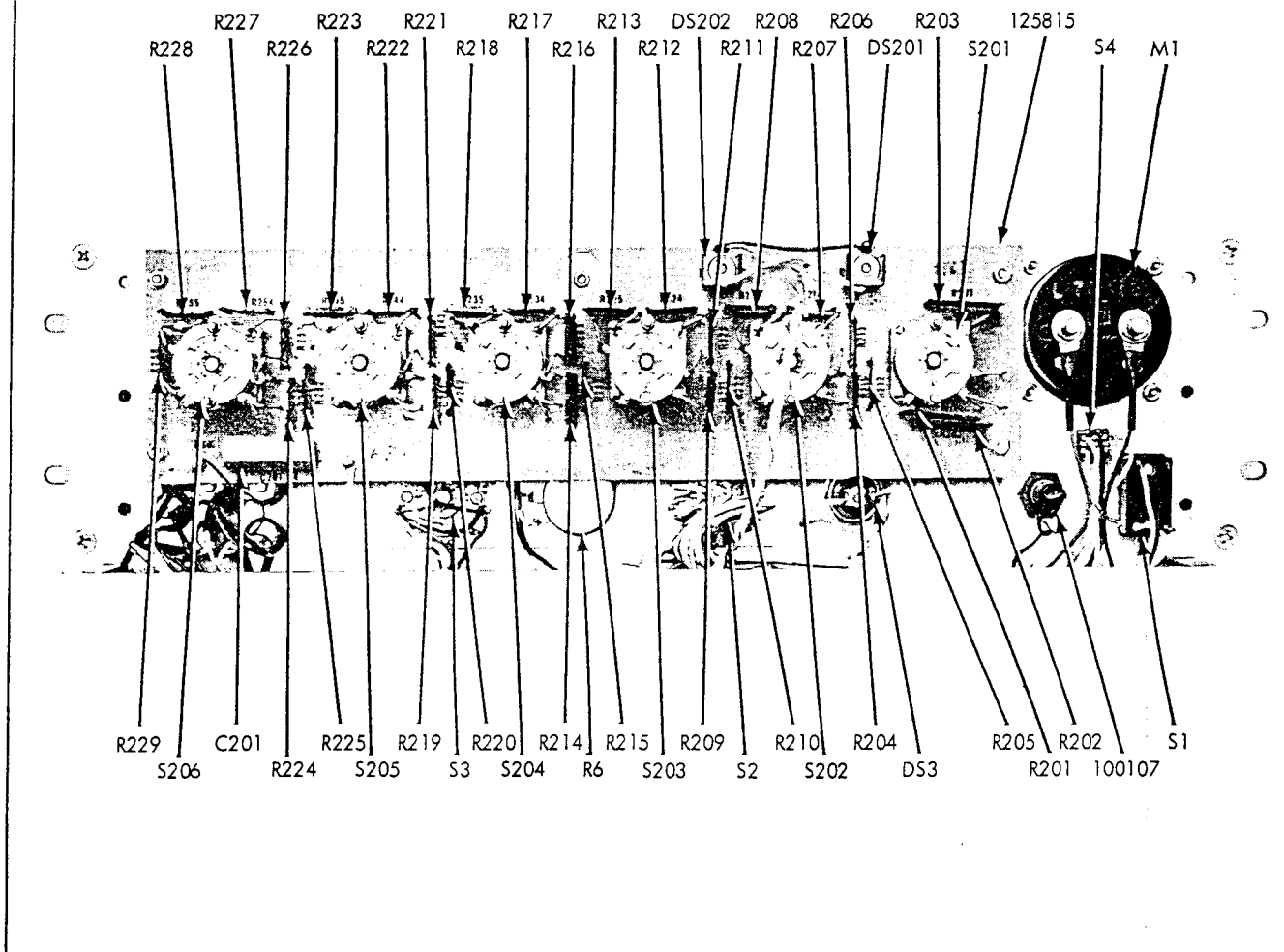


Figure 5-2. FRONT PANEL ASSEMBLY

REFERENCE DESIGNATION	DESCRIPTION	FLUKE STOCK NO.	USE CODE
	Master Voltage Reference Assembly	*145003 (313A-401)	
	NOTE 1: When ordering the Master Voltage Reference Assembly, be sure to provide the information on the Zener Reference Oven decal and the instrument serial number. These two assemblies contain matched components, and the decal information is necessary for complete identification. On older units, a three-digit number stamped on the 313A-401 circuit board must also be provided.		
C101	Capacitor, plastic, 0.1 uf $\pm 20\%$, 200V	106435	
R101, R102	Resistor, variable, wirewound, $50\Omega \pm 10\%$, 1-1/4W	144774	C
R103	Resistor, variable, wirewound, $300\Omega \pm 10\%$, 1-1/4W	112870	C
	Resistor, variable, wirewound, $150\Omega \pm 10\%$, 1-1/4W	113092	D
R107	Resistor, wirewound, factory selected		
	NOTE 2: When ordering, supply information requested in note 1.		
R109	Resistor, wirewound, $200\Omega \pm 0.015\%$, 1/2W	*131656	
R110	Resistor, wirewound, $8.0K \pm 0.1\%$, 1/2W	*145169 (Use with 313A-430 only)	EE
	Resistor, wirewound, $8.0K \pm 0.1\%$, 1W	*131946 (Use with 313A-430 only)	FF
	Resistor, wirewound, $5.0K \pm 0.1\%$, 1/2W	*149708 (Use with 313A-431 only)	DD
R111	Resistor, wirewound, $1.02K \pm 0.1\%$, 1/2W	*145128	
	NOTE 3: R110 and R111 are matched according to resistance accuracy, and must be ordered as a set. Part number 192203 identifies a matched set for serial numbers 267 and on.		
R112	Resistor, wirewound, $8.1K \pm 0.1\%$, 1/2W	*145144 (Use with 313A-430 only)	CC
	Resistor, wirewound, $5.418K \pm 0.1\%$, 1/2W	*147470 (Use with 313A-431 only)	NN
	Resistor, wirewound, $6K \pm 0.1\%$, 1/2W	*147462 (Use with 871A-412 only)	OO
R113	Resistor, wirewound, $1.0K \pm 0.1\%$, 1/2W	*145151 (Use with 313A-430 only)	EE
	Resistor, wirewound, $1.0K \pm 0.1\%$, 1W	*131623 (Use with 313A-430 only)	FF
	Resistor, wirewound, $668\Omega \pm 0.1\%$, 1/2W	*147488 (Use with 871A-412 only)	DD

REFERENCE DESIGNATION	DESCRIPTION	FLUKE STOCK NO.	USE CODE
R114	Resistor, wirewound, 9.0K \pm 0.05%, 1/2W	*145102 (Use with 313A-430 only)	CC
	Resistor, wirewound, 6.0K \pm 0.1%, 1/2W	*147462 (Use with 313A-431 only)	DD
R115	Resistor, variable, wirewound, 200 Ω \pm 10%, 1-1/4W	144766	C
	Resistor, wirewound, 180 Ω \pm 0.1%, 1/8W	*156000	D
	NOTE 4: R115 is factory selected for each instrument. When ordering, supply the information requested in note 1.		
R116	Resistor, variable, wirewound, 100 Ω \pm 20%, 1-1/4W	112797	C
	Resistor, variable, wirewound, 25 Ω \pm 10%, 1-1/4W	113431	NN
	Resistor, variable, wirewound, 300 Ω \pm 10%, 1-1/4W	154583	OO
R117	Resistor, variable, wirewound, 50 Ω \pm 10%, 1-1/4W	144782	C
	Resistor, variable, wirewound, 25 Ω \pm 10%, 1-1/4W	113431	D
R118	Resistor, wirewound, 4K \pm 0.03%, 1/2W	*131672	OO
R119	Resistor, wirewound, 50K \pm 0.1%, 1W	*156455	OO

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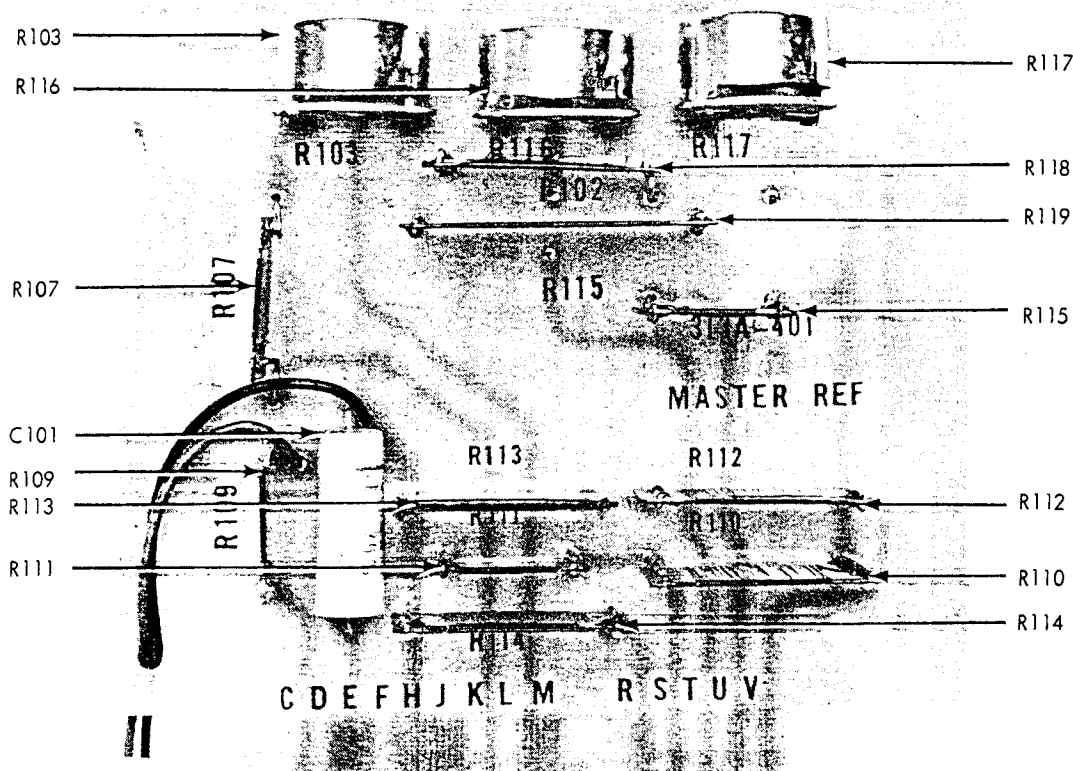
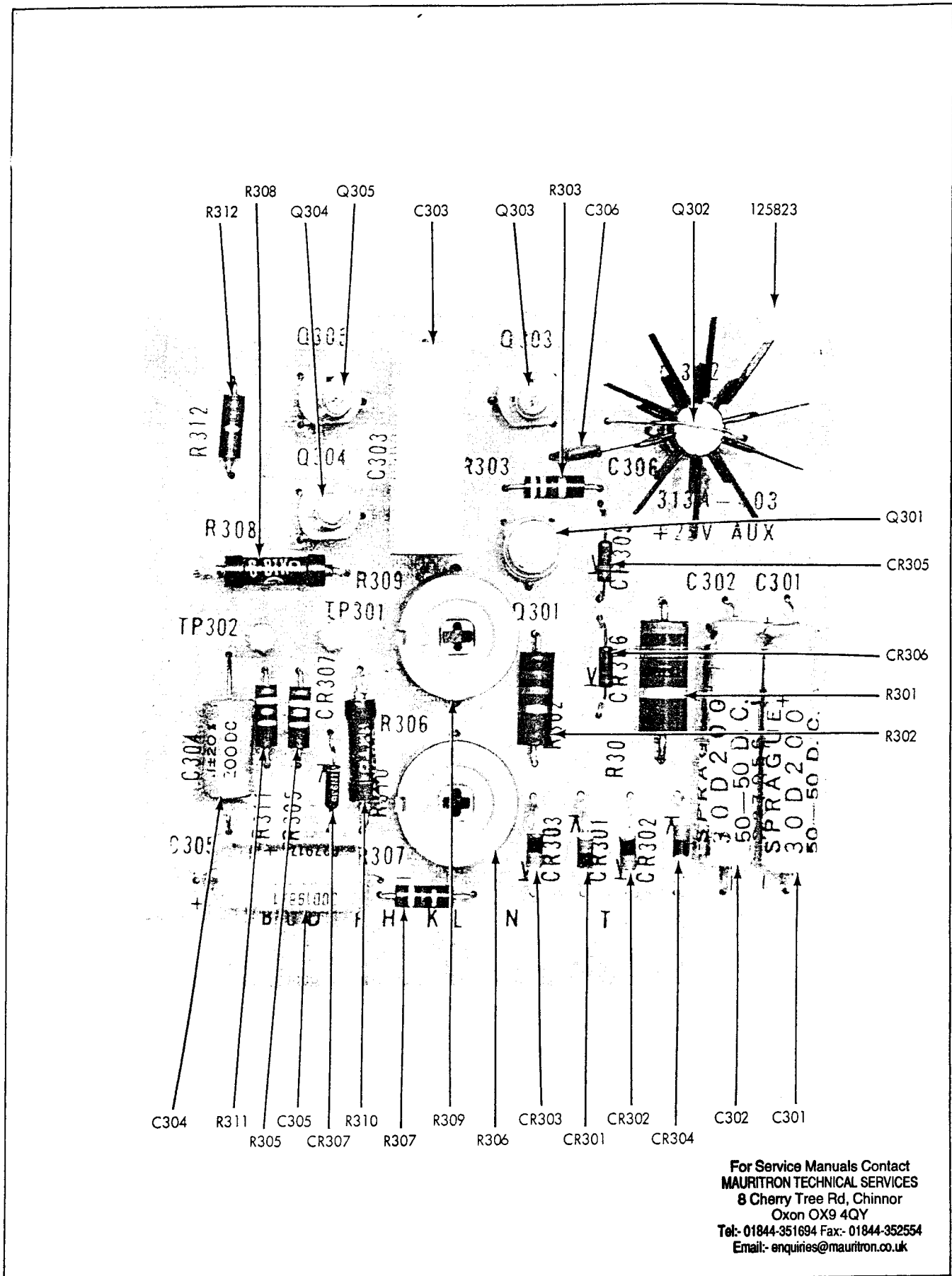


Figure 5-3. MASTER VOLTAGE REFERENCE

REFERENCE DESIGNATION	DESCRIPTION	FLUKE STOCK NO.	USE CODE
	Auxiliary Power Supply Assembly +25V	125823 (313A-403)	
C301, C302	Capacitor, electrolytic, 50 uf -10/+100%, 50V	105122	
C303	Capacitor, plastic, 2 uf ±20%, 100V	106963	
C304	Capacitor, plastic, 0.1 uf ±20%, 200V	106435	
C305	Capacitor, electrolytic, 20 uf -10/+100%, 50V	106229	
C306	Capacitor, ceramic, 300 pf ±10%, 500V	105734	
CR 301 thru CR304	Diode, silicon, 600 PIV, 0.75A Diode, silicon, 100 PIV, 1A	112383 116111	F G
CR305, CR306	Diode, silicon, 6 PIV, 0.10A	113308	
CR307	Diode, zener, 9V, 7.5 ma Diode, zener, 6.3V, 7.5 ma	113373 172148	X Y
Q301	Transistor, PNP, germanium, type 2N1373 Transistor, PNP, germanium, type 2N1372	116723 116129	O P
Q302	Transistor, NPN, silicon, type 2N2040 Transistor, NPN, silicon, type CDQ10449	117200 153551	O P
Q303 thru Q305	Transistor, NPN, silicon, type NS734 Transistor, NPN, silicon, type CDQ10449	117192 153551	O P
R301	Resistor, composition, 68Ω ±10%, 2W Resistor, composition, 120Ω ±10%, 2W	110205 155531	C D
R302	Resistor, composition, 5.1K ±5%, 1W	109918	
R303	Resistor, composition, 470Ω ±10%, 1/2W	108415	
R305	Resistor, composition, 2.7Ω ±10%, 1/2W	108845	
R306	Resistor, variable, wirewound, 500Ω ±10%, 1-1/4W	112433	
R307	Resistor, composition, 1.3K ±5%, 1/2W Resistor, composition, 750Ω ±5%, 1/2W	109157 108894	X Y
R308	Resistor, deposited carbon, 6.81K ±1%, 1/2W Resistor, metal film, 8.06K ±1%, 1/2W	107979 159467	X Y
R309	Resistor, variable, wirewound, 1K ±20%, 1-1/4W Resistor, variable, wirewound, 500Ω ±10%, 1-1/4W	111575 112433	X Y
R310	Resistor, deposited carbon, 3.89K ±1%, 1/2W Resistor, metal film, 2.55K ±1%, 1/2W	107268 176362	X Y
R311	Resistor, composition, 2.7Ω ±10%, 1/2W	108845	
R312	Resistor, composition, 2.2K ±5%, 1/2W Resistor, composition, 2.4K ±5%, 1/2W	108506 108902	X Y



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Figure 5-4. AUXILLARY POWER SUPPLY ASSEMBLY, +25V

REFERENCE DESIGNATION	DESCRIPTION	FLUKE STOCK NO.	USE CODE
	Auxiliary Power Supply Assembly, -15V	125831 (313A-404)	
C401, C402	Capacitor, electrolytic, 50 uf, -10/+100%, 50V	105122	
C403	Capacitor, plastic, 2 uf $\pm 20\%$, 100V	106963	
C404	Capacitor, plastic, 0.1 uf $\pm 20\%$, 200V	106435	
C405	Capacitor, electrolytic, 20 uf -10/+100%, 50V	106229	
C406	Capacitor, ceramic, 0.0027 uf, GMV, 600V	106211	D
CR401 thru CR404	Diode, silicon, 600 PIV, 0.75A Diode, silicon, 100 PIV, 1A	112383 116111	F G
CR405, CR406	Diode, silicon, 6 PIV, 0.10A	113308	
CR407	Diode, silicon, 600 PIV, 0.75A Diode, silicon, 100 PIV, 1A	112367 116111	T AA
CR408	Diode, zener, 9V at 7.5 ma Diode, zener, 6.3V at 7.5 ma	113373 172148	X Y
Q401	Transistor, NPN, germanium, type 2N1304	117127	
Q402	Transistor, NPN, silicon, type 2N2270 Transistor, NPN, silicon, type CDQ10449 Transistor, NPN, silicon, type 2N3053	117135 153551 150359	E Z Y
Q403 thru Q405	Transistor, PNP, germanium, type 2N1379	117143	
R401	Resistor, composition, $82\Omega \pm 10\%$, 1W	109884	
R402	Resistor, composition, $2.2K \pm 10\%$, 1W	109843	
R403	Resistor, composition, $390\Omega \pm 10\%$, 1/2W	108365	
R404	Resistor, composition, $560\Omega \pm 10\%$, 1/2W	108316	
R405	Resistor, composition, $2.7\Omega \pm 10\%$, 1/2W	108845	
R406	Resistor, composition, $500\Omega \pm 10\%$, 1-1/4W	112433	
R407	Resistor, composition, $1.2K \pm 10\%$, 1/2W Resistor, composition, $750\Omega \pm 5\%$, 1/2W	108803 108894	X Y
R408	Resistor, deposited carbon, $2.7K \pm 1\%$, 1/2W Resistor, metal film, $2.55K \pm 1\%$, 1/2W	107276 176362	X Y
R409	Resistor, variable, wirewound, $1K \pm 20\%$, 1-1/4W Resistor, variable, wirewound, $500\Omega \pm 10\%$, 1-1/4W	111575 112433	X Y
R410	Resistor, deposited carbon, $3.89K \pm 1\%$, 1/2W Resistor, metal film, $2.0K \pm 1\%$, 1/2W	107268 151266	X Y
R411	Resistor, composition, $2.7\Omega \pm 10\%$, 1/2W	108845	
R412	Resistor, composition, $820\Omega \pm 5\%$, 1/2W Resistor, composition, $1.1K \pm 5\%$, 1/2W	109066 160432	X Y
R413, R414	Resistor, variable, wirewound, $5K \pm 5\%$, 1-1/4W	111609	

REFERENCE DESIGNATION	DESCRIPTION	FLUKE STOCK NO.	USE CODE
	Chopper Amplifier Assembly	125849 (313A-405)	
C501	Capacitor, plastic, 2 uf $\pm 20\%$, 100V	106963	
C502	Capacitor, electrolytic, 40 uf -10/+100%, 6V	105205	
C503	Capacitor, plastic, 0.047 uf $\pm 20\%$, 100V	106096	
C504	Capacitor, electrolytic, 20 uf -10/+100%, 50V	106229	
C505	Capacitor, electrolytic, 40 uf -10/+100%, 6V	105205	
C506, C507	Capacitor, electrolytic, 20 uf -10/+100%, 50V	106229	
C508, C509	Capacitor, electrolytic, 500 uf -10/+100%, 3V	106328	
C510	Capacitor, electrolytic, 2 uf -10/+100%, 50V	105197	
G501	Chopper, DPDT	104349	
Q501	Transistor, NPN, silicon, type NS734	117192	O
	Transistor, NPN, silicon, type CDQ10449	153551	P
Q502	Transistor, PNP, germanium, type 2N1372	116129	
Q503	Transistor, NPN, silicon, type NS734	117192	O
	Transistor, NPN, silicon, type CDQ10449	153551	P
Q504	Transistor, PNP, germanium, type 2N1372	116129	
Q505	Transistor, NPN, germanium, type 2N1304	117127	
R501	Resistor, deposited carbon, 26.6K $\pm 1\%$, 1/2W	107680	
R502	Resistor, composition, 62K $\pm 5\%$, 1/2W	108522	
R503	Resistor, deposited carbon, 8.2K $\pm 1\%$, 1/2W	107243	
R504	Resistor, composition, 1.8K $\pm 5\%$, 1/2W	109140	
R505	Resistor, composition, 47K $\pm 10\%$, 1/2W	108480	
R506	Resistor, composition, 22K $\pm 10\%$, 1/2W	108209	A
	Resistor, composition, 8.2K $\pm 10\%$, 1/2W	109017	B
R507	Resistor, composition, 75 Ω $\pm 5\%$, 1/2W	108753	
R508	Resistor, composition, 62K $\pm 5\%$, 1/2W	108522	
R509	Resistor, composition, 8.2K $\pm 10\%$, 1/2W	109017	
R510	Resistor, composition, 1.8K $\pm 5\%$, 1/2W	109140	
R511	Resistor, composition, 47K $\pm 10\%$, 1/2W	108480	
R512	Resistor, composition, 22K $\pm 10\%$, 1/2W	108209	A
	Resistor, composition, 8.2K $\pm 10\%$, 1/2W	109017	B
R513	Resistor, composition, 75 Ω $\pm 5\%$, 1/2W	108753	
R514	Resistor, composition, 3K $\pm 5\%$, 1/2W	109090	

REFERENCE DESIGNATION	DESCRIPTION	FLUKE STOCK NO.	USE CODE
R515	Resistor, composition, 2.7K ±5%, 1/2W	109074	
R516, R517	Resistor, composition, 10K ±10%, 1/2W	108118	
R518	Resistor, composition, 39K ±10%, 1/2W	108555	
R519	Resistor, composition, 47K ±10%, 1/2W	108480	
R520	Resistor, composition, 18K ±10%, 1/2W	108183	

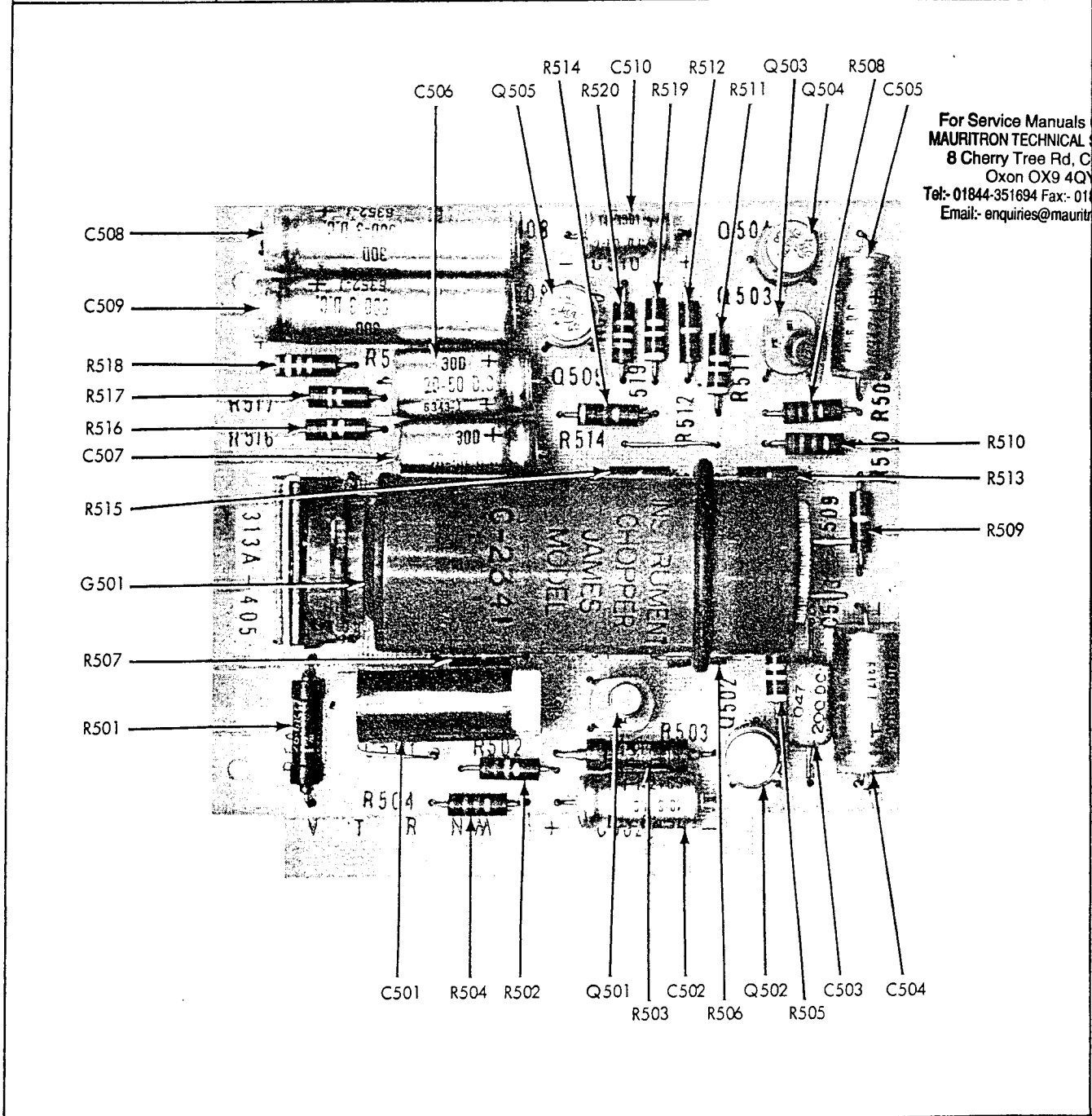
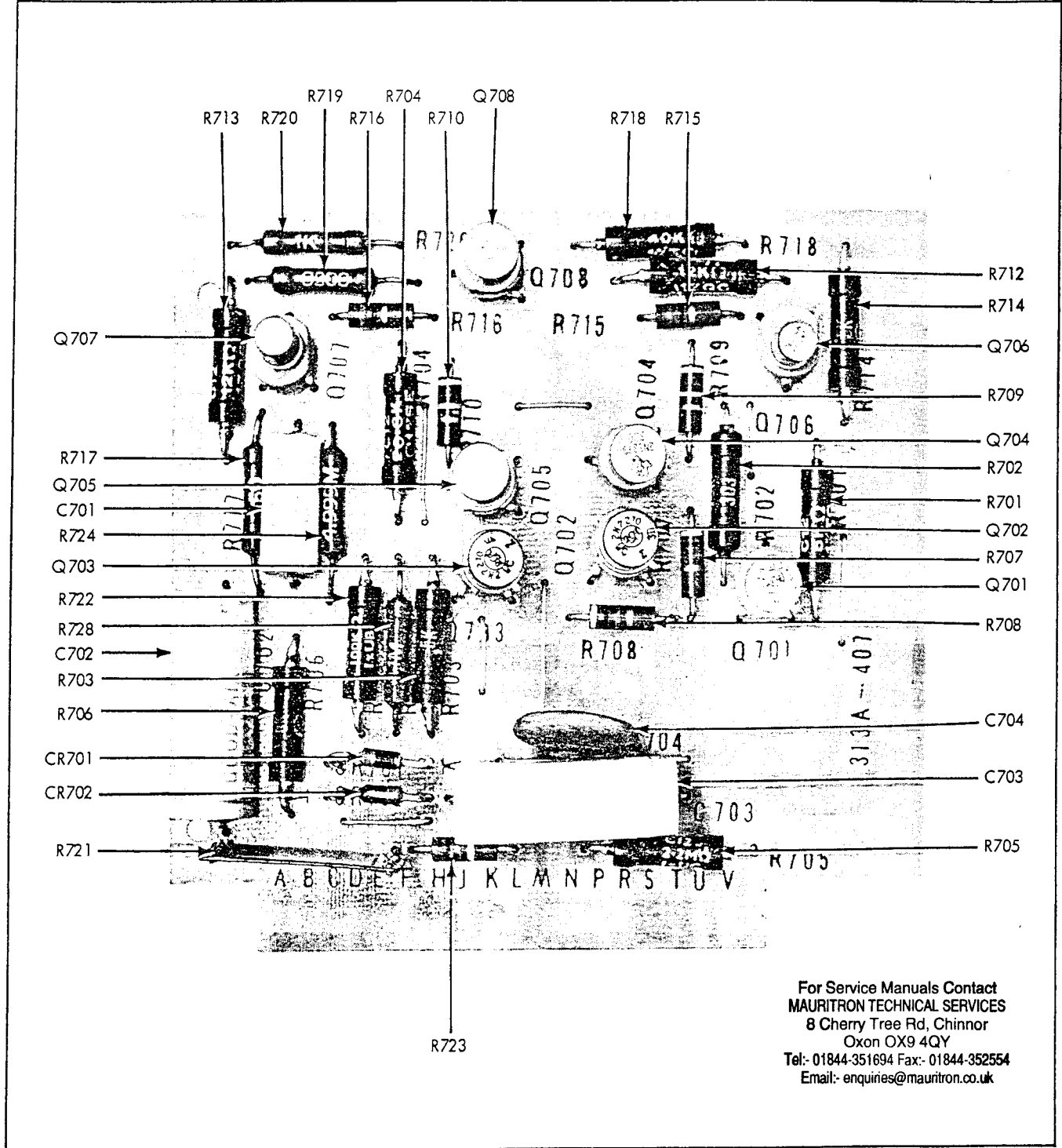


Figure 5-6. CHOPPER AMPLIFIER ASSEMBLY

REFERENCE DESIGNATION	DESCRIPTION	FLUKE STOCK NO.	USE CODE
	Main Amplifier Assembly	145011 (313A-407)	
C701	Capacitor, plastic, 0.068 uf $\pm 10\%$, 200V	105981	
C702	Capacitor, plastic, 2 uf $\pm 20\%$, 100V	106963	
C703	Capacitor, electrolytic, 10 uf $\pm 20\%$, 6V Capacitor, electrolytic, 2 uf $\pm 20\%$, 100V	106906 106963	D C
C704	Capacitor, ceramic, 0.05 uf -20/+80%, 500V	105676	
CR701, CR702	Diode, silicon, 600 PIV, 0.75A Diode, silicon, 100 PIV, 1A	112383 116111	F G
Q701	Transistor, NPN, germanium, type 2N1304	117127	
Q702, Q703	Transistor, NPN, silicon, type 2N2270 Transistor, NPN, silicon, type CDQ10449	117135 153551	F G
Q704, Q705	Transistor, PNP, germanium, type 2N1379 Transistor, PNP, silicon, type SM4144	117143 190389	F G
Q706, Q707	Transistor, PNP, germanium, type 2N2189	144816	
Q708	Transistor, PNP, germanium, type 2N1379	117143	
R701	Resistor, deposited carbon, 5K $\pm 1\%$, 1/2W	107110	
R702	Resistor, deposited carbon, 10K $\pm 1\%$, 1/2W	107128	
R703	Resistor, deposited carbon, 5K $\pm 1\%$, 1/2W	107110	
R704	Resistor, deposited carbon, 26.6K $\pm 1\%$, 1/2W	107680	
R705	Resistor, deposited carbon, 2.2M $\pm 1\%$, 1/2W	107227	C
R706	Resistor, deposited carbon, 5K $\pm 1\%$, 1/2W	107110	
R707, R708	Resistor, composition, 300 Ω $\pm 5\%$, 1/2W	108829	
R709, R710	Resistor, composition, 75K $\pm 5\%$, 1/2W Resistor, composition, 470K $\pm 5\%$, 1/2W	108928 108290	F G
R712, R713	Resistor, deposited carbon, 12K $\pm 1\%$, 1/2W	144709	
R714	Resistor, deposited carbon, 5K $\pm 1\%$, 1/2W	107110	
R715, R716	Resistor, composition, 51 Ω $\pm 5\%$, 1/2W	144717	
R717	Resistor, composition, 150 Ω $\pm 1\%$, 1/2W	144683	
R718	Resistor, deposited carbon, 40K $\pm 1\%$, 1/2W	107151	
R719	Resistor, deposited carbon, 8.2K $\pm 1\%$, 1/2W	107243	
R720	Resistor, deposited carbon, 1K $\pm 1\%$, 1/2W	107086	
R721	Resistor, wirewound, factory selected Resistor, wirewound, 6K $\pm 0.05\%$, 1W	107086 147462	V W
R722	Resistor, deposited carbon, 100K $\pm 1\%$, 1/2W	107185	

REFERENCE DESIGNATION	DESCRIPTION	FLUKE STOCK NO.	USE CODE
R723	Resistor, composition, 100Ω ±10%, 1/2W	108100	
R724	Resistor, deposited carbon, 4.999 M, ±1%, 1/2W	144691	C
R728	Resistor, deposited carbon, 100K ±1%, 1/2W	107185	D
	Resistor, deposited carbon, 1 M ±1%, 1/2W	107219	C



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Figure 5-7. MAIN AMPLIFIER ASSEMBLY

REFERENCE DESIGNATION	DESCRIPTION	FLUKE STOCK NO.	USE CODE
	SCR Firing Circuit Assembly	125864 (313A-408)	
C801	Capacitor, ceramic, 0.05 uf -20/+80%, 500V	105676	
C802	Capacitor, plastic, 0.1 uf $\pm 20\%$, 200V	106435	
C804	Capacitor, electrolytic, 200 uf -10/+100%, 6V	105189	
C805	Capacitor, plastic, 0.22 uf $\pm 10\%$, 200V	105767	
C806	Capacitor, electrolytic, 50 uf -10/+100%, 50V	105122	
C807	Capacitor, electrolytic, 100 uf -10/+100%, 25V	106518	
C808	Capacitor, ceramic, 0.05 uf -20/+80%, 500V	105676	
C809	Capacitor, ceramic, 560 pf $\pm 10\%$, 600V	106203	
CR801 thru CR804	Diode, silicon, 600 PIV, 0.75A	112383	
CR805	Diode, zener, 18V, 14 ma	113365	
CR806, CR807	Diode, silicon, stabistor, 6 PIV, 0.150A	113308	
CR808, CR809	Diode, silicon, 600 PIV, 0.75A Diode, silicon, 100 PIV, 1A	112383 116111	F G
CR810 thru CR813	Diode, silicon, 600 PIV, 0.75A Diode, silicon, 100 PIV, 1A	112383 116111	F G
CR814	Diode, zener, 20V, 6.2 ma	113340	
CR815	Diode, zener, 10V, 12.5 ma	113324	
CR816, CR817	Diode, zener, 3.9V, 20 ma	113316	
CR818	Diode, silicon, 600 PIV, 0.75A	112383	F
CR819	Diode, silicon, stabistor, 6 PIV, 0.150A	113308	F
CR818, CR819	Diode, silicon, 100 PIV, 1A	116111	G
Q802	Transistor, unijunction, type 2N1671	117176	
Q803	Transistor, PNP, germanium, type 2N1372	116129	
Q804	Transistor, NPN, germanium, type 2N1304	117127	
R802	Resistor, composition, 270K $\pm 10\%$, 1/2W	108258	
R803, R804	Resistor, composition, 100 Ω $\pm 10\%$, 1/2W	108100	
R805	Resistor, composition, 2.7K $\pm 10\%$, 1/2W	108837	
R806	Resistor, composition, 2.2K $\pm 10\%$, 1/2W	108605	
R808	Resistor, composition, 1.5K $\pm 10\%$, 1/2W	108159	

REFERENCE DESIGNATION	DESCRIPTION	FLUKE STOCK NO.	USE CODE
	Overcurrent Limiter Assembly	125872 (313A-409)	
C901	Capacitor, ceramic, 0.05 uf -20/+80%, 500V	105676	O
C902	Capacitor, ceramic, 180 pf $\pm 10\%$, 500V	105890	O
C904	Capacitor, ceramic, 560 pf $\pm 10\%$, 600V	106203	
C905	Capacitor, ceramic, 0.01 uf -20/+80%, 500V	105668	
C906	Capacitor, electrolytic, 15 uf -10/+75%, 6V	105700	P
C907	Capacitor, ceramic, 0.002 uf, GMV, 1000V	105569	P
CR901	Diode, zener, 16V, 7.8 ma	113332	
CR902	Diode, silicon, stabistor, 6 PIV, 0.15A	113308	
CR908	Diode, zener, 12V, 10.5 ma	113456	
CR909	Diode, silicon, stabistor, 6 PIV, 0.15A	113308	
Q901	Transistor, NPN, silicon, type TI496 Transistor, NPN, silicon, type CDQ10449	117218 153551	O P
Q902	Transistor, NPN, silicon, type 2N2270 Transistor, NPN, silicon, type CDQ10449	117135 153551	O P
Q903 thru Q905	Transistor, PNP, germanium, type 2N1372	116129	
R901	Resistor, composition, 22K $\pm 10\%$, 1/2W	108209	
R902	Resistor, composition, 100K $\pm 10\%$, 1/2W	108126	
R903	Resistor, composition, 820 Ω $\pm 10\%$, 1/2W	108423	
R904	Resistor, composition, 3.9K $\pm 10\%$, 2W	110213	
R907	Resistor, composition, 6.8M $\pm 10\%$, 1/2W Resistor, composition, 220K $\pm 10\%$, 1/2W	108662 108217	O P
R908	Resistor, composition, 5.1K $\pm 5\%$, 1/2W	109108	
R909	Resistor, variable, wirewound, 100 Ω $\pm 20\%$, 1-1/4W	112797	
R910	Resistor, composition, 1K $\pm 10\%$, 1/2W	108563	
R911	Resistor, variable, wirewound, 3K $\pm 10\%$, 1-1/4W	112458	
R912	Resistor, composition, 5.1K $\pm 5\%$, 1/2W	109108	
R913	Resistor, composition, 8.2K $\pm 10\%$, 1/2W	109017	
R914	Resistor, composition, 20K $\pm 5\%$, 1/2W	109041	
R915	Resistor, composition, 10K $\pm 5\%$, 1/2W	109165	
R916	Resistor, composition, 33.3K $\pm 1\%$, 1/2W	107714	

REFERENCE DESIGNATION	DESCRIPTION	FLUKE STOCK NO.	USE CODE
R918	Resistor, composition, 52.14K ±1%, 1/2W	107284	
R919	Resistor, composition, 2.7Ω ±10%, 1/2W	108845	
R921	Resistor, composition, 430Ω ±5%, 1/2W	109058	
R922	Resistor, composition, 6.8K ±10%, 1/2W	108399	
R923	Resistor, composition, 10K ±10%, 1/2W	108118	
R924	Thermistor, 10K ±10%, 3 mw	104596	
R925	Resistor, composition, 560Ω ±10%, 1/2W	108316	P
R926	Resistor, composition, 5.1K ±5%, 1/2W	109918	P

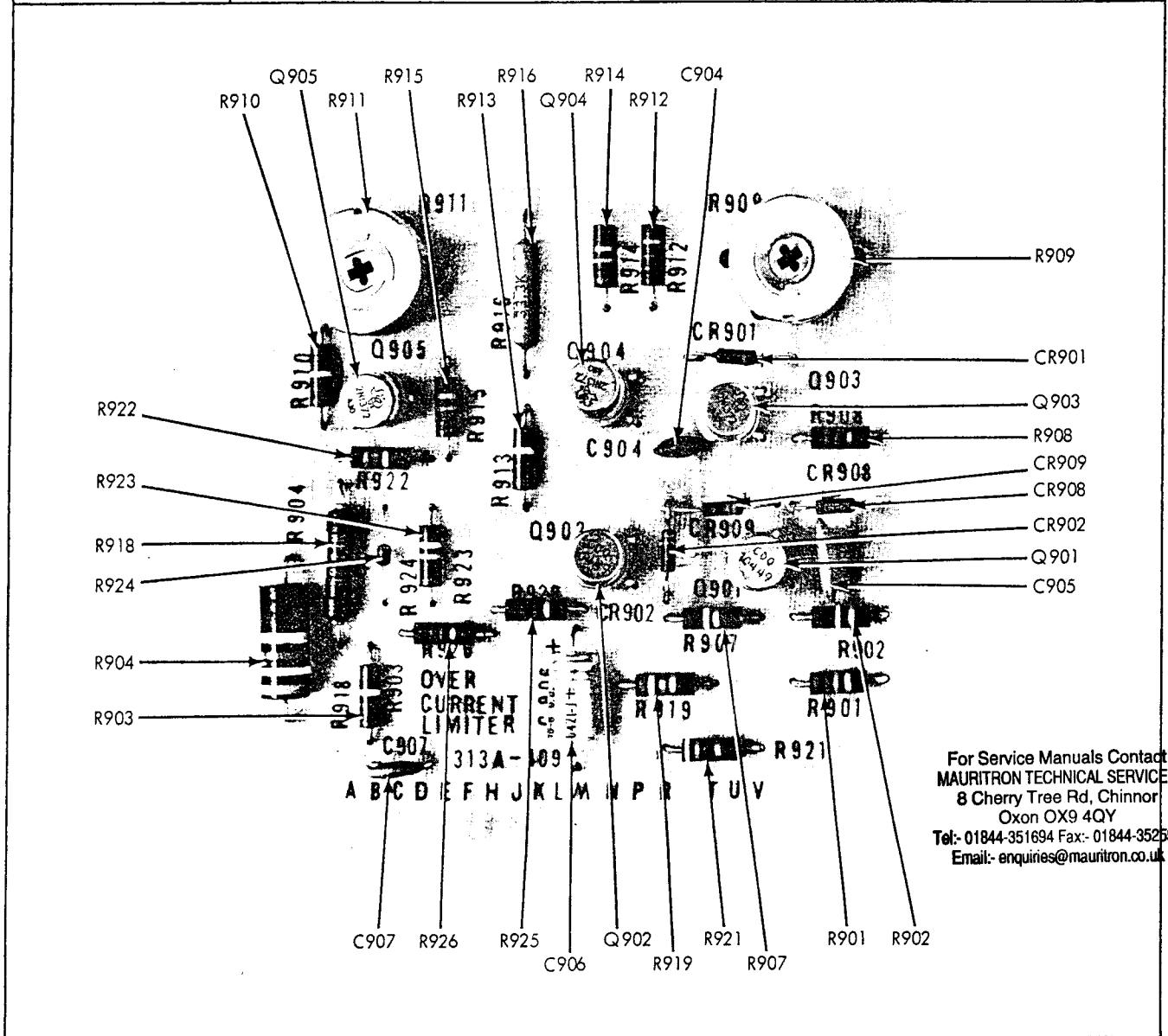


Figure 5-10. OVERCURRENT LIMITER ASSEMBLY

REFERENCE DESIGNATION	DESCRIPTION	FLUKE STOCK NO.	USE CODE
	Meter Shunt Assembly	*125880 (313A-410)	
C1001	Capacitor, electrolytic, 50 uf -10/+100%, 50V	105122	O
C1002	Capacitor, electrolytic, 100 uf -10/+100%, 25V	106518	O
CR1001	Diode, silicon, 600 PIV, 0.75A Diode, silicon, 100 PIV, 1A	112383 116111	F G
R1001	Resistor, wirewound, 15Ω ±1%, 1/2W	113464	
R1002	Resistor, deposited carbon, 165Ω ±1%, 1W	107946	
R1003	Resistor, deposited carbon, 4.75K ±1%, 1/2W	107961	
R1004	Resistor, deposited carbon, 7.5K ±1%, 1/2W	108027	
R1005	Resistor, deposited carbon, 44.2K ±1%, 1/2W	107912	
R1006	Resistor, composition, 100Ω ±10%, 1/2W	108092	
R1007	Resistor, deposited carbon, 20K ±1%, 1/2W	107136	
R1008	Resistor, deposited carbon, 43.5K ±1%, 1/2W	107706	

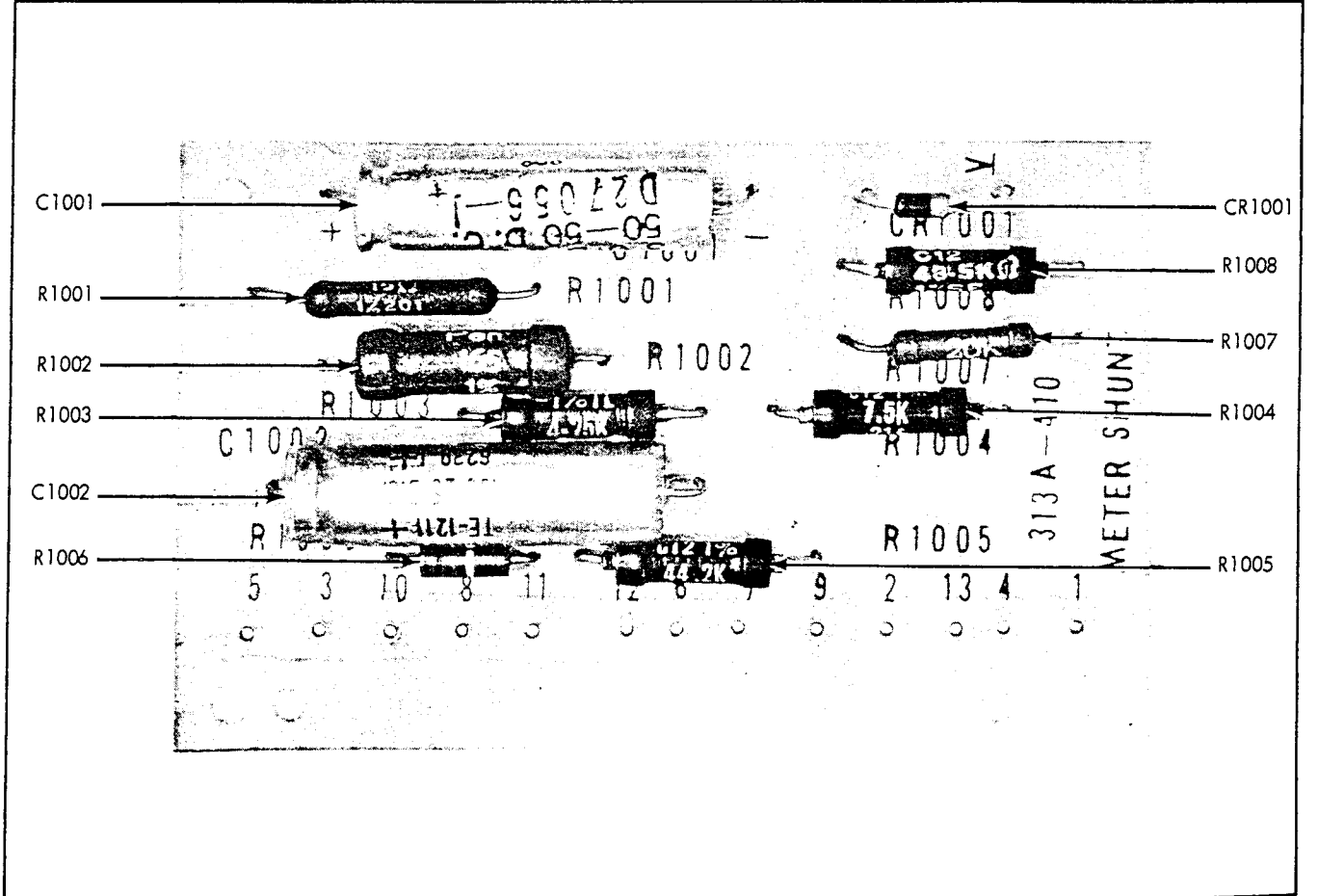


Figure 5-11. METER SHUNT ASSEMBLY

REFERENCE DESIGNATION	DESCRIPTION	FLUKE STOCK NO.	USE CODE
	Driver Assembly	*125898	
		(313A-411)	
C1101	Capacitor, plastic, 0.047 uf $\pm 20\%$, 100V	106096	
C1102	Capacitor, plastic, 0.1 uf $\pm 20\%$, 200V	106435	
C1103	Capacitor, ceramic, 500 pf $\pm 10\%$, 500V	105692	BB
	Capacitor, ceramic, 1200 pf $\pm 10\%$, 500V	106732	W
CR1101, CR1102	Diode, silicon, 6V, 0.10A	113308	
CR1103, CR1104	Diode, silicon, 600 PIV, 0.75A	112383	F
	Diode, silicon, 100 PIV, 1A	116111	G
CR1105	Diode, silicon, 6V, 0.10A	113308	F
	Diode, silicon, 100 PIV, 1A	116111	G
Q1101	Transistor, NPN, silicon, type T1496	117218	R
	Transistor, NPN, silicon, type CDQ10449	153551	S
Q1102	Transistor, PNP, germanium, type 2N2042	117226	F
	Transistor, PNP, silicon, type SM4144, selected	188938	G
Q1103	Transistor, PNP, germanium, type 2N1187	117150	
Q1104	Transistor, PNP, germanium, type 2N1372	116129	
Q1105	Transistor, NPN, silicon, type NS734	117192	F
	Transistor, NPN, silicon, type 2N2270	117135	Q
	Transistor, NPN, silicon, type CDQ10449	153551	P
Q1106	Transistor, NPN, silicon, type T1496	117218	L
	Transistor, NPN, silicon, type CDQ10449	153551	M
Q1107	Transistor, PNP, germanium, type 2N379	117168	A
	Transistor, PNP, germanium, type 2N2869	152868	B
Q1108	Transistor, PNP, germanium, type 2N2042	117226	F
	Transistor, PNP, silicon, type SM4144, selected	188938	G
R1101	Resistor, composition, 27K $\pm 10\%$, 2W	110098	
R1103	Resistor, deposited carbon, 200 Ω $\pm 1\%$, 1/2W	107060	
R1104	Resistor, composition, 5.6K $\pm 10\%$, 1/2W	108324	
R1105	Resistor, composition, 6.8K $\pm 10\%$, 2W	110064	
R1106	Resistor, composition, 2.2K $\pm 10\%$, 1/2W	108605	
R1107	Resistor, composition, 27K $\pm 10\%$, 1/2W	108878	
R1108	Resistor, composition, 510 Ω $\pm 5\%$, 1/2W	108951	
R1113	Resistor, composition, 220 Ω $\pm 10\%$, 1/2W	108191	L
	Resistor, composition, 100 Ω $\pm 10\%$, 1/2W	108100	M
R1114	Resistor, composition, 560 Ω $\pm 10\%$, 1/2W	108316	A
	Resistor, composition, 820 Ω $\pm 10\%$, 1/2W	108423	B
R1115	Resistor, composition, 560 Ω $\pm 10\%$, 1/2W	108316	A
	Resistor, composition, 330 Ω $\pm 10\%$, 1/2W	108589	B
R1116	Resistor, variable, wirewound, 1K $\pm 20\%$, 1-1/4W	111575	

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REFERENCE DESIGNATION	DESCRIPTION	FLUKE STOCK NO.	USE CODE
R1117, R1118	Resistor, composition, $22\Omega \pm 10\%$, 1/2W	108670	
R1119	Resistor, composition, $220K \pm 10\%$, 1/2W	108217	

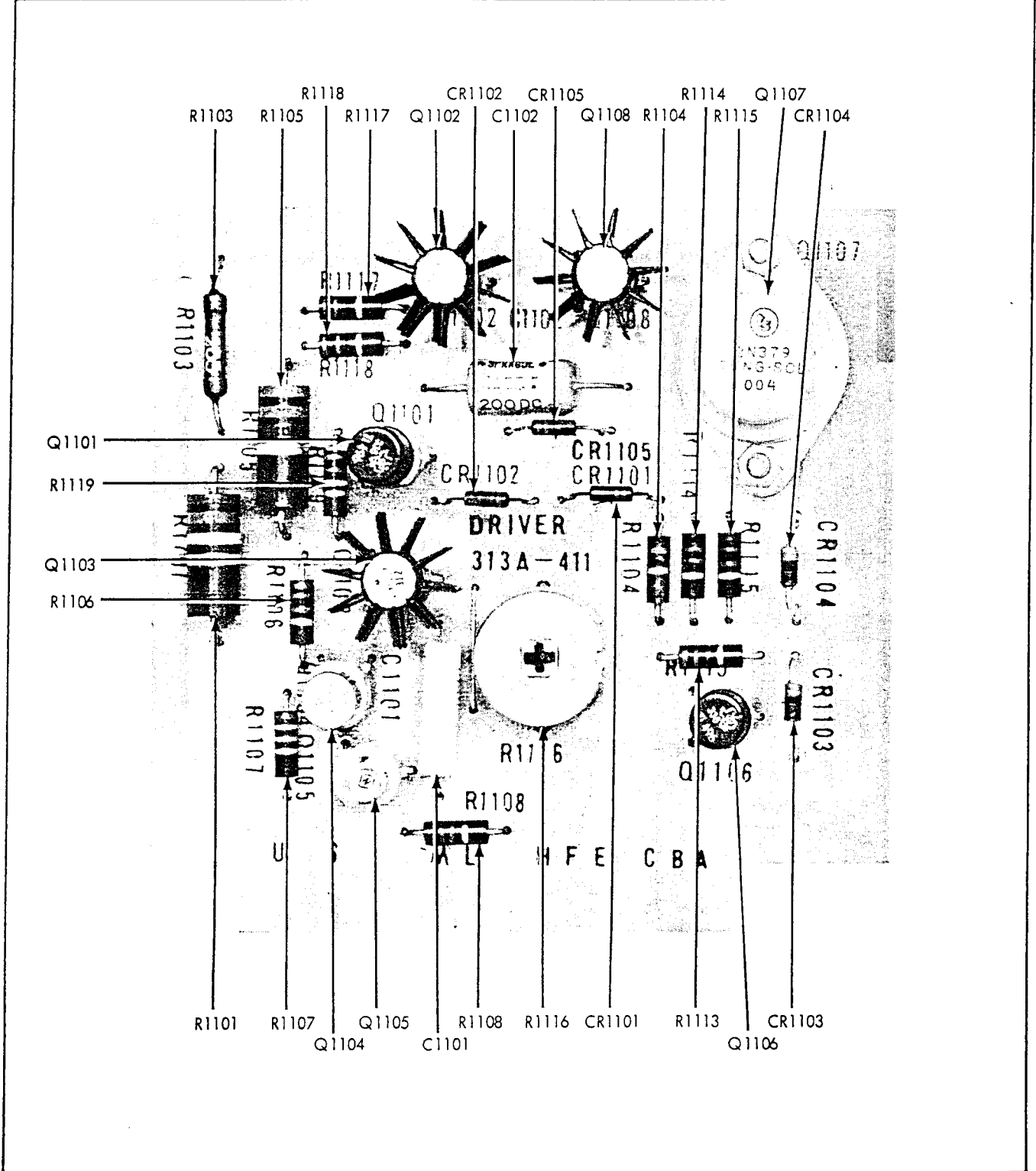
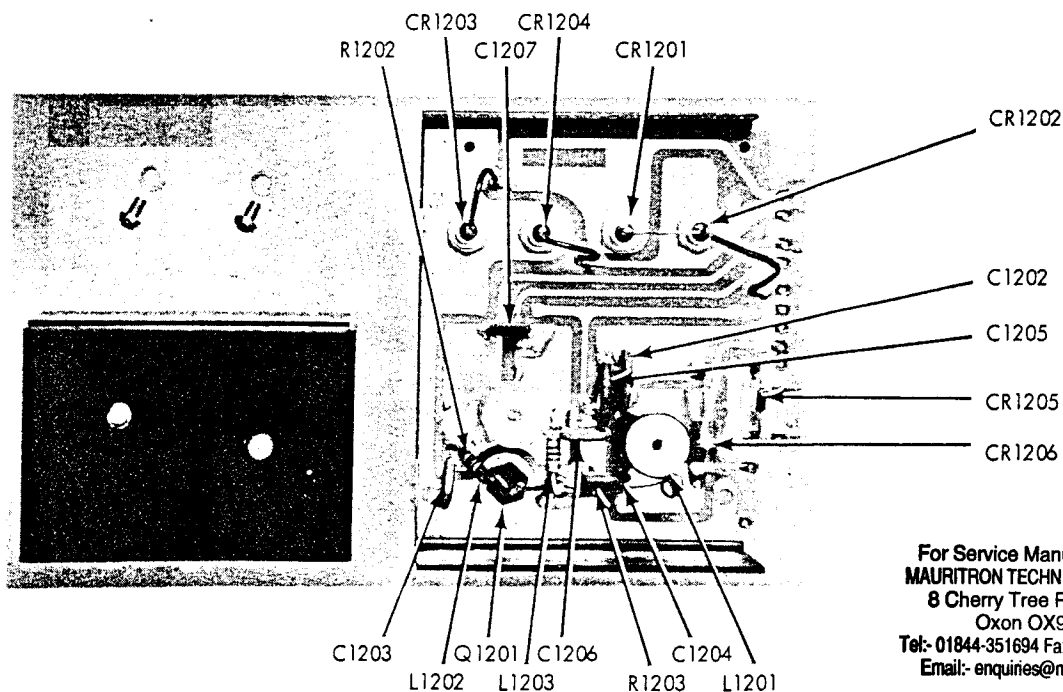


Figure 5-11. DRIVER ASSEMBLY

REFERENCE DESIGNATION	DESCRIPTION	FLUKE STOCK NO.	USE CODE
	Rectifier Assembly	*125906 (313A-412)	
C1202	Capacitor, ceramic, 0.05 uf -20/+80%, 500V	105676	
C1203, C1204	Capacitor, ceramic, 0.001 uf \pm 20%, 3000V	105635	
C1205	Capacitor, ceramic, 0.05 uf -20/+80%, 500V	105676	
C1206	Capacitor, ceramic, 0.001 uf \pm 20%, 3000V	105635	
C1207	Capacitor, ceramic, 0.01 uf -20/+80%, 500V	105668	
CR1201 thru CR1204	Diode, silicon, 200 PIV, 1.5A Diode, silicon, 200 PIV, 12A	113357 188854	KK LL
CR1205	Diode, silicon, 600 PIV, 0.75A Diode, silicon, 600V, 0.75A	112383 112680	I H
CR1206	Diode, silicon, 600 PIV, 0.75A	112383	
L1201	Choke, RF	125963	
L1202, L1203	Choke, RF, 100 uh \pm 5%, 1/2W	111542	
Q1201	Silicon controlled rectifier, 1A, 150V breakover	113472	
R1202	Resistor, composition, 470 Ω \pm 10%, 1/2W	108415	
R1203	Resistor, composition, 180 Ω \pm 10%, 1/2W	108571	



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Figure 5-12. RECTIFIER ASSEMBLY

5-3. USE CODE EFFECTIVITY

The following list of use codes allows the customer to determine the effectivity of all replaceable parts. All parts with no code are used on all instruments having serial number 123 and on. New codes will be added as required by instrument changes.

USE CODE	EFFECTIVITY
No Code	Model 313A, serial number 123 and on.
A	Model 313A, serial number 123 thru 146.
B	Model 313A, serial number 147 and on.
C	Model 313A, serial number 123 thru 166.
D	Model 313A, serial number 167 and on.
E	Model 313A, serial number 147 thru 166.
F	Model 313A, serial number 123 thru 186.
G	Model 313A, serial number 187 and on.
H	Model 313A, serial number 123 thru 172.
I	Model 313A, serial number 173 and on.
J	Model 313A, serial number 148 thru 150, 152 thru 155, 157 thru 163, 165 thru 167, 169 thru 183, 186.
K	Model 313A, serial number 147, 151, 156, 164, 168, 184, 185, 187 and on.
L	Model 313A, serial number 123 thru 195.
M	Model 313A, serial number 196 and on.
N	Model 313A, serial number 147, 151, 156, 164, 168, 184, 185, 187 and on.
O	Model 313A, serial number 123 thru 206.
P	Model 313A, serial number 207 and on.
Q	Model 313A, serial number 187 thru 206.
R	Model 313A, serial number 123 thru 266.
S	Model 313A, serial number 267 and on.
T	Model 313A, serial number 123 thru 254.
U	Model 313A, serial number 255 and on.
V	Model 313A, serial number 123 thru 266.
W	Model 313A, serial number 267 and on.
X	Model 313A, serial number 123 thru 282.
Y	Model 313A, serial number 283 and on.
Z	Model 313A, serial number 167 thru 282.
AA	Model 313A, serial number 255 thru 282.
BB	Model 313A, serial number 187 thru 266.
CC	Model 313A, any of serial number 123 thru 266.
DD	Model 313A, any of serial number 123 thru 266; serial number 267 and on.
EE	Model 313A, any of serial number 123 thru 166.
FF	Model 313A, any of serial number 167 thru 266.
GG	Model 313A, any of serial number 123 thru 266; serial number 267 thru 282.
HH	Model 313A, serial number 123 thru 246
II	Model 313A, serial number 123 thru 300, and 303 thru 312.
JJ	Model 313A, serial number 301, 302, 313 and on.
KK	Model 313A, serial number 123 thru 289.
LL	Model 313A, serial number 290 and on.
MM	Model 313A, serial number 207 thru 246.
NN	Model 313A, serial number 267 thru 342 (approx.)
OO	Model 313A, serial number 343 and on. (approx.)

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WARRANTY

The JOHN FLUKE MFG. CO., INC. warrants each instrument manufactured by them to be free from defects in material and workmanship. Their obligation under this Warranty is limited to servicing or adjusting an instrument returned to the factory for that purpose, and to making good at the factory any part or parts thereof; except tubes, fuses, choppers and batteries, which shall, within one year after making delivery to the original purchaser, be returned by the original purchaser with transportation charges prepaid, and which upon their examination shall disclose to their satisfaction to have been thus defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at a nominal cost. In this case, an estimate will be submitted before work is started, if requested.

If any fault develops, the following steps should be taken.

1. Notify the John Fluke Mfg. Co., Inc., giving full details of the difficulty, and include the Model number, type number, and serial number. On receipt of this information, service data or shipping instructions will be forwarded to you.
2. On receipt of the shipping instructions, forward the instrument prepaid, and repairs will be made at the factory. If requested, an estimate of the charges will be made before the work begins, provided the instrument is not covered by the Warranty.

SHIPPING

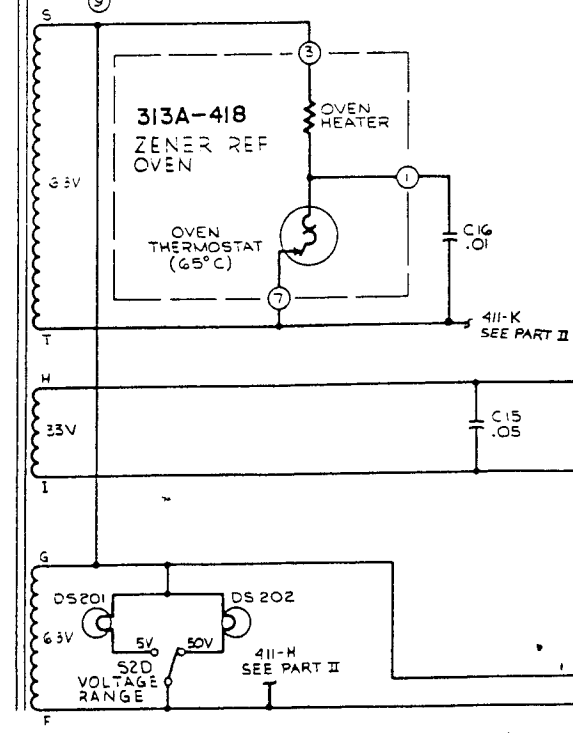
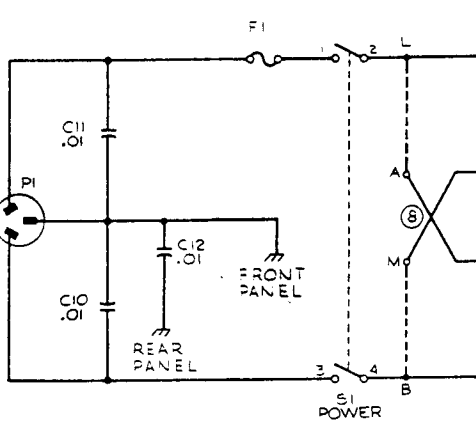
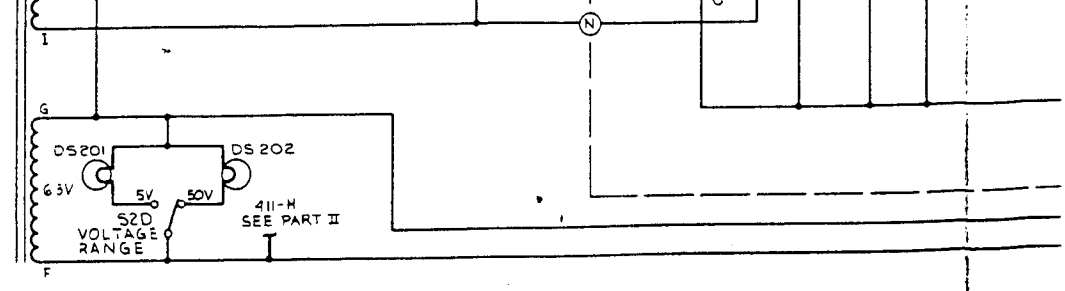
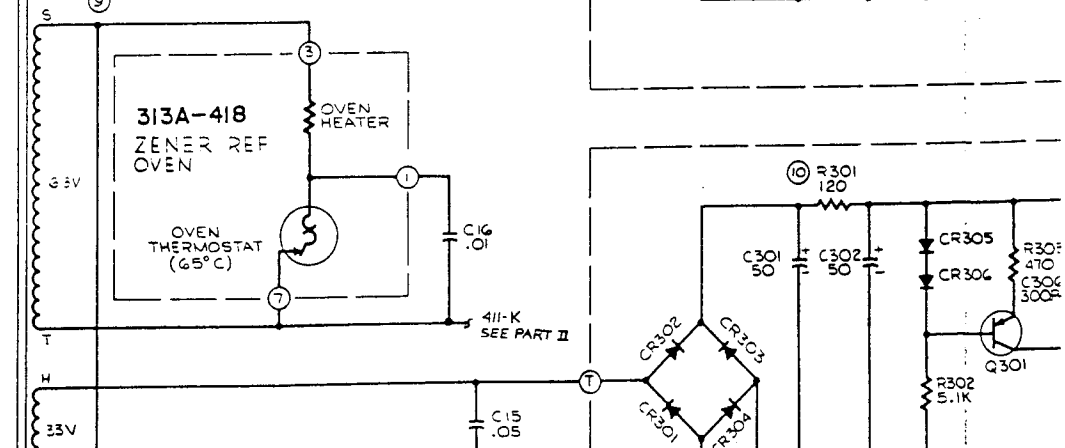
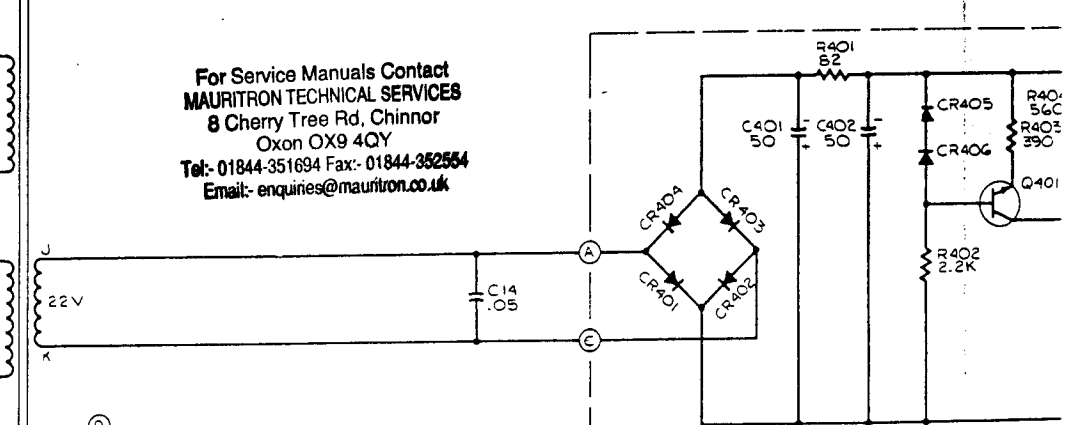
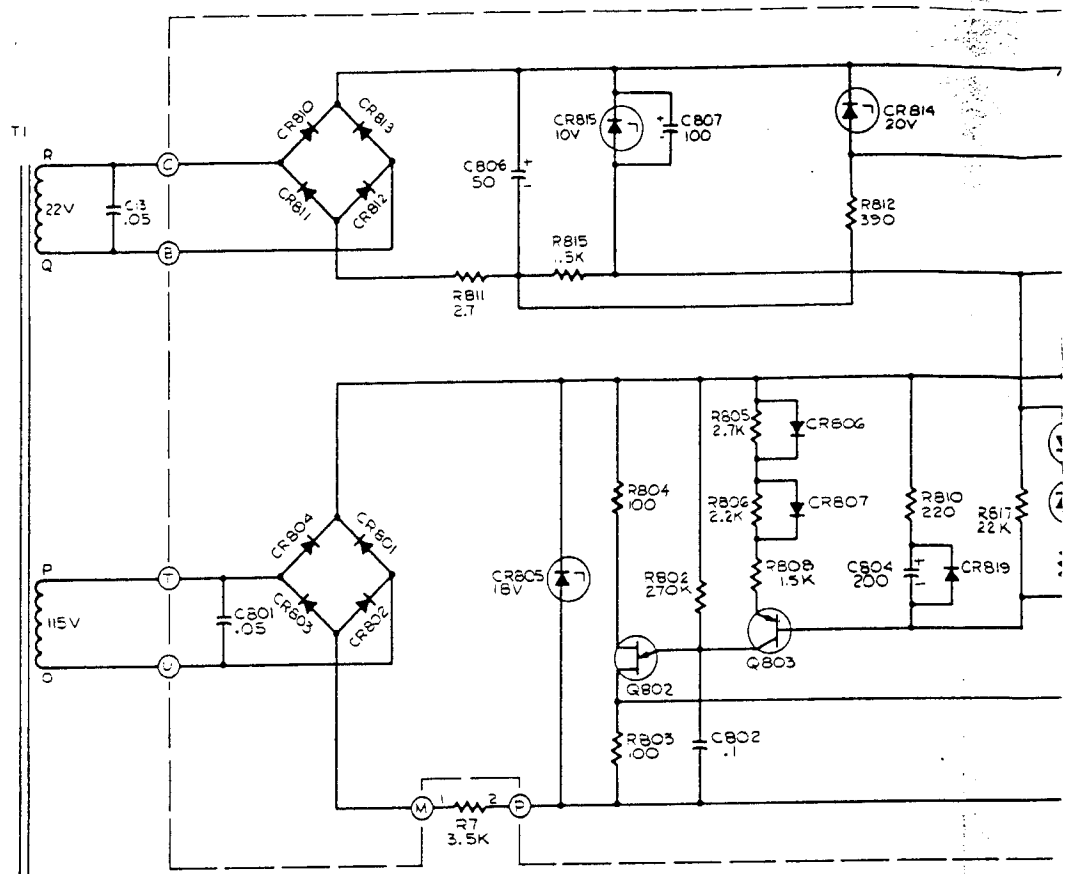
All shipments of John Fluke Mfg. Co., Inc. instruments should be made via Railway Express prepaid. The instrument should be shipped in the original packing carton; or if it is not available, use any suitable container that is rigid. If a substitute container is used, the instrument should be wrapped in paper and surrounded with at least four inches of excelsior or similar shock-absorbing material.

CLAIM FOR DAMAGE IN SHIPMENT

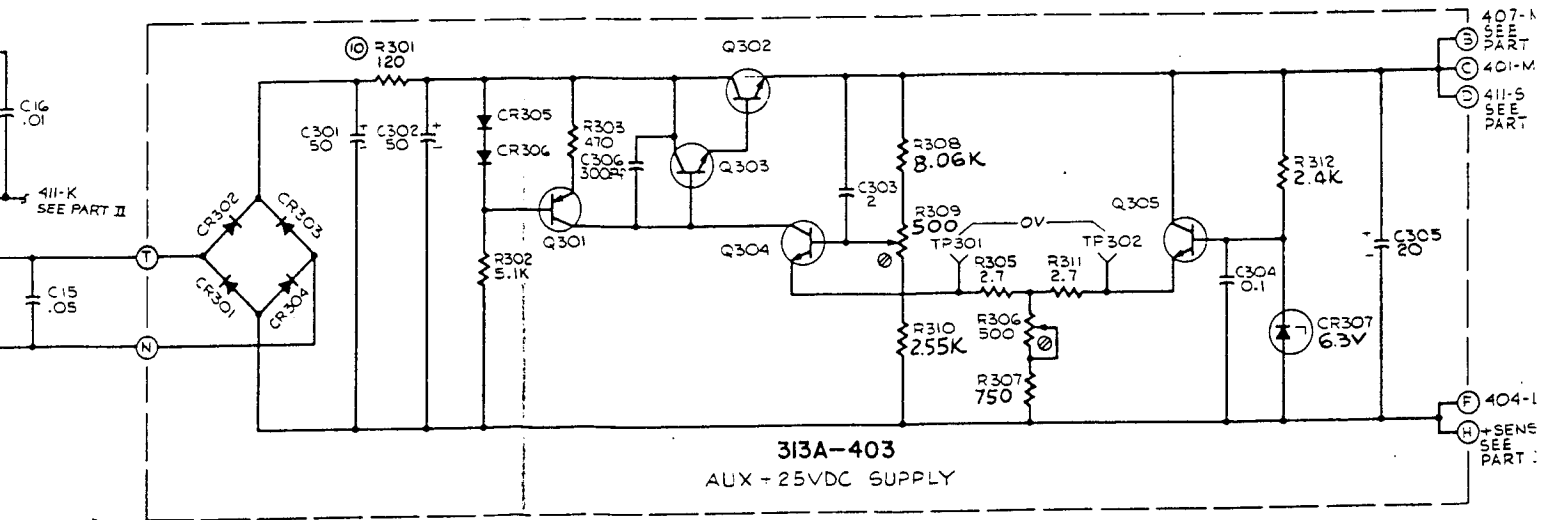
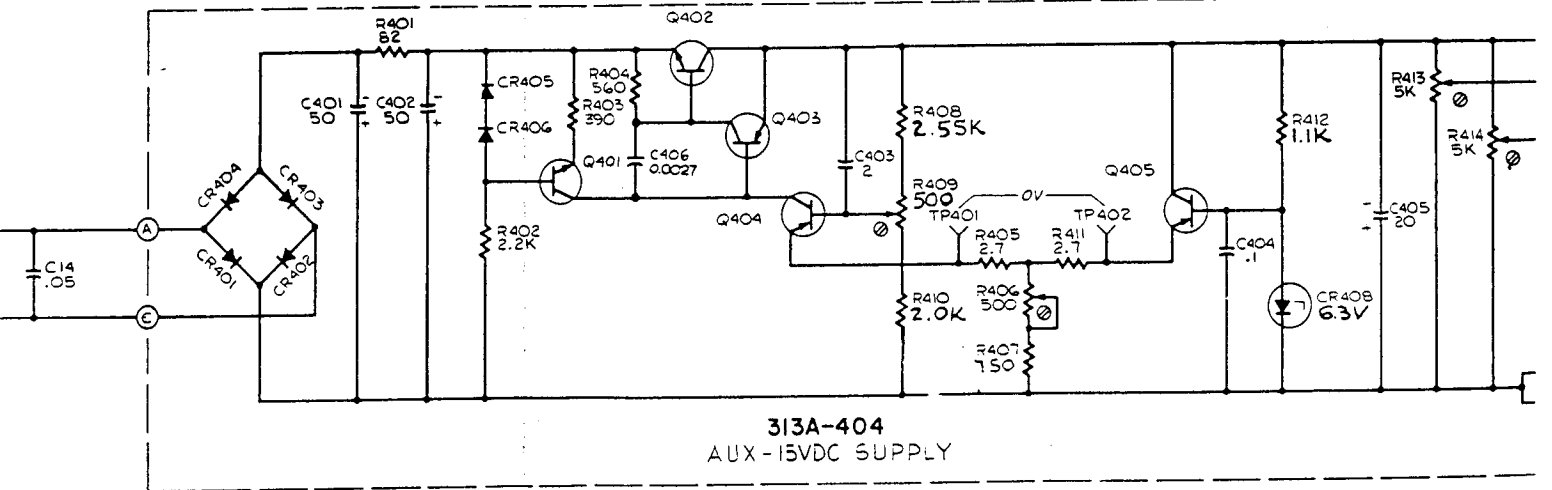
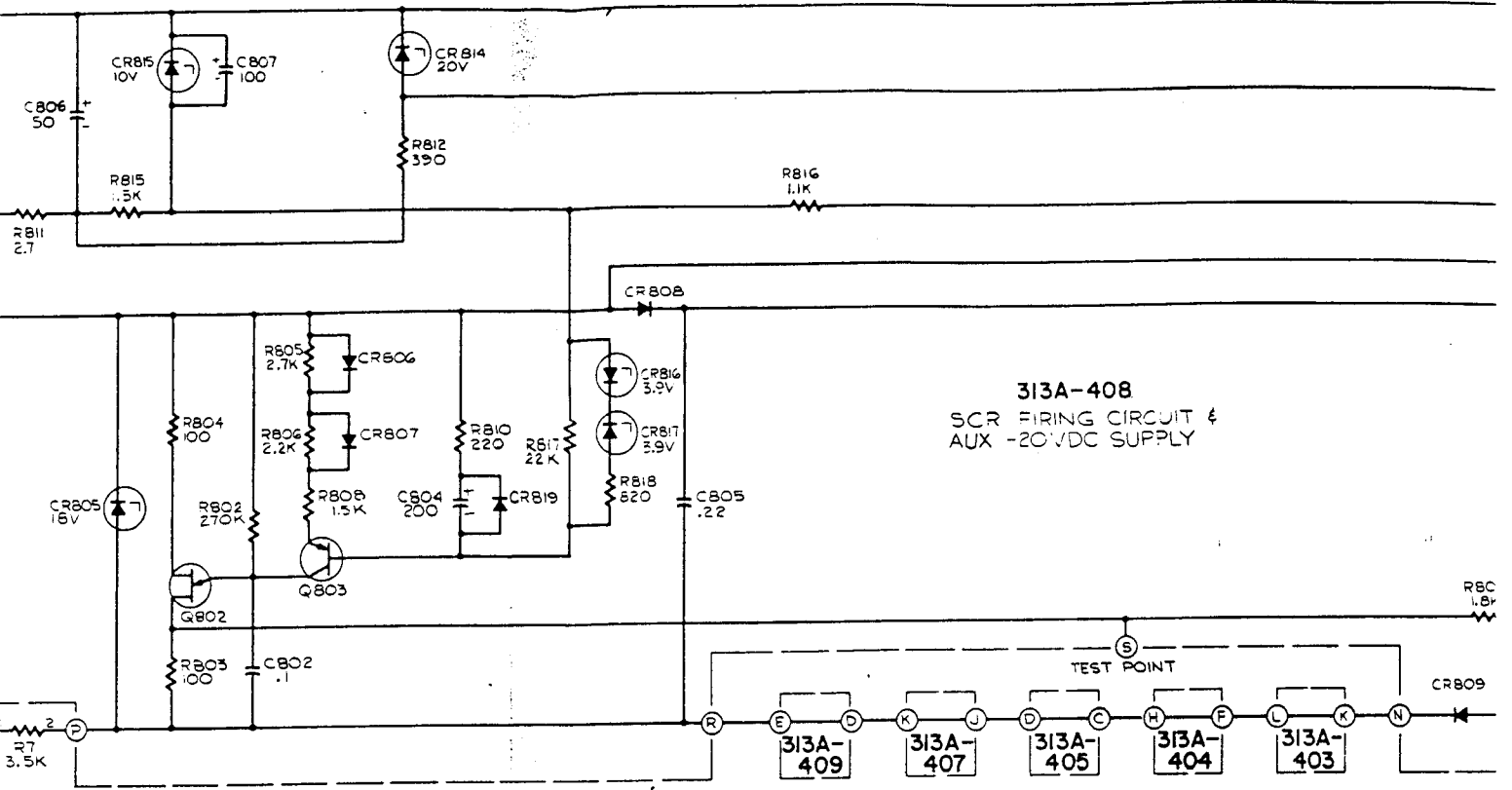
The instrument should be thoroughly inspected immediately upon receipt. All material in the container should be checked against the enclosed packing list. The manufacturer will not be responsible for shortages against the packing sheet unless notified immediately. If the instrument fails to operate properly, or is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent, and this report should be forwarded to John Fluke Mfg. Co., Inc. Upon receipt of this report you will be advised of the disposition of the equipment for repair or replacement. Include the model number, type number, and serial number when referring to this instrument for any reason.

The John Fluke Mfg. Co., Inc. will be happy to answer all application questions which will enhance your use of this instrument. Please address your requests to:

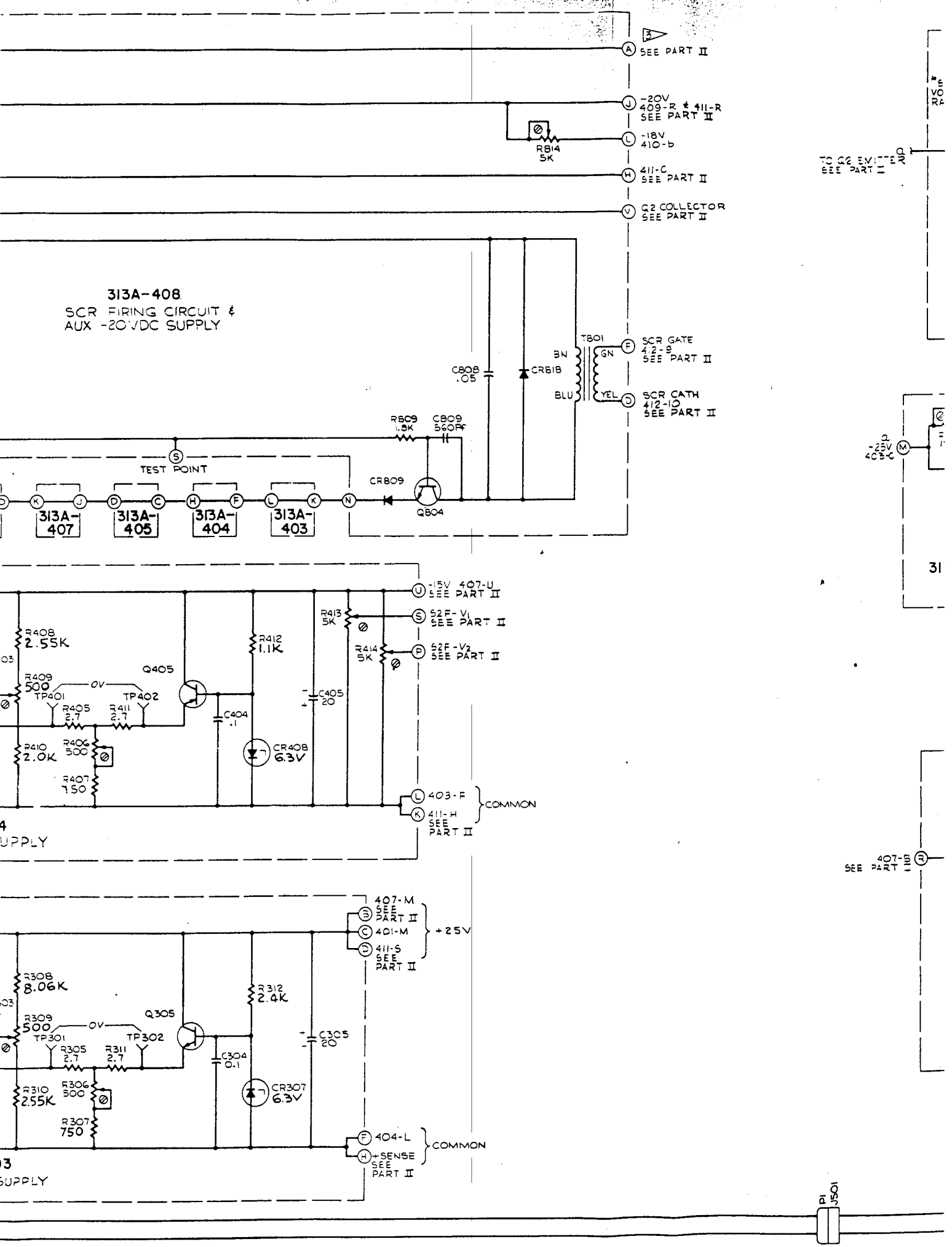
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313A-408
SCR FIRING CIRCUIT &
AUX -20VDC SUPPLY



TO Q2 EMITTER
SEE PART II

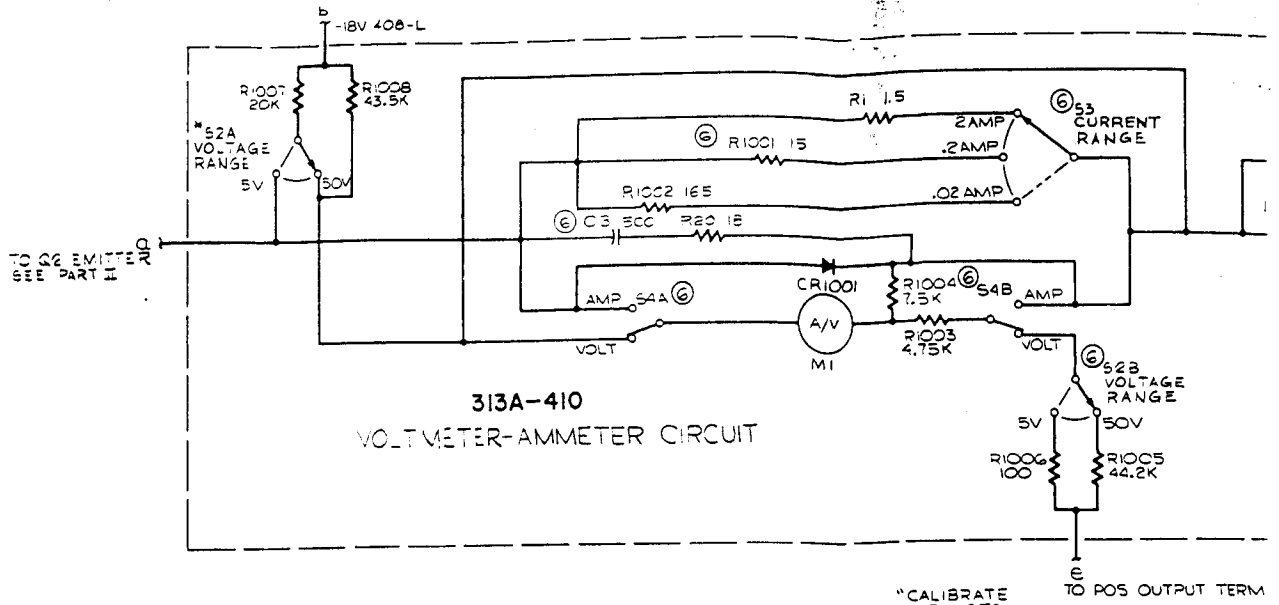
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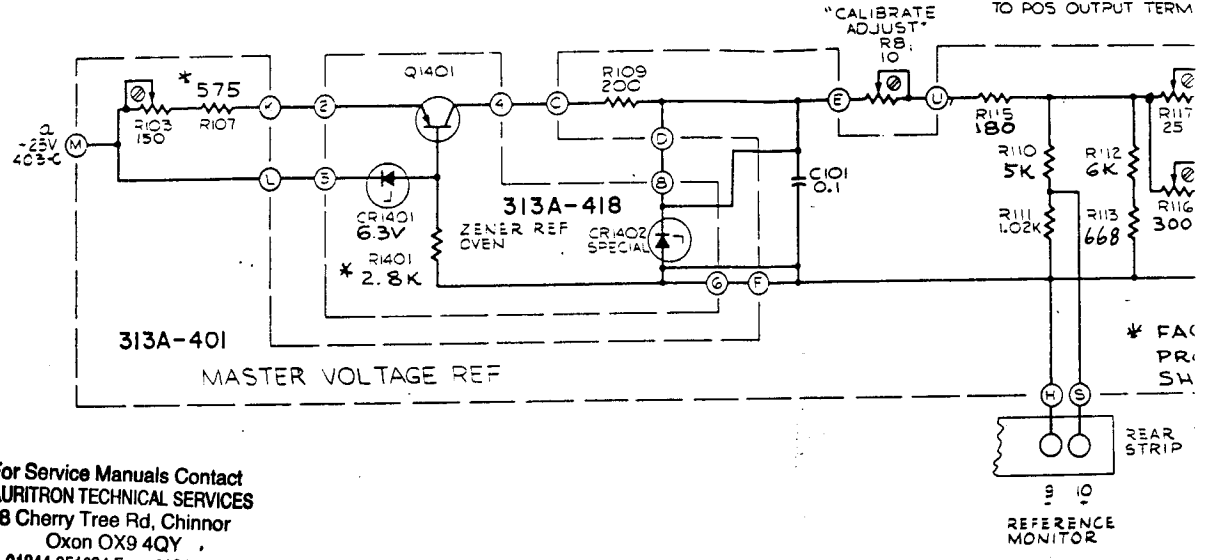
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SEE PART II

PI 1501

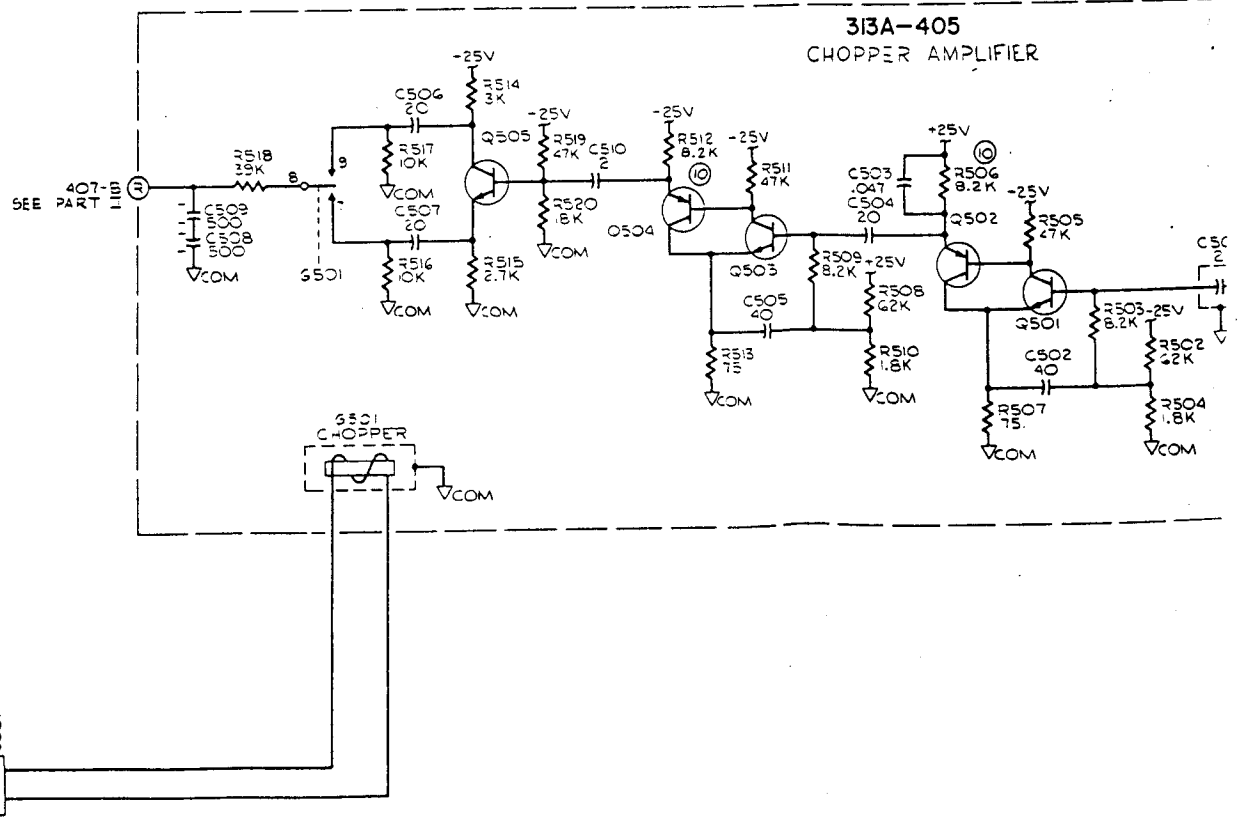
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 2OV
 09-R & 411-R
 SEE PART II
 5V
 10-b
 1-C
 SEE PART II
 2 COLLECTOR
 SEE PART II

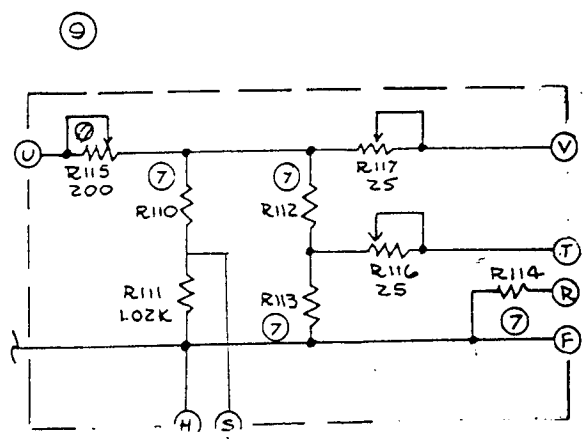
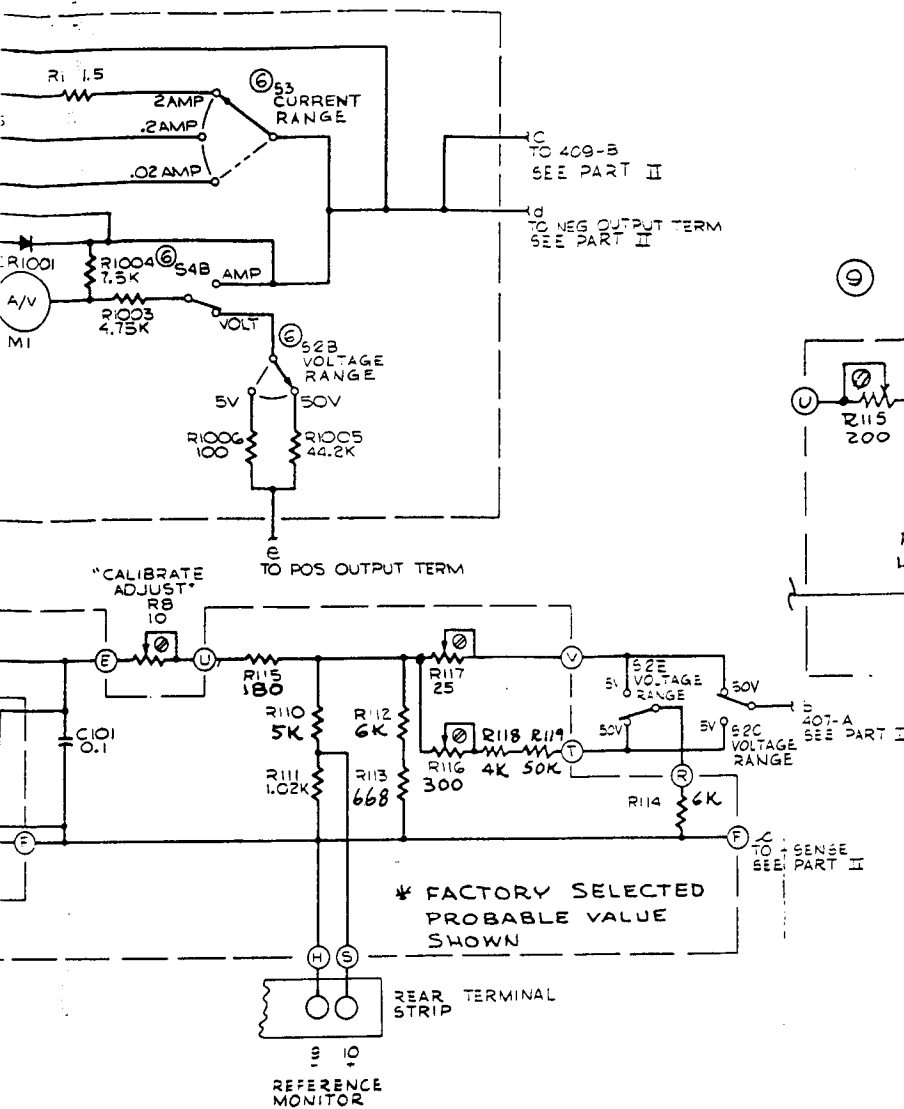


CR GATE
 2-9
 SEE PART II
 CR CATH
 12-10
 SEE PART II



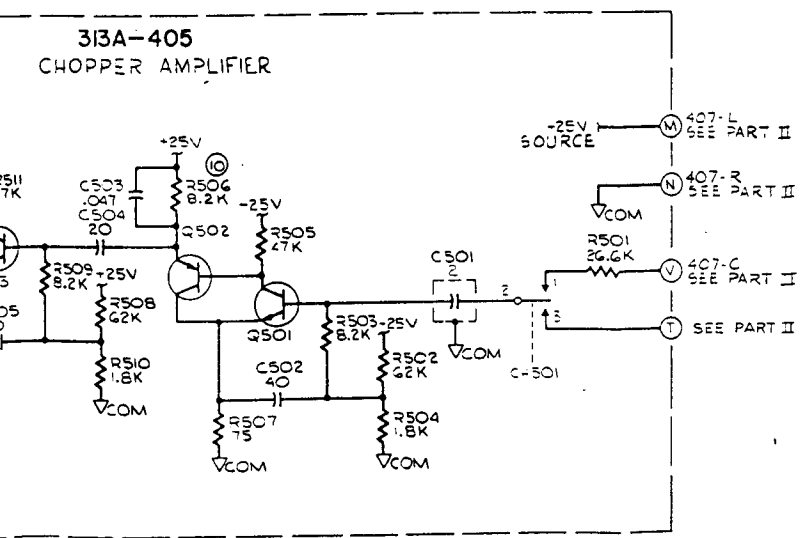
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- NOTES:
- ① ALL FLAG NOTES WITH THE SAME NUMBER ARE CONNECTED.
 - ② RESISTANCE IN OHMS. CAPACITANCE IN MICROFARADS UNLESS OTHERWISE NOTED.
 - ③ ALL VOLTAGES ARE DC UNLESS OTHERWISE NOTED.
 - ④ INDICATES INTERNAL ADJUSTMENT
 - ⑤ INDICATES CHASSIS GROUND.
 - ⑥ THESE PARTS NOT LOCATED ON THIS BOARD.
 - ⑦ VALUES OF R107, R112, R113, AND R114 ARE DETERMINED BY THE VOLTAGE OF CR1402.
 - ⑧ TRANSFORMER CONNECTIONS SHOWN ARE FOR 115 VOLT OPERATION. FOR 230 VOLT OPERATION, REMOVE CONNECTIONS FROM A TO L AND M TO B; CONNECT M TO A.
 - ⑨ FOR SER. NO'S 283 THRU 342. USE CIRCUIT CONFIGURATION SHOWN.



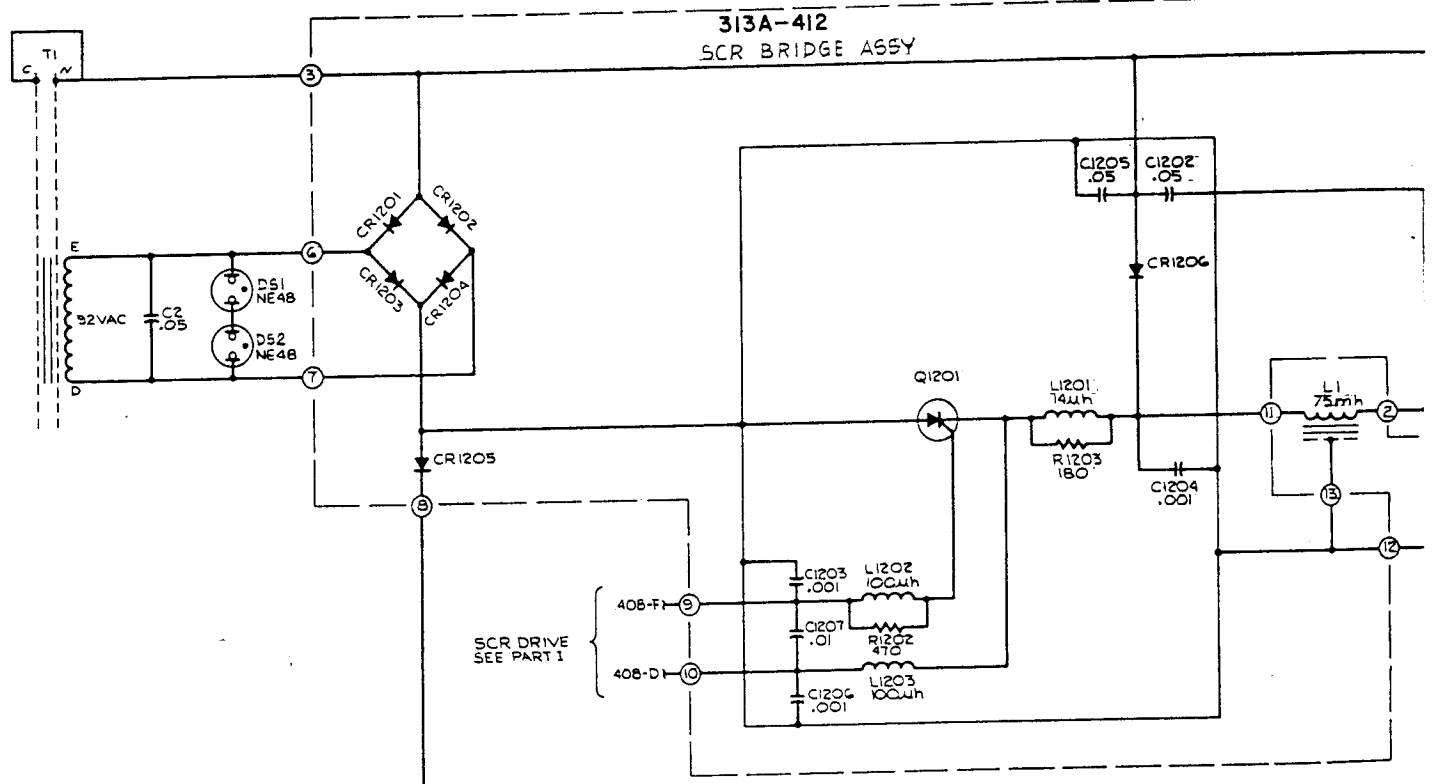
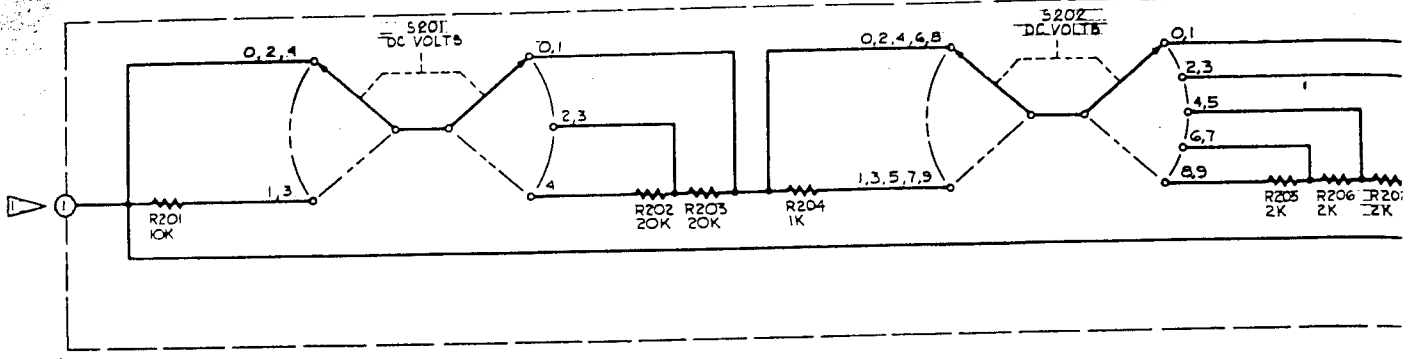
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VOLTAGE CALIBRATOR

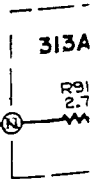
MODEL 313A PART I

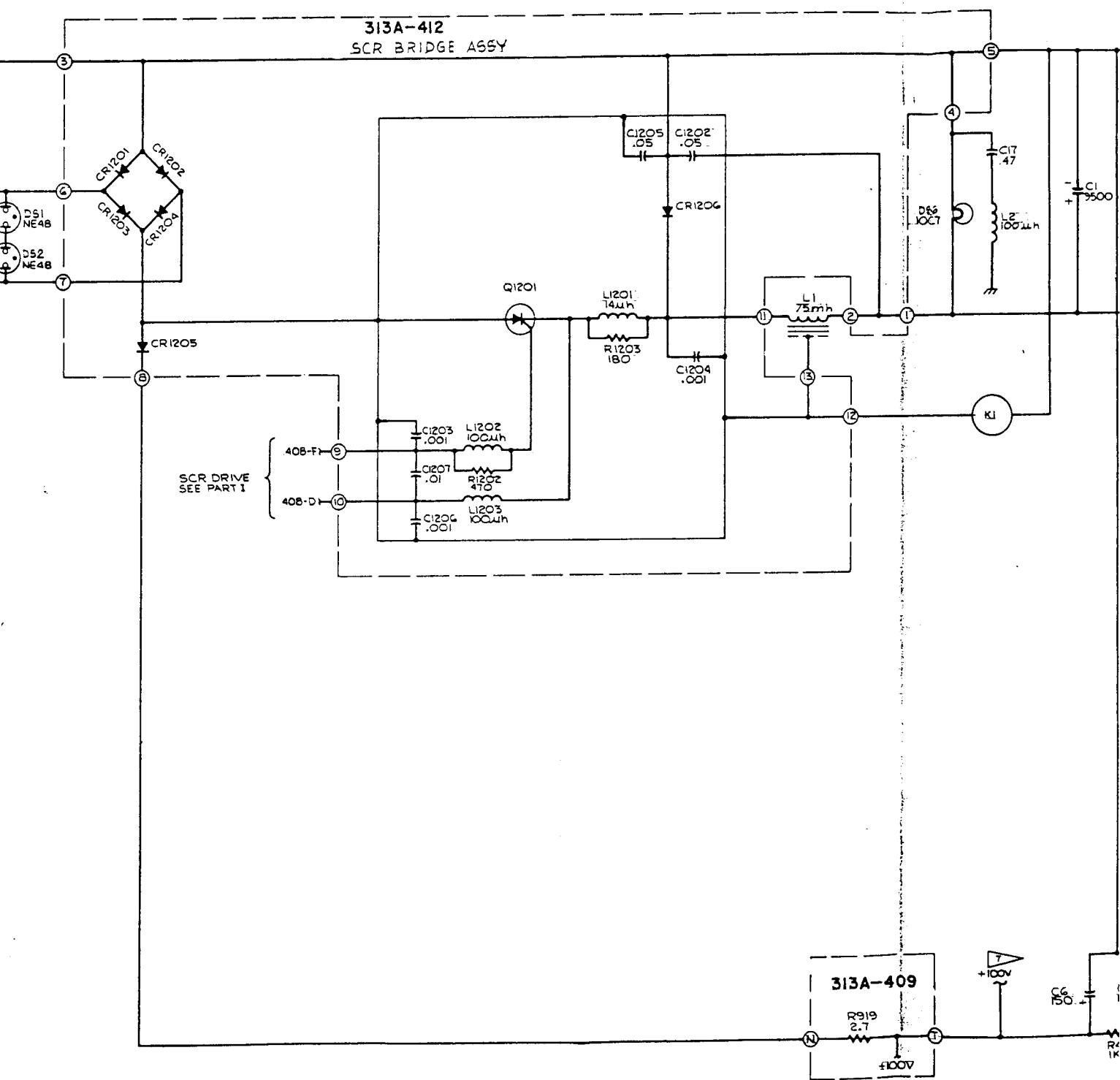
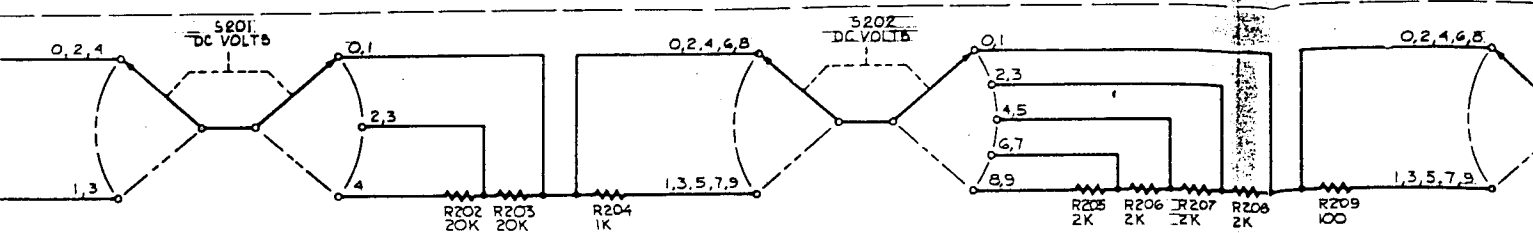
313A SER. NO. 283 & ON

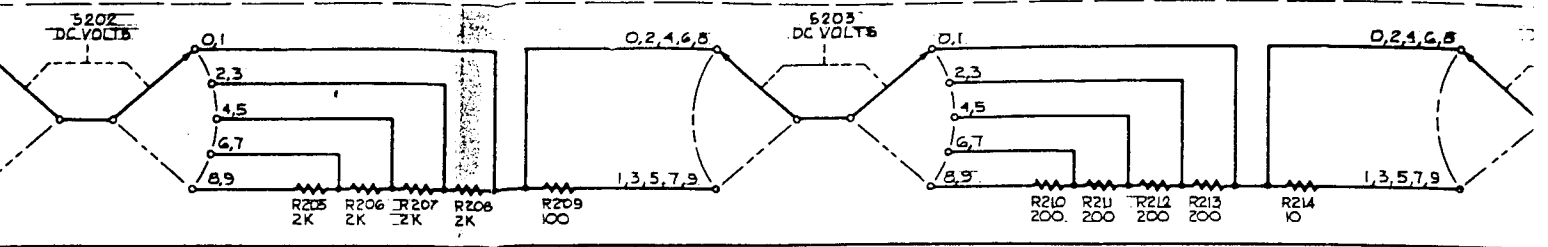
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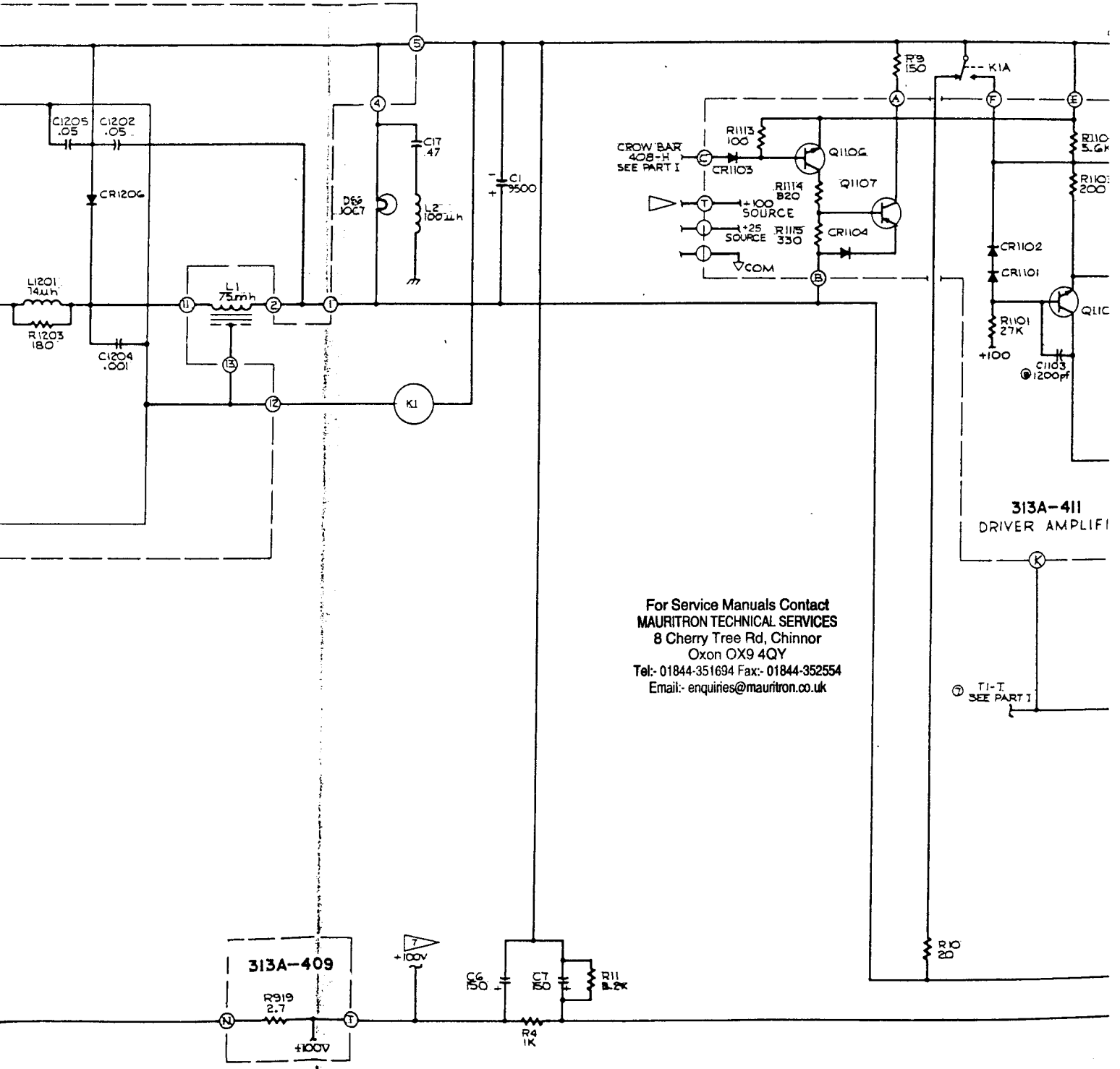
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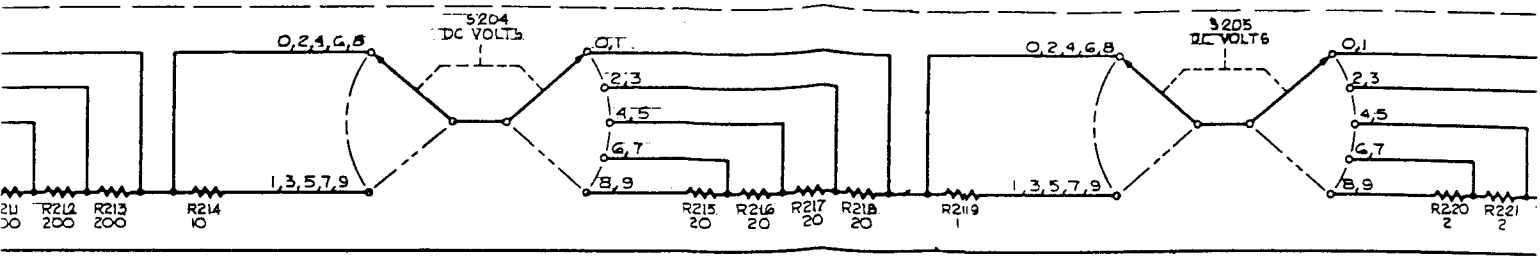


**313A-402
VOLTAGE CONTROL**

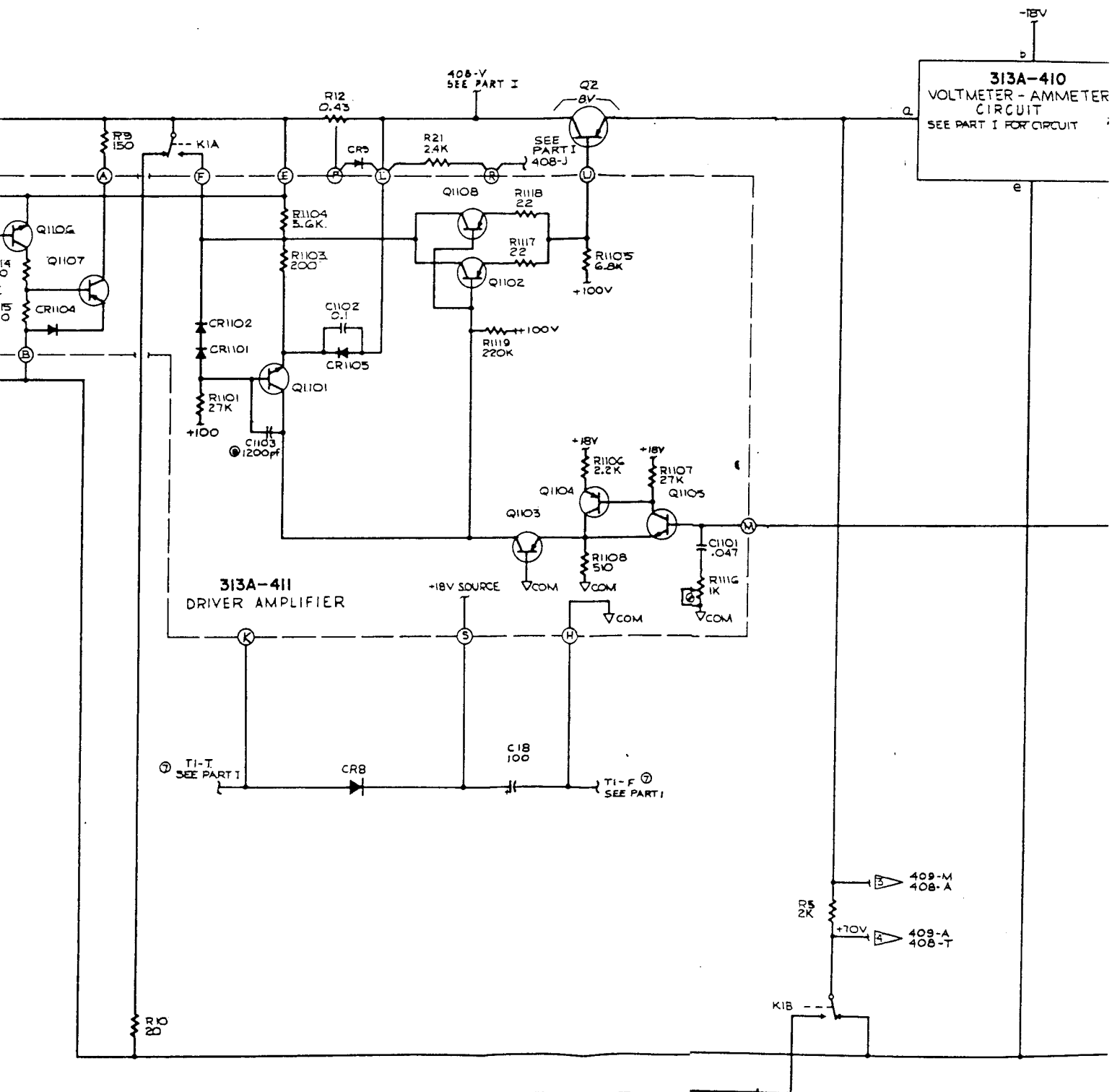


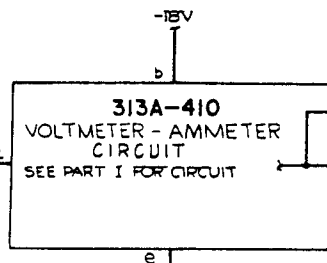
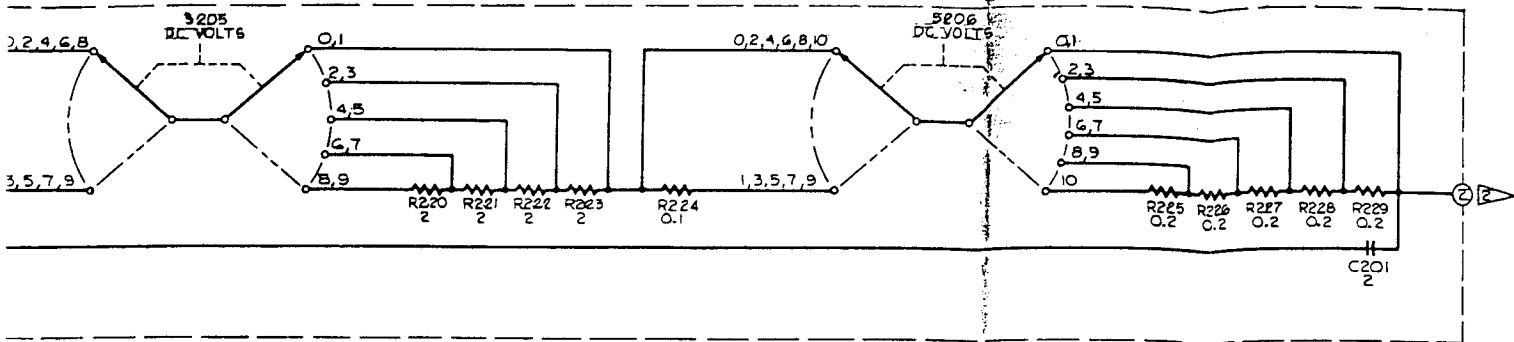
For Service Manuals Contact
MAURITRON TECHNICAL SERVICES
 8 Cherry Tree Rd, Chinnor
 Oxon OX9 4QY
 Tel: 01844-351694 Fax: 01844-352554
 Email: enquiries@mauritron.co.uk

TI-T SEE PART I

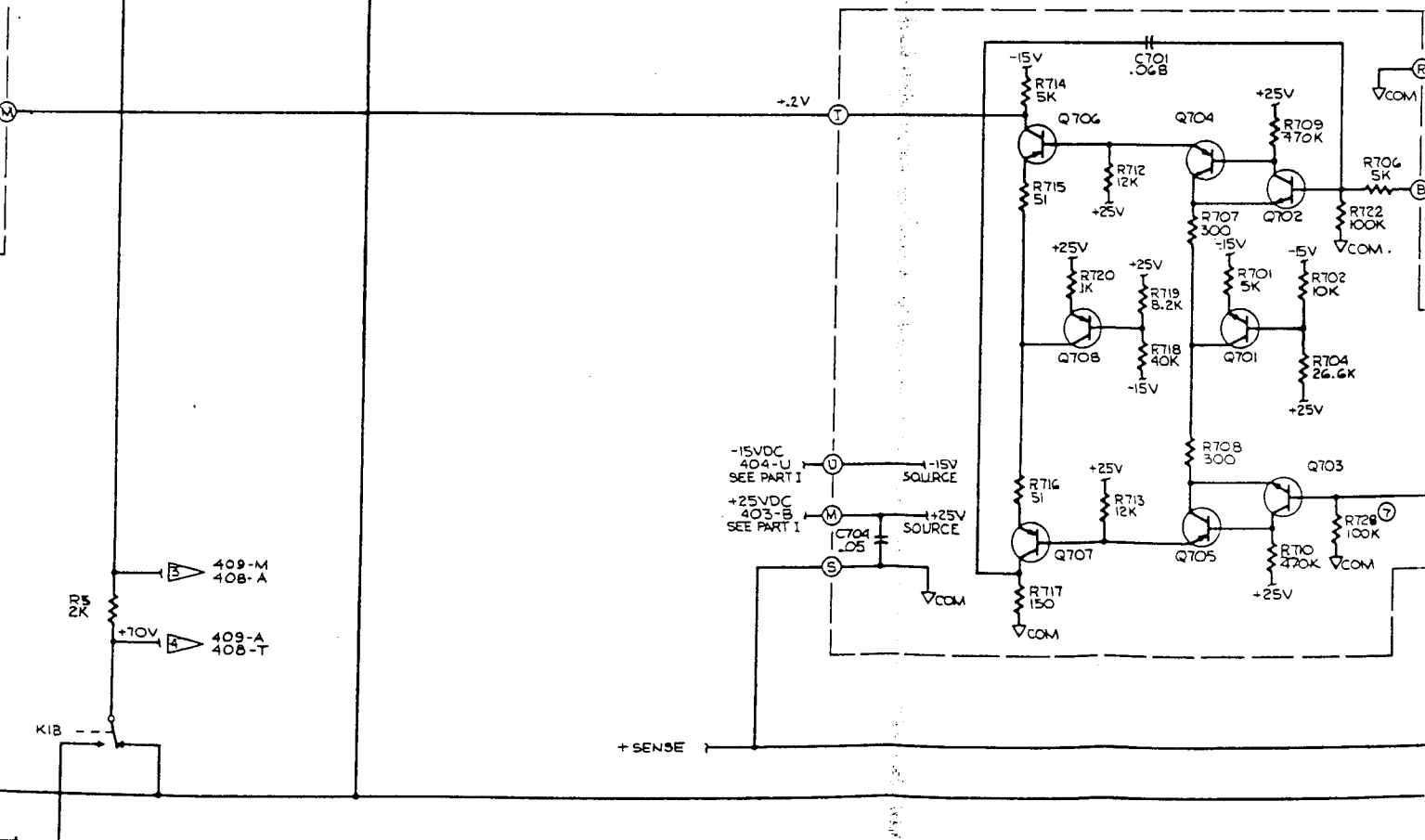


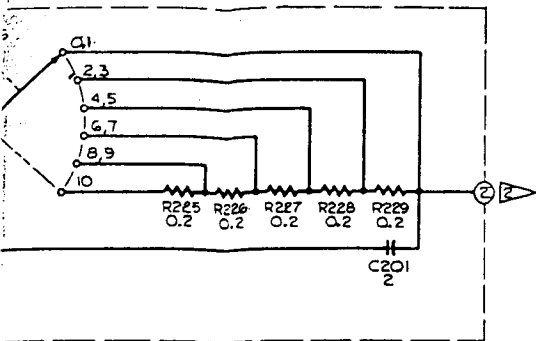
313A-402
VOLTAGE CONTROL



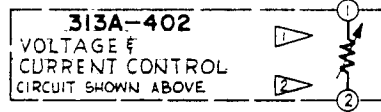


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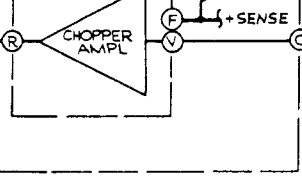
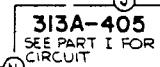
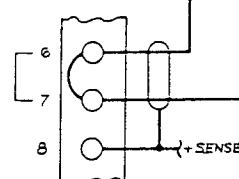




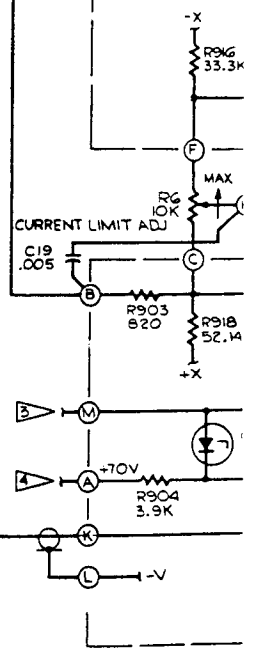
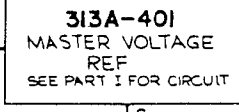
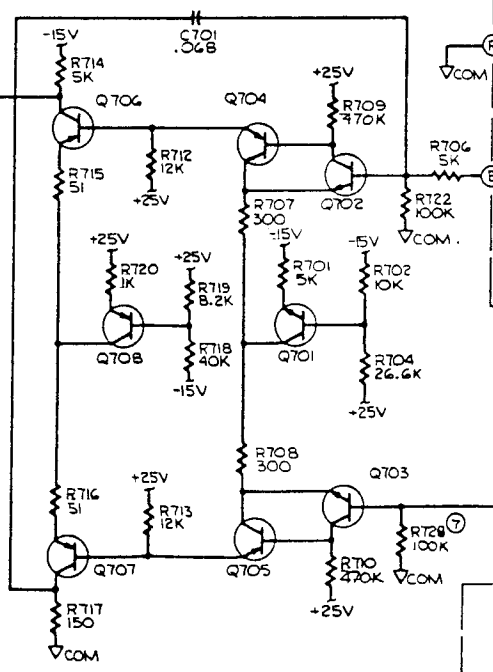
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 Email: enquiries@mauritron.co.uk



REAR TERMINAL STRIP



313A-407
 MAIN AMPLIFIER



-15V SOURCE
 +25V SOURCE
 VCOM

50V
 5V
 +25V
 V2
 V1
 SEE PART I

R721 6K
 C702 2

C19 .005

R903 820

R918 52.14

R904 3.9K

R906 100K

R907 33.3K

R908 33.3K

R909 33.3K

R910 33.3K

R911 33.3K

R912 33.3K

R913 33.3K

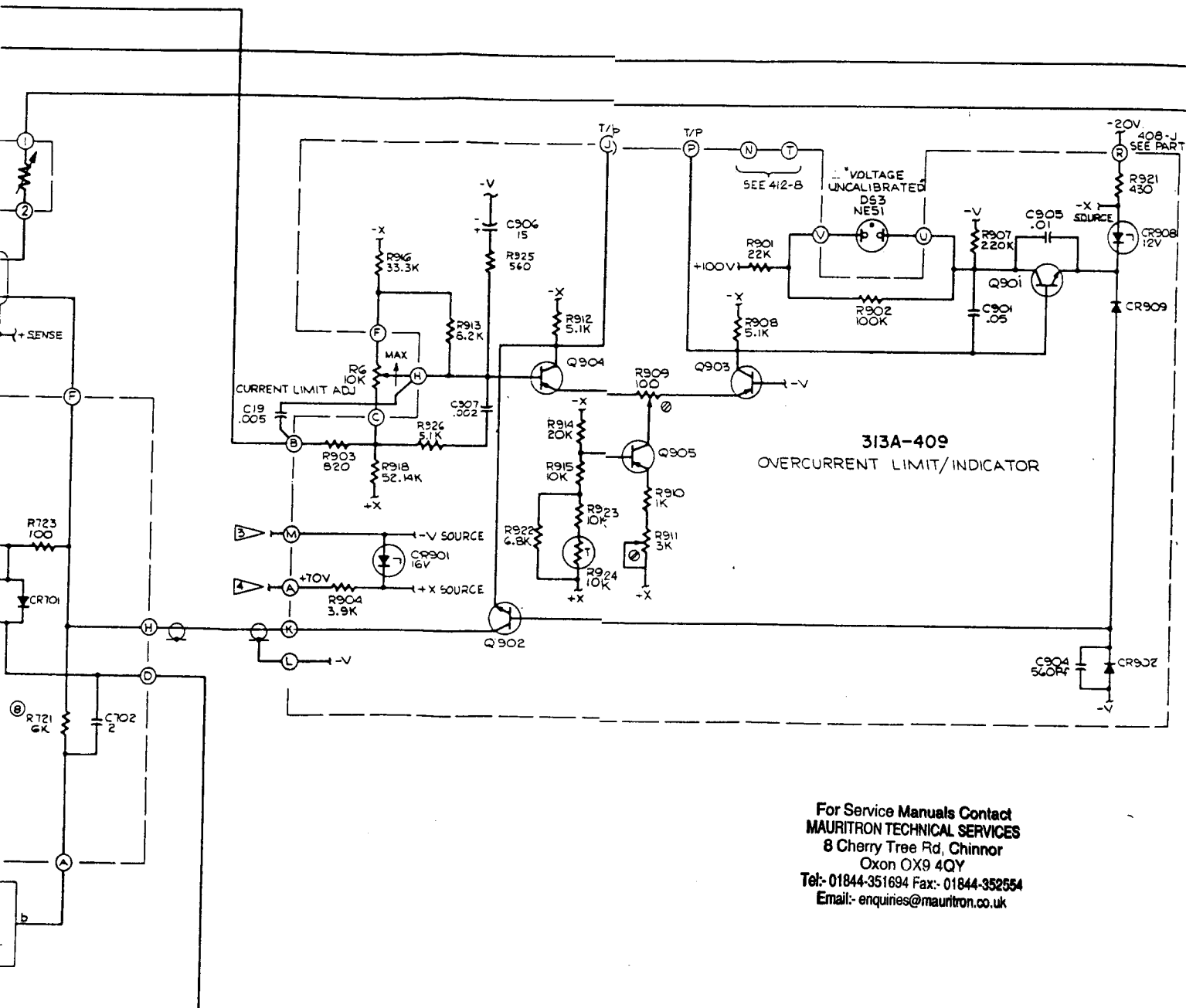
R914 33.3K

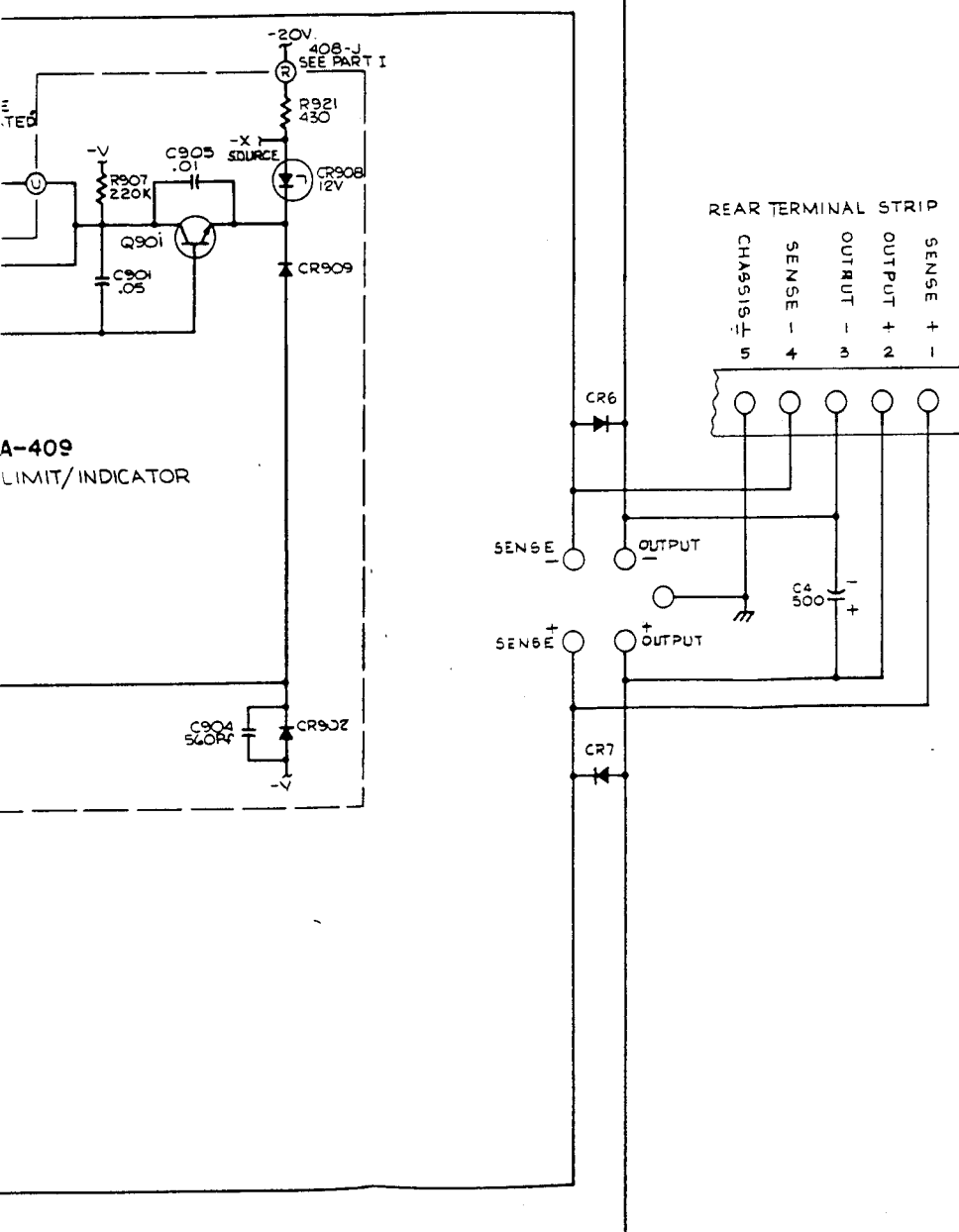
R915 33.3K

R916 33.3K

R917 33.3K

R918 33.3K

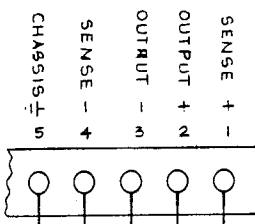




A-409
LIMIT/INDICATOR

For Service Manuals Contact
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 Oxon OX9 4QY
 Tel: 01844-351694 Fax: 01844-352554
 Email: enquiries@mauritron.co.uk

REAR TERMINAL STRIP



NOTES:

- ① ALL FLAG NOTES WITH THE SAME NUMBER ARE CONNECTED.
 - ② RESISTANCE IN OHMS, CAPACITANCE IN MICROFARADS UNLESS OTHERWISE NOTED.
 - ③ ALL VOLTAGES ARE DC UNLESS OTHERWISE NOTED.
 - ④ INDICATES INTERNAL ADJUSTMENT.
 - ⑤ INDICATES CHASSIS GROUND.
 - ⑥ THE VALUE OF R721 IS DETERMINED BY THE VOLTAGE OF CR1402.
 - ⑦ FOR SERIAL NUMBERS 201 THRU 225: CONNECTIONS FROM T1-T AND T1-F TO THE 411 BOARD WERE INTERCHANGED, WHICH SOMETIMES DEGRADED LINE REGULATION.
 - ⑧ FOR SERIAL NUMBERS 207 THRU 266: C1103 WAS 500pf. R721 WAS FACTORY SELECTED.
 - ⑨ FOR SERIAL NUMBERS 207 THRU 282: R16 WAS 125K.
- FOR SERIAL NUMBERS 207 THRU 246: C19 (.005) WAS CONNECTED BETWEEN PINS H & B OF 409 BOARD.

FUNCTIONAL SCHEMATIC J

VOLTAGE CALIBRATOR

MODEL 313A PART II

313A SER. NO. 207 & ON

JOHN FLUKE MFG. CO., INC.
 P.O. Box 7428 Seattle, Washington 98133