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ION-1 Technical Manual

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ION-1 TECHNICAL MANUAL

by

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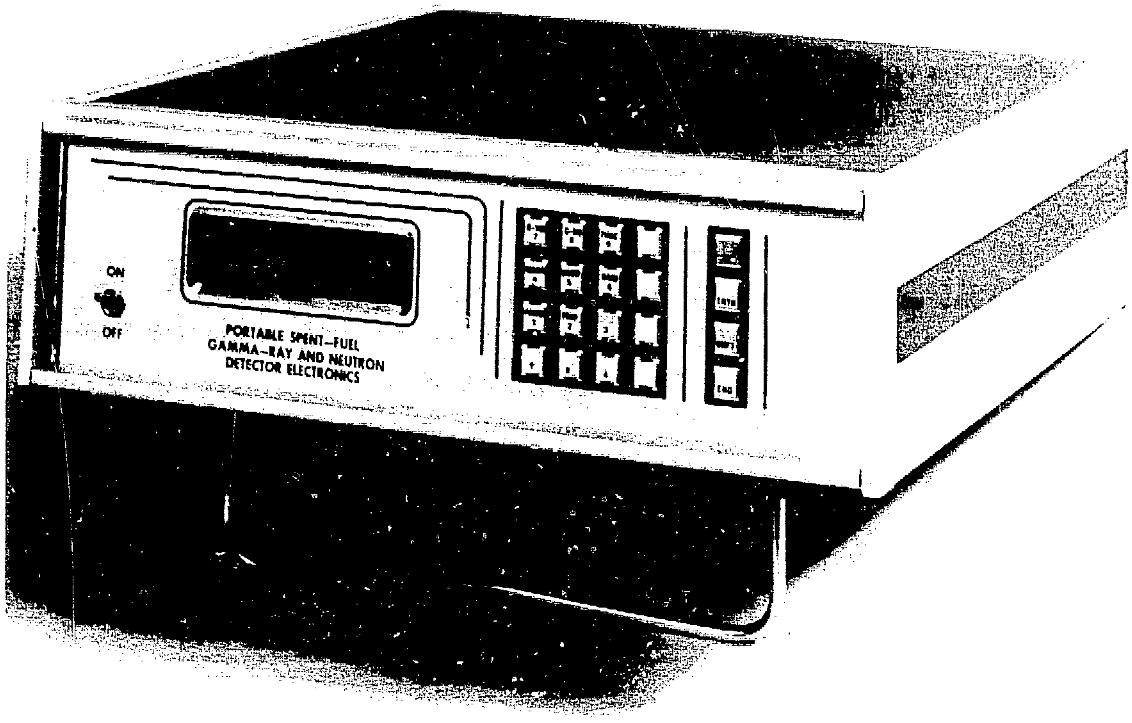
ABSTRACT

The portable gamma-ray and neutron detector electronics (ION-1) gives a digital readout of the current-mode response produced by gamma rays in an ion chamber and of amplification and scaling of pulses received from a neutron detector. The primary application is the measurement of gamma-ray and neutron activity of irradiated reactor fuels stored at a reactor or at a storage pond away from a reactor.

ION-1 is the first such instrument to use a design that allows communication of procedures, responses, and results between instrument and inspector. It prompts the inspector through procedures, carries out programmed measurement steps, calculates results and error estimates, and performs internal diagnostic checks.

This Technical Manual describes adjustment procedures and limited technical information that enable the inspector to troubleshoot at the board level.


ON
OFF
PORTABLE SPENT-FUEL
GAMMA-RAY AND NEUTRON
DETECTOR ELECTRONICS

The intelligent, portable, spent-fuel gamma-ray and neutron detector electronics (ION-1) represents a revolutionary step in the design of instruments used by the International Atomic Energy Agency. Such instruments prompt the inspector through measurements, perform internal diagnostics, and make some decisions without inspector interaction. The inspector can concentrate on the measurement's meaning without being distracted by having to remember detailed procedures, check hand calculations, or worry that an instrument is not working properly.

Two manuals accompany ION-1. The User Manual, provided by the manufacturer, describes the operation of the instrument and supplies a minimum of technical information. This Technical Manual is a companion to the User Manual. It gives the inspector a general understanding of the basic operation of the unit, explains adjustment procedures, and gives nominal values for important parameters. This manual is sufficiently detailed that a knowledgeable person can make adjustments to and perform limited maintenance on the unit. It is not a complete maintenance manual. However, its user can identify maintenance problems at the board level and replace boards to repair a malfunctioning unit.

If it is necessary to set up or repair ION-1, carry out the procedures in the TESTING AND ADJUSTMENT section of this manual. However, an inspector who is not already familiar with ION-1 and its operation should first read the DESCRIPTION and OPERATION sections.

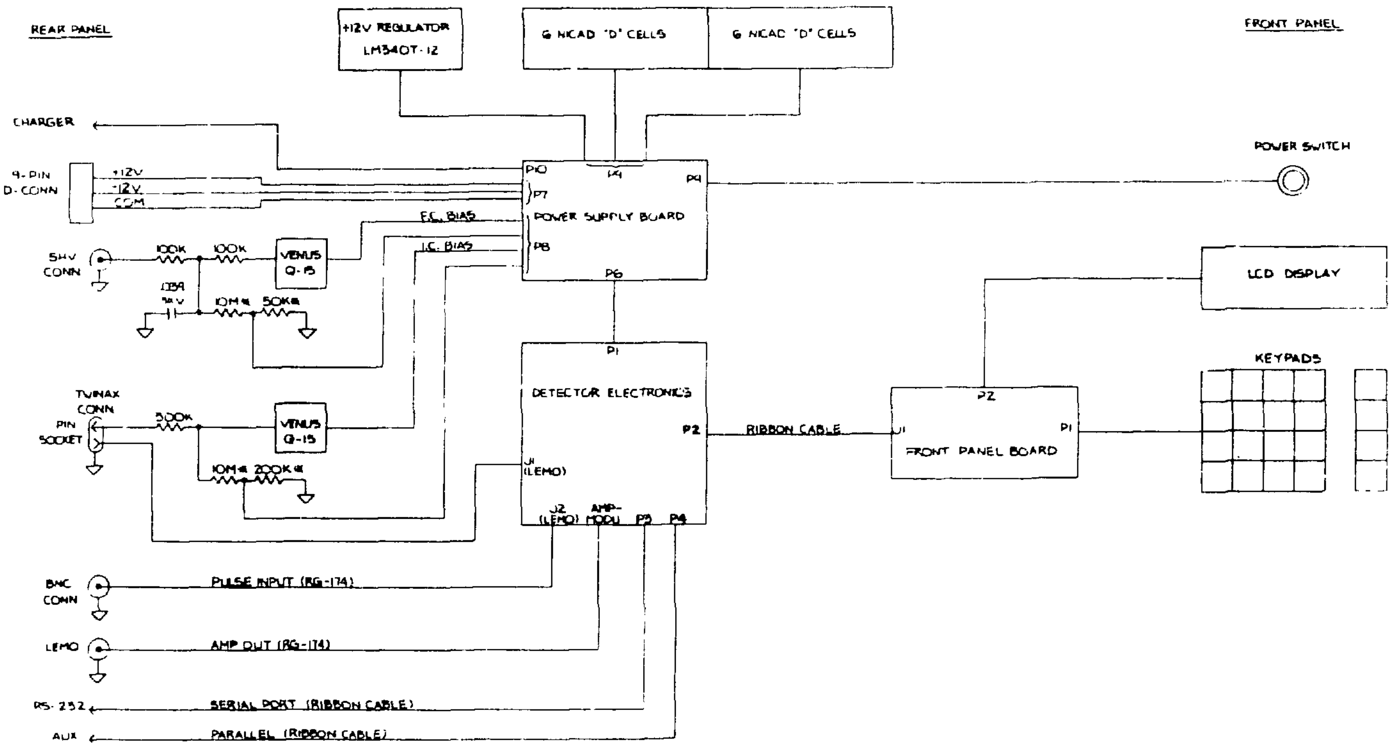


Fig. 1. Chassis wiring diagram (system interconnections).

PHYSICAL COMPONENTS

Figure 1 is an overview wiring diagram. See CIRCUITRY for detailed wiring diagrams and discussion.

Front Panel

On the front panel (Fig. 2) are the following:

(A) power switch
(B) 32-character (ASCII) display
(C) control and entry/command keypads
(D) charger-operating LED (light-emitting diode).

Rear Panel

On the rear panel (Fig. 3) are the following:

(A) battery charger input
(B) fission chamber high-voltage output
(C) fission chamber signal input
(D) neutron channel amplifier output
(E) fission chamber preamplifier dc power output
(F) auxiliary parallel I/O connector
(G) RS-232 serial interface connector
(H) ion chamber signal input
(T) retaining screws.

Circuit Board and Power Supply

The main circuit board (Fig. 4) is in the top of the box. The power supply board and batteries (Fig. 5) are in the lower compartment. A metal shield mounted inside the rear panel encloses the high-voltage supplies.

REAR-PANEL CONNECTORS

Ion Chamber

The twin-axial connector (Fig. 3,H) supplies both the bias for and signal input from the ion chamber. The connector shell is the terminal for the cable shield. The pin is the signal input,

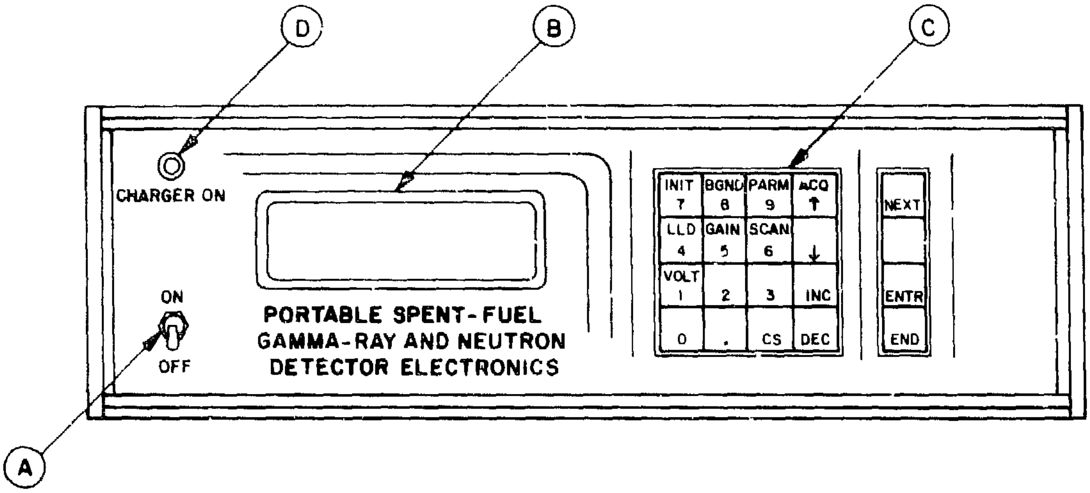


Fig. 2. ION-1 front panel.

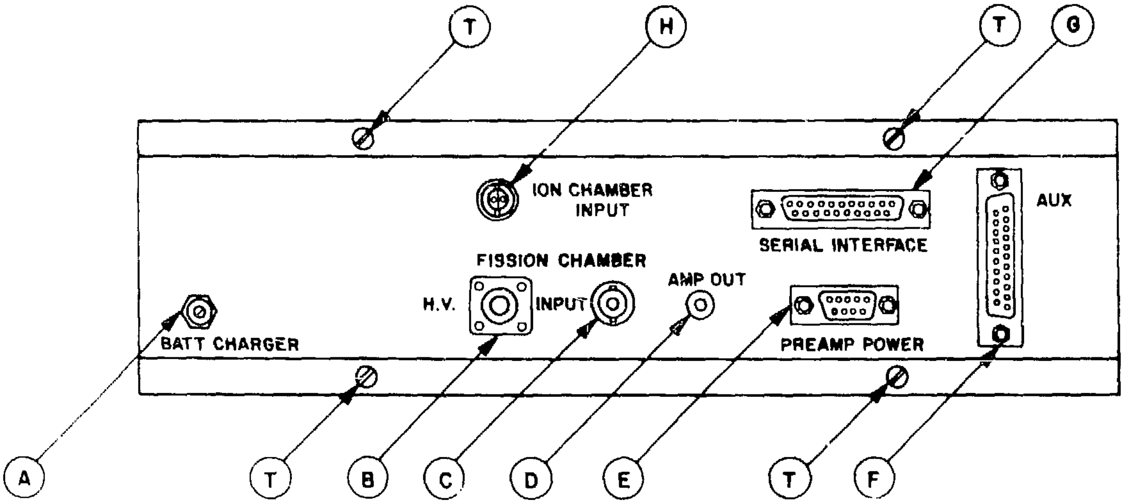


Fig. 3. ION-1 rear panel.

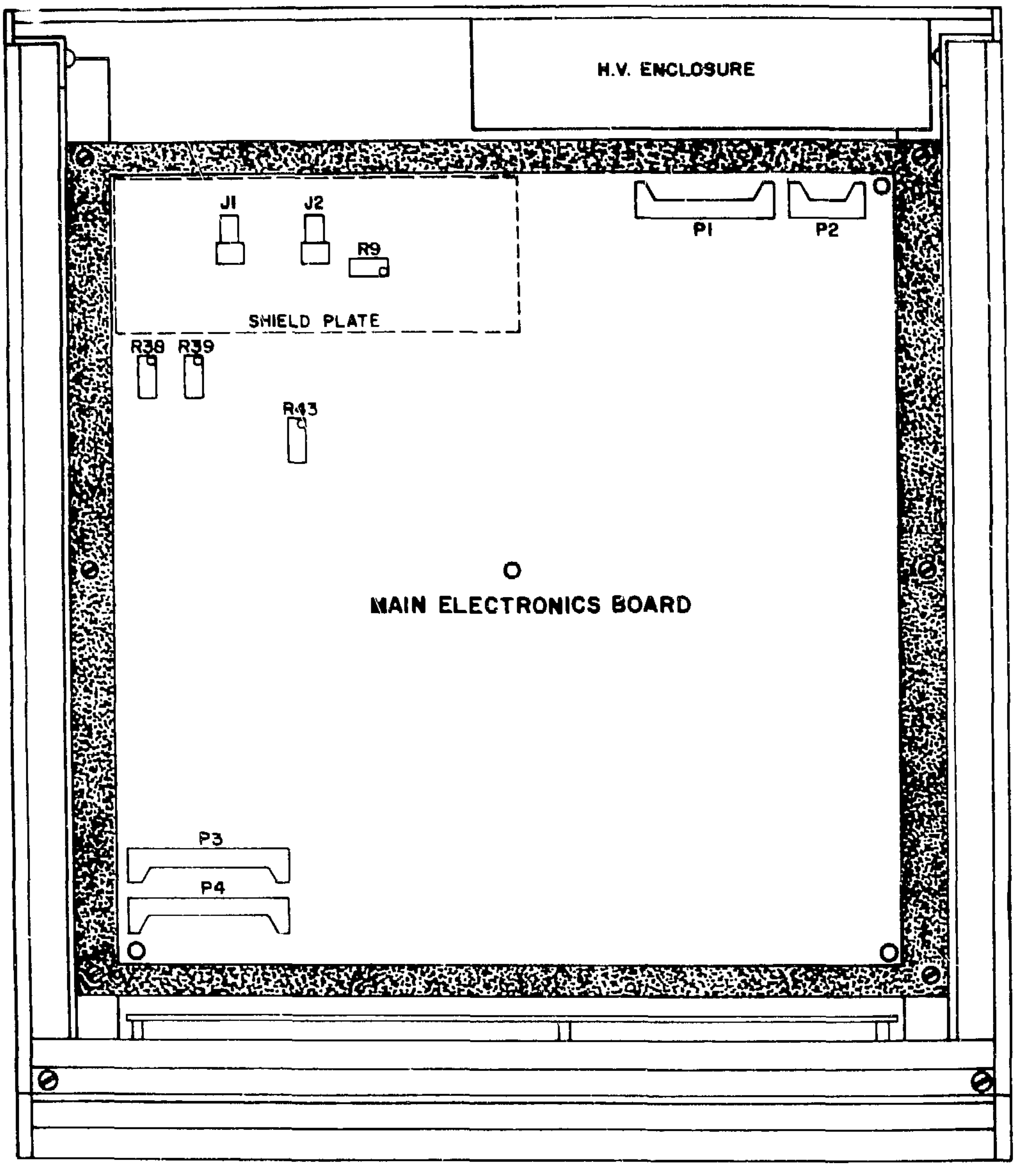


Fig. 4. Main circuit board in upper part of ION-1.

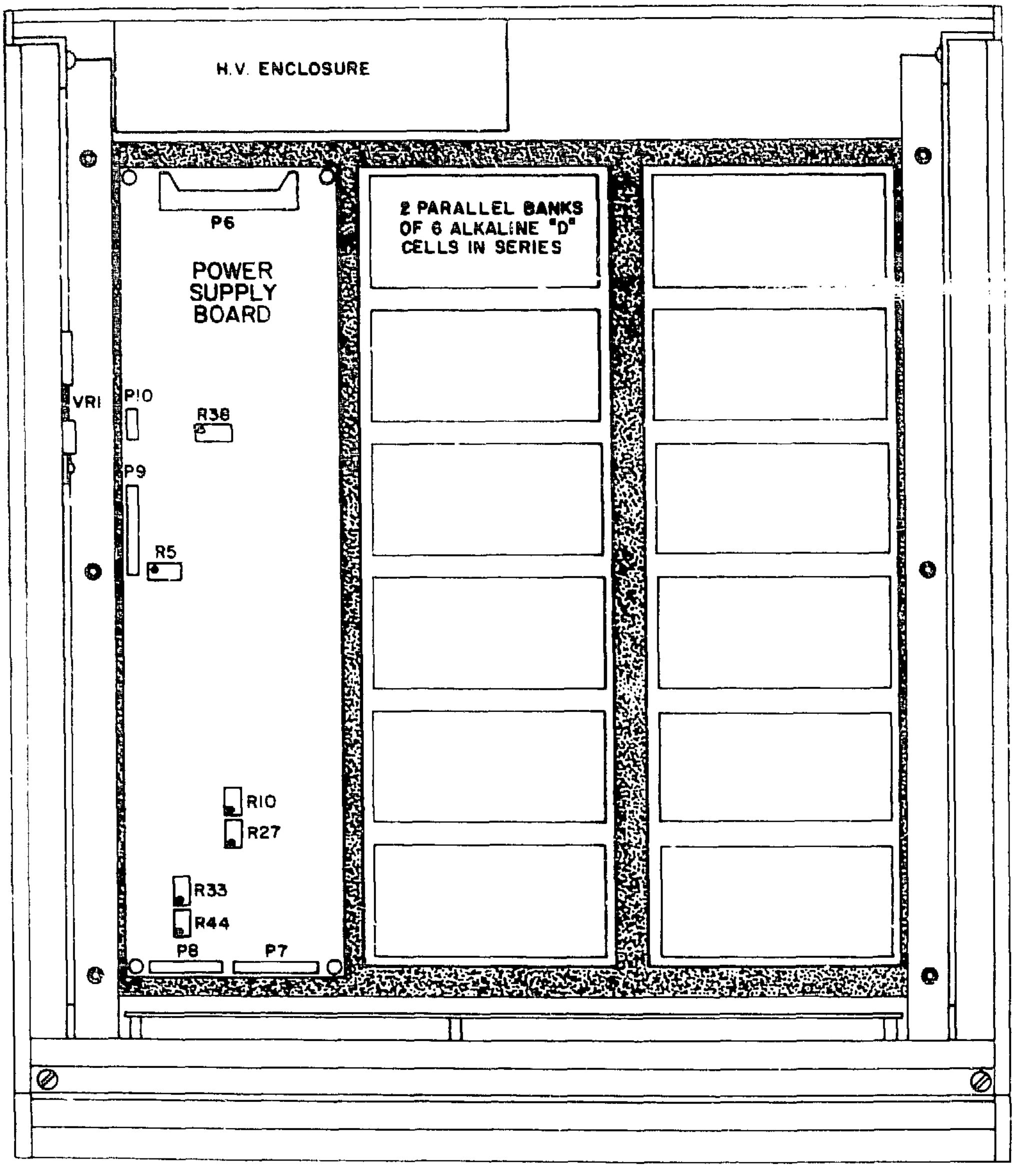


Fig. 5. Power supply board and batteries in lower part of ION-1.

Ion Chamber (cont)

and the socket is the bias output. (The bias is typically -100 V.)

Pulse (Neutron) Detector

The bias is supplied through the SHV connector (Fig. 3,B). The bias is positive and is adjustable from 500 to 1500 V. Preamplifier power is supplied from the 9-pin D-connector (Fig. 3,E). The pin-out of the connector is as follows:

Pin	Signal
1	Case GND
2	Signal GND
4	+12.5 V
9	-12.5 V

The signal input (Fig. 3,C) is a standard BNC connector. An amplifier output signal is provided at the Lemo connector (Fig. 3,D).

Battery Charger

The battery charger connector is an input for 22 to 24 Vdc at 0.8 A from an external source. The charger input to ION-1 should be filtered direct current. The power input supplies power to the main electronics in place of batteries, and it supplies power to charge the batteries. Internal to ION-1 are a constant-current charger circuit for the batteries and a 12-V passive regulator that regulates the input power for the main electronics.

Serial Port

The 25-pin, female D-connector (Fig. 3,G) marked SERIAL INTERFACE is used for serial communication. The signal levels are compatible with RS-232

Serial Port (cont)

specifications, and the following signals are on the pins:

Pin	Signal
1	Chassis GND (n/c)
2	ION-1 receive data
3	ION-1 transmit data
5	*
6	*
7	Signal GND
8	*
20	*

*Jumpered together in ION-1.

Auxiliary Port

The auxiliary port supplies 8 bits of input and 8 bits of output. The 25-pin, female D-connector marked AUX (Fig. 3,F) has the following pin-out.

Pin	Function	Pin	Function
1	IN 0	14	IN 1
2	IN 2	15	IN 3
3	IN 4	16	IN 5
4	IN 6	17	IN 7
5	OUT 0	18	OUT 1
6	OUT 2	19	OUT 3
7	OUT 4	20	OUT 5
8	OUT 6	21	OUT 7

This interface can be used with a parallel-type printer interface or for external control or status read-back of external devices. It is not supported by the software at this time.

MEASUREMENTS

ION-1 measures the current-mode response of a gas-filled ion chamber (gamma signal) and measures neutrons by amplifying and scaling pulses received from a neutron detector, specifically a ^{235}U fission chamber or B-10 chamber.

Gamma

ION-1 measures gamma dose rate with an ion chamber operating in the current mode. The sensitivity of the actual measurement is dependent on both the current sensitivity of ION-1 and the gamma sensitivity of the ion chamber used. The sensitivity of the ION-1 gamma signal channel ranges from 0.0001 to 2557 relative units (one unit nominally corresponds to 2.50×10^{-10} A). The conversion of gamma signal value to gamma dose is a function of the specific ion chamber used.

Neutrons

The pulse-counting channel counts neutrons detected in a fission chamber, although it can count most types of pulses typically found in nuclear counting applications. (There is a 10- to 15-μs fixed deadtime.) The input is differentiated with 0.5-μs time constant, and the signal is amplified by 50. The amplifier output is fed to a low-level discriminator (LLD), whose value is set through software from the front panel controls. ION-1 counts pulses that exceed the LLD. The neutron scaler counts 65 535 pulses before overflowing, and the inspector can set the neutron counting period from 1 to 65 535 s.

PREAMPLIFIER

The preamplifier for the neutron electronics should be as near the neutron detector as the radiation field permits. The preamplifier generally used is of the same design as the preamplifier in the high-level neutron coincidence counter now used by the International Atomic Energy Agency.

POWER

ION-1 supplies dc power to the neutron detector preamplifier and high-voltage bias to the ion chamber and fission chamber.

Six or twelve D-cell batteries power ION-1, which is supplied with rechargeable nickel-cadmium (NiCad) cells and a charging supply. With the cells that are supplied, the operating time per charge is longer than two 8-h working days, and the cells can be recharged in 12 to 16 h. In the event of cell or charger failure, you may replace the cells with alkaline D-cells.

CAUTION: Do not operate the ION-1 with non-NiCad cells when the charger is plugged in. You can use the unit with the charger and no cells.

GENERAL

If your ION-1 is new or fails during operation, follow these testing and adjustment steps.

SUPPLY AND REFERENCE VOLTAGES

Battery Voltage

1. With the power switch OFF, check the battery voltage.

   After charging the batteries for more than 12 h, measure the battery voltage input to the power supply board between P9-8 and P9-7 (see Dwg No. 101Y-230839-D4).

   IF the voltage is ≥7.5 V, go to step 2.

   IF the voltage is <7.5 V, replace the batteries with NiCad D-cells of 4 A/h capacity OR charge the batteries overnight and remeasure the voltage.

Power Supply Output Voltages

2. With the power switch OFF, remove the cable connector from P6 on the power supply board. On Dwg No. 101Y-230839-D4, P6 is shown as two parts, P6-1 and P6-2.

   Turn the power switch ON.

   Measure the ±5 Vdc and ±15 Vdc outputs on P6 pins. Table I lists pin numbers and acceptable voltage ranges.

TABLE I

POWER SUPPLY VOLTAGE AND TEST POINTS

Voltage	Acceptable Voltage Range (Vdc)	Dwg No. 101Y-230839-D4 P-6 Pin No.
+5	4.75 to 5.4	16
-5	-4.0 to -6.0	20
+15	15.0 to 16.0	12
-15	-14.0 to -15.0	8
Common		14, 15, 18, 7, 10, or 11

Power Supply Output Voltages (cont)

Repair or adjust the power supply as necessary to obtain the proper voltage levels at P6.

Turn the power switch OFF and reconnect the cable to connector P6.

Main and Display Board Digital Voltages

3. Turn the power switch ON and look at the front-panel display.

IF the display is present and seems normal, go to step 4.

IF the display is missing or is abnormal in contrast, measure the +5 Vdc supply voltage at any of the logic integrated circuits on the main printed circuit board and on the display board. The -5 Vdc voltage can be measured on Pin 2 of connector P2 of the display board. Use Dwg Nos. 101Y-230858-D1 and -D2 to identify the components on the main circuit board and

Main and Display Board Digital Voltages (cont)

Dwg No. 101Y-230858-D3 to identify components on the display board.

IF the voltage levels are correct, but the display is still missing or is abnormal, you must use a logic-state analyzer and standard digital logic troubleshooting techniques to find and correct the problem.
Then go to step 4.

Analog Circuitry Voltages

4. When the ION-1 front panel is operational, check the ±15-Vdc supply voltages at the analog integrated circuits (see Dwg No. 101Y-230858-D1). With the power switch ON, measure the +V' and -V' voltage levels at chips U2, U7, and U8 (see Table II). The absolute value of the test points should be ≥5.4 V.

   IF the value is ≥5.6 V, go to step 5.

   IF the value is <5.6 V, do the following.
   - Turn the power switch OFF.
   - Remove chips U2, U7, and U8.

   > CAUTION: Handle chips U2, U7, and U8 with MOS and CMOS handling procedures.

   Turn the power switch ON and remeasure the test points. If the absolute values are still <5.6 V, turn the power switch OFF and do the following:

TABLE II

±V' VOLTAGE CHECK POINTS
(DWG NO. 101Y-230858-D1)

Chip	Pin Number +V'	-V'
U2	7	4
U7	11	8
U8	11	8

Analog Circuitry Voltages (cont)

Replace CR4 for a bad +V' and/or CR5 for a bad -V'.

Replace chips U2, U7, and U8 one at a time (turn the power OFF during replacement) to find which one pulls the absolute value below 5.6 V. Replace that chip with a new one.

IF the absolute value of the test points is still <5.6 V, check and replace R15, R16, C15, and/or C24.

5. Turn the power ON. Monitor the voltage at pin 23 of U16 (Dwg. No. 101Y-230858-D1) with a digital voltmeter. Adjust R43 to make this voltage -10.00 Vdc.

6. Adjust R39 to obtain a voltage of -5.00 Vdc at pin 15 of U15. Make sure that jumper J2 is in place by connecting pins 2 and 3 of U15.

PULSE CHANNEL ADJUSTMENTS

7. Referring to Dwg No. 101Y-230858-D1, make sure that a 5000-Ω, 1% resistor is installed for R5, 220 pF for C8, and 10 pF for C9. Connect an oscilloscope to the AMP OUT LEMO connector on the rear panel.

   Adjust R38 for an output of 0.00 ± 0.01 Vdc.

   Use a pulse generator to supply positive pulses of 3-μs duration and 100-mV amplitude to the FISSION CHAMBER INPUT BNC connector on the rear panel.

   Verify that differentiated pulses are present at AMP OUT. The amplitude of the output pulses depends upon the input pulse risetime and amplitude.

   Using the controls of the pulser, adjust the input pulse amplitude as necessary to produce a positive output pulse height of 3 to 4 V.

LLD Function

8. Using the keypad, select the low-level discriminator (LLD) function.

   Connect an oscilloscope probe to pin 2 of U1. Change the LLD threshold level (using the keypad) and verify that the voltage on pin 2 changes in accordance with Table III.

   The ac ripple voltage should be 20 mV peak-to-peak or less. The number in parentheses on the

TABLE III

LLD SETPOINT VOLTAGES

LLD Setpoint	Pin 2 U1 (V)	LLD Readout
10	0.19	10
50	0.99	50
100	1.96	100
250	4.89	249

LLD Function (cont)

liquid crystal display (LCD) is the voltage being read by the internal analog-to-digital converter (ADC). The units are relative, ranging from 0 (∿0 V) to 255 (∿5 V). The LCD readout should equal the LLD threshold setpoint ±2 counts.

Return the LLD to its original value (30). Trigger pulses should be present at pin 1 of U3.

Connect the oscilloscope probe to U3, pin 13.

Neutron Channel Logic Pulse

Adjust the values of R7 and C7 as necessary to produce a positive pulse at pin 13 with a duration of 10- to 13-μs. Ensure that the displayed value of counts/s agrees with the repetition rate of the input pulses.

Increase the LLD threshold voltage until zero counts/s are registered. The LLD reading where this occurs should be (V_p x 225/5), where

Neutron Channel Logic Pulse (cont)

V_p is the pulse height measured at the amplifier out. Reduce the threshold to 30 and disconnect the pulse generator.

CURRENT CHANNEL ZERO ADJUSTMENT

9. Refer to Dwg No. 101Y-230858-D1. Ensure that pin 3 of U2 is connected to ground; R10 equals 0 Ω. With the copper-clad shield board in place above the analog input section of the main electronics board, select the GAIN function on the front panel and enter a 1 for the manual mode.

   Set the gain to 163840 and connect an oscilloscope probe to pin 13 of U10. Adjust R9 (Fig. 3) for a dc baseline of approximately -1.00 V as read from the scope. This should produce an ADC count of approximately 1600.

   Step through all eight gain settings to ensure that the offset voltage does not exceed 0 V. The offset varies with changes in gain, but over a short term it should remain constant for a given gain setting.

Crystal Frequency

10. Use an oscilloscope probe to connect the input of a frequency counter to pin 9 of U20 (Dwg No. 101Y-230858-D2). Adjust C62 for an output frequency of 2.457 ± 0.0005 MHz.

BIAS SUPPLY VOLTAGE ADJUSTMENTS

11. Referring to Dwg No. 101Y-230839-D4, locate potentiometers R33 and R44 on the power supply board (Fig. 4).

Ion Chamber Bias Range

Connect a high-input impedance (10 MΩ minimum) voltmeter to the socket of the ION CHAMBER INPUT twin-axial connector on the rear panel. The bias voltage should vary between 0 and -425 Vdc as you turn R43 through its adjustment range. The standard setpoint for the ion chamber bias is -100 Vdc.

Fission Chamber Bias Voltage Range

Using a high-voltage probe or a voltmeter capable of measuring to 2000 Vdc, monitor the bias voltage at the FISSION CHAMBER H.V. SHV connector. As you adjust R44, the output should change from +500 to +1500 Vdc. The standard setpoint for the fission chamber bias is +750 Vdc.

Preamp Power Voltages

Check the PREAMP POWER connector for ground on pin 1, +15 Vdc on pin 4, and -15 Vdc on pin 9.

Voltage Readout

12. Step through the values shown on the front panel VOLT display to ensure that they agree nominally with the measured values.

Current Channel

13. Use an adapter cable to connect a picoampere source, such as a Keithly Model 261, to the pin of the ION CHAMBER INPUT twin-axial connector. Although the ION-1 acquires only a relative current reading from an ion chamber, the absolute current calibration is

Current Channel (cont)

in close agreement between the units. Tables IV through VIII show the measured values for main circuit board No. 10. Use these values as a guide for checking the operation and calibration of the unit being tested. Investigate any large variations from the tables. Minus signs have been omitted for clarity; remember that all values shown are negative.

TABLE IV

ADC ZERO VALUES

Gain	ADC
163840	1836
40960	1996
10240	2036
2560	2046
640	1836
160	1997
40	2037
10	2047

TABLE V

ANALOG CHANNEL CALIBRATION VALUES

Input Current (A)	GG	Gain	ADC	Net ADC
3.5×10^{-11}	0.1293	163840	2679	843
3.5×10^{-10}	1.294	10240	2566	530
3.5×10^{-9}	12.75	640	2163	327
3.5×10^{-8}	128.4	160	2821	824
3.5×10^{-7}	1288.	10	2562	515

TABLE VI

TYPICAL ANALOG CHANNEL VALUES

Input Current (A)	GG	Gain	ADC	Net ADC
5.00×10^{-12}	0.0190	163840	1958	122
2.00×10^{-11}	0.0739	40960	2117	121
8.00×10^{-11}	0.2965	10240	2158	122
3.20×10^{-10}	1.174	2560	2167	121
1.28×10^{-9}	4.575	640	1955	119
5.12×10^{-9}	18.57	160	2117	120
2.05×10^{-8}	75.00	40	2158	121
8.19×10^{-8}	300.0	10	2167	120
1.00×10^{-11}	0.0369	163840	2076	240
4.00×10^{-11}	0.1479	40960	2239	243
1.60×10^{-10}	0.5905	10240	2279	243
6.40×10^{-10}	2.367	2560	2289	243
2.56×10^{-9}	9.267	640	2075	239
1.02×10^{-8}	37.29	160	2237	240
4.10×10^{-8}	151.3	40	2279	242
1.64×10^{-7}	597.5	10	2286	239
2.00×10^{-11}	0.0736	163840	2315	479
8.00×10^{-11}	0.2963	40960	2482	486
3.20×10^{-10}	1.183	10240	2521	485
1.28×10^{-9}	4.734	2560	2531	485
5.12×10^{-9}	18.65	640	2315	479
2.05×10^{-8}	75.19	160	2480	483
8.19×10^{-8}	301.9	40	2520	483
3.28×10^{-7}	1208.	10	2530	483

TABLE VII

TYPICAL ANALOG CHANNEL VALUES

Input Current (A)	GG	Gain	ADC	Net ADC
4.00×10^{-11}	0.1477	163840	2800	964
1.60×10^{-10}	0.5902	40960	2962	966
6.40×10^{-10}	2.369	10240	3004	968
2.56×10^{-9}	9.467	2560	3015	969
1.02×10^{-8}	37.30	640	2791	955
4.10×10^{-8}	150.7	160	2963	966
1.64×10^{-7}	604.4	40	3004	967
6.55×10^{-7}	2410.	10	3012	965

TABLE VIII

ANALOG CHANNEL CALIBRATION CONSTANTS

Gain	Measured Current/Volt[a] (A/V)
10	1.38×10^{-7}
40	3.45×10^{-8}
160	8.64×10^{-9}
640	2.17×10^{-9}
2560	5.39×10^{-10}
10240	1.35×10^{-10}
40960	3.36×10^{-11}
163840	8.28×10^{-12}

[a]Measured at U8 pin 10, Dwg No. 101Y-230858-D1.

CURRENT CHANNEL

See Dwg No. 101Y-230858-D1. The current channel (the circuitry that processes the current from the ion chamber) converts the current into a voltage and then digitizes the voltage for display.

Because of the extreme sensitivity of the current channel, the input (connector J2) to the current channel is connected to the input (pin 2) of amplifier U2 with Teflon-insulated wire and the junction is a standoff with a Teflon base.

Amplifier U2 is a current-to-voltage converter. Relay K1 selects between the two U2 conversion gains. Table IX lists the conversion gains and time constants.

TABLE IX

CONVERSION GAINS AND TIME CONSTANTS

Relay K1	Conversion Gain (μV/pA)	Time Constant
Open	100	0.2 s
Closed	0.75	7.5 ms

Resistor R9 adjusts for current and voltage zero offsets. The U2 output is filtered by R12, C23, with a time constant of 0.22 ms. Amplifier U7 is a fixed-gain (10.24), auto-zero amplifier.

U9 and U8 form a variable-gain auto-zero stage, with gain values of 1, 4, 16, and 64. The output of this stage feeds a 47-ms, time-constant filter

CURRENT CHANNEL (cont)

R48, C46, and the input to channel 0 of the analog multiplexer (MUX), U10. Table X lists all inputs to the MUX.

TABLE X

ANALOG MULTIPLEXER INPUT SIGNALS

Channel	Signal	ADC Multiplier
0	Current input	a
1	Fission chamber bias	1.000489
2	Ionization chamber bias	0.2501221
3	5-V supply	0.0100489
4	Battery voltage	0.0200098
5	LLD voltage	0.0050024
6	-15-V supply	0.0185276
7	+15-V supply	0.0185276

[a]Constants for each gain are listed in the User Manual in GAIN COMMAND.

ANALOG MULTIPLEXER AND ANALOG-TO-DIGITAL CONVERTER

The channels are digitally selected through software. The analog multiplexer (MUX) output feeds a 12-bit analog-to-digital converter (ADC), U16, which has an internal -10 V reference that can be adjusted with potentiometer R43 (see Ion Chamber Bias Range under TESTING AND ADJUSTMENT).

The conversion clock for the ADC is derived from the microprocessor system clock. The start synchronization is done with U17, U18, and associated circuitry. The microprocessor issues the start command and then waits for the end-of-convert (EOC) signal from the ADC.

ANALOG MULTIPLEXER AND ANALOG-TO-DIGITAL CONVERTER (cont)

The displayed value of the channel being measured depends on the gain of the channel. The gain is a function of the state of K1 and the gain selected by the U9, U8 stage. The LLD value is a direct input, but the remaining inputs have voltage divider networks. The microprocessor multiplies the net ADC reading by the appropriate conversion factor from Table X and arrives at the displayed value. Hence, any design modification requires a software modification.

A unique feature of ION-1 is its ability to correct for day-to-day changes in the offset and leakage currents in the current channel. These changes can arise from changes in humidity, for example.

The dynamic range of the ADC is ±10 V. The dynamic range used by the current channel is ∿5 V. The zero of the current channel is adjusted significantly (∿-1 V) below 0.

When you first turn on the unit, the microprocessor prompts you to disconnect the ion chamber input cable. It then reads the offset or zero values for all eight gain settings. When ION-1 makes actual measurements, it subtracts offset for the gain being used from the ADC reading and obtains the net ADC value.

PULSE CHANNEL

See Dwg No. 101Y-230858-D1. C6, R2 (1 μs) differentiates the input of the pulse channel

PULSE CHANNEL (cont)

(connector J1), and U4, which has a 1-μs integration constant, amplifies the differentiated signal.

The output of the amplifier feeds comparator U1. The DAC, U15, sets the LLD value. The reference voltage for U15 is derived from the internal reference of U16 and is adjusted with R39.

Comparator-output pulses trigger a one-shot, U3, which interrupts the microprocessor. The pulse width of the one-shot is adjusted between 10 and 15 μs. (NOTE: Counting dead-time is determined by the software interrupt-servicing routine.)

The counter is a software register, not a hardware register.

POWER SUPPLY

See Dwg No. 101Y-230839-D4. The need to minimize battery drain complicates the generation of the various voltages required by ION-1. Switching power supplies were used to obtain high efficiency.

Battery Supply

The battery supply consists of two parallel banks of six NiCad D-cells in series. ION-1 can operate on a single bank. The charging circuit charges both banks in series to make the ION-1 unit operable with the MCA charger. Relay K1 operates off the charger input and switches the battery banks from parallel to series. When you plug in the

Battery Supply (cont)

charger, 12 V is applied to the power supply board circuitry through the LM-340T-12 regulator.

Digital and Analog Voltages

Three basic supply voltages (+5 and ±15) and two bias supply voltages are generated (ion chamber bias is adjustable from 0 to -425 V, and fission chamber bias is adjustable from +500 to +1500 V).

The +5-V supply is composed of chips Z2, Z3, and Z7. Chip Z2 generates -18 V, and Z7 generates +18 V. R10 and R27 determine the voltage setpoints of these chips. Capacitors C10 and C11 filter the outputs. Chip Z3 is a dual-balanced tracking regulator. The output of this regulator is ±15 V, and the outputs are filtered with C16, C17, and C19.

Bias Voltages

Commercial dc-dc converters (Venus Q-15) generate the bias voltages. The supply voltages are controlled by R33 for the ion chamber bias and R44 for the fission chamber bias. The Q-15's and the associated filters and dividers are mounted on the internal rear panel inside a metal cover, providing both shielding and protection.

Voltage Display

ION-1 can display the digital, analog, bias, and battery supply voltages. Resistors R18 and R19 form the voltage divider that supplies the +5-V input to the ADC on the main electronics board. R20 and R21 form a similar divider for the +15-V supply. The ADC expects a positive unipolar input; hence, the -15-V supply signal is inverted by Z4, which has less-than-unity gain.

Voltage Display (cont)

Chip Z6 is an inverter-buffer for the ion chamber bias readout. Chip Z5 is the buffer for the fission chamber bias divider that feeds the ADC.

On the main circuitry board (Dwg No. 101Y-230839-D1), ±5.6 V is required for the ICL 7600 amplifiers. Zener regulators CR4, CR5, R15, and R16 generate the voltages. The regulators use the ±15-V supplies for their source.

DIGITAL CONTROL PROCESSOR

The heart of ION-1 is a Motorola M6802 microprocessor used for control, data acquisition, diagnostics, and calculations. Dwg No. 101Y-230858-D2 shows the main digital circuitry. The firmware is software stored in read-only memory (ROM), in chips U41-U47. The random-access memory (RAM) is in chips U38-U39.

Front Panel

The main communication with the microprocessor is through the front-panel keyboard and display. The interface is executed through chips U29-U31. The front-panel circuitry (Dwg No. 101Y-230839-D3) consists basically of a keypad encoder Z1, a display memory Z3 (32 x 8) holding the display characters, and a character generator ROM Z6. Connector P2 connects the LCD module (EPSON MA-B956B) to the board.

LCD Module

The LCD module provides character addresses, P2 pins 12-16, and row scan addresses, P2 pins 9-11. Chips Z10 and Z11 apply the character row data to the LCD module. These exclusive OR gates allow

LCD Module (cont)

inverse character display when bit 7 of the character data is set (>2 V). Chips Z5 and Z4 are three-state buffers that feed the appropriate address information to the display memory Z3. Chips Z8 and Z12 furnish the appropriate gating of Z4 and Z5, as well as the write-data strobe for Z3.

Keypad Scan

Chip Z1 scans the keypad. When a key is pushed, the data-available line Z1, pin 13, goes high and stays high as long as the key is pressed. This level is fed to the microprocessor through data line D0 on chip U29 of the main electronics board (Dwg No. 101Y-230858-D2). The going high of the data-available line sets the Q output of Z7 (Dwg No. 101Y-230839-D3), which indicates that there has been a key push since the last read of the Z1 output. The Z7 output is reset by the signal from Z12, pin 12, which is strobed by the trailing edge of the read-enable pulse that transfers the Z1 data to the microprocessor through chip U29 on the main electronics board.

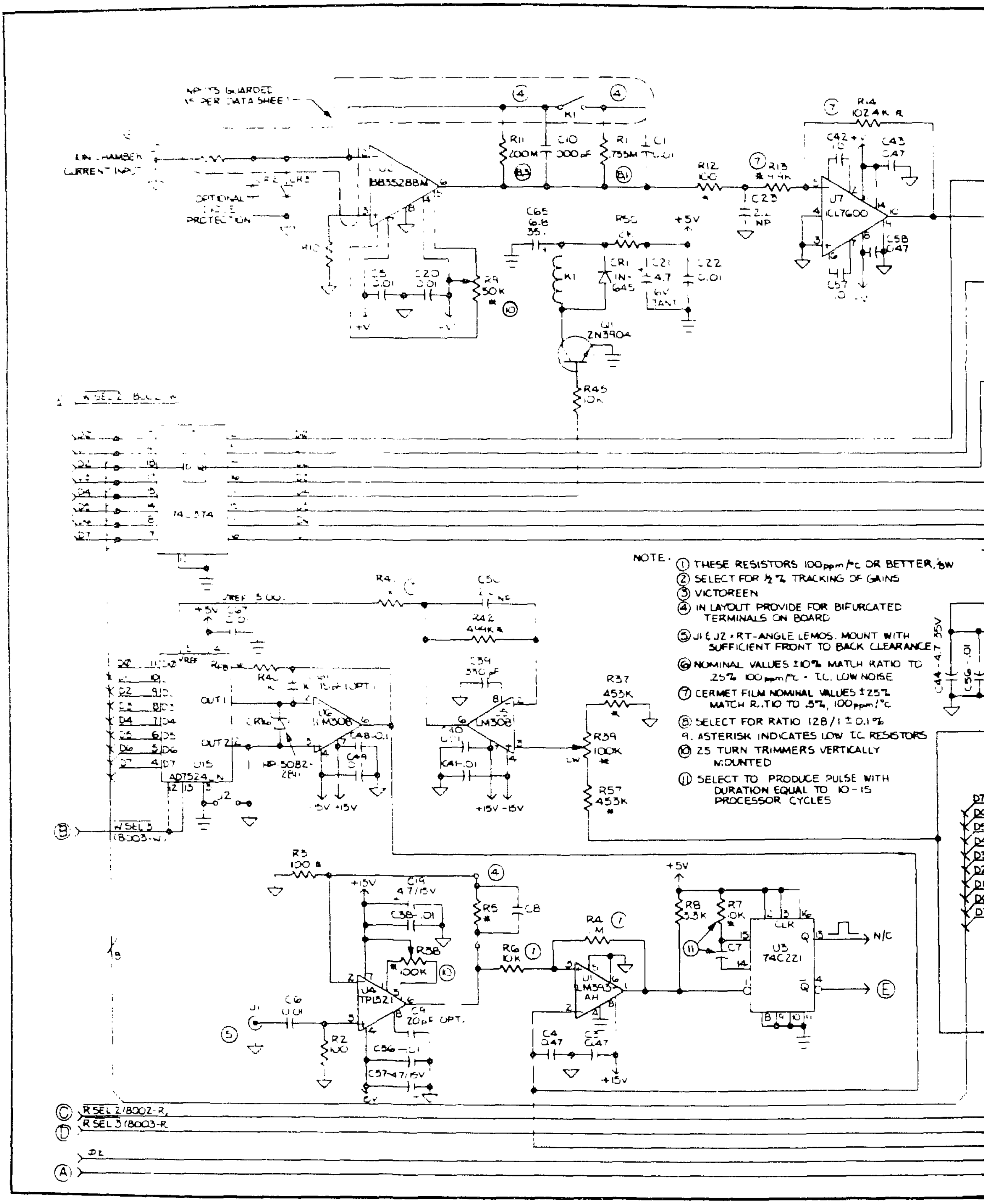
Serial Interface

Additional communication with the processor is made with an RS-232 level compatible serial interface. Chip U22 (Dwg No. 101Y-230839-D3) is the serial interface chip used. The baud rate is set from software using circuitry associated with chip U20. The level shifting for the input/output is done using the circuitry between connector P2 and the serial interface.

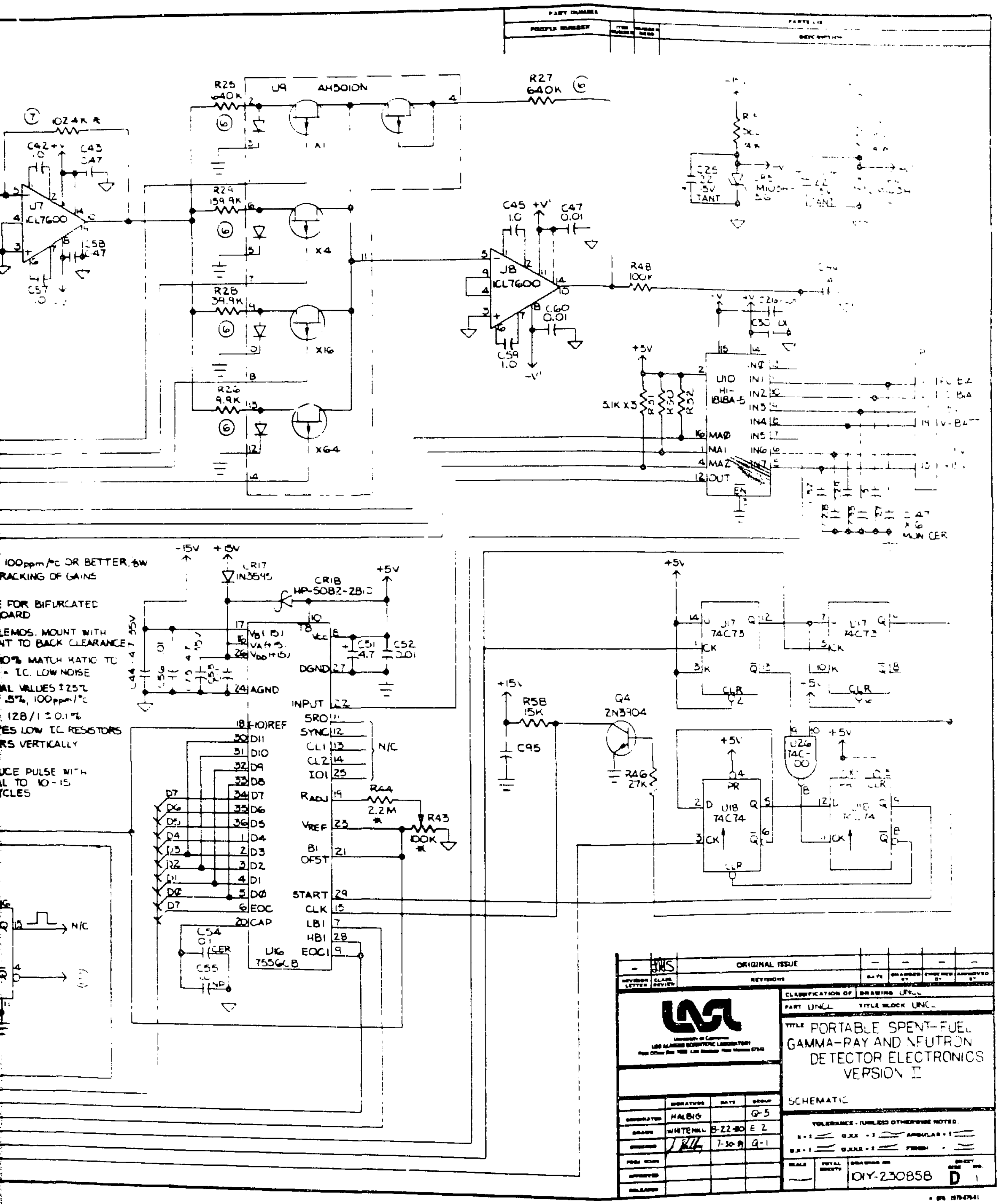
Real-Time Clock

Chip U25 and the MM5368 generate the real-time clock interrupts. Interrupts occur every 200 ms.

*U.S. GOVERNMENT PRINTING OFFICE: 1985-0-576-034/20096

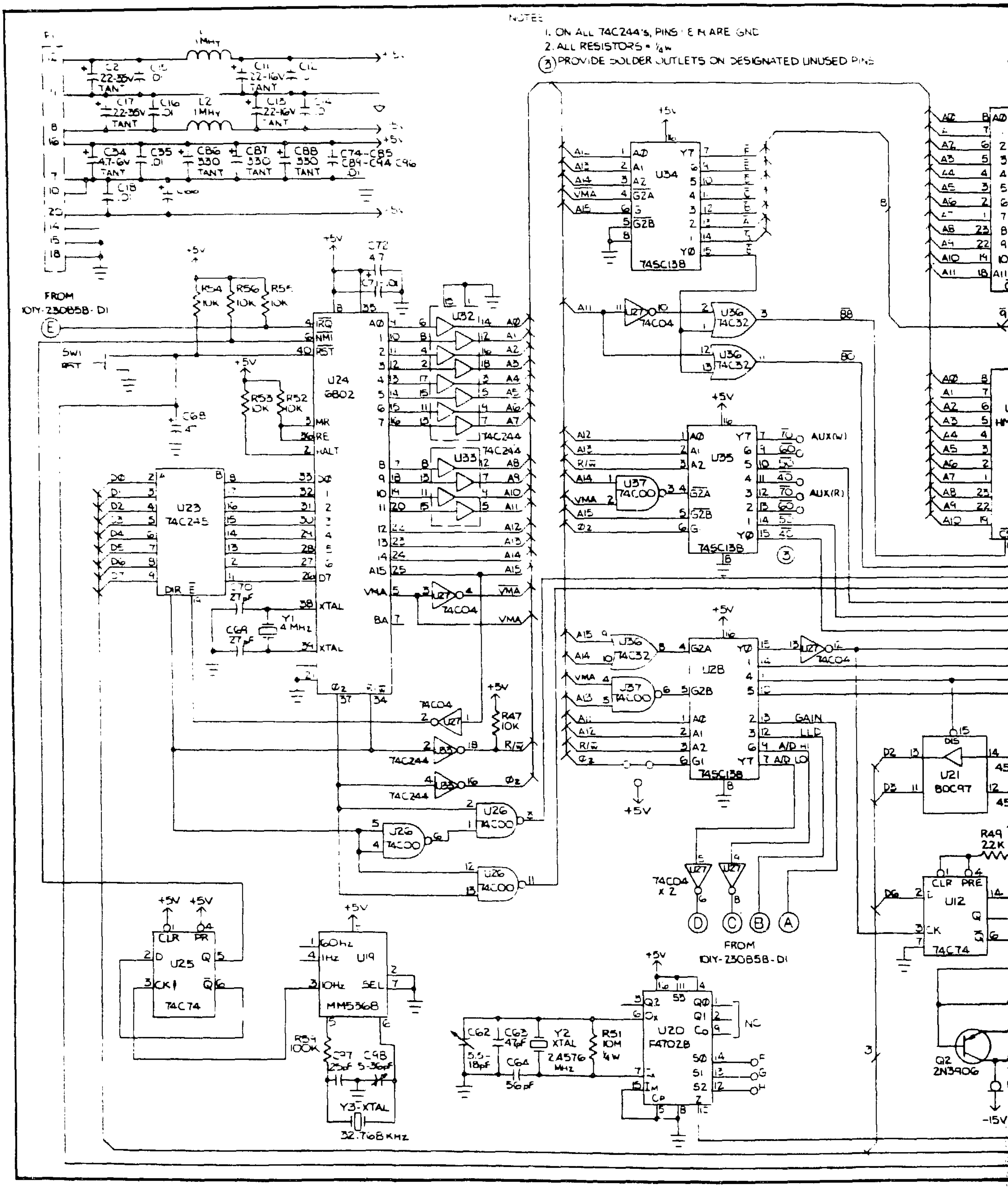


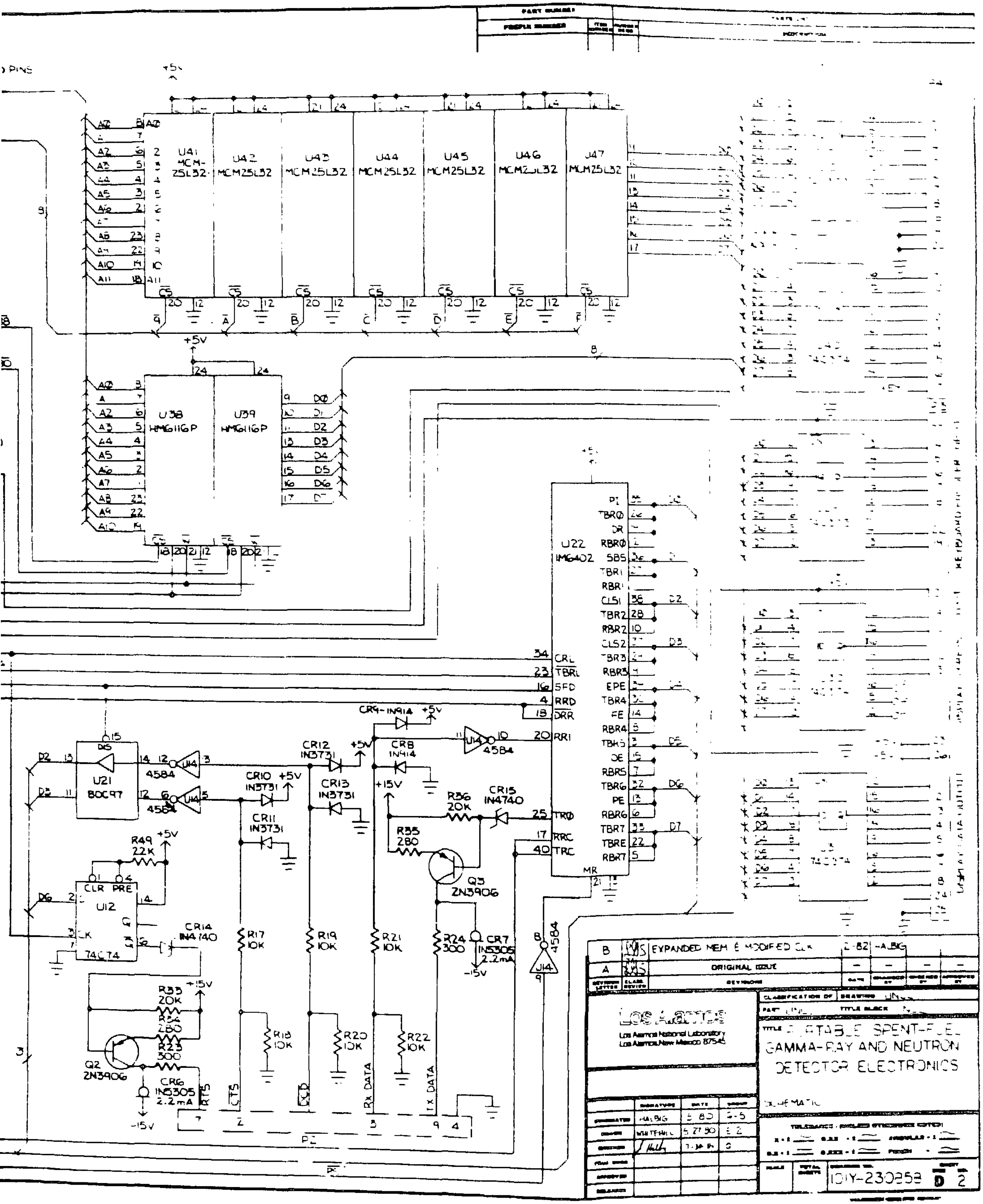
INPUTS GUARDED AS PER DATA SHEET
ION CHAMBER CURRENT INPUT
OPTIONAL DIODE PROTECTION
BB3528BM
R11 200M
C10 300pF
R1 .755M
C1 0.01
K1
R12 100
R13 4.99K
C23 2.2 NP
R14 1024K
ICL7600
C42
C43 .047
C58 .047
C57 .01
C65 6.8 35V
R50 2K
+5V
CR1 IN-645
C21 4.7 6V TANT
C22 0.01
Q1 2N3904
R45 10K
R9 50K
C5 0.01
C20 0.01
74LS74
VREF 5.00
R4
C50
R42 444K
C39 390pF
R37 453K
R39 100K
R57 453K
LM308
AD7524
CR16
HP-5082-2811
C48 0.1
C49
C41 .01
+15V -15V
W SEL 3 (8003-W)
R3 100
R5
C8
C19 4.7/15V
C38 .01
R38 100K
TP1321
C9 20pF OPT.
C6 0.01
R2 100
C56 .01
C57 4.7/15V
R4 1M
R6 10K
LM393AH
C4 0.47
C3 0.47
+15V
R8 3.3K
R7 10K
C7
U3 74C221
CLR
Q
N/C
R SEL 2 (8002-R)
R SEL 3 (8003-R)
NOTE:
1. THESE RESISTORS 100ppm/°C OR BETTER, 1/8W
2. SELECT FOR 1/2% TRACKING OF GAINS
3. VICTOREEN
4. IN LAYOUT PROVIDE FOR BIFURCATED TERMINALS ON BOARD
5. J1 & J2 = RT-ANGLE LEMOS. MOUNT WITH SUFFICIENT FRONT TO BACK CLEARANCE
6. NOMINAL VALUES ±10% MATCH RATIO TO .25% 100ppm/°C • T.C. LOW NOISE
7. CERMET FILM NOMINAL VALUES ±25% MATCH RATIO TO .5%, 100ppm/°C
8. SELECT FOR RATIO 128/1 ± 0.1%
9. ASTERISK INDICATES LOW T.C. RESISTORS
10. 25 TURN TRIMMERS VERTICALLY MOUNTED
11. SELECT TO PRODUCE PULSE WITH DURATION EQUAL TO 10-15 PROCESSOR CYCLES



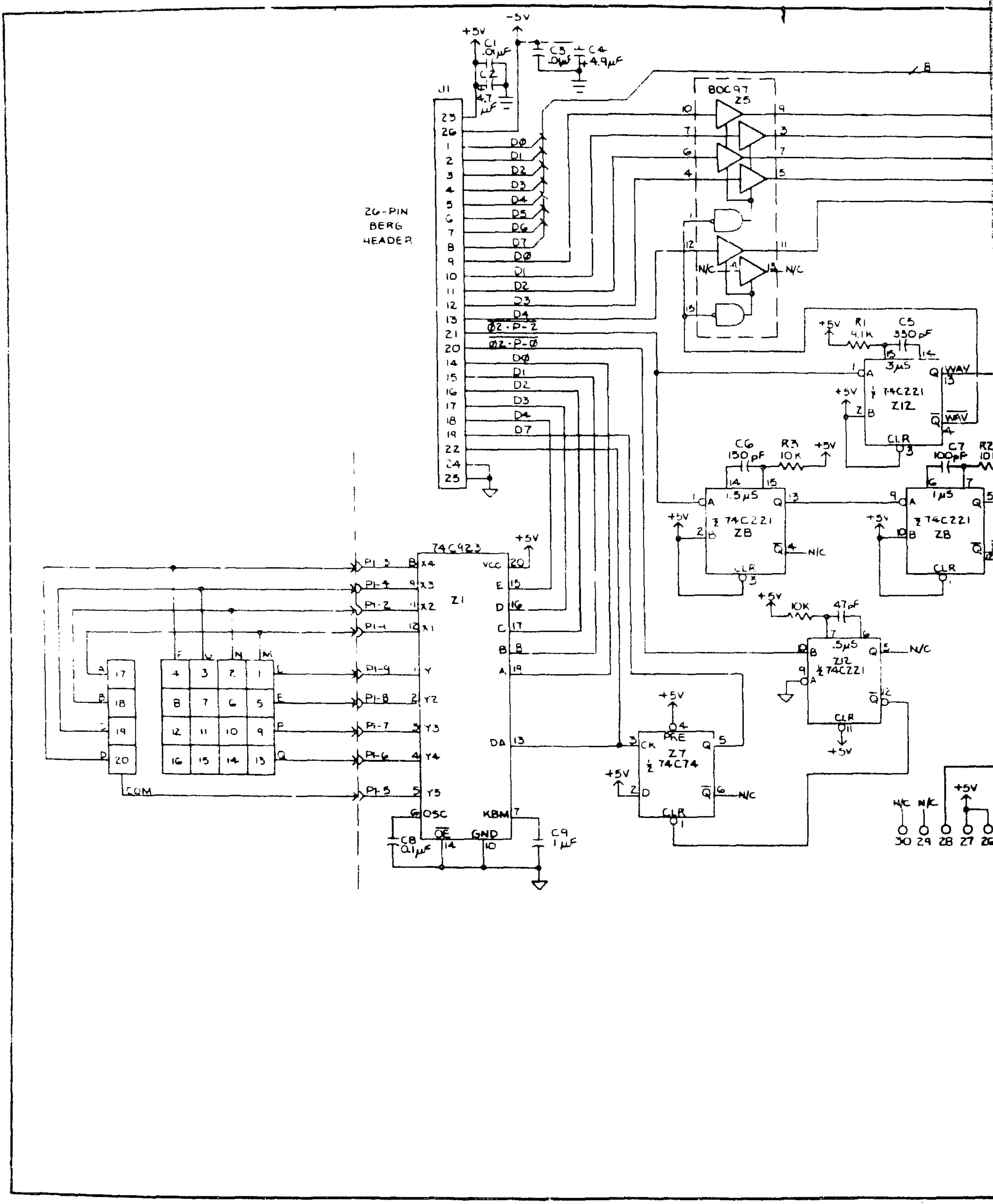
U9 AH5010N
R25 640K
R27 640K
R24 159.9K
R28 39.9K
R26 9.9K
U7 ICL7600
U8 ICL7600
R48 100K
U10 HI-1818A-5
5.1K X3
CR17 1N3595
CR18 HP-5082-2810
U16 7556CB
R44 2.2M
R43 100K
R58 15K
C95
Q4 2N3904
R46 27K
U17 74C73
U18 74C74
U26 74C00
N/C
ORIGINAL ISSUE
CLASSIFICATION OF DRAWING UNCL
PART UNCL TITLE BLOCK UNCL
TITLE PORTABLE SPENT-FUEL GAMMA-RAY AND NEUTRON DETECTOR ELECTRONICS VERSION II
SCHEMATIC
HALBIG Q-5
WHITENILL 8-22-80 E 2
7-30-81 G-1
DRAWING NO. 0IY-230858
SIZE D
SHEET 1

1

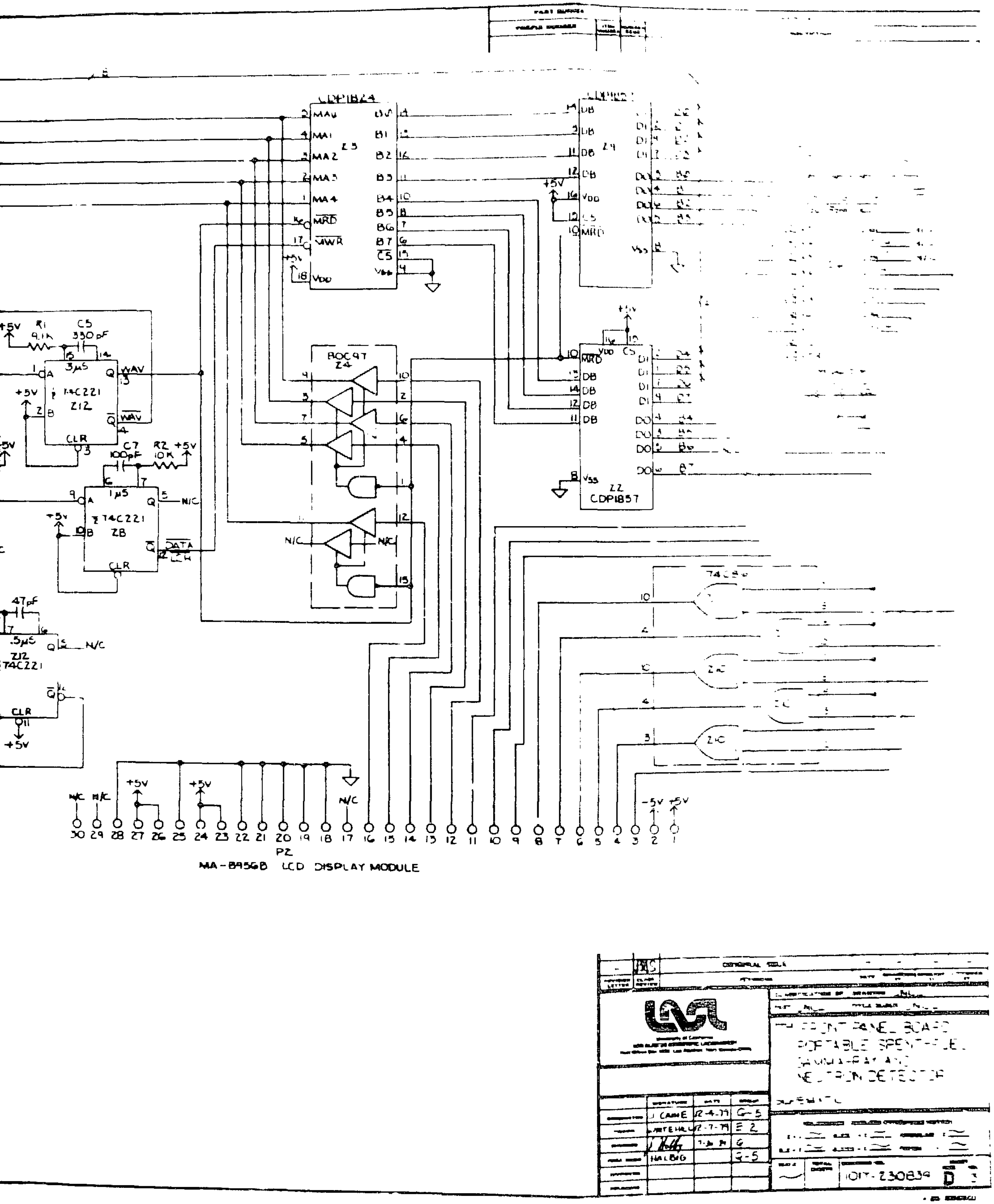

NOTES
1. ON ALL 74C244's, PINS 1 & 19 ARE GND
2. ALL RESISTORS = ¼W
(3) PROVIDE SOLDER OUTLETS ON DESIGNATED UNUSED PINS
FROM
1DIY-230858-D1
U24
6802
U23
74C245
U34
74SC138
U35
74SC138
U28
74SC138
U36
74C32
U37
74C00
U26
74C00
U27
74C04
U32
74C244
U33
74C244
U25
74C74
U19
MM5368
U20
F4702B
U21
80C97
U12
74C74
Q2
2N3906
Y1
4 MHz
Y2
XTAL
2.4576 MHz
Y3-XTAL
32.768 KHz
AUX(W)
AUX(R)
GAIN
A/D HI
A/D LO
NC
FROM
1DIY-230858-D1
74C04
X 2
SW1
RST

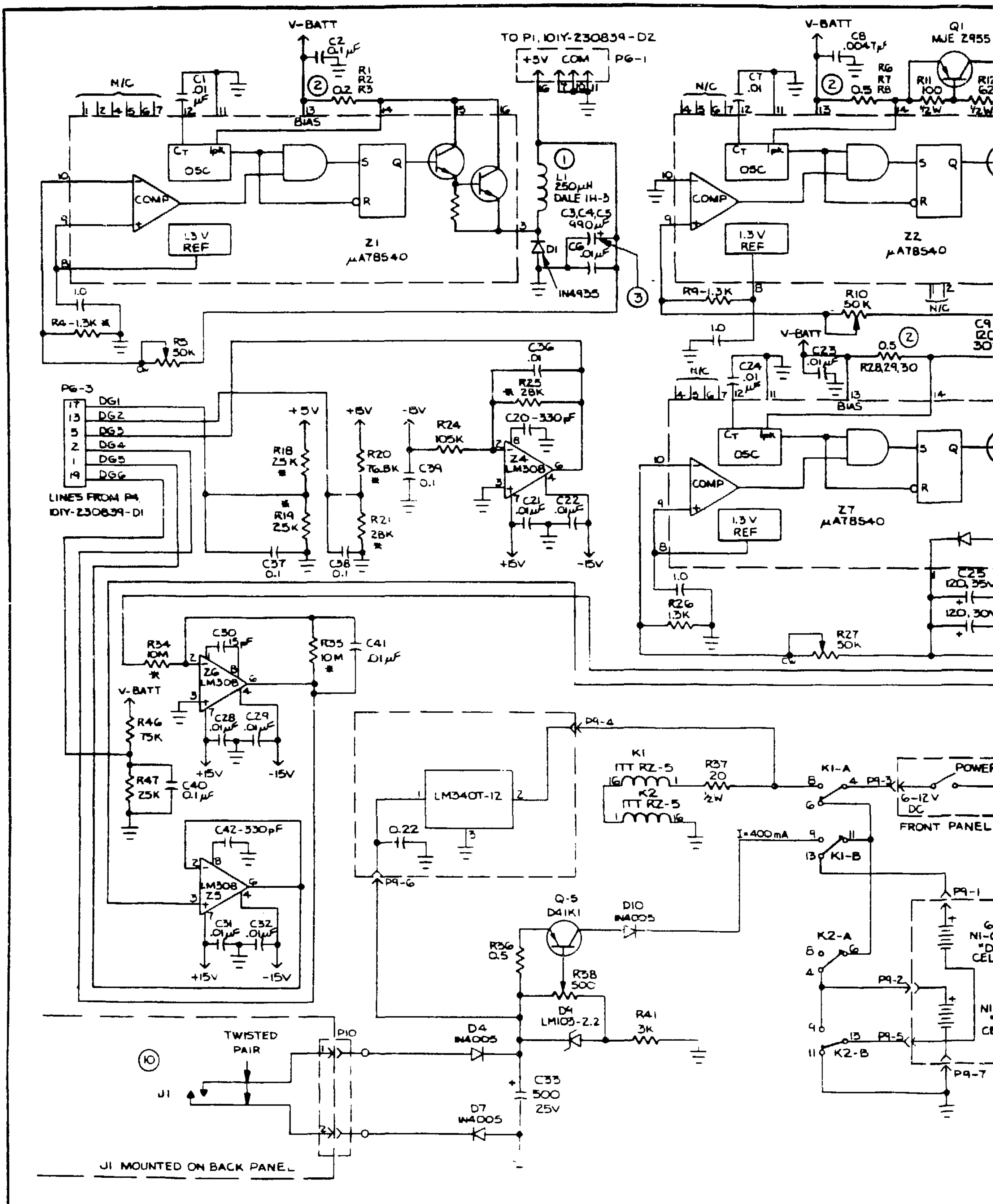


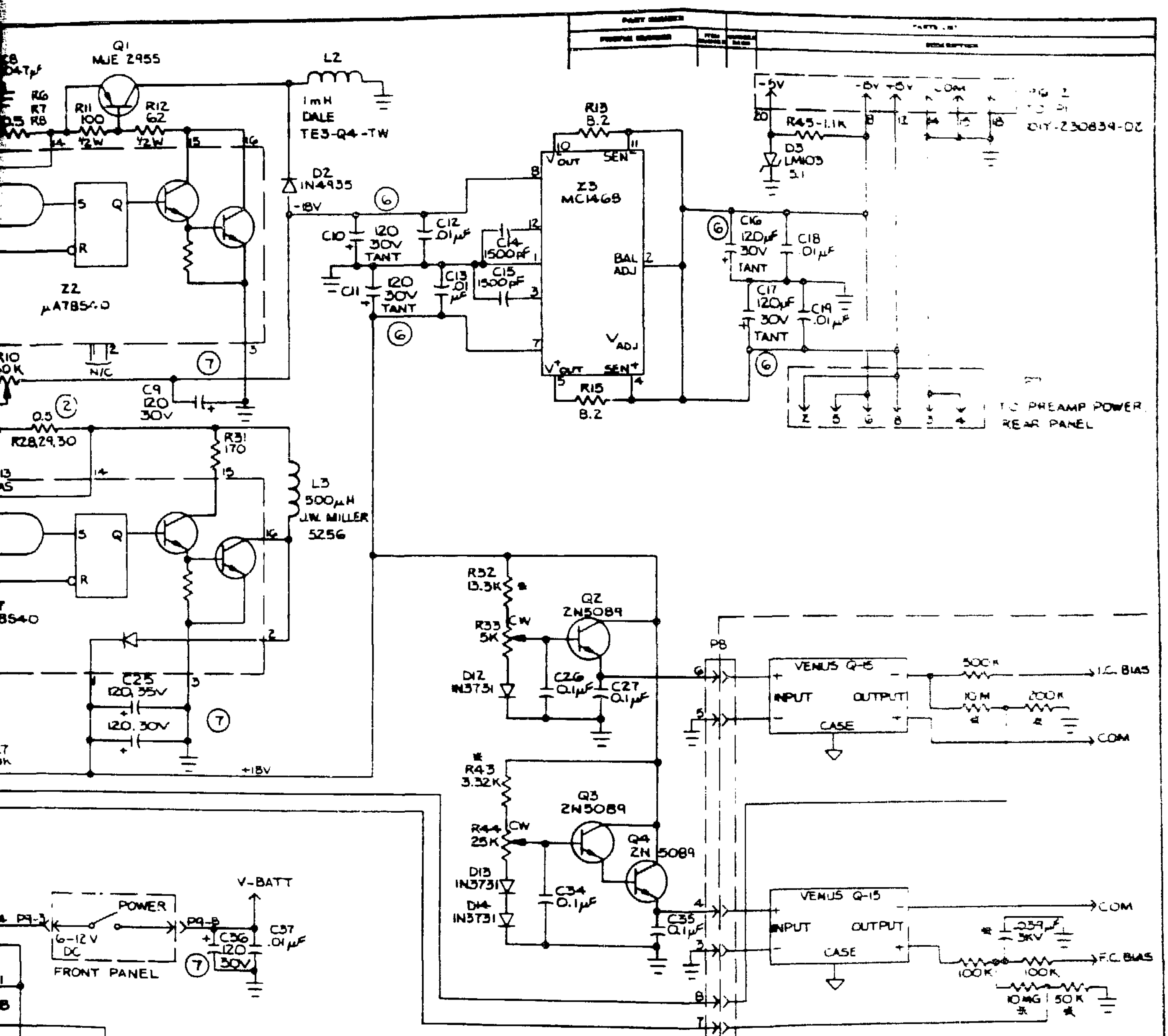
PINS
+5V
U41 MCM-25L32
U42 MCM25L32
U43 MCM25L32
U44 MCM25L32
U45 MCM25L32
U46 MCM25L32
U47 MCM25L32
A0 A1 A2 A3 A4 A5 A6 A7 A8 A9 A10 A11
CS
U38 HM6116P
U39 HM6116P
D0 D1 D2 D3 D4 D5 D6 D7
U22 IM6402
PI TBR0 DR RBR0 SBS TBR1 RBR1 CLS1 TBR2 RBR2 CLS2 TBR3 RBR3 EPE TBR4 FE RBR4 TBR5 OE RBR5 TBR6 PE RBR6 TBR7 TBRE RBR7 MR
CRL TBRL SFD RRD DRR RRI TRO RRC TRC
U21 80C97
U14 4584
U12 74C74
CLR PRE CK
CR9 - IN914
CR8 IN914
CR12 IN3731
CR13 IN3731
CR10 IN3731
CR11 IN3731
CR14 IN4740
CR15 IN4740
CR6 IN5305 2.2mA
CR7 IN5305 2.2mA
R49 22K
R36 20K
R35 280
R33 20K
R34 280
R23 300
R24 300
R17 10K
R18 10K
R19 10K
R20 10K
R21 10K
R22 10K
Q2 2N3906
Q3 2N3906
+15V
-15V
RTS CTS DCD RX DATA TX DATA
P2
74C374
B | WS | EXPANDED MEM & MODIFIED CLK | 2-82 | HALBIG
A | WS | ORIGINAL ISSUE
LOS ALAMOS
Los Alamos National Laboratory
Los Alamos, New Mexico 87545
TITLE PORTABLE SPENT-FUEL GAMMA-RAY AND NEUTRON DETECTOR ELECTRONICS
SCHEMATIC
HALBIG 5-80
WHITEHILL 5-27-80
101Y-230258 D 2

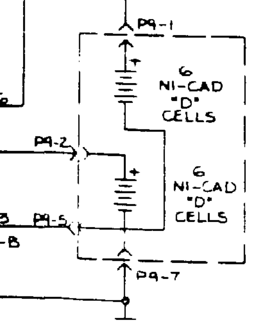


26-PIN
BERG
HEADER
J1
8OC97
Z5
74C923
Z1
74C221
Z12
Z8
Z7
74C74


CDP1824
Z3
MA0
MA1
MA2
MA3
MA4
MRD
MWR
VDD
B0
B1
B2
B3
B4
B5
B6
B7
CS
VSS
Z4
DB
VDD
CS
MRD
VSS
+5V
R1
9.1K
C5
330 pF
3μS
74C221
Z12
WAV
CLR
C7
100pF
R2
10K
1μS
74C221
Z8
DATA
N/C
80C97
Z4
47pF
.5μS
Z12
74C221
CDP1857
Z2
74C86
MA-B956B LCD DISPLAY MODULE
P2
FRONT PANEL BOARD
PORTABLE SPENT-FUEL
GAMMA-RAY AND
NEUTRON DETECTOR
J CAME
12-4-79
G-5
WITEHALL
12-7-79
E 2
HALBIG
G-5
10IY-230839
D


V-BATT
C2 0.1µF
R1 R2 R3
0.2
TO P1, 101Y-230839-D2
+5V COM
P6-1
N/C
C1 .01 µF
BIAS
OSC
COMP
1.3 V REF
Z1
µA78540
L1 250µH DALE IH-3
C3,C4,C5 990µF
C6 .01µF
D1
1N4935
R4-1.3K
R5 50K
C36 .01
R25 28K
C20-330pF
R24 105K
Z4 LM308
C21 .01µF
C22 .01µF
+15V
-15V
+5V
+15V
-15V
R18 25K
R19 25K
R20 76.8K
R21 28K
C39 0.1
C37 0.1
C38 0.1
P6-3
DG1
DG2
DG3
DG4
DG5
DG6
LINES FROM P4, 101Y-230839-D1
R34 10M
C30 15pF
Z6 LM308
R35 10M
C41 .01µF
C28 .01µF
C29 .01µF
V-BATT
R46 75K
R47 25K
C40 0.1µF
C42-330pF
LM308 Z5
C31 .01µF
C32 .01µF
P9-4
LM340T-12
0.22
P9-6
K1 ITT RZ-5
K2 ITT RZ-5
R37 20 ½W
K1-A
P9-3
6-12 V DC
POWER
FRONT PANEL
I=400mA
K1-B
Q-5 D41K1
D10 IN4005
R36 0.5
R38 500
D9 LM103-2.2
R41 3K
D4 IN4005
D7 IN4005
C33 500 25V
P10
TWISTED PAIR
J1
J1 MOUNTED ON BACK PANEL
K2-A
K2-B
P9-1
P9-2
P9-5
P9-7
V-BATT
C8 .0047µF
Q1 MJE 2955
R6 R7 R8
0.5
R11 100 ½W
Z2
µA78540
R9-1.3K
R10 50K
N/C
C23 .01µF
C24 .01
R28,29,30
Z7
µA78540
R26 1.3K
R27 50K
C25 120, 35V
120, 30V





NOTES:

1. DALE IH-3, 250μH
2. LAYOUT FOR 3 PARALLEL RESISTORS, ¼W, COMP
3. LAYOUT FOR 3 PARALLEL CAPACITORS, 330μF, 10V, MALLORY 337M010P1C
4. MALLORY 501U025D1N
5. ALL POTS = BOURNS MODEL 3282
6. SPRAGUE CSR-13F226KM
7. 15 VDC, SPRAGUE CSR-13D157MM
8. ALL RESISTORS ¼ W, 10% UNLESS OTHERWISE NOTED
9. ASTERISK INDICATES ¼W CERMET FILM
10. J1 = MINIATURE PHONE JACK CONN FOR CHARGING CONVERTER
11. P6 = 20-PIN BERG CONN. P7 = 8-PIN AMPMODU
P8 = 8-PIN AMPMODU P9 = 8-PIN AMPMODU
P10 = 2-PIN AMPMODU

B		REVISED & REDRAWN	2/80	RW
A		ORIGINAL ISSUE		

LASL

POWER SUPPLY
PORTABLE SPENT-FUEL GAMMA-RAY AND NEUTRON DETECTOR
SCHEMATIC

DURAN | G-5
WHITEHILL | 1-24-80 | E-2

10TY-230839 D 4