ELECTRO-NEUTRONICS, INC

Instruction and Maintenance Manual

RADIOLOGICAL SURVEY METER

OCDM ITEM NO. CD V-700, MODEL 6b

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MANUFACTURED BY

ELECTRO-NEUTRONICS, INC.

BERKELEY, CALIFORNIA

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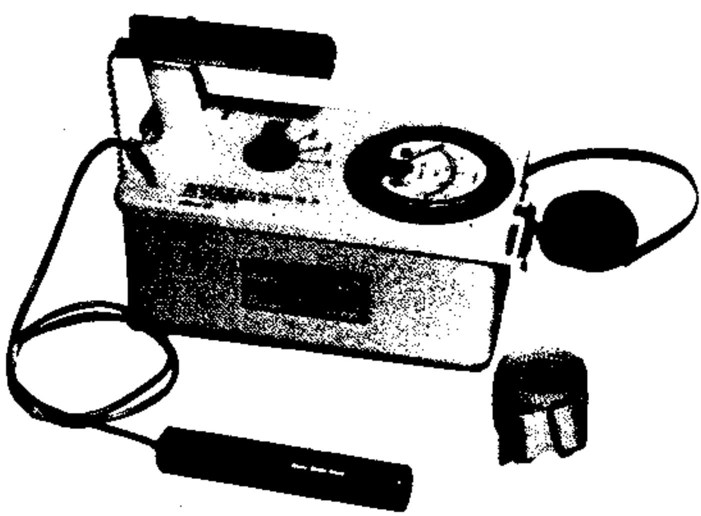

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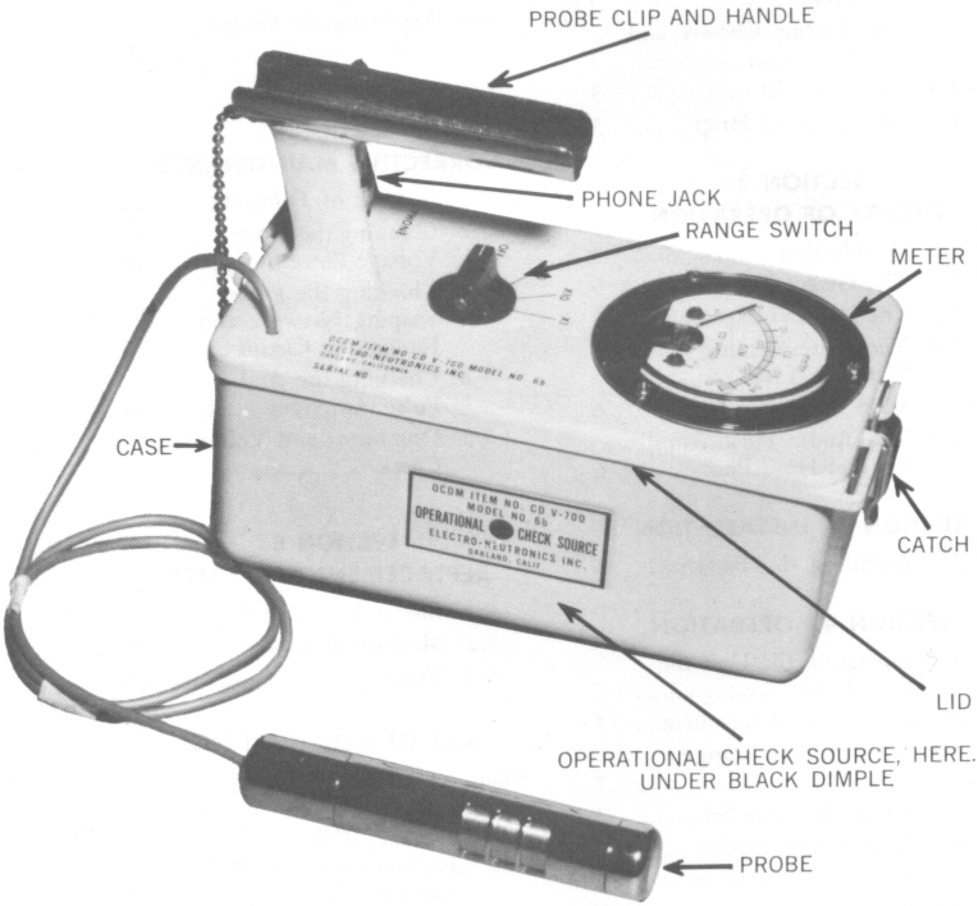


Fig. 1 — ENI CD V-700 Survey Meter

I. GENERAL DESCRIPTION

1.1 INTRODUCTION

The ENI V-700 is a portable, battery-powered, transistorized survey meter with a regulated power supply using a 6993 stainless steel, halogen quenched Geiger-Mueller tube as the detector. The geiger tube is mounted in a probe connected to three feet of cable. The instrument and its accessories include a circuit chassis, a probe, a headphone, a carrying strap and a radioactive source mounted under the name plate. (See Fig. 1 and cover photo)

1.2 THE PROBE

The probe consists of a nickel plated brass housing with a beta window provided with detents which can lock it in either the open or closed position. The probe contains the geiger tube which is sensitive to moderate and high energy beta radiation and to gamma radiation down to low energies. The geiger tube is mounted through a rubber gasket and is held in place by a coil spring. (See Fig. 2)

1.3 THE CIRCUIT CHASSIS AND CASE

The circuit chassis and case consists of four each 1.5 volt type D supply batteries, a transistorized pulse shaping network, a detecting (metering) circuit, a regulated transistorized power supply, an audio pulse amplifier and a radioactive Radium D+E source. The system is shockproof and waterproof, and is secured with rapid takedown clamps in order to make access very simple. The battery bracket faces out for rapid removal and replacement of batteries, and protection of the circuitry from battery "leakage."

1.4 THE HEAD SET

The head set is a single piece magnetic phone with a connector mated to the watertight jack mounted on the lid. The watertight jack is kept covered by a plastic dust cover.

1.5 THE CARRYING STRAP

The carrying strap is made of plastic. It is provided with adjustment clips. The strap is adjustable from 30 inches to 60 inches in length.

II. THE THEORY OF OPERATION

2.1 INTRODUCTION

This instrument consists of a halogen quenched beta-gamma geiger tube radiation detector, a regulated power supply, a transistorized pulse shaping and metering network, an indicating meter, an audio pulse amplifier and head phone for audible monitoring of activity.

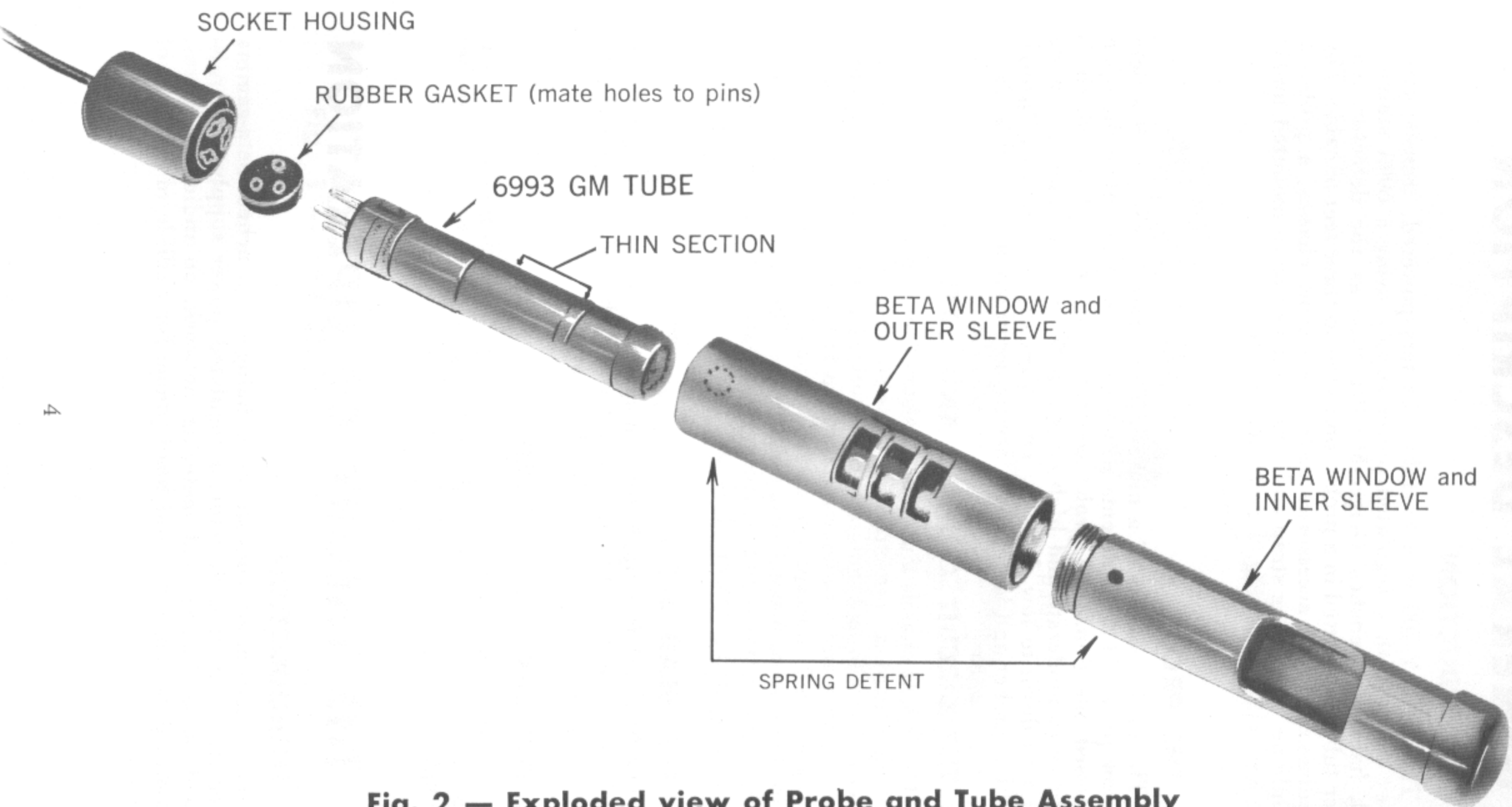


Fig. 2 — Exploded view of Probe and Tube Assembly

2.2 THE GEIGER TUBE

The geiger tube consists of a thin cylindrical shell which is the cathode, a fine wire anode suspended along the longitudinal axis of the shell, and an inert gas into which a small amount of a halogen gas is inserted to act as a quenching agent. A voltage slightly less than that required to produce a discharge is applied between the anode and cathode. When a beta particle of sufficient energy impinges upon the tube, some of the particle's kinetic energy is used to ionize a gas molecule. The electrons, resulting from this ionization, are accelerated toward the anode by the electric field and in movement toward the anode cause additional ions to be formed. Similarly, gamma rays impinging upon the cathode wall cause secondary electrons to be ejected which in turn become the ionizing event. The creation of additional ions is very rapid thus producing a discharge in the gas. The small amount of halogen gas in the tube serves to help in quenching the discharge without self-consumption and restores the tube to its original condition. This discharge results in a pulse in the external circuit. The frequency of such pulses is proportional to the intensity of radiation field.

2.3 THE HIGH VOLTAGE SUPPLY

The high voltage supply consists of a blocking oscillator circuit in which pulses are generated by a transistor, V4, alternately cut-off and saturated. The transformer windings between the base and collector are so phased that when the collector current starts to flow, the voltage at the base goes in the negative direction. By virtue of the base going negative, the collector current will increase still further causing the base to go more negative The collector current increases until the transistor saturates, at which point the collector cannot supply the current demanded by the signal at the base. At this point, since there is no rate of change of current in the transformer, there is no signal induced in the base winding. Therefore, the emitter current decreases, decreasing the collector current. The signal then induced at the base of the transistor is such as to make this action cumulative until the transistor cuts off. The collector current stops abruptly, causing a large rate of change of current in the transformer. This makes the base go negative, which in turn starts the collector current flowing and the cycle repeats.

The step-up turns ratio between the collector winding and the secondary winding produces a high voltage pulse, which is then rectified by the selenium rectifier, CR5.

The DC output voltage developed across capacitator, C-8, is regulated in the primary section of the transformer where the Zener Diode CR6 is limiting the amplitude of the transistor pulser. The high voltage is hence regulated at 930 volts $\pm$ 20 volts.

2.4 THE PULSE SHAPING AND METERING CIRCUIT

The pulse shaping and metering circuit is composed of two transistors, a rectifier and a meter. Transistors, V2 and V3, form a monostable multivibrator. A negative pulse from the

Geiger tube is coupled to the base of V2, the normal cut-off transistor. This pulse causes V2 to conduct, and a positive pulse is developed on its collector. The positive pulse is coupled to the base of V3 through the timing capacitator and cuts off transistor, V3. The resulting negative pulse on the collector of V3 is coupled to the base of V2 via Choke L_1. This condition with V2 conducting and V3 cut off will continue for a period determined by resistor, R8, and the timing capacitator selected by the range switch. The voltage pulse at the collector of V2 is rectified by silicon rectifier, CR3, and fed to the meter, M. The voltage pulses at the meter are integrated by capacitator, C1. The average voltage indicated on the meter is proportional to the frequency of the input pulses. The pulse frequency is proportional to the radiation field intensity, and the meter can therefore be calibrated to indicate the dose rate directly in milliroentgens per hour.

2.5 SCALE RANGES

Three operating ranges (X1, X10, X100) as calibrated with a Radium D+E standard are provided. These correspond respectively to 0.5 milliroentgens per hour, 5 milliroentgens per hour and 50 milliroentgens per hour equivalent radiation. The scales also indicate approximate counts per minute. Scale changing is effected by switching capacitators and meter resistors, thus changing the pulse width of the multivibrator and the series resistance of the metering circuit.

2.6 THE AUDIO PULSE AMPLIFIER AND HEAD PHONE

Aural monitoring is achieved by a transistorized pulse amplifier and a headphone. Each pulse counted by the pulse shaping circuit develops a negative pulse at the collector of V2. The pulse is shaped and isolated from the headphone by diodes CR1 and CR2, capacitator C2 and resistor R1. When the 1000 ohm headphone is connected at the jack a pulse of approximately 11 volts is developed across the headphone, resulting in a clear audible click.

III. INSTALLATION

3.1 INSTALLING THE BATTERIES

The instruments are shipped with the batteries packed separately. To put the instrument into operation:

1. Open the case by releasing the clamps at both ends, and remove the lid assembly.
2. Remove the batteries from their package, taking care not to drop them.
3. Remove battery clamps.
4. Place the "D" cell batteries, negative end first, against the "finger" springs and slide the positive terminals down in their respective grooves. Be sure all spring contacts are positively

pressing against each battery. This may be adjusted with long nosed pliers if necessary. (See Fig. 3)

5. Replace clamps.
6. Replace lid assembly on case.

IV. OPERATION

4.1 OPERATING THE UNIT THE FIRST TIME

With probe in the handle clip, switch the instrument to the times ten (X10) scale with the beta window closed. Wait 30 seconds. The meter should read substantially zero. Present the open window of the probe to the center of the nameplate under which is a radioactive sample (See Fig. 1), make sure the geiger tube is directly over the dimple on the nameplate. The indicator should fall between 1.5 milliroentgens per hour (mr/hr) and 2.5 mr/hr, averaging about 2.0 mr/hr.

4.2 CALIBRATION ADJUSTMENT

Note: **The uranium beta source under the nameplate should be the only source of radiation. Calibration adjustment must not be undertaken when the background is above normal (Sect. 4.5) or in a radiation field other than that produced by the known beta source under the nameplate.**

If the meter indication differs from the above, it may be corrected by adjusting the screw of the potentiometer, R4, as shown in Fig. 4. To gain access to this potentiometer, loosen both clamps, remove the instrument from the case and tilt the instrument to one side. Use a screwdriver. Advancing the screw clockwise increases the reading; rotating it counter-clockwise decreases the reading.

4.3 "ON-OFF" AND RANGE SWITCH

The range switch controls an "OFF" position and three ranges labeled, "X100," "X10," and "X1." These are respectively 100 times, 10 times and 1 times the scale reading in mr/hr and counts per minute. The printed meter scale goes to 0.5 mr/hr and 300 counts per minute respectively.

4.4 USING THE HEAD SET

To use a head set, the phone connector is attached to the terminal located immediately to the left of the post of the handle. In using the head set the counting rate is indicated by distinct clicks, the frequency of which is equal to the count rate.

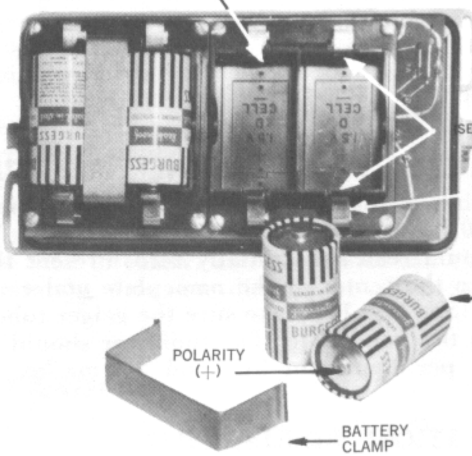


Fig. 3 — V-700 Showing Battery Section

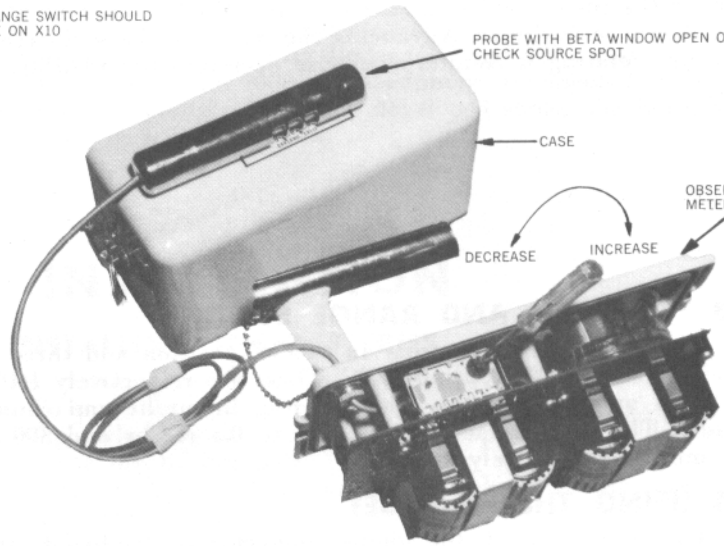


Fig. 4 — Calibration Adjustment

4.5 NORMAL BACKGROUND

Since normal background of radioactivity will be in the order of 0.01 to 0.02 mr/hr, as recorded on this type of instrument, little activity will normally be seen or heard. Under background conditions only, about 20 per minute of these "clicks" will occur. They are randomly spaced so that one may wait for several seconds before any "click" is heard; then there may be two or three.

4.6 CHECKING CALIBRATION

The operator should periodically check the calibration of the instrument to verify that it is correct. This operation is described in paragraph 4.2. Precise recalibration should be done with approved standards in a radiology laboratory.

4.7 USING THE CARRYING STRAP

The instrument may be carried in the hand or by a strap over the shoulder. The strap anchors are arranged in such a way that the meter is visible when carried over either the left or right shoulder. Quick "connect and disconnect" fasteners are provided.

V. PREVENTIVE MAINTENANCE

5.1 BATTERY LIFE

Caution: *Make Certain the Instrument is Turned OFF Whenever Not in Use.* ("OFF" position places the range switch perpendicular to the handle axis.) The life of the batteries is at least 100 hours under continuous use; for intermittent use the life may be extended. The indications that the instrument is ON are: (a) the position of the range switch, (b) clicks in the headphone. In emergency two batteries can be used instead of four with a minimum battery life of 50 hours under these conditions. When using two batteries install one on each end of the battery compartment.

5.2 STORAGE

The instruments are shipped in a packing container and should be left this way until ready to be put into operation. This prevents the accumulation of dirt, moisture, and radioactive contamination, which would interfere with proper operation of the instrument. For storage purposes it is best, wherever possible, to keep the instrument in a moderately cool area, as this will provide greater shelf life for the batteries. At all times one should attempt to prevent contamination of the instrument and particularly the probe. The instruments should not be stored with the batteries installed.

5.3 DECONTAMINATION

Because this equipment may be used in areas where radioactive contamination is possible, it is recommended that the instrument, probe and accessories be cleaned (after exposure to such condition) in an accepted manner to avoid both spurious counting or residual radiation hazards.

The probe housing has been specifically designed to permit decontamination. To clean its parts, unscrew the cap end; slide the beta shield sleeve off the housing. All the component parts of the probe may now be cleaned. (See Fig. 2)

5.4 BATTERY INSPECTION

Even under continuous use with leak-proof cells, it is advisable to check the batteries for leakage at least once per month.

VI. OPERATOR'S MAINTENANCE

6.1 REPLACING THE BATTERIES

Whenever the instrument fails to respond to the operational check source, check the batteries. To replace the "D" cells, see Paragraph 3.1. If a voltmeter is available, one can check the "D" cells. Cells showing signs of corrosion or providing less than 1.5 volts should be replaced at this time.

6.2 REPLACING THE GEIGER TUBE

The chief maintenance required by this instrument is replacing the batteries (see Paragraph 6.1). The geiger tube is halogen quenched so that its operating life is unaffected by use and therefore rarely requires replacement. However, if fresh batteries are installed, and the instrument still does not work correctly, it is preferable to check it with a new geiger tube before making any further attempts at circuit checking.

Caution: *In Removing or Replacing Geiger Tube Do Not Grasp Tube at Thin Section. (See Fig. 2)*

VII. CORRECTIVE MAINTENANCE

7.1 IN CASE OF DIFFICULTY

Open case and make visual inspection for shorts, broken wires, and obviously damaged or broken components.

7.2 CHECKING HIGH VOLTAGE POWER SUPPLY

Measurements in the high voltage power supply must be made with a high impedance voltmeter. Either an electrostatic voltmeter or a vacuum tube voltmeter with a high voltage probe having an input impedance of 1,000 megohms or higher should be used. With an instrument of this type, the high voltage may be measured between pins 1 & 3 (pin 1 is positive) of the Geiger tube socket. The probe cover and the Geiger tube must be removed to make the pins of the socket available for this measurement. The voltage between pins 1 & 3 of the tube socket will normally be 930 volts ± 20 volts.

If a high impedance meter is not available, a sensitive microammeter may be used in conjunction with a large resistor. If a 500 megohm resistor is used, a current between 1.7 and 1.9 microamperes should be measured. Should the high voltage check incorrectly, the following tests should be made:

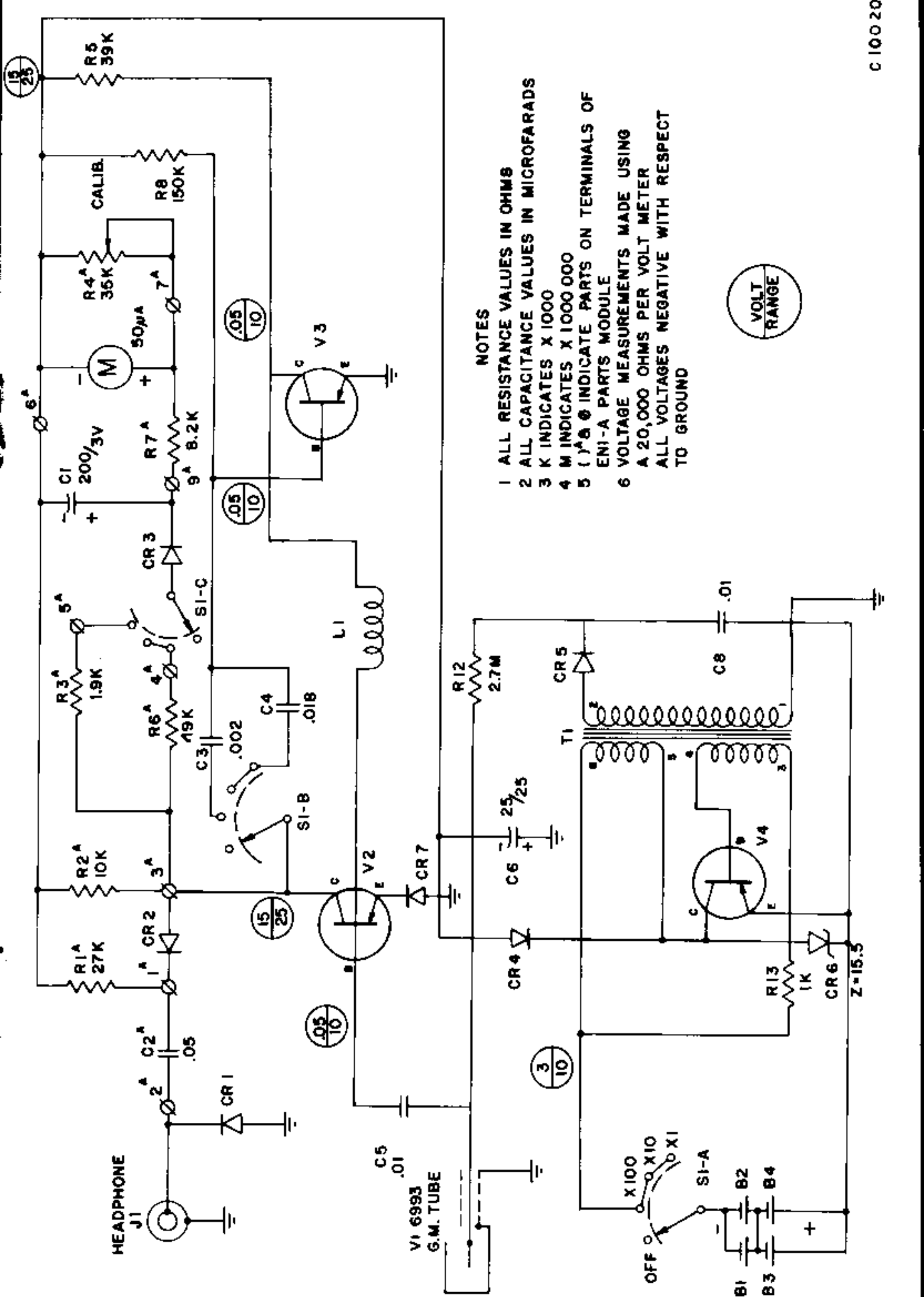


Fig. 5 — Schematic for V-700

1. Check the batteries with the instrument turned on. The battery voltage should read at least 2.2 volts.
2. If the high voltage is low, check the voltage at 6A. This voltage should be at least 15 volts. If this voltage is low, replace the rectifier, CR4.
3. If the high voltage is higher than 970 volts, replace the Zener Diode CR6.

7.3 CHECKING THE PULSE SHAPING NETWORK AND INTEGRATING CIRCUIT

In order to check the pulse and integrating circuit, connect the headphone and listen while tapping pin 1 of the Geiger tube socket with an insulated screwdriver. (Note: Do not touch the shaft of the screwdriver or ground it to the case.) This should create a series of clicks in the headphone and should cause the meter to deflect when the range switch is in the X1 position. If no clicks are heard, try the same test by touching the screwdriver to junction R12-C5. If this produces clicks, replace the cable assembly since it is permanently potted at the connector and, cannot be repaired. If no clicks are heard when tapping the junction check the voltage at transistors, V2 and V3, as indicated on the schematic drawing. If the voltages are correct, replace capacitator C-5. If the voltage on the collector of V3 is too high, replace V3.

If tapping the junction produces clicks, but the meter does not deflect, replace CR3 and circuit module A in that order, checking after each replacement. If the meter deflects and returns quickly at the zero position, replace C1. If none of the above replacements produces a meter deflect, replace the meter.

7.4 CHECKING THE AUDIO PULSE AMPLIFIER

If the meter is functioning, but no clicks are heard in the headphone, first check the connections of the headphone plug to the jack on the lid of the equipment and the headphone cable connections. If clicks are still not heard, replace CR2; and if this fails, replace CR1, followed by circuit module A if the trouble is not cured.

7.5 OHMMETER AND VOLTMETER CHECK

If the instrument is inoperative after the above checks, a resistance check may be made with a 20,000 ohm-volt meter. A voltmeter check with the same instrument will determine if an active element (transistor) or component (resistor, capacitor, etc.) is bad.

Resistance check — The values indicated on the schematic, Fig. 5, should be measured with the switch on the OFF position, that is, with the circuit not energized.

Voltage check — The values indicated on Fig. 5 should be measured with the switch on the X100 position. In this position the instrument will be energized. NOTE: Measurements should not be made in a high count rate area.

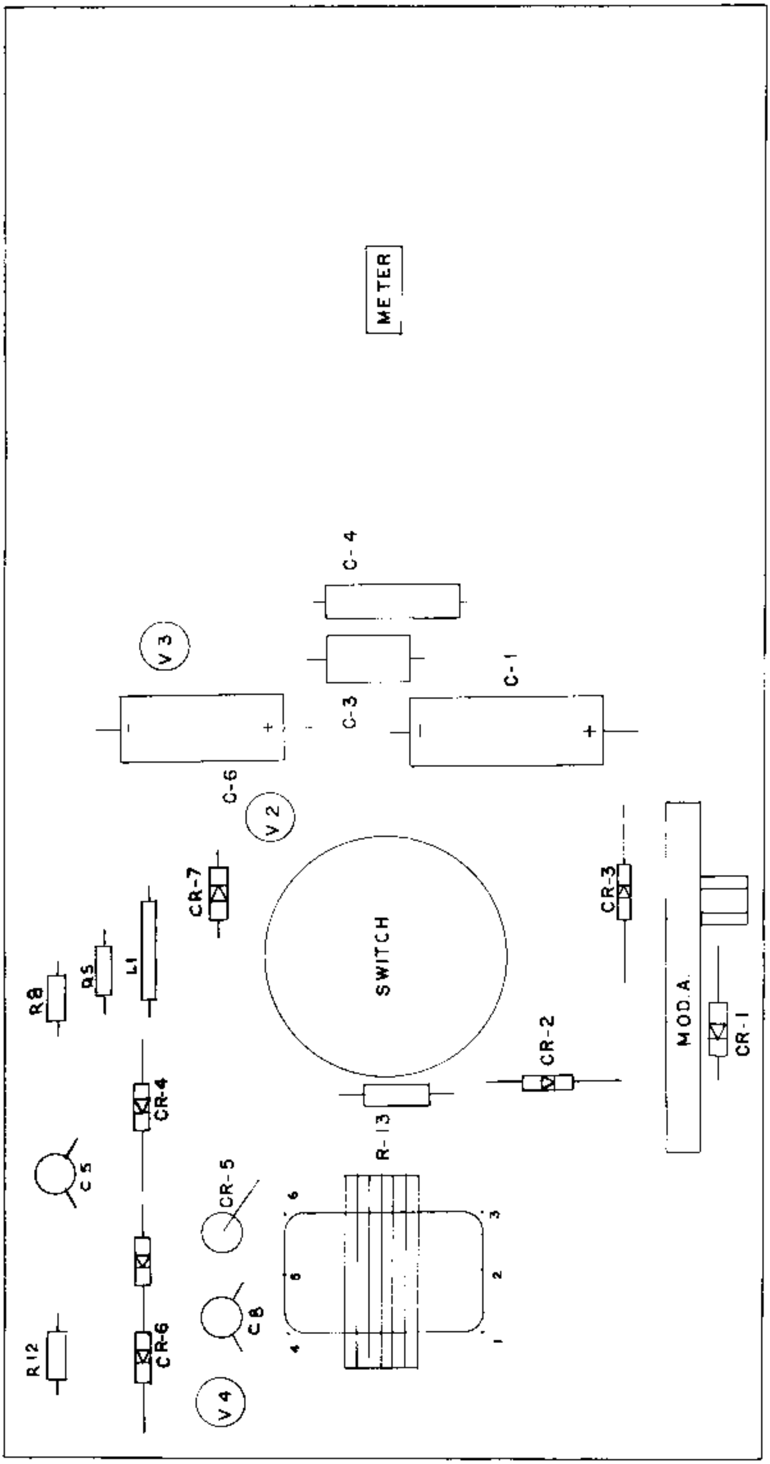
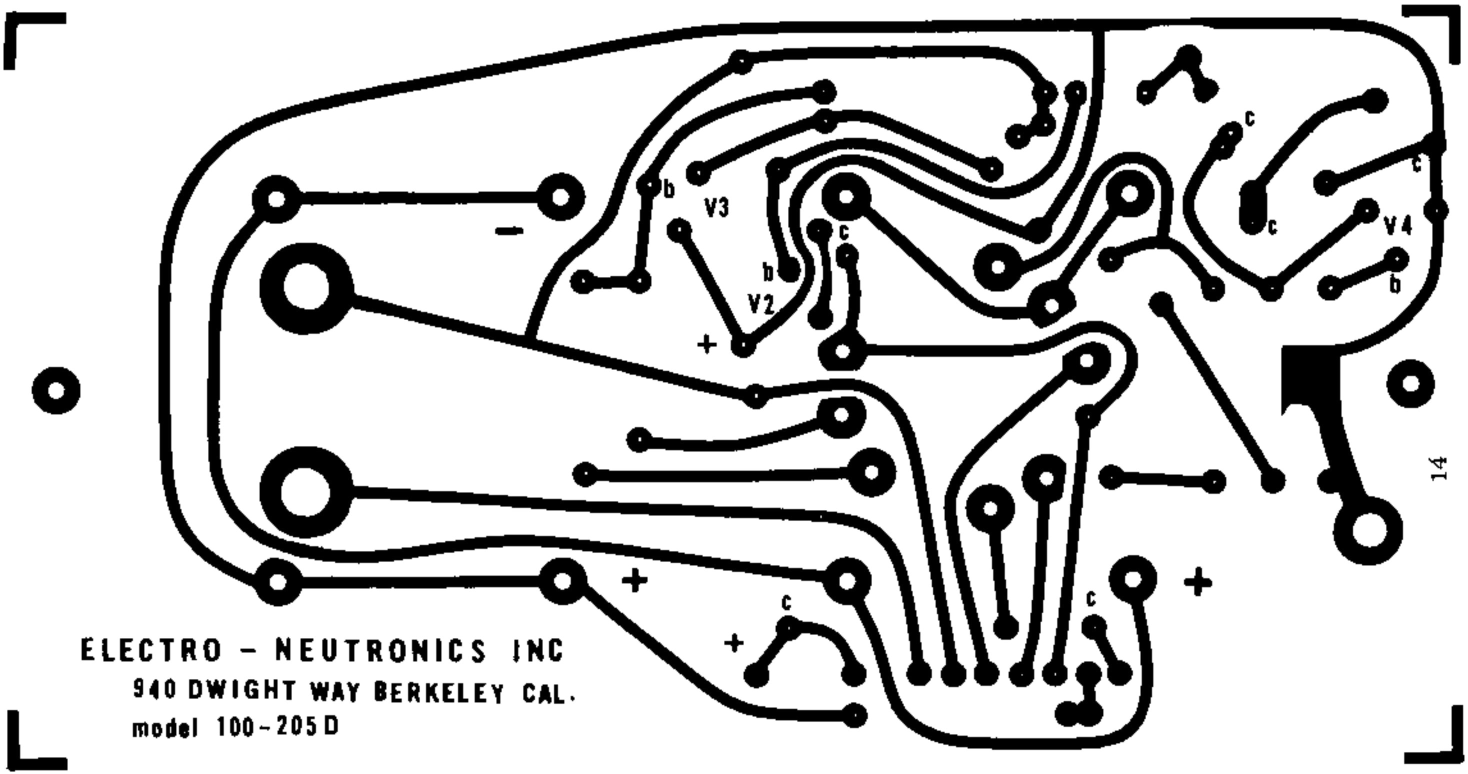


Fig. 6 — Printed Circuit Board (Component Side)


ELECTRO - NEUTRONICS INC
940 DWIGHT WAY BERKELEY CAL.
model 100-205D
V2
V3
V4
b
c
+
-

VIII. REPLACEMENT PARTS

8.1 ELECTRICAL COMPONENTS

Symbol	Quant. per Equip.	Description	Specification	Suppliers	Supplier Part No.	ENI Part No.	Rec. Spares/ 5 Units
$B_{1,2,3,4}$	4	Battery	"D" Cell Neda Type 13	UC		100201-$B_{1,2,3,4}$	20
C_1	1	Capacitor	200μf/3V	IEI, S	APD-071	100201-C-1	1
C_3	1	Capacitor	.002 μf/50V	C, GI	CPE 002	100201-C-3	1
C_4	1	Capacitor	.018 μf/50V	GI, C	107B1831	100201-C-4	1
$C_{5,8}$	1	Capacitor	.01μf	C, S		100201-$C_{5,8}$	1
C_6	1	Capacitor	25μf/25V	IEI, S	APD-056	100201-C-6	1
$CR_{1,2,3,4}$	4	Diode	Silicon 30PIV forward 10ma at 1V leakage 0.5μa	H, TR	ENI-4	100203	1
CR_5	1	High Voltage Rectifier	Selinium 1350V PIV 100μa forward Current Reverse current 7μa at 1000V DC	IRC, TI	67-5967	100202	1
CR_6	1	Zener Diode	15.5V ± 3% at 2ma. Temp. coefficient less than 0.04%/ C	H, TR	ENI-145	100213	1
CR_7	1	Diode	Germanium 30PIV 1ma	Tr, H	S-3302G	100204	1
H	1	Head Set	Impedance 4000 ohms at 1000 CPS. Single adjustable headband 36" Cable with Amphenol 75-MC-1F connector O.E.	ENI	100214	100214	1
J_1	1	Jack Headphone Connector	Amphenol 75-PC-1M O.E.	ENI	100215	100215	1
L_1	1	Choke	24 mh. 150 ohms	PR, ST	100388	100388	1
M	1	Meter	0-50 μa 2% 1850 ohms 10%	GM, W	Model 300s	100201-M	1
PB	1	Printed Circuit Board	1 oz. copper one side	ENI	100205	100205	
PM-A	1	Parts Module	Contains R_1, R_2, R_3, R_4, R_6, R_7, C_2	C, IR	100211	100211	1
R5		Resistor	.39 K ½W 10%	AB, IR		100201-R5	1
R8		Resistor	150K ½W 10%	AB, IR		100201-R8	1
R12		Resistor	2.7M ½W 10%	AB, IR		100201-R12	1
R13	1	Resistor	1000 ohms 5%	AB, IR	Type GBT	100201-R13	1
S_1	1	Switch	3 Pole, 4 Position	C, IR	100206	100206	1
T_1	1	Transformer	Chopper LV & HV Supply	TRI, PR	100207	100207	1
V_1	1	Geiger-Mueller Tube	Halogen Quenched GM Tube 6993	LI, EON	6993	100201-V_1	1
V_2	1	Transistor	Multivibrator	ETC, TI	ENI 2	100208	1
V_3	1	Transistor	Multivibrator	ETC, TI	ENI 3	100209	1
V_4	1	Transistor	LV-HV Power Supply	ETC, TI	ENI 1	100210	1

8.2 MECHANICAL COMPONENTS

Quant. per Equip.	Description and Function	Supplier	Supplier's Part. No.	Rec. Spares for 5 Units
1	Meter Gasket	ENI	100217/1	2
1	Knob Indicator	ENI	100218	2
1	Jack Gasket	ENI	100217/2	2
1	Probe Cable Assembly, Hold GM Tube	ENI	100228	1
2	Battery Holder	ENI	100219	1
1	Gland, Water Seal & Hold Probe Cable	ENI	100227	1
1	Panel, Top Cover	ENI	100216	1
1	Panel Gasket	ENI	100242	2
1	Handle Assembly—Holds Probe	ENI	100221	1
1	Handle Gasket	ENI	100217/3	2
1	Case Assembly, Bottom Cover	ENI	100222	1
1	Name Plate, Contains Operational Check Source	ENI	100223	1
2	Battery Clamp, Holds Batteries	ENI	100241	2
1	Cap & Chain Assembly, Cover Phone Jack	ENI	100224	1
1	Strap Assembly, Carrying Strap	ENI	100225	1

8.3 VENDORS

Symbol	Name	Address	
AB	Allen Bradley	136 W. Greenfield Ave.	Milwaukee, Wisconsin
C	Centralab	900 East Keefe Avenue	Milwaukee, Wisconsin
ENI	Electro-Neutronics, Inc.	940 Dwight Way	Berkeley, California
EON	EON Corporation	175 Pearl Street	Brooklyn, New York
ETC	Electronic Transistor Corporation	153-13 North Boulevard	Flushing, New York
GI	General Instruments	65 Gouverneur Street	Jamaica, New York
GM	General Meters	P. O. Box 1701	Grand Junction, Colorado
H	Hughes Semiconductor Div.	Florence & Teale Streets	Culver City, California
IEI	International Electronic Industries Div.	P. O. Box 9036	Nashville, Tennessee
IRC	International Rectifier Corporation	233 Kansas Street	El Segundo, California
IR	International Resistance Corporation	401 N. Broad Street	Philadelphia, Pennsylvania
LI	Lionel Electronic Labs	1226 Flushing Avenue	Brooklyn 37, New York
PR	Price Electronics	1387 Main Street	Springfield, Massachusetts
S	Sprague Electric Company	481 Marshall Street	North Adams, Massachusetts
ST	Stanwyck Winding Co., Inc.	137-151 Walsh Ave.	Newburgh, New York
TI	Texas Instruments, Inc.	P. O. Box 5012	Dallas, Texas
TR	Transitron	168 Albion Street	Wakefield, Massachusetts
TRI	Triad Transformer Corporation	4055 Redwood Avenue	Venice, California
UC	Union Carbide	270 Park Avenue	New York, New York
W	Weston Instruments & Electronics	1125 Marshall Street	Redwood City, California