

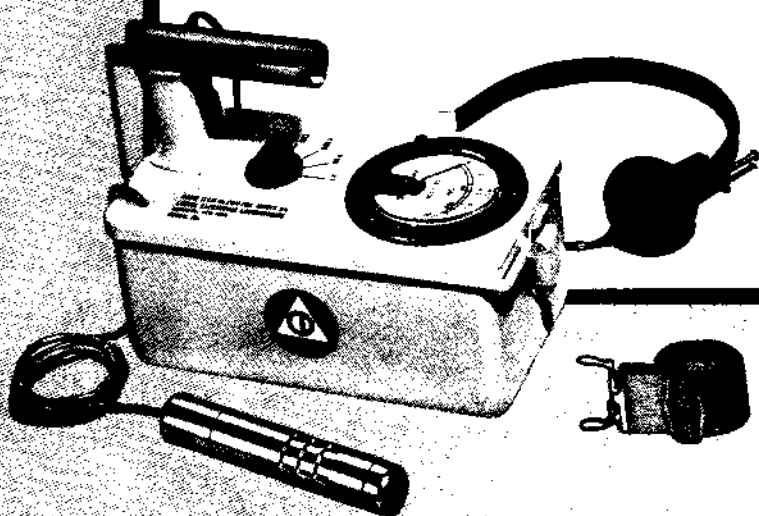


# Instruction and Maintenance Manual

**RADIOLOGICAL SURVEY METER**  
**OCDM ITEM NO. CD V-700, MODEL 6B**

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MANUFACTURED BY  
**LIONEL ELECTRONIC LABORATORIES, INC.**  
BROOKLYN 37, NEW YORK

1962-1963



## ERRATA

Replace paragraph 4.2 with the following:

CALIBRATION: NOTE: The uranium beta source must constitute the sole source of radiation when calibration is performed. Calibration must not be undertaken when the background is above normal or when the probe is in a radiation field other than that produced by the known beta source supplied with the instrument. If the indication falls above or below this range, it may be corrected by the screw-driver adjustment inside the case. Advancing the adjustment clockwise increases the reading.

# TABLE OF CONTENTS

## SECTION 1. GENERAL DESCRIPTION

| Paragraph                             | Page |
|---------------------------------------|------|
| 1.1 Introduction .....                | 3    |
| 1.2 The Probe .....                   | 3    |
| 1.3 The Panel Assembly and Case ..... | 3    |
| 1.4 The Head Set.....                 | 3    |
| 1.5 The Carrying Strap.....           | 3    |

## SECTION 2. THEORY OF OPERATION

|                                                  |   |
|--------------------------------------------------|---|
| 2.1 Introduction .....                           | 3 |
| 2.2 The Geiger Tube.....                         | 5 |
| 2.3 The Power Supply .....                       | 5 |
| 2.4 The Pulse Shaping and Metering Circuit ..... | 6 |
| 2.5 Scale Ranges .....                           | 6 |
| 2.6 The Audio Circuit and Head Phone .....       | 6 |

## SECTION 3. INSTALLATION

|                                  |   |
|----------------------------------|---|
| 3.1 Installing the Batteries.... | 6 |
|----------------------------------|---|

## SECTION 4. OPERATION

|                                             |    |
|---------------------------------------------|----|
| 4.1 Operating the Unit the First Time ..... | 7  |
| 4.2 Calibration Adjustment ..               | 7  |
| 4.3 "On-Off" and Range Switch .....         | 7  |
| 4.4 Using the Head Set.....                 | 7  |
| 4.5 Normal Background .....                 | 10 |
| 4.6 Checking Calibration .....              | 10 |
| 4.7 Using the Carrying Strap..              | 10 |

## SECTION 5. PREVENTIVE MAINTENANCE

|                              |    |
|------------------------------|----|
| 5.1 Battery Life .....       | 10 |
| 5.2 Storage .....            | 10 |
| 5.3 Decontamination .....    | 10 |
| 5.4 Battery Inspection ..... | 10 |

## SECTION 6. OPERATOR'S MAINTENANCE

| Paragraph                           | Page |
|-------------------------------------|------|
| 6.1 Replacing the Batteries....     | 11   |
| 6.2 Replacing the Geiger Tube ..... | 11   |

## SECTION 7. CORRECTIVE MAINTENANCE

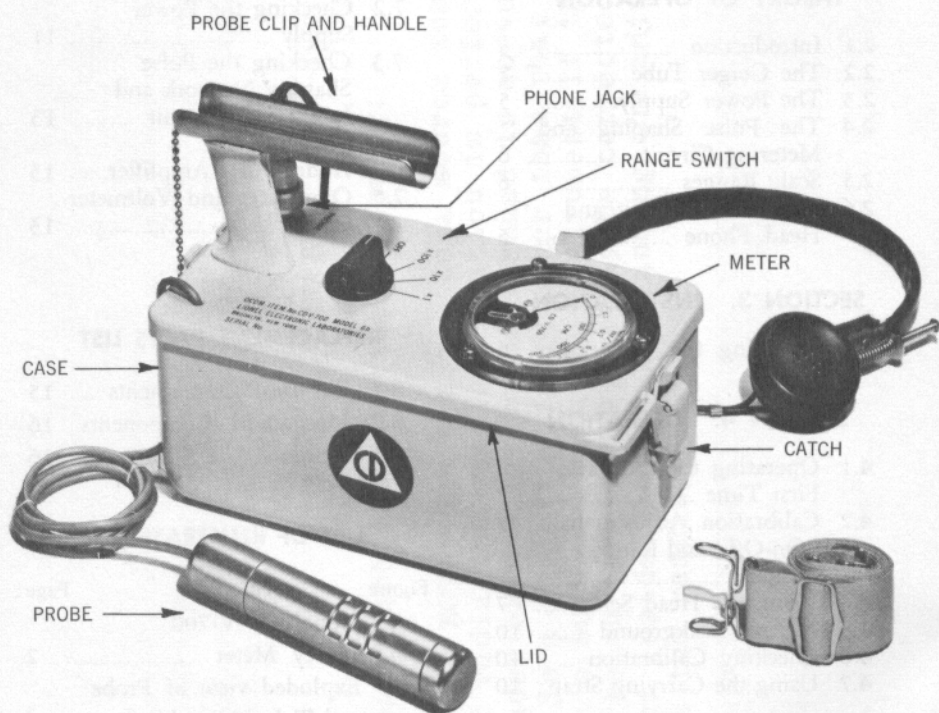
|                                                                      |    |
|----------------------------------------------------------------------|----|
| 7.1 In Case of Difficulty.....                                       | 11 |
| 7.2 Checking the Power Supply .....                                  | 11 |
| 7.3 Checking the Pulse Shaping Network and Integrating Circuit ..... | 13 |
| 7.4 Checking the Audio Pulse Amplifier.....                          | 13 |
| 7.5 Ohmmeter and Voltmeter Check .....                               | 13 |

## SECTION 8. REPLACEMENT PARTS LIST

|                              |    |
|------------------------------|----|
| 8.1 Electrical Components .. | 15 |
| 8.2 Mechanical Components..  | 16 |
| 8.3 Vendors .....            | 16 |

## LIST OF ILLUSTRATIONS

| Figure | Title                                         | Page |
|--------|-----------------------------------------------|------|
| 1.     | Lionel CD V-700 Survey Meter .....            | 2    |
| 2.     | Exploded view of Probe and Tube Assembly..... | 4    |
| 3.     | V-700 Showing Battery Section .....           | 8    |
| 4.     | Calibration Adjustment ....                   | 9    |
| 5.     | Schematic for V-700. ....                     | 12   |
| 6.     | Printed Circuit Board (Component Side) .....  | 14   |



**Fig. 1 — Lionel CD V-700 Survey Meter**

# **I. GENERAL DESCRIPTION**

## **1.1 INTRODUCTION**

The Lionel V-700 is a portable, battery powered, transistorized survey meter with a regulated power supply using a Lionel type 114/6993 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 PANEL ASSEMBLY AND CASE**

The panel assembly and case consists of 2 each 1½ volt type D supply batteries, a transistorized pulse shaping network, a detecting (metering) circuit, a regulated transistorized high voltage power supply, an audio output circuit and a radioactive Radium D+E source. The system is shock proof and water proof, 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.

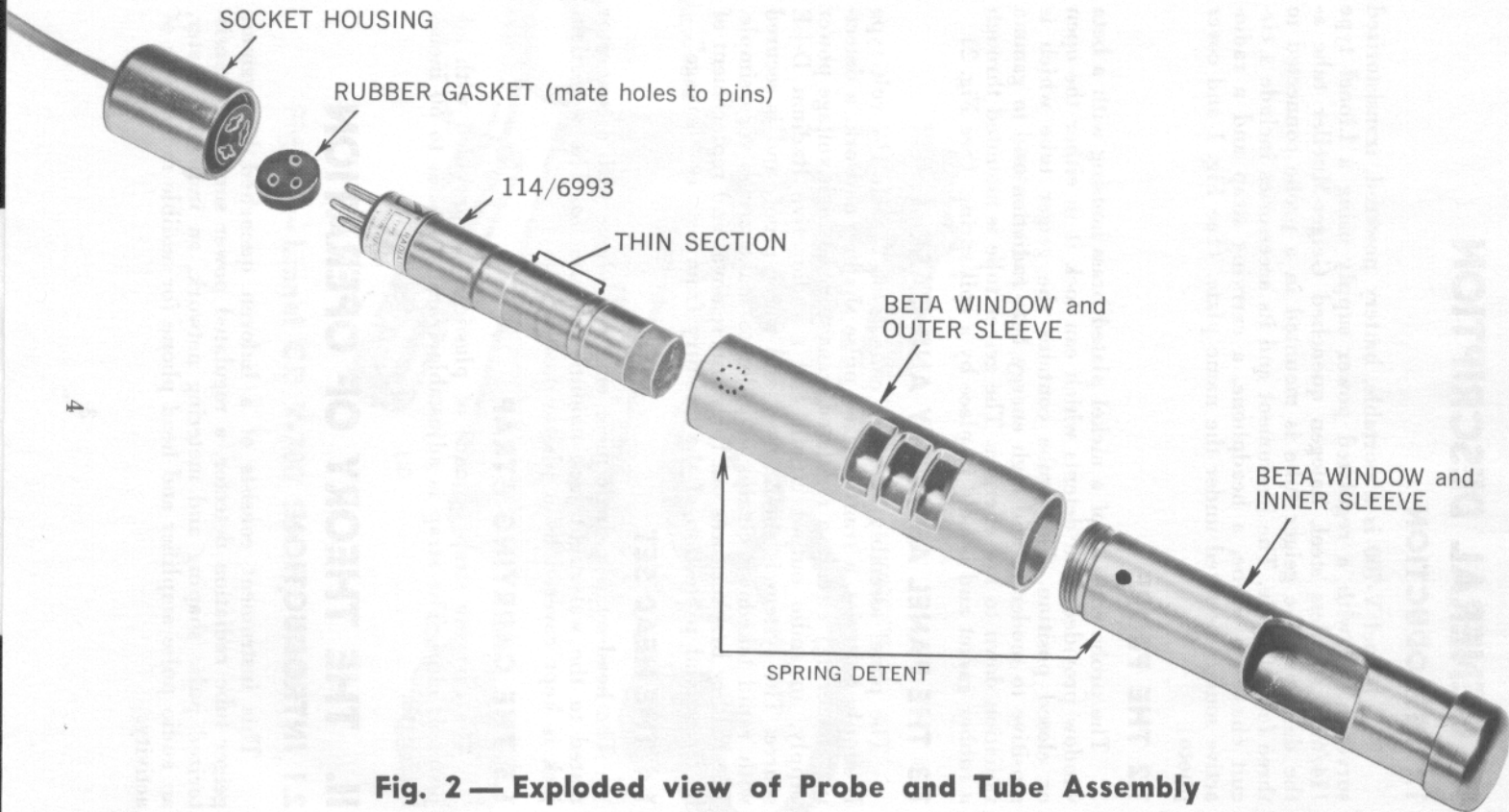
## **1.5 THE CARRYING STRAP**

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 POWER SUPPLY

The power supply consists of a blocking oscillator circuit in which pulses are generated by a transistor, V1, 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, CR1.

The D.C. output voltage developed across capacitor, C-2 is regulated by the corona discharge voltage regulator tube, V4. This regulation stabilizes the voltage supply to the Geiger-Mueller tube for battery voltages within the normal operating range. The high voltage is regulated at  $920 \text{ volts} \pm 20 \text{ volts}$ .

At the same time the negative voltage at the collector of the transistor is rectified by CR-2. Capacitor C-3 is used as a filter and the resultant negative voltage is used as a supply for the audio and

metering circuits. During each pulse the voltage regulator tube conducts heavily and saturates the core of the transformer. This saturation clips the pulse at the collector and regulates the voltage across capacitor C-3.

## **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 an collector coupled, 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 capacitor and cuts off transistor, V3. The resulting negative pulse on the collector of V3 is coupled to the base of V2 by the resistive voltage divider consisting of R12 and R5. This condition with V2 conducting and V3 cut off will continue for a period determined by resistor, R14, and the time capacitor selected by the range switch. The voltage pulse at the collector of V2 is rectified by silicon rectifier, CR5, and fed to the meter, M. The voltage pulses at the meter are integrated by capacitor, C8. 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 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 timing capacitors C6 and C7 and current limiting resistors R9 and R10.

## **2.6 THE AUDIO CIRCUIT AND HEAD PHONE**

Aural monitoring is achieved by diode coupling and a head set. Each pulse counted by the pulse shaping circuit develops a positive pulse at the collector of V2. This pulse is coupled to the head phone jack by CR-4 and differentiated by capacitor C-5. When the 4000 ohm head set is connected at the jack, a pulse of approximately 12 volts is developed across the head set 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 clamp by squeezing.
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 clamp.
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 radium D + E 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, R13, 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.

Note: The half-life of Radium D+E is approximately 22 years, therefore:

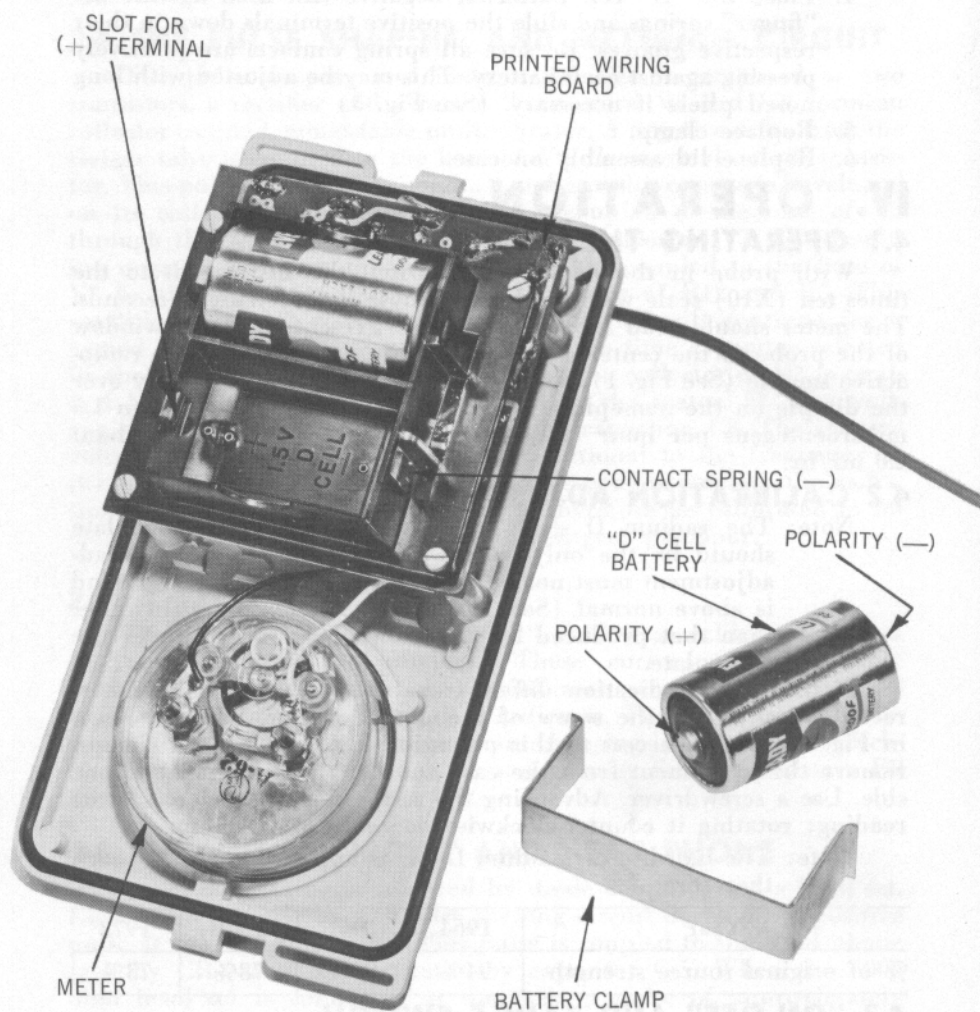
| Year                          | 1964 | 1967 | 1970 | 1972 |
|-------------------------------|------|------|------|------|
| % of original source strength | 94%  | 85%  | 78%  | 73%  |

### 4.3 "ON-OFF" AND RANGE SWITCH

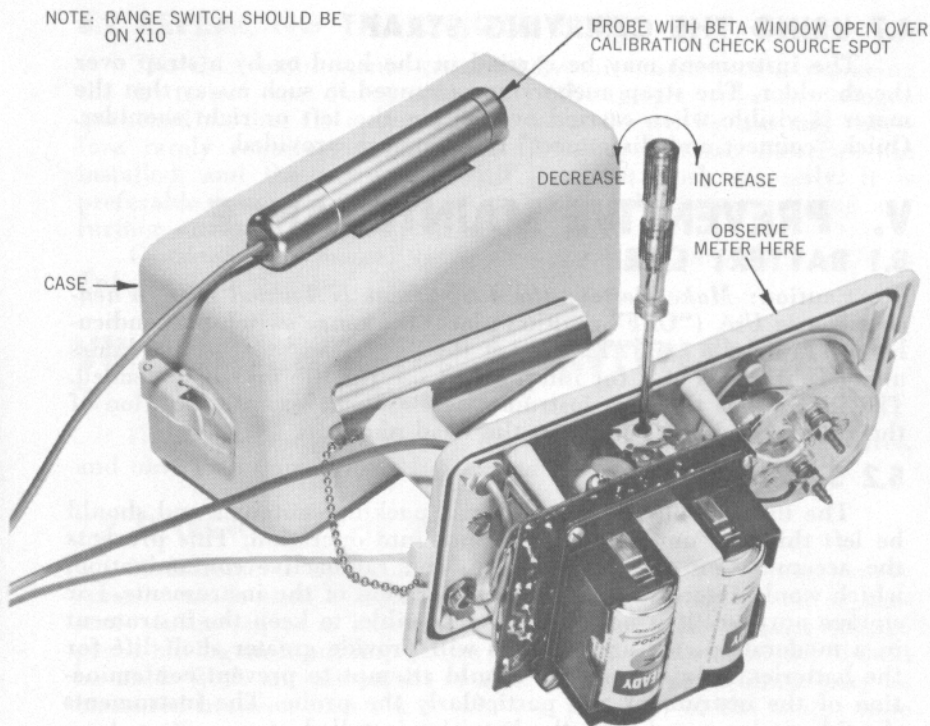
The range switch controls an "OFF" position and three ranges labeled, "X100," "X10," and "X1." These are respectively 100 times, 10 times and 1 times the scale reading in mr/hr and counts per minute. The printed meter scale goes to 0.5 mr/hr and 300 counts per minute respectively.

### 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 head phone.

## 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 instruments. 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.

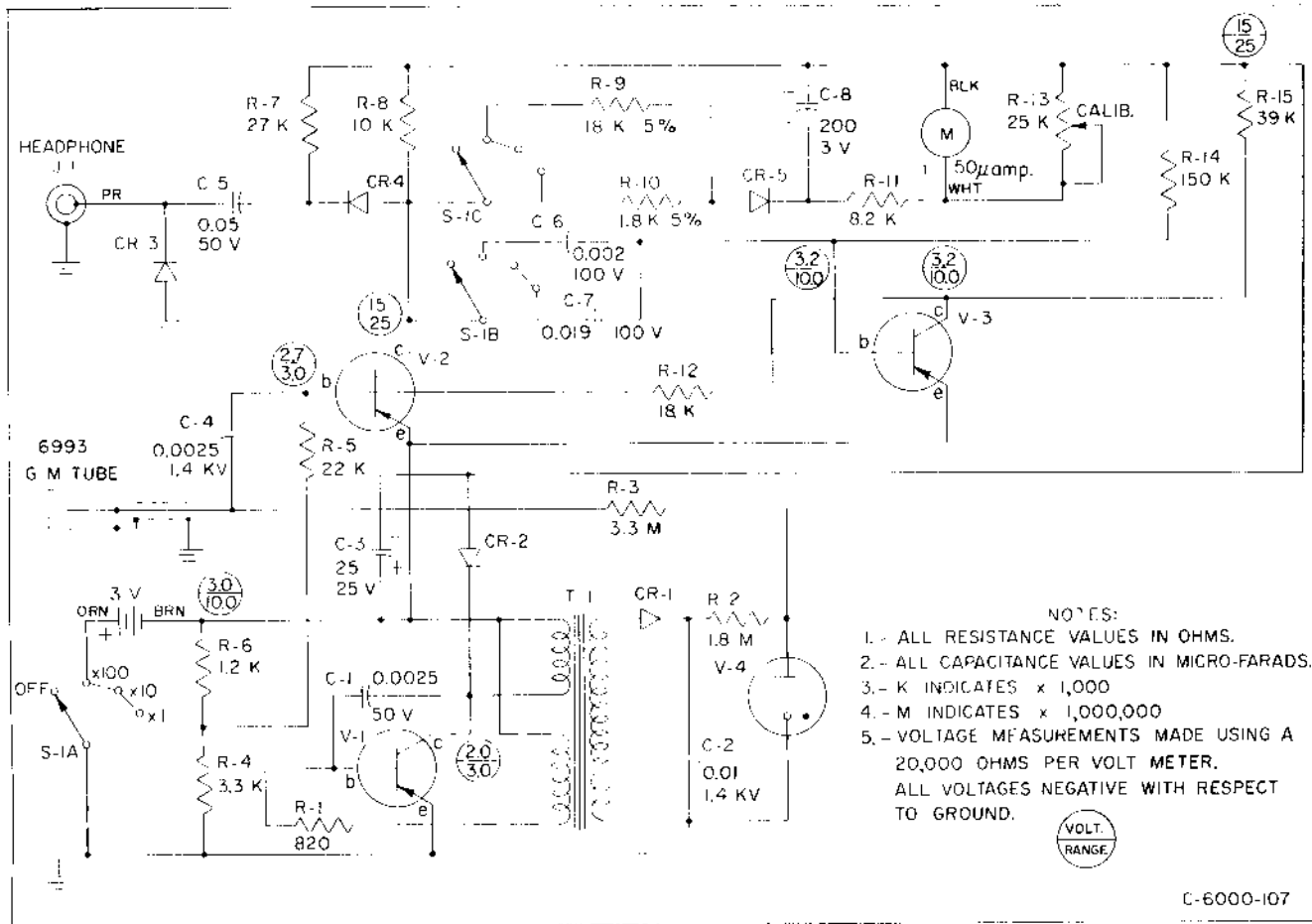
## 7.2 CHECKING THE POWER SUPPLY

Measurements in the high voltage section of the 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 920 volts  $\pm$  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:

1. Check the batteries with the instrument turned on. The 3 volt supply should read at least 2 volts.

Fig. 5 — Schematic for V-700



2. If the high voltage is low, check the voltage at the collector of transistor, V1. This voltage should be at least 1.7 volts. If this voltage is low, replace V1. If the collector voltage is sufficiently high, but the output voltage is still low, replace rectifier, CR1.
3. If the high voltage is higher than 950 volts, replace the VR tube, V4.

## 7.3 CHECKING THE PULSE SHAPING NETWORK AND INTEGRATING CIRCUIT

In order to check the pulse and integrating circuit, connect the head phone 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 head phone and should cause the meter to deflect when the range switch is in the VI position. If no clicks are heard, try the same test by touching the screwdriver to junction R3-C4. If this produces clicks, the cable assembly is defective and must be replaced. The cable assembly is permanently potted at the connector and, therefore, 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 capacitor, C4. 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 CR5, and C8 in that order, checking after each replacement. If the meter deflects and returns quickly at the zero position, replace C8. If none of the above replacements produces a meter deflection, replace the meter.

## 7.4 CHECKING THE AUDIO PULSE AMPLIFIER

If the meter is functioning, but no clicks are heard in the head phone, first check the connection of the head phone plug to the jack on the lid of the equipment. If clicks are still not heard, replace CR-4; and if this fails, replace C5 followed by CR-3 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.



# VIII. REPLACEMENT PARTS

## 8.1 ELECTRICAL COMPONENTS

| Schematic Symbol | Quant. Per Equip. | Description and Function                                        | Supplier | Supplier's Part No. | LEL Part No. | Rec. Spares for 5 Units |
|------------------|-------------------|-----------------------------------------------------------------|----------|---------------------|--------------|-------------------------|
| C1               | 1                 | Capacitor, 0.0025uf +80% 50v                                    | CRL      |                     | T3-536       | 1                       |
| C2               | 1                 | Power Supply Feedback Capacitor -20%                            | CRL      |                     | T3-534       | 1                       |
| C3               | 1                 | Capacitor 0.01uf High voltage filter +80% 1.4kv                 | CRL      |                     | T3-534       | 1                       |
| C4               | 1                 | Capacitor 25uf 25v Low voltage filter -20%                      | U.M.     |                     | T3-3         | 1                       |
| C5               | 1                 | Capacitor 0.0025uf Signal coupling and D.C. blocking +80% 1.4kv | CRL      |                     | T3-535       | 1                       |
| C6               | 1                 | Capacitor 0.05uf Audio coupling and differentiating +80% 50v    | CRL      |                     | T3-537       | 1                       |
| C7               | 1                 | Capacitor Mylar 0.002uf 100v Timing X 100 range                 | GDL      | Type 630            | T3-532       | 1                       |
| C8               | 1                 | Capacitor Mylar 0.01uf 100v Timing X 10 and X 1 range           | GDL      | Type 630            | T3-533       | 1                       |
| R1               | 1                 | Capacitor 200uf 3v Current integrating                          | U.M.     |                     | T3-500       | 1                       |
| R2               | 1                 | Resistor 820 ohm 1/2w 10% V1 base bias                          | U.M.     |                     | T10-235      | 1                       |
| R3               | 1                 | Resistor 1.8 megohm 1/2w 10% VR tube load resistor              | U.M.     |                     | T10-275      | 1                       |
| R4               | 1                 | Resistor 3.3 megohm 1/2w 10% GM tube load resistor              | U.M.     |                     | T10-278      | 1                       |
| R5               | 1                 | Resistor 3.3K ohm 1/2w 10% Bias divider for V2                  | U.M.     |                     | T10-242      | 1                       |
| R6               | 1                 | Resistor 22K ohm 1/2w 10% V2 base resistor                      | U.M.     |                     | T10-252      | 1                       |
| R7               | 1                 | Resistor 1.2K ohm 1/2w 10% Bias divider for V2                  | U.M.     |                     | T10-237      | 1                       |
| R8               | 1                 | Resistor 27K ohm 1/2w 10% Rectifier CR-4 reference resistor     | U.M.     |                     | T10-253      | 1                       |
| R9               | 1                 | Resistor 10K ohm 1/2w 10% V2 collector load                     | U.M.     |                     | T10-248      | 1                       |
| R10              | 1                 | Resistor 18K ohm 1/2w 5% Current limiting X 100 and X 10 ranges | U.M.     |                     | T10-118      | 1                       |
| R11              | 1                 | Resistor 1.8K ohm 1/2w 5% Current limiting X 1 range            | U.M.     |                     | T10-94       | 1                       |
| R12              | 1                 | Resistor 8.2 ohm 1/2w 10% Meter time constant                   | U.M.     |                     | T10-247      | 1                       |
| R13              | 1                 | Resistor 18K ohm 1/2w 10% Multivibrator cross coupling          | U.M.     |                     | T10-251      | 1                       |
| R14              | 1                 | Potentiometer 25 K ohm ± 30% Calibration control                | CTS      |                     | T10-1504     | 1                       |
| R15              | 1                 | Resistor 150K ohm 1/2w 10% V3 base resistor                     | U.M.     |                     | T10-242      | 1                       |
| GM               | 1                 | Resistor 39K ohm 1/2w 10% V3 collector load                     | U.M.     |                     | T10-255      | 1                       |
| S1               | 1                 | Geiger Tube, Detector                                           | LEL      | 6993                | 6993         | 1                       |
| M                | 1                 | Switch, Range Selection                                         | CTS      |                     | T13-206      | 1                       |
| B                | 2                 | Meter 0-50ua, Indicator                                         | LEL      | T6-85               | T6-85        | 1                       |
| T1               | 1                 | Batteries "D" size 1 1/2 volt Power Supply                      | N.C.     | 950                 | T1-19        | 10                      |
| CR-1             | 1                 | Transformer, Blocking Osc. Power Supply                         | LEL      | T14-185             | T14-185      | 1                       |
| CR-2             | 1                 | Rectifier—H.V. Rectifier                                        | EDI      |                     | T8-108       | 1                       |
| CR-3             | 1                 | Rectifier, Silicon, L.V. Rectifier                              | LEL      | T8-127              | T8-127       | 1                       |
| CR-4             | 1                 | Rectifier, Silicon, Audio Clipping                              | LEL      | T8-127              | T8-127       | 1                       |
| CR-5             | 1                 | Rectifier, Silicon, Audio Coupling                              | LEL      | T8-127              | T8-127       | 1                       |
| V1               | 1                 | Rectifier, Silicon, Meter Rectifier                             | LEL      | T8-127              | T8-127       | 1                       |
| V2               | 1                 | Transistor, PNP, Power Supply                                   | LEL      | T8-124              | T8-124       | 1                       |
| V3               | 1                 | Transistor, PNP, Multivibrator                                  | LEL      | T8-125              | T8-125       | 1                       |
| V4               | 1                 | Transistor, PNP, Multivibrator                                  | LEL      | T8-126              | T8-126       | 1                       |
| PB               | 1                 | Voltage Regulator Tube                                          | LEL      | 416                 | 416          | 1                       |
| H                | 1                 | Printed Circuit Board                                           | LEL      | T11-529             | T11-529      | 1                       |
|                  | 1                 | Head Phone                                                      | LEL      | T12-21              | T12-21       | 1                       |

## 8.2 MECHANICAL COMPONENTS

| Quant.<br>Per<br>Equip. | Description and Function               | Supplier | Suppliers<br>Part No. | LEL<br>Part No. | Rec.<br>Spares for<br>5 Units |
|-------------------------|----------------------------------------|----------|-----------------------|-----------------|-------------------------------|
| 1                       | Meter Gasket                           | LEL      | T20-1011              | T20-1011        | 2                             |
| 1                       | Knob Indicator                         | LEL      | T11-512               | T11-512         | 2                             |
| 1                       | Jack, Head Phone Connector             | LEL      | T11-967               | T11-967         | 1                             |
| 1                       | Jack Gasket                            | LEL      | T20-962               | T20-962         | 2                             |
| 1                       | Probe Cable Assembly, Hold GM Tube     | LEL      | T32-1                 | T32-1           | 1                             |
| 1                       | Battery Holder Assembly                | LEL      | T32-2                 | T32-2           | 1                             |
| 1                       | Gland, Water Seal, Holds Probe Cable   | LEL      | T20-968               | T20-968         | 1                             |
| 1                       | Panel                                  | LEL      | T28-60                | T28-60          | 1                             |
| 1                       | Panel Gasket                           | LEL      | T21-46                | T21-46          | 2                             |
| 1                       | Handle Assembly—Holds Probe            | LEL      | T32-3                 | T32-3           | 1                             |
| 1                       | Handle Gasket                          | LEL      | T20-992               | T20-992         | 2                             |
| 1                       | Case Assembly, Bottom Cover            | LEL      | T32-4                 | T32-4           | 1                             |
| 1                       | Battery Clamp, Holds Batteries         | LEL      | T28-62                | T28-62          | 2                             |
| 1                       | Cap & Chain Assembly, Cover Phone Jack | LEL      | T32-5                 | T32-5           | 1                             |
| 1                       | Strap Assembly, Carrying Strap         | LEL      | T20-989               | T20-989         | 1                             |

## 8.3 VENDORS

| Symbol | Name                          | Address             |
|--------|-------------------------------|---------------------|
| CRL    | Centralab                     | Milwaukee, Wis.     |
| CTS    | CTS Corp.                     | Elkhart, Ind.       |
| EDI    | Electronic Devices Inc.       | New Rochelle, N. Y. |
| GDI    | Good-All Electric Mfg. Co.    | Ogallala, Nebr.     |
| LEL    | Lionel Electronic Labs., Inc. | Brooklyn, N. Y.     |
| NC     | National Carbon               | New York, N. Y.     |
| UM     | United Mineral                | New York, N. Y.     |