INSTRUCTION MANUAL

FOR

EBERLINE 112

GEIGER COUNTER

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EBERLINE INSTRUMENT DIVISION
OF
REYNOLDS ELECTRICAL & ENGINEERING CO.,
INC.
80S EARLY ST. SANTA FE, N. M.

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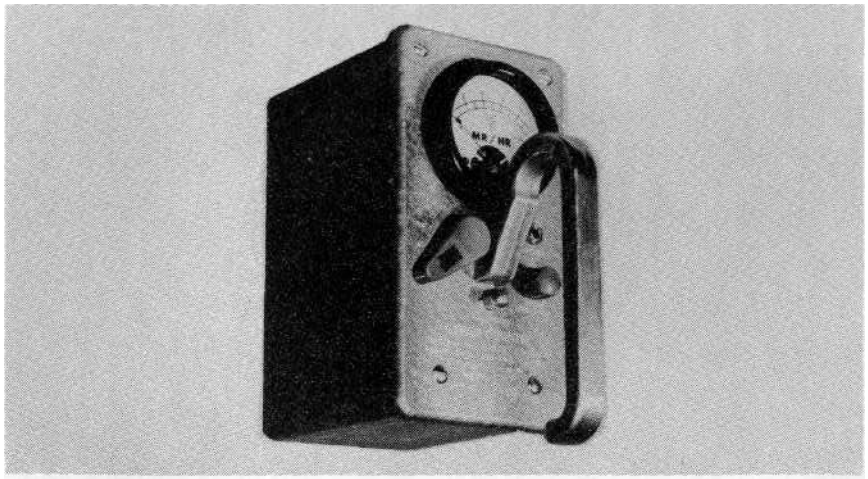
CIRCUIT DIAGRAMS

FOREWORD

You have just purchased a fine precision instrument that will prove its value many times over in dependability, portability and accuracy.

The sound engineering and careful workmanship that went into every part of this instrument is not a matter of chance. As any manufactured product reflects the attitude of its maker, so the philosophy of the Eberline Instrument Division can be seen in the quality of this Geiger counter.

We are concerned with long range benefits derived from a customer service of permanent and satisfactory performance. We want no unearned dollars, nor any progress temporarily reflected by them. We want friendly repeat customers who are benefiting by our presence in the instrumentation industry. Every instrument we build must behave properly within the scope of its design and the design must serve the need which demanded it.



THE EBERLINE 112 GEIGER COUNTER

GENERAL DESCRIPTION

The Eberline 112 Geiger Counter is designed for maximum field dependability, accuracy suitable for laboratory measurements, and reliability adequate for stringent monitoring requirements. For prospecting and survey work, every part has been designed so that the probability of failure in the field approaches the vanishing point. The accuracy, linearity and stability of the instrument make it completely satisfactory for quantitative measurement of low level gamma radiation. Continuous hard usage and constant operation under mill and mine monitoring conditions will not affect the performance or the life of the instrument. Its small size, light weight, ease of maintenance and rugged construction insure operational satisfaction.

The aluminum case is fastened to the frame by two screws in the bottom of the counter. A neoprene gasket makes a dust and moisture tight seal between case and cover. No probe or other external detector is necessary. The plug-in earphone may be used to give an audible signal indicating radiation.

Carrying weight of the instrument with all accessories is 3 pounds, 13 ounces. The case is 3 inches wide, 4 inches high, and 6 inches long. The cast aluminum handle extends another 2 1/2 inches up from the cover.

Located on the cover are the controls and the count-rate meter which indicates gamma radiation field strength in scales of ten, one, and one-tenth milliroentgens per hour (MR/HR).

The following units are located in the case:

1. 2 Victoreen 1B85 or 6306 Geiger tubes mounted horizontally at the bottom of the frame.
2. 1 Eveready #467 67 1/2 volt B battery mounted vertically across the back.
3. 2-1.34 volt Mallory mercury A batteries mounted in a phenolic box in front of the B battery, reached from the right side.
4. 2 spare 1.34 volt A batteries, mounted in a phenolic tube between the two Geiger tubes.
5. 1 plug-in HIGH VOLTAGE POWER SUPPLY reached from the right side.
6. 1 Plug-in TRIGGER - AMPLIFIER UNIT reached from the right side.

7. 2 padder capacitors for individual scale calibration on the left side of the frame.
8. Associated circuitry for the meter circuit and filter.

The instrument comes supplied with the following accessories:

1. Carrying case: The case is supplied to provide a convenient means of carrying and protecting the instrument. The shoulder strap is adjustable.
2. Earphone: The earphone is a Telex hearing aid unit. Disconnecting the earphone does not affect the operation of the counter.
3. Gamma Source: The white wafer contains a small amount of radium. It is used to check calibration. See **Calibration** under OPERATING INSTRUCTIONS.
4. Instruction Manual: Keep the manual in the carrying case. This will prevent its loss or damage. It is printed on a special washable plastic paper giving the book durability and long life.

Each of the components in this counter has been selected for maximum reliability under extreme conditions. Each part is rated well above its normal use, and is the best available.

1B85 Geiger Muller Tubes—Victoreen. In average field use they will have a life of several hundred hours. In addition to doubling the efficiency of the counter, the use of two tubes insures that if one tube fails in the field, the counter will continue to be operable until the bad tube is replaced. (See "Maintenance".)

6306 Bismuth-Lined Geiger Tubes—Victoreen. The use of these tubes will increase the over-all performance of the counter at low levels to about 10 times that obtainable with a single 1B85. They are interchangeable with the 1B85.

The battery pack consists of one 67 1/2 volt Eveready Minimax B battery and four 1.34 volt Mallory mercury cells for filament supply, two of which are installed, and two located in the spare compartment. This set of five batteries will supply 180 hours of continuous service.

The two spare A batteries are to replace filament supply battery BAT-2 marked "50 ma" which has a life of 70 hours. Filament supply BAT-1, marked "20 ma" has a life of 180 hours. The values in quotes refer to current drain in milliamperes. The B supply has a life of about 220 hours, at which time the output voltage drops below 50 volts. The spare mercury cells are contained in the phenolic tube between the Geiger tubes. Since there is little warning by this type of battery of approaching exhaustion, keep new spares in the counter so that battery failure will not interrupt field use. When changing batteries, put the spares into the circuit and replace the spares at the earliest opportunity, thus assuring a continuously fresh supply.

OPERATING INSTRUCTIONS

The counter comes completely equipped and ready to use. All tubes, batteries and accessories for the first 180 hours of operation are installed or enclosed. The instrument has been tested and found in perfect working condition and calibration at the factory. Unless it has been damaged in transit, or has been sitting idle for several months, it is ready to operate.

Description of Controls

The controls are as follows:

1. The scale switch. On the left is a four-position switch which turns the instrument on and selects one of three meter scales, X1.0, X0.1 and X.01. The numbers refer to the factor by which the meter reading is multiplied in order to give the field strength in milliroentgens per hour. For example, if the needle points to 8 on the meter and the switch is set to X0.1, the field strength is 8 X 0.1 or 0.8 MR/HR.

2. The meter response control. This control, marked METER RESPONSE, governs the rate of response of the meter to changes in field strength. Full counter clockwise rotation causes the meter to respond slowly to changes in radiation.

At the clockwise extreme the meter will respond quickly to radiation changes, but will fall away as rapidly. There will be much needle movement. THE SETTING OF THE CONTROL DOES NOT AFFECT THE ACCURACY OF THE READING. If the counter is placed in a constant field, setting of the knob will have no effect except to smooth the meter response.

3. **The meter calibration control.** The acorn nut covers a screwdriver adjustment which is used to adjust the meter to agree with a known source. (Refer to "Calibrating the Instrument".)

The receptacle for earpiece is marked PHONE.

Calibrating the Instrument

The counter was originally calibrated at the factory against a 10 milligram radium source in pressure equilibrium. Under normal use, adjustments will not be necessary. However, if under certain circumstances such as changing to one tube or different tube operation it is desired to check the calibration, use the radioactive source as follows:

Set the range switch to the X0.l scale and the meter response to extreme counter-clockwise. Place the wafer flat against the bottom of the case, in the circle, with the printed side turned to the case. The meter should show the value stamped on the wafer. If the meter reads differently by more than one scale division, remove the acorn nut on the panel and adjust the calibration control to bring the needle to the correct value. Do not attempt to remove differences smaller than one scale division. NEVER ATTEMPT TO ADJUST THE PADDER CAPACITORS.

WHAT THE METER INDICATES

The Eberline 112 Geiger Counter is designed to measure intensity of gamma radiation. Uranium ore will emit a steady field of radiation whose strength varies with the depth of deposit, the density and character of the covering material, the size of the deposit, and its chemical nature. Thus there is no way of measuring accurately the character of a deposit by knowing only the field strength. However, if there is a definite increase in the field strength as the location of the counter changes, ore may be present.

The Geiger Counter measures gamma rays and some high energy beta particles, the gamma being most important. The speed of response of a counter depends in part upon the **efficiency** of the detector. The efficiency is the ratio between the number of rays that pass through the detector and the number that are counted. Efficiency also depends on the energy level of the rays, which in turn depends on the type of source being measured. A uranium ore deposit will emit rays which are of many energy levels by the time they reach the counter.

For average field use, where the source is an unknown mixture, about 1% of the rays passing through a 1B85 Geiger tube will be counted. With two tubes, the volume of interception is doubled, increasing the efficiency of the counter to about 2%. By coating the inside of the tube with a material of, high atomic weight, the efficiency of the tube can be increased. High energy rays, most of which would pass through the tube without being counted are brought down to an energy level where the chance of their being counted is larger. Thus the bismuth lined 6306 tube has an efficiency of approximately 5%, and with two bismuth tubes, the efficiency of the counter is doubled.

There are two important sources of error in any radiation detecting device—background count and coincidence loss. Since radioactivity is a universal phenomenon, it is impossible to find a place where some radiation is not present. It may be in the form of cosmic rays, together with radiation from radon and thoron gases and their decay products in the atmosphere out of doors. This low intensity, reasonably constant field will be continuously measured by the counter together with any local fields which may be present. Thus it is necessary to measure the background level

before attempting to measure specific radioactivity.

Determining Background Count

Turn on the counter and set it at the lowest, or X.01 scale with the meter response control at the extreme counterclockwise position. It should be remembered that all radiation sources such as the calibrating wafer and radium dials will add to the background reading. Average background will fall between .01 and .04 milliroentgens per hour. Since some needle movement will occur due to the random occurrence of radiation, it is advisable to take an average over **a** period of a few minutes of meter readings. This figure is the background for this particular area. It must be subtracted from any further readings to indicate the absolute local field strength. If the counter is taken into a different area where there is a change in terrain, vegetation, altitude, etc., it is advisable to make another reading of background. If the count goes above twice background for any length of time, it is no longer background, but an indication of local radioactivity.

DO NOT ATTEMPT TO ZERO OUT BACKGROUND BY ADJUSTING THE CALIBRATION CONTROL. THIS WILL DE

STROY THE ACCURACY OF ALL THREE SCALES, BY DECREASING THE SENSITIVITY OF THE COUNTER.

At the two extremes of counter response, there exists the possibility of misleading readings. At the low end of the scale, the random nature of background count may mask small local variations in field strength, while at high levels, coincidence loss caused by the small time separation of pulses, some of which will not be counted, introduces a small error.

Theory of Operation

The basic theory of operation of the Eberline 112 is simple. The signal developed across the output of the Geiger tube is used to trigger a pulse of power. This pulse is combined with other uniform pulses, and the total power delivered is averaged and presented as a meter reading. The meter reading is essentially the average rate of occurrence of ionization in the Geiger tubes.

Before the Geiger tube will operate in a stable fashion, it is necessary to apply a regulated dc voltage. This is determined by the "plateau" or region of fixed response, and must be maintained within 2% of 900 volts if the counter is to work satisfactorily. The high voltage is developed by the plug-in HIGH VOLTAGE POWER SUPPLY in the following manner. A single swing blocking oscillator consisting of V-3 Tl, R10, R11, R16 and C4 running at a repetition rate of about 600 pulses per second generates a pulse voltage in the primary of T1; this is then stepped up by T1 and fed to the voltage quadrupler circuit made up of the four selenium rectifiers SR-1 through SR-4, and C5 and C6. This voltage is then applied to the shunt regulator tube, V4, through

R12, where it is regulated to 900 volts, and filtered in R13 and C7. This regulated voltage is then applied to G-l and G-2 through R-15. The R14, C8 and R13, C7 filter networks effectively decouple the H.V. Power Supply from the rest of the circuit and eliminate the power supply oscillator tone in the earphone.

When a gamma ray collides with an atom of the gas inside the Geiger tube, it causes ionization and starts an avalanche of electrons toward the center electrode. The 900 volt potential across the Geiger tube suddenly drops producing a negative going pulse or signal which is applied to the grid of V-l through C9. V-l is normally conducting, developing cathode bias across R-5, which in turn cuts off V-2. The negative signal applied to the grid of V-l causes a positive pulse of fixed amplitude to appear at the plate. The pulse passes through the time constant network selected from Cll through C14 by S-1A, and R-6, and causes V-2 to conduct, further biasing the grid of V-l by adding to the signal from G-l and G-2. This process will continue until V-l is completely cut off and V-2 is conducting heavily. As current flows through R-6 into the capacitance in series with it, the grid of V-2 goes gradually negative, decreasing the current through V-2 and de-

creasing the bias on V-l. When this bias reaches the point where current can flow in V-l, the circuit quickly returns to its original stable state, and is ready for the next pulse from the Geiger tubes. When V-2 is conducting, current flows through R-7, R-9 and M-l, developing a voltage drop across them, which in turn charges C10. When V-2 ceases conducting, C10 discharges back through R-7, R-9 and M-l, hence keeping a current flow through M-l during non-conducting states of V-2, which results in a smooth indication on M-l. The greater the resistance setting of R-9, the greater the voltage drop across R-7, R-9, M-l and C10, and the slower the response on M-l to changes through V-2, resulting in a smoother indication on M-l.

R-6 and the capacitance in series with it, determined by the position of S-1A, constitute the pulse shaping network and determine the time it will take for the complete cycle to occur and the amount of current that will flow through V-2 during its conducting cycle. R-8 and C-3 form a decoupling network. The circuit recovers so much faster than the Geiger tube that ' dead time" in the circuit does not enter into performance characteristics.

Mechanical Disassembly

The Eberline 112 is held together by 42 screws, and is easily disassembled for replacement of parts or cleaning. To remove the counter from the case, remove the two screws in the bottom of the case, and, holding by case and handle, work apart gently. The plug-in units are attached by one screw each to the frame. To remove, take out the screw and work the unit gently from side to side until it comes free.

To change B battery pry off connector pad, replace battery, snap pad back on.

To change A batteries, remove plate marked TO CHANGE BATTERIES REMOVE THIS SCREW. Batteries will pop out. Replace batteries POSITIVE (+) POLE INWARD.

Spare batteries are located in the phenolic tube between the two geiger tubes.

To change geiger tubes, loosen screws at collars, and pull tube straight out. To replace, push the tube into the socket, making sure that the spring contact goes inside the stem. Tighten screws. DO NOT OVERTIGHTEN. EXCESS PRESSURE CAN DAMAGE TUBE.

To clean, remove all batteries, plug-ins and geiger tubes. Main frame comes loose from end frame, geiger lead block drops out when spare battery tube is removed. With low pressure air hose blow out dust and dirt which may have accumulated inside counter. Wash case inside and out with soap and water. A small dry paint brush may be used to work dust out of cracks and recesses.

Trouble Shooting

If the counter is not abused, maintenance will consist simply of replacing components, such as tubes and batteries. The least rugged unit is the meter. It may be damaged by severe shock.

If the counter fails to register when exposed to the calibrating source, make the following sequence of tests, checking the counter for operation after each step.

1. Change A batteries (first BAT-2 then BAT-1).
2. Test B battery voltage with counter operating. If voltage is below 50 volts, replace battery.
3. Make a visual check for:
   a. Loose connections at plug-ins, snap-in leads, geiger leads and broken wires.

b. Loose screws and nuts; disorientation of parts.

c. Short circuits. If counter was dropped, component leads may have been bent into contact with frame. Check for dust and dirt paths in high voltage circuit.

d. Swollen or leaking batteries.

All the above faults can be corrected by tightening or cleaning or other field maintenance.

4. Remove left Geiger tube.
5. Re-insert left Geiger tube and remove right Geiger tube.
6. Replace both Geiger tubes.
7. Replace power supply plug-in unit.
8. Replace trigger-amplifier.

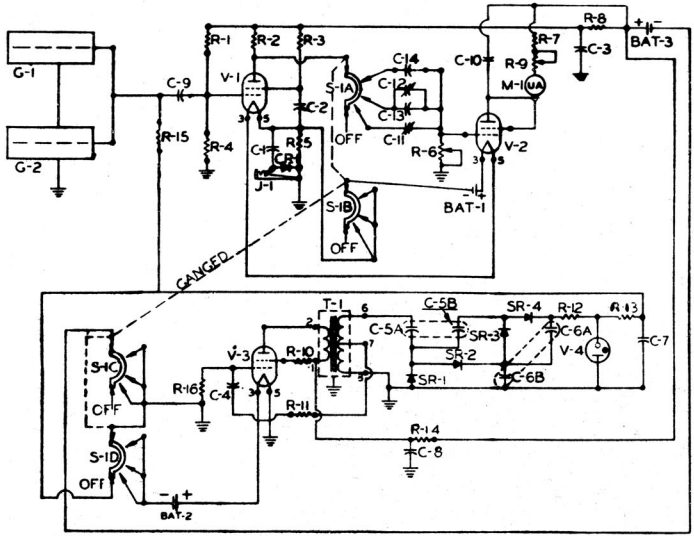
It is recommended that the entire sequence up to the correcting measure be completed before putting the original parts back in, since a double failure can occur and confuse the symptoms.

If one Geiger tube appears to be bad, the counter can still be used without serious loss of information. Remove the defective tube and recalibrate. Efficiency will now be half of what it was, otherwise there will be no significant change.

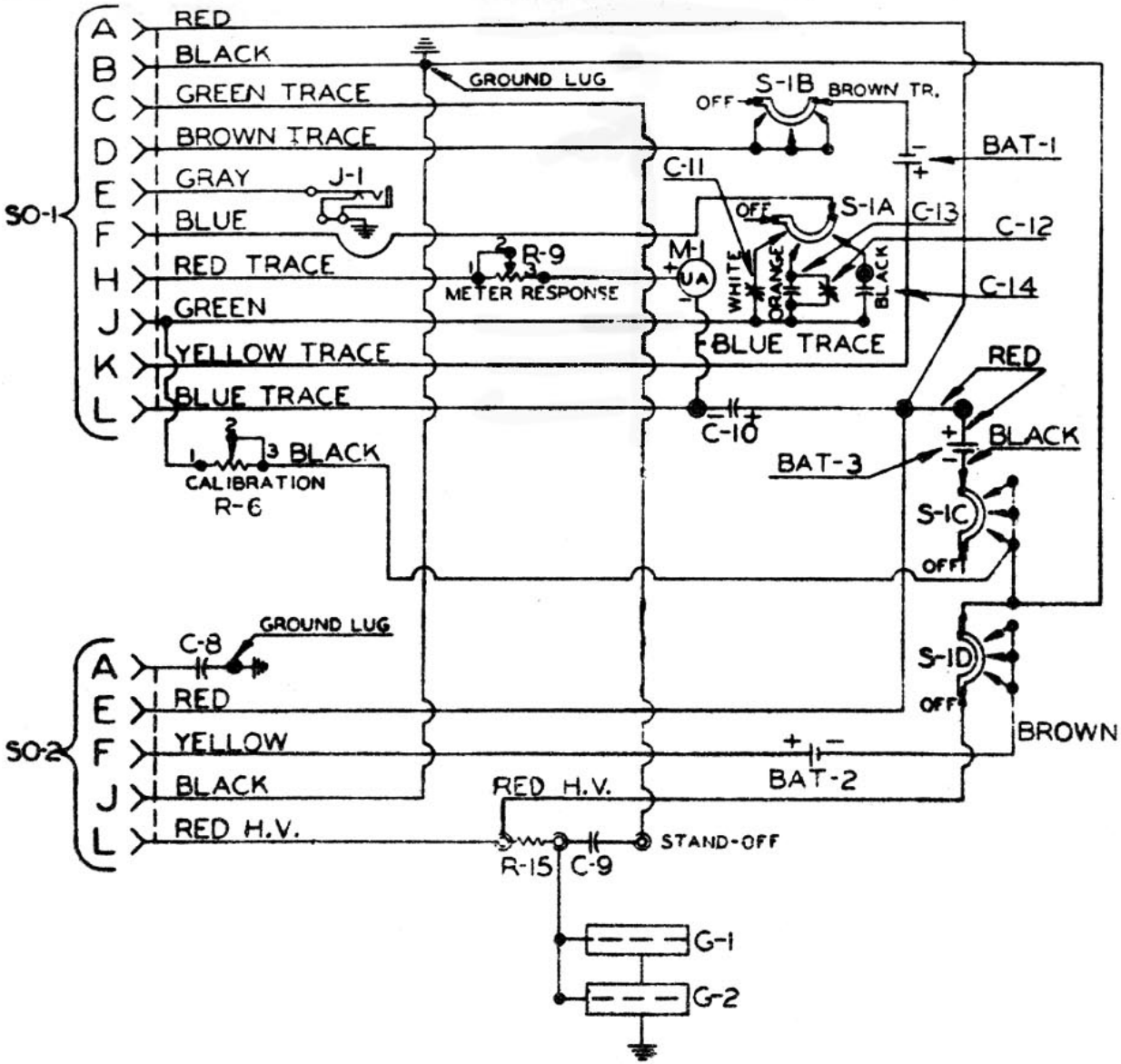
If none of the above repairs put the counter back into operation, the fault may lie in the operation of the meter, the four position switch, the variable resistors or the electrolytic capacitors. For these repairs it is advisable to return the counter with all accessories and extra parts to the factory, Eberline Instrument Division, P. O. Box 1539, Santa Fe, N. M., by parcel post. Be sure it is carefully wrapped with complete return address and marked FRAGILE—DELICATE INSTRUMENT. Necessary repairs will be made, and the counter returned with a C.O.D. bill covering charges.

If the defect can be repaired by substitution of the plug-in units return the defective units to the factory in the way specified in the previous paragraph. The unit will be immediately repaired or replaced and mailed you with a C.O.D. covering repair charges.

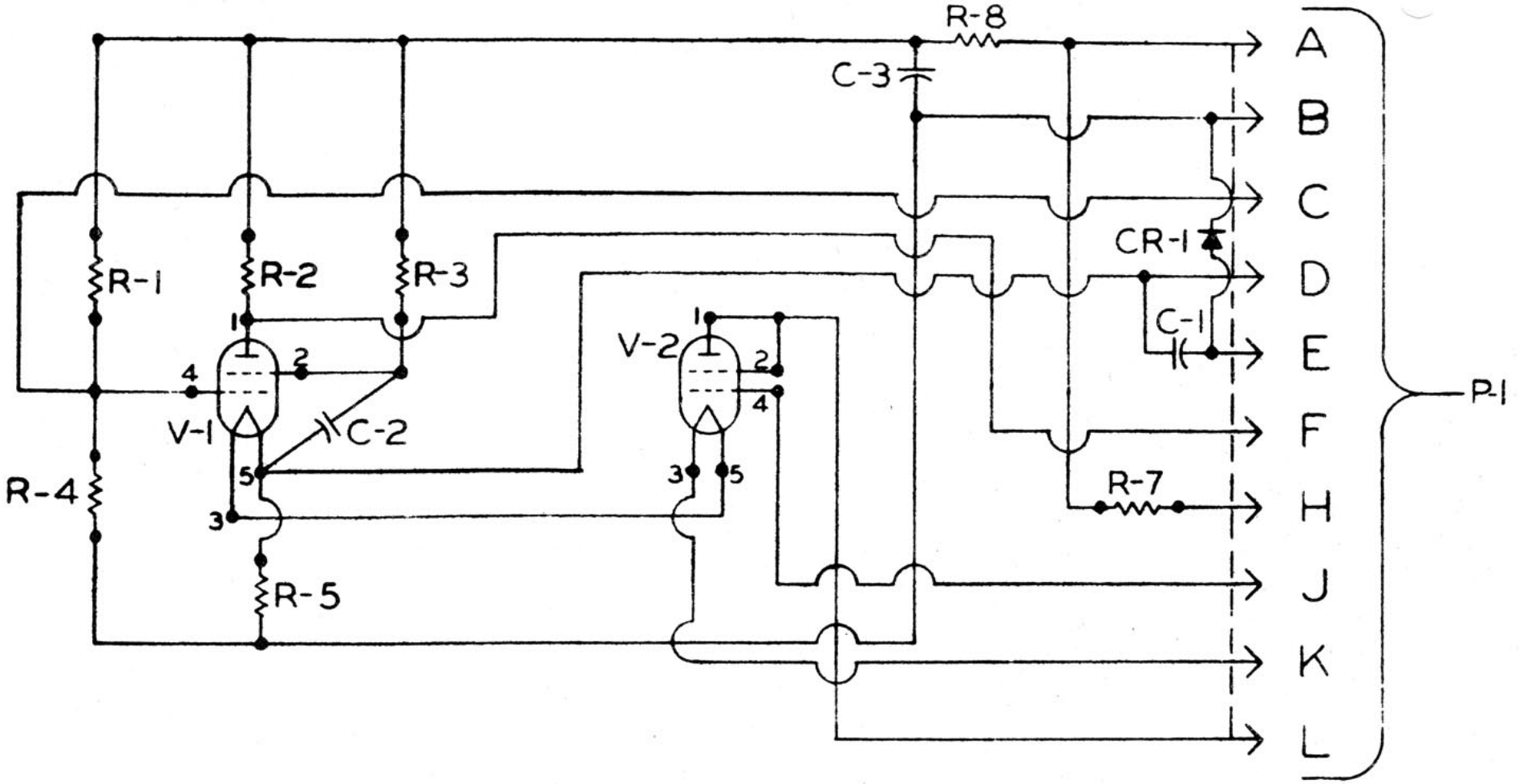
Batteries, Geiger tubes, and accessories will be supplied from stock by return mail.



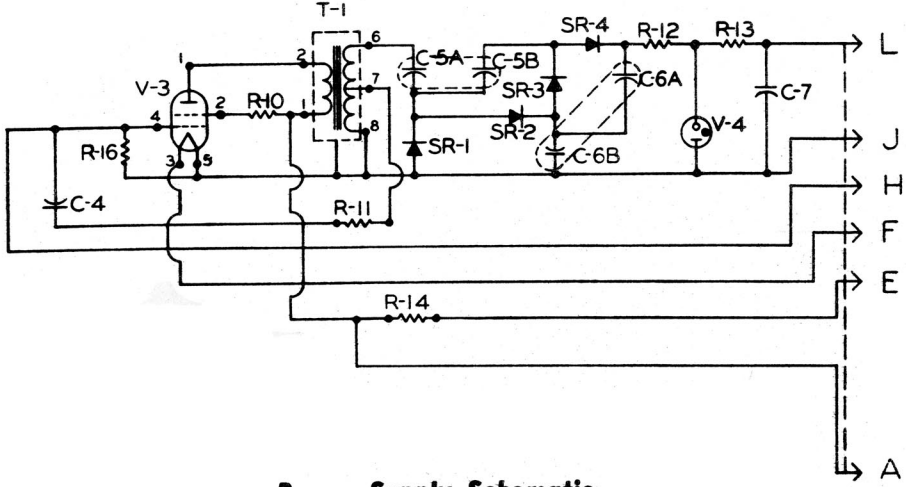
General Schematic



Chassis Schematic



Trigger Amplifier Schematic



Power Supply Schematic

COMPLETE PARTS LIST

ELECTRONIC PARTS RESISTORS

All Resistors are Allen-Bradley, 1/2 watt, fixed type EB.

R-1	18 Megohm	5%
R-2	220 K Ohm	5%
R-3	470 K Ohm	5%
R-4	2.2 Megohm	5%
R-5	47 K Ohm	10%
R-6	1 Megohm Potentiometer Type G Adjustable	
R-7	10 K Ohm	10%
R-8	6.8 K Ohm	10%
R-9	50 K Ohm Potentiometer Type G Adjustable	
R-10	20 K Ohm	5%
R-11	22 Megohm	5%
R-l2	1 Megohm	5%
R-l3	3.9 Megohm	5%
R-14	1 K Ohm	5%
R-15	1 Megohm	10%
R-l6	10 Megohm	5%

CAPACITORS

C-1	.005 mfd	200 V	Aerovox P83Z Microminiature Metallized Tubular
C-2	.1 mfd	200 V	Aerovox P82 Aerolite Metallized Tubular
C-3	.1 mfd	200 V	Aerovox P82 Aerolite Metallized Tubular
C-4	250 mfd	600 V	Aerovox Cl-1 Hi Q Tubular Ceramic
C-5A&B 2 X	.01 mfd	500 V	Comell-Dubilier DK082 Ceramic Disc
C-6A&B 2 X	.01 mfd	500 V	Comell-Dubilier DK082 Ceramic Disc
C-7	.015 mfd	1600 V	Comell-Dubilier ST16S15 Budroc Tubular
C-8	5 mfd	150 V	Aerovox Type SRE Bantam Electro-lytic Metal Cased Tubular
C-9	500 mfd	3 KV	Sprague Electric 30GAT5 Ceramic Disc
C-10	50 mfd	6 V	Aerovox Type SRE Bantam Electro-lytic Metal Cased Tubular

C-ll	24-200 mmf	350 V	Mica Trimmer—The Electro-Motive Mfg. Co. T51511
C-12	90-400 mmf	350 V	Mica Trimmer—The Electro-Motive Mfg. Co. T51911
C-13	2000 mmf	500 V	Aerovox Sl-2 Hi-Q Tubular Ceramic
C-14	.03 mfd	200 V	Aerovox Type P82 Aerolite Metallized Tubular

TUBES

G-l	Geiger Tube	Victoreen #6306 or 1B85
G-2	Geiger Tube	Victoreen #6306 or 1B85
V-l	Vacuum Tube	Raytheon CK512AX
V-2	Vacuum Tube	Raytheon CK512AX
V-3	Vacuum Tube	Raytheon CK5672
V-4	900 V Corona Voltage Regulator	Victoreen #5841

MISCELLANEOUS

M-l	O-20UA Meter	Simpson #185 or Triplett #221PL
J-l	Jack	Telex Inc. #8570
T-l	Transformer	United Transformer Corp. #0-7
S-l	Switch	Oak Mfg. Co. #64461-F-2,4P4T
CR-l	Diode, Germanium	Transitron #1N56A
SR-1	Selenium Rectifier	International Rectifier Corp. U20HP
SR-2	Selenium Rectifier	International Rectifier Corp. U20HP
SR-3	Selenium Rectifier	International Rectifier Corp. U20HP
SR-4	Selenium Rectifier	International Rectifier Corp. U20HP
BAT-1	1.34 V Battery	P. R. Mallory and Co. RM-12
BAT-2	1.34 V Battery	P. R. Mallory and Co. RM-12
BAT-3	67 1/2 V Battery	Eveready #467 or Equivalent
	Telex Plastic Earset, 2000 Ohms Impedance Telex Earset Cord with Miniature Plug to Match Jack #8570	
P-l	COMPLETE TRIGGER AMPLIFIER	
P-2	COMPLETE 900 VOLT POWER SUPPLY	
SO-1	Winchester #K 10S	
SO-2	Winchester #K 10S	
CN-1	BAT-3 Battery Connector	

MECHANICAL PARTS LIST

Part No.	Quantity	Description
1	1	Complete H.V. Power Supply Assembly including:
1A	1	Transformer Bracket
1B	1	Tube Clamp with Fibre Cushion
1C	2	#2-56x1/8" Rd. Hd. Mach. Screw with Washer
ID	1	#4-40x1/2" Rd. Hd. Mach. Screw
IE	1	Printed Circuit Card of P-2 with Terminals
2	1	Complete Trigger Amplifier Assembly including:
2A	1	Tube Clamp with Fibre Cushion
2B	2	#4-40xV4" Rd. Hd. Mach. Screw
2C	1	#4-40x1/4" Fit. Hd. Mach. Screw
2D	1	Printed Circuit Card for P-1 with Terminals
3	1	Battery Case Assembly including:
3A	1	Battery Case
3B	1	Printed Circuit Cover

3C	2	Phosphor Bronze Contacts
3D	2	Springs
3E	4	#4-40x1/4" Rd. Hd. Mach. Screw
3F	1	#6-32x5/16" Rd. Hd. Mach. Screw
4	1	Spare Battery Case
5	1	Chassis Support Bracket Assembly including:
5A	1	Chassis Support Bracket
5B	2	#4-40x1/4" Rd. Hd. Mach. Screw
5C	3	#6-32X5/16 Oval Hd. Mach. Screw
5D	1	#4-40x1/8" Rd. Hd. Mach. Screw
6	1	Counter Tube Clamp Assembly including:
6A	1	Counter Tube Clamp
6B	2	#4-40x1/4" Rd. Hd. Mach. Screw
6C	2	#4-40x5/8" Fillister Hd. Mach. Screw

Part No.	Quantity	Description
7	1	Counter Tube Contact Block Assembly including:
7A	1	Contact Block
7B	1	Bronze Wire Contact
7C	1	Terminal Lug
7D	2	#4-40x3/16" Rd. Hd. Mach. Screw with Washer
8	1	Chassis Mounting Top Block Assembly including:
8A	1	Chassis Mounting Top Block
8B	4	#4-40x1/4" Fit. Hd. Mach. Screw
8C	2	#6-32x5/16" Oval Hd. Mach. Screw
9	1	Case Mounting Block Assembly including:
9A	1	Case Mounting Block
9B	2	#4-40xV4" Fit. Hd. Mach. Screw
9C	1	#6-32X5/16" Oval Hd. Mach. Screw

10	1	Main Chassis Assembly including:
10A	1	Chassis
10B	1	Battery Chassis
10C	7	Insulated Standoff
10D	1	Grommet—1/4" Dia.
10E	11	#2-56x1/4" Fit. Hd. Mach. Screw
10F	4	#4-40x3/8" Rd. Hd. Mach. Screw
10G	2	Lugs
11	1	Case Cover including:
11A	1	Case Cover Gasket
12	1	Case
13	1	Handle including:
13A	2	#6-32x3/8" Truss Hd. Mach. Screw with Lock Wash
14	1	Slot Window Knob including:
14A	1	#6-32x3/16" Slot Hd. Set Screw

Part No.	Quantity	Description
15	1	Round Knob including:
15A	1	#6-32x1/8" Slot Hd. Set Screw
16	1	Calibration Control Acorn Nut
17	1	Simpson Meter Gasket
18	1	Triplett Meter Gasket
19	6	Case Lead Washer
20	1	Radioactive Source Disc
21	1	Carrying Case