Instruction Manual

FOR

RADIATION SURVEY METER
FCDA Item No. CD V-720, Model No. 2

(VICTOREEN MODEL 720)

Part No. 720-2

The Victoreen Instrument Co.
5806 HOUGH AVENUE -:- CLEVELAND 3, OHIO

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CD V-720, MODEL 2 SURVEY METER

Section 1
GENERAL DESCRIPTION

1. INTRODUCTION

The CD V-720, Model 2, Victoreen Model 720 is a portable monitoring instrument for the measurement of gamma radiation dose rates as high as 500 roentgens per hour and in addition can detect beta radiation from fission products. It is designed to be used by radiological Civil Defense personnel in determining radioactive contamination levels that may result from an enemy attack or other nuclear disaster.

Instrument accuracy on any of its three ranges is within +15% of the true dose rate from Co^{60} gamma radiation. This accuracy is maintained throughout a temperature range of —20 degrees F to + 125 degrees F, relative humidities to 100% and at altitudes from sea level to 25,000 feet.

2. SENSING ELEMENT

The detecting element in the CD V-720 is an hermetically sealed ionization chamber. This chamber is located in the lower front portion of the instrument as shown in Figure 1 to make the instrument equally sensitive to radiation from the bottom, front and both sides. The plastic lined steel chamber has a stainless steel window on the bottom to permit detection of beta particles. The bottom of the instrument case contains a sliding shield to permit discrimination against beta particles if desired. The ionization chamber is hermetically sealed to eliminate changes in sensitivity due to changes in air pressure resulting from altitude changes, temperature changes, and moisture effects. The chamber is replaceable without disturbing the calibration of the instrument.

3. ELECTRONIC CIRCUITRY

A gasketed aluminum circuit box, located above the ion chamber, houses all of the electrical components and wiring of the instrument. This circuitry serves to measure the minute current from the ionization chamber which indicates the presence of ionizing radiation.

4. BATTERIES

The CD V-720, Model 2, is powered by two "D" size flashlight cells (NEDA 13) and a 22½ volt miniature hearing-aid battery (NEDA 215). The batteries will operate the instrument continuously for over 150 hours and much longer on an intermittent basis. The battery contacts and holders are fastened to the circuit box as shown in Figure 1 to make a simple, rugged and unified circuitry.

5. METER AND CONTROLS

The CD V-720 uses a ruggedized, sealed meter to meet the instrument requirements for water-tightness, shock and vibration resistance. Two controls are provided. One control is a range switch which turns the instrument on, checks its operation and serves to select the proper range. The second is a zero control which is used to adjust the instrument to assure proper reading.

6. PHYSICAL FEATURES

The instrument is housed in a tough, shock and scratch resistant plastic case molded of high-impact polystyrene. Carrying strap loops and the zero control guard are permanently molded in. The nameplate and the information for the control knobs is indelibly molded into the case. Two toggle action spring clips serve to fasten the bottom half of the case to the top. The gasket, which is retained by the circuit plate, is fastened to the top half of the instrument and provides a watertight seal when the instrument is closed. The instrument is approximately 8½″ long, 4¾″ wide and 4″ high, excluding the handle. The instrument weighs three pounds and will float in water.

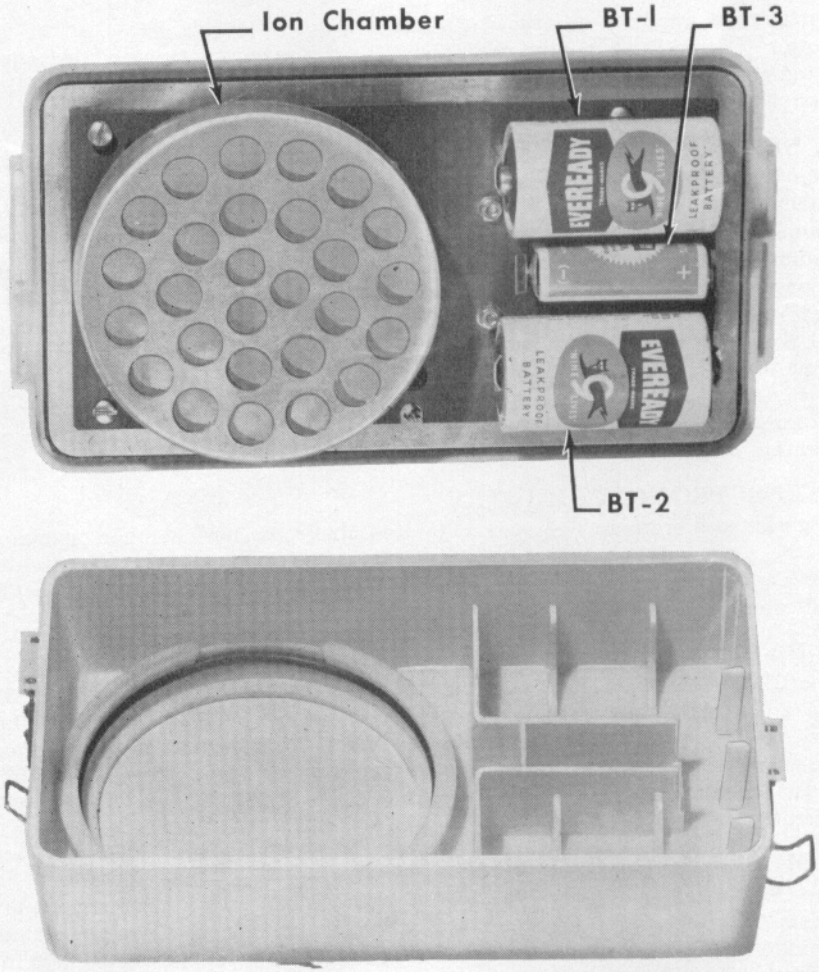


Figure 1. The CD V-720, Model 2. With Case Opened

Section 2
THEORY OF OPERATION

1. IONIZATION CHAMBER

The detecting element of the CD V-720 is an hermetically sealed air equivalent ionization chamber. It consists of a conducting cylindrical container of plastic and steel called the shell and a thin conducting disk called the collector, located in the center of the shell, which are respectively the positive and negative electrodes. The collector is insulated from the shell by an extremely high resistance feed-thru insulator. A voltage, called the collecting voltage, is applied between these two chamber electrodes. This makes the shell 22½ volts positive with respect to the collector. See Figure 2.

Ionizing radiation, in passing through the air contained in the chamber, causes air molecules to become charged or ionized. These charged particles or ions are attracted to the chamber electrode having the opposite charge; that is, positive ions move toward the center electrode of the chamber and negative ions toward the shell.

The arrival of these ions at the electrodes of the chamber constitutes a flow of current whose magnitude is proportional to the number of ions collected. Since the number of ions created is proportional to the radiation intensity, this ionization current is proportional to the radiation intensity in the ionization chamber.

2. INPUT CIRCUIT

The ionization current is extremely small—about 0.00005 microamperes at 5 r/hr which is full scale on the most sensitive range. It flows through a very high resistance (25,000 megohms) called a "Hi-Meg" connected to the collector of the ionization chamber as shown in Figure 2. This ionization current (0.00005 microamperes when the meter reads its full scale of 5 r/hr) develops a voltage drop of about 1.2 volts across the "Hi-Meg" resistor with the polarity as shown.

The voltage developed is applied to the grid of a vacuum tube for amplification. Any of the minute ionization current flowing to the grid of the tube instead of through the "Hi-Meg" resistor would result in amplification of only a portion of the signal. A special vacuum tube called an electrometer tube capable of amplifying voltages at extremely small grid currents is used to prevent this error. This tube is connected as a triode as shown in Figure 2.

3. MEASURING CIRCUIT

In order to permit zeroing the instrument in a radiation field, a section of the range switch is used to short circuit the "Hi-Meg" resistor and prevent any ionization signal from being sensed by the input circuit on the "ZERO" position. A "ZERO" control is located on the top cover of the instrument for balancing out static plate current. This balancing is accomplished by changing the grid bias on the electrometer tube by means of the potentiometer, Rc.

The measurement of the grid voltage of the electrometer tube is accomplished by metering the change in plate current directly. The static plate current is cancelled by running a reverse current, supplied by the filament battery BT1, through the meter.

Battery BT2 is incorporated to permit compensation of plate current changes that would occur due to changes in voltage of plate supply battery BT3.

Sensitivity of the instrument is changed by switching "Hi-Meg" resistors, which is accomplished by the range switch.

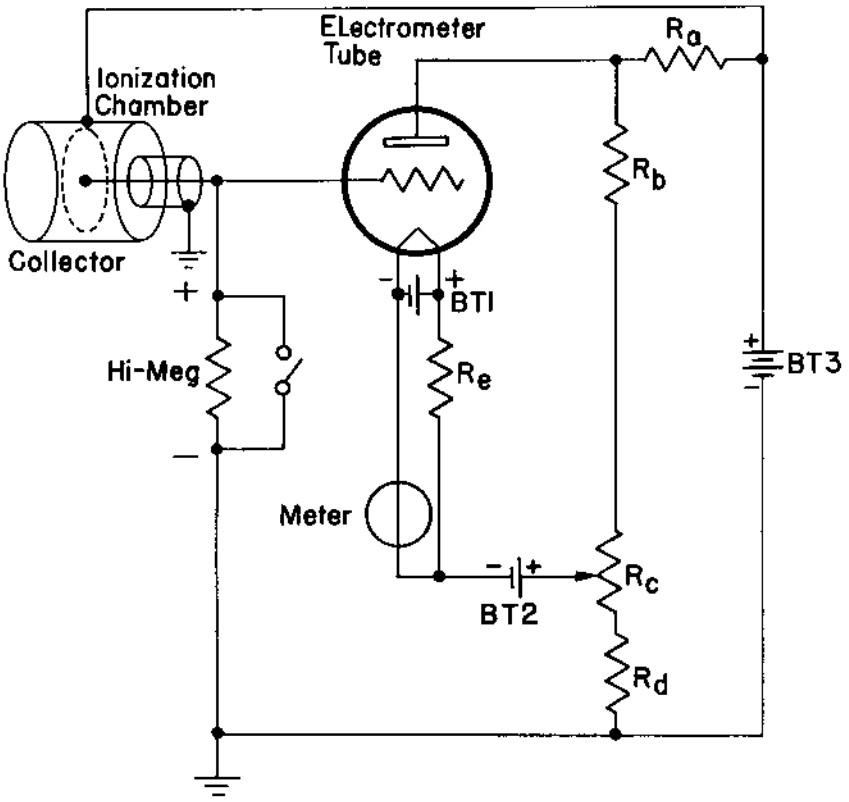


Figure 2. Simplified Schematic Diagram

Section 3
INSTALLATION

1. INSPECTION

The instrument is shipped with batteries and carrying strap removed from the instrument and packed separately. Inspect the batteries for possible leakage before installation. Do not install leaking batteries. Inspect the instrument for damage in shipment. If damage is apparent the batteries should not be installed, thus preventing further damage due to possible short circuits.

2. BATTERY INSTALLATION

Open the instrument by snapping open the toggle clip at each end of the case and separating the two halves of the case. This exposes the battery holder and battery clips as shown in Figure 1. Insert the batteries in the appropriate clips as indicated on the battery label card. **Observe battery polarity.** Close the case by aligning the top and bottom halves carefully and squeeze the two halves of the instrument together firmly. Snap toggle clips closed.

3. SHOULDER STRAP INSTALLATION

The carrying strap and two carrying strap slides are packed separately. They are affixed to the molded-in carrying strap loops in the end of the case as shown in Figure 3, and the length is adjusted to suit the operator.

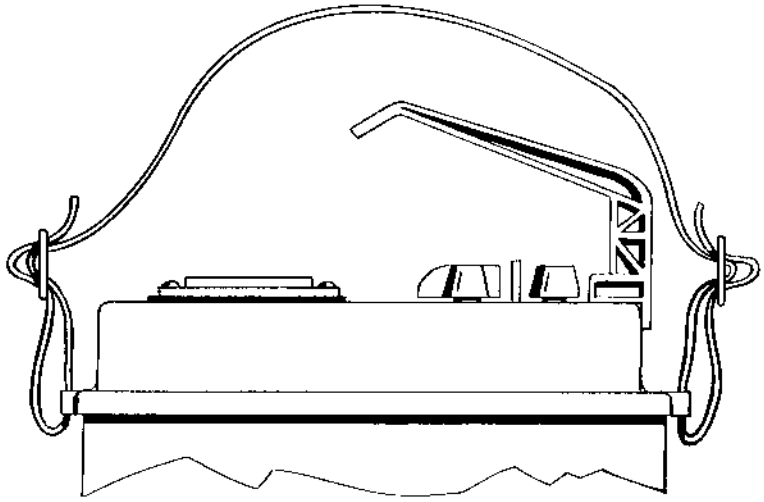


Figure 3. Method of Attaching Shoulder Straps

Section 4
OPERATION

There are three simple basic steps recommended for proper operation of the CD V-720. They are described as follows:

1. ZERO ADJUST

Turn the instrument on by turning the range switch from "OFF" to the "ZERO" position. Wait about a minute to allow the electrometer tube to warm up, then orient the "ZERO" control until the meter needle indicates zero on the meter.

CAUTION

If the instrument is not zeroed properly, readings taken on any of the three ranges will be erroneous. The drift will be in an upscale direction at a very slow rate.

2. CIRCUIT CHECK

Turn the range switch counter clockwise from the "ZERO" position through the "OFF" position to the "CIRCUIT CHECK" position. This position is spring-loaded to return to "OFF". The range switch must be held in this position for the circuit check. The meter should read in the red outlined section labeled "CIRCUIT CHECK". If it does not, either the batteries are low or trouble exists in the circuit. See Sections 5 and 7 for proper procedures. Make certain the instrument is zeroed before making the circuit check.

Low or dead batteries are indicated by inabilty to zero the instrument or by a meter reading below the check band when the range switch is in the "CIRCUIT CHECK" position.

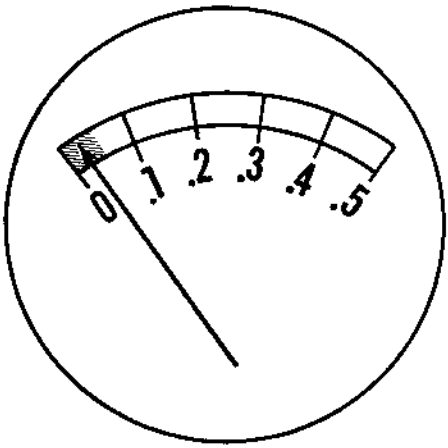
3. RANGE SELECTION AND READING

Turn the range switch to the "X100", "X10" or "X1" range as necessary to obtain an upscale reading on the meter.

The meter reading observed must be multiplied by the factor indicated by the position of the range switch to obtain the radiation dose rate in roentgens per hour (r/hr).

EXAMPLE:	METER READING	3.8
	RANGE	"X100"
	INTENSITY OF RADIATION	380 r/hr

Another example is a meter reading of 2.4 on the "X10" range which indicates a dose rate of 24 roentgens per hour while the same reading obtained with the instrument turned to the "X100" range corresponds to 240 roentgens per hour.



READINGS SHOULD NOT BE TAKEN WITH POINTER INDICATING IN LOWER 10% OF SCALE (SHADED IN ILLUSTRATION). TURN TO NEXT MOST SENSITIVE RANGE UNTIL POINTER INDICATES IN UPPER 90% OF SCALE (UNSHADED).

A sliding beta window shutter is provided in the bottom of the instrument. This shutter has three indexed positions.

1. Completely closed — The shutter is in its most forward position and covers the beta window of the chamber.
2. 25% Open -- The shutter exposes 25% of the beta window to radiation from the bottom of the instrument.
3. Completely open — The shutter is in its most rearward position and exposes the complete beta window of the chamber.

For the measurement of gamma radiation dose rates only, the shutter should be in the completely closed position.

If beta radiation plus gamma radiation is to be measured, the shutter should be in the completely open or 25% open position. Under these conditions the instrument will give a reading which is the sum of the gamma and beta radiation levels. To determine the beta level alone the reading with the shutter completely closed (gamma dose rate only) should be subtracted from the reading with the shutter in an open position.

It is recommended that the beta shutter be kept closed as much as possible in order to protect the 0.001 inch thick stainless steel beta window from damage. It is also recommended that the instrument be kept turned off, except for periods where frequent readings are required, in order to conserve battery life.

The "ZERO" or "CIRCUIT CHECK" may be performed at any time, whether the instrument is in a radiation field or not.

Section 5
OPERATOR'S MAINTENANCE

1. BATTERY REPLACEMENT

Battery replacement is indicated whenever the instrument can no longer be zeroed or when the meter indicates below the "CIRCUIT CHECK" band. To replace the batteries, snap open the end clips and separate the two halves of the instrument. Remove all three batteries from their clips. Install new batteries as indicated in Section 3, Battery Installation. (If a voltmeter is available the batteries may be checked in accordance with Section 7.3). Batteries should be removed from the instrument and stored separately if the instrument is to be stored more than a few weeks.

2. CLEANING

WARNING:

Do not use cleaning solvents on the plastic parts.

To clean the case, use soap and water. If the batteries have leaked, remove the case bottom and fill only the battery compartment with warm water. The battery spillage will be loosened in a short while and can be rinsed out. Be careful not to soak off the circuit diagram or the CD decal.

Section 6
PREVENTIVE MAINTENANCE

1. PREVENTIVE MAINTENANCE

It is recommended that preventive maintenance procedures be carried out once a month when the instrument is in use, and about once every six months when the instrument is in storage.

Preventive maintenance should be carried out as follows:

a. Remove the batteries, clean battery contacts and battery terminals if necessary and remove any corrosion present.
b. Replace the batteries making certain that all batteries make good contact and exceed minimum voltage.
c. Perform the operation indicated in Section 4.1, ZERO, and Section 4.2, CIRCUIT CHECK.

Batteries should be removed from the instrument and stored separately if the instrument is to be stored more than a few weeks.

Section 7
CORRECTIVE MAINTENANCE

WARNING

Calibration should be attempted only by personnel trained in the use of radioactive isotope sources.

1. CALIBRATION

The CD V-720 is calibrated by being placed in a gamma radiation field of known dose rate. Such fields are most commonly produced by using a radioactive material such as radium or Cobalt^{60}. As an example a 1 curie radium source will produce a radiation dose rate of 4 r/hr, at a distance of 18.1 inches. The CD V-720 should read this dose rate when so positioned with the center of the ion chamber at this distance. If it does not, the instrument should be recalibrated. This is accomplished by removing it from its case and adjusting the individual "CAL" controls for the corresponding ranges. The distance from the center of the CD V-720 ionization chamber to the calibrating source should be at least 12 inches to obtain reasonable geometry (reasonably uniform radiation intensity over the volume of the ionization chamber).

2. DISASSEMBLY FOR CORRECTIVE MAINTENANCE

First remove the batteries from the CD V-720, Model 2. Open the circuit box by removing the four screws on the bottom of the circuit plate. Remove the knobs from the shafts on the top cover of the instrument. Press firmly on the top of the two exposed shafts, causing the circuit plate to be ejected from the instrument top. Remove the circuit shield, exposing the electronic components for any necessary repairs.

A view of the circuit plate is shown in Figure 4.

3. TROUBLE-SHOOTING

The majority of the electrical components of the CD V-720, Model 2, are standard parts familiar to electronic technicians and are readily checked by conventional means. The electrometer tube, the "Hi-Meg" resistors, the ion chamber insulator and the ceramic switch section are the only components requiring special precaution. These components are all part of the high resistance input circuit. **The insulating portions of these four components should not be handled.** They should be touched only with clean tools when repairs are made. If surface leakage on any of these items is suspected, cleaning with clean alcohol using a clean camel hair brush is recommended. Avoid solder flux splattering on these components when repairs are made.

All batteries as well as the measuring circuit are checked by the "CIRCUIT CHECK". If trouble exists, batteries should be checked with any voltmeter having a sensitivity of 1000 ohms/volt or more. The "D" cells, BT1 and BT2, should read higher than 1.2 volts and the "B" battery, BT3, higher than 17 volts.

Circuit malfunctions may be traced with the aid of the schematic circuit diagram, Figure 5. Voltage measurements shown on this diagram are measured with respect to ground and are those obtained with a voltmeter having a sensitivity of 20,000 ohms per volt. Such voltage checks should be taken with the instrument range switch turned to the "ZERO" range and with the zero control adjusted so that the instrument reads zero.

The following troubles and corrective action are presented as an aid to trouble shooting.

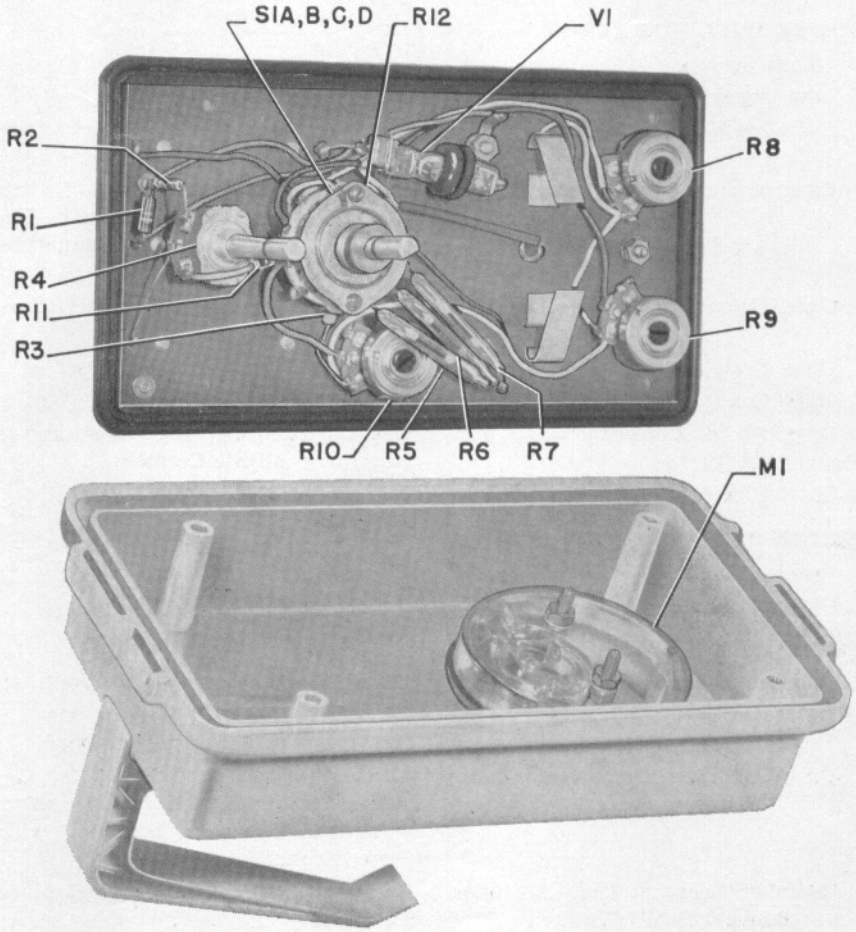


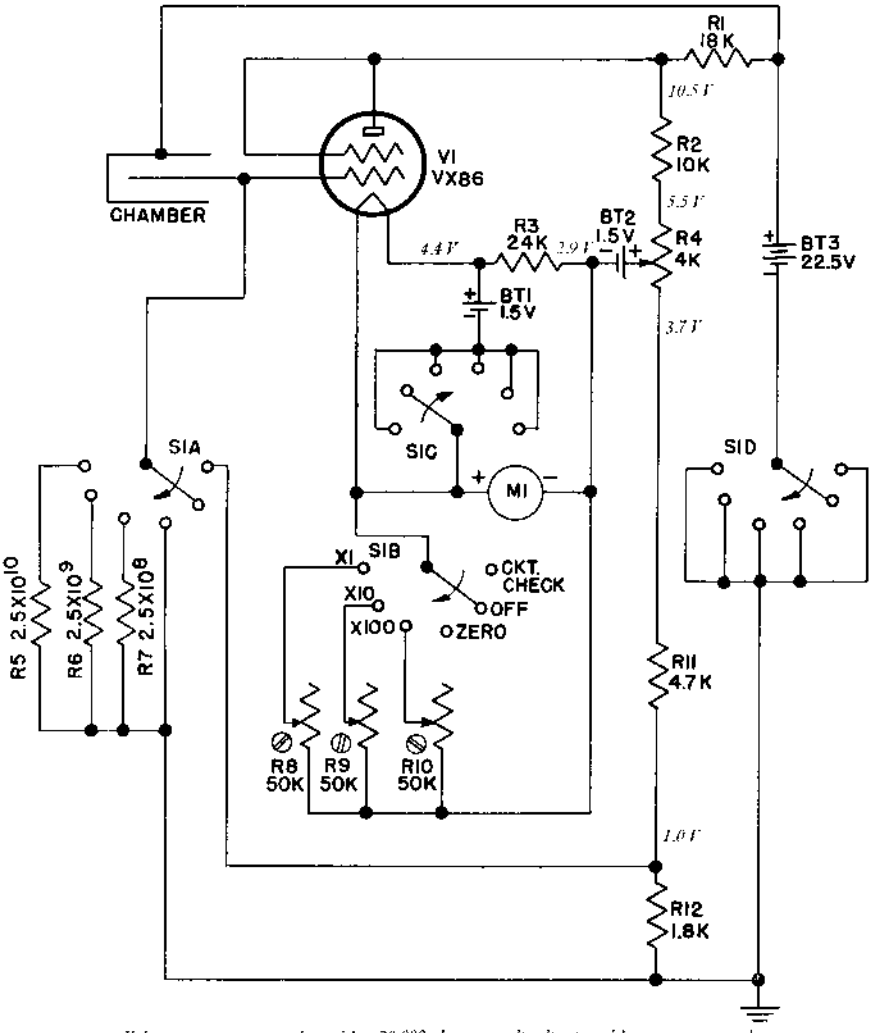
Figure 4. View of Circuit Plate Assembly

TROUBLE SHOOTING CHART

Trouble and Cause	Corrective Action
NO READING	
Low Batteries	Replace all low batteries
Corroded Battery Contacts	Inspect and Clean Battery Contacts
Calibration Control, Improperly Adjusted	Turn Calibration Control Clockwise and use "CIRCUIT CHECK" position to Test
Meter Damaged	Replace Meter
Chamber Damaged	Replace Chamber
Open Connection	Inspect All Solder Joints and Wiring
METER WILL NOT ZERO (reads upscale)	
Low Batteries	Replace All Low Batteries
Corroded Battery Contacts	Clean and Brighten All Battery Contacts
Electrometer Tube Filament Open	Remove "D" Cells. Set Range Switch to "ZERO". Measure Resistance Between Battery Contacts. Should be Approximately 150 Ohms.
Open Potentiometer	Check Potentiometers with Ohmmeter
Open Resistor	Check Resistor with Ohmmeter
Open Connection	Inspect All Solder Joints and Wiring
Open Switch Contact	Check Switch Contacts. Clean and if Necessary Adjust Contacts
Short Circuit	Inspect for Mechanical Damage
METER WILL NOT ZERO (reads downscale)	
Defective Tube	Check Tube Filament
INSTRUMENT READS LOW	
Calibration Control Disturbed	Check Calibration as Outlined in Section 7,1. Calibration
Faulty Electrometer Tube	Replace with New VX86 or 5886
Dirty High Resistance Components	Clean the "Hi-Meg" Resistors, Ceramic Switch Deck, Electrometer Tube and Chamber Insulator with Pure Alcohol
Chamber Leaks at High Altitudes Because Seal is Broken	Locate and Repair Leak or Replace Chamber
Meter Damaged	Replace Meter

INSTRUMENT READS HIGH

Calibration Control Improperly Adjusted	Check Calibration as Outlined in Section 7.1. Calibration
If High Reading on Only One Range, a "Hi-Meg" Resistor may be damaged	Replace Suspected "Hi-Meg" Resistor
Calibration Control Open	Check with Ohmmeter and Replace if Necessary



Voltage measurements taken with a 20,000 ohms per volt voltmeter with respect to ground.

Figure 5. Schematic Diagram

Section 8
REPLACEABLE PARTS LISTS
ELECTRICAL COMPONENTS

Circuit Symbol	Description	Function	Manufacturer	Mfg. Part No.	Victoreen Part No.
BT1	Battery; 1.5 volt, "D" size flashlight	Filament	National Carbon	Eveready 950	263-17
BT2	Same as BT1	Grid Bias	" "		
BT3	Battery; 22½ volt, Min. hearing-aid	Plate Supply	" "	Eveready 412	356-38
M1	Meter, 0-50 ua	Indicating	Phaestron	———	720-8
R1	Resistor; 18K ½W ±10%	Voltage Divider	IRC	———	185-360
R2	Resistor; 10K ½W ±10%	" "	"	———	185-253
R3	Resistor; 24K ½W ±5%	Plate Current Bias	"	———	185-305
R4	Potentiometer, 4K ±20%	Zero Adjust	Centralab	———	710-77
R5	Resistor; Hi-Meg 2.5 x 10^{10} ohm ±10%	Grid Res. Range "X1"	Victoreen	185-1017	185-1017
R6	Resistor; Hi-Meg 2.5 x 10^{9} ohm ±10%	" " " "X10"	"	185-1134	185-1134
R7	Resistor; Hi-Meg 2.5 x 10^{8} ohm ±10%	" " " "X100"	"	185-1014	185-1014
R8	Potentiometer; 50K ±30%	Cal. Adj. " "X1"	Stackpole	———	710-41
R9	Potentiometer; " "	" " " "X10"	"	———	"
R10	Potentiometer; " "	" " " "X100"	"	———	"
R11	Resistor, 4.7K ½W ±10%	Voltage Divider	IRC	———	185-175
R12	Resistor, 1.8K ½W ±5%	Circuit Check	"	———	185-347
S1a,b, c & d	Switch	Function Selector	Oak	———	720-6
V1	Electrometer tube	Elect. Amplifying Tube	Victoreen	VX86, 5886	720-58
			Raytheon	5886	———
	Ionization Chamber Assembly	Detecting Element	Victoreen	720-20	720-20

Note: See Maintenance Supply Parts for Hi-Meg Color Code

MECHANICAL COMPONENTS

Qty. Req'd	Nomenclature	Mfg. & No.	Victoreen No.
1	Case Top and Handle Assembly	Victoreen	720-45
1	Case Bottom Assembly	"	720-46
1	Switch	Oak	720-6
1	Range Switch Knob	Harry Davies Moulding Co.	710-85
1	Zero Control Knob	" " " "	710-86
1	Meter Gasket	Victoreen	720-14
1	Case Gasket	"	710-94
1	Circuit Plate Assembly	"	720-35
1	Circuit Shield	"	720-44
2	Washers	"	720-48
1	Spring	"	720-47
2	Case Clip	"	720-36
2	Retaining Ring	"	720-28
2	Carrying Strap Buckles	Waterbury No. 8075	710-44
1	Carrying Strap	Keller Product Co.	710-45
2	"O" Ring	Parker Appliance	710-42
1	"O" Ring	" "	728-33
1	Beta Shield Assembly	Victoreen	720-54
1	Index Ball	"	720-31
1	Instruction Manual	"	720-2

MAINTENANCE SUPPLY PARTS

Suggested supply for five instruments for one year (400 hrs.) of operation.

Qty.	Circuit Symbol	Description	Victoreen Part No.
20	BT1,2	"D" Cell Battery	263-17
10	BT3	22½ Volt Battery	356-38
1	V1	Electrometer Tube	720-58
1	M1	Meter	720-8
2	—	Carrying Strap	710-45
4	—	Carrying Strap Buckles	710-44
1	R4	Zero Potentiometer 4K	710-77
2	R5	Hi-Meg 2.5 x 10^{10} (White Dot)	185-1017
2	R6	Hi-Meg 2.5 x 10^{9} (Blue Dot)	185-1134
2	R7	Hi-Meg 2.5 x 10^{8} (Green Dot)	185-1014
1	—	Ion Chamber Assembly	720-20
1	—	Knob, Zero Control	710-86
1	—	Knob, Range Switch	710-85
1	S1a,b,c,d	Switch	720-6
1	—	Tube Socket	720-40

NAMES AND ADDRESSES OF MANUFACTURERS

CENTRALAB, INC.
900 Keefe Avenue
Milwaukee, Wisconsin

HARRY DAVIES MOLDING CO.
1428 North Wells Street
Chicago 10, Illinois

INTERNATIONAL RESISTANCE
401 North Broad Street
Philadelphia, Pennsylvania

KELLER PRODUCTS
3099 Vine Street
Cleveland 13, Ohio

NATIONAL CARBON CO.
30 East 42nd Street
New York, New York

OAK MANUFACTURING CO.
1260 Clybourn Avenue
Chicago 10, Illinois

PARKER APPLIANCE
3865 Carnegie Avenue
Cleveland, Ohio

PHAOSTRON
151 Pasadena Avenue
Pasadena, California

PHILPOTT RUBBER
2077 East 30th Street
Cleveland, Ohio

RAYTHEON MANUFACTUR'G CO.
55 Chapel Street
Newton 58, Massachusetts

STACKPOLE CARBON CO.
St. Mary's Pennsylvania

VICTOREEN INSTRUMENT CO.
5806 Hough Avenue
Cleveland 3, Ohio

WATERBURY BUCKLE CO.
862 South Main Street
Waterbury, Connecticut

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