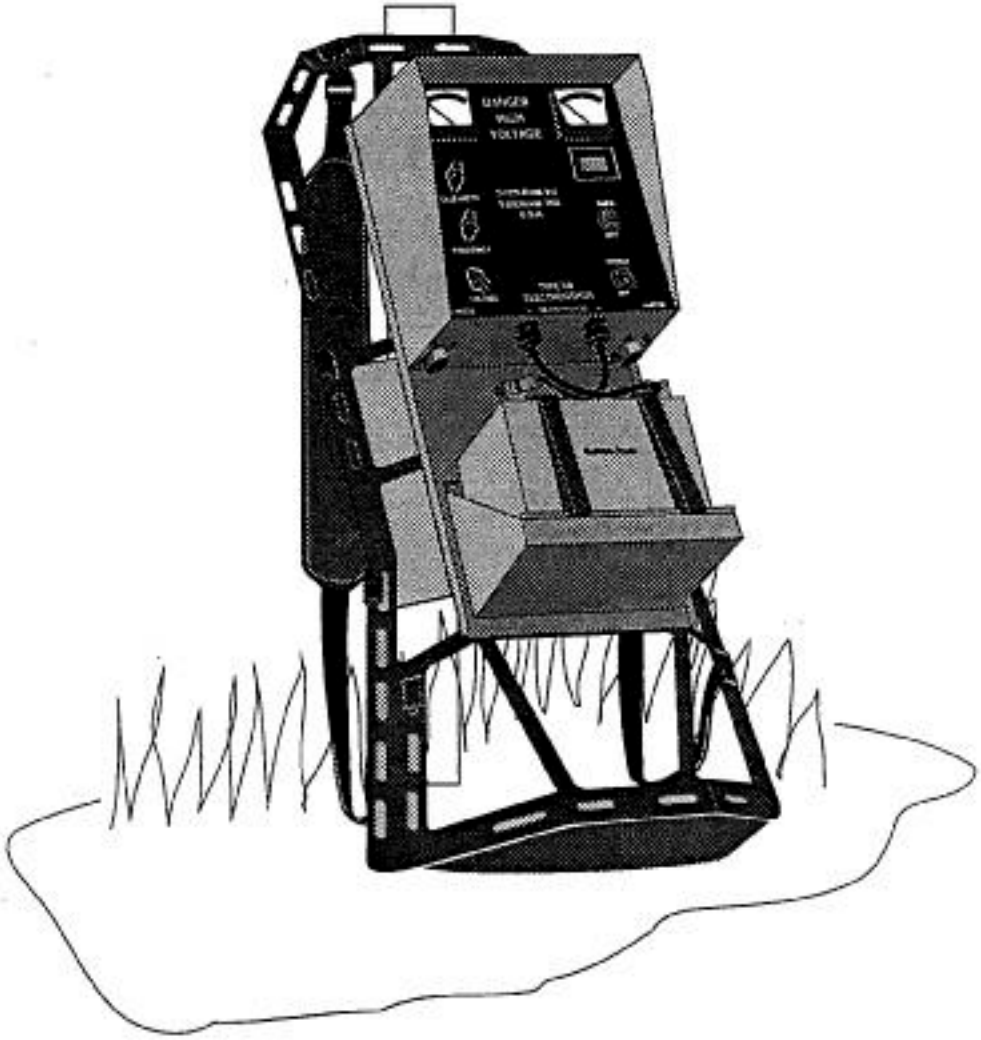
Battery Powered BackPack ElectroFisher Model VII

Operation Manual



Smith-Root, Inc.
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Vancouver, WA U.S.A. 89686

THEORY OF OPERATION

Power Distribution

When the power switch/breaker S105 is on, the input voltage from the battery is applied across a normally reverse-biased diode D107, which protects against inadvertant reversed polarity battery connection. The supply voltage at this point is called +12V1, the return is called ground 1 or board ground. The input voltage meter M101 is connected across this supply. The +12V1 supply and ground 1 are connected to the inverter circuit by 20 inch long, AWG 12 wires. The inverter ground is connected to the case of the electrofisher. The supply voltage at this point is called +12V2, the return is called ground 2 or box ground. When the power switch is on, the +12V1 supply energizes the control relay RL101 if the mercury tilt switch S104 is closed (when the orientation of the electrofisher is within about 45 degrees of upright), the anode pole is plugged in and its control switch S106 is on, and the cathode is plugged in. When control relay RL101 is energized the +12V1 supply is connected to the supply point called +12V3. Circuits supplied by +12V3 are returned to ground 1.

Inverter Driver Board

The inverter driver board SR704B has a relaxation oscillator including unijunction transistor Q1 that produces pulses at 800 Hz. Transistor Q2 drives integrated circuit IC1 unless the signal from the overload detector board SR703B pulls down the collector of Q2, which shuts down the output of the inverter driver board. The integrated circuit IC1 has a D-type flip-flop connected so as to produce a push-pull output operating at 400 Hz, with which transistors Q5 and Q6 drive the output transistors Q3 and Q4.

Inverter

The outputs of inverter driver board SR704B drive power transistors Q101 and Q102 of the inverter. When inverter relay RL102 is energized by the +12V3 supply, it connects the center tap of the primary of inverter transformer T102 to +12V1, turning on the inverter. The four secondaries of transformer T102 drive power transistors Q103 to Q106 which drive the four primaries of high voltage transformer T101. The in-phase circuits of transistors Q103 and Q105 operate in push-pull with the in-phase circuits of transistors Q104 and Q106. Each transistor pair operating in phase has matched gains to ensure equal load sharing. The secondary of high voltage transformer T101 with its taps is connected to voltage selector switch S103.

High Voltage Power Supply

The AC voltage from voltage selector switch S103 is full wave rectified by diodes D103 to D106 and filtered by toroid inductor L101 and capacitors C101 and C102 of the high voltage power supply. Capacitors C101 and C102 are discharged when the electrofisher is turned off, by resistor R103 being

connected across them through the contacts closed when control relay RL101 is de-energized. The DC voltage is formed into output pulses by the switching action of mercury-wetted relay RL103 or the relay replacement board MRR-88. The output pulses are sent through resistor R108 to the anode. The cathode is connected through output current meter M102 to the negative side of the high voltage power supply.

Oscillator Board, Relay Driver Section

The mercury-wetted relay or its replacement board is driven by the output of one section of the pulse shaper board SR702C which is driven by one section of the oscillator board SR701A. On the oscillator board, capacitor C1, rheostats R1 and R2, with frequency rheostat R101 on the front panel, form the timing network of the relaxation oscillator including unijunction transistor Q1. Rheostat R1 adjusts the minimum period (18 milliseconds), rheostat R2 adjusts the maximum period (35 milliseconds) of the oscillator to be set by the frequency rheostat R101. Transistor Q2 buffers the pulse output of the oscillator, driving the relay driver section of pulse shaper board SR702C.

Pulse Shaper Board, Relay Driver Section

The pulse from the oscillator board to the relay driver section of the pulse shaper board SR702C turns on transistor Q1, pulling its collector to ground. This causes the charge on capacitor C2 to cut off transistor Q2, allowing its collector to rise toward +12 volts. This voltage is fed back through resistor R5 and diode D1 to the base of transistor Q1, latching it on. Capacitor C2 discharges through resistor R4, rheostats R6 and R7, and pulse width rheostat R102 on the front panel until transistor Q2 is forward-biased again and unlatches transistor Q1. Rheostat R7 adjusts the minimum pulse width (4 milliseconds), rheostat R6 adjusts the maximum pulse width (8 milliseconds) set by the pulse width rheostat R102. The pulse from transistor Q2 is used by transistor Q3 to drive output transistor Q4, providing the output that drives the mercury-wetted relay or its replacement board.

Oscillator Board, Timer Driver Section

The timer driver section of the oscillator board SR701A works in a way similar to the relay driver section. Rheostat R7 is adjusted to set the frequency of the oscillator to 1 Hz.

Pulse Shaper Board, Timer Driver Section

The timer driver section of the pulse shaper board SR702C works in a way similar to the relay driver section. The pulse formed at the collector of transistor Q6 is 50 milliseconds wide. Transistor Q8's base is normally at +12 volts, but is pulled down when the overload detector board SR703B is triggered. This causes the base of output transistor Q9 to be pulled up to +12 volts, swamping out the normal drive to the timer MR101.

Overload Detector Board

The overload detector board SR703B has an operational amplifier on integrated circuit IC1 which compares the ratio between the voltage from+12V1 to ground 1 and the voltage from +12V2 to ground 2. A large voltage drop indicates that the inverter is overloaded. Potentiometer R6 is adjusted at the overload threshold to the ratio that will cause the operational amplifier to output a positive voltage that will trigger silicon controlled rectifier Q1. When the SCR is triggered it will draw toward ground the three outputs of the board. Pin 13 disables the pulse shaper board SR702C's drive to the timer MR101. Pin 11 turns on the overload indicator lamp IND101. Pin 12 disables the output of the inverter driver board SR704B.

Relay Replacement Board

The relay replacement board MRR-88 is a plug-in board that replaces the mercury-wetted relay's mechanical switching with electronic switching to accomplish pulse forming for output to the anode. The switching regulator integrated circuit IC1 is configured to operate power transformer T1 in push-pull mode at 40 KHz. Capacitor C1 and resistor R4 set the frequency of the oscillator on IC1 at 80 KHz. The E1 pin 9 and E2 pin 10 output returns are returned in common to ground through a 0.5 ohm resistor R6 to provide a current sense voltage which is coupled to the error amp 2 + input pin 16. The error amp 2 – input pin 15 is held at a small fraction of a volt above ground by the voltage divider R1 and R2 between the +5 volt reference out pin 13 and ground. When excessive current is drawn by T1, the current sense voltage coupled to the error amplifier causes the pulse width of the outputs to be reduced to limit average current. Having the output control input pin 14 connected to the +5 V reference out causes the pulse steering flip-flop to alternately gate the pulses to the output transistors on IC1, giving an output of 40 KHz. The collectors of the transistors C1 pin 8 and C2 pin 11 drive the primaries of power transformer T1. The circuit of IC1 is returned to ground 1 via a wire attached to the negative side of input voltage meter M101. The power +5.5 volt and -12 volt power supplies run by the secondaries of power transformer T1 are returned to a floating ground tied to the cathode of gate turn-off device Q3. The infrared-emitting diode on optoisolator integrated circuit IC2 is turned on for the duration of the pulse output by pulse shaper board SR702C, which turns on the phototransistor. The emitter of the phototransistor is pulled up to the +5.5 volt supply, cutting off Darlington transistor Q2 and turning on Darlington transistor Q1. Transistor Q1 provides turn-on current to the gate of the gate turn-off device Q3. The gate turn-off device accomplishes the switching in place of the mercury-wetted relay contacts. At the end of the pulse from the pulse shaper board, the phototransistor on IC2 turns off, allowing its emitter to rise toward the -12 volt supply. This cuts off transistor Q1 and turns on transistor

Q2 which provides turn-off current to the gate of the gate turn-off device Q3.

TEST PROCEDURE

Preliminary Setup

Remove the front panel, which is attached to the box by three screws on the top and two on the bottom. CAUTION: Take care when pulling the panel away from the box NOT to catch the wafer of the voltage select switch, behind the panel, on the lip of the box, as the switch wafer could be broken. Mount the front panel to the box using a right angle bracket. This allows the box to be set on its back while supporting the front panel upright. Clean the front panel with window cleaner. Blow any dirt and debris out of the inside of the box with compressed air. Clean the contacts of the voltage select switch with electrical contact cleaner. Clean the contacts of the control relay with a contact burnishing tool and electrical contact cleaner. Inspect solder connections for mechanical tightness and good solder joints. Inspect wires for breaks and insulation damage. Inspect battery leads and connectors for corrosion and burns.

Test Procedure

1. Connect the electrofisher to the test fixture shown in figure 1. The output voltage is monitored with an oscilloscope which has a 100X probe connected across the water load. The input current is monitored with a voltmeter connected across a 50 millivolt at 50 amp (0.001 ohm) shunt resistor which is in series with the battery and the electrofisher. The voltmeter readout in millivolts will be equal to the input current in amps.
2. Power the electrofisher with a 12 volt 10 amp capacity regulated power supply until the possibility of a short within the electrofisher is eliminated. A short could cause wires to burn. Idle current, drawn by the electrofisher operating with no load, should be about two to four amps.
3. Set the Voltage Selector, Frequency, and Pulse Width controls on the front panel to minimum.

WARNING: Do NOT touch the electrodes in the water load with the electrofisher in operation. Potentially lethal voltage is applied. The electrofisher is designed to discharge the high voltage power supply when not in operation, but do not take the operation of the discharge circuit for granted.

4. Set the water load to provide a light load by adjusting the depth the anode electrode is in the water load to about an inch. The amount of load provided depends on the depth of immersion of the electrode and the conductivity of the water. If the water has very low conductivity, adding salt to the water will increase the load provided.
5. Turn on the Power switch on the electrofisher. Observe the battery voltage of about 12 volts is shown on the Input Voltage meter on the front panel, and the Output Current meter is showing a low current.
6. Observe the output waveform shown on the oscilloscope is positive DC

pulses of about 200 volts peak, 4 milliseconds in duration, with a period of repetition of 35 milliseconds.

7. Check the current through the 2N4280 transistors in matched pairs Q103/Q105 and Q104/Q106, mounted in the back of the box. Using a current probe, clamp around the wire that connects the emitter of each transistor to the power transformer T101. The transistors of each pair operate in phase to drive the power transformer, and should pull about the same average current in order to equally share the load. Smith-Root marks transistors for matching with numbers according to responses on a curve tracer.

CAUTION: When taking measurements on the mercury relay replacement board MRR-88 do NOT attach the ground lead of the oscilloscope to the common side of the on-board power supplies if the oscilloscope ground is also attached to the cathode output of the electrofisher. This would cause a short across the output of the electrofisher, since the common side of the on-board power supplies is connected to the cathode of the gate turn-off device, which switches the output of the high voltage power supply to the anode.

8. If the mercury relay replacement board MRR-88 is installed, measure the voltages of the on-board power supplies. Measure across capacitor C5 for the +5.5 volt supply, and across C6 for the −12 volt supply. Locations of the test points are shown on figure 4.

9. Observe the range of the Pulse Width control sets the width of the output pulses from 4 milliseconds at minimum to 8 milliseconds at maximum. Minimum range is set by rheostat R7, maximum by rheostat R6 on pulse shaper board SR702C. Control locations are shown in figure 2. Return the Pulse Width control to minimum.

10. Observe the range of the Frequency control sets the period of repetition of the output pulses from 35 milliseconds at minimum to 18 milliseconds at maximum. Minimum range is set by rheostat R2, maximum by rheostat R1 on oscillator board SR701A. Control locations are shown in figure 2. Return the Frequency control to minimum.

CAUTION: Never change the setting of the Voltage Selector switch while the electrofisher is in operation, to avoid damage due to contact arc-over and transient spikes.

11. Observe the peak voltage of the output pulse is approximately the same as marked at the setting of the Voltage Selector switch for all settings. Turn off a safety switch on the test adapter to disable the electrofisher before changing the setting of the Voltage Selector.

12. Turn off the power to the electrofisher, and increase the load provided by inserting the anode deeper into the water load.

13. Check the trip point of the overload detector by increasing the settings of

the voltage selector, frequency, and pulse width controls until the input current, as monitored on the voltmeter across the shunt resistor, approaches 40 amps. Continue slowly to increase the input current drawn until the overload detector trips. This will light the overload lamp, shut down the high voltage power supply and thereby the output, and stop the timer. It should occur at about 40 amps, but it will occur at lower currents as the current-sensing wire in the power supply heats up. The trip point is adjusted by potentiometer R6 on overload detector board SR703B. The control location is shown in figure 2.

14. Run the electrofisher for a few minutes and check the circuit breaker/ power switch S105 for heating, and observe the input voltage meter for a sudden drop in reading. Either condition indicates a faulty circuit breaker.

15. Return Voltage Selector to lowest setting. Turn on Timer switch and observe timer counts occur one per second. Timer count period is adjusted by rheostat R7 on oscillator board SR701A.

16. Cycle the electrofisher safety switch circuit on and off at a 50% duty cycle of 30 seconds for approximately 1000 seconds.

17. Repeat test procedure steps 3 through 14.

18. Reinstall the front panel.

19. Check the operation of the tilt switch by setting the electrofisher upright and operating it into the test fixture. When the electrofisher is tilted forward or back more than approximately 45 degrees from upright, output should cease due to the safety circuit being opened.

20. Attach the box to the packboard.

21. Repeat test procedure steps 3 through 6, 8 through 12, and 14.

22. If unit checks out good, attach a tag with a green dot initialled as OK and dated.

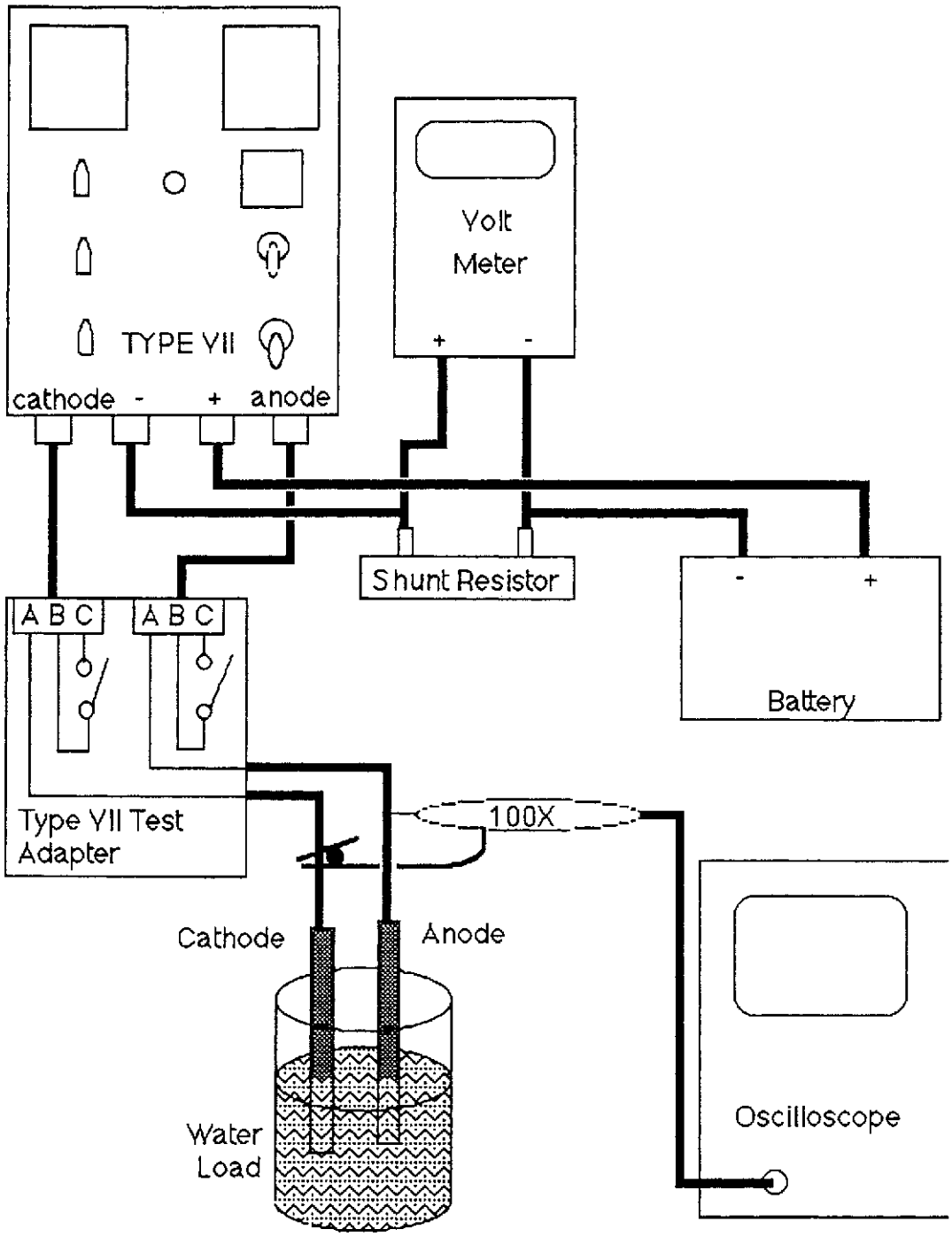
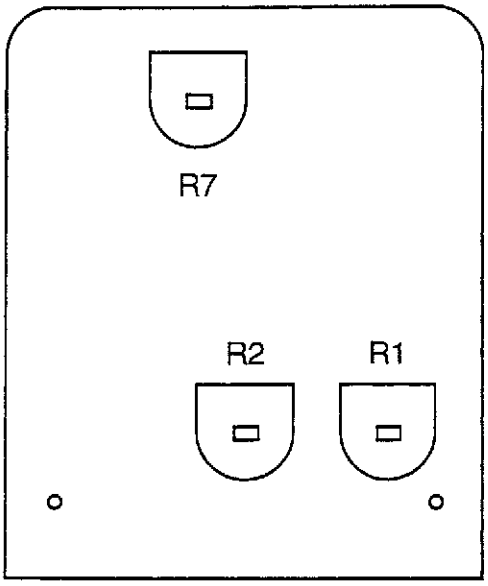
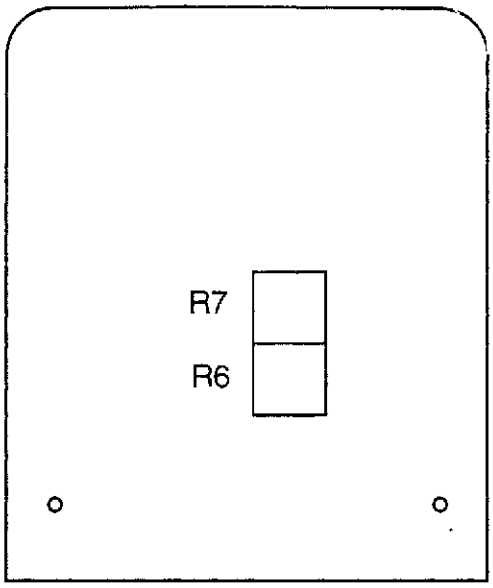


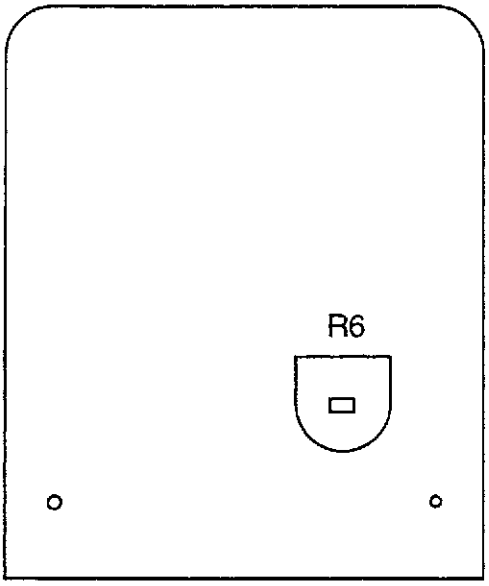
Figure 1. Type VII Electrofisher test fixture



SR-701A Oscillator Board



SR-702C Pulse Shaper Board



SR-703B Overload Detector Board

Figure 2. Control Locations on Plug-in Circuit Boards (Component Side View)

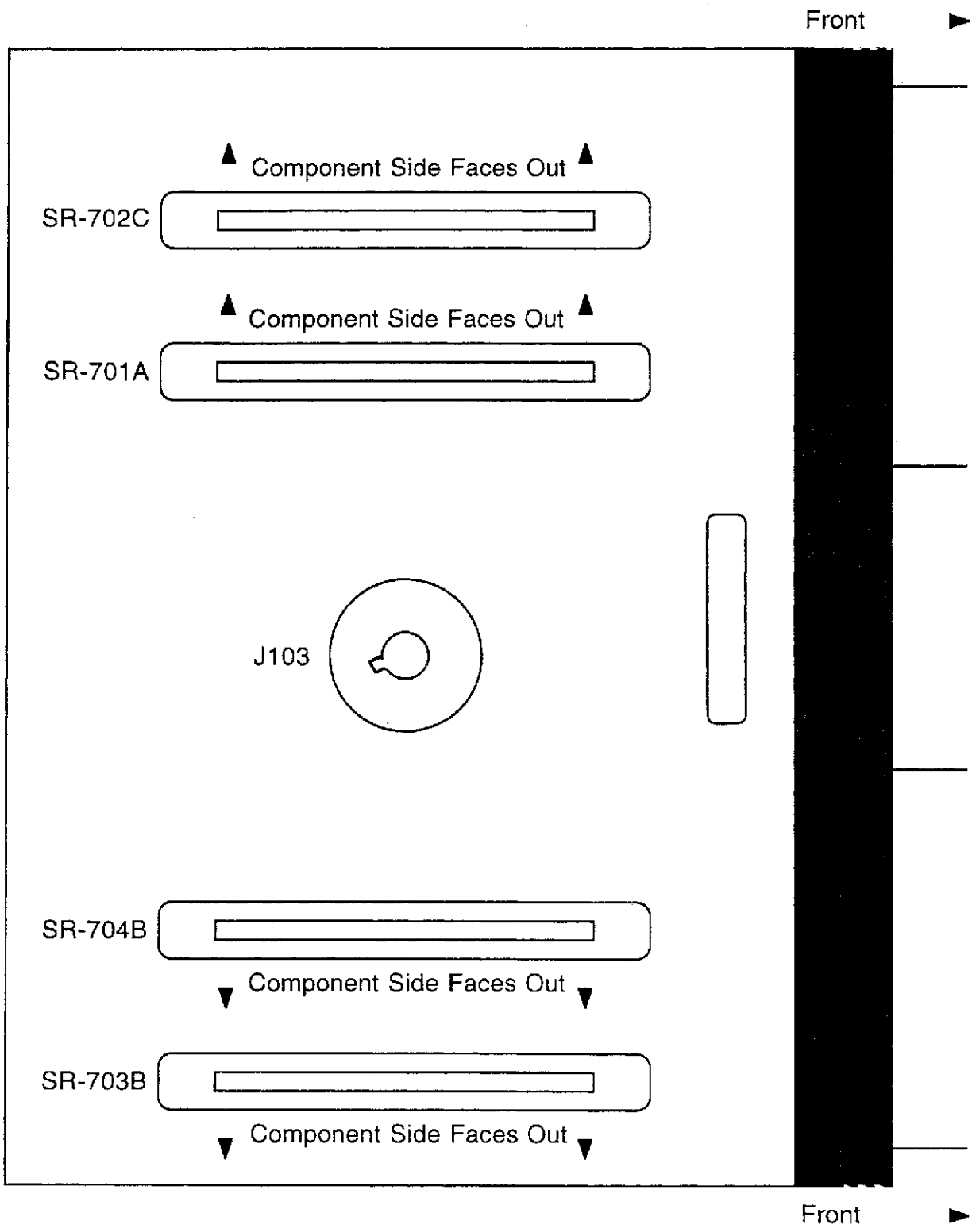


Figure 3. Location of Plug-in Circuit Boards on Mother Board (Top View)

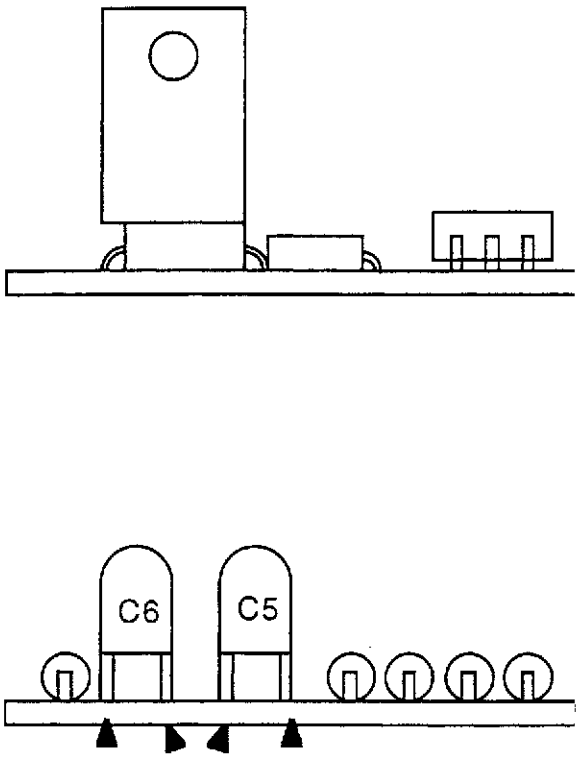


Figure 4. Power Supply Test Points on Mercury Relay Replacement Board MRR-88 (Top View)

PARTS LIST

Ckt. ID/ (Qty.)	Line #	Description	Manufacturer Part #
(1)		CHASSIS	
C105	58	Cap., 0.1 µF 10% 100 V poly.	
C106	2674	Cap., 5 µF 100 VDC	Sprague #735P505X9100SPL
D101	104	Diode, 1 KV 1 Amp	Motorola #1N4007
D102	104	Diode, 1 KV 1 Amp	Motorola #1N4007
D107	109	Diode, 50V 35 Amp rev case	1N1183R
IND101	166	Lamp, miniature 16V	Sylvania #16ESB
J101	4	Receptacle, 4 Pin circular	Amphenol #MS3102E18-4S
J102	4	Receptacle, 4 Pin circular	Amphenol #MS3102E18-4S
M101	173	Meter, 0-15 VDC	Mercer #922
M102	172	Meter, 0-1.5 Amp	Mercer #922
MR101	1078	Mech. Counter, 4 digit	Redington #P24-4904-12DC
P104	2325	Plug, banana large red	H. H. Smith #285-102
P105	2326	Plug, banana large black	H. H. Smith #285-103
Q101	603	Transistor, power NPN TO-3	2N3055
Q102	603	Transistor, power NPN TO-3	2N3055
Q103	611	Transistor, pwr. Ge. PNP TO-3	2N4280
Q104	611	Transistor, pwr. Ge. PNP TO-3	2N4280
Q105	611	Transistor, pwr. Ge. PNP TO-3	2N4280
Q106	611	Transistor, pwr. Ge. PNP TO-3	2N4280
R101	201	Pot., 25 KΩ panel mount	Claro #RV4NAYSD253A
R102	202	Pot., 50 KΩ panel mount	Claro #RV4NAYSD503A
R104	207	Res., 0.15 Ω 5 W wire wound	Dale #CP-5.15 OHM
R105	207	Res., 0.15 Ω 5 W wire wound	Dale #CP-5.15 OHM
R106	207	Res., 0.15 Ω 5 W wire wound	Dale #CP-5.15 OHM
R107	207	Res., 0.15 Ω 5 W wire wound	Dale #CP-5.15 OHM
R112	243	Res., 47 Ω 5% 1/4 W carbon	
R113	310	Res., 1 KΩ 5% 1/2 W carbon	
RL101	199	Relay, DPDT 12 V coil	Magnecraft #W88X-7
RL102	199	Relay, DPDT 12 V coil	Magnecraft #W88X-7
S101	597	Switch, toggle SPST	C-H #7580K6
S103	595	Switch, rotary DP5T	Oak #399327F
S104	596	Switch, mercury tilt	Mercoid #9-6107-SC
S105	3	Circuit breaker, 40 Amp 1 pole	Potter & B. #W31X2M1G40
T101	702	Transformer, inverter	Amertran #NS0031
T102	701	Transformer, driver	Amertran #NS0070
(1)	127	Mounting clip, tilt switch	Mercoid#7-57

(2)	2500	Insulator, TO-3, 9 mil	Berquist #7403-09FR-05
(3)	769	Knob, short pointer	H. H. Smith #2223
(1)	583	Socket, lamp IND101	Sylvania #30153-0
(1)	103	Cover, lamp IND101 Red	Sylvania #LPRR-38001
(2)	174	Lock-nut, conduit 1/2"	T&B #141
(2)	1522	Conn., liq.-tight .50 X .25-.37	Heyco #3231 BLK
(5)	1191	Solder lug, 1 terminal	H. H. Smith #861
(1)	587	Standoff, threaded 6-32 X 3/8	H. H. Smith #8422
(1)	1257	Ring lug, 1/4" #8 wire	PDL #R681430-BB
(1)	2681	Ring lug, #10 #8 wire	
(1)	707	Ring Lug, 1/4" Yellow	
20"	1334	Wire, #12 AWG	
(1)	128	Carrying handle, black	P. H. C. #919-414-173
(1)	2498	Switchboot, 1-pole ckt. brkr.	Hexseal #N-1030B
(1)		MOTHER BOARD SR-700	
C101	95	Cap., 100 µF 350 V Al. electro.	Sprague #TVA-1620
C102	95	Cap., 100 µF 350 V Al. electro.	Sprague #TVA-1620
C103	61	Cap., 0.22 µF 1000 V	Sprague #196P224910S2
C104	15	Cap., 0.01 µF 1000 V disc	Centralab #DD-1032
D103	104	Diode, 1 KV 1 Amp	Motorola #1N4007
D104	104	Diode, 1 KV 1 Amp	Motorola #1N4007
D105	104	Diode, 1 KV 1 Amp	Motorola #1N4007
D106	104	Diode, 1 KV 1 Amp	Motorola #1N4007
D108	2446	Diode, fast recovery 1KV 3 A	DII #FR307
J103	584	Socket, octal PC mount	R. D. I. #8R
L101	599	Toroid core, 1.125" diameter	Amidon #FT114-75
R103	343	Res., 5 KΩ 5W wire wound	Clarostat #VC5E 5K
R108	212	Res., 10 Ω 25W wire wound	Clarostat #VP-25K 10 Ohm
R109	423	Res., 220 KΩ 10% 2W carbon	
R110	423	Res., 220 KΩ 10% 2W carbon	
R111	261	Res., 100 Ω 5% 3W wire wnd	Clarostat #VC3D 100 Ohm
(4)	5	Edge Conn., 15 pin PC mount	Elco #6007-015-938-012
(1)	587	Standoff, threaded 6-32 X 3/8	H. H. Smith #8422
(2)	588	Standoff, threaded 6-32 X 3.25	H. H. Smith #8247
(1)	2313	Bracket, card hold-down	
(1)	591	OSCILLATOR BOARD SR-701A	
C1	36	Cap., 0.68 µF 35 V, dip. tant.	
C2	700	Cap., 4700 pF 10% 100 V poly	

C3	1551	Cap., 47 µF 25 V, dip. tant.	
C4	2263	Cap., 4.7 µF 25 V, dip. tant.	
C5	82	Cap., 10 µF 25 V, Al. electro.	
C6	700	Cap., 4700 pF 10% 100 V poly	
C7	8	Cap., 51 pF, ceramic 5X6	
C8	689	Cap., 220 pF, ceramic Y5P 3X4	
C9	84	Cap., 22 µF 16 V, Al. electro.	
D1	118	Diode, signal 75 V 10 mA	T. I. #914B
D2	118	Diode, signal 75 V 10 mA	T. I. #914B
Q1	617	UJT, 0.3 W 50 mA Ic	2N4871
Q2	610	Transistor, PNP 0.62W	2N3906
Q3	617	UJT, 0.3 W 50 mA Ic	2N4871
Q4	610	Transistor, PNP 0.62W	2N3906
R1	205	Trimpot, 25 KΩ	Mallory #MTC253L4
R2	203	Trimpot, 100 KΩ	Mallory #MTC15L4
R3	276	Res., 220 Ω 5% 1/4 W carbon	
R4	324	Res., 2.2 KΩ 5% 1/4 W carbon	
R5	324	Res., 2.2 KΩ 5% 1/4 W carbon	
R6	276	Res., 220 Ω 5% 1/4 W carbon	
R7	203	Trimpot, 100 KΩ	Mallory #MTC15L4
R8	276	Res., 220 Ω 5% 1/4 W carbon	
R9	324	Res., 2.2 KΩ 5% 1/4 W carbon	
R10	324	Res., 2.2 KΩ 5% 1/4 W carbon	
R11	276	Res., 220 Ω 5% 1/4 W carbon	

(1)	592	PULSE SHAPER BOARD SR-702C	
C1	58	Cap., 0.1 µF 10% 100 V poly.	
C2	58	Cap., 0.1 µF 10% 100 V poly.	
C3	49	Cap., 0.01 µF 10% 100 V poly.	
C4	2263	Cap., 4.7 µF 25 V dip. tant.	
C5	1551	Cap., 47 µF 25 V dip. tant.	
C6	58	Cap., 0.1 µF 10% 100V poly.	
C7	68	Cap., 1 µF 35 V dip. tantalum	
C8	689	Cap., 220 pF,ceramic Y5P 3X4	
C9	2263	Cap., 4.7 µF 25 V dip. tant.	
C10	689	Cap., 220 pF ceramic Y5P 3X4	
C11	689	Cap., 220 pF ceramic Y5P 3X4	
C12	2263	Cap., 4.7 µF 25 V dip. tant.	
D1	118	Diode, signal 75 V 10 mA	T. I. #914B
D2	118	Diode, signal 75 V 10 mA	T. I. #914B
D3	912	Diode, Zener 6.2 V 41 mA	Motorola #1N4735A

D4	118	Diode, signal 75 V 10 mA	T. I. #914B
D5	104	Diode, 1 KV 1 Amp	Motorola #1N4007
D7	118	Diode, signal 75 V 10 mA	T. I. #914B
D8	118	Diode, signal 75 V 10 mA	T. I. #914B
D9	104	Diode, 1 KV 1 Amp	Motorola #1N4007
Q1	609	Transistor, NPN 0.62 W	2N3904
Q2	609	Transistor, NPN 0.62 W	2N3904
Q3	609	Transistor, NPN 0.62 W	2N3904
Q4	636	Transistor, PNP 10 W	Motorola #MPS-U51
Q5	609	Transistor, NPN 0.62 W	2N3904
Q6	609	Transistor, NPN 0.62 W	2N3904
Q7	609	Transistor, NPN 0.62 W	2N3904
Q8	610	Transistor, PNP 0.62 W	2N3906
Q9	636	Transistor, PNP 10 W	Motorola #MPS-U51
R1	358	Res., 10 KΩ 5% 1/4 W carbon	
R2	358	Res., 10 KΩ 5% 1/4 W carbon	
R3	358	Res., 10 KΩ 5% 1/4 W carbon	
R4	309	Res., 1 KΩ 5% 1/4 W carbon	
R5	317	Res., 1.5 KΩ 5% 1/4 W carbon	
R6	206	Trimpot, 500 KΩ 0.4" sq.	Murata #3386P-1-504
R7	1423	Trimpot, 100 KΩ 0.4" sq.	Beckman #72PR100K
R8	332	Res., 3.3 KΩ 5% 1/4 W carbon	
R9	909	Res., 47 KΩ 5% 1/4 W carbon	
R10	317	Res., 1.5 KΩ 5% 1/4 W carbon	
R11	269	Res., 150 Ω 5% 1/2 W carbon	
R12	340	Res., 4.7 KΩ 5% 1/4 W carbon	
R13	259	Res., 100 Ω 5% 1/4 W carbon	
R14	358	Res., 10 KΩ 5% 1/4 W carbon	
R15	358	Res., 10 KΩ 5% 1/4 W carbon	
R16	332	Res., 3.3 KΩ 5% 1/4 W carbon	
R17	309	Res., 1 KΩ 5% 1/4 W carbon	
R18	399	Res., 68 KΩ 5% 1/4 W carbon	
R19	909	Res., 47 KΩ 5% 1/4 W carbon	
R20	332	Res., 3.3 KΩ 5% 1/4 W carbon	
R21	317	Res., 1.5 KΩ 5% 1/4 W carbon	
R22	340	Res., 4.7 KΩ 5% 1/4 W carbon	
R23	259	Res., 100 Ω 5% 1/4 W carbon	
R24	309	Res., 1 KΩ 5% 1/4 W carbon	
R25	309	Res., 1 KΩ 5% 1/4 W carbon	
R26	317	Res., 1.5 KΩ 5% 1/4 W carbon	

(2)	2702	Resistor, 0 Ω 1/4 W package	
(1)	591	OVERLOAD BOARD SR-703B	
C1	58	Cap., 0.1 µF 10%100 V poly.	
C2	84	Cap., 22 µF 16 V, Al. electro.	
C3	58	Cap., 0.1 µF 10%100 V poly.	
D1	104	Diode, 1 KV 1 Amp	Motorola #1N4007
D2	104	Diode, 1 KV 1 Amp	Motorola #1N4007
D3	104	Diode, 1 KV 1 Amp	Motorola #1N4007
D4	118	Diode, signal 75 V 10 mA	T. I. #914B
IC1	157	I. C., operational amplifier	Nat. Semi. #LM741CN
Q1	124	SCR, 400 V 0.8 A plastic	Teccor #EC103D
R1	293	Res., 470 Ω 5% 1/2 W carbon	
R2	269	Res., 150 Ω 5% 1/2 W carbon	
R3	341	Res., 4.7 KΩ 5% 1/2 W carbon	
R4	341	Res., 4.7 KΩ 5% 1/2 W carbon	
R5	341	Res., 4.7 KΩ 5% 1/2 W carbon	
R6	204	Trimpot, 1 KΩ, 0.4" square	Murata #3386P-1-102
R7	341	Res., 4.7 KΩ 5% 1/2 W carbon	
(1)	594	INVERTER DRIVER BOARD SR-704B	
C1	2263	Cap., 4.7 µF 25 V dip. tant.	
C2	54	Cap., 0.047 µF 10% 100V poly	Newark #44F6125
C3	2263	Cap., 4.7 µF 25 V dip. tant.	
C4	93	Cap., 100 µF 25 V Al. electro.	Newark #46F6956
C5	58	Cap., 0.1 µF 10% 100 V poly.	
C6	58	Cap., 0.1 µF 10% 100 V poly.	
C7	8	Cap., 51 pF ceramic 5X6	
C8	8	Cap., 51 pF ceramic 5X6	
D1	118	Diode, signal 75V 10 mA	T. I. #914B
D2	118	Diode, signal 75V 10 mA	T. I. #914B
D3	118	Diode, signal 75V 10 mA	T. I. #914B
D4	118	Diode, signal 75V 10 mA	T. I. #914B
IC1	142	I. C., dual 'D' flip-flop	Motorola # MC14013B
Q1	617	UJT, 0.3 W 50 mA Ic	2N4871
Q2	609	Transistor, NPN 0.62 W	2N3904
Q3	635	Transistor, NPN 10 W	Motorola #MPS-U01
Q4	635	Transistor, NPN 10 W	Motorola #MPS-U01
Q5	609	Transistor, NPN 0.62 W	2N3904
Q6	609	Transistor, NPN 0.62 W	2N3904

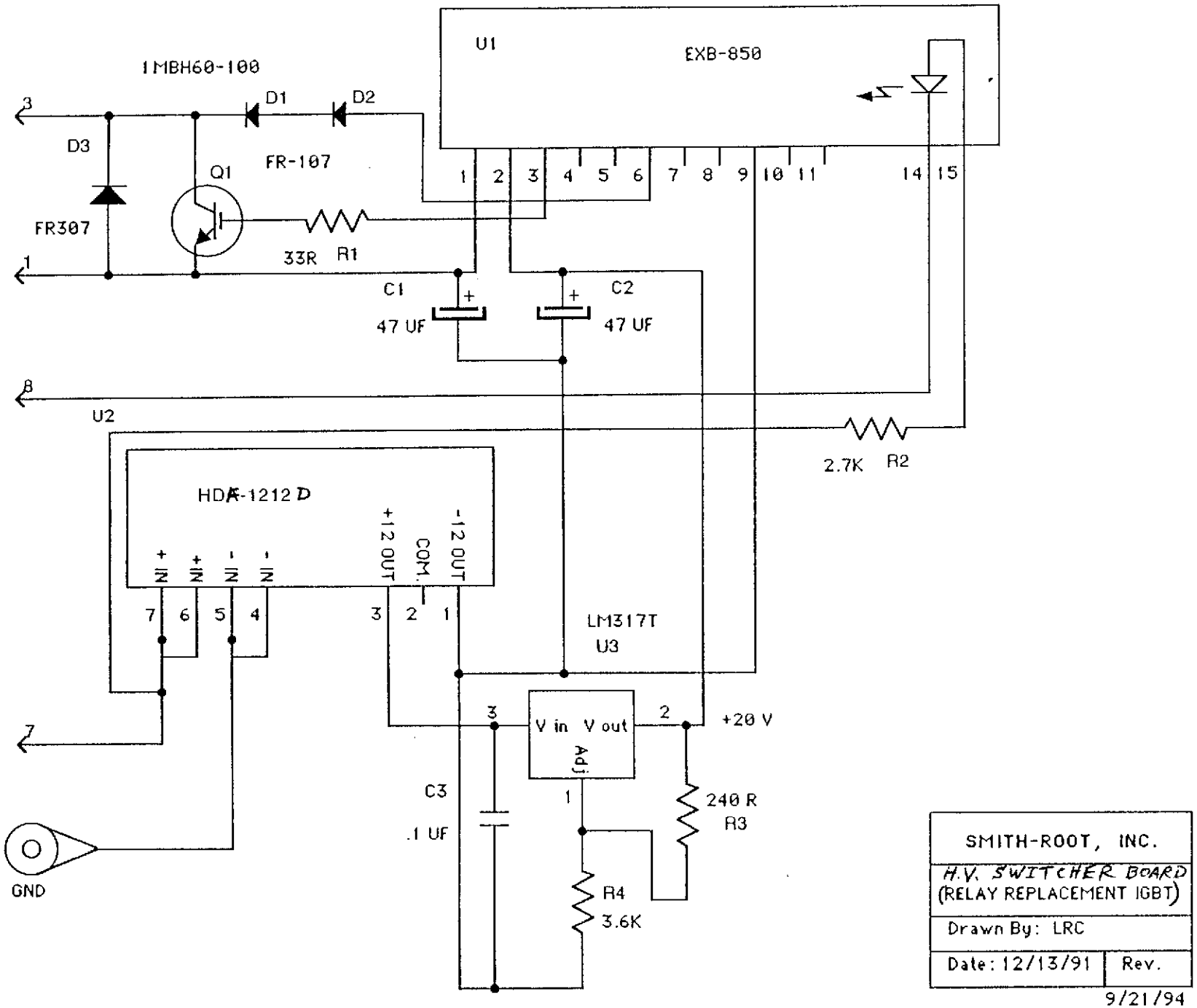
R1	368	Res., 16 KΩ 5% 1/4 W carbon	
R2	259	Res., 100 Ω 5% 1/4 W carbon	
R3	276	Res., 220 Ω 5% 1/4 W carbon	
R4	324	Res., 2.2 KΩ 5% 1/4 W carbon	
R5	259	Res., 100 Ω 5% 1/4 W carbon	
R6	259	Res., 100 Ω 5% 1/4 W carbon	
R7	260	Res., 100 Ω 5% 1/2 W carbon	
R8	260	Res., 100 Ω 5% 1/2 W carbon	
R9	276	Res., 220 Ω 5% 1/4 W carbon	
R10	358	Res., 10 KΩ 5% 1/4 W carbon	
R11	358	Res., 10 KΩ 5% 1/4 W carbon	
R12	358	Res., 10 KΩ 5% 1/4 W carbon	
R13	259	Res., 100 Ω 5% 1/4 W carbon	
R14	407	Res., 100 KΩ 5% 1/4 W carbon	
R15	407	Res., 100 KΩ 5% 1/4 W carbon	

(1)	2979	RELAY REPLACEMENT BOARD MRR-88	
C1	44	Cap., 2200 pF 10% 100 V poly	
C2	39	Cap., 0.001 µF 10% 100 V poly	
C3	77	Cap., 4.7 µF 35 V dip. tant.	
C4	1551	Cap., 47 µF 25 V dip. tant.	
C5	1407	Cap., 10 µF 35 V dip. tant.	
C6	1407	Cap., 10 µF 35 V dip. tant.	
C7	700	Cap., 4700 pF 10% 100 V poly	
IC1	1071	I. C., switching regulator	Motorola #TL494CN
IC2	1812	I. C., optoisolator 6 pin DIP	Motorola #MCT-2
D1	118	Diode, signal 75V 10 mA	T. I. #914B
D2	1484	Diode, fast recov. 1K V 1 A	Digikey #FR107-ND
D3	1484	Diode, fast recov. 1K V 1 A	Digikey #FR107-ND
D4	1484	Diode, fast recov. 1K V 1 A	Digikey #FR107-ND
D5	1484	Diode, fast recov. 1K V 1 A	Digikey #FR107-ND
D6	1484	Diode, fast recov. 1K V 1 A	Digikey #FR107-ND
D7	104	Diode, 1 KV 1 Amp	Motorola #1N4007
Q1	1745	Transistor, Darlington NPN	Motorola #TIP120
Q2	2617	Transistor, Darlington PNP	Motorola #TIP125
Q3	1730	Gate Turn-off SCR, 50 Amp	Hitachi #GFT50B12
R1	286	Res., 360 Ω 5% 1/4 W carbon	
R2	3267	Res., 22 KΩ 5% 1/8 W carbon	
R3	2128	Res., 47 KΩ 5% 1/8 W carbon	
R4	346	Res., 5.6 KΩ 5% 1/4 W carbon	
R5	2128	Res., 47 KΩ 5% 1/8 W carbon	

R6	2564	Res., 0.5 Ω 5% 2W wire wnd	Dale #CW-2B
R7	293	Res., 470 Ω 5% 1/2 W carbon	
R8	407	Res., 100 KΩ 5% 1/4 W carbon	
R9	358	Res., 10 KΩ 5% 1/4 W carbon	
R10	211	Res., 10 Ω 5% 1/2 W carbon	
(2)	2022	Pot core half, transformer T1	Ferroxcube #1811PL003B7
(1)	2804	Bobbin, transformer T1	
(1)	2957	Plug-in header, octal 1-3/8"	Keystone #681
(4)	2958	Bracket, universal .453 X .312	Keystone #616
(4)	520	Screw, pan hd Phil 6-32 X 3/8"	
(2)	178	Nut, hex 6-32 X 1/4"	
(1)	646	Lock washer, internal star #6	
(1)	170	Locking lug, #6 bent	H. H. Smith #1416-6
(4)	492	Screw, pan hd Phil 4-40 X 1/4"	
(4)	1204	Screw, pan hd Phil 4-40X5/16"	
(4)	641	Lock washer, internal star #4	
(4)	176	Nut, hex 4-40 X 1/4"	
(1)	507	Screw, pan hd Phil 4-40 X 3/4"	
(1)	1695	Standoff, insulating 6-32 X 1"	H. H. Smith #8697
(1)	1739	Locking lug, 1/4"	H. H. Smith #1468
(1)	645	Shoulder washer, nylon #6	H. H. Smith #2660
(1)	1256	Nut, ESNA 4-40 X 1/4"	

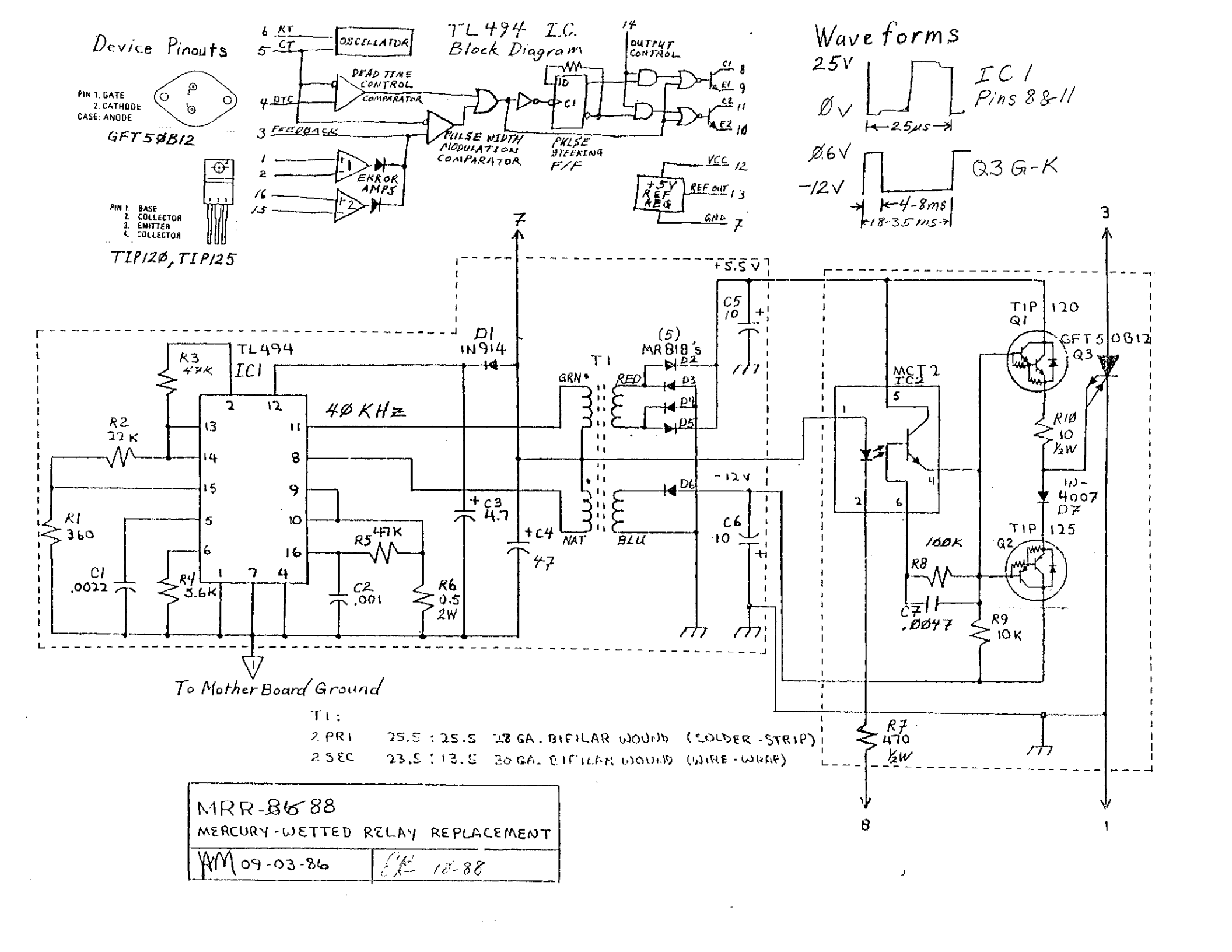
(1)	4075	HIGH VOLTAGE SWITCHER BOARD	
C1	1551	Cap., 47 µF 25 V dip. tant.	
C2	1551	Cap., 47 µF 25 V dip. tant.	
C3	58	Cap., 0.1 µF 10% 100 V poly.	
D1	1484	Diode, fast recov. 1K V 1 A	Digikey #FR107-ND
D2	1484	Diode, fast recov. 1K V 1 A	Digikey #FR107-ND
R1	235	Res., 33 Ω 5% 1/4 W carbon	
R2	328	Res., 2.7 KΩ 5% 1/4 W carbon	
R3	278	Res., 240 Ω 5% 1/4 W carbon	
R4	334	Res., 3.6 KΩ 5% 1/4 W carbon	
U1	4068	IC, IGBT Driver	Fuji Electric #EXB850
U2	4175	IC, DC to DC Converter	Shindengen #HDF-1212D
U3	1507	IC, Adj. Voltage Regulator	Nat. Semi. #LM317T
(1)	2702	Resistor, 0 Ω	
(1)	2957	Plug-in header, octal 1-3/8"	Keystone #681
(2)	2958	Bracket, universal .453 X .312	Keystone #616
(5)	492	Screw, pan hd Phil 4-40 X 1/4"	

(1)	1204	Screw, pan hd Phil 4-40X5/16"	
(2)	641	Lock washer, internal star #4	
(2)	176	Nut, hex 4-40 X 1/4"	
(1)	1739	Locking lug, 1/4"	H. H. Smith #1468
(1)	1040	Spacer, Al 4-40 X 1/2"	H. H. Smith #2332



SMITH-ROOT, INC.	
H.V. SWITCHER BOARD (RELAY REPLACEMENT IGBT)	
Drawn By: LRC	
Date: 12/13/91	Rev.

9/21/94


Device Pinouts
PIN 1. GATE
2. CATHODE
CASE: ANODE
GFT50B12
PIN 1. BASE
2. COLLECTOR
3. EMITTER
4. COLLECTOR
TIP120, TIP125
TL494 I.C. Block Diagram
OSCILLATOR
DEAD TIME CONTROL COMPARATOR
PULSE WIDTH MODULATION COMPARATOR
PULSE STEERING F/F
OUTPUT CONTROL
ERROR AMPS
+5V REF REG
Waveforms
25V
0V
25μs
IC 1 Pins 8 & 11
0.6V
-12V
4-8ms
18-35ms
Q3 G-K
TL494 IC1
D1 IN914
(5) MR818's
T1
MCT2 IC2
TIP 120 Q1
GFT50B12 Q3
TIP 125 Q2
IN-4007 D7
+5.5V
-12V
40KHz
R1 360
R2 22K
R3 47K
R4 5.6K
R5 47K
R6 0.5 2W
R7 470 ½W
R8 100K
R9 10K
R10 10 ½W
C1 .0022
C2 .001
C3 4.7
C4 47
C5 10
C6 10
C7 .0047
GRN
RED
NAT
BLU
To Mother Board Ground
T1:
2 PRI 25.5 : 25.5 28 GA. BIFILAR WOUND (SOLDER-STRIP)
2 SEC 23.5 : 13.5 30 GA. BIFILAR WOUND (WIRE-WRAP)
MRR-8688
MERCURY-WETTED RELAY REPLACEMENT
09-03-86
10-88