Navy
AN/PDR 27-5

HDER G-01

Technical Manual

Operation & Maintenance Instructions

ITEM	DESCRIPTION
CASE	HDER-G01 CASE, HDER-G01 SET
EQUIPMENT	See Table 1-2
DIMENSIONS AND WEIGHTS	See Table 1-2
OPERATING TEMPERATURE	-40 degrees to-+60 degrees C
OPERATING ALTITUDE	Any altitude up to 50,000 feet
POWER REQUIREMENTS	2 each internal 1-1/2 volt "D" Cell Batteries
ACCURACY	+20% from 10% of full scale on each temperature range throughout entire operating temperature range
RANGE INDICATION	Meter Type Indication Provided on Four Ranges 0-0.5, 0-5, 0-50, 0-500 mR/hr
ENERGY RANGE	Measures gamma radiation from 80 keV to 2MeV. Detects beta radiation on 0-0.5 and 0-5 mR/hr ranges.
BATTERY CHECK	Meter indication of Battery condition provided
METER LIGHT	Momentary switched meter light provided

SAFETY SUMMARY

The following are general safety precautions that are not related to any specific procedures and, therefore, do not appear elsewhere in this publication. These are recommended precautions that personnel must understand and apply during many phases of operation and maintenance.

DO NOT SERVICE OR ADJUST ALONE

Under no circumstances should any person reach into or enter the enclosure for the purpose of servicing or adjusting the equipment except in the presence of someone who is capable of rendering aid.

RESUSCITATION

Personnel working with or near high voltages should be familiar with modern methods of resuscitation! Such as CPR.

The following warning appears in the text in this volume and is repeated here for emphasis.

WARNING

High voltage is used in the operation of this equipment. Severe shock may result if personnel fail to observe safety precautions. Learn the areas containing high voltage in each piece of equipment. Be careful not to contact high voltage connections when installing or working on this equipment. When servicing, ground points of high potential before touching them.

SUMMARY OF PRECAUTIONS CITED IN TEXT

Avoid contact with the window of low range G-M tube. It is fragile and easily damaged which might necessitate replacement of the tube.

CHAPTER 1: GENERAL INFORMATION

1-1. GENERAL DESCRIPTION. The HDER-G01 is a portable, battery operated radiation detector and indicator (figure 1-1) capable of detecting and measuring up to 500mR/hr of gamma radiation and can detect the presence of beta radiation. The HDER-G01 is equipped with a carrying handle and detachable shoulder harness. The G-M Probe, attached to the HDER-G01 by a coiled cable, is a two-compartment probe which is stowed in the mounting well in the case. HDER-G01 includes a carrying case, dry-cell batteries, headset, harness, spare tubes, and one copy of this technical manual.

1-2. DESCRIPTION OF THE HDER-G01. Mounted on the panel are an indicating meter, a range switch, a push button switch, and headset jack. Mounted to the underside of the panel (figure 6-4) is the printed circuit board containing the electronic circuitry?

The indicating meter is placed behind a sealed plastic window for waterproofing. It has five movable scales which are mechanically coupled to the range switch so that the scale corresponding to the switch position is presented.

The carrying handle provides space for stowing the detector cable when then detector is placed into its mounting well.

The push-button switch controls the meter lamp.

A. The Geiger Mueller (GM) Probe. The HDER-G01 detector is a probe consisting of a type JAN-5979 Geiger-Mueller Tube and a type JAN-5980 Geiger Mueller tube, each enclosed in its own cylindrical metal housing (figure 1-1). The two housings are clamped together into one

JAN 5980 dead time 45 microseconds
*3,5 CPS = 1 mR/hr
JAN 5979
* 45 CPS = 1 mR/hr
dead time = 100 micro seconds
*Both counts for gamma radiation

21CPM/uSv/hr

270CPM/uSv/hr

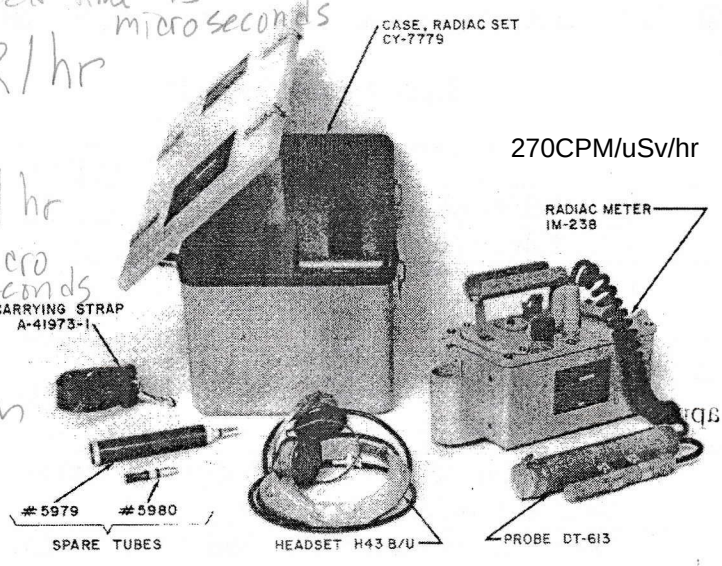


Figure 1-1 Relationship of units

unit. A movable metal shield normally covers the mica window of the larger tube. When the shield is over the window, beta radiation is excluded from the tube. The shield can be swung aside when beta-plus gamma radiation readings are desired.

CAUTION

Since the mica window is only 0.0005-inches thick, it is extremely fragile. Do not touch the window under any circumstances, as damage to the tube will result. Do not rely upon the guard ring to protect the mica window. The guard ring openings are large enough so that sharp objects may pierce the window.

Electrical connections for both G-M tubes are made at the ends of the housings where the shielded cables pass through waterproof packing glands to the tube electrodes. The probe cable is flexible and kink proof and is normally coiled in the space in the top of the handle.

B. HEADSET H-43B/U. The headset provides the operator with aural indications of radiation intensity when plugged into the jack on the panel (figure 2-1).

C. HARNESS. The shoulder harness, an adjustable strap made of non-absorbent plastic, is used for carrying the HDER-G01 during operation. Clip fasteners on each end of the strap snap into holes in small projections on the HDER G-01 panel (figure 2-1).

D. SPARE PARTS. The field spares, consisting of one each of the G-M tubes are carried in the spare parts compartments (figure 1-1) of the carrying case.

1-3. EQUIPMENT ACCESSORIES AND DOCUMENTS SUPPLIED. Table 1-1 lists reference data for HDER G-01. Table 1-2 lists the dimensions and weights of all the components of the HDER G-01.

Table 1-1 Reference Data

Item	Description
Equipment Supplied	See Table 1-2
Dimensions and Weights	See Table 1-2
Operating Temperature	-40° to +60° C
Operating Altitude	Any Altitude up to 50,000 Feet.
Power Requirements	2 each internal 1.5 volt "D" Cell Batteries
Accuracy	+ 20% from 10% of full scale on each range throughout entire operating temperature range.
Range Indication	Meter type indication provided on four ranges: 0-0.5, 0-5, 0-50, 0-500 mR/hr
Energy Range	Measures gamma radiation from 80 keV to 2MeV. Detects beta radiation on 0-0.5 and 0-5 mR/hr ranges.
Battery Check	Meter indication of Battery condition provided.
Meter Light	Momentary switched meter light provided.

Table 1-2 Equipment and Accessories Supplied

Name	Height inches	Width inches	Depth inches	Weight lbs.	Volume in^3
HDER G-01 Set	7.75	13	10	10	289
Meter w/batteries	7	9.75	4.5	5.6	136
Case	5.25	9	6.13	2.5	289
Probe	1.25	8	2.5	1.1	11.4
Carrying Strap	54	1	.06	.3	.003
Headset	6.12	7	2.12	.05	.087
Tube, GM Spare	1 diameter	-	5	.17	3.95
Tube, GM Spare	.37 diameter	-	4	.02	.44

CHAPTER 2: OPERATION

2-1. INTRODUCTION. HDER-G01 is used to measure gamma radiation up to an intensity of 500 mR/hr and to detect beta radiation. The HDER-G01 consists primarily of regulated high and low voltage power supplies, a mica-end window Geiger-Mueller (G-M) tube for low range (0-0.5 and 0-5 mR/hr) coverage and beta detection, a G-M tube (no mica window) for high range (0-50, 0-500 MR-hr) coverage, rate meter and indicating circuits which provides a meter reading that is proportional to the radiation field intensity irradiating the G-M tube detectors.

2-2. CONTROLS AND INDICATORS. Refer to Figure 2-1 which shows the operating controls. A single six position selector switch turns the unit on, provides for battery (BAT) check and selects the 500mR/hr, 50mR/hr, 5mR or 0.5mR/hr range. There is a screw cover which, when removed exposes the four calibration controls. These are marked 500, 50, 5 and 0.5 indicating the range being switched. Also located on the top panel is the BNC connector for the headset. The operator is permitted to handle only the operational controls; namely, the selector switch, the LIGHT switch, attach the headset and attach the carrying strap.

2-3. OPERATING PROCEDURES

A. Preparation for use.

1) Remove HDER-G01 from case.
2) Remove and connect headset if aural indications are desired.
3) Remove the battery cover by loosening the two captive screws holding it down and insert batteries (1-1/2 volt D cells) into battery compartment according to polarity markings on the top of the front panel under the battery cover. Replace battery cover and tighten securely.
4) Rotate selector switch to BAT position to check condition of batteries. The meter should read within the area marked "BATTERY". If not, replace with fresh batteries.
5) Attach clips on harness strap through holes in each end of HDER-G01 panel if shoulder carrying is desired. Adjust strap to comfortable length.

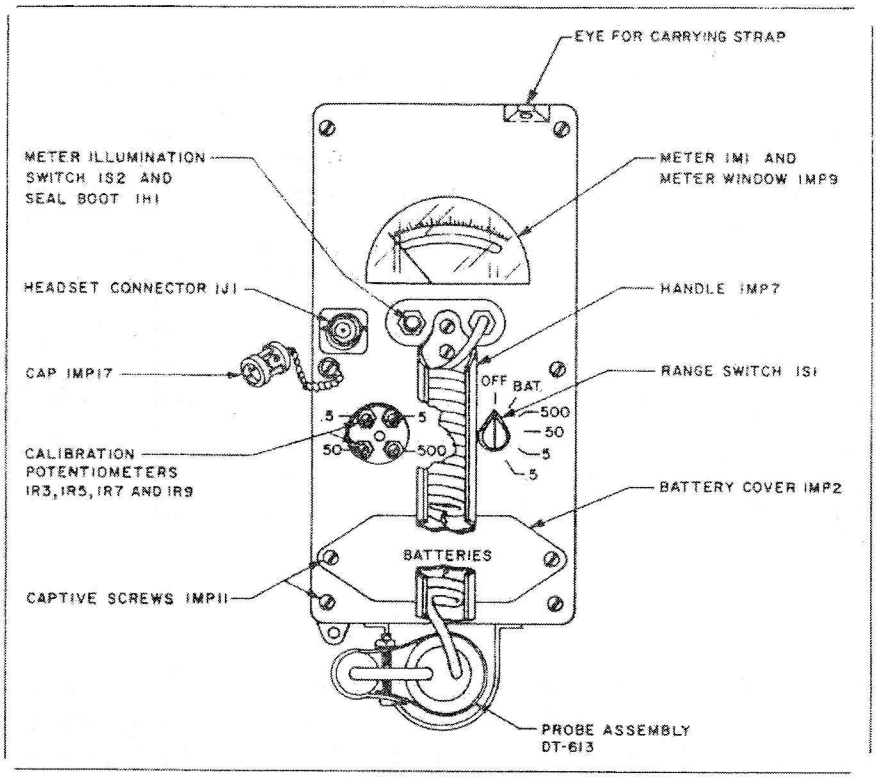


Figure 2-1 HDER G-01 Top Panel Controls.

B. To Measure Gamma Radiation.

1) Rotate the range selector to the 500 position. If the reading is below 10% of full scale, rotate to the 50 range. If reading is below 10% of full scale, rotate to the 5 position. If reading is again below 10% of full scale, rotate to the 0.5 position.
2) Listen for clicks in the headset or observe the meter reading while approaching the radioactive object or area. In a weak field it is necessary to use the headset because the clicks can be heard clearly even when the movement of the meter pointer is very small.
3) Turn the range switch to a lower (more sensitive) range whenever the meter reading is less than 5 divisions: turn it to a higher (less sensitive) range if the meter pointer approaches the high end of the scale.
4) When using the headset for searching for a radioactive object, start with the range switch at 0.5. If the clicks increase to a steady noise, turn to a higher scale.
5) When it is desired to locate a radioactive object or the center of a radioactive area, move the HDER G-01 in the direction that produces an increase in the meter reading or in the frequency of the clicks in the headset. Continue moving in the direction until the point of maximum radiation intensity is found.
6) If the object or area to be investigated is relatively inaccessible, remove the HDER G-01 detector from its mounting well and pass the detector probe back and forth over the area.
7) When the radiation from an object or area is extremely weak, bring the detector probe within a few inches of the object in order to obtain the largest possible indication on the meter or the loudest sound in the headset. A close approach is necessary because the radiation intensity decreases rapidly with distance.

C. To Detect Beta Radiation

To observe the combined beta and gamma radiation of an object, turn the range switch to 0.5 or 5, remove the HDER-G01 detector from its mounting well and swing open the beta shield on the end of the large cylinder of the probe. Point the exposed end of the probe at the object and move it, slowly, until a readable meter indication is obtained.

2-4. OPERATOR'S CHECK

A. If the equipment has been used continuously for more than 60 hours, check the condition of the batteries in the HDER-G01 by turning the range switch to BAT. When the meter pointer rests to the left of the center line, not in the area marked BATTERY, replace the batteries as instructed in paragraph 2-3, a, (3).
B. With the range switch in the 0.5 position, the meter pointer may occasionally deflect up scale slightly due to ambient background radiation and occasionally clicks may be heard from the headset. This is normal and indicates that the unit is operating.
C. Stop the equipment by turning the range selector switch to OFF. Remove the harness and headset from the HDER-G01, place the HDER-G01 detector into its mounting well, and stow items in the carrying case.

2-4. EMERGENCY OPERATION. If one or more of the parts of Table 7-1, which is prefixed with Notes 1 & 2, is changed, the HDER-G01 will probably be out of calibration. However, even though the HDER-G01 may be inaccurate with respect to absolute intensity, it will still be usable to indicate relative intensity within any one scale position.

This means that it is possible to recognize in which of two locations the intensity is higher, even though the actual intensities are in error. If readings are taken in the two locations on the same scale position, the higher reading correctly represents the higher intensity.

CHAPTER 3: FUNCTIONAL DESCRIPTION

3-1. FUNCTIONAL OPERATION. With reference to the Functional Block Diagram, Figure 3-1, the primary power source consisting of two series connected (1-1/2 volts) D-cell batteries, provides over sixty hours of continuous instrument operation. A transistorized power supply converts the three volts from the batteries into a regulated +710 volt G-M tube anode voltages and a ± 4.5 volt output for the computer-indicating circuitry operation. Beta particles (on the 0.5 and the 5.0 mR/hr ranges) and gamma rays on all ranges cause the Geiger tubes to produce voltage pulses which are then fed through a differentiating amplifier to a pulse generator followed by a meter drive circuit. The pulse generator provides pulses to the headphone for aural monitoring and supplies a DC current, proportional to the average pulse repetition frequency, to the indicating meter.

Power for all functional blocks is obtained through the low voltage Power Supply. The regulated Power Supply circuit assures that all operating voltages are maintained constant throughout the useful life of the batteries (battery life is in excess of 60 hours).

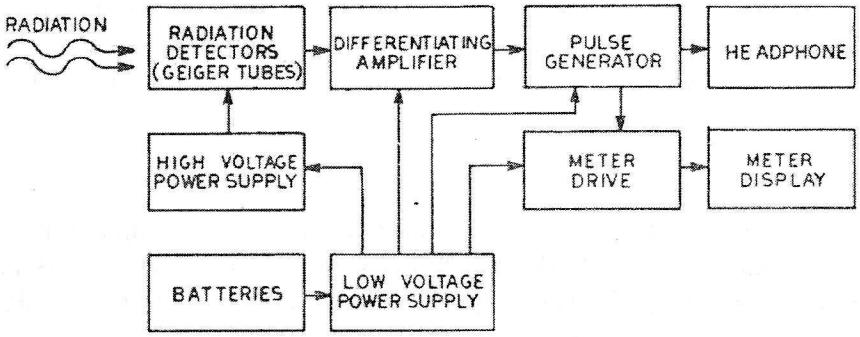


Figure 3-1. Functional Block Diagram.

3-2. FUNCTIONAL SECTIONS.

A. Power Supply. Refer to Figure 3-2, Power Supply Schematic. Transistors Q3, Q4, and Transformer T1 operate as a free running saturating oscillator that induces, by virtue of the transformer turns ratio, substantially larger AC voltage across the secondary windings 10-11 and 7-8-9. The AC voltage is converted to DC as follows:

1) Winding 10-11 voltage quadrupler consisting of CR4 to CR7 and C13 to C16 for a +710 volt output.
2) Winding 7-8-9 full wave rectifier consisting of CR9, CR10 and C19 for a +4.5 volt output.
3) Winding 7-8-9 full wave rectifier consisting of CR8, CR11 and C18 for a -4.5 volt output.

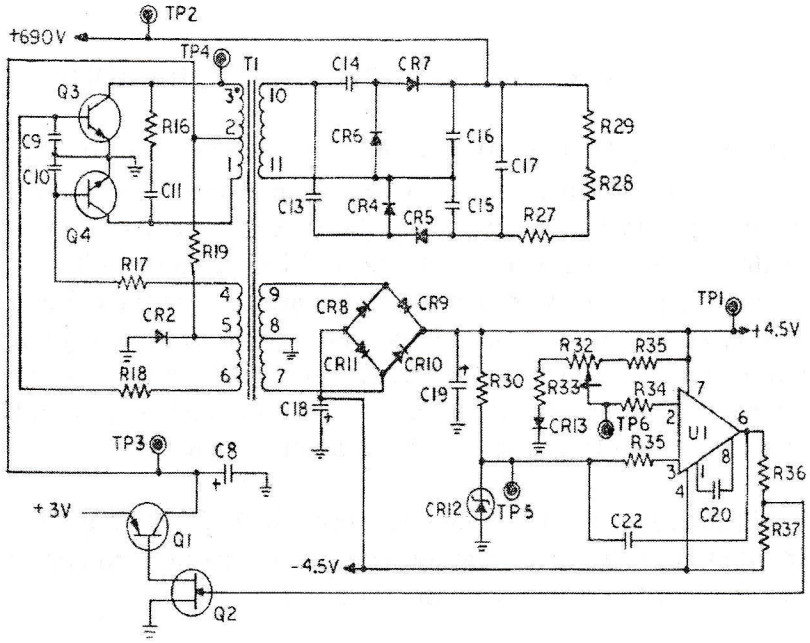


Figure 3-2. Power Supply Schematic

Voltage regulation is accomplished by sensing any change in the +4.5 volt output by the divider string of R31, R32, R33 and CR13, and applying this change to an input gate of the operational amplifier V1. Any change with respect to the 2.4 volt micro-current zener reference diode, CR12, results in an output current to the base of control FET Q2. The output of Q2 drives the regulator transistor Q1, which supplies the power for the oscillator. In general, for the same output voltage, the collector impedance of Q1 must be decreased as the battery voltage decreases. All other outputs are stabilized to the regulated volt supply through the controlled oscillator transformer T1. R32 is the output voltage adjust and CR13 corrects the operational amplifier output for zener reference variations over the full operating temperature range.

B. Radiation Detectors. (Refer to Figure 3-3) The 710 volt power supply provides HV to the two G-M tubes, V1 and V2. The contacts of the range switch are connected to supply HV to V1only on the 0.5 mR/hr and 5.0 mR/hr ranges while V2 is energized at all times (on all four ranges). When radiation causes either of the G-M tubes to discharge, a negative voltage pulse is generated across R2 or R11, and coupled to the pulse counting circuit (computer) through C6 or C7.

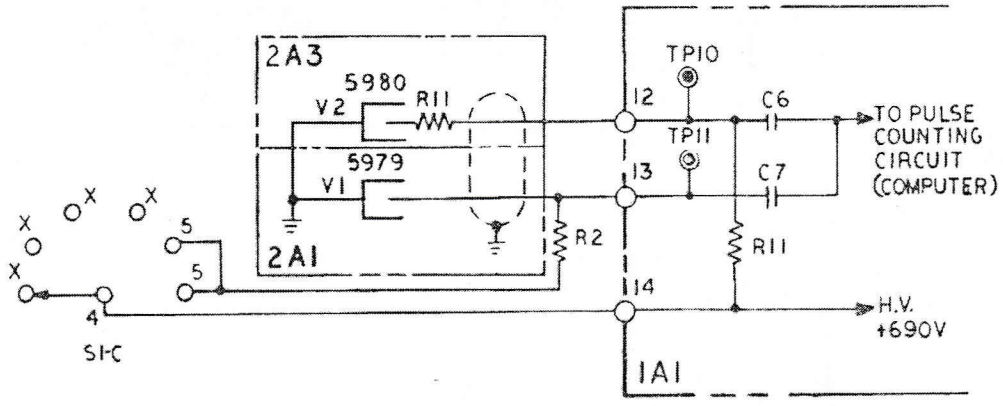


Figure 3-3 Radiac Detector

C. Computer Circuit. (Refer to Figure 3-4) The pulse from the G-M tube is coupled to the input of the transistor Q5. The amplifier Q5 is normally biased "on". A negative going pulse turns Q5 off for the duration of the input pulse. CR1 is a protection diode that protects the base of Q5 from being damaged by large negative input pulses. The positive pulse formed on the collector of Q5 turns the amplifier inverter transistor Q6 "on" for the duration of the input pulse. The negative pulse on the collector of Q6 is differentiated by the network of C12 and R15 and this differentiated pulse is impressed on the base of the switch transistor Q7. Diode CR3 is used to clamp the positive part of the differentiated pulse to .5 volts to protect the base of Q7 from being damaged.

Transistors Q8 and Q10 form a monostable multivibrator. The normal state of the monostable multivibrator corresponds to full conduction (saturation) of Q10 by its base being connected to the positive 4.5 volts DC supply through one of the following listed networks, depending on the setting of range switch S1B. The following lists the associated timing capacitor used within each range.

Range	Resistor Network	Timing Capacitor
0.5 mR/hr	R3, R4	C5
5.0 mR/hr	R5, R6	C4
50 mR/hr	R7, R8	C3
500 mR/hr	R9, R10	C2

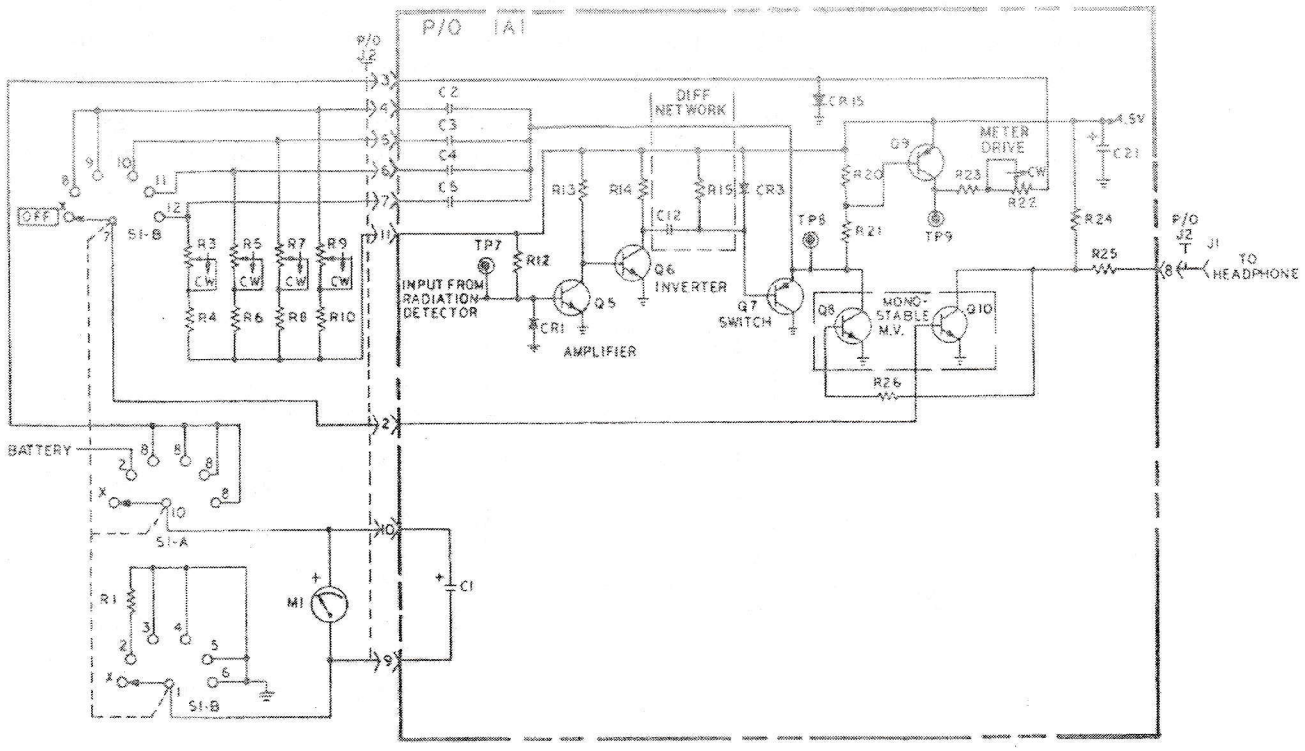


Figure 3-4. Computer Circuit

Transistor Q8 is normally "off" since its base is returned to ground through R26 and saturated transistor Q10. Transistor Q9 is an amplifier whose collector is connected to the meter M1 through R23 and adjustable resistor R22. With Q8 being "off" in the normal state, there is no current to flow through the meter M1. In this state the meter will indicate zero.

When a negative going pulse from the differentiation network arrives at the base of Q7 (refer to Figure 3-5) transistor switch Q7 turns on (saturates) and pulls one end of the timing capacitor C2, C3, C4, or C5, depending on the setting of the range switch S1B, to ground. This causes a negative pulse at the base of Q10, turning Q10 "off". As the collector of Q10 goes to +4.5 volts, Q8 is turned on via the resistor R26. Q8 saturates and holds the timing capacitor at ground while Q7 turns off at the end of the negative input pulse. The action of Q7 and Q8 turning "on" causes current to flow through R20 and R21. The voltage developed by the current in R20 biases the

transistor Q9 "on" and current flows through Q9, R23, R22 and the meter M1. After a time determined by the value of the timing capacitor and resistor network, the timing capacitor completes its discharge and begins to charge toward the +4.5 volt DC supply through the resistor network. This causes a positive voltage at the base of Q10, turning Q10 "on" (saturated). This causes the current to the base of Q8 to stop, turning Q8 "off", turning off Q9, which stops the current flow through the meter M1. The monostable multivibrator has now returned to its "normal" state. Thus, each received pulse from the G-M tubes has caused a fixed current to flow through the meter for a fixed time determined by the timing capacitor and resistor network. As long as this fixed conduction time interval is small compared to the average interval between received pulse, the average current which flows through the meter will be directly proportional to

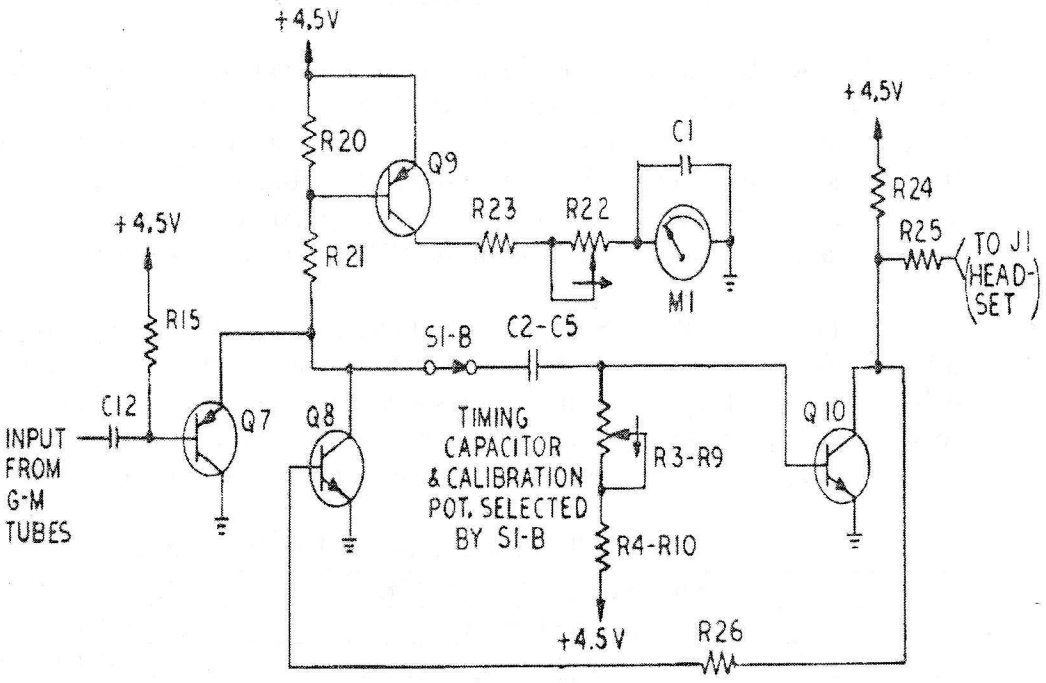


Figure 3-5. Monostable Multivibrator

the average repetition rate of the received pulses and the meter's indication will be linear. Capacitor C1 smoothes out the current pulses to the meter so that rapid fluctuations are suppressed. Diode CR15 protects the meter against damage from over voltage. The pulses at the collector of Q10 are fed to the headphone jack J1 via R25 for aural monitoring.

CHAPTER 4: SCHEDULED MAINTENANCE

4-1. INTRODUCTION. Scheduled maintenance is that maintenance required to be performed on the equipment at regular scheduled intervals whether or not the equipment is in use. The purpose of scheduled or preventative maintenance is to keep the equipment is good working order and to insure proper performance when the equipment is needed.

Table 4-1. Scheduled Maintenance Action Index

Interval	Maintenance Action	Reference
Monthly (M)	Check that the HDER-G01 cover screws and calibration access screws are seated firmly.	
Monthly (M)	Operational checks	Follow procedures in paragraph 2-3 and 2-4

Note: No special equipment or special tools are required to perform scheduled maintenance.

4-2. SCHEDULED MAINTENANCE ACTION INDEX. The maintenance checks and procedures of Table 4-1 should be performed at the intervals indicated.

4-3. SPECIAL TOOLS. There are no special tools required to operate maintain or disassemble the HDER-G01. A "pencil" soldering iron will be useful as will be soldered wick for component removal. Care should be taken when soldering to apply minimum heat and to avoid burning nearby leads and components. A heat sink (such as long nose pliers, alligator clips, etc..,) is required when soldering semiconductors. Disturb lead dressing as little as possible. Take care to keep foreign particles (dust, smoke, metal filings, solder, etc.) out of the HDER-G01 during repair.

4-4. SPECIAL TEST EQUPIMENT. Although there is no special test equipment required, any repair and calibration facility would have sufficient electronic instrumentation to facilitate electronic troubleshooting and repair. Table 4-2 lists a grouping of some of the preferred test equipment. Only one of each category is needed i.e., one scope with two probes, one counter, one electrostatic voltmeter or one high impedance precision voltmeter, and one low voltage voltmeter.

Table 4-2. Special Test Equipment

Model No.	Nomenclature & Mfr. (NOTE)	Use or Application
453	Tektronix Oscilloscope	Test Point Wave shapes
465M	Tektronix Oscilloscope	Test Point Wave shapes
P6009	Tektronix 100X Probe	Test Point Wave shapes
P6008	Tektronix 1X Probe	Test Point Wave shapes
EH139B	E.H. Research Labs. Pulse Generator	Electronic Calibration
5340	Hewlett Packard Counter	Electronic Calibration
MD6057	Systron Donner Counter	Electronic Calibration
ESD,0-1KV	Sensitive Research ESVM	H.V. Measurements
8100A	J. Fluke Differential VM	L.V. Measurements
8100A	80K-40KV Probe	H.V. Measurements
	VOM	L.V. Measurements
	Calibration Source	Cobalt-60 Calibration Source
	Calibration Source	Cesium-137 Calibration Source

Note: Equivalent test equipment may be used.

4-5. RADIOACTIVE TEST SAMPLE. A low level radioactive test source (not supplied) is necessary for checking operability on all ranges. Known sources of gamma radiation are required for equipment calibration. For availability of such sources, contact your designated HDER health physics society technical liaison.

CHAPTER 5: TROUBLESHOOTING

5-1. TROUBLESHOOTING, GENERAL. Troubleshooting of the HDER-G01 will be easier if an orderly procedure is used. Procedures in this section are intended to help localize trouble in defective components quickly.

A. Symptom Recognition. This is the first step in the troubleshooting procedure and is based on a complete knowledge and understanding of equipment operating characteristics. All equipment troubles are not the direct result of component failure. Therefore, trouble in the equipment is not always easy to recognize since all conditions of less than peak performance are not always apparent. This type of equipment trouble is usually discovered while accomplishing preventive maintenance procedures. It is important that the "not so apparent" troubles, as well as the apparent troubles, be recognized. See Table 5-2 for Maintenance Turn-on Procedures.

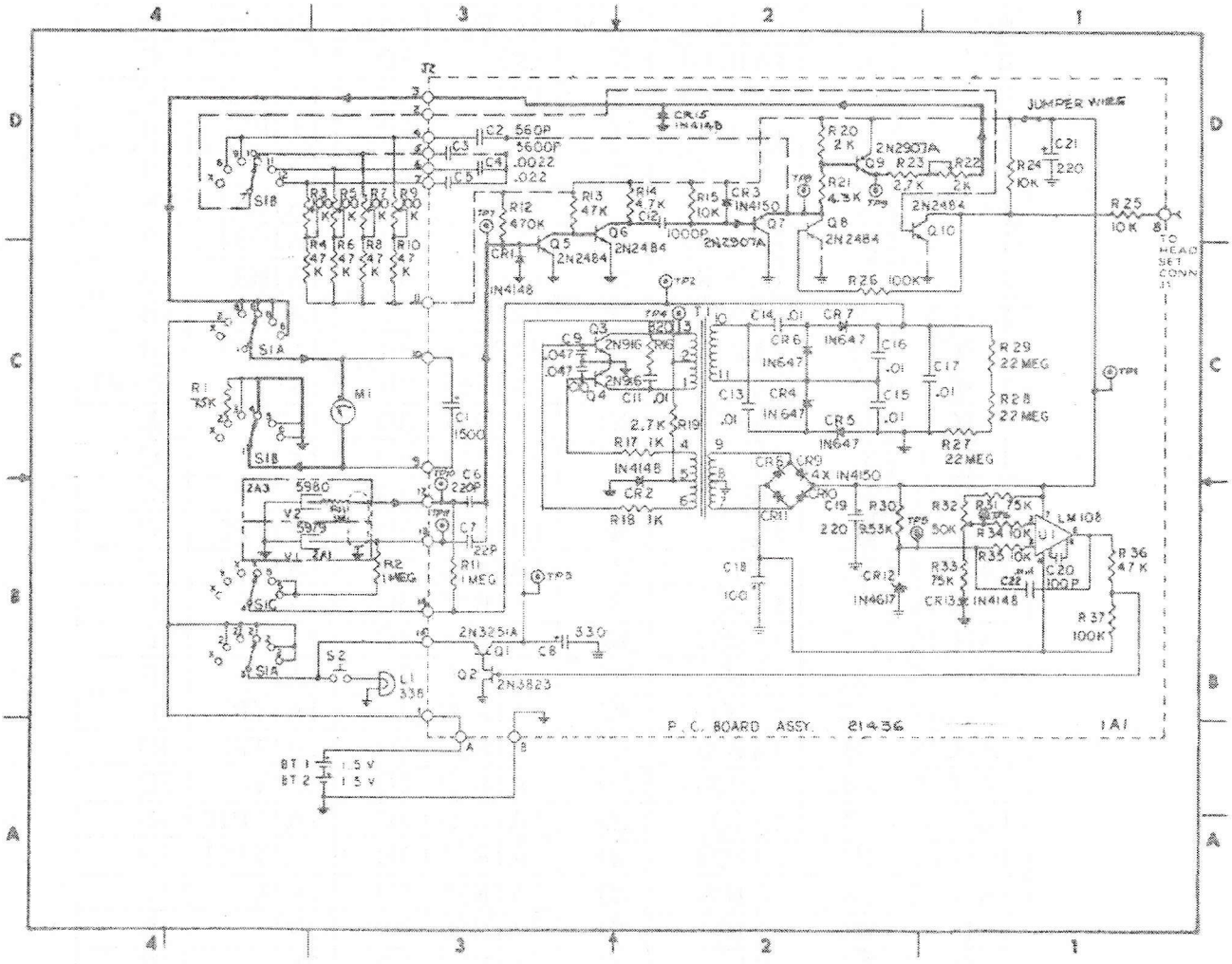


Figure 5-1. Overall Schematic

B. Symptom Elaboration. After equipment trouble has been "recognized", all available aids designed into the equipment should be used to further elaborate on the original trouble symptom. Use of front panel controls and other built-in indicating or testing aids should provide better identification of the original trouble symptom. Also checking or otherwise manipulating the operating controls may eliminate the trouble.

General Notes

Unless Otherwise Specified:

A. All resistor Values Are In Ohms.
B. All Capacitance Values Are In Microfarads.
C. Signal Flow Is Shown In 50 mR/hr.
D. Solid Line Indicates Signal Flow In Meter Drive Circuit.
E. Dashed Line Indicates Multivibrator Timing Circuit.

Part Location Index for Figure 5-1.

Ref Des	Zone	Ref Des	Zone	Ref Des	Zone	Ref Des	Zone
BT1	3A	1A1CR4	2C	1R3	3D	1A1R29	1C
BT2	3A	1A1CR5	2C	1R4	3C	1A1R30	2C
1A1C1	3C	1A1CR6	2C	1R5	3D	1A1R31	1B
1A1C2	3D	1A1CR7	2C	1R6	3C	1A1R32	1B
1A1C3	3D	1A1CR8	2B	1R7	3D	1A1R33	1B
1A1C4	3D	1A1CR9	2B	1R8	3C	1A1R34	1B
1A1C5	3D	1A1CR10	2B	1R9	3D	1A1R35	1B
1A1C6	3B	1A1CR11	2B	1R10	3C	1A1R36	1B
1A1C7	3B	1A1CR12	2B	2A3R11	3B	1A1R37	1B
1A1C8	3B	1A1CR13	1B	1A1R11	3B	1S1	4B-4D
1A1C9	3C	1A1CR15	2D	1A1R12	3D	1S2	3B
1A1C10	3C	1J1	1C	1A1R13	3D	1A1T1	2C
1A1C11	3C	1J2	3D	1A1R14	3D	1A1TP1	1C
1A1C12	2D	1L1	3B	1A1R15	3D	1A1TP2	2C
1A1C13	2C	1M1	2C	1A1R16	3D	1A1TP3	2C
1A1C14	2C	1A1Q1	3B	1A1R17	3C	1A1TP4	2C
1A1C15	2C	1A1Q2	3B	1A1R18	3C	1A1TP5	1B
1A1C16	2C	1A1Q3	3C	1A1R19	3C	1A1TP6	1B
1A1C17	1C	1A1Q4	3C	1A1R20	2D	1A1TP7	3D
1A1C18	2B	1A1Q5	3D	1A1R21	2D	1A1TP8	2D
1A1C19	2B	1A1Q6	3D	1A1R22	1D	1A1TP9	2D
1A1C20	1B	1A1Q7	2D	1A1R23	1D	1A1TP10	3B
1A1C21	1D	1A1Q8	2D	1A1R24	1D	1A1TP11	3B
1A1C22	1B	1A1Q9	2D	1A1R25	1D	1A1U1	1B
1A1CR1	3G	1A1Q10	2D	1A1R26	2C	2V1	3B
1A1CR2	3C	1R1	4C	1A1R27	1C	2V2	3B
1A1CR3	2D	1R2	3B	1A1R28	1C		

C. Listing Probable Faulty Function. The next step in logical troubleshooting is to formulate a number of "logical choices" as to the cause and likely location (functional section) of the trouble. The logical choices are mental decisions which are based on knowledge of the equipment operation, a full identification of the trouble symptom, and information contained in this manual. The overall functional description and is associated block diagram should be referred to when selecting possible faulty functional sections. See Figure 3-1 and Table 5-1.

Table 5-1. Troubleshooting Index, HDER-G01

Functional Area	Trouble-shooting Paragraph	Trouble-shooting Table	Functional Description Paragraph	Alignment/Adjust Paragraph
Overall	3-1	5-3	3-1	
Power Supply	5-2. b.(1)	5-4	3-2.a	Table 5-4
Radiation Detectors	6-2.a	5-3	3-2.b	Par 6-3.d
Computer Circuit	5-2. b.(1)	5-5	3-2.c	Par 6-3 c

D. Use of Test Points. Troubleshooting of the HDER-G01 has been greatly simplified by display of many test points. The faulty circuit can be rapidly determined by comparing the observed waveform against the normal pattern shown in Figure 5-2.

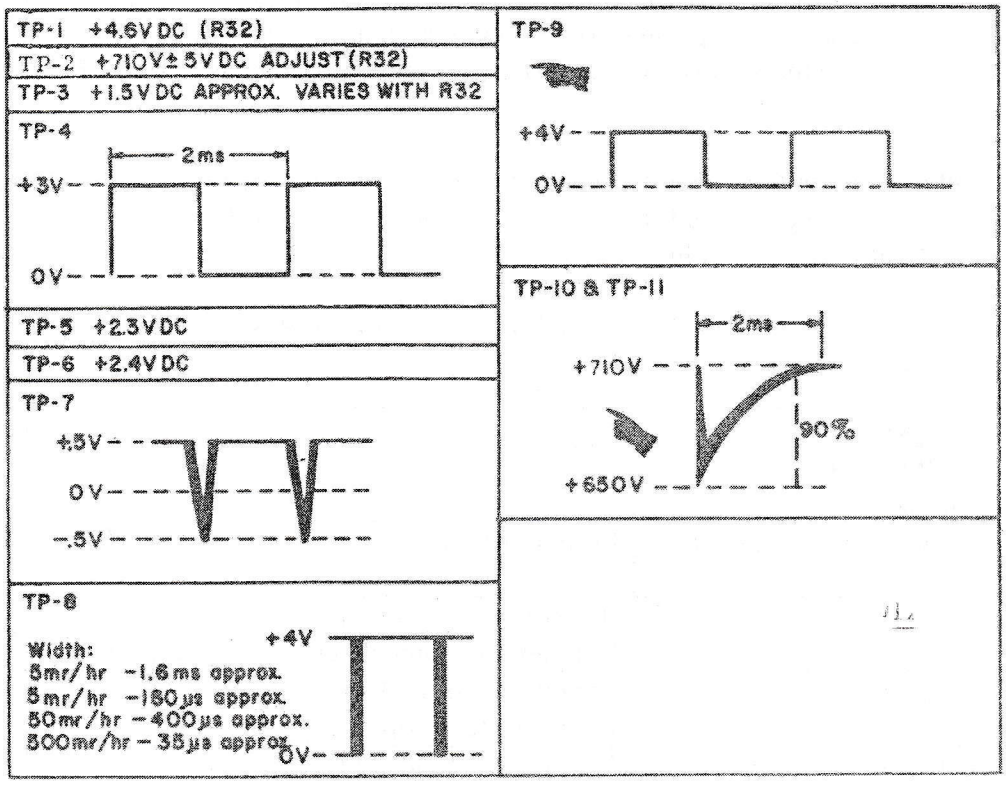


Figure 5-2. Test Point Waveforms

-2. TROUBLESHOOTING PROCEDURES.

A. Preliminary Check-General. Before proceeding with any electrical tests, the following mechanical inspection procedure should be followed:

1) The instrument housing should be examined for any mechanical damage.
2) The range switch should be turned to its various positions to see that the switch knob and meter scales index properly.
3) The meter should be examined. Observe the meter needle to see that it is not bent. Observe whether the needle is mechanically zeroed. Meter zeroing may be accomplished by removing the HDER-G01 from its housing and turning the meter zero adjusting screw located on the rear of M1. (See Figure 6-1). A clearance hole is provided in the printed circuit board for this purpose.
4) The battery cover should be removed, and the battery contacts inspected for cleanliness. Check to insure that the batteries have been properly installed and that the battery condition (BAT on selector switch) indicates satisfactorily.
5) The instrument housing should now be opened by loosening the six captive screws holding the housing and cover together. Visually examine the internal assembly.
6) Turn the range switch S1 and observe the operation of the switch to see that is appears to be working satisfactorily.

WARNING

With batteries installed, advancing the range switch, even to BAT, puts that HDER-G01 in operation. High voltage (710 volts), is present at many places on the printed wiring board and also at V1 and V2 anode. Exercise extreme caution when working on the exposed chassis or probes.

Any troubles found in the above steps should be corrected before proceeding any further. The instrument should be prepared for operation and the procedure followed as indicated in Table 5-2. Reference should be made to Figure 2-1.

Table 5-2. Maintenance Turn-on Procedure

Step	Observe	Reference
1. Preliminary Procedure		
a. Examine instrument case for mechanical damage.		
b. Turn range switch to its various positions	Proper switch indexing.	Par. 2-2;5-2.a. (2)
c. Examine meter	If meter needle is bent. If meter mechanical zero is not properly set.	Par. 5-2.a. (3)
d. Remove battery cover	Cleanliness of battery contacts. Proper installation of batteries.	Par. 5-2. a. (4)
2. Set range switch in BAT position	Meter should indicate within the area marked BATTERY.	Par. 2-3. a (4)
3. Set range switch in "500" position	Meter should indicate zero.	Par. 2-3. b
4. Set range switch in "50" position	Meter should indicate zero.	Par. 2-3. b.
5. Set range switch in "5" position	Meter could indicate slight background.	Par. 2-3. b
6. Set range switch in 0.5 position	Meter should indicate slight upscale indications due to background radiation.	Par. 2-3. b

B. Power Supply and Computer Circuit.

1) Preliminary check. After determining from Steps 7, and 8 of Table 5-3 that the power supply is operating improperly, proceed as follows: visually inspect all connections and printed wiring for breaks.
2) Use of Troubleshooting Charts. Follow the procedures as indicated in Tables 5-4 and 5-5. References should be made to Figure 3-1 through 3-5 and Paragraphs 3-2, a through c. All voltage measurements are made with selector switch in BAT position.

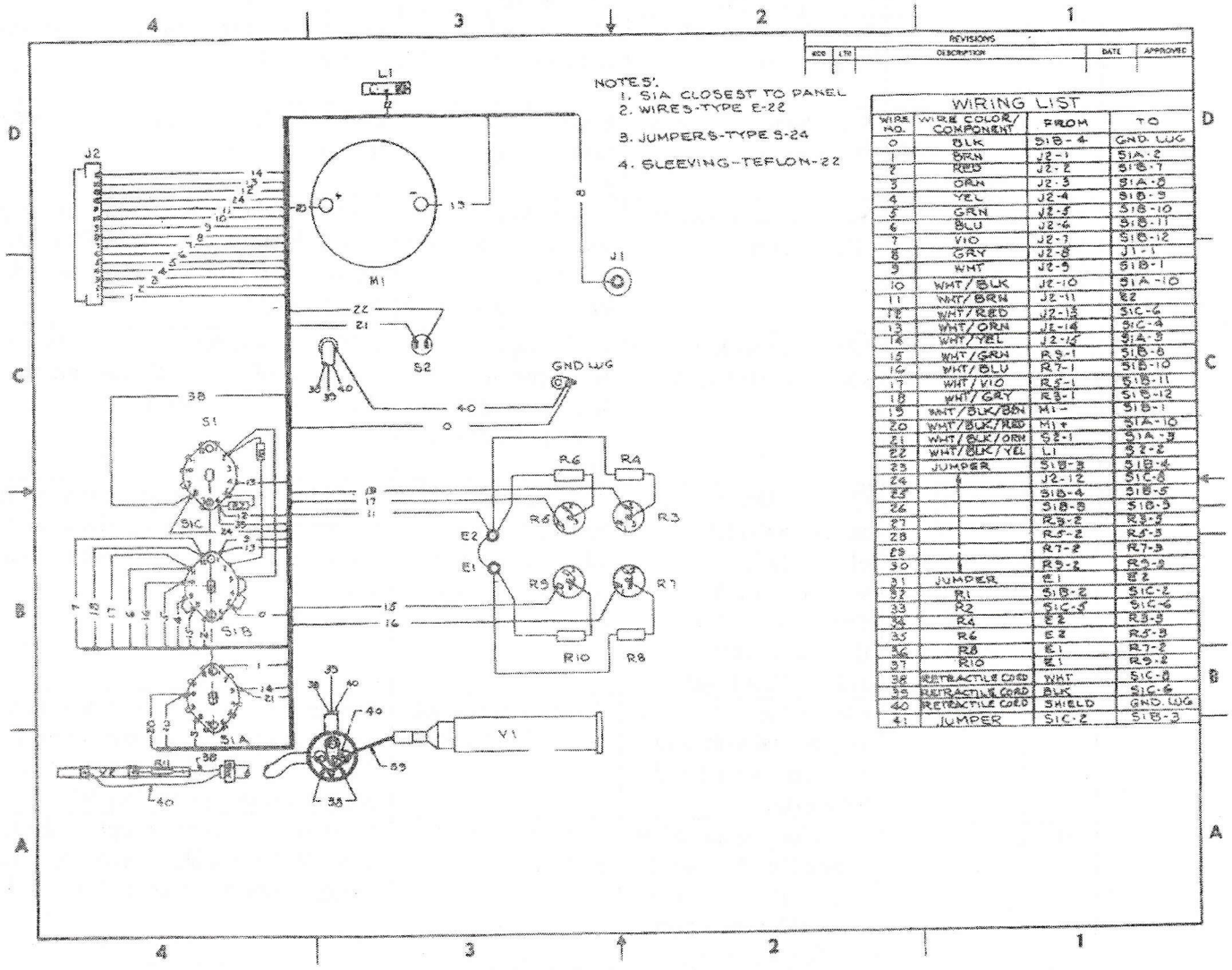
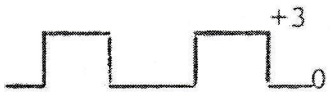


Figure 5-3. Wiring Diagram

Table 5-3. System Troubleshooting Chart

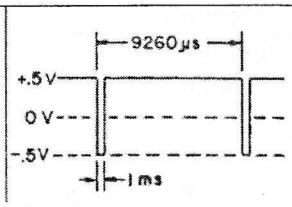
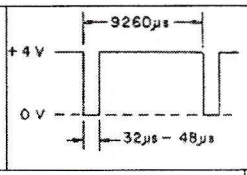
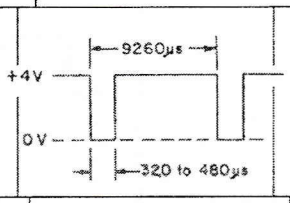
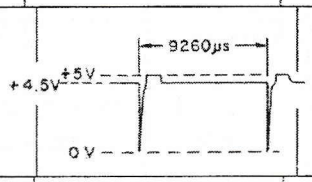
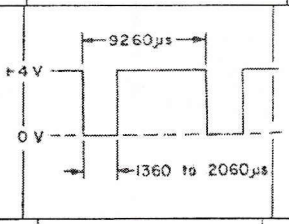
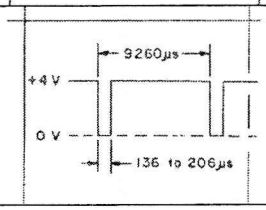
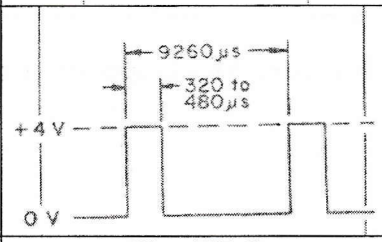
Step	Test Point Figure	Preliminary Action	Normal Indication	Next Step
1.		Set selector switch in BAT position.	Meter should indicate within the area marked BATTERY	Replace batteries if they do not check good. If there is no meter indication and the batteries are known to be good, check M1, S1, and the applicable circuitry to and from S1.
2.		Set selector switch in "500" position.	Meter should indicate zero.	Observe whether indication is correct, and then go to step 3.
3.		Set selector switch in "50" position.	Meter should indicate zero.	Observe whether indication is correct, and then go to step 4.
4.		Set selector switch in "5" position.	Meter should indicate slight background.	Observe whether indication is correct, and then go to step 5.
5.		Set selector switch in "0.5" position.	Meter should indicate occasional upscale background kicks.	If meter indication is correct on steps 2, 3, 4, & 5 then refer to Step 6. If meter indication is incorrect on steps 2, 3, 4, or 5 go to step 6.
6.		Utilize a low level source of radiation.	Each range should read upscale when source is placed in close proximity to probe.	If HDER-G01 responds then unit may just require calibration. If unit fails to respond then proceed to Step 7.
7.	TP-2	Connect the ground lead of a 0-1KV electrostatic voltmeter to the chassis or –BAT, then connect the high side to Test Point 2.	Volt meter should be +710 $\pm$ 5 volts DC. Adjust R32 for correct value.	If reading is correct, go to step 8. If proper reading is not obtained refer to power supply trouble-shooting chart, Table 5-4.
8.	TP-1	Connect a multimeter or a digital voltmeter between ground and Test Point 1.	Voltmeter should read 4.5 $\pm$0.3 volts DC	If proper readings are not obtained, refer to power supply troubleshooting chart, Table 5-4. If reading is correct and unit is not performing go to Step 9.
9.		Substitute spare tubes (See Para 6-2, a (1) for V1 Para 6-2, a (4) for V2) and repeat Steps 2 thru 5.	Same as Steps 2, 3, 4, and 5.	If trouble is corrected replace the faulty tube. If the trouble persists, re-place the original tube and refer to Table 5-5.

Table 5-4. Power Supply Circuit Trouble Analysis

Step	Test Point	Test Equipment	HDER-G01 Controls	Normal Indication	If Indication is Normal	If Indication is Abnormal
1.	TP-1	Digital Volt Meter	Selector to BAT	4.5 ± 0.3 VDC	Proceed to Step 5.	If voltage is low, proceed to Step 2. If voltage is high, proceed to Step 3.
2.	TP-4	Oscilloscope & 1:1 probe	Same as 1	4.5 ± 0.3 VDC 	If waveform is correct and 4 was low, check CR9 and CR10, C19 & transformer winding 7, 8, & 9. If both TP-1 and TP-4 voltages are correct proceed to Step 5.	
3.	TP-5	Digital Volt Meter	Same as 1	2.3 ± .2 VDC	Proceed to Step 5.	If CR12 voltage is high, replace CR12
4.			Same as 1. Apply short across R37.	Power supply output should go from high to low.		If outputs stay high check Q1 and Q2. If voltage goes low, replace U1.
5.	TP-2	0-1 KV Electrostatic Voltmeter	Same as 1.	+710 ± 5 VDC.	Trim as necessary by R32 and repeat Step 1, if necessary.	+710 volts is set by R32. Note that 4.5V output is affected by adjustment of R32. If output is low and cannot be adjusted check CR4, 5, 6, and 7 and C13, 14, 15, 16 and 17.

Caution: Exercise caution when using Measuring equipment as any accidental short on the +710 outputs may damage V1.

Table 5-5. Computer Circuit Trouble Analysis

Step	Test Point	Test Equipment	HDER-G01 Controls	Normal Indications	If Indication is Normal	If Indication is Abnormal
1	TP-7	Pulse Gen thru .01 mf cap to TP7 (set Pulse Gen Output to 1V at 108 Hz ± .5 Hz) Oscilloscope	Selector to 500		Proceed to Step 2	Check and Readjust Pulse Gen
2	TP-8	Same as 1	Same as 1		Proceed to Step 4	Proceed to Step 3
3	Base of Q7	Same as 1	Same as 1		Check Q7, Q8, Q10, R26, R9, R10, C2, & S1	Check CR1, CR3, Q5, Q6, C12 and R15
4	TP 8	Same as 1	Selector to 50		Proceed to Step 5	Check R7, R8, C3, and S1
5.	TP 8	Same as 1	Selector to 5		Proceed to Step 6	Check R5, R6, C3, and S1
6.	TP 8	Same as 1	Selector to 0.5		Proceed to Step 7	Check R3, R4, C5 and S1
7	TP 9	Same as 1	Selector to 50		Proceed to Step 8	Q9, R20, R21
8	M1 & Full Scale Reading	Digital Volt Meter	Same as 7	70 m VDC	Check M1	Check R23, R22, CR15, S1 and C1

CHAPTER 6: CORRECTIVE MAINTENANCE

6-1. INTRODUCTION. The HDER-G01 has been designed for ease of maintenance. No tools other than the usual service tools are required. A pencil or gun type soldering iron will be useful, particularly the type that can accommodate an in line desoldering tip when removing integrated circuits. Care should be taken when soldering to apply minimum heat to avoid burning nearby leads and components. A heat sink (such as long nose pliers, alligator clips, etc.) is required when soldering semiconductors. Disturb lead dressing as little as possible. Take care to keep foreign particles (duct, smoke, metal fillings, solder, etc.) out of the HDER-G01 during repair. Be sure to remove the batteries to preclude any possibility of energizing the set during repair. Refer to WARNING of paragraph 5-2, a (6).

6-2. REPAIR PROCEDURES

A. Tube Replacement. Both tubes are housed in the probe. V1 is a type 5979 Geiger-Mueller tube and is the low range (0.5 and 5 mR/hr) detector. V2 is a type 5980 Geiger Mueller tube and is the high range (50 and 500 mR/hr) detector. Refer to Figure 6-1 and 6-2.

CAUTION

The cathode end of V1 has a thin and delicate mica window. Do not allow any sharp pointed object to touch the mica window.

1) To replace V1 unscrew both the window cover assembly 2A2MP31 and the rear (cable end) knurled nut 2A3MP45.
2) Using fingers or long nosed pliers pull off anode contact 2A3MP49 and push out tube.
3) Remove "O" ring seal 2A2MP33 and install on new tube. Assemble in reverse order.
4) To replace V2, unscrew the small knurled nut 2A3MP50 and pull tube and mounting board out of probe.
5) Replace V2 and reinsert board assembly 2A3A1 in probe making sure that the board is positioned toward large probe while reassembling.

B. Printed Circuit Board Removal and Replacement. See Figure 6-3.

1) Unscrew 6 captive screws on top panel and remove panel from housing.
2) Remove four 6/32 screws and hardware holding P.C. board 1A1 to HDER-G01. The two screws attaching board to battery compartment are shorter then the front two and must be replaced in correct order.
3) Remove connector, reconnect new board assembly and reassemble in reverse order.

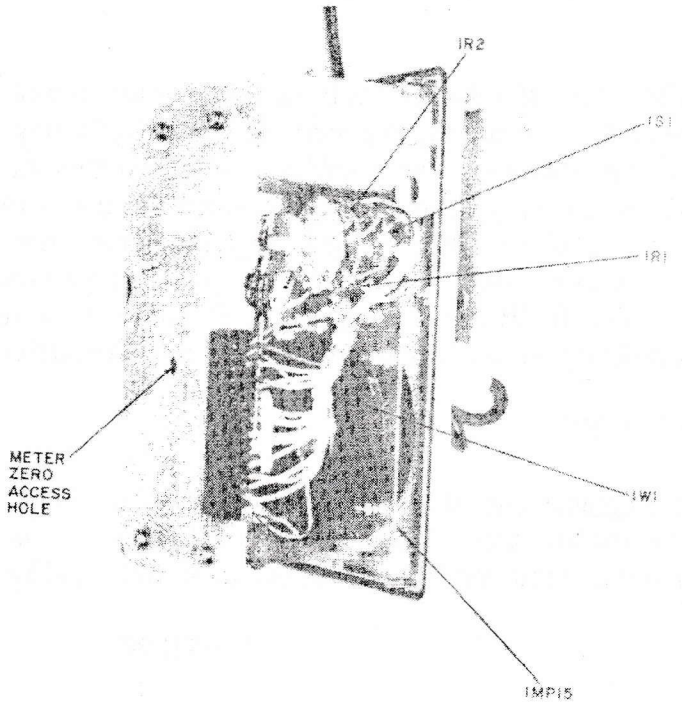


Figure 6-1. HDER G-01 Right Side

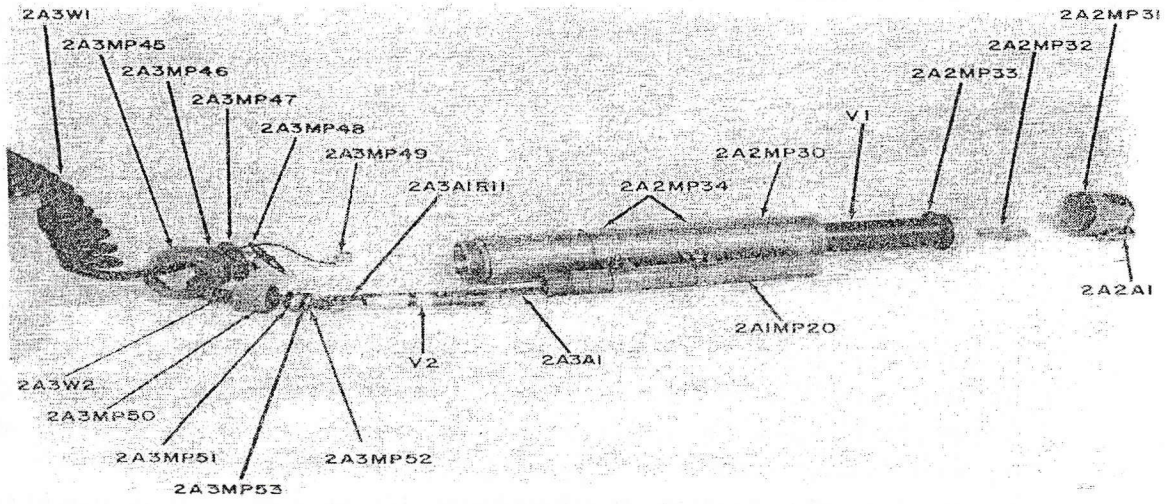


Figure 6-2 HDER-G01 Probe Disassembled

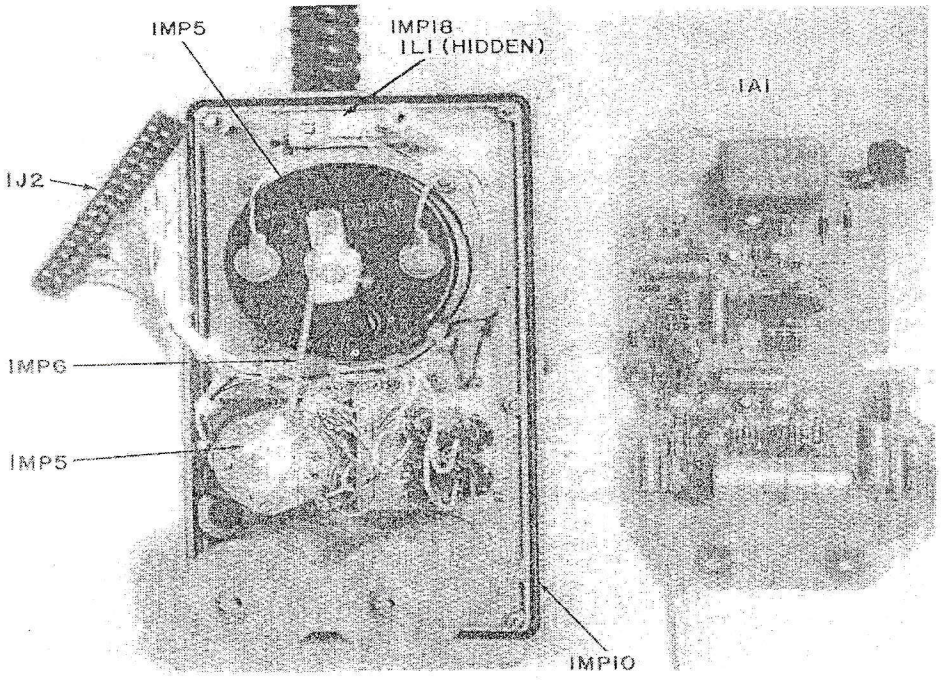


Figure 6-3 Rear view of Top Panel

C. Meter Replacement. See Figure 6-3

1) Unscrew and remove the calibration port cover from the top panel.
2) Remove the P.C. board as outlined in paragraph 6-2, b.
3) Loosen 4-40 screw holding clamp on meter flag shaft and remove clamp from meter.
4) Remove two hex stand-offs and hardware from front of meter bracket.
5) Remove two 6-32 screws and hardware from rear of meter bracket.
6) Unsolder meter wires, note color code and polarity.
7) Pivot meter bracket to the side permitting access to the four 6-32 meter mounting screws. Remove four 6-32 screws and hardware.
8) Remove and install new meter in reverse order.
9) Place meter clamp over flag shaft and turn range switch to 50 position.
10) Using long nose pliers, rotate flag shaft to center white 10-50 scale. Tighten 4-40 clamp screw.
11) Check all ranges for scale alignment and readjust clamp position if necessary.

D. Meter Illumination Switch Replacement. See Figure 6-3

1) Remove meter mounting bracket as outlined in paragraph 6-2C(1) through (5).
2) Place common bladed screwdriver down hole marked S2 and in between terminals of S2 to prevent rotation as the boot hex nut, 1H1 is unscrewed from the top panel handle mount (3/8 spintite).

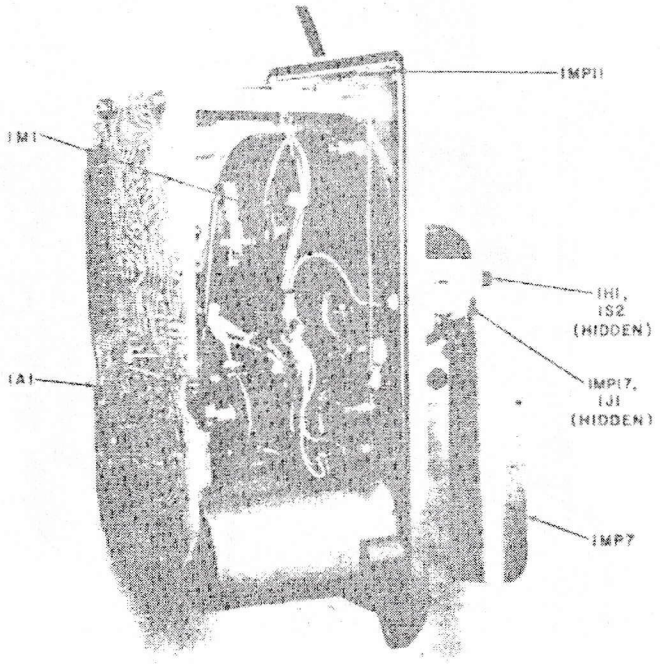


Figure 6-4. HDER G-01 Left Side

3) Pull switch out of handle mount, cut or unsolder the two wires, install new shrink tubing over the wires, resolder to new switch terminals (no polarity), slip tubing over terminals and using heat of soldering iron shrink to terminal.
4) Push switch into mounting hole using screwdriver between the terminals and screw on boot 1H1.
5) Reassemble meter mounting bracket as outlined in paragraph 6-2, c. (8) though (11).

E. Range Switch Replacement. See Figure 6-3.

1) Remove P.C. Board assembly 1A1 as outlined in paragraph 6-2, b.
2) Loosen 4-40 clamp linkage screw on rear of switch shaft. Remove clap from shaft.
3) Loosen two 4-40 set screws in knob using a .050 allen wrench. Remove knob.
4) Remove nut and hardware from switch shaft using ½" spintite.
5) Identify each wire and terminal while unsoldering. Replace 1R1 and 1R2 on new switch, solder wires and install in panel with re-non-rotational tab properly seated. Fasten switch and knob. Set screw in rear of knob must run into flat on switch shaft.
6) Place meter mechanism clamp over switch shaft and turn switch to 50 position.
7) Rotate meter flag until white 10-50 scale is centered. Tighten 4-40 clamp screw on switch shaft.
8) Check all ranges for scale alignment and readjust clamp position if necessary.

F. Meter Lamp Replacement. See Figure 6-3

1) Remove HDER-G01 from housing.
2) Using fingers or pliers pivot lamp L1 contact plate 1MP18 toward front of unit. Replace lamp.

6-3. ADJUSTMENT AND CALIBRATION

A. General. HDER-G01 is calibrated at time of manufacture. Recalibration is usually not required unless certain critical components are replaced or there is evidence that the four ranges do not track each other properly (see table 7-1 Notes 1 and 2 for list of critical components).

B. Equipment Required for Calibration. The special test equipment outlined in Table 4-2 is adequate for complete equipment calibration or troubleshooting.

1) A stand and equipment to adequately postion and hold the HDER-G01 and probe in a fixed relation to the radiation source used.
2) A small screwdriver.

C. Pre-alignment. If electronic repair or replacement has been performed on the HDER-G01, basic adjustments or alignment must be certified before attempting source calibration. Proceed as follows:

1) Withdraw HDER-G01 from its housing. Remove calibration cover.
2) Check batteries, replace if necessary and turn range switch to 500.
3) Adjust R32 for 710±5 volts at TP-2.
4) Check low voltage for 4.3-4.8 volts at TP-1.
5) Connect a pulse generator (high side) to TP-7 through a 0.01 mfd (100 volt minimum) capacitor. Set generator for 1080± 5 pps, negative going, and 5 to 10 volts amplitude.
6) Connect an oscilloscope probe (either 1:1 or 10:1) to TP-9.
7) Adjust 1R9 to provide a pulse width of 35 ± 1 microsecond at TP-1.
8) Adjust R22 to its maximum CCW position (at least 20 turns CCW.)

D. Source Calibration. Should calibration of the HDER-G01 be required contact your HPS Technical Liaison for options.

CHAPTER 7: PARTS LIST

7-1. INTRODUCTION. This parts list is applicable for the HDER-G01 only. Reference designations have been assigned to identify all maintenance parts of the equipment. The first digit in the reference designation is one (1) for all parts in the HDER-G01 less the coil cord and probe assembly whose associated parts are designated two (2). Those parts which are part of the printed circuit board assembly are designated 1A1. Following the initial sub-assembly designation a letter or letters describing the type of part (BT for Battery, C for Capacitor, V for tube,) etc. The last number indicates which of a group of

similar parts is being designated. Example 1AC3 is capacitor C3 located on the printed circuit board. The name and description of the part provides a more complete description of the part including the supplier and part number where applicable. The figure and Item Numbers indicate the figure number where the part is shown and the call out used to designate the part on the figure. Table 7-1 is the complete parts list.

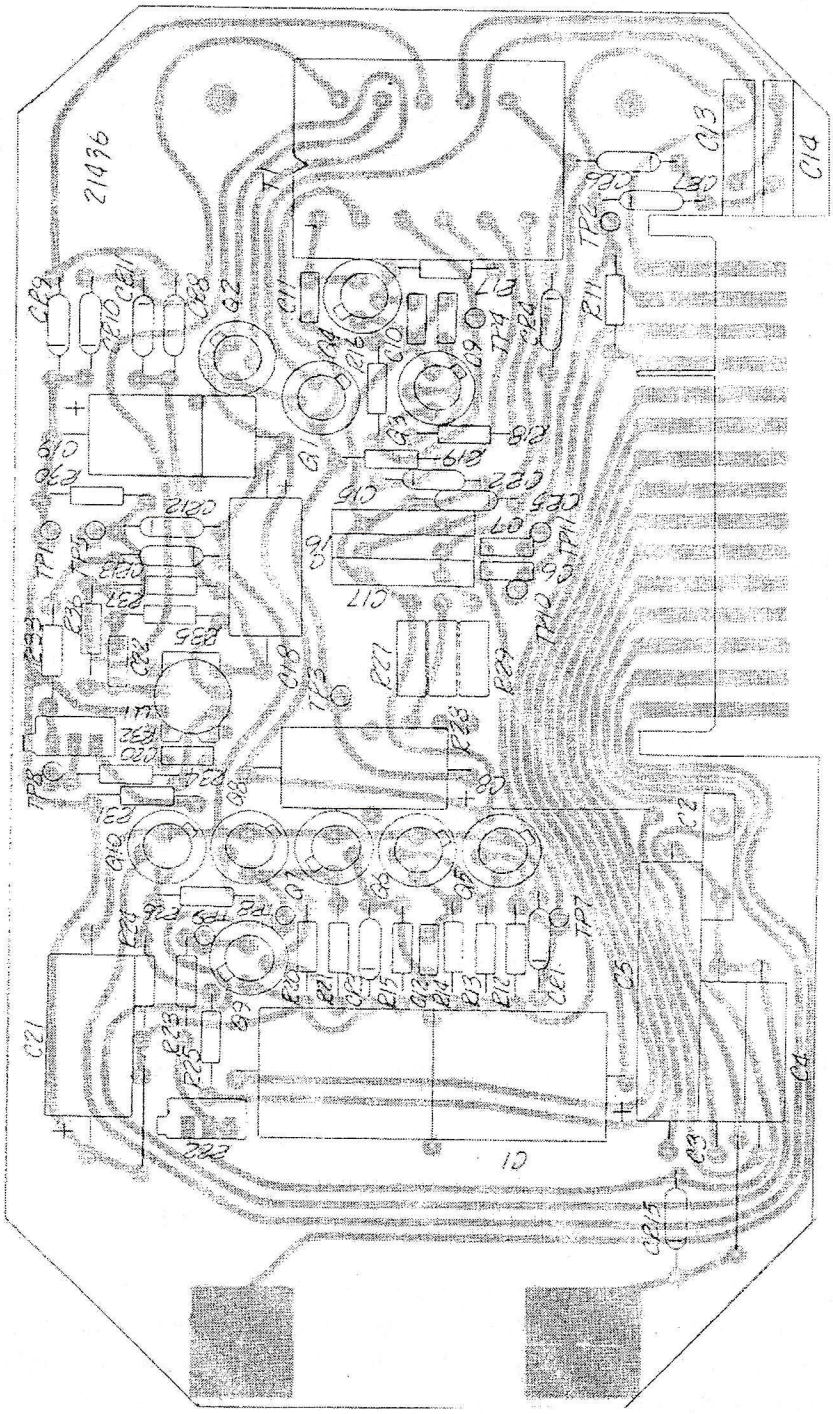


Figure 7-1 Parts Location, Printed Circuit Board Assembly

Table 7-1 Maintenance Parts List

Ref. Design	Name and Description	Fig. No. (Item)
	Instrument Set HDER- G01 measures Gamma, detects Beta, 4 ranges 0-500, 50, 5 and .5 mR/hr,	1-1
1HT1	Headset; MIL type H43B/U	1-1
1MP1	CARRYING STRAP; mfr. NRC, Dwg, A41973-1	1-1
2V1	TUBE G-M, end window, low range; JAN5979 (spare)	1-1
2V2	TUBE G-M, high range; JAN5980	1-1
1&2	INSTRUMENT HDER-G01; mfr NRC, Dwg. 21382	1-1
1BT1 thru 1BT2	BATTERY, Dry Cell, 1.5 Volt; BA-30	7-2, (BT1), (BT2)
1H1	BOOT, dust and moisture seal, Silicone Rubber, mfr. APM, part no. N5045	2-1, (H1)
1J1	CONNECTOR, BNC series	2-1, (J1)
1J2	CONNECTOR P.C. Board, 15 pin; mfr TRW, part no. 250-15-30-171, modified by mfr. NRC, Dwg A21393	6-3, (J2)
1L1	LAMP, INCANDESCENT, mfr. GE, part no. 338	6-3, (L1)
1M1	METER, 50 Microamperes DC Full Scale Deflection ± 2%, scale changing. Five Scales; OFF BATTERY 0-500 mR/h 0-50 mR/h, 0-5 mR/h, 0-0.5 mR/h, MIL type MIL-M-10304/18A type MR 36M201 Spec. R. Modified by mfr. NRC Dwg. 21385 (Attaching Parts) (4) SCREW, MACHINE-PAN HEAD, CROSS-REDESSED, CREW; MS-51957-31, 6-32 thd. UNC-2A; 5/8 in. lg. (4) WASHER, LOCK, SPLIT, HELICAL, LIGHT SERIES; MS-35338-136, .151 in ID, .239 in. OD. (4) WASHER FLAT, METAL ROUND; MS-15795-805, .156 in. ID, .312in. OD, .048 in. THK, NO 6 size (4) NUT, PLAIN-HEX; MS-35649-264, 6-32 UNC-2A, .312 in. across flats, .361 in. across corners, .114 in. THK.	6-4 (M1)
1MP2	BATTERY COVER ASSY; mfr. NRC, part no. B21392	2-1 (MP-2)
1MP3	GASKET, BATTERY COVER; mfr. NRC, part no. 41974	7-2 (MP-3)
1MP4	SCREW CAPTIVE; mfr. NRC, part no. A21419-2	7-2 (MP-4)
1MP16	CASE, BOTTOM; mfr. NRC, part no. C21386	7-2 (MP16)
1MP17	CAP, CONNECTOR;	2-1 (MP17)
1MP18	CONTACT, LAMP; mfr NRC, part no. A21397	6-3 (MP18)
1R1	RESISTOR, FIXED, COMPOSITION, 75K ohms, ± 10%, ¼ w,	6-1 (R1)

1R2	RESISTOR, FIXED, COMPOSITION1M ohms, ± 10%, ¼ w,	6-1 (R2)
1R3	RESISTOR, VARIABLE, COMPOSITION 100K ohms, ± 10%, ½ w, 0.5 mR/hr CAL adjust,	2-1 (R3)
1R4	RESISTOR, FIXED, COMPOSITION 47K ohms, ± 10%, ¼ w,	5-3 (R4)
1R5	Same as 1R3, 5 mR/hr CAL adjust	2-1 (R5)
1R6	Same as 1R4	6-3 (R6)
1R7	Same as 1R3, 50 mR/hr CAL adjust	2-1 (R7)
1R8	Same as 1R4	5-3 (R8)
1R9	Same as 1R3, 500 mR/hr CAL adjust	2-1 (R9)
1R10	Same as a 1R4	5-3(R10)
1S1	SWITCH, ROTARY; 2 section, 5 poles, 6 position 30 degree indexing, style SRO2S3OB1MPC; MFR. NRC, part no. D21377	2-1(S1)
1S2	SWITCH, PUSH, MOMENTARY, NO; mfr. GYH, part no. 30-1	2-1(S2)
1W1	HARNESS WIRING; mfr. NRC, part no. C21389	6-1(W1)
1A1	PRINTED CIRCUIT BOARD ASSEMBLY; mfr NRC, part no. D21436. (ATTACHING HARDWARE) (2) SCREW, MACHINE – PAN HEAD, CROSS-RECESSED, CRES; MS51957-27, 6-32 the. UNC-2A, 5/16" long (2) SCREW, MACHINE – PAN HEAD, CROSS-RECESSED, CREW; MS51957-26, 6-32 thd., UNC-2A, 4" long (4) WASHER, FLAT-METAL, ROUND, CRES; MS15795-805, .156 I.D., .312 O.D., .048 thk., NO. 6 size (4) WASHER, LOCK SPLIT, CRES; MS35338-136. .151 I.D., .2239 O.D., .031 thk, NO. 6 size	6-4(1A1)
1A1C1	CAPACITOR, FIXED ELECTROLYTIC; 1500MF, -10 +75%, 7VDCW,	7-1(C1)
1A1C2	CAPACITOR, FIXED, MICA; 560PF, ±5%, 200VDCW,	7-1(C2)
1A1C3	CAPACITOR, FIXED, MYLAR; 5600PF, ± 5%, 50VDCW,	7-1(C3)
1A1C4	CAPACTIOR, FIXED, MYLAR; 2200PF, ±5%, 100VDCW	7-1(C4)
1A1C5	CAPACITOR, FIXED, MYLAR; 22000PF, ± 5%, 100VDCW	7-1(C5)
1A1C6	CAPACITOR, FIXED, CERAMIC; 220PF, ± 10%, 1KVDCW	7-1(C6)
1A1C7	CAPACTIOR, FIXED, CERAMIC; 22PF, ±10%, 1KVDCW	7-1(C7)
1A1C8	CAPACTIOR, FIXED, ELECTROLYTIC; ±20%, 330MF, 6VDCW	7-1(C8)
1A1C9 thru 1A1C10	CAPACTIOR, FIXED, CERMAIC; .047MF, ±20%	7-1(C9)(C10)
1A1C11	CAPACITOR, FIXED, CERAMIC; .01MF, ±20%, 200VDCW	7-1(C11)
1A1C12	CAPACITOR, FIXED, CERMAIC; 1000PF, ± 20%, 200VDCW	7-1(C12)
1A1C13 thru 1A1C17	CAPACITOR, FIXED, CERAMIC; .01MF, ± 20%, 1KVDCW	7-1(C13-C17)

1A1C18	CAPACITOR , FIXED, ELECTROLYTIC; 100MF, ±20%, 10VDCW	7-1(C18)
1A1C19	CAPACITOR, FIXED, ELECTROLYTIC, 220MF, ±20&, 10VDCW	7-1(C19)
1A1C20	CAPACITOR, FIXED, CERMAIC, 100PF, ±20%, 200VDCW	7-1(C20)
1A1C21	Same as 1A1C19	7-1(C21)
1A1C22	Same as 1A1C11	7-1
1A1CR1 thru 1A1CR2	SEMICONDUCTOR, DIODE	7-1(CR1,CR2)
1A1CR3	SEMICONDUCTOR, DIODE	7-1(CR3)
1A1CR4 thru 1A1CR7	SEMICONDUCTOR, DIODE 1N647-1	7-1(CR4-CR7)
1A1CR8 thru 1A1CR11	Same as 1A1CR3	7-1(CR8-CR11)
1A1CR12	SEMICONDUCTOR, DIODE, ZENER 1N4617	7-1(CR12)
1A1CR13	Same as 1A1CR1	7-1(CR13)
1A1CR14	Not Used	
1A1CR15	Same as 1A1CR1	7-1(CR15)
1A1R1 thru 1A1R10	Not Used	
1A1R11	RESISTOR, FIXED, COMPOSITION; 1 Megohm, ±10%, 1/4w,	7-1(R11)
1A1R12	RESISTOR, FIXED, COMPOSITION; 470 ohms, ±10%, 1/4w	7-1(R12)
1A1R13	RESISTOR, FIXED, COMPOSITION; 47K ohms, ± 10%, 1/4w,	7-1(R13)
1A1R14	RESISTOR FIXED, COMPOSITION; 4,7K ohms, ±10%, 1/4w,	7-1(R14)
1A1R15	RESISTOR, FIXED, COMPOSITION; 10K ohms, ± 10%, 1/4w	7-1(R15)
1A1516	RESISTOR, FIXED, COMPOSITION; 820 ohms, ± 10%, 1/4w	7-1(R16)
1A1R17 thru 1A1R18	RESISTOR, FIXED, COMPOSITION; 1K ohms, ± 10%, 1/4w	7-1(R17-R18)
1A1R19	RESISTOR, FIXED, COMPOSITION; 2.7K ohms, ±5%, 1/4w	7-1(R19)
1A1R20	RESISTOR, FIXED, COMPOSITION; 2.7K ohms, ±5% 1/4w	7-1(R20)
1A1R21	RESISTOR, FIXED, COMPOSITION; 4.3K ohms, ± 5%, 1/4w	7-1(21)
1A1R22	RESISTOR, VARIABLE COMPOSITION; 2K ohms, ± 10%, 1/4w	7-1(R22)
1A1R23	Same as 1A1R19	7-1(R23)
1A1R24 thru 1A1R25	Same as 1A1R15	7-1(R24, R25)
1A1R26	RESISTOR, FIXED, COMPOSITION; 100K ohms, ±10%, 1/4w	7-1(R26)
1A1R27 thru 1A1R29	RESISTOR, FIXED, COMPOSITION; 22 Megohms, ±10%, 1/4w	7-1(R27-29)
1A1R30	RESISTOR, FIXED, COMPOSITION; 9.53K ohms ±1%, 108w,	7-1(R30)
1A1R31	RESISTOR, VARIABLE, COMPOSITION; 50K ohms, ±10%, 1/2w,	7-1(R31)
1A1R32	RESISTOR, VARIABLE, COMPOSITION; 50K ohms, ±10%, 1/2w,	7-1(R32)
1A1R33	Same as 1A1R31	7-1(R33)
1A1R34 thru 1A1R35	Same as 1A1R15	7-(R34,R35)
1A1R36	Same as 1A1R13	7-1(R36)
1A1R37	Same as 1A1R26	7-1(R37)
1A1T1	TRANSFORMER, SATURATING OSCILLATOR, Encapsulated per mfr. NRC, part no. C21435	7-1(T1)
1A1U1	SEMICONDUCTOR DEVICE, INTEGRATED CIRCUIT; type LM108H	7-1(U1)
1A1Q1	SEMICONDUCTOR DEVICE, TRANSISTOR, type 2N3251A	7-1(Q1)
1A1Q2	SEMICONDUCTOR DEVICE, TRANSISTOR; type 2N3823	7-1(Q2)
1A1Q3 thru 1A1Q4	SEMICONDUCTOR DEVICE, TRANSISTOR, type 2N916	7-1(Q3,Q4)
1A1Q5 thru 1A1Q6	SEMICONDUCTOR DEVICE, TRANSISTOR, type 2N2484	7-1(Q5,Q6)
1A1Q7	SEMICONDUCTOR DEVICE, TRANSISTOR, type 2N2907A	7-1(Q7)
1A1Q8	Same as 1A1Q5	7-1(Q8)
1A1Q9	Same as 1A1Q7	7-1(Q9)
1A1Q10	Same as 1A1Q5	7-1(Q10)
2	INSTRUMENT PROBE HDER-G01	1-1
2A1MP20	HOUSING, HIGH RANGE PROBE; mfr. NRC, part no. B21415	6-2
2A2A1	COVER, LATCH ASSEMBLY; mfr. NRC, part no. A21556	6-2

2A2MP30	HOUSING, LOW RANGE PROBE, mfr. NRC, part no. B21399	6-2
2A2MP31	NUT, RETAINER, mfr. NRC, part no. C21410	6-2
2A2MP32	GUARD, WINDOW; mfr. NRC, part no. A21401	6-2
2A2MP33	"O" RING, neoprene	6-2
2A2MP34	CLAMP; mfr. NRC, part no. A21458	6-2
2A3A1	ASSEMBLY TUBE HOLDER; mfr. NRC, part no. A21439	6-2
2A3A1R11	RESISTOR, FIXED COMPOSITION; 1 Megohm ± 10%, 1/4w,	6-2 (R11)
2A3MP45	NUT, RETAINER, mfr. NRC, part no. B21402	6-2
2A3MP46	WASHER, END CAP; mfr. NRC, part no. A21409	6-2
2A3MP47	END CAP; mfr NRC, part no. A21404	6-2
2A3MP48	"O" RING, NEOPRENE,	6-2
2A3MP49	CAP, ELECTRICAL; mfr. HHS, part no. 1454	6-2
2A3MP50	NUT, RETAINER; mfr NRC, part no. B21413	6-2
2A3MP51	WASHER, FLAT	6-2
2A3MP52	END CAP; mfr. NRC, part no. B21412	6-2
2A3MP53	"O" RING, NEOPRENE;	6-2
2A3W1	CABLE, RETRACTABLE, mfr. NRC, part no. B21443	6-2
2A3W2	CABLE, JUMPER; mfr. NRC, part no. B21442	6-2
2V1	TUBE, G-M, end window, low range, type JAN5979	6-2 (V1)
2V2	TUBE, G-M, high range Notes: 1. If component is changed, pre-alignment should be performed. Refer to par 6-4, c. 2. If component is changed a source calibration should be performed. Refer to par 6-4, d.	6-2 (V2)

7-2. LISTS OF MANUFACTURERS. Table 7-2 lists the manufacturers of all parts. The first column includes the abbreviations used in Table 7-1 to indicate the manufacturer. The second and third columns show the full name and address of each manufacturer.

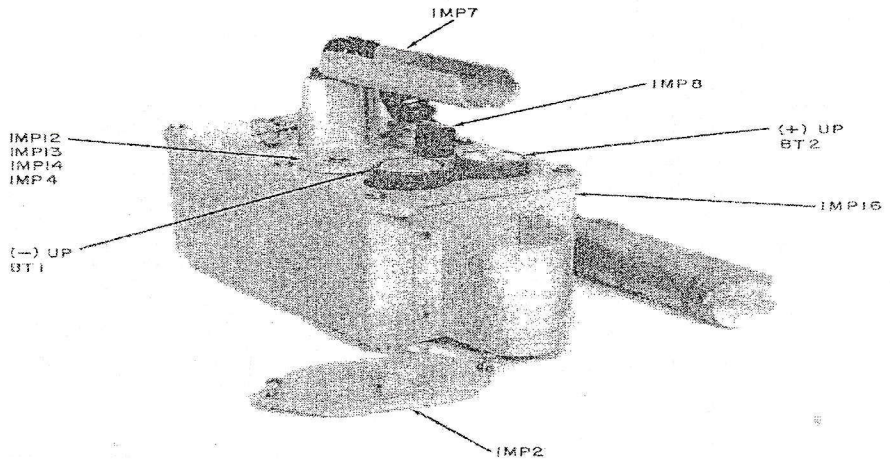


Figure 7-2 Parts Location

Table 7-2. List of Manufacturers

Supplier	Manufacturer	Address
NRC	Nuclear Research Corporation	2 Richwood Place Denville, N.J. 07834
GE	General Electric Company Miniature Lamp Division	Nela Park Cleveland, Ohio 44112
TRW	TRW Cinch Division	1501 Morse Avenue Elk Grove, Ill. 60007
GYH	Grayhill, Incorporated	561 Hillgrove Avenue La Grange, Ill 60525
HHS	H. H. Smith, Inc.	812 Sneiker Avenue New York, N.Y. 11207
APM	Automatic and Precision Manufactures, Inc.	44 Honeck Street Englewood, N.J. 07631

3	CDV 138	0-200 mR
2	883	0-500 mR
2	CDV725	0-5 R (DCP-5)
2	CDV 730	0-20R
2	CDV 740	0-100 R
3	CDV 742	0-200 R
1		