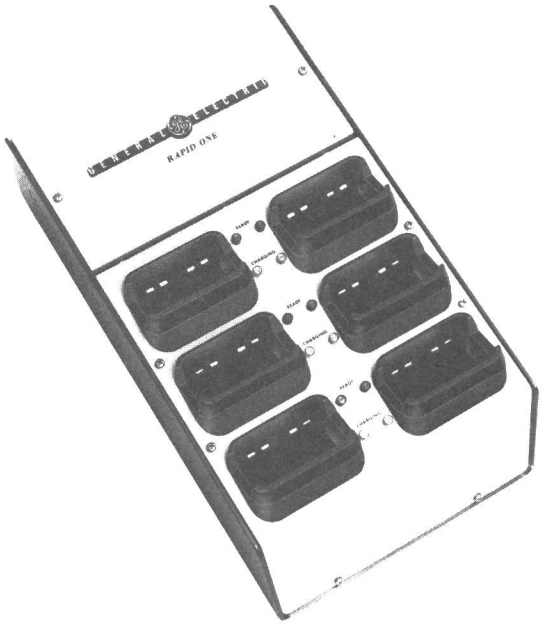
1010A

MOBILE RADIO

MPR Personal Series

RAPID ONE MULTI-CHARGER COMBINATIONS



1 HOUR MULTI-CHARGER COMBINATIONS

SPECIFICATIONS *

Dimensions (H x W x D)	5.66" x 9.16" x 16.4" (14.4 cm x 23.3 cm x 41.7 cm)
Weight	15 pounds (6.8 Kilograms)
Capacity	6 Charging Inserts
Indicators	Amber CHARGING Green READY
Charge Time (<100%)	≈1 hour (1200 mAh battery pack)
Charging Temperature Range	5°C to 45°C
Typical Charge Current High Rate Trickle Rate	 1200 Milliamps 85 Milliamps

*These specifications are intended primarily for the use of the serviceman. Refer to the appropriate Specification Sheet for the complete specifications.

TABLE OF CONTENTS

ILLUSTRATIONS

COMBINATION NOMENCLATURE

Digit 1	Digit 2	Digit 3	Digit 4	Digit 5	Digit 6	Digit 7	Digit 8
Product Line	Application	Package	Input Voltage	Charge Time	Version	Type	Frequency Range
3 Charger	**5** MPR (750 mAh & 1200 mAh Batt.)	**2** Wall	**L** 121 VAC (50/60 Hz)	**4** 1 Hour	**B** Multi Socket	**1**	**X** Not Frequency Sensitive
			M 240 VAC (50/60 Hz)		**C** Multi Socket With Discharger		

GENERAL ELECTRIC COMPANY • MOBILE COMMUNICATIONS DIVISION
WORLD HEADQUARTERS • LYNCHBURG, VIRGINIA 24502 U.S.A.

GENERAL ELECTRIC*
U.S.A.

DESCRIPTION

General Electric Rapid 1 Multi-Charger combinations will recharge both 750 mAh and 1200 mAh battery packs used with MPR Personal Series, FM, two-way radios. A fully discharged 1200 mAh battery pack will recharge in 1 hour at a 1200 milliamp charge rate. The 750 mAh battery will also charge at 1200 milliamp charge rate, but will fully recharge in less than one hour.

When a battery pack is inserted into any one of six charging inserts, of the multi-charger, an amber LED indicator labeled "CHARGING", will light, indicating contact has been made and the battery pack is ready to be charged. When the battery pack is fully charged, a green LED indicator labeled "READY", will light and the charging circuit will automatically switch to a safe trickle charge rate.

The multi-charger uses heat sensors to constantly monitor ambient temperature, temperature of cells in the battery pack and temperature of the power transformer. When a battery pack is inserted into a charging insert, and contact is made, the amber LED lights and the trickle charge begins. The charging circuit looks at the ambient temperature, transformer temperature and battery temperature. If the battery is cold, the charger will wait until the battery pack warms up, then automatically apply the high charge rate on a variable duty cycle.

The variable duty cycle reduces the "gassing" risk which occurs when cold cells are charged. The duty cycle varies from 0% charge rate at 0°C to 100% charge rate at 20°C battery pack temperature.

If the battery pack is hot, the charger checks its memory to see if it had ever charged that battery pack. Since the memory had been reset, the charger waits until the battery pack cools down below the trip temperature then automatically begins the high charge rate. The memory is reset by removing the battery pack from the charging insert or a loss of AC power for more than 0.5 seconds. During the high charge rate, when the battery pack overcharges enough to heat the cells to 10°C greater than ambient, the charger chuts off the high charge rate and lights the green LED READY indicator. The memory is also set so the charger will not recharge the battery pack again until the memory has been reset.

If the ambient temperature is outside the rated range (5°C to 45°C) all charging stops until a safe temperature exist.

If the temperature of a battery pack inserted into a charging insert is not within safe limits, the green READY indicator will blink until a safe temperature exist. The battery pack will then be treated normally.

A microprocessor controller continuously monitors the transformer temperature and prevents the transformer from overheating by sharing the available current between the battery packs currently being charged.

A multi-charger equipped with a Battery Tester/Discharger option allows a fully charged battery pack to be discharged to 6.0 Volts at a switch selectable rate of 750 milliamps or 1200 milliamps. While being discharged a display module will indicate DC (discharge). On completion of discharge the display indicates percentage of charge from 0 to 99%.

For chargers operating on an AC line frequency of 60 Hz only, minutes rather than percent may be selected as the display unit.

Internal jumpers are present on the circuit board to allow use of the charger at 50 Hz power line frequency.

The display will also indicate CO, if the ambient temperature is cold or "EA" for excessive ambient when the charger refuses to operate in an unsafe environment.

A multi-charger combination consists of a metal cabinet with six charging inserts and a power supply. The base of the cabinet has rubber feet so it can be used as a desk, top charger and key hole slots are provided for wall mounting.

OPERATION

Temperature characteristics of nickel-cadmium batteries, prevent a full charge at temperature extremes. For a maximum charge, recharge the battery pack at room temperatures of 65° to 85° Fahrenheit whenever possible.

WARNING

In this Maintenance Manual, General Electric Chargers are designed for charging GE 750 mAh battery pack 19D429763G1 and 1200 mAh battery pack 19D429777G1 only. Charging any other battery pack or batteries may result in damage to equipment, leakage or explosion.

To use the multi-charger, plug the power cable into the applicable AC, 50/60 Hz source (See Figure 1). Place the radio to be recharged into a charging insert with the speaker facing away from the power supply or place the battery pack into the insert with the arrow on the yellow label pointing toward the power supply. The amber LED indicator labeled "CHARGING" will light, indicating the battery is being charged. To charge the battery to maximum capacity, let the battery pack charge for at least one hour or until the "READY" indicator is on.

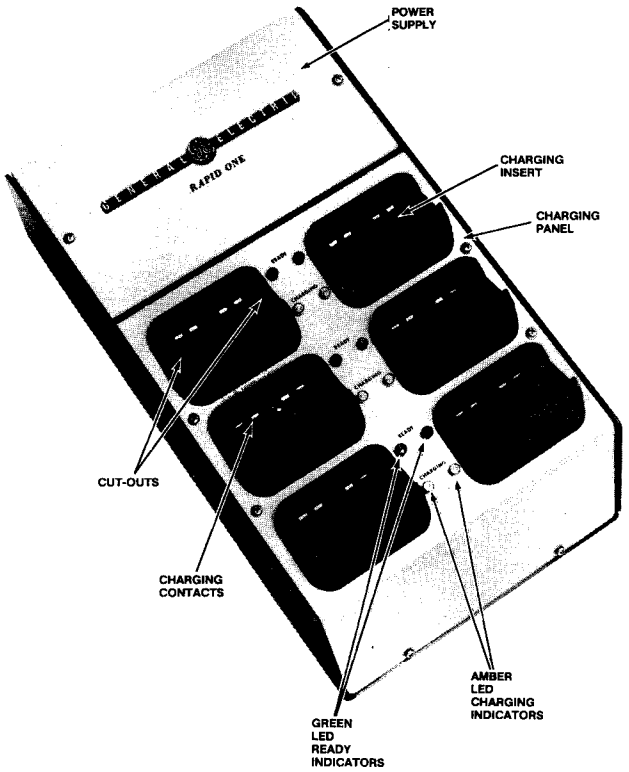


Figure 1 - Multi-Charger

A battery pack is removed from the charger by simply reaching into the cut outs provided in the sides of the charging insert, and lifting the battery pack out.

The radio is not useful while being charged in the charger and it is recommended that the unit be turned off prior to charge.

Battery Discharge Option

To use the battery discharge option, place the DISCHARGE RATE switch, S1, in the correct position corresponding the capacity of the battery pack to be discharged. Connect the charged battery pack to battery pack connector J1. The digital display will read "DC" indicating the discharge has begun. When the discharge is complete, the actual battery pack capacity will be displayed by the digital display as a percentage (0-99%) of the time required to discharge a fully charged battery pack to six Volts.

If the AC line frequency is 60 Hz, internal strapping will permit minutes rather than a percentage to be displayed by the digital display. This time display is the time required to discharge a charged battery pack to six Volts.

SYSTEM ANALYSIS

The hardware of the one hour multi-charger controls charging current for six battery packs and one LED READY indicator, associated with each battery pack. If equipped with a battery discharge option, a seventh battery pack may be discharged to a fixed voltage while the time required for the discharge is recorded and displayed, either as percentage of the time or as actual minutes required to discharge the battery pack from full charge to 6 Volts. Control for the multi-charger hardware is provided by microprocessor U2.

Microprocessor U2 determines the correct and safe charging cycle by multiplexing voltage and temperature data from each battery pack to a single comparator circuit, AR3.

Comparator circuit AR3 checks the battery pack voltage against a reference voltage, generated by digital to analog converter U5. U5 is also controlled by the microprocessor. The results on the output of Comparator AR3 are returned to a single input (PB7), of the I/O portion of U1, for analysis. The input to PB7 is either a logical "1" or a logical "0".

All communication with charger hardware, by the microprocessor is carried out through the 16-bit, I/O port of U1 and the interrupt line ($\overline{IRQ}$) of microprocessor U2.

Initially, when the AC power cord is plugged into an electrical outlet, capacitor C2 charges up and resets or clears all circuit devices. Microprocessor U2 then, on the first clock pulse, addresses the memory portion of device U1 for the first instruction. All instructions are programmed in U1. Refer to Figure 2.

The clock pulse is generated between U2 and NOT circuits U3A and U3B.

When the R/W control line is a logical "1" instructions are "read" from memory into the microprocessor through an eight conductor Data Bus. The microprocessor in turn "writes" output instructions back through the Data Bus through the I/O ports of U1 to an eight conductor Output Bus. The R/W control line is a logical "0" during the "write" mode.

The output bus is connected to the inputs of octal dual flip-flops U6 and the digital inputs of da converter U5. Octal dual flip-flop U6 outputs instructions through two, four conductor address lines to the inputs of eight-bit address latch circuits U7 and U8, Level shifter circuits U9 and optional display units DS1 and DS2.

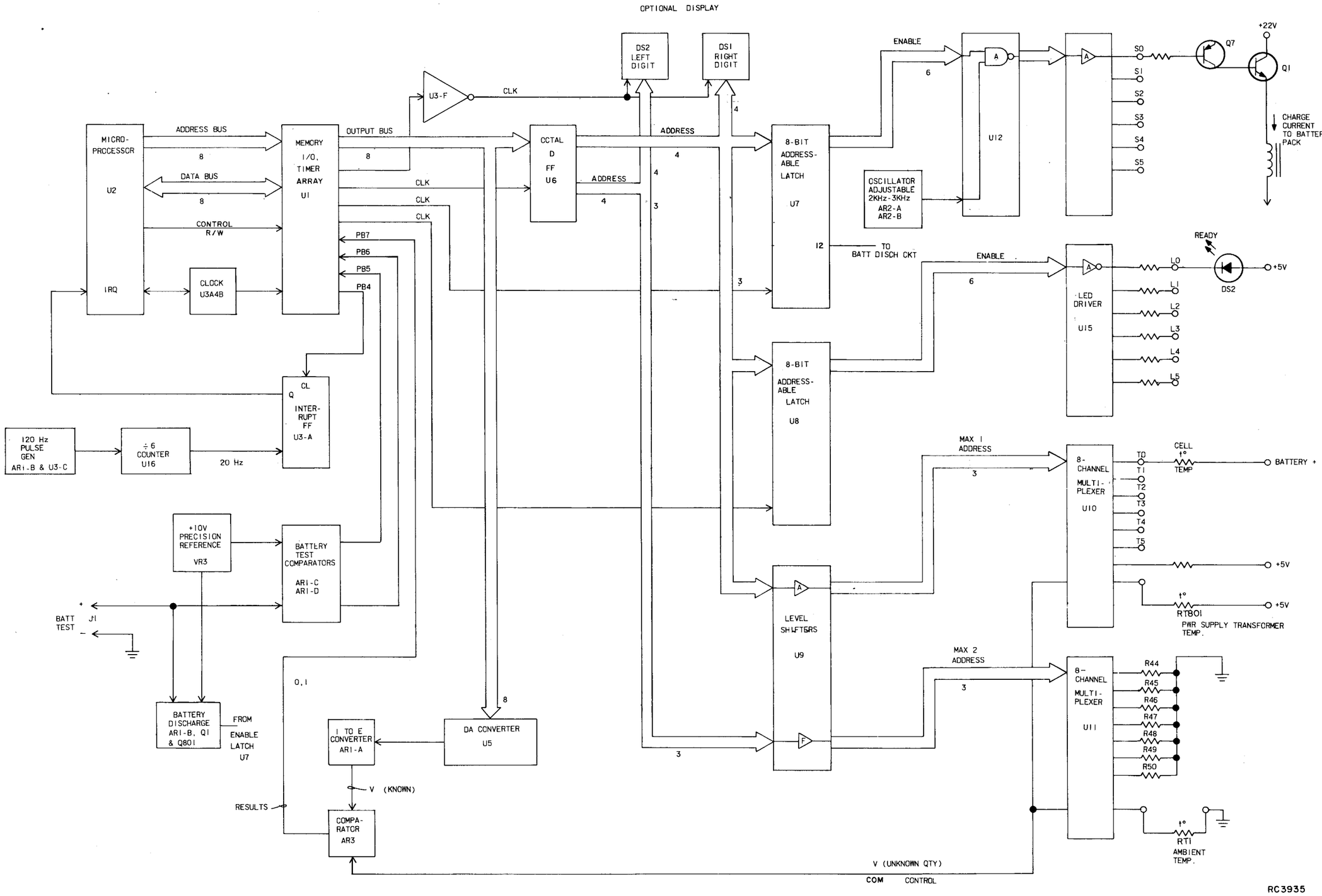


Figure 2 - Block Diagram

DA converter U5 converts the digital output data of U1 to an analog current. The current from U5 is further converted by I to E converter circuit AR1-A to a voltage. This voltage is connected to an input of comparator circuit AR3 and compared to the output of multi-plexer circuits U10 and U11.

The first series of tests, the microprocessor makes, is to check the ambient temperature. The output from level shifter circuits U9 to the inputs of 8-channel multiplexer circuit U11, connects ambient temperature thermistor RT1 into the circuit. The first ambient temperature test is for excessive ambient. If the ambient temperature is excessive (above 45°C), the resistance of RT1 is low enough to pull the COM control line low. This low voltage or an input of comparator AR3 is comparated to a reference voltage generated by DA converter U5. The reference voltage is the analog equalivent of the digital input from the microprocessor to the da converter, and represents the maximum ambient temperature at which the charger will charge. If the temperature is excessive the microprocess will not allow any charging circuits to charge. A multiple charger equipped with the battery discharge option, will write on the display unit "EA", for excessive ambient. "EA" will continue to be displayed until a safe charging condition exist. When a safe condition is present the microprocessor continues its test.

The second ambient temperature test is for a cold ambient. If the ambient temperature is too cold for a safe charge (below 5°C), RT1 is a high resistance. The high value of RT1 causes the COM control line to be high. The high voltage on the COM control line is compared to a reference voltage equivalent to the digital input from the microprocessor to the DA converter. The reference voltage this time, represents the minimum safe temperature at which the charger will charge. If the ambient temperature is too cold for safely charging a battery pack, the microprocessor will not allow any charging circuits to charge. A multiple-charger equipped with the battery discharge option will write on the display unit "CO", for cold. "CO" will continue to be displayed until a safe charging condition exist. When, as before, a safe charging condition is present, the microprocessor continues its test.

If an excessive ambient condition or a cold ambient condition does not exist, the microprocessor will then check the temperature of power transformer T801. Inputs to 8-channel multiplexer U10 connects power supply thermister RT801 into the circuit. The resulting voltage on the COM control line is compared to the reference voltage programmed into the da converter by the microprocessor. The first reference voltage corresponds to 60°C. If the temperature of the transformer is less than 60°C, the charger charges as it would normally. If the temperature is higher than 60°C, the microprocessor programs into the DA converter a reference voltage corresponding to 70°C. If the temperature of the transformer is less than 70°C, the microprocessor limits the charger to a 50% duty cycle. If the temperature is higher than 70°C the duty cycle is limited to 25%.

Before initiating the charge, the microprocessor executes a temperature and absolute voltage check on each battery pack to be charged. The temperature check is accomplished by connecting the thermistor of each battery pack, one at a time, into the circuit. Voltage on the COM control line is to be compared to a reference voltage generated by the microprocessor and DA converter. The first temperature check is for excessive cell temperature. If the cell temperature is higher than 10°C above ambient, the charger will not charge that particular battery pack. The microprocessor will initiate a signal to 8-bit addressable latch U8 to cause the green "READY" indicator to blink until the hot battery pack cools down. If the cell temperature is below 5°C, the charger will not charge that particular battery pack until it has warmed up. The green "READY" indicator will blink the same as with a hot battery pack.

The absolute voltage measurement is accomplished by addressing U11 to connect a high value resistor, 10 meg ohms, into the circuit to form a voltage divider with the battery pack thermistor. This is to measure the open circuit battery voltage. The unknown battery voltage on the COM control line is compared by successive approximation to a known voltage from the microprocessor and da converter. If the unknown voltage is less than the known voltage the seventh bit input, PB7 of the microprocessor, receives a negative sign (0). If the unknown voltage is larger than the known voltage, the seventh bit receives a positive sign (1). Equality is not valid.

After the absolute battery voltage has been established the microprocessor addresses 8-bit addressable latch U7 to open the gate in U12 and start the charge current flowing to the battery pack. The charge current frequency is controlled by oscillator AR2-A & B. This frequency is adjustable from approximately 2000 Hz to 3000 Hz. As the battery pack is charging the voltage and cell temperature checks continue. When a battery pack voltage reaches 9.3 volts or the cell temperature reaches 10°C above ambient, 8-bit addressable latch U8 is addressed to light the green LED READY indicator corresponding to the battery pack being charged. U7 is addressed to stop the high rate of charge. The battery pack then goes to trickle charge.

Timer Board A101 is mounted on the back of the charger board (A801).

When the output sequence of A801-U7 is correct, the output at U2-3 on A101 is low. This keeps A101-Q1 turned off. If the output of U7 should stop, U1-3 goes high and turns on Q1. Turning on Q1 resets microprocessor A801-U1.

Optional Battery Discharger

The optional battery discharger circuit is a controlled current sink for a 750 mAh or 1200 mAh, MPR battery pack. Its function is to discharge a fully charged battery pack to 6 volts and display the percentage of an hour required.

As an alternative to displaying the percentage of time, the battery discharge can be modified to display the actual time. Time display is available in 60 Hz units only.

The fully charged battery pack is connected to battery discharge connector J1. When the microprocessor has completed all other checks on battery packs being charged, it then checks to see if a battery pack is present at J1. If a battery pack is present and the output of comparator AR1-D is high, the battery pack voltage is larger than 6 volts and has not been discharged. The discharge will not start if the battery pack voltage is less than 6 volts. If a battery pack is not present at J1, the output of comparator AR1-C will be high indicating the voltage at J1 less than 3 volts or missing. The microprocessor will then continue its normal routine.

With the fully charged battery pack present at J1, and the 5th bit (PB5) high, the microprocessor addresses U7 to initiate the discharger circuit. The display unit displays DC. Current sink transistors Q1 and Q801 conducts at a controlled rate determined by S1 and AR1-A (750/1200 mA). As the battery pack is discharging the battery voltage is compared by comparator AR1-C to a ten volt reference generated by voltage regulator UR3. The reference voltage is dropped to 6 volts on the negative input terminal of AR1-C. When the battery pack voltage drops to 6 volts the output of AR1-C goes low. The low on the 6th bit (PB6), of the microprocessor stops the discharge. The microprocessor then displays on the display unit the percentage of time or time required for the discharge.

The 120 Hz pulse generator AR1-B, inverter U3-C, Counter U16, and interrupt flip-flop U4-A, provide from the power line frequency, the time base for recording the duration of the battery discharge test. The interrupt service routine clears the interrupt flip-flop at the end of execution.

Power Supply

The power supply for the MPR one hour multi-charger can be powered from a 121 VAC (50/60 Hz) source or a 250 VAC (50/60 Hz) source. The component difference between the AC power requirements is the power transformer. For 121 VAC domestic requirements, the power supply uses transformer T801. For 240 VAC domestic requirements and 105 VAC through 240 VAC international requirements the power supply uses transformer T802.

Both transformers T801 and T802 are step down transformers from the primary voltage to 10 volts ±0.5 volts at 4 amps.

The secondary of the power transformer is connected across a diode bridge rectifier circuit consisting of CR801,CR802, CR1 and CR2. The transformer secondary is also connected across a half-wave rectifier circuit consisting of diodes CR3 and CR4.

The output of diodes CR801 and CR802 at H11 is connected to the inputs of voltage regulator circuits VR801 and VR802. VR801 provides a regulated +12 VDC at H4 of circuit board A801. VR802 provides a regulated +5 VDC at H5 of circuit board A801.

The output of diodes CR3 and CR4 provide a +16 to a +22 VAC at H3 of A801. This AC voltage source provides the timing for the 120 Hz pulse generator as well as being the charging voltage.

The output of diodes CR1 and CR2 at H24 is connected to the input of voltage regulator circuit VR803. VR803 provides a -12 VDC at H7 of A801. The -12 VDC is used to power DA converter U5.

INSTALLATION (ON WALL)

Multi-chargers should be mounted on a wall close to the applicable AC (50/60 Hz) source. Care should be taken when mounting to insure proper top and bottom ventilation. A minimum air space of two inches is required between the bottom of a multi-charger and other surfaces.

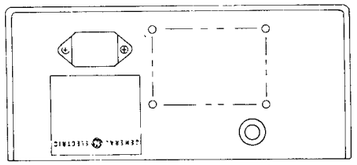
MAINTENANCE

Access

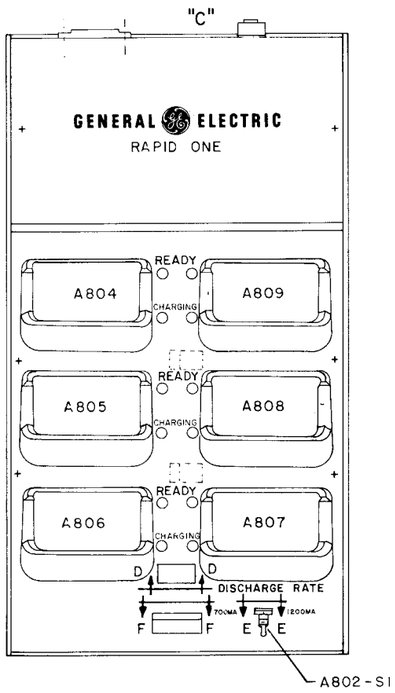
To gain access to the circuitry of the charger combination, first remove the AC power to the charger, then remove the ten screws holding the panel in the base. Lift the panel from the base. The charger panel must be removed to replace any LED indicators. To replace a fuse it is necessary only to remove the fuse from the fuse holder on power supply.

Troubleshooting

Should a difficult service problem arise, a Troubleshooting Procedure is provided to assist the service technician (see Table of Contents). Also, voltages are provided on the Schematic Diagram to further assist the service technician to isolate any problem.



VIEW IN DIRECTION
OF ARROW "C"



VIEW IN DIRECTION
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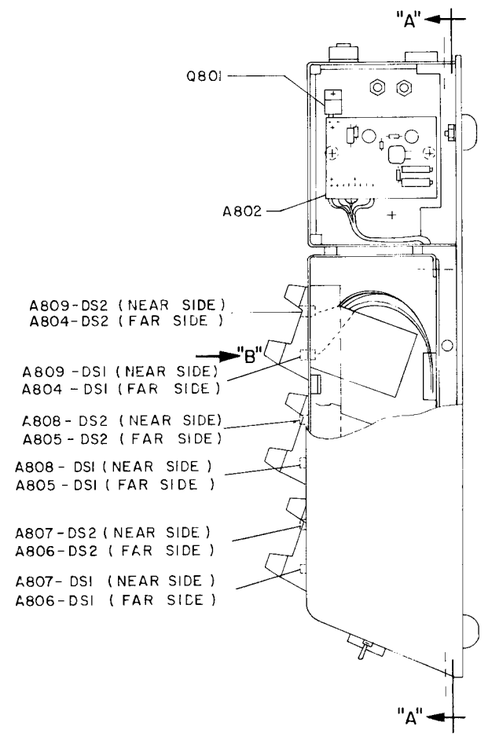
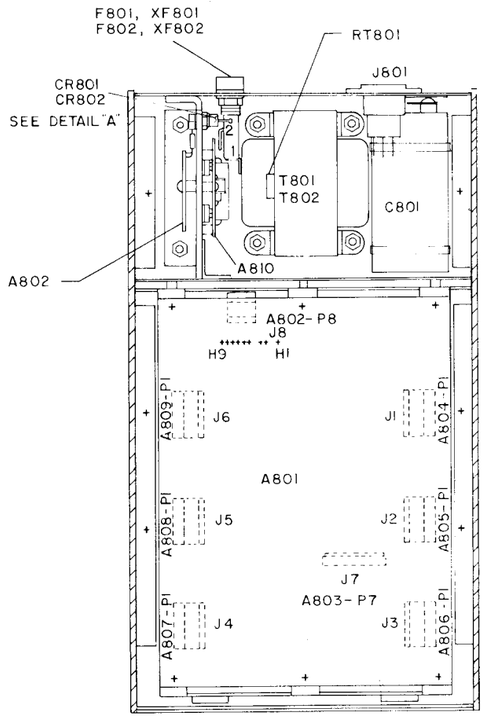
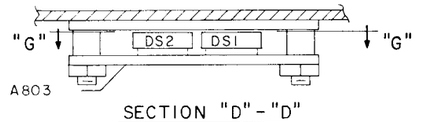


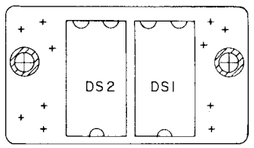
A804 - A809



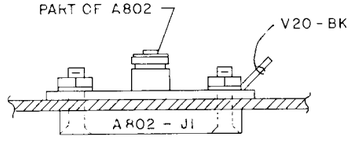
SECTION "A" - "A"



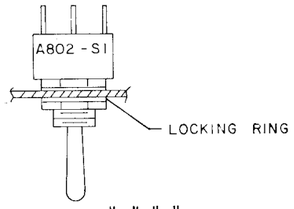
SECTION "D" - "D"



SECTION "G"-"G"
ORIENTATION IMPORTANT



SECTION "F"-"F"



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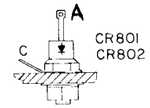
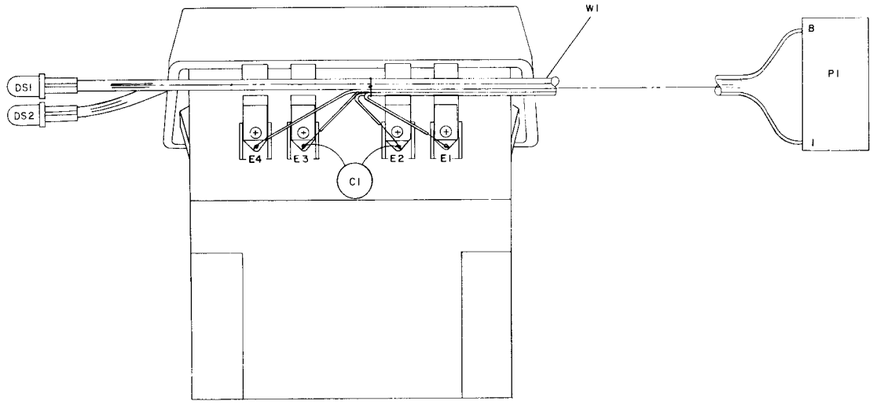


DETAIL "A"

(19D430976, Rev. 0)

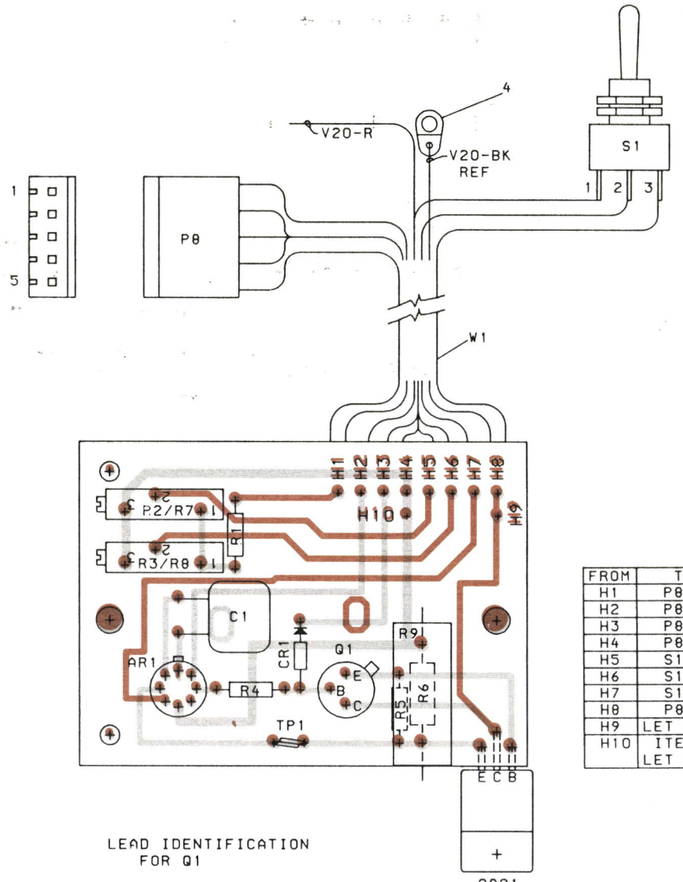


(19C330612, Rev. 0)

OUTLINE DIAGRAM

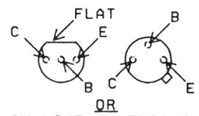
RAPID 1 MULTI-CHARGER
(Sheet 1)

A802
BATTERY DISCHARGE BOARD



FROM	TO	WIRE
H1	P8-1	SF24-W
H2	P8-5	SF24-BL
H3	P8-3	SF24-O
H4	P8-2	SF24-BK
H5	S1-3	SF24-Y
H6	S1-1	SF24-G
H7	S1-2	SF24-V
H8	P8-4	SF24-R
H9	LET HANG	V20-R
H10	ITEM 4 LET HANG	V20-BK

LEAD IDENTIFICATION FOR Q1



OR

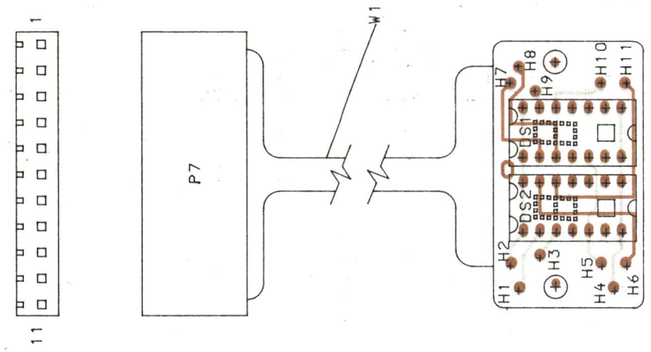
IN-LINE TRIANGULAR

TOP VIEW

NOTE: LEAD ARRANGEMENT, AND NOT CASE SHAPE, IS DETERMINING FACTOR FOR LEAD IDENTIFICATION.

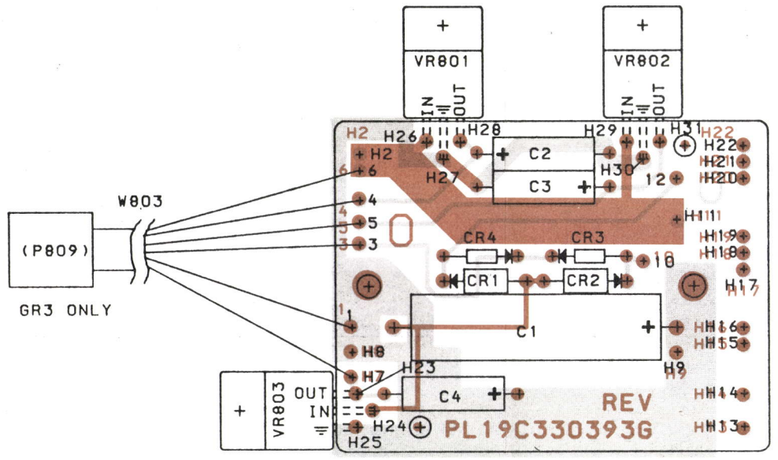
(19C330182, Rev. 2)
(19A138479, Sh. 1, Rev. 0)
(19A138479, Sh. 2, Rev. 0)

A803
DISPLAY BOARD

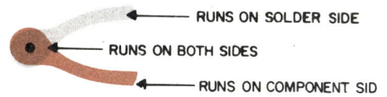


(19B233318, Rev. 0)
(19A142579, Sh. 1, Rev. 0)
(19A142579, Sh. 2, Rev. 0)

A810
POWER SUPPLY



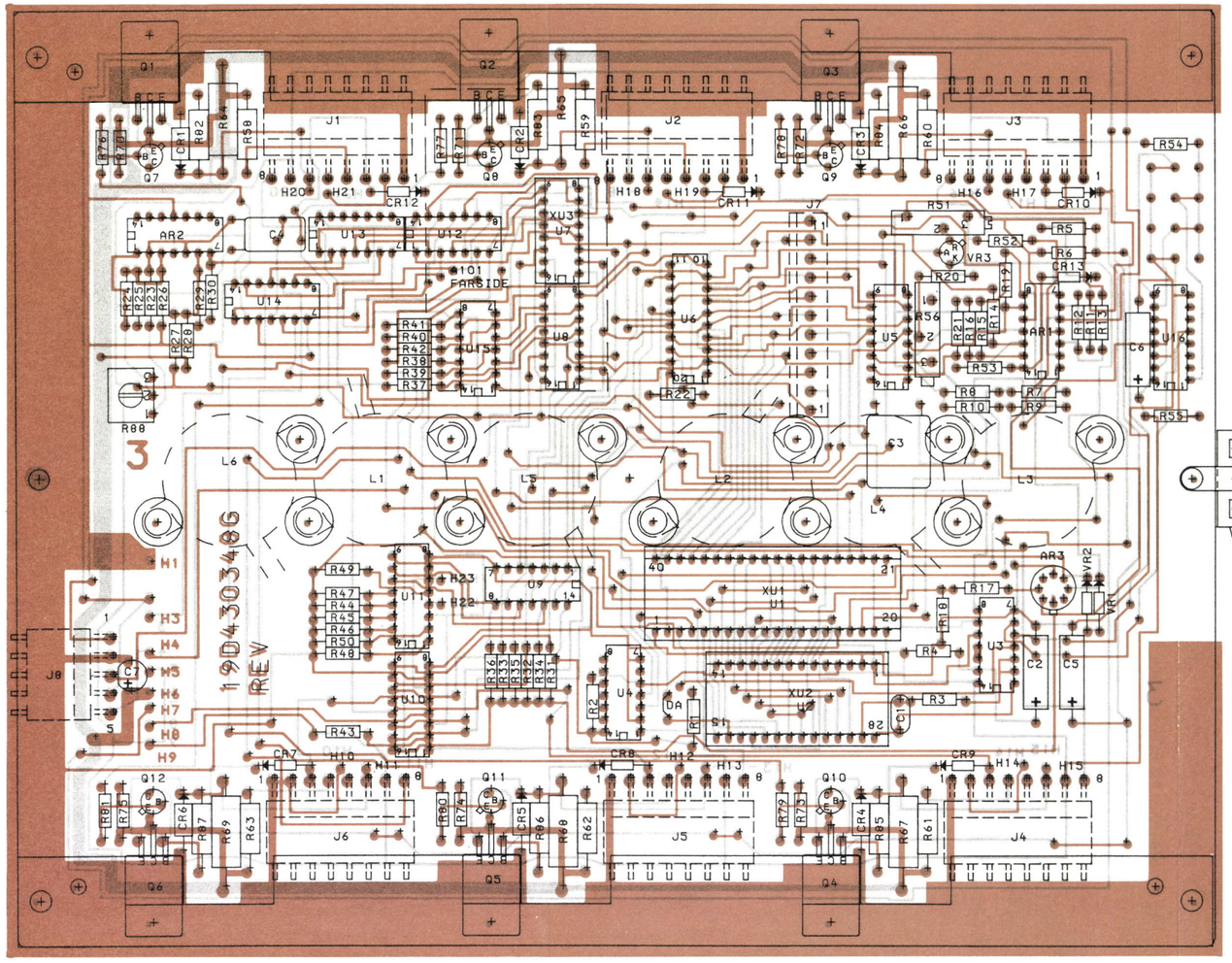
(19C330395, Rev. 1)
(19A142786, Sh. 1, Rev. 0)
(19A142786, Sh. 2, Rev. 0)



OUTLINE DIAGRAM

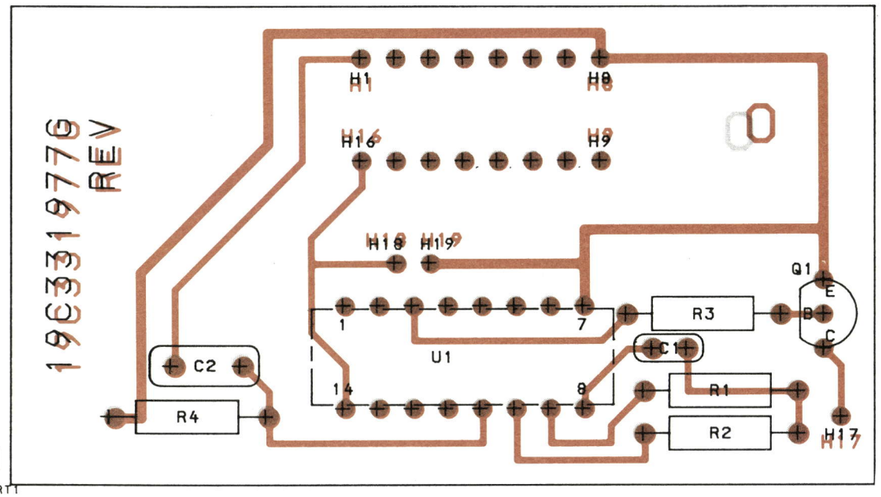
RAPID 1 MULTI-CHARGER
(Sheet 2)

A801
CHARGER BOARD

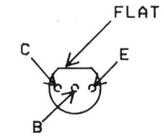


(19D430349, Rev. 5)
(19A138447, Sh. 1, Rev. 3)
(19A138447, Sh. 2, Rev. 3)

A101
TIMER BOARD



LEAD IDENTIFICATION
FOR Q1



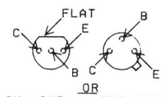
IN-LINE
TOP VIEW

NOTE: LEAD ARRANGEMENT, AND NOT CASE SHAPE, IS DETERMINING FACTOR FOR LEAD IDENTIFICATION.

(19C331978, Rev. 0)
(19A144966, Sh. 1, Rev. 0)
(19A144966, Sh. 2, Rev. 0)

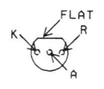
CONNECTION CHART			
FROM		TO	
L1	Y	H21	
	BK	H20	
L2	Y	H19	
	BK	H18	
L3	Y	H17	
	BK	H16	
L4	Y	H15	
	BK	H14	
L5	Y	H13	
	BK	H12	
L6	Y	H11	
	BK	H10	
TB1	1◆◆	H22	◆◆SF24-W
	2◆	H23	◆SF24-BK

LEAD IDENTIFICATION
FOR Q7-Q12



IN-LINE TRIANGULAR
OR
TOP VIEW

LEAD IDENTIFICATION
FOR VR3

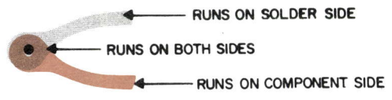


IN-LINE
TOP VIEW

NOTE: LEAD ARRANGEMENT, AND NOT CASE SHAPE, IS DETERMINING FACTOR FOR LEAD IDENTIFICATION.

OUTLINE DIAGRAM

RAPID 1 MULTI-CHARGER
(Sheet 3)

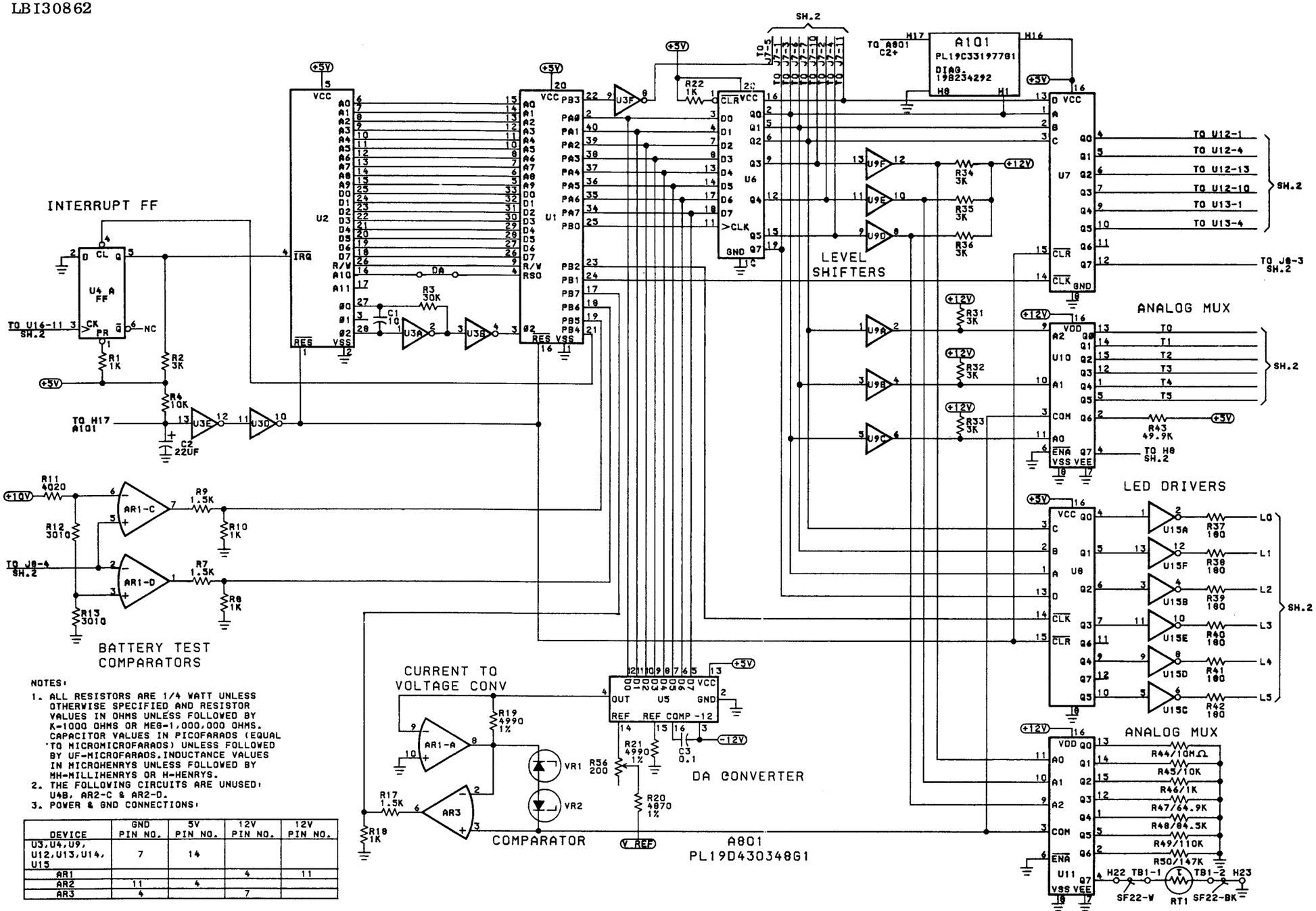


PARTS LIST

MPR 1-HOUR MULTI-CHARGER
19D430514G1 120 V DISCHARGE OPTION
19D430514G2 120 V
19D430514G3 240 V DISCHARGE OPTION
19D430514G4 240 V
ISSUE 4

SYMBOL	GE PART NO.	DESCRIPTION
A801		CHARGER BOARD 19D430348G1 REV E
A101		TIMER BOARD 19C331977G1
		- - - - - - - - - - CAPACITORS - - - - - - - - - -
C1	19A116192P1	Ceramic: 0.01 uF ±20%, 50 VDCW; sim to Erie 8121 Special.
C2	T644ACP210K	Polyester: .0010 uF ±10%, 50 VDCW.
		- - - - - - - - - - TRANSISTORS - - - - - - - - - -
Q1	19A700023P1	Silicon, NPN; sim to Type 2N3904.
		- - - - - - - - - - RESISTORS - - - - - - - - - -
R1	H212CRP310C	Deposited carbon: 10K ohms ±5%, 1/4 w.
R2 and R3	H212CRP347C	Deposited carbon: 47K ohms ±5%, 1/4 w.
R4	H212CRP410C	Deposited carbon: 0.1M ohms ±5%, 1/4 w.
		- - - - - - - - INTEGRATED CIRCUITS - - - - - - - -
U1	19A700029P49	CMOS. 14-STAGE COUNTER/DIVIDER & OSCILLATOR.
		- - - - - - - - INTEGRATED CIRCUITS - - - - - - - -
AR1 and AR2	19A134511P1	Linear: QUAD OP AMP; sim to LM224J.
AR3	19A134379P1	Linear: sim to RCA CA3130T.
		- - - - - - - - - - CAPACITORS - - - - - - - - - -
C1	19A116656P10J8	Ceramic disc: 10 pF ±5%, 500 VDCW; temp coef -80 PPM.
C2	5496267P10	Tantalum: 22 uF ±20%, 15 VDCW; sim to Sprague Type 150D.
C3	19A116080P107	Polyester: 0.1 uF ±10%, 50 VDCW.
C4	19A700005P6	Polyester: 6800 pF ±10%, 50 VDCW.
C5	5496267P10	Tantalum: 22 uF ±20%, 15 VDCW; sim to Sprague Type 150D.
C6	5496267P14	Tantalum: 15 uF ±20%, 20 VDCW; sim to Sprague Type 150D.
C7	315A6047P685U	Tantalum: 6.8 uF ±20%, 35 VDCW.
		- - - - - - - - DIODES AND RECTIFIERS - - - - - - - -
CR1 thru CR6	19A115845P1	Silicon, rectifier: sim to 1H4004
CR7 thru CR13	19A115250P1	Silicon, fast recovery, 225 mA, 50 PIV.
		- - - - - - - - JACKS AND RECEPTACLES - - - - - - - -
J1 thru J6	19A116659P183	Connector, printed wiring: 8 contacts; sim to Molex 09-75-1086.
J7	19A116659P110	Connector, printed wiring: 11 contacts; sim to Molex 09-60-1111.
J8	19A116659P177	Printed wire: 5 contacts rated @ 5 amps; sim to Molex 09-75-1051.
		- - - - - - - - - - INDUCTORS - - - - - - - - - -
L1 thru L6	19B233305G1	Coil.
		- - - - - - - - - - TRANSISTORS - - - - - - - - - -
Q1 thru Q6	19A116742P1	Silicon, NPN.
Q7 thru Q12	19A134960P1	Silicon, PNP; sim to Type 2N4403.
		- - - - - - - - - - RESISTORS - - - - - - - - - -
R1	19A700106P63	Composition: 1K ohms ±5%, 1/4 w.
R2	3R152P302J	Composition: 3K ohms ±5%, 1/4 w.
R3	3R152P303J	Composition: 30K ohms ±5%, 1/4 w.
R4	19A700106P87	Composition: 10K ohms ±5%, 1/4 w.
R5	3R152P202J	Composition: 2K ohms ±5%, 1/4 w.
R6	19A700106P63	Composition: 1K ohms ±5%, 1/4 w.
R7	19A700106P67	Composition: 1.5K ohms ±5%, 1/4 w.
R8	19A700106P63	Composition: 1K ohms ±5%, 1/4 w.
R9	19A700106P67	Composition: 1.5K ohms ±5%, 1/4 w.
R10	19A700106P63	Composition: 1K ohms ±5%, 1/4 w.
R11	19A701250P259	Metal film: 4.02K ohms ±1%, 1/4 w.
R12 and R13	19A701250P247	Metal film: 3.01K ohms ±1%, 1/4 w.
R14	19A700106P63	Composition: 1K ohms ±5%, 1/4 w.
R15 and R16	3R152P302J	Composition: 3K ohms ±5%, 1/4 w.
R17	19A700106P67	Composition: 1.5K ohms ±5%, 1/4 w.
R18	19A700106P63	Composition: 1K ohms ±5%, 1/4 w.
R19	19A701250P268	Metal film: 4.99K ohms ±1%, 1/4 w.
R20	19A701250P267	Metal film: 4.87K ohms ±1%, 1/4 w.
R21	19A701250P268	Metal film: 4.99K ohms ±1%, 1/4 w.
R22	19A700106P63	Composition: 1K ohms ±5%, 1/4 w.
R23	19A700106P81	Composition: 5.6K ohms ±5%, 1/4 w.
R24	H212CRP310C	Deposited carbon: 10K ohms ±5%, 1/4 w.
R25 and R26	H212CRP410C	Deposited carbon: 0.1M ohms ±5%, 1/4 w.
R27	19A701250P368	Metal film: 49.9K ohms ±1%, 1/4 w.
R28	19A701250P317	Metal film: 14.7K ohms ±1%, 250 VDCW, 1/4 w.
R29	19A701250P226	Metal film: 1.82K ohms ±1%, 1/4 w.
R30	19A700106P47	Composition: 220 ohms ±5%, 1/4 w.
R31 thru R36	3R152P302J	Composition: 3K ohms ±5%, 1/4 w.
R37 thru R42	191700106P45	Composition: 180 ohms ±5%, 1/4 w.
R43	19A701250P368	Metal film: 49.9K ohms ±1%, 1/4 w.
R44	3R152P106J	Composition: 10.0 megohms ±5%, 1/2 w.
R45	19A701250P301	Metal film: 10K ohms ±1%, 1/4 w.
R46	19A700106P63	Composition: 1K ohms ±5%, 1/4 w.
R47	19A701250P379	Metal film: 64.9K ohms ±1%, 1/4 w.
R48	19A701250P390	Metal film: 84.5K ohms ±1%, 1/4 w.
R49	19A701250P405	Metal film: 110K ohms ±1%, 1/4 w.
R50	19A701250P417	Metal film: 147K ohms ±1%, 1/4 w.
R51	19A700043P8	Variable, ceremet: 10K ohms ±10%, 200 VDCW, 3/4 watt.
R52	19A700106P51	Composition: 330 ohms ±5%, 1/4 w.
R53	19A700106P91	Composition: 15K ohms ±5%, 1/4 w.
R54 and R55	19A700106P63	Composition: 1K ohms ±5%, 1/4 w.
R56	19A116430P3	Variable, cermet: 200 ohms ±10%, 0.75 w; sim to Helitrim Model 79P.
R58 thru R63	3R77P361J	Composition: 360 ohms ±5%, 1/2 w.
R64 thru R69	19A700111P51	Composition: 330 ohms ±5%, 2 w.
R70 thru R75	19A700106P63	Composition: 1K ohms ±5%, 1/4 w.
R76 thru R81	H212CRP268C	Deposited carbon: 6.8K ohms ±5%, 1/4 w.
R82 thru R87	19A700113P39	Composition: 100 ohms ±5%, 1/2 w.
R88	19A116559P104	Variable cermet: 2500 ohms ±20%, 1/2 w; sim to CTS Series 360.
		- - - - - - - - - - THERMISTORS - - - - - - - - - -
RT1	19C300048P6	Disc: 50K ohms ±10%; sim to NL Ind. 4D 103.
		- - - - - - - - - - TERMINAL BOARDS - - - - - - - -
TB1	7487424P10	Miniature, phen: 2 terminals.
		- - - - - - - - INTEGRATED CIRCUITS - - - - - - - -
U1	19A134782P1	Digital: Outline for 40 Pin Plastic Dip Case.
U2	19A134714P2	Digital: Outline for 28 Pin Dip Case: 6505 microprocessor, plastic package with tin leads.
U3	19A700037P313	Digital: HEX SCHMITT-TRIGGER INVERTER.
U4	19A700037P335	Digital: DUAL D-TYPE POSITIVE-EDGE-TRIGGERED FLIP-FLOP WITH PRESENT & CLEAR.
U5	19A134826P1	Silicon, Outline for 16-Pin Dip Case; sim to MC1408L8.
U6	19A700037P411	Digital: DF-F WITH CLEAR.
U7 and U8	19A700037P410	Digital: 8-BIT ADDRESSABLE LATCH.
U9	19A116180P56	Digital: HEX BUFFERS/DRIVERS WITH OPEN-COLLECTOR HIGH VOLTAGE OUTPUT.
U10 and U11	19A700029G36	Digital: SINGLE 8-CHANNEL MULTIPLEXER.
U12 and U13	19A700037P301	Digital: QUAD 2-INPUT POSITIVE-NAND GATE.
U14	19A116180P56	Digital: HEX BUFFERS/DRIVERS WITH OPEN-COLLECTOR HIGH VOLTAGE OUTPUT.
U15	19A116180P33	Digital: HEX INVERTER BUFFER/DRIVER (OPEN COLLECTOR).
U16	19A116180P48	Digital: SYNCHRONOUS 4-BIT UP/DOWN COUNTER.
		- - - - - - - - VOLTAGE RFGULATORS - - - - - - - -
VR1 and VR2	4036887P6	Zener: 500 mW, 6.5 v. nominal.
VR3	19A134936P1	Integrated circuit, linear: sim to T1 TL430C.
		- - - - - - - - - - SOCKETS - - - - - - - - - -
XU1	19A700156P5	Socket, integrated circuit: 40 contacts; sim to Augat 340-AG39D.
XU2	19A700156P3	Integrated circuit: 28 contacts; sim to AMP 640362P3.
XU3	19A116384P6	Integrated circuit: 16 contacts; sim to Aries 16-501-20.
A802		BATTERY DISCHARGE BOARD 19C330184G1
		- - - - - - - - INTEGRATED CIRCUITS - - - - - - - -
AR1	19A134379P1	Linear: sim to RCA CA3130T.

*COMPONENTS ADDED, DELETED OR CHANGED BY PRODUCTION CHANGES



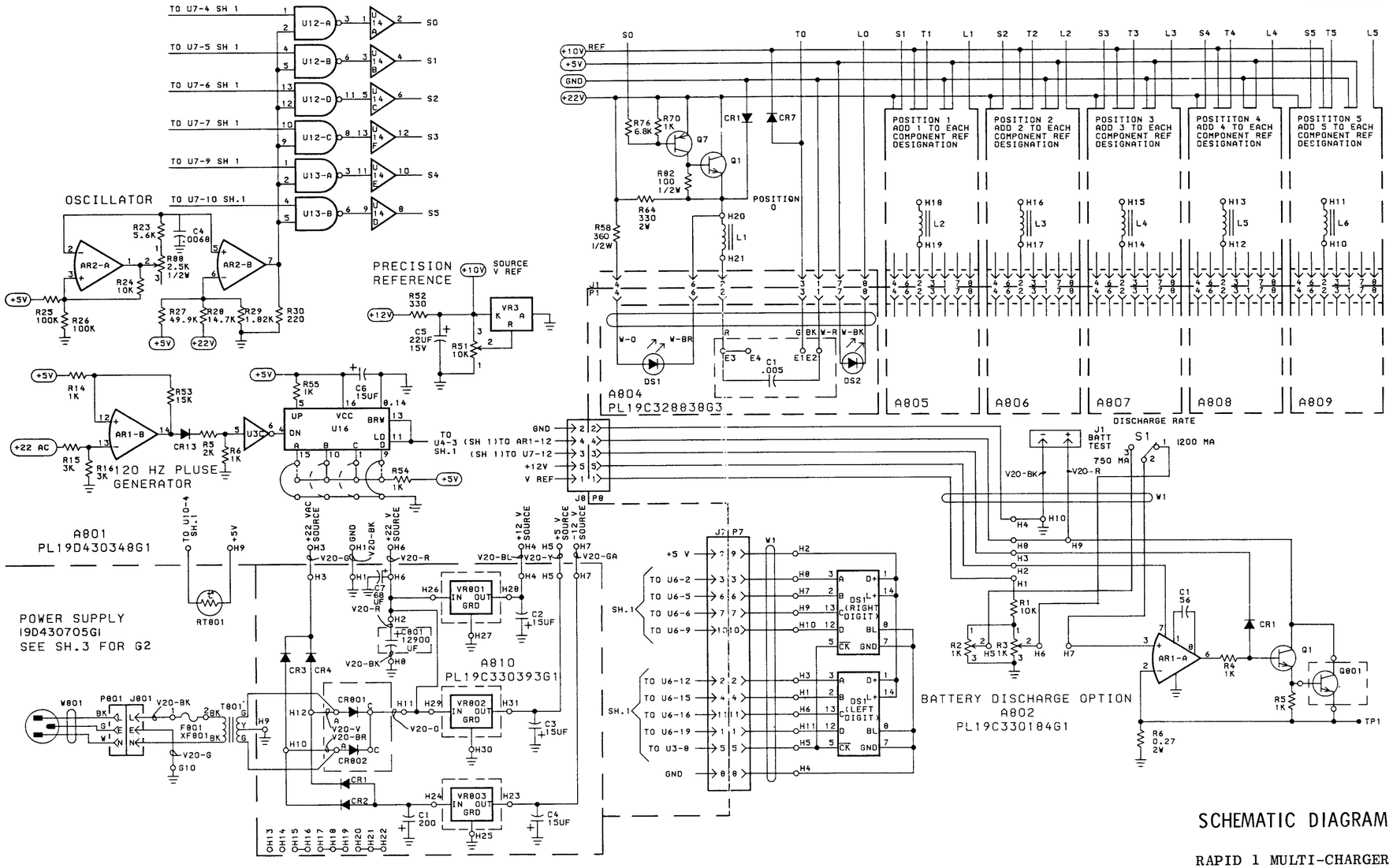
NOTES:

1. ALL RESISTORS ARE 1/4 WATT UNLESS OTHERWISE SPECIFIED AND RESISTOR VALUES IN OHMS UNLESS FOLLOWED BY K=1000 OHMS OR MEG=1,000,000 OHMS. CAPACITOR VALUES IN PICOFARADS (EQUAL TO MICROMICROFARADS) UNLESS FOLLOWED BY UF=MICROFARADS. INDUCTANCE VALUES IN MICROHENRYS UNLESS FOLLOWED BY MH=MILLIHENRYS OR H=HENRYS.
2. THE FOLLOWING CIRCUITS ARE UNUSED: U4B, AR2-C & AR2-D.
3. POWER & GND CONNECTIONS:

DEVICE	GND PIN NO.	5V PIN NO.	12V PIN NO.	12V PIN NO.
U3,U4,U9, U12,U13,U14, U15	7	14		
AR1			4	11
AR2	11	4		
AR3	4		7	

SCHEMATIC DIAGRAM

RAPID 1 MULTI-CHARGER
(Sheet 1)



(19D430570, Sh. 2, Rev. 4)

SCHEMATIC DIAGRAM

RAPID 1 MULTI-CHARGER
(Sheet 2)

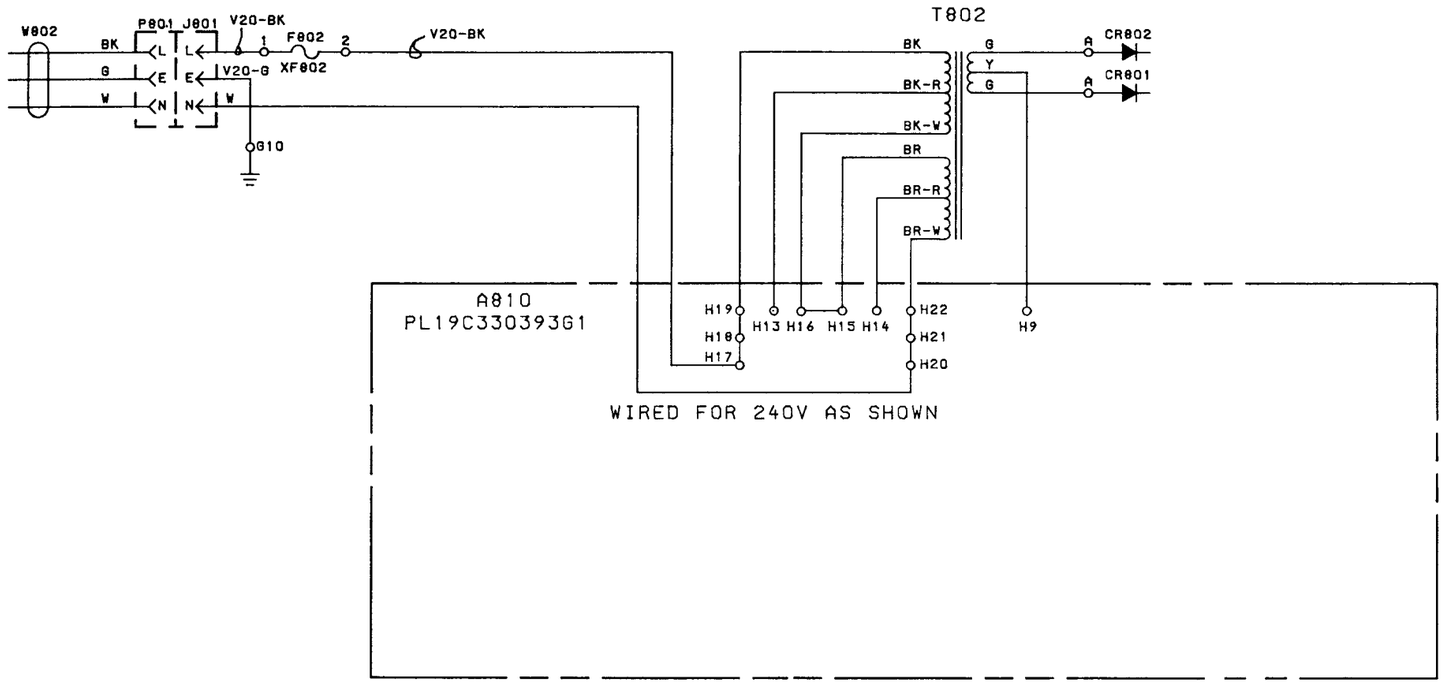
SYMBOL	GE PART NO.	DESCRIPTION
		- - - - - - - - - - CAPACITORS - - - - - - - - - -
C1	19A700105P28	Mica: 56 pF ±5%, 500 VDCW.
		- - - - - - - DIODES AND RECTIFIERS - - - - - - -
CR1	19A115250P1	Silicon, fast recovery, 225 mA, 50 PIV.
		- - - - - - - JACKS AND RECEPTACLES - - - - - - -
J1		Connector. Includes:
	19D413467P1	Fastener.
	19B233782G1	Spring.
	N84P5006C6	Machine screw, phillips, flathead: No. 2-56 x 3/8
	N210P5C6	Hex nut: No. 2-56.
	N404P8C6	Lockwasher.
		- - - - - - - - - - PLUGS - - - - - - - - - -
P8		Connector. Includes:
	19A116659P18	Shell.
	19A116781P6	Contact, electrical: wire range No. 22-26 AWG; sim to Molex 08-50-0108.
		- - - - - - - - - - TRANSISTORS - - - - - - - - - -
Q1	19A115300P2	Silicon, NPN; sim to Type 2N3053.
		- - - - - - - - - - RESISTORS - - - - - - - - - -
R1	19A700106P87	Composition: 10K ohms ±5%, 1/4 w.
R2 and R3	19A116430P5	Variable, cermet: 1000 ohms ±10%, 0.75 w; sim to Helitrim Model 79P.
R4 and R5	19A700106P63	Composition: 1K ohms ±5%, 1/4 w.
R6	19A700050P6	Wirewound: 0.27 ohms ±10%, 2 w.
		- - - - - - - - - - SWITCHES - - - - - - - - - -
S1	19A116648P6	Toggle: SPDT, contacts rated 5 amps at 28 VDC or 115 VAC; sim. to C & K 7101SDG.
		- - - - - - - - - - TEST POINTS - - - - - - - - - -
TP1	19B211379P1	Spring (Test Point).
		- - - - - - - - - - CABLES - - - - - - - - - -
W1		CABLE ASSEMBLY 19C33018462 (Includes J1, P8, & S1)
A803		DISPLAY OPTION BOARD 19B233309G1
		- - - - - - - INDICATING DEVICES - - - - - - -
DS1 and DS2	19A134818P1	Display, optoelectronic: red; sim to T1 L311.
		- - - - - - - - - - PLUGS - - - - - - - - - -
P7		Connector. Includes:
	19A116659P124	Shell.
	19A116781P6	Contact, electrical: wire range No. 22-26 AWG; sim to Molex 08-50-0108.
		- - - - - - - - - - CABLES - - - - - - - - - -
W1	19B233309G2	Display Option Component Board. (Includes P7).
A804 thru A809		SLEEVE ASSEMBLY 19C328838G3
		- - - - - - - - - - CAPACITORS - - - - - - - - - -
C1	5494481P26	Ceramic disc: 5000 pF ±10%, 1000 VDCW; sim to RMC Type JF Discap.

SYMBOL	GE PART NO.	DESCRIPTION
		- - - - - - - - - - TERMINALS - - - - - - - - - -
E1 thru E4		Contact. Includes:
	19C327044P1	Spring contact.
	N136P503C	Tap screw, phillips head: No. 2-32 x 3/16.
		- - - - - - - - - - CABLES - - - - - - - - - -
W1		CABLE ASSEMBLY 19B233104G1
		- - - - - - - - - - INDICATING DEVICES - - - - - - - -
DS1	19A134354P2	Diode, optoelectronic: yellow; sim to Hew. Packard 5082-4555.
DS2	19A134354P3	Diode, optoelectronic: Green; sim to Hew. Packard 5082-4955.
		- - - - - - - - - - PLUGS - - - - - - - - - -
P1		Connector. Includes:
	19A116659P20	Shell.
	19A116781P6	Contact, electrical: wire range No. 22-26 AWG; sim to Molex 08-50-0108.
		- - - - - - - - - - TRANSISTORS - - - - - - - - - -
Q801	19A116118P1	Silicon, NPN.
		POWER SUPPLY 19D430705G1 120 VOLT 19D430705G2 240 VOLT
A810		POWER SUPPLY BOARD 19C330393G1
		- - - - - - - - - - CAPACITORS - - - - - - - - - -
C1	19A115680P10	Electrolytic: 200 uF +150-10%, 18 VDCW; sim to Mallory Type TTX.
C2 thru C4	5496267P14	Tantalum: 15 uF ±20%, 20 VDCW; sim to Sprague Type 150D.
		- - - - - - - DIODES AND RECTIFIERS - - - - - - -
CR1 and CR2	4037822P1	Silicon, 1000 mA, 400 PIV.
CR3 and CR4	19A115250P1	Silicon, fast recovery, 225 mA, 50 PIV.
		- - - - - - - - - - CAPACITORS - - - - - - - - - -
C801	5496520P21	Electrolytic: 12900 pF -10 + 100%, 40 VDCW, 43F86F159M.
		- - - - - - - DIODES AND RECTIFIERS - - - - - - -
CR801 and CR802	19A115202P1	Silicon; sim to Type 1N1613.
		- - - - - - - - - - FUSES - - - - - - - - - -
F801	7487942P5	Cartridge, slow blow: 1 amps at 250 v; sim to Bussmann MDL 1.
F802	19A134961P10	Cartridge: 1/2 amp @ 250 volts; sim to Littlefuse 213.500
		- - - - - - - JACKS AND RECEPTACLES - - - - - - -
J801	19B800914P1	Power receptacle housing; sim to Molex 15-04-0703.
		- - - - - - - - - - THERMISTORS - - - - - - - - - -
RT801	19A142671G1	Thermistor.
		- - - - - - - - - - TRANSFORMERS - - - - - - - - - -
T801	19A116218P4	Power, stepdown: Pri: 117 VRMS; Sec: 15.25 VRMS each side of CT (no load).
T802	19A116218P6	Power, stepdown: Pri: 105/120/210/240; Sec: 16 VDC.

SYMBOL	GE PART NO.	DESCRIPTION
		- - - - - - - - - VOLTAGE REGULATORS - - - - - - - -
VR801	19A134717P2	Integrated circuit, linear: POSITIVE VOLTAGE REGULATOR; sim to UA7812U.
VR802	19A134717P1	Integrated circuit, linear: 4K PROGRAMMED MEMORY
VR803	19A134718P2	Integrated circuit, linear: NEGATIVE VOLTAGE REGULATOR; sim to uA 7912U.
		- - - - - - - - - - SOCKETS - - - - - - - - - -
XF801	4037402P1	Fuseholder: 15 amps at 250 v; sim to Littelfuse 341001.
XF802	19A134796P2	Fuseholder; sim to Schurter 031.1677.
		ASSOCIATED PARTS
		- - - - - - - - - - CABLES - - - - - - - - - -
W801	19A134713P1	Power: 3 wire, rated 10 amps @ 125 volts, 7-1/2 foot long; sim to Belden 17250.
W802	19A134713P2	Power: 3 wire, rated 10 amps @ 125 volts, 6-1/2 foot long.
		MECHANICAL PARTS (SEE RC3937)
1	19A700068P1	Insulator, bushing. (Used with Q1-Q6 on A801).
2	19A116023P1	Insulator, plate. (Used with Q8010.
3	N80P9007C6	Machine screw, phillips: No. 4-40 x 7/16. (Secures Q801).
4	7141225P2	Hex nut: No. 4-40. (Secures Q1-Q6 on A801 & Q801).
5	N404P11C6	Lockwasher, internal: No. 4. (Secures Q1-Q6 on A801 & Q801).
6	N402P35C6	Washer, steel: No. 4. (Secures Q1-Q6 on A801 & Q801).
7	19A701332P4	Insulator, washer: nylon. (Used with Q1 on A802).
8	19B233062G1	Base assembly.
9	7150186P107	Spacer: No. 6 x 1/4.
10	19B233413G1	Heat sink.
11	19B201074P306	Tap screw, Phillips POZIDRIV®: No. 6-32 x 3/8.
12	19A134796P4	Fuseholder: sim to Schurter 031.1663.
13	19A134796P5	Nut: sim to Schurter 583.0016.
14	19A701863P27	Clip, loop.
15	19C330295G1	Cover.
16	19A142819P1	Insulator.
17	19B209268P106	Terminal, solderless: sim to AMP 41184. (NOT USED).
18	19B800914P2	Contact: rated 15 amps @ 125 VAC; sim to Molex 16-02-1103. (Quantity 3 - located on J801).
19	19B233255P1	Support. (C801).
20	19J706152P9	Retaining strap; sim to Dennison BAR-LOK 08471. (C801).
21	19A134141P1	Rubber grommet. (Used with L1-L6).
22	19A700115P3	Insulator, plate. (Used with Q1-Q6 on A8010.
23	N80P9008C6	Machine screw: No. 4-40 x 1/2. (Secures Q1-Q6 on A801).
24	19B201074P305	Tap screw, Phillips POZIDRIV: No. 6-32 x 5/16. (Secures A801).
25	N80P9004C6	Machine screw: No. 4-40 x 1/4.
26	7142162P20	Spacer, hex: No. 4-40. (Secures TB1).
27	4037559P9	Rubber bumper.
28	N210P15C6	Nut, hex: No. 8-32. (Secures rubber bumpers, item 1).
29	N403P16C6	Lockwasher, internal tooth: No. 8. (Secures rubber bumpers).

SYMBOL	GE PART NO.	DESCRIPTION
30	19C330308G1	Chassis. (Discharge option).
31	19C328758G2	Chassis. (Without Discharge option).
32	19A134403P4	Cable clip. (Quantity 2).
33	NP280762	Nameplate. (DISCHARGE RATE).
34	N84P5007C6	Machine screw, phillips head: No. 2-56 x 7/16.
35	19D413467P1	Fastener.
36	19A142573P1	Window.
37	7150186P4	Spacer, sleeve.
38	NP280667P1	Nameplate. (CHARGING).
39	19A134521P3	Lens: amber.
40	19A134521P2	Lens: green.
41	NP280667P4	Nameplate. (RAPID ONE).
42	19B209572P2	Identification plate. (GENERAL ELECTRIC).
43	19C307038P7	Nut, push on. (Secures GE identification plate).

POWER SUPPLY
(AS SHOWN FOR 19D430705G2
OTHERWISE SAME AS G1)



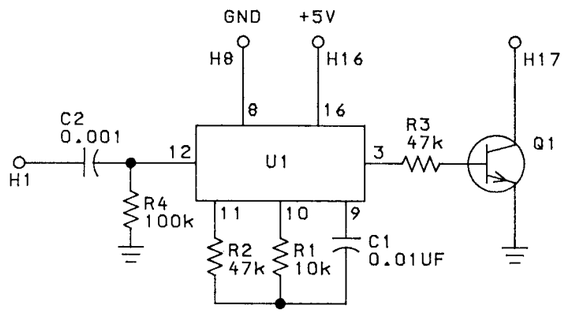
(19D430570, Sh. 3, Rev. 7)

SEE APPLICABLE PRODUCTION CHANGE SHEETS IN INSTRUCTION BOOK SECTION DEALING WITH THIS UNIT, FOR DECRIPTION OF CHANGES UNDER EACH REVION LETTER.

THIS ELEM DIAG APPLIES TO	
MODEL NO.	REV. LETTER
PL19D430348G1	F

CONNECTION CHART

INPUT VOLTS AC	FROM	TO	WIRE	FUSE
			PART OF	
105	T802-BK	A810-H19	T802	
	T802-BK/R	A810-H22	T802	
	T802-BR	A810-H18	T802	
	T802-BR/R	A810-H15	T802	
	F802-2	A810-H17	V20-BK	
	J801-N	A810-H20	V20-W	
			PART OF	
	T802-BK/W	A810-H13	T802	
	T802-BR/W	A810-H14	T802	
			PART OF	
120	T802-BK	A810-H19	T802	
	T802-BR	A810-H18	T802	
	T802-BK/W	A810-H22	T802	
	T802-BR/W	A810-H15	T802	
	T802-BK/R	A810-H13	T802	
	T802-BR/R	A810-H14	T802	
	F802-2	A810-H17	V20-BK	
	J801-N	A810-H20	V20-W	
			PART OF	
210	T802-BK/R	A810-H15	T802	
	T802-BR	A810-H16	T802	
	T802-BK	A810-H19	T802	
	T802-BR/R	A810-H22	T802	
	T802-BK/W	A810-H13	T802	
	T802-BR/W	A810-H14	T802	
	F802-2	A810-H17	V20-BK	
	J801-N	A810-H20	V20-W	
			PART OF	
240	T802-BK	A810-H19	T802	
	T802-BK/R	A810-H13	T802	
	T802-BK/W	A810-H16	T802	
	T802-BR	A810-H15	T802	
	T802-BR/R	A810-H14	T802	
	T802-BR/W	A810-H22	T802	
	F802-2	A810-H17	V20-BK	
	J801-N	A810-H20	V20-W	



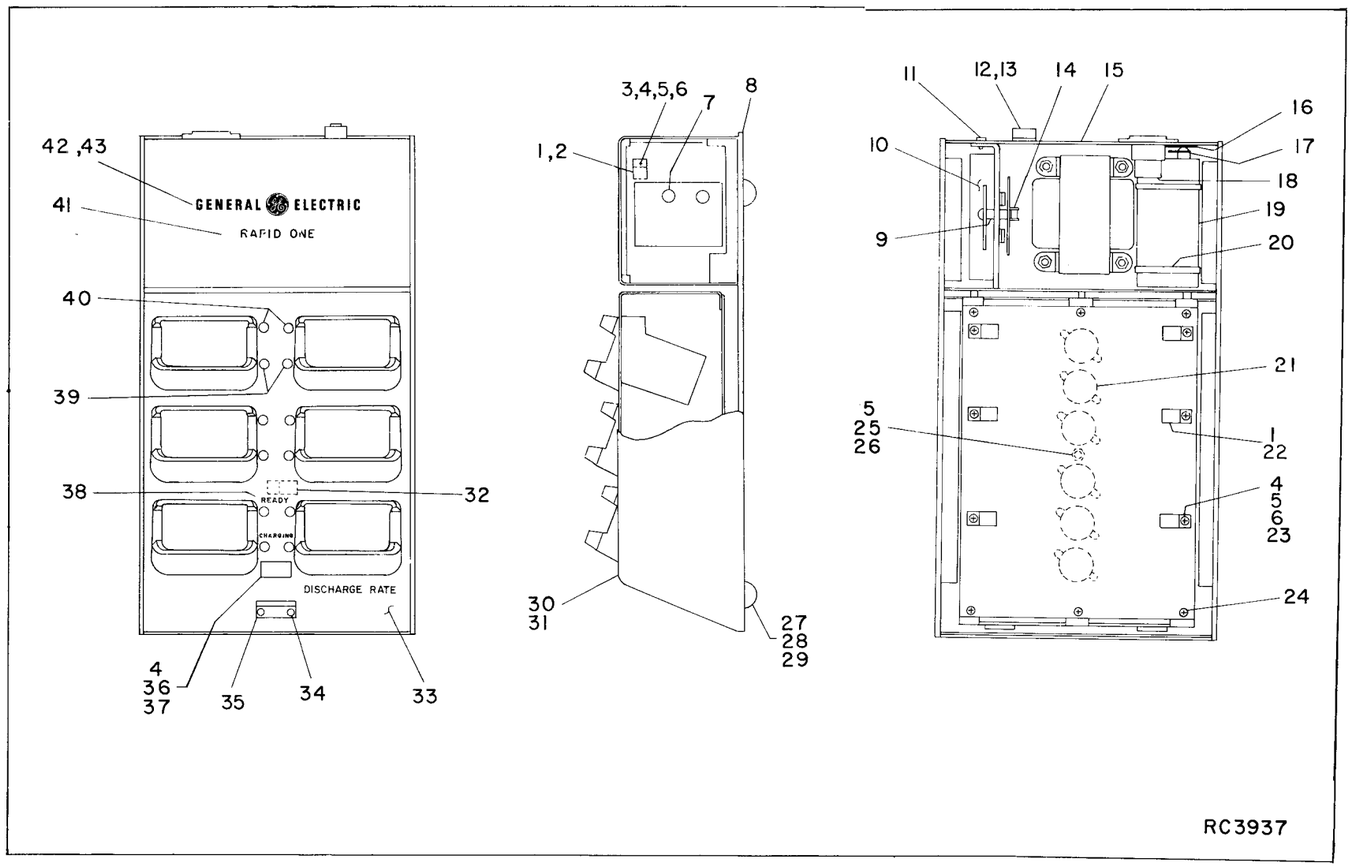
(19B234292, Rev. 0)

ALL RESISTORS ARE 1/4 WATT UNLESS OTHERWISE SPECIFIED AND RESISTOR VALUES IN OHMS UNLESS FOLLOWED BY K-1000 OHMS OR MEG-1,000,000 OHMS. CAPACITOR VALUES IN PICOFARADS (EQUAL TO MICROMICROFARADS) UNLESS FOLLOWED BY UF-MICROFARADS. INDUCTANCE VALUES IN MICROHENRYS UNLESS FOLLOWED BY MH-MILLIHENRYS OR H-HENRYS.

MODEL NO.	REV. LETTER
PL19C331977	

SCHEMATIC DIAGRAM

RAPID 1 MULTI-CHARGER
(Sheet 3)



PRODUCTION CHANGES

Changes in the equipment to improve performance or to simplify circuits are identified by a "Revision Letter," which is stamped after the model number of the unit. The revision stamped on the unit includes all previous revisions. Refer to the Parts List for descriptions of parts affected by these revisions.

REV. A - Charger Board 19D430348G1

To incorporate more stable resistors. Changed R24, R25 and R26.
R24 - 3R152P103J Composition, 10K ohms ±5%, 1/4W.
R25 - 3R152P104J Composition,100K ohms ±5%, 1/4W.
and
R26

REV. B - To improve performance. Added Timer Board 19C331923G1.

REV. C - To incoporate improved timer. Changed timer board A101.
Timer Board was: 19C331923G1.

REV. D - To incorporate new Schematic Diagram. Added Schematic Diagram 19B234292.

REV. E - To decrease the trickle charge from 120 mA to 50 mA, and to improve heat dissipation. Changed R64-R69, R76-R81, added C7, changed test spec. and changed Q7-Q12.

R64-R69: 19A700111P51; R76-R81: 19A700019P47;
C7: 19A701534P16; Q7-Q12: 19A134960P1

REV. F - To prevent latch-up in some charge modes. Moved ambient senser RT1 to a cooler location. Move to component side of board and mount with existing screw near U16.

TROUBLESHOOTING PROCEDURE

A. CHARGER COMPLETELY DEAD:

1. Check fuse F801
2. Check line voltage
3. Known good battery pack

B. CHARGER MALFUNCTIONS

1. No sleeve functions properly

a. Check power supplies:

+22V source at H6

+12V source at H4

+5 V source at H5

-12V source at H7

If any supply voltage is wrong, (+22 is unreg) disconnect the load and retry. The regulators UR801-803 are designed to shut down on overcurrent or over-temperature so if normal supply voltage returns with no load, the problem may well be on main board A801. Notwithstanding direct shorts, the offending component will likely be quite hot.

If supplies are OK:

b. Check the 10.00 volt reference at VR3(K). Must be accurately w/R51.

c. Check the microprocessor clock at U1 pin 3. Must be a near square-wave at 0.7-1.0 MHz, TTL LEVEL. Frequency is not critical but should not exceed 1.0 MHz.

If bad, remove U1 and retest.
Check U2, U3, R3, C1.

d. If the clock is OK, perform a cursory test of the microprocessor by observing the INTERRUPT SERVICE FLIP-FLOP U4a.

U4a pin 3 should have a low frequency TTL pulse whose leading edge 5 causes pin 5 to go low supplying an IRQ signal to U2 pin 4.

The microprocessor should reply to this input by driving U2 pin 21 low and then high, which in turn sets U4a to its original state.

While this test does not completely confirm that U1 and U2 are good, the probability is high, since in order for this to succeed, a lot of things have to happen right!

e. If this test fails, observe the 20 address and data leads between U1 and U2, using an oscilloscope.

None should be stuck high or low and none should have voltages other than normal TTL levels, i.e., $\leq$0.4V or $\geq$2.4V.

Watch for identical patterns on adjacent runs. They may indicate shorts.

f. Check the System Reset pulse on U2 pin 1, U1 pin 16, U8 and U7 pin 15. It must go low when power is applied and return high several milliseconds later.

g. Check U3, R4, C2 if not.

2. One or more sleeves function properly while others do not

It is probably true that the following sections are not at fault since the proper operation of at least one sleeve indicates they are operating properly.

a. Microprocessor section U1 thru U4.

b. Voltage Reference VR3.

c. D-A convertor U5 and associated AR1-A, AR3, and VR1, VR2.

d. Temperature sensor RT1, 801 and standard resistors R43-R50.

e. Analog multiplexer U11 but not U10.

f. Oscillator AR2 and associated components.

g. Power supplies

3. No sleeve functions and all sleeves act similarly

It is probably true that one or more of the following sections are at fault since their operation is essential and a failure would affect all sleeves alike.

a. Power supplies +22, + and -12 and +5V.

b. Voltage Reference AR3 must be 10.00 volts.

c. D-A Convertor U5 and associated AR1-A, AR3, VR1, VR2 and associated components.

d. Temperature sensor RT1, 801 and standard resistors R43-R50.

e. Analog multiplexers U10 and U11.

f. Oscillator AR2 and associated components.

g. Microprocessor section U1-U4.

h. Addressable latches U7 or U8 although U8 only affects the GREEN LED's.

i. Level shifter U9.

4. No sleeve functions and failures are not similar

This unlikely mode may result from multiple failures or the inability of the microprocessor to individually address each sleeve.

a. The circuit from U6, all Q outputs, including U7 thru 11 and R31-36, should be free of floating, stuck or indeterminate nodes.

b. One or more oscillating or noisy power supplies may contribute to such illogical failures.

c. A noisy, oscillating or poorly adjusted 10.00 volt reference may cause this also.

C. SPECIFIC PROBLEM TYPES AND THE COMPONENT GROUPS WHICH CAUSE THEM

1. Yellow LED should light whenever a battery is placed in a sleeve.

a. If a single sleeve fails, the components R64, R65, DS1, J1/P1 or the battery may be at fault.

b. If all sleeves are defective, then the +22 volt power supply is at fault.

2. On inserting a battery, after a short delay charging should commence. You may use a charger calibrator to measure the current or simply listen for a squeal from the pot-cores in the current limit circuit.

If charging fails to start, one of the following may have occurred:

a. The battery is defective and the trickle charge current cannot bring the voltage above 7.2V.

b. The temperature at RT1 inside the charger is below 0°C or above 55°C and the microprocessor will not allow charging.

c. The transformer temperature of 7801 is beyond allowable limits and the microprocessor will not allow charging.

d. The oscillator AR2 is not functional. Check AR2 pin 5 for a triangle wave and pin 7 for a TTL level pulse.

D. DISCHARGE OPTION MALFUNCTIONS

1. If all other functions work, it is probable that the microprocessor and associated circuitry is okay.
2. Check connections in P7 and 8.
3. A802 H7 should be 0.189V for 700 mA setting and 0.324 for 1200 mA.
4. P8-3 should be a logical 1.
5. Check AR1, Q1 and Q801.
6. If the display does not function and all connections are good, replace DS1 or DS2 that is defective.

APPENDIX

```
**********************************************************************
*                                                                    *
*  USER DOCUMENT: MPR ONE HOUR MULTI-CHARGER 06 JUN 79 R.J.MARTIN    *
*                                                                    *
**********************************************************************
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I. HARDWARE DESCRIPTION

A. GENERAL

HARDWARE CONTROLLED BY THE MICROPROCESSOR IS USED TO CONTROL THE CHARGING CURRENT FOR SIX BATTERIES. ONE L.E.D. INDICATOR IS ASSOCIATED WITH EACH. A SEVENTH BATTERY MAY BE DISCHARGED TO A FIXED VOLTAGE WHILE THE TIME REQUIRED TO SO IS RECORDED AND DISPLAYED EITHER AS PERCENTAGE OF FULL CHARGE OR AS MINUTES.

TO DETERMINE THE CORRECT AND SAFE CHARGING CYCLE, HARDWARE IS CONTROLLED BY THE MICROPROCESSOR TO MULTIPLEX VOLTAGE AND TEMPERATURE DATA FROM EACH BATTERY TO A SINGLE COMPARATOR WHICH TESTS THE BATTERY DATA AGAINST A SINGLE TEST VOLTAGE GENERATED BY AN A TO D CONVERTER ALSO DRIVEN BY THE MICROPROCESSOR. RESULTS ARE RETURNED TO A SINGLE INPUT FOR ANALYSIS. TWO OTHER INPUTS AND COMPARATORS ARE USED TO DETERMINE THE STATE OF THE BATTERY DISCHARGING SOCKET. THE RECTIFIED POWER LINE FREQUENCY IS USED TO INTERRUPT THE MICROPROCESSOR FOR THE PURPOSE OF TIME-KEEPING.

B. MICROPROCESSOR CONFIGURATION

THE PROCESSOR IS A ROCKWELL OR MOS TECHNOLOGY 6505 DEVICE USED IN A SIMPLE TWO CHIP CONFIGURATION ALONG WITH A 6530 MASKED ROM, RAM, TIMER, AND INPUT/OUTPUT DEVICE. ALL COMMUNICTION WITH THE CHARGER HARDWARE IS CARRIED OUT THROUGH THE 16 BIT I/O PORT OF THE 6530 AND THE INTERRUPT LINE OF THE PROCESSOR. AT NO POINT ARE THE DATA, ADDRESS, OR CONTROL SIGNALS USED IN THE CHARGER, THUS ALLOWING EASY RE-CONFIGURATION AS A SINGLE CHIP COMPUTER SYSTEM IN THE FUTURE.

C. INPUT SIGNAL DESCRIPTIONS

FOUR SIGNALS ARE SUPPLIED TO THE PROCESSOR FROM THE CHARGER CIRCUITS.

1. INTERRUPT

IN ORDER TO USE THE POWER LINE FREQUENCY TO PROVIDE AN ACCURATE TIME BASE TO RECORD THE DURATION OF A BATTERY DISCHARGE TEST, THE RECTIFIED POWER IS DIVIDED FIRST BY A CONSTANT (OPTIONS) AND THEN APPLIED TO AN INTERRUPT REQUEST FLIP-FLOP. THE INTERRUPT SERVICE ROUTINE WILL CLEAR THIS FLIP-FLOP AT THE END OF EACH EXECUTION. IT IS REQUIRED DUE TO THE LEVEL SENSITIVE NATURE OF THE IRQ LINE.

2. COMPARATOR RESULTS ---- PERIPHERAL DATA REGISTER B, BIT 7

ALL ANALOG INPUTS ARE READ BY THE PROCESSOR INTO BIT 7 OF PORT B. SINCE THIS IS THE SIGN BIT, AND THE NEGATIVE FLAG IN THE PROCESSOR STATUS WORD IS SET OR CLEARED AUTOMATICALLY ON EACH READ OPERATION BRANCHES MAY BE MADE ACCORDING TO THE VALUE OF THIS BIT WITHOUT FURTHER INSTRUCTIONS. ALL ANALOG MEASUREMENTS ARE MADE USING THIS INPUT, BY SENDING A VALUE TO THE DIGITAL TO ANALOG CONVERTER, PRODUCING A KNOWN VOLTAGE, ADDRESSING THE ANALOG MULTIPLEXERS TO CONNECT THE DESIRED SIGNAL, AND READING THE RESULTING DEFFIERNCE FROM THE COMPARATOR. ABSOLUTE VOLTAGE READINGS ARE MADE BY SUCCESSIVE APPROXIMATION IN SOFTWARE USING THE SAME INPUT.

3. DISCHARGE BATTERY < 3.0 V. ---- PERIPHERAL DATA REGISTER B, BIT 6

THIS INPUT WILL BE HIGH WHEN THE BATTERY VOLTAGE AT THE OPTIONAL DISCHARGE SOCKET IS BELOW 3.0 V OR MISSING.

4. DISCHARGE BATTERY > 6.0 V. ---- PERIPHERAL DATA REGISTER B, BIT 5

THIS INPUT WILL BE HIGH WHEN THE BATTERY VOLTAGE AT THE OPTIONAL DISCHARGE SOCKET IS ABOVE 6.0 V. OR NOT YET DISCHARGED.

D. OUTPUT SIGNAL DESCRIPTIONS

ALL EIGHT BITS OF PERIPHERAL DATA REGISTER A AND THE LOW ORDER FIVE BITS OF PERIPHERAL DATA REGISTER B ARE PROGRAMMED AS OUTPUTS.

TYPICALLY A VALUE OR BIT PATTERN IS WRITTEN TO PORT A AND ONE OR MORE OF THE PORT B BITS IS USED TO STROBE THAT VALUE OR PATTERN INTO ONE OR MORE OF THE DEVICES CONNECTED TO PORT A. THE DIGITAL TO ANALOG CONVERTER IS ALWAYS ACTIVE AND PRODUCES A VOLTAGE FROM 0 TO 10 VOLTS FOR VALUES OF $00 TO $FF.

1. DIGITAL TO ANALOG CONVERTER

PORT A BIT 0	LSB
PORT A BIT 1	:
PORT A BIT 2	:
PORT A BIT 3	:
PORT A BIT 4	:
PORT A BIT 5	:
PORT A BIT 6	:
PORT A BIT 7	MSB

2. EIGHT BIT TEMPORARY LATCH

PORT A BIT 0	LSB
PORT A BIT 1	:
PORT A BIT 2	:
PORT A BIT 3	:
PORT A BIT 4	:
PORT A BIT 5	:
PORT A BIT 6	:
PORT A BIT 7	MSB
PORT B BIT	CLOCK

3. EIGHT BIT ADDRESSABLE LATCH FOR CURRENT SWITCH CONTROL

LATCH BIT 0	ADDRESS LSB (BATTERY NUMBER)
LATCH BIT 1	:
LATCH BIT 2	ADDRESS MSB
PORT B BIT 1	CLOCK
LATCH BIT 6	DATA (ONE FOR ON -- ZERO FOR OFF)

4. EIGHT BIT ADDRESSABLE LATCH FOR LED INDICATOR CONTROL

LATCH BIT 0	ADDRESS LSB (BATTERY NUMBER)
LATCH BIT 1	:
LATCH BIT 2	ADDRESS MSB
PORT B BIT 2	CLOCK
LATCH BIT 7	DATA (ONE FOR ON -- ZERO FOR OFF)

5. ANALOG MULTIPLEXER CONTROLLING BATTERY SELECTION AND RT-2

LATCH BIT 0	ADDRESS LSB (BATTERY NUMBER OR RT-2)
LATCH BIT 1	:
LATCH BIT 2	ADDRESS MSB

6. ANALOG MULTIPLEXER CONTROLLING RESISTOR SELECTION OR RT-1

LATCH BIT 3	ADDRESS LSB
LATCH BIT 4	:
LATCH BIT 5	ADDRESS MSB

7. OPTIONAL DISPLAY INDICATOR, 2 DIGITS 0-F

LATCH BIT 0	LSB RIGHT DIGIT
LATCH BIT 1	:
LATCH BIT 2	:
LATCH BIT 3	MSB RIGHT DIGIT
LATCH BIT 4	LSB LEFT DIGIT
LATCH BIT 5	:
LATCH BIT 6	:
LATCH BIT 7	MSB LEFT DIGIT
PORT B BIT 3	CLOCK

8. INTERRUPT SERVICE REQUEST FLIP-FLOP

PORT B BIT 4	DRIVEN LOW TO SET THE FLIP-FLOP (CLEARING THE REQUEST)

D. ADDRESSING CONSIDERATIONS

1. READ ONLY MEMORRY

ROM IS ADDRESSED FROM 0C00 HEX TO 0FFF HEX. SINCE THE ADDRESS BITS ABOVE BIT 11 ARE NOT CONNECTED THE INTERRUPT AND RESET VECTORS AT THE TOP OF MEMORY FUNCTION TO SELECT THE TOP SIX BYTES IN THE LIMITED RANGE OF THE SYSTEM ROM.

2. RANDOM ACCESS MEMORY

RAM IS ADDRESSED FROM 0000 HEX THROUGH 003F HEX FOR DATA OPERATIONS AND FROM 01FF HEX DOWNWARD TO 0100 HEX FOR STACK OPERATIONS. SINCE ADDRESS BITS 6 THROUGH 8ARE NOT INCLUDED IN THE RAM DECODE, IT RESPONDS TO ALL ADDRESSES FROM 0000 HEX TO 01FF HEX WHICH ARE NOT EXPLICITY DECODED AS I/O. THEREFORE STACK ACCESSES ARE MADE FROM 01FF HEX DOWNWARD AND DATA ACCESSES ARE MADE FROM 0000 HEX UPWARD, SHARING THE SAME 64 BYTES. (NON-OVERLAPPING)

3. INPUT-OUTPUT

SHARING THE RAM ADDRESS SPACE IN ZERO-PAGE IS 16 BYTES OF SPACE ASSIGNED TO I/O AS FOLLOWS:

0040	READ PER. DATA REG A	WRITE PER. DATA REG A
0041	READ DATA DIRECTION A	WRITE DATA DIRECTION A
0042	READ PER. DATA REG A	WRITE PER. DATA REG B
0043	READ DATA DIRECTION B	WRITE DATA DIRECTION B
0045	READ TIMER FLAG	
0047		WRITE TIMER DATA, DISABLE INT.

OTHER I/O ADDRESS EXIST BUT ARE NOT USED.

2. SOFTWARE DESCRIPTION

SOFTWARE OPERATES IN THREE PRIMARY MODES, POWER APPLIED RESET, MAIN LOOP, AND INTERRUPT SERVICE.

A. POWER APPLIED RESET

POWER APPLIED RESET PASSES CONTROL INDIRECTLY THROUGH THE RESET VECTOR TO LABEL 'RESET',

RESET:
STACK POINTER IS PRESET TO TOP OF RAM
I/O INITIALIZATION IS ACCOMPLISHED BY COPYING T'TABL1'
INTO THE I/O COMPONENT USING AN INDEXED LOOP.

RES3:
ALL BATTERY CURRENT SWITCHES AND LEDS ARE TURNED OFF BY
CALLING SUBROUTINES 'SWIOFF' AND 'LEDOFF' IN AN INDEXED LOOP
THEN THE TEST BATTERY CURRENT DRAIN IS DISABLED BY A CALL TO 'TSTOFF'
CONTROL IS UNCONDITIONALLY PASSED TO 'SYSTST' WHICH WILL RETURN
CONTROL HERE ONLY IF HARDWARE TESTS ARE SUCESSFUL.

RESET1:
ON SUCCESSFUL COMPLETION OF HARDWARE TESTS, THE PROCESSOR REGISTERS
ARE AGAIN INITIALIZED,THE OPTIONAL DISPLAY DATA IS SET TO '00',
AND ALL VARIABLES ARE INITIALIZED BY COPYING 'TABL2' INTO RAM
USING AN INDEXED LOOP.

B. MAIN LOOP

THIS LOOP WILL BE REPEATED FOREVER, AND ON EACH PASS, A DIFFERENT BATTERY IS EXAMINED. TWO MAJOR CALLS TO EXTERNAL ROUTINES ARE MADE.

LOOP:
THE SUBROUTINE 'TEST' IS CALLED TO SERVICE THE OPTIONAL BATTERY DISCHARGER AND DISPLAY. IN THE EVENT NO OPTION IS INSTALLED, IT WILL BE A USELESS CALL BUT WILL ALWAYS RETURN CONTROL.

INTERRUPTS ARE ALLOWED

THE AMBIENT TEMPERATURE IS TESTED. IF IT IS GREATER THAN 'TMAX' THEN "EA" (EXCESSIVE AMBIENT) IS SENT TO THE DISPLAY VARIABLE 'DISPNO' AND 'MASK00' IS WRITTEN TO THE VARIABLE 'MDUTY' THEREBY PREVENTING ANY CHARGING TO OCCUR.

THE AMBIENT TEMPERATURE IS AGAIN TESTED. IF IT IS LESS THAN 'TMIN' THEN "C0" (COLD) IS SENT TO THE DISPLAY VARIABLE 'DISPNO' AND 'MDUTY' IS ALSO SET TO 'MASK00'.

LOOP3:
IF THE AMBIENT TEMPERATURE IS FOUND WITHIN THE LIMITS 'TMIN' TO 'TMAX' THEN THE POWER TRANSFORMER TEMPERATURE RISE IS TESTED. AN ABSOLUTE VOLTAGE MEASUREMENT IS MADE BY CALLING THE SUBROUTINE 'ADCONV'. THE RESULT IS COMPARED WITH 'TST60', 'TST70', ETC IDENTIFYING THE TRANSFORMER AS BEING BETWEEN 60 AND 70 DEGREES C, BETWEEN 70 AND 80 DEGREES C AND SO ON. ACCORDINGLY, ONE OF THE CONSTANTS 'MSK100', 'MASK50', ETC WILL BE WRITTEN INTO THE VARIABLE 'MDUTY' WHICH IS USED BY THE SUBROUTINE 'CHARGE' TO LIMIT THE DUTY CYCLE AT WHICH ALL BATTERIES MAY BE CHARGED.
FINALLY A CALL TO SUBROUTINE 'CHARGE' IS MADE TO SERVICE THE N'TH BATTERY.

ON RETURN, THE VARIABLE 'BATNUM' WHICH IDENTIFIES THE CURRENTLY ACTIVE BATTERY IS INCREMENTED, TESTED FOR OVERFLOW AND CONTROL IS PASSED BACK TO THE LABEL 'LOOP' RESTARTING THE SEQUENCE FOR THE NEXT BATTERY.

DISPLA: (SUBROUTINE)
TRANSFERS THE CONTENTS OF THE ACCUMULATOR TO THE OPTIONAL DISPLAY

CLKL: (SUBROUTINE)
TRANSFERS THE CONTENTS OF PER. DATA REG A TO THE TEMPORARY DATA LATCH

CLKS: (SUBROUTINE)
TRANSFERS THE TEMPORARY LATCH TO THE EIGHT BIT ADDRESSABLE LATCH CONTROLLING THE CURRENT SWITCHES FOR THE BATTERIES (0-5) AS FOLLOWS:
BITS 0,1,2 CONTAIN THE BATTERY ADDRESS
BIT 6 CONTAINS 1 FOR ON - 0 FOR OFF

```
CLKS: (SUBROUTINE)
  TRANSFERS THE TEMPORARY LATCH TO THE EIGHT BIT ADDRESSABLE LATCH
  CONTROLLING THE LED INDICATORS FOR THE BATTERIES (0-5) AS
  FOLLOWS:
     BITS 0,1,2 CONTAIN THE BATTERY ADDRESS
     BIT 7 CONTAINS 1 FOR ON - 0 FOR OFF

MISNG: (SUBROUTINE)
  DETERMINES IF THE BATTERY ADDRESSED BY THE X REG IS STILL IN THE SOCKET.
  THE OPEN CIRCUIT VOLTAGE AT THE THERMISTOR TERMINAL IS COMPARED WITH
  'V3X0' (3.0V). TWO IDENTICAL RESULTS ARE REQUIRED SEPARATED BY
  A 50 MILLISECOND DELAY INORDER TO RETURN A "MISSING" INDICATION.
  RESULTS RETURNED IN THE SIGN BIT OF THE PROCESSOR STATUS BYTE, NEGATIVE
  IF BATTERY IS MISSING.

ADCONV: (SUBROUTINE)
  THE REGISTER X IS TAKEN AS ADDRESSES FOR THE ANALOG MULTIPLEXERS
  AND AN ABSOLUTE VOLTAGE MEASUREMENT IS MADE ON THE REQUESTED VOLTAGE
  BY SOFTWARE SUCESSIVE APPROXIMATION. RESULTS ARE RETURNED IN THE
  ACCUMULATOR.

COMPAR: (SUBROUTINE)
CMPDAC: (SUBROUTINE)
  THE REGISTER X (FOR CMPDAC) OR THE ACCUMULATOR (FOR COMPAR) IS TAKEN
  AS ADDRESSES FOR THE ANALOG MULTIPLEXERS, AND THE REGISTER Y AS THE
  KNOWN VALUE. THE VOLTAGE ADDRESSED BY THE MULTIPLEXERS IS COMPARED
  TO THE KNOWN VALUE AND RESULTS RETURNED AS FOLLOWS:
     SIGN = NEG IF Y>UNKNOWN
            POS IF Y<UNKNOWN
          EQUALITY IS NOT VALID, AS SOME DECISION MUST BE MADE.

DLY: (SUBROUTINE)
  A SHORT DELAY LOOP USED FOR ANALOG SETTLING TIME WAITS.

SWIOFF: (SUBROUTINE)
  TURNS OFF THE CURRENT TO THE BATTERY ADDRESSED BY THE 3 LEAST
  SIGNIFICANT BITS OF THE X REG.

SWION: (SUBROUTINE)
  TURNS ON THE CURRENT TO THE BATTERY ADDRESSED BY THE 3 LEAST
  SIGNIFICANT BITS OF THE X REG.

LEDOFF: (SUBROUTINE)
  TURNS OFF THE INDICATOR ADDRESSED BY THE 3 LEAST SIGNIFICANT
  BITS OF THE X REG.

LEDON: (SUBROUTINE)
  TURNS ON THE INDICATOR ADDRESSED BY THE 3 LEAST SIGNIFICANT
  BITS OF THE X REG.

TESTON: (SUBROUTINE)
  TURNS ON THE CURRENT DRAIN FOR THE OPTIONAL BATTERY TEST CIRCUIT
```

```
TESTOFF: (SUBROUTINE)
  TURNS OFF THE CURRENT DRAIN FOR THE OPTIONAL BATTERY TEST CIRCIUT.

TEST: (SUBROUTINE)
   TESTS THE LEAST SIGNIFICANT THREE BITS OF 'TESTAT' TO DETERMINE
   THE CURRENT STATUS OF THE BATTERY UNDER TEST, AND TRANSFERS
   CONTROL TO 'FREE','DUMP',OR 'DEAD' ACCORDINGLY BY EXECUTING
   A COMPUTED INDIRECT JUMP TO THE N'TH ENTRY IN 'TTABL'
   NOTE: THE ONLY MODIFICATION OF THE DISPLAY IS IN THESE THREE
   SUBROUTINES. THEREFORE THE PROIORITY OF THE DISPLAY IS DETERMINED
   TO BE: FIRST    DISCHARGE FUNCTIONS
          SECOND   OVER-UNDER TEMP


FREE: (CASE 0 OF 'TEST')

   IT IS ASSUMED THAT NO BATTERY IS INSERTED IN THE DISCHARGE
   CONNECTOR.
   THE CONTENTS OF 'DISPNO' ARE SENT TO THE DISPLAY.
   BIT 5 OF PORT B IS TESTED TO DETERMINE IF A BATTERY OF GREATER
   THAN 6.0 VOLTS HAS BEEN INSERTED, AND IF NOT, CONTROL IS TRANSFERRED
   TO 'DEL', WHICH RETURNS CONTROL TO THE CALLING ROUTINE.
   OTHERWISE, 'TESTAT' IS CHANGED TO 1, POINTING TO 'DUMP' AND
   THE VALUE OF 'MINS' IS INITIALIZED TO '00' TO BEGIN
   TIMING THE DISCHARGE CYCLE.
   CONTROL PASSES THROUGH 'DEL' TO THE CALLING ROUTINE.

DUMP: (CASE 1 OF 'TEST')
   IT IS ASSUMED THAT A BATTERY IS BEING DISCHARGED.
   TRANSFERS 'DC' (DISCHARGE) TO THE DISPLAY, RATHER THAN THE
   VALUE SAVED IN 'DISPNO', AND CALLS 'TESTON' TO ENABLE THE
   CONSTANT CURRENT DISCHARGE OF THE TEST BATTERY. TESTS BIT 5 OF
   PORT B TO DETERMINE IF THE BATTERY HAS FINISHED DISCHARGING
   AND TRANSFERS CONTROL TO 'DEL' IF NOT. OTHERWISE, TURNS OFF THE
   DISCHARGE CURRENT SINK AND COPIES THE ACCUMULATED VALUE FROM 'MINS'
   FOR DISPLAY.
   'TESTAT' IS CHANGED TO 2, POINTING TO 'DEAD' AND CONTROL
   PASSES THROUGH 'DEL' BACK TO THE CALLING ROUTINE.

DEAD: (CASE 2,3 OF 'TEST')

   IT IS ASSUMED THAT THE BATTERY HAS BEEN DISCHARGED BELOW 6.0 VOLTS
   'BATIME', THE ACCUMULATED DISCHARGE TIME, IS TRANSFERRED TO THE
   DISPLAY.
   BIT 7 OF PORT B IS TESTED TO SEE IF THE BATTERY IS BELOW 3.0 VOLTS,
   INDICATING REMOVAL. IF THE BATTERY HAS NOT BEEN REMOVED, THEN
   CONTROL PASSES THROUGH 'DEL' BACK TO THE CALLING ROUTINE.
   IF THE BATTERY HAS BEEN REMOVED, THEN 'TESTAT' IS SET TO '0', POINTING
   TO CASE 'FREE' AGAIN, AND CONTROL IS PASSED THROUGH 'DEL' BACK TO
   THE CALLING ROUTINE.
```

CHARGE: (SUBROUTINE)

THIS IS THE MAIN BATTERY SERVICE ROUTINE. IT IS ENTERED WITH 'BATNUM' CONTAINING A POINTER TO THE BATTERY TO BE SERVICED, AND 'STAT' INDEXED BY BATNUM INDICATES THE CURRENT STATUS OF THAT BATTERY.

DEPENDING ON THE CONTENTS OF 'STAT'('BATNUM'), A COMPUTED INDIRECT JUMP IS MADE TO ONE OF 5 POSSIBLE CASES, 'NOBATT','RDY', 'UNSAFE','CHRG',OR 'DONE'.

NOBATT: (CASE 0 OF 'CHARGE')

IT IS ASSUMED THAT NO BATTERY IS INSTALLED IN THE N'TH CHARGING SOCKET. TWO CONSECUTIVE TESTS ARE MADE, SEPARATED BY 50 MS. TO DETERMINE IF THE SOCKET VOLTAGE IS > 7.2 V. IF EITHER FAILS, NO BATTERY PRESENT IS ASSUMED, AND CONTROL IS RETURNED TO TE CALLING ROUTINE WITHOUT CHANGE. IF BOTH PASS, THEN 'STAT' IS SET TO 1, POINTING TO 'RDY' FOR THIS BATTERY AND CONTROL IS RETURNED.

RDY: (CASE 1 OF 'CHARGE')

IT IS ASSUMED THAT A BATTERY GREATER THAN 7.2 VOLTS HAS BEEN FOUND IN THE SOCKET. A CALL IS MADE TO 'SETDTY' TO DETERMINE THE MAXIMUM CHARGE RATE FOR THIS BATTERY. IF 'SETDTY' RETURNS A NON-SAFE RESULT, (ZERO FLAG SET) THEN STAT FOR THIS BATTERY IS SET TO 2, POINTING TO 'UNSAFE', AND CONTROL IS RETURNED. IF 'SETDTY' RETURNS A SAFE CONDITION (ZERO FLAG CLR) THEN THE OPEN CIRCUIT BATTERY VOLTAGE IS MEASURED BY CALLING 'ADCONV' AND MULTIPLIED BY 0.612. THE RESULT IS COMPARED WITH THE VOLTAGE FROM THE BATTERY WITH THE AMBIENT THERMISTOR CONNECTED, AND IF THE RESULT IS TOO HIGH, 'STAT' IS SET TO 2 (UNSAFE, THE BATTERY IS ALREADY TO HOT) AND CONTROL IS RETURNED. IF THE VOLTAGE IS LOWER, THEN 'STAT' IS SET TO 3 (CHRG) AND CONTROL RETURNED IN THIS EVENT THE LED FOR THIS BATTERY IS TURNED OFF UNCONDITIONALLY, SINCE IT MAY HAVE HAS BEEN ON OR BLINKING.

UNSAFE: (CASE 2 OF 'CHARGE')

IT IS ASSUMED THAT A BATTERY IS IN THE SOCKET, BUT IT HAS BEEN MARKED AS UNSAFE TO CHARGE, DUE TO TEMPERATURE OF THE CELLS. FIRST A TEST IS MADE TO DETERMINE IF THE BATTERY HAS BEEN REMOVED BY CALLING 'MISNG'. IF IT IS FOUND TO HAVE BEEN REMOVED, THEN 'STAT' IS SET TO 0 ('NOBATT') AND THE INDICATOR IS UNCONDITIONALLY TURNED OFF, CONTROL IS RETURNED TO THE CALLING ROUTINE.
IF IT IS STILL THERE, A CALL IS MADE TO THE CASE 1 ROUTINE, WHICH ORIGINALLY DETERMINED THE STATUS OF THE BATTERY, FOR A RE-TEST. IF 'RDY' FINDS THE BATTERY ACCEPTABLE TO CHARGE, THE VALUE OF 'STAT' WILL HAVE BEEN CHANGED IN THAT ROUTINE TO 3. IF NOT IT WILL AGAIN BE RETURNED AS 2 'UNSAFE'. WHEN THE UNSAFE INDICATION IS RETURNED, THE VALUE OF 'BLINK' IS INCREMENTED ONCE FOR EACH EXECUTION, AND DEPENDING ON THE RESULTING STATE OF BIT 0 THE INDICATOR WILL BE TURNED ON OR OFF, CAUSING IT TO BLINK APPROX-IMATELY THREE TIMES PER SECOND AS LONG AS THE BATTERY REMAINS IN THIS STATE.
CONTROL IS RETURNED TO THE CALLING ROUTINE.

CHRG: (CASE 3 OF 'CHARGE')

IT IS ASSUMED THAT THE BATTERY IS NOW BEING CHARGED. FIRST A CALL TO 'SWIOFF' STOPS THE CHARGING CURRENT DURING THESE TESTS. A 10 MS. DELAY IS EXECUTED TO ALLOW THE CELL VOLTAGE TO STABALIZE. THE ABSOLUTE BATTERY VOLTAGE IS MEASURED BY CALLING 'ADCONV'. IF THE VOLTAGE IS GREATER THAN 9.15 V. THEN 'STAT' IS MARKED 'DONE' BY SETTING IT TO 4, AND CONTROL IS RETURNED TO THE CALLING ROUTINE. OTHERWISE, THE CELL VOLTAGE TIMES 0.625 IS COMPARED TO THE BATTERY VOLTAGE WITH THE AMBIENT THERMISTOR CONNECTED BY CALLING 'COMPAR'. IF THE CELL TEMPERATURE IS HIGHER THAN 10 DEG. C. ABOVE AMBIENT, THEN 'STAT' IS LIKEWISE MARKED 'DONE' DUE TO TEMPERATURE SHUTOFF, AND CONTROL IS RETURNED TO THE CALLING ROUTINE. OTHERWISE, A CALL IS MADE TO 'MISNG' IN THE EVENT THE BATTERY HAS BEEN REMOVED, AND IF SO, IT IS IMMEDIATELY MARKED 0 AND CONTROL IS RETURNED.
IF THE BATTERY IS NOT MISSING, NOT OVERVOLTAGE, AND NOT OVER-TEMPERATURE THEN CHARGING CONTINUES:
THE VALUE OF 'DUTY' SAVED FOR EACH BATTERY IS PRESET WITH ONES IN THE MOST SIGNIFICANT BITS, SUCH THAT ALL ONES INDICATES 100% CHARGE, AND LESS ONES INDICATES A LOWER PERCENTAGE CHARGE CUTY CYCLE. IT IS ROTATED RIGHT FOR EACH EXECUTION OF 'CHRG' AND IF THE LSB IS A ONE, CURRENT IS SUPPLIED TO THE BATTERY FOR THIS CYCLE. ALL ZEROES INDICATES THAT EITHER ALL ONES HAVE BEEN SHIFTED OUT TO THE RIGHT, OR THE REQUIRED DUTY CYCLE WAS 0%. IN EITHER CASE, A CALL IS MADE TO 'SETDTY' TO REFRESH THE VALUE. CONTROL IS RETURNED TO THE CALLING ROUTINE.

DONE: (CASE 4 OF 'CHARGE')

IT IS ASSUMED THAT THE BATTERY HAS BEEN CHARGED, AND IS WAITING TO BE REMOVED.
A CALL TO 'MISNG' DETERMINES IF THE BATTERY IS STILL THERE. IF IT IS THE LED IS TURNED ON (REPEATEDLY) AND CONTROL IS RETURNED. IF IT IS NOT STILL THERE, THE INDICATOR AND CHARGE CURRENT ARE TURNED OFF AND THE 'STAT' MARKED 'NOBATT' FOR A NEW CYCLE. CONTROL IS RETURNED TO THE CALLING ROUTINE.

SETDTY: (SUBROUTINE)

THE BATTERY TEMPERATURE IS PLACED IN ONE OF SEVERAL CATEGORIES BY COMPARING ONE HALF THE OPEN CIRCUIT VOLTAGE WITH THE VOLTAGE OBTAINED WITH VARIOUS FIXED RESISTORS CONNECTED IN PLACE OF THE AMBIENT THERMISTOR. A 'MASK' VALUE IS WRITTEN IN THE 'DUTY' LOCATION FOR A BATTERY WHICH INCLUDES THE EFFECTIVE CURRENT VALUE OF 'MDUTY' OR THE MASTER DUTY CYCLE WHICH IS DETERMINED FROM TRANSFORMER AND AMBIENT TEMPERATURES.

BATT TEMP	DUTY CYCLE
>=20 DEG	100 %
>=15 DEG	75 %
>=10 DEG	50 %
>= 5 DEG	25 %
< 5 DEG	00 %

DEL: (SUBROUTINE)

THIS SUBROUTINE DELAYS 40 MILLISECONDS BEFORE RETURNING CONTROL TO THE CALLER.

SYSTST: (MAINLINE SYSTEM TEST ROUTINE)

THIS ROUTINE IS NOT CALLED AS A SUBROUTINE, SINCE IT DESTROYS THE CONTENTS OF THE STACK AND IT'S RETURN ADDRESS.

USING THE POLYNOMIAL X↑8 + X↑5 + X↑3 + 1 , THE CYCLIC REDUNDENCY CHECK WORD IS CALCULATED FOR THE CONTENTS OF ALL READ ONLY MEMORY PRIOR TO THIS ADDRESS. IT IS COMPARED TO 'GOOD', WHICH HAS BEEN INDEPENDENTLY CALCULATED AND SUPPLIED TO THE PROGRAM AS AN EQUATE STATEMENT. ON FAILURE CONTROL IS PASSED TO 'FAILED', WHERE THE PROGRAM BECOMES TRAPPED, AND NO CHARGING OCCURS.

IF THE READ ONLY MEMORY HAS NO ERRORS, THEN THE RAM IS TESTED BY WRITING THE ADDRESS OF EACH CELL UPWARD THROUGH MEMORY, READING THEM BACKWARD AND TESTING EACH ONE, THEN INVERTING, WRITING BACK, AND TESTING EACH CELL. THIS INSURES THAT EACH LOCATION CAN BE UNIQUELY ADDRESSED AND THAT EACH BIT OF EACH CELL CAN BE WRITTEN AND READ. THIS IS NOT A FOOLPROOF TEST !!!!!

IF RAM AND ROM ARE BOTH ACCEPTED THEN CONTROL IS PASSES TO 'LOOP' WHICH IS THE MAIN BODY OF THE PROGRAM. OTHERWISE CONTROL IS PASSED TO 'FAILED' WHERE "FA" IS DISPLAYED AND NO CHARGING CAN OCCUR.

C. INTERRUPT SERVICE

IRQ: (THE INTERRUPT SERVICE ROUTINE)

THE INTERRUPT SERVICE FLIP-FLOP IS RESET (ACTIVE) BY A TRANSISTION OF THE BORROW OUTPUT OF THE COUNTER CONNECTED TO THE RECTIFIED POWER TRANSFORMER OUTPUT.
IT WILL REMAIN IN THAT STATE UNTIL SET BY A NEGATIVE PULSE FROM PORT B BIT 4, WHICH IS GENERATED WITHIN THE INTERRUPT SERVICE ROUTINE.
THE PURPOSE OF THE INTERRUPT SERVICE ROUTINE IS TO COUNT POWER LINE TRANSISTIONS AND ACCUMULATE A VALUE 'MINS', WHICH MAY BE USED TO INDICATE THE NUMBER OF MINUTES THAT WERE REQUIRED TO DISCHARGE THE TEST BATTERY, OR ALTERNATELY THE PERCENT OF FULL CHARGE CONTAINED IN THAT BATTERY. 720 INTERRUPTS ARE REQUIRED TO ADVANCE THE CONTENTS OF 'MINS' ONE COUNT. THE POWER LINE SIGNAL IS FULLWAVE RECTIFIED PROVIDING 120 PULSES PER SECOND AT 60 HZ., AND 100 PULSES PER SECOND AT 50 HZ.

OPTIONAL TRACE CUTTING ON THE CIRCUIT BOARD ALLOWS THE FOLLOWING:

DIVIDER MODULO = 10 POWER LINE FREQ = 60 HZ.

PROVIDES 12 INTERRUPTS PER SECOND OR 720 PER COUNT CAUSING THE OPTION DISPLAY TO READ 'MINUTES' OF DISCHARGE, 00-99

DIVIDER MODULO = 6 POWER LINE FREQ = 60 HZ.

PROVIDES 20 INTERRUPTS PER SECOND OR 720 PER COUNT CAUSING THE OPTION DISPLAY TO READ 'PERCENT' OF ONE HOUR DISCHARGE, 00-99

DIVIDER MODULO = 5 POWER LINE FREQ = 50

PROVIDES 20 INTERRUPTS PER SECOND OR 720 PER COUNT CAUSING THE OPTION DISPLAY TO READ 'PERCENT' OF ONE HOUR DISCHARGE, 00-99

** NO PROVISION IS MADE TO INDICATE MINUTES AT 50 HZ.

EOF

SOFTWARE LISTING

```
LINE #  LOC   CODE    LINE

0002  0000           ;
0003  0000           ;*****************************************************
0004  0000           ;*
0005  0000           ;* MPR I HR MULTI CHARGER CONTROLLER V2.7 09 MAY 79
0006  0000           ;*
0007  0000           ;*****************************************************
0008  0000           ;
0009  0000           ;
0010  0000           ;HARDWARE DEPENDANT ADDRESSES
0011  0000           ;----------------------------
0012  0000           ;
0013  0000           RAMBAS = $0000          ;BEGIN RAM
0014  0000           RAMSIZ = 64             ;NR BYTES RAM
0015  0000           STACK  = RAMBAS+RAMSIZ-1
0016  0000           ROMBAS = $C00           ;PERMANENT
0017  0000           ROMSIZ = 1024
0018  0000           NMI    = IRQ
0019  0000           IOBASE = $40
0020  0000           PRA    = IOBASE+0
0021  0000           PRB    = IOBASE+2
0022  0000           SETIME = IOBASE+7       ;1024 X TIMER NO INTRPT
0023  0000           RDTIME = IOBASE+5
0024  0000           ;
0025  0000           ;CONSTANTS
0026  0000           ;---------
0027  0000           ;
0028  0000           TIME   = 10             ; DELAY IN LOOP
0029  0000           TMAX   = $23            ;HIGHEST AMBIENT TEMP
0030  0000           TMIN   = $64            ;LOWEST AMBIENT TEMP
0031  0000           OFF    = %10111111      ;SWITCH OFF MASK
0032  0000           ON     = %01000000      ;SWITCH ON MASK
0033  0000           LOFF   = %01111111      ;LED OFF MASK
0034  0000           LON    = %10000000      ;LED ON MASK
0035  0000           ATEMP  = %00111110      ;RT1 AND R43 TO MUX
0036  0000           BTEMP  = %00111000      ;RT1 AND BATT
0037  0000           BTEM20 = %00011000      ;R47 AND BATT TO MUX
0038  0000           BTEM15 = %00100000      ;R48 AND BATT TO MUX
0039  0000           BTEM10 = %00101000      ;R49 AND BATT TO MUX
0040  0000           BTEM05 = %00110000      ;R50 AND BATT TO MUX
0041  0000           XTEMP  = %00001111      ;RT2 AND R45 O MUX
0042  0000           TST80  = 85             ;80 DEG C VALUE
0043  0000           TST70  = 74             ;70
0044  0000           TST60  = 62             ;60
0045  0000           MSK100 = %11111111      ;100 % DUTY CYCLE
0046  0000           MASK75 = %11111100
0047  0000           MASK50 = %11110000      ;50  %
0048  0000           MASK25 = %11000000      ;25  %
0049  0000           MASK00 = %00000000      ;00  %
0050  0000           V7X2   = 184            ;(7.2/10)*256
0051  0000           V3X0   = 77             ;(3.0/10)*256
0052  0000           V9X1   = 232            ;(9.1/10)*256
0053  0000           CLRMSK = %11101111      ;BIT 4 RESETS FF
0054  0000           IRQMSK = %00010000      ;BIT 4 ALLOWS FF
0055  0000           ;
0056  0000           ;ZERO PAGE ASSIGNMENTS
```

```
LINE # LOC      CODE        LINE

0057  0000                ;---------------------
0058  0000                ;
0059  0000                        *=0
0060  0000                STAT    *=*+6           ;CURRENT STATUS WORD
0061  0006                DUTY    *=*+6           ;CURRENT DUTY CYCLE
0062  000C                BLINK   *=*+6
0063  0012                MDUTY   *=*+1           ;TRANSFORMER TEMP
0064  0013                TIC     *=*+1           ;FRAC SECOND
0065  0014                SECS    *=*+1           ;SECOND
0066  0015                MIN     *=*+1           ;MINUTES (DECIMAL) 0-99
0067  0016                BATNUM  *=*+1           ;INDEX TO ACTIVE BATT
0068  0017                TESTAT  *=*+1           ;TEST BATTERY STATUS
0069  0018                DISPNO  *=*+1           ;NUMBER TO DISPLAY
0070  0019                MASK    *=*+1           ;VARIABLE MASK FOR A-D CONV
0071  001A                JMPLOC  *=*+2           ;JMP IND HERE TO CASE(N)
0072  001C                REG     *=*+1           ;REGISTER FOR SETDTY
0073  001D                BATIME  *=*+1           ;TIME TO DISPLAY
0074  001E                ;
0075  001E                ;BEGINNING OF ROM
0076  001E                ;----------------
0077  001E                ;
0078  001E                        *=ROMBAS
0079  0C00                ;
0080  0C00  4C 22 0C             JMP RESET
0081  0C03                ;
0082  0C03                ;INITIALIZATION TABLE
0083  0C03                ;--------------------
0084  0C03                ;
0085  0C03                ;I/O SETUP IMAGE
0086  0C03                ;
0087  0C03                TABL1
0088  0C03  00                   .BYTE %00000000 ;PRA
0089  0C04  FF                   .BYTE %11111111 ;DDRA
0090  0C05  16                   .BYTE %00010110 ;PRB
0091  0C06  1F                   .BYTE %00011111 ;DDRB
0092  0C07  01                   .BYTE %00000001 ;TIMER IX NO INT
0093  0C08                ;
0094  0C08                ;ZERO PAGE IMAGE
0095  0C08                ;---------------
0096  0C08                ;
0097  0C08                TABL2
0098  0C08  00                   .BYTE 0,0,0,0,0,0 ;INITIAL STATUS
0098  0C09  00
0098  0C0A  00
0098  0C0B  00
0098  0C0C  00
0098  0C0D  00
0099  0C0E  00                   .BYTE 0,0,0,0,0,0 ;INITIAL DUTY CYCLE
0099  0C0F  00
0099  0C10  00
0099  0C11  00
0099  0C12  00
0099  0C13  00
0100  0C14  00                   .BYTE 0,0,0,0,0,0 ;INITIAL BLINK BIT
0100  0C15  00
```

```
LINE # LOC     CODE       LINE

0100  0C16  00
0100  0C17  00
0100  0C18  00
0100  0C19  00
0101  0C1A  00                    .BYTE 0          ;INITIAL MASTER DUTY CYCLE
0102  0C1B  0C                    .BYTE 12,60,0    ;INITIAL TIME
0102  0C1C  3C
0102  0C1D  00
0103  0C1E  00                    .BYTE 0          ;INITIAL BATT NO.
0104  0C1F  00                    .BYTE 0          ;INITIAL TEST BATT STAT
0105  0C20  00                    .BYTE 0          ;INITIAL DISP NUM
0106  0C21  C0                    .BYTE %11000000  ;INITIAL MASK
0107  0C22                     ;
0108  0C22                     ;COLD START VECTORS HERE TO INITIALIZE
0109  0C22                     ;
0110  0C22                     RESET
0111  0C22                     ;
0112  0C22                     ;SET UP STACK POINTER
0113  0C22                     ;
0114  0C22  A2 3F                      LDX #RAMSIZ-1
0115  0C24  9A                        TXS
0116  0C25                     ;
0117  0C25                     ;THEN THE I/O MUST BE SETUP
0118  0C25                     ;
0119  0C25  A2 03                      LDX #3           ;NO. OF LOCS
0120  0C27                     RES1
0121  0C27  BD 03 0C                  LDA TABL1,X      ;GET BYTE FROM TABLE
0122  0C2A  95 40                     STA IOBASE,X     ;WRITE IT TO PIA
0123  0C2C  CA                        DEX              ;NEXT
0124  0C2D  10 F8                     BPL RES1         ;LOOP UNTIL DONE
0125  0C2F                     ;
0126  0C2F                     ;THEN BATTERIES MUST BE MADE SAFE
0127  0C2F                     ;AND INDICATORS TURNED OFF
0128  0C2F                     ;
0129  0C2F  A2 05                      LDX #5           ;SIX PORTS ON 74LS259
0130  0C31                     RES3
0131  0C31  20 35 0D                  JSR SWIOFF       ;TURN OFF SWITCH
0132  0C34  20 46 0D                  JSR LEDOFF       ;TURN OFF LED
0133  0C37  CA                        DEX              ;NEXT
0134  0C38  10 F7                     BPL RES3         ;LOOP UNTIL DONE
0135  0C3A  20 5C 0D                  JSR TSTOFF       ;THE TEST BATT TOO
0136  0C3D  4C 40 0F                  JMP SYSTST       ;CHECK THE HARDWARE VALIDITY
0137  0C40                     ;
0138  0C40                     ;RETURN HERE IF HARDWARE IS OK
0139  0C40                     ;
0140  0C40                     RESET1
0141  0C40  78                        SEI              ;DISABLE INTS
0142  0C41  D8                        CLD              ;CLEAR DECIMAL MODE
0143  0C42  A2 3F                     LDX #STACK
0144  0C44  9A                        TXS              ;INITIALIZE STACK POINTER ***
0145  0C45  A9 00                     LDA #0           ;DEFAULT DISPLAY VALUE
0146  0C47  85 18                     STA DISPNO
0147  0C49                     ;
0148  0C49  A2 19                      LDX #MASK        ;MOVE ZERO PG VAR
0149  0C4B                     RES2
```

```
LINE # LOC     CODE        LINE

0150  0C4B  BD 08 0C          LDA TABL2,X     ;GET VALUE
0151  0C4E  95 00             STA RAMBAS,X    ;PUT VALUE
0152  0C50  CA                DEX             ;COUNT
0153  0C51  10 F8             BPL RES2
0154  0C53                ;
0155  0C53                ;
0156  0C53                ;******** MAIN LOOP ********
0157  0C53                ;
0158  0C53                LOOP
0159  0C53  20 61 0D          JSR TEST        ;SERVICE THE TEST BATT AND DISP
0160  0C56  58                CLI             ;ALLOW INTERRUPTS NOW
0161  0C57  A0 23             LDY #TMAX       ;AMB TEMP LIMIT (HOT)
0162  0C59  A2 3E             LDX #ATEMP      ;ADDRESS THE AMB THERM
0163  0C5B  20 1B 0D          JSR CMPDAC      ;MAKE TEST
0164  0C5E  30 09             BMI LOOP1       ;BRANCH IF OK
0165  0C60  A9 EA             LDA #$EA        ;"EXCESS AMBIENT"
0166  0C62  85 18             STA DISPNO      ;SHOW IT
0167  0C64                LOOP4
0168  0C64  A9 00             LDA #MASK00     ;KILL ALL BATTS
0169  0C66  4C 9A 0C          JMP LOOP12      ;SKIP XFMR TST
0170  0C69                LOOP1
0171  0C69  A0 64             LDY #TMIN       ;AMB TEMP LIMIT (COLD)
0172  0C6B  20 1B 0D          JSR CMPDAC      ;MAKE TEST
0173  0C6E  10 07             BPL LOOP3       ;BRANCH IF OK
0174  0C70  A9 C0             LDA #$C0        ;"COLD"
0175  0C72  85 18             STA DISPNO
0176  0C74  4C 64 0C          JMP LOOP4
0177  0C77                ;
0178  0C77                ;DETERMINE THE XFMR TEMP AND
0179  0C77                ;LIMIT DUTY CYCLE ACCORDINGLY
0180  0C77                ;
0181  0C77                LOOP3
0182  0C77  A9 00             LDA #0
0183  0C79  85 18             STA DISPNO      ;SHOW SAFE IN DISP
0184  0C7B  A2 0F             LDX #XTEMP      ;XFMR TEMP MEAS
0185  0C7D  20 F3 0C          JSR ADCONV      ;READ XFMR TEMP
0186  0C80  C9 3E             CMP #TST60
0187  0C82  B0 04             BCS LOOP6       ;BR IF T>60
0188  0C84  A9 FF             LDA #MSK100
0189  0C86  D0 12             BNE LOOP12
0190  0C88                LOOP6
0191  0C88  C9 4A             CMP #TST70
0192  0C8A  B0 04             BCS LOOP7       ;BR IF T>70
0193  0C8C  A9 F0             LDA #MASK50
0194  0C8E  D0 0A             BNE LOOP12
0195  0C90                LOOP7
0196  0C90  C9 55             CMP #TST80
0197  0C92  B0 04             BCS LOOP8       ;BR IF T>80
0198  0C94  A9 C0             LDA #MASK25
0199  0C96  D0 02             BNE LOOP12
0200  0C98                LOOP8
0201  0C98  A9 00             LDA #MASK00
0202  0C9A                LOOP12
0203  0C9A  85 12             STA MDUTY       ;STORE LIMIT MASK
0204  0C9C                ;
```

```
LINE # LOC     CODE        LINE

0205  0C9C                ;CHARGE THE BATTERY ADDRESSED BY THE
0206  0C9C                ;CONTENTS OF BATNUM
0207  0C9C                ;
0208  0C9C  20 C0 0D             JSR CHARGE
0209  0C9F                ;
0210  0C9F                ;INDEX TO THE NEXT BATT AND
0211  0C9F                ;TEST FOR FINISHED
0212  0C9F                ;
0213  0C9F  E6 16             INC BATNUM      ;NEXT BATT
0214  0CA1  A9 05             LDA #5          ;TEST VAL
0215  0CA3  C5 16             CMP BATNUM      ;DONE ?
0216  0CA5  B0 04             BCS LOOP5
0217  0CA7  A9 00             LDA #0          ;RESTART AT FIRST BATT
0218  0CA9  85 16             STA BATNUM
0219  0CAB                LOOP5
0220  0CAB  4C 53 0C          JMP LOOP        ;AND CONTINUE
0221  0CAE                ;
0222  0CAE                ;******** SUBROUTINE DISPLA  ********
0223  0CAE                ;
0224  0CAE                ;STORE THE A REG INTO THE OPTION DISPLAY
0225  0CAE                ;A,P,LATCH MODIFIED
0226  0CAE                ;
0227  0CAE                DISPLA
0228  0CAE  85 40             STA PRA         ;PUT IN PORT
0229  0CB0  20 BF 0C          JSR CLKL        ;SHIFT TO LATCH
0230  0CB3  A9 08             LDA #%00001000 ;TO SET BIT 3
0231  0CB5  05 42             ORA PRB         ;COMBINE WITH PORT
0232  0CB7  85 42             STA PRB
0233  0CB9  49 08             EOR #%00001000 ;CLEAR SAME BIT
0234  0CBB  85 42             STA PRB         ;AND RESTORE PORT
0235  0CBD  60                RTS
0236  0CBE                ;
0237  0CBE  60             RTS
0238  0CBF                ;
0239  0CBF                ;
0240  0CBF                ;******** SUBTOUTINE CLKL ********
0241  0CBF                ;
0242  0CBF                ;--FOR ALL FUNCTIONS EXCEPT D-A CONV--
0243  0CBF                ;CLOCK THE CONTENTS OF PRA INTO THE LATCH
0244  0CBF                ;P MODIFIED
0245  0CBF                ;
0246  0CBF                CLKL
0247  0CBF  E6 42             INC PRB         ;LSB == 1
0248  0CC1  C6 42             DEC PRB         ;LSB == 0
0249  0CC3  60                RTS
0250  0CC4                ;
0251  0CC4                ;
0252  0CC4                ;******** SUBROUTINE CLKS ********
0253  0CC4                ;
0254  0CC4                ;--FOR THE SWITCHES--
0255  0CC4                ;CLOCK THE DATA ON LATCH BIT 6 TO THE
0256  0CC4                ;OUTPUT PIN ADDRESSED BY THE 3 LSB OF
0257  0CC4                ;THE LATCH
0258  0CC4                ;A,P MODIFIED
0259  0CC4                ;
```

```
LINE # LOC     CODE        LINE

0260  0CC4                CLKS
0261  0CC4  A9 FD                LDA #%11111101 ;MASK TO CLR BIT 1
0262  0CC6  25 42                AND PRB        ;PRESERVE OLD
0263  0CC8  85 42                STA PRB        ;STORE NEW
0264  0CCA  09 02                ORA #%00000010 ;RESTORE BIT
0265  0CCC  85 42                STA PRB        ;AND REPLACE IT
0266  0CCE  60                   RTS
0267  0CCF                ;
0268  0CCF                ;
0269  0CCF                ;******** SUBROUTINE CLKI ********
0270  0CCF                ;
0271  0CCF                ;--FOR THE LEDS--
0272  0CCF                ;CLOCK THE DATA ON LATCH BIT 7 TO THE
0273  0CCF                ;OUTPUT PIN ADDRESSED BY THE 3 LSB OF
0274  0CCF                ;THE LATCH
0275  0CCF                ;A,P MODIFIED
0276  0CCF                ;
0277  0CCF                CLKI
0278  0CCF  A9 FB                LDA #%11111011 ;MASK TO CLR BIT 2
0279  0CD1  25 42                AND PRB        ;PRESERVE OLD
0280  0CD3  85 42                STA PRB        ;STORE NEW
0281  0CD5  09 04                ORA #%00000100 ;RESTORE BIT
0282  0CD7  85 42                STA PRB        ;AND REPLACE IT
0283  0CD9  60                   RTS
0284  0CDA                ;
0285  0CDA                ;
0286  0CDA                ;******** SUBROUTINE MISNG ********
0287  0CDA                ;
0288  0CDA                ;COMPARE THE BATTERY VOLTS WITH 3.0 TO
0289  0CDA                ;SEE IF IT IS STILL IN THE SOCKET
0290  0CDA                ;RETURN SIGN NEG IF STILL THERE
0291  0CDA                ;
0292  0CDA                MISNG
0293  0CDA  A0 4D                LDY #V3X0      ;3 VOLTS
0294  0CDC  A5 16                LDA BATNUM     ;GET BATT NO.
0295  0CDE  20 1A 0D             JSR COMPAR     ;COMPARE A,VOLTS
0296  0CE1  30 0F                BMI MISS01     ;STILL THERE
0297  0CE3  A9 32                LDA #50        ;50 MS. WAIT
0298  0CE5  85 47                STA SETIME     ;SETUP TIMER
0299  0CE7                MISS02
0300  0CE7  24 45                BIT RDTIME     ;TEST FOR TIMEOUT
0301  0CE9  10 FC                BPL MISS02
0302  0CEB  A5 16                LDA BATNUM     ;GET NO. BACK
0303  0CED  A0 4D                LDY #V3X0      ;RESTORE TEST VAL
0304  0CEF  20 1A 0D             JSR COMPAR     ;RETEST IT
0305  0CF2                MISS01
0306  0CF2  60                   RTS
0307  0CF3                ;
0308  0CF3                ;******** SUBROUTINE ADCONV ********
0309  0CF3                ;
0310  0CF3                ;STORE X IN LATCHES AND RETURN THE
0311  0CF3                ;RESULTING MEASUREMENT IN ACC
0312  0CF3                ;
0313  0CF3                ADCONV
0314  0CF3  86 40                STX PRA        ;STORE X
```

```
LINE #  LOC    CODE        LINE

0315   0CF5   20 BF 0C            JSR CLKL        ;LATCH IT
0316   0CF8   A9 C0              LDA #$C0        ;SET UP MASK
0317   0CFA   85 19              STA MASK        ;IN ZERO PAGE
0318   0CFC   0A                 ASL A           ;ACC == $80
0319   0CFD   85 40              STA PRA         ;DRIVE THE DAC
0320   0CFF                   ADTEST
0321   0CFF   20 2F 0D           JSR DLY         ;ANALOG SETTLE TIME
0322   0D02   24 42              BIT PRB         ;TEST MSB FOR COMPARATOR STATE
0323   0D04   30 09              BMI ADINCR      ;BRANCH IF V(DAC) < V(UNKN)
0324   0D06   A5 19              LDA MASK        ;GET CURRENT MASK
0325   0D08   45 40              EOR PRA         ;CLEAR CURRENT BIT
0326   0D0A   85 40              STA PRA         ;AND SET THE NEXT LOWER ONE
0327   0D0C   4C 15 0D           JMP ADEND
0328   0D0F                   ADINCR
0329   0D0F   A5 19              LDA MASK        ;GET CURRENT MASK
0330   0D11   05 40              ORA PRA         ;LEAVE CURRENT BIT SET
0331   0D13   85 40              STA PRA         ;AND SET THE NEXT LOWER ONE
0332   0D15                   ADEND
0333   0D15   46 19              LSR MASK        ;SHIFT MASK FOR LOWER BIT
0334   0D17   D0 E6              BNE ADTEST      ;BRANCH IF NOT DONE
0335   0D19   60                 RTS             ;RETURN WHEN MASK IS EMPTY
0336   0D1A                   ;
0337   0D1A                   ;******** SUBROUTINE CMPDAC ********
0338   0D1A                   ;******** SUBROUTINE COMPAR ********
0339   0D1A                   ;
0340   0D1A                   ;COMPARE THE CONTENTS OF THE Y REG WITH
0341   0D1A                   ;THE ANALOG INPUT ADDRESSED BY THE X REG
0342   0D1A                   ;ALTERNATE ENTRY COMPAR IF ACC=ADDR
0343   0D1A                   ;
0344   0D1A                   ;RETURN:  SIGN=1 IF Y > UNKN
0345   0D1A                   ;         SIGN=0 IF Y < UNKN
0346   0D1A                   ;
0347   0D1A                   ;A,P,Y,LATCH MODIFIED
0348   0D1A                   ;
0349   0D1A                   COMPAR
0350   0D1A   AA                    TAX
0351   0D1B                   CMPDAC
0352   0D1B   A9 16              LDA #%00010110 ;TO PURGE LEAKAGE
0353   0D1D   85 40              STA PRA
0354   0D1F   20 BF 0C           JSR CLKL
0355   0D22   86 40              STX PRA         ;OUTPUT THE ADDRESS
0356   0D24   20 BF 0C           JSR CLKL        ;AND LATCH IT
0357   0D27   84 40              STY PRA         ;OUTPUT THE TEST VAL
0358   0D29   20 2F 0D           JSR DLY         ;WAIT FOR SETTLING
0359   0D2C   24 42              BIT PRB         ;TEST THE RESULT
0360   0D2E   60                 RTS
0361   0D2F                   ;
0362   0D2F                   ;
0363   0D2F                   ;******** SUBROUTINE DLY ********
0364   0D2F                   ;
0365   0D2F                   ;EXECUTES A DEAD LOOP FOR (TIME) COUNTS
0366   0D2F                   ;Y,P MODIFIED
0367   0D2F                   ;
0368   0D2F                   DLY
0369   0D2F   A0 0A                 LDY #TIME       ;GET VALUE OF DELAY
```

```
LINE # LOC     CODE        LINE

0370  0D31                DLY1
0371  0D31  88                    DEY
0372  0D32  D0 FD                 BNE DLY1
0373  0D34  60                    RTS
0374  0D35                ;
0375  0D35                ;
0376  0D35                ;******** SUBROUTINE SWIOFF ********
0377  0D35                ;
0378  0D35                ;TURN OFF THE CURRENT TO THE BATTERY
0379  0D35                ;ADDRESSED BY THE (X) REG
0380  0D35                ;A,P MODIFIED
0381  0D35                ;
0382  0D35                SWIOFF
0383  0D35  8A                    TXA             ;FETCH THE BATT NO.
0384  0D36  29 BF                 AND #OFF        ;CLEAR BIT 6
0385  0D38                SWI1
0386  0D38  85 40                 STA PRA
0387  0D3A  20 BF 0C              JSR CLKL        ;SHIFT TO LATCH
0388  0D3D  20 C4 0C              JSR CLKS        ;SHIFT TO OUTPUT
0389  0D40  60                    RTS
0390  0D41                ;
0391  0D41                ;
0392  0D41                ;******** SUBROUTINE SWION ********
0393  0D41                ;
0394  0D41                ;TURN ON THE CURRENT TO THE BATTERY
0395  0D41                ;ADDRESSED THE THE (X) REG
0396  0D41                ;A,P MODIFIED
0397  0D41                ;
0398  0D41                SWION
0399  0D41  8A                    TXA             ;FETCH THE BATT NO.
0400  0D42  09 40                 ORA #ON         ;SET BIT 6
0401  0D44  D0 F2                 BNE SWI1        ;BRANCH ALWAYS
0402  0D46                ;
0403  0D46                ;
0404  0D46                ;******** SUBROUTINE LEDOFF ********
0405  0D46                ;
0406  0D46                ;TURN OFF THE LED ADDRESSED BY
0407  0D46                ;THE (X) REG
0408  0D46                ;A,P MODIFIED
0409  0D46                ;
0410  0D46                LEDOFF
0411  0D46  8A                    TXA             ;FETCH THE BATT NO.
0412  0D47  29 7F                 AND #LOFF       ;CLEAR BIT 7
0413  0D49                OFF1
0414  0D49  85 40                 STA PRA         ;TO PORT
0415  0D4B  20 BF 0C              JSR CLKL        ;TO LATCH
0416  0D4E  20 CF 0C              JSR CLK1        ;TO LEDS
0417  0D51  60                    RTS
0418  0D52                ;
0419  0D52                ;
0420  0D52                ;******** SUBROUTINE LEDON ********
0421  0D52                ;
0422  0D52                ;TURN ON THE LED ADDRESSED BY
0423  0D52                ;THE (X) REG
0424  0D52                ;A,P MODIFIED
```

```
LINE # LOC     CODE        LINE

0425  0D52                ;
0426  0D52                LEDON
0427  0D52  8A                    TXA             ;FETCH THE BATT NO.
0428  0D53  09 80                 ORA #LON        ;SET BIT 7
0429  0D55  D0 F2                BNE OFF1        ;BRANCH ALWAYS
0430  0D57                ;
0431  0D57                ;******** SUBROUTINE TESTON ********
0432  0D57                ;
0433  0D57                ;TURN ON THE TEST BATTERY DRAIN
0434  0D57                ;A,P MODIFIED
0435  0D57                ;
0436  0D57                TESTON
0437  0D57  A9 47                LDA #%01000111  ;BIT 7 SW LATCH ON
0438  0D59  4C 38 0D            JMP SWI1        ;CLOCK AND EXIT
0439  0D5C                ;
0440  0D5C                ;******** SUBROUTINE TSTOFF ********
0441  0D5C                ;
0442  0D5C                ;TURN OFF THE TEST BATT DRAIN
0443  0D5C                ;A,P MODIFIED
0444  0D5C                ;
0445  0D5C                TSTOFF
0446  0D5C  A9 07                LDA #%00000111  ;BIT 7 SW LATCH
0447  0D5E  4C 38 0D            JMP SWI1        ;CLOCK AND EXIT
0448  0D61                ;
0449  0D61                ;****** SUBROUTINE TO SERVICE THE TEST BATTERY *******
0450  0D61                ;
0451  0D61                ;TEST VOLTAGE AND HISTORY AND DO INDICATED JOB
0452  0D61                ;
0453  0D61                TEST
0454  0D61  A5 17                LDA TESTAT      ;GET HISTORY
0455  0D63  29 03                AND #3          ;MASK JUST IN CASE
0456  0D65  0A                  ASL A           ;TIMES 2
0457  0D66  AA                  TAX             ;TO INDEX
0458  0D67  BD 74 0D            LDA TTABL,X     ;PUT VECTOR IN IND JUMP LOC
0459  0D6A  85 1A                STA JMPLOC
0460  0D6C  BD 75 0D            LDA TTABL+1,X
0461  0D6F  85 1B                STA JMPLOC+1
0462  0D71  6C 1A 00            JMP (JMPLOC)    ;GO DO IT
0463  0D74                TTABL
0464  0D74  7C 0D                .WORD FREE,DUMP,DEAD,DEAD
0464  0D76  92 0D
0464  0D78  AE 0D
0464  0D7A  AE 0D
0465  0D7C                ;
0466  0D7C                ;CASE FREE ---- NO BATT IN TEST SOCKET
0467  0D7C                ;
0468  0D7C                FREE
0469  0D7C  A5 18                LDA DISPNO      ;
0470  0D7E  20 AE 0C            JSR DISPLA
0471  0D81  A9 20                LDA #%00100000
0472  0D83  25 42                AND PRB
0473  0D85  F0 08                BEQ FRE1        ;BRANCH IF NO BATT
0474  0D87  A9 01                LDA #1
0475  0D89  85 17                STA TESTAT
0476  0D8B  A9 00                LDA #0
```

```
LINE # LOC     CODE       LINE

0477  0D8D  85 15             STA MIN          ;SET CLOCK
0478  0D8F                FREI
0479  0D8F  4C 37 0F          JMP DEL          ;EXIT THROUGH DELAY ROUTINE
0480  0D92                   ;
0481  0D92                   ;CASE DUMP ---- FOUND BATT IN SOCKET
0482  0D92                   ;
0483  0D92                   DUMP
0484  0D92  A9 DC             LDA #$DC         ;'DISCHARGE'
0485  0D94  20 AE 0C          JSR DISPLA
0486  0D97  20 57 0D          JSR TESTON       ;DISCHARGE IT
0487  0D9A  A9 20             LDA #%00100000
0488  0D9C  25 42             AND PRB
0489  0D9E  D0 0B             BNE DUMI         ;BRANCH IF NOT DEAD YET
0490  0DA0  A9 03             LDA #3
0491  0DA2  85 17             STA TESTAT
0492  0DA4  20 5C 0D          JSR TSTOFF
0493  0DA7  A5 15             LDA MIN          ;GET ELAPSED TIME
0494  0DA9  85 1D             STA BATIME       ;FOR DISPLAY
0495  0DAB                   DUMI
0496  0DAB  4C 37 0F          JMP DEL          ;EXIT THROUGH DELAY
0497  0DAE                   ;
0498  0DAE                   ;CASE DEAD ---- RAN IT DOWN, WAIT REMOVAL
0499  0DAE                   ;
0500  0DAE                   DEAD
0501  0DAE  A5 1D             LDA BATIME
0502  0DB0  20 AE 0C          JSR DISPLA       ;SHOW IT
0503  0DB3  A9 40             LDA #%01000000
0504  0DB5  25 42             AND PRB
0505  0DB7  F0 04             BEQ DEAD1        ;BRANCH IF NOT REMOVED
0506  0DB9  A9 00             LDA #0
0507  0DBB  85 17             STA TESTAT
0508  0DBD                   DEAD1
0509  0DBD  4C 37 0F          JMP DEL
0510  0DC0                   ;
0511  0DC0                   ;******** SUBROUTINE TO CHARGE ONE BATT ********
0512  0DC0                   ;          FOR ONE CYCLE
0513  0DC0                   ;
0514  0DC0                   ;BATNUM CONTAINS THE NUMBER OF THE BATTERY TO BE
0515  0DC0                   ;SERVICED ON THIS PASS
0516  0DC0                   ;STAT (BATNUM) CONTAINS THE LAST KNOWN STATUS OF
0517  0DC0                   ;THAT BATTERY
0518  0DC0                   ;
0519  0DC0                   ;THERE ARE FIVE POSSIBILITIES:
0520  0DC0                   ;
0521  0DC0                   ;   0  NO BATT IN SOCKET:     GOTO NOBATT
0522  0DC0                   ;   1  UNKN BATT IN SOCKET    GOTO RDY
0523  0DC0                   ;   2  BAD BATT IN SOCKET     GOTO UNSAFE
0524  0DC0                   ;   3  GOOD BATT IN SOCKET    GOTO CHRG
0525  0DC0                   ;   4  FINISHED               GOTO DONE
0526  0DC0                   ;
0527  0DC0                   CHARGE
0528  0DC0  A6 16             LDX BATNUM       ;GET THE NEXT BATT NO.
0529  0DC2  B5 00             LDA STAT,X       ;GET STAT FOR THAT BATT
0530  0DC4  29 07             AND #7           ;STRIP TO 3 BITS
0531  0DC6  0A               ASL A            ;TIMES 2
```

```
LINE # LOC      CODE        LINE

0532  0DC7  AA                    TAX             ;X=STAT*2
0533  0DC8  BD D5 0D              LDA JTABL,X     ;GET LO PC FRM TBL
0534  0DCB  85 1A                 STA JMPLOC
0535  0DCD  BD D6 0D              LDA JTABL+1,X   ;GET HI PC FRM TBL
0536  0DD0  85 1B                 STA JMPLOC+1
0537  0DD2  6C 1A 00              JMP (JMPLOC)    ;DO CASE (STAT)
0538  0DD5                  ;
0539  0DD5                  ;
0540  0DD5                  ;JUMP TABLE FOR  DO CASE (STAT(BATNUM))
0541  0DD5                  ;
0542  0DD5                  JTABL
0543  0DD5  DF 0D                   .WORD NOBATT    ;CASE 0
0544  0DD7  FF 0D                   .WORD RDY       ;CASE 1
0545  0DD9  2D 0E                   .WORD UNSAFE    ;CASE 2
0546  0DDB  50 0E                   .WORD CHRG      ;CASE 3
0547  0DDD  9E 0E                   .WORD DONE      ;CASE 4
0548  0DDF                  ;
0549  0DDF                  ;
0550  0DDF                  ;---- CASE 0 -- NOBATT ----
0551  0DDF                  ;
0552  0DDF                  ;SEE IF A BATT HAS BEEN INSERTED
0553  0DDF                  ;IF V>7.2 THEN SET STAT(N)=RDY
0554  0DDF                  ;ELSE DO NOTHING
0555  0DDF                  ;
0556  0DDF                  NOBATT
0557  0DDF  A0 B8                   LDY #V7X2
0558  0DE1  A5 16                   LDA BATNUM      ;FOR BATT VOLTS
0559  0DE3  AA                      TAX
0560  0DE4  20 1B 0D                JSR CMPDAC      ;MAKE TEST
0561  0DE7  10 15                   BPL NOB1        ;JMP IF V(BATT) < 7.2
0562  0DE9  A9 32                   LDA #50
0563  0DEB  85 47                   STA SETIME      ;START TIMER FOR 50 MS.
0564  0DED                  NOB2
0565  0DED  24 45                   BIT RDTIME      ;DONE ?
0566  0DEF  10 FC                   BPL NOB2
0567  0DF1  A0 B8                   LDY #V7X2       ;RESTORE Y
0568  0DF3  20 1B 0D                JSR CMPDAC      ;RE-TEST TO DEBOUNCE
0569  0DF6  10 06                   BPL NOB1
0570  0DF8  A9 01                   LDA #1          ;MAKE STAT RDY
0571  0DFA  A6 16                   LDX BATNUM
0572  0DFC  95 00                   STA STAT,X      ;UPDATE STAT
0573  0DFE                  NOB1
0574  0DFE  60                      RTS             ;FINISHED
0575  0DFF                  ;
0576  0DFF                  ;---- CASE 1 -- RDY ----
0577  0DFF                  ;
0578  0DFF                  ;A BATT IS IN SOCKET
0579  0DFF                  ;DETERMINE THE TEMP AND SETUP A DUTY
0580  0DFF                  ;CYCLE LIMIT
0581  0DFF                  ;IF DUTY CYC IS 0 THEN MAKE STAT UNSAFE
0582  0DFF                  ;ELSE TURN OFF LED AND MAKE STAT CHRG
0583  0DFF                  ;
0584  0DFF                  RDY
0585  0DFF  20 B6 0E                JSR SETDTY      ;DETERMINE DUTY CYCLE FROM TEMP
0586  0E02  F0 22                   BEQ RDY1        ;RESULT UNSAFE
```

```
LINE # LOC      CODE        LINE

0587  0E04  A6 16           LDX BATNUM      ;GET BATT NO.
0588  0E06  20 F3 0C        JSR ADCONV      ;READ BATT VOLTS
0589  0E09  4A              LSR A           ;V/2
0590  0E0A  85 1C           STA REG
0591  0E0C  4A              LSR A           ;V/4
0592  0E0D  4A              LSR A           ;V/8
0593  0E0E  4A              LSR A           ;V/16
0594  0E0F  18              CLC
0595  0E10  65 1C           ADC REG         ;NOW = 0.612 * VOLTS
0596  0E12  A8              TAY
0597  0E13  A5 16           LDA BATNUM
0598  0E15  09 38           ORA #BTEMP
0599  0E17  20 1A 0D        JSR COMPAR
0600  0E1A  30 0A           BMI RDY1
0601  0E1C  A6 16           LDX BATNUM
0602  0E1E  20 46 0D        JSR LEDOFF      ;THURN OFF THIS LED
0603  0E21  A9 03           LDA #3          ;CASE CHRG
0604  0E23  95 00           STA STAT,X      ;ENABLE THIS BATT TO CHARGE
0605  0E25  60              RTS
0606  0E26                 RDY1
0607  0E26  A6 16           LDX BATNUM
0608  0E28  A9 02           LDA #2          ;CASE UNSAFE
0609  0E2A  95 00           STA STAT,X      ;MARK THIS BATT UNSAFE
0610  0E2C  60              RTS
0611  0E2D                 ;
0612  0E2D                 ;---- CASE 2 -- UNSAFE ----
0613  0E2D                 ;
0614  0E2D                 ;A BATTERY IS IN THE SOCKET WHICH
0615  0E2D                 ;HAS NOT BEEN PROVEN SAFE TO CHARGE
0616  0E2D                 ;TEST TEMP UNTIL OK AND BLINK
0617  0E2D                 ;THE LED
0618  0E2D                 ;
0619  0E2D                 UNSAFE
0620  0E2D  20 DA 0C           JSR MISNG       ;REMOVED ??
0621  0E30  30 08             BMI UNS3        ;BR IF STILL THERE
0622  0E32  A9 00             LDA #0          ;MARK IT GONE
0623  0E34  95 00             STA STAT,X
0624  0E36  20 46 0D          JSR LEDOFF
0625  0E39  60                RTS
0626  0E3A                   UNS3
0627  0E3A  20 FF 0D          JSR RDY         ;CHECK TEMP
0628  0E3D  C9 02             CMP #2          ;STILL UNSAFE ?
0629  0E3F  D0 0A             BNE UNS1        ;RETURN IF NOT
0630  0E41  F6 0C             INC BLINK,X
0631  0E43  B5 0C             LDA BLINK,X
0632  0E45  4A                LSR A
0633  0E46  90 04             BCC UNS2        ;ODD/EVEN
0634  0E48  20 46 0D          JSR LEDOFF
0635  0E4B                   UNS1
0636  0E4B  60                RTS
0637  0E4C                   UNS2
0638  0E4C  20 52 0D          JSR LEDON
0639  0E4F  60                RTS
0640  0E50                 ;
0641  0E50                 ;---- CASE 3 -- CHRG ----
```

```
LINE # LOC      CODE        LINE

0642  0E50                ;THE BATTERY IN THE SOCKET IS NOW
0643  0E50                ;BEING CHARGED. WATCH TEMP AND
0644  0E50                ;VOLTS AND QUIT WHEN DONE
0645  0E50                ;
0646  0E50                CHRG
0647  0E50  A6 16                LDX BATNUM
0648  0E52  20 35 0D             JSR SWIOFF      ;MEASURE WITH NO CURRENT
0649  0E55  A9 0A                LDA #10         ;AFTER 10 MS DELAY
0650  0E57  85 47                STA SETIME
0651  0E59                CHRG01
0652  0E59  24 45                 BIT RDTIME
0653  0E5B  10 FC                BPL CHRG01      ;LOOP FOR 10 MS
0654  0E5D  20 F3 0C             JSR ADCONV      ;MEASURE THE BATTERY
0655  0E60  C9 E8                CMP #V9X1
0656  0E62  90 07                BCC CHRG02      ;BRANCH IF V<9.3
0657  0E64                CHRG03
0658  0E64  A9 04                LDA #4          ;CUTOFF ON VOLTS MARK
0659  0E66  A6 16                LDX BATNUM      ;THIS BATT
0660  0E68  95 00                STA STAT,X      ;DONE
0661  0E6A  60                  RTS
0662  0E6B                CHRG02
0663  0E6B  4A                  LSR A           ;0.5 V
0664  0E6C  85 1C                STA REG         ;SAVE 0.5 V
0665  0E6E  4A                  LSR A           ;0.25 V
0666  0E6F  4A                  LSR A           ;0.125 V
0667  0E70  18                  CLC
0668  0E71  65 1C                ADC REG         ;0.625*V
0669  0E73  A8                  TAY
0670  0E74  A5 16                LDA BATNUM
0671  0E76  09 38                ORA #BTEMP      ;ADDRESS AMB THERM AND BATT
0672  0E78  20 1A 0D             JSR COMPAR      ;COMPARE Y,TEMP
0673  0E7B  30 E7                BMI CHRG03      ;BR IF TEMP CUTOFF
0674  0E7D  20 DA 0C             JSR MISNG       ;SEE IF BATT REMOVED
0675  0E80  30 0A                BMI CHRG04      ;STILL THERE
0676  0E82  A6 16                LDX BATNUM
0677  0E84  20 46 0D             JSR LEDOFF
0678  0E87  A9 00                LDA #0          ;MARK NO BATT
0679  0E89  95 00                STA STAT,X
0680  0E8B  60                  RTS
0681  0E8C                CHRG04                   ;NOW CHARGE ACCORDING TO DUTY
0682  0E8C  A6 16                LDX BATNUM      ;GET BATT NO.
0683  0E8E  B5 06                LDA DUTY,X      ;THIS BATT DUTY CYC
0684  0E90  D0 03                BNE CHRG05      ;BR IF DONE
0685  0E92  20 B6 0E             JSR SETDTY      ;RESET TO NEW VAL
0686  0E95                CHRG05
0687  0E95  4A                  LSR A           ;BIT 0 THIS CYCLE
0688  0E96  95 06                STA DUTY,X      ;FOR NEXT PASS
0689  0E98  90 03                BCC CHRG06      ;LEAVE OFF IF 0
0690  0E9A  20 41 0D             JSR SWION       ;TURN ON IF 1
0691  0E9D                CHRG06
0692  0E9D  60                  RTS
0693  0E9E                ;
0694  0E9E                ;---- CASE 4 -- DONE ----
0695  0E9E                ;
0696  0E9E                ;THE BATTERY IN THE SOCKET HAS BEEN
```

```
LINE # LOC     CODE        LINE

0697  0E9E                ;CHARGED AND IS BEING WATCHED FOR
0698  0E9E                ;REMOVAL.  WHEN GONE TURN OFF THE LED
0699  0E9E                ;
0700  0E9E                DONE
0701  0E9E  20 DA 0C            JSR MISNG
0702  0EA1  30 0F               BMI DON02       ;BR IF STILL THERE
0703  0EA3  A6 16               LDX BATNUM
0704  0EA5  20 35 0D            JSR SWIOFF      ;TURN OFF
0705  0EA8  20 46 0D            JSR LEDOFF      ;AND TURN OFF LED
0706  0EAB  A9 00               LDA #0
0707  0EAD  95 00               STA STAT,X      ;MARK BATT GONE
0708  0EAF  95 06               STA DUTY,X      ;MARK FOR NEW DUTY
0709  0EB1  60                  RTS             ;NEW MODE = NOBATT
0710  0EB2                DON02
0711  0EB2  20 52 0D            JSR LEDON       ;GREEN LED ON
0712  0EB5  60                  RTS
0713  0EB6                ;
0714  0EB6                ;******** SUBROUTINE SETDTY ********
0715  0EB6                ;
0716  0EB6                ;MEASURE THE TEMP OF BATT (BATNUM) AND
0717  0EB6                ;SETUP DUTY CYCLE(BATNUM) ACCORDINGLY
0718  0EB6                ;
0719  0EB6                SETDTY
0720  0EB6  A6 16               LDX BATNUM      ;GET BATT NO.
0721  0EB8  20 F3 0C            JSR ADCONV      ;GET THE BATT VOLTAGE
0722  0EBB  4A                  LSR A           ;HALF IT
0723  0EBC  85 1C               STA REG         ;SAVE TO REUSE
0724  0EBE  A8                  TAY             ;TEST VAL = V/2
0725  0EBF  A5 16               LDA BATNUM      ;GET BAT NO.
0726  0EC1  09 18               ORA #BTEM20     ;ADDR R47 AND BATT
0727  0EC3  20 1A 0D            JSR COMPAR
0728  0EC6  10 0B               BPL SET01
0729  0EC8  A9 FF               LDA #MSK100     ;100% DUTY CYC OK
0730  0ECA                SETX
0731  0ECA  A6 16               LDX BATNUM      ;GET BATT NO8
0732  0ECC  25 12               AND MDUTY       ;INCLUDE XFMR TEMP
0733  0ECE  95 06               STA DUTY,X      ;ASSIGN TO BATT
0734  0ED0  B5 06               LDA DUTY,X      ;RCL TO SET Z FLG
0735  0ED2  60                  RTS
0736  0ED3                SET01
0737  0ED3  A4 1C               LDY REG         ;RECALL VOLTS/2
0738  0ED5  A5 16               LDA BATNUM
0739  0ED7  09 20               ORA #BTEM15     ;ADDRESS R48 AND BATT
0740  0ED9  20 1A 0D            JSR COMPAR
0741  0EDC  10 04               BPL SET02
0742  0EDE  A9 FC               LDA #MASK75
0743  0EE0  D0 E8               BNE SETX
0744  0EE2                SET02
0745  0EE2  A4 1C               LDY REG
0746  0EE4  A5 16               LDA BATNUM
0747  0EE6  09 28               ORA #BTEM10     ;ADDRESS R49 AND BATT
0748  0EE8  20 1A 0D            JSR COMPAR
0749  0EEB  10 04               BPL SET03
0750  0EED  A9 F0               LDA #MASK50     ;50% DUTY CYCLE
0751  0EEF  D0 D9               BNE SETX
```

```
LINE # LOC      CODE        LINE

0754  0EF1                SET03
0755  0EF1  A4 1C                LDY REG
0756  0EF3  A5 16                LDA BATNUM
0757  0EF5  09 30                ORA #BTEM05     ;ADDRESS R50 AND BATT
0758  0EF7  20 1A 0D             JSR COMPAR
0759  0EFA  10 04                BPL SET04
0760  0EFC  A9 C0                LDA #MASK25     ;25% DUTY CYCLE
0761  0EFE  D0 CA                BNE SETX
0762  0F00                SET04
0763  0F00  A9 00                LDA #MASK00     ;0% DUTY CYCLE
0764  0F02  F0 C6                BEQ SETX
0765  0F04                ;
0766  0F04                ;
0767  0F04                ;INTERRUPT SERVICE ROUTINE
0768  0F04                ;-------------------------
0769  0F04                ;
0770  0F04                ;12*60=720 INTRPTS PER COUNT ON DISPLAY
0771  0F04                ;FOR DISPLAY TO READ SECONDS:
0772  0F04                ;   DIVIDE 120 HZ LINE CLK BY 10 (12/SEC)
0773  0F04                ;FOR DISPLAY TO READ PERCENT OF ONE HOUR
0774  0F04                ;   DIVIDE 120 HZ LINE CLK BY 6  (20/SEC)
0775  0F04                ;FOR 50 HZ POWER AND PCT READOUT
0776  0F04                ;   DIVIDE 100 HZ LINE CLK BY 5  (20/SEC)
0777  0F04                ;
0778  0F04                ;
0779  0F04                IRQ
0780  0F04  48                  PHA             ;SAVE ACC
0781  0F05  8A                  TXA
0782  0F06  48                  PHA             ;SAVE X REG
0783  0F07  98                  TYA
0784  0F08  48                  PHA             ;SAVE Y REG
0785  0F09  C6 13                DEC TIC         ;1/12TH SEC
0786  0F0B  10 18                BPL IRQ1        ;RETURN IF NO OVFLW
0787  0F0D  A9 0B                LDA #11         ;RESTORE
0788  0F0F  85 13                STA TIC
0789  0F11  C6 14                DEC SECS        ;1 SECOND
0790  0F13  10 10                BPL IRQ1        ;RETURN IF NO OVFLW
0791  0F15  A9 3B                LDA #59
0792  0F17  85 14                STA SECS        ;RESTORE
0793  0F19  A5 15                LDA MIN         ;GET MINUTES
0794  0F1B  C9 99                CMP #$99        ;OVERFLOWED ?
0795  0F1D  F0 06                BEQ IRQ1        ;YES STOP COUNTING
0796  0F1F  F8                  SED             ;DECIMAL MODE FOR MINS
0797  0F20  18                  CLC             ;NO CARRY
0798  0F21  69 01                ADC #1          ;INCREMENT MINS
0799  0F23  85 15                STA MIN
0800  0F25                ;
0801  0F25                ;RESET THE EXTERNAL INTERRUPT FLIP-FLOP
0802  0F25                ;
0803  0F25                IRQ1
0804  0F25  A9 EF                LDA #CLRMSK
0805  0F27  25 42                AND PRB
0806  0F29  85 42                STA PRB
0807  0F2B  A9 10                LDA #IRQMSK
0808  0F2D  05 42                ORA PRB
```

```
LINE #  LOC     CODE        LINE

0809   0F2F   85 42              STA FRE         ;INT FF NOW RESET
0810   0F31   68                 PLA             ;RESTORE Y
0811   0F32   A8                 TAY
0812   0F33   68                 PLA             ;RESTORE X
0813   0F34   AA                 TAX
0814   0F35   68                 PLA             ;RESTORE A
0815   0F36   40                 RTI             ;END OF INTERRUPT
0816   0F37                    ;
0817   0F37                    ;DECIMAL MODE DID NOT NEED TO BE RESET (RTI)
0818   0F37                    ;
0819   0F37                    ;
0820   0F37                    ;IDLE WAITING LOOP MAINLY FOR BLINK RATE
0821   0F37                    ;
0822   0F37                    DEL
0823   0F37   A9 40                LDA #$40
0824   0F39   85 47                STA SETIME
0825   0F3B                    DEL1
0826   0F3B   24 45                BIT RDTIME
0827   0F3D   10 FC                BPL DEL1
0828   0F3F   60                   RTS
0829   0F40                    ;
0830   0F40                    ;
0831   0F40                    ;THIS ROUTINE TESTS THE ROM CYCLIC
0832   0F40                    ;REDUNDANCY CODE TO INSURE THE ROM
0833   0F40                    ;CONTENTS ARE CORRECT
0834   0F40                    ;
0835   0F40                    ;SCRATCH AREAS IN RAM DEFINED HERE
0836   0F40                    ;
0837   0F40                    PTR     = 0
0838   0F40                    END     = 2
0839   0F40                    TMASK   = 4
0840   0F40                    CRC     = 5
0841   0F40                    POLY    = $94           ;X^8 + X^5 + X^3 + 1
0842   0F40                    GOOD    = $24
0843   0F40                    ;
0844   0F40                    ENDROM = *
0845   0F40                    SYSTST
0846   0F40   A9 00                LDA #<ROMBAS    ;POINT TO AREA TO TEST
0847   0F42   85 00                STA PTR
0848   0F44   A9 0C                LDA #>ROMBAS
0849   0F46   85 01                STA PTR+1
0850   0F48   A9 40                LDA #<ENDROM    ;POINT TO END OF TEST AREA
0851   0F4A   85 02                STA END
0852   0F4C   A9 0F                LDA #>ENDROM
0853   0F4E   85 03                STA END+1
0854   0F50                    ;
0855   0F50                    ;BEGIN TST LOOP
0856   0F50   A0 00                LDY #0          ;INITIAL INDEX
0857   0F52   98                   TYA             ;COPY
0858   0F53   85 05                STA CRC         ;ZERO THE CRC RESULT
0859   0F55   18                   CLC             ;ZERO CARRY INITIALLY
0860   0F56                    ;
0861   0F56                    ;BEGIN TEST LOOP PER BIT AND
0862   0F56                    ;LOOP PER BYTE
0863   0F56                    ;
```

```
LINE # LOC     CODE        LINE

0864  0F56                 CRC00
0865  0F56  A9 80                LDA #$80        ;MSB SET
0866  0F58  85 04                STA TMASK       ;SAVE IN RAM
0867  0F5A                 CRC01
0868  0F5A  06 05                ASL CRC         ;MSB OF CRC TO CARRY 0 TO LSB
0869  0F5C  B1 00                LDA (PTR),Y     ;GET A BYTE TO TEST
0870  0F5E  25 04                AND TMASK       ;STRIP ALL BUT MASK BIT
0871  0F60  F0 04                BEQ CRC02       ;BRANCH IF BIT IS ZERO
0872  0F62  B0 0A                BCS NOCHA       ;NO CHANGE IF BIT=1 AND CY=1
0873  0F64  90 02                BCC CHANG       ;   CHANGE IF BIT=1 AND CY=0
0874  0F66                 CRC02
0875  0F66  90 06                BCC NOCHA       ;NO CHANGE IF BIT=0 AND CY=0
0876  0F68                 CHANG
0877  0F68  A9 94                LDA #POLY       ;FETCH THE POLYNOMIAL
0878  0F6A  45 05                EOR CRC         ;XOR WITH THE RESULT
0879  0F6C  85 05                STA CRC         ;SAVE IT
0880  0F6E                 NOCHA
0881  0F6E  46 04                LSR TMASK       ;MOVE TO NEXT BIT
0882  0F70  D0 E8                BNE CRC01       ;UNLESS FINISHED A BYTE
0883  0F72                 ;
0884  0F72                 ;MOVE POINTER TO NEXT BYTE UNTIL DONE
0885  0F72                 ;
0886  0F72  E6 00                INC PTR
0887  0F74  D0 02                BNE CRC03
0888  0F76  E6 01                INC PTR+1
0889  0F78                 ;
0890  0F78                 ;TEST FOR FINISHED
0891  0F78                 ;
0892  0F78                 CRC03
0893  0F78  A5 01                LDA PTR+1
0894  0F7A  C5 03                CMP END+1
0895  0F7C  D0 D8                BNE CRC00       ;MSB IS DIFFERENT,CONTINUE
0896  0F7E  A5 00                LDA PTR
0897  0F80  C5 02                CMP END
0898  0F82  D0 D2                BNE CRC00       ;LSB IS DIFFERENT, CONTINUE
0899  0F84                 ;
0900  0F84                 ;OUT OF BYTES: IS CRC OK ????
0901  0F84                 ;
0902  0F84  A5 05                LDA CRC
0903  0F86  C9 24                CMP #GOOD
0904  0F88  F0 03                BEQ RAMCHK      ;ROM CRC IS OK, TST RAM
0905  0F8A  4C AF 0F             JMP FAILED      ;ROM IS BAD -- DIE GRACEFULLY
0906  0F8D                 ;
0907  0F8D                 ;THIS ROUTINE TESTS THE VALIDITY OF
0908  0F8D                 ;THE SYSTEM RAM BY INVERTING AND
0909  0F8D                 ;WRITING BACK THE CONTENTS OF EACH
0910  0F8D                 ;LOCATION AND TESTING RESULTS
0911  0F8D                 ;
0912  0F8D                 RAMCHK
0913  0F8D  A2 3F                LDX #RAMSIZ-1   ;SETUP INDEX
0914  0F8F                 RAM1
0915  0F8F  8A                   TXA             ;FETCH INDEX
0916  0F90  95 00                STA 0,X         ;WRITE IT IN THE RAM
0917  0F92  CA                   DEX             ;NEXT
0918  0F93  10 FA                BPL RAM1        ;LOOP UNTIL DONE
```

```
LINE # LOC     CODE        LINE

0919  0F95                 ;
0920  0F95                 ;HERE THE RAM HAS BEEN WRITTEN WITH IT'S OWN ADDRESS
0921  0F95                 ;
0922  0F95                 RAM2
0923  0F95  E8                    INX             ;  RETURN X TO 0
0924  0F96  8A                    TXA             ;FETCH INDEX
0925  0F97  D5 00                 CMP 0,X         ;WAS IT WRITTEN OK
0926  0F99  D0 14                 BNE FAILED      ;NO
0927  0F9B  E0 3F                 CPX #RAMSIZ-1   ;NEXT
0928  0F9D  D0 F6                 BNE RAM2        ;LOOP UNTIL DONE
0929  0F9F                 ;
0930  0F9F                 ;ADDRESS DECODES OK, NOW TRY INVERTS
0931  0F9F                 ;
0932  0F9F                 RAM3
0933  0F9F  B5 00                 LDA 0,X         ;GET THE BYTE
0934  0FA1  49 FF                 EOR #$FF        ;INVERT IT
0935  0FA3  95 00                 STA 0,X         ;WRITE IT BACK
0936  0FA5  D5 00                 CMP 0,X         ;DID IT WRITE ?
0937  0FA7  D0 06                 BNE FAILED      ;NO
0938  0FA9  CA                    DEX             ;NEXT
0939  0FAA  10 F3                 BPL RAM3        ;LOOP UNTIL DONE
0940  0FAC                 ;
0941  0FAC                 ;HERE THE RAM HAS BEEN PROVEN FUNCTIONAL
0942  0FAC                 ;
0943  0FAC  4C 40 0C              JMP RESET1      ;RAM AND ROM OK, CONT
0944  0FAF                 ;
0945  0FAF                 ;HERE THE RAM HAS BEEN PROVEN DEFECTIVE
0946  0FAF                 ;
0947  0FAF                 FAILED                  ;GET HERE IF ANY RESET TESTS FAIL
0948  0FAF  A9 FA                 LDA #$FA
0949  0FB1  20 AE 0C              JSR DISPLA
0950  0FB4  4C AF 0F              JMP FAILED      ;DEAD LOOP --- STAY HERE
0951  0FB7                 ;
0952  0FB7                      *=ROMBAS+ROMSIZ-6
0953  0FFA                 NMIVEC
0954  0FFA  04 0F                 .WORD NMI
0955  0FFC                 RESVEC
0956  0FFC  22 0C                 .WORD RESET
0957  0FFE                 IRQVEC
0958  0FFE  04 0F                 .WORD IRQ
0959  1000                      .END


ERRORS = 0000 <0000>
END OF ASSEMBLY
```

```
PASS1
PASS2
ERRORS = 0000 <0000>



SYMBOL TABLE

SYMBOL    VALUE

ADCONV    0CF3    ADEND     0D15    ADINCR    0D0F    ADTEST    0CFF
ATEMP     003E    BATIME    001D    BATNUM    0016    BLINK     000C
BTEM05    0030    BTEM10    0028    BTEM15    0020    BTEM20    0018
BTEMP     0038    CHANG     0F68    CHARGE    0DC0    CHRG      0E50
CHRG01    0E59    CHRG02    0E6B    CHRG03    0E64    CHRG04    0E8C
CHRG05    0E95    CHRG06    0E9D    CLKI      0CCF    CLKL      0CBF
CLKS      0CC4    CLRMSK    00EF    CMPDAC    0D1B    COMPAR    0D1A
CRC       0005    CRC00     0F56    CRC01     0F5A    CRC02     0F66
CRC03     0F78    DEAD      0DAE    DEAD1     0DBD    DEL       0F37
DEL1      0F3B    DISPLA    0CAE    DISPNO    0018    DLY       0D2F
DLY1      0D31    DON02     0EB2    DONE      0E9E    DUM1      0DAB
DUMP      0D92    DUTY      0006    END       0002    ENDROM    0F40
FAILED    0FAF    FRE1      0D8F    FREE      0D7C    GOOD      0024
IOBASE    0040    IRQ       0F04    IRQ1      0F25    IRQMSK    0010
IRQVEC    0FFE    JMPLOC    001A    JTABL     0DD5    LEDOFF    0D46
LEDON     0D52    LOFF      007F    LON       0080    LOOP      0C53
LOOP1     0C69    LOOP12    0C9A    LOOP3     0C77    LOOP4     0C64
LOOP5     0CAB    LOOP6     0C88    LOOP7     0C90    LOOP8     0C98
MASK      0019    MASK00    0000    MASK25    00C0    MASK50    00F0
MASK75    00FC    MDUTY     0012    MIN       0015    MISNG     0CDA
MISS01    0CF2    MISS02    0CE7    MSK100    00FF    NMI       0F04
NMIVEC    0FFA    NOB1      0DFE    NOB2      0DED    NOBATT    0DDF
NOCHA     0F6E    OFF       00BF    OFF1      0D49    ON        0040
POLY      0094    PRA       0040    PRB       0042    PTR       0000
RAM1      0F8F    RAM2      0F95    RAM3      0F9F    RAMBAS    0000
RAMCHK    0F8D    RAMSIZ    0040    RDTIME    0045    RDY       0DFF
RDY1      0E26    REG       001C    RES1      0C27    RES2      0C4B
RES3      0C31    RESET     0C22    RESET1    0C40    RESVEC    0FFC
ROMBAS    0C00    ROMSIZ    0400    SECS      0014    SET01     0ED3
SET02     0EE2    SET03     0EF1    SET04     0F00    SETDTY    0EB6
SETIME    0047    SETX      0ECA    STACK     003F    STAT      0000
SWI1      0D38    SWIOFF    0D35    SWION     0D41    SYSTST    0F40
TABL1     0C03    TABL2     0C08    TEST      0D61    TESTAT    0017
TESTON    0D57    TIC       0013    TIME      000A    TMASK     0004
TMAX      0023    TMIN      0064    TST60     003E    TST70     004A
TST80     0055    TSTOFF    0D5C    TTABL     0D74    UNS1      0E4B
UNS2      0E4C    UNS3      0E3A    UNSAFE    0E2D    V3X0      004D
V7X2      00B8    V9X1      00E8    XTEMP     000F
END OF ASSEMBLY
```