Operation and Maintenance Manual

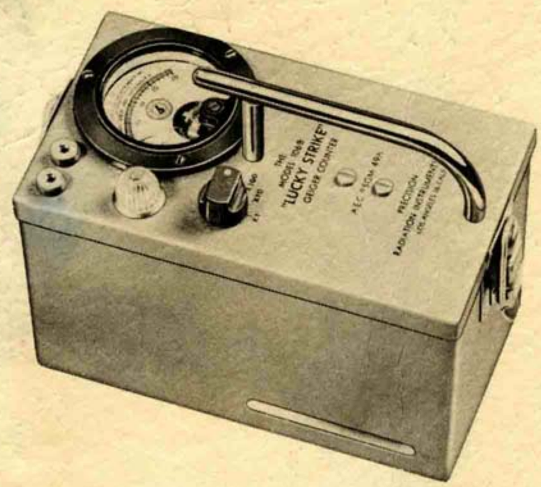
Precision Geiger Counters

*Model 106B "Lucky Strike"**
and
*Model 107B "Professional"**

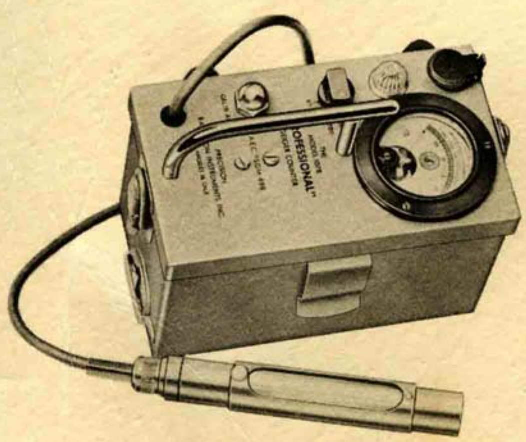
*U.S. Reg. Pat. Off.

PRECISION RADIATION INSTRUMENTS, INC.
Los Angeles 16, California

World's Largest Manufacturer of Portable Radiation Instruments



Model 106B "Lucky Strike"



Model 107B "Professional"

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Precision Radiation Instruments, Inc.

INSTRUCTION AND MAINTENANCE MANUAL

MODELS 106B, 107B

I. General Description

Models 106B and 107B are battery operated Geiger Counters. These instruments have three scale ranges; 0.2, 2, and 20 milliroentgens per hour (MR/HR) and employ Geiger tubes as detecting elements. The presence of radioactivity is indicated by a meter, a neon light and through an earphone.

The Model 106B detects Beta and Gamma radiation. It is ideally suited to the prospector. A thin wall Geiger tube is mounted in the bottom of the case and is most sensitive to radiation that passes through the windows in the case.

The Model 107B differs from the 106B in that the Geiger tube is mounted in a waterproof probe. This probe has a sliding shield which may be operated by loosening the knurled head screw on the probe. When the shield is closed the instrument detects Gamma rays only. With the shield open it will detect both Betas and Gammas. The 107B can be used in the laboratory as well as for civil defense surveys and prospecting.

The Model 107B has a calibration adjustment and is waterproof, whereas the Model 106B does not have these features. The calibration adjustment is on the top panel of the 107B. The Model 106B is supplied with an assayed sample of uranium ore and the model 107B is supplied with a calibrated radium disc mounted in a clip on the end of the case.

II. Definition of Terms

There are terms encountered in the use of radioactive materials which are peculiar to this use and which should be explained in order to make this text more understandable.

Radioactivity. The process whereby certain elements emit particles or rays due to the disintegration of the nuclei of their atoms. The main types of radioactivity are alpha particles, beta particles and gamma rays. Gamma rays penetrate matter in much the same manner as X-rays. Since gamma rays are the only type of radiation with appreciable penetrating power, they are the only ones that are important to the prospector. Beta particles have slight penetrating power and a reading from betas reflects only the radiation on the surface of the sample. Since the radiation is not usually uniformly distributed through the sample a reading of beta radiation can give a false impression of the value of the ore. Alpha particles can be stopped by a thin sheet of paper and are therefore of no interest to the prospector.

Milliroentgen: the common unit of radiation intensity. This term is usually expressed with a unit of time; i.e., milliroentgens per hour (abbreviated MR/HR), and expresses the number of units of radiation intensity per hour. If a man stays twelve hours in a radiation field whose intensity is five milliroentgens per hour, he will have been exposed to 60 milliroentgens. This is the maximum amount which the A.E.C. considers to be totally harmless even when repeated day after day.

Background: a certain portion of any radioactivity measurement is not attributable to the radioactive sample being measured, but comes from other sources. This portion of the measurement is called "background." It is caused by cosmic radiation, natural radioactivity of the earth, and other sources. Since background can vary greatly, it must be measured separately and subtracted from any measurement upon which it will have an effect.

EXAMPLE:

Sample reading .... 35 MR/HR
Background reading .... .02 MR/HR
Corrected reading .... 33 MR/HR

In order to correctly establish the background effective in the measurement of a particular sample, the sample must be moved far enough away from the instrument so that it has no effect on the background reading.

III. General Information

The presence of radiation can be detected by taking a count with a Geiger Counter. The count may be taken by counting the flashes of the neon bulb, the clicks in the earphone or by observing the meter reading.

The instrument will normally produce clicks in the earphones at the rate of about 30 to 50 per minute. This is the normal background count caused by cosmic rays and does not indicate the presence of radiation. When radiation is present the number of clicks per minute will increase. A fair amount of radiation will cause the clicks to be as rapid as the firing of a machine gun. This can be demonstrated by bringing the sample supplied with the instrument up to the Geiger tube.

To permit accurate meter readings over a very wide range of radioactivity intensities, the instrument is provided with three ranges of sensitivity.

In general, the instrument should be set to the most sensitive range that allows "on-scale" meter readings. If the meter needle stays at or frequently touches the extreme right hand end of the scale, a less sensitive range should be used. For example, if this occurs on the XI scale, the meter should be set on the X10 scale. For virtually all prospecting work and for low level area surveys in civilian defense work, the XI range should be used. The needle of the meter will fluctuate because of the random nature of the radiation being measured. The correct reading is the average of the fluctuations. Example: with the range switch set to XI, if the meter needle fluctuates about the center of the scale but half the time is to the right of the .10 mark and half the time is to the left of the .10 mark, the reading is .10 MR/HR. Example: with the range switch set to X10, if the meter needle fluctuates about the .15 mark on the scale, the reading is .15 x 10 or 1.5 MR/HR. Similarly, if the meter needle points to .15 with the range switch set at XI00, the reading is .15 x 100 or 15 MR/HR.

The following chart indicates the correct reading of various indications on each range switch setting.

Meter Reading Chart

When range switch is set at	XI	X10	X100
And meter needle points to	.05	.5 MR/HR	5 MR/HR
Correct reading is	.05 MR/HR		
When meter needle points to	.10	1.0 MR/HR	10 MR/HR
Correct reading is	.10 MR/HR		
When meter needle points to	.15	1.5 MR/HR	15 MR/HR
Correct reading is	.15 MR/HR		
When meter needle points to	.20	2.0 MR/HR	20 MR/HR
Correct reading is	.20 MR/HR		

The random manner in which radioactive rays are produced and detected is the basic cause of meter fluctuation. In fields of high radioactivity, more rays are detected each second and the average of a large number of fluctuating rays can be more accurately measured than the average of a small number. Thus readings taken at high levels of radioactivity on the XI00 range will be much more steady (and accurate) than readings of very low intensity taken on the XI range. The setting of the range switch does not affect the number of clicks heard in the phones or the number of flashes observed on the neon flasher. The individual clicks however are loudest on the XI range. Since the intensity of radiation falls off with the square of the distance, the sample should be brought as close as possible to the probe, or the window in the case of the 106B.

Geiger Counters do not detect metals, minerals or any material that is not radioactive. A metal locator is required for such purposes.

IV. Prospecting for Uranium

A very important factor in seeking radioactive minerals is to know when the instrument being used is actually giving an indication of the presence of such minerals.

The normal background reading will usually fall between .01 and .03 MR/HR, depending on location and other factors. Some prospectors adhere to the policy that any reading over normal background is good excuse for further investigation of the location; such as surveying the surrounding area or taking samples from below the surface. This is good practice since a deposit may be buried under rock or soil overburden which would reduce the intensity reading at the surface or in the air above it.

There are several ways in which to search for uranium with a Geiger Counter. The method used should be chosen to fit the prospector's particular requirements.

The most direct method is to simply hold the instrument close to a sample of every type of rock encountered on a prospecting mission. If any sample shows higher than normal radioactivity then its origin should be located and more samples tested until it can be determined whether or not significant values of radioactivity are present.

As the survey is being conducted, the location where an increase in meter reading is encountered should be noted. If possible, a survey should be made in a circle of 50 yards radius around the location. If nothing further is encountered, this would indicate that the material is in a pocket, or that the rest of the vein is covered by a large quantity of earth or rock. At this point, the prospector may dig below the surface to determine the size and value of his original find, or look further for a larger indication in another location. Care should be taken in planning surveys to make sure that as much of the area as possible is surveyed.

Samples should be collected from the area of high radioactivity and should be checked by holding them against the probe of the 107B, or the window of the 106B and observing the meter reading. If the ore appears to have promise, send at least a one-pound sample to the U.S. Geological Survey, Geochemistry and Petrology Branch, Bldg. 213, Naval Gun Factory, Washington, D.C. They will assay the sample without charge and give their report only to the individual submitting the sample. If their report indicates the ore has commercial value, it should be offered to the U.S. Atomic Energy Commission, 70 Columbus Avenue, New York 23, New York, Attention: Raw Materials Operations.

The best method for locating radioactive deposits is to construct radioactivity contour maps or grids. To do this it is necessary to systematically take readings over a large area and to record them on a map. The area to be explored should be ruled off like a checkerboard, or grid, and readings should be made at the corners of every square. In preliminary work, when it is desirable to cover the most ground in the shortest time, the squares may be made quite large, say 300 feet on a side. If after all the readings have been mapped, there appear to be significant variations in some part of the area covered, then, in the region of interest, additional readings should be made at the centers of each of the squares. This will generally produce a total set of readings from which reliable radioactivity contours (called *is or ads)* may be drawn. The purpose in making the additional set of readings at the center of the squares formed by the first set is to obtain the most uniform coverage, i.e., each new point is located at the maximum possible distance from all other points.

When taking readings in this manner it is desirable to hold the instrument as high above ground as convenient so that the radioactivity from a fairly large area of ground is averaged in the measurement at each point. The choice of distance to be used between points in such a survey depends very much upon the local topography. For example,- if the region is very flat with few or no outcroppings, then fairly large distances between points may be used. If, however, the terrain is very irregular, the readings should be taken at intervals close enough together to insure that at least a few readings are taken near each topographic feature. For purposes of finally determining the extent of a newly discovered radioactive ore body, readings are often taken every 10 to 20 feet.

After a satisfactory number of readings have been taken in an area and recorded in their respective locations on a map, it will be found generally that the easiest way to develop contours is to divide all the readings into three ranges, high, intermediate, and low; then with a red pencil circle each high value and, with a blue or green pencil, circle each low value. By holding the map at some distance from the eyes, it usually will be possible to distinguish any significant pattern that may be present.

If there are any well defined areas in which the readings are uniformly high, or in which only one figure is outstandingly high, then such areas should be investigated further by taking readings on particular samples or by making radioactivity measurements in test drill holes put down to whatever depth is practical for the area. To measure radioactivity in drill holes the Precision Radiation Model 120 Drill Hole Geiger Counter is recommended.

For additional information on prospecting, the book "PROSPECTING FOR URANIUM," can be obtained from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D.C., price 55 cents.

V. Detection Range

It is not possible to specify the distance at which a Geiger Counter will detect a deposit. This depends on many factors such as the size and quality of the deposit, the thickness and type of overburden covering the deposit, whether the overburden itself is radioactive, etc. It appears that important, though very small, traces of radioactivity are often located in the soil many yards away from, or over the actual ore body. Such traces of radioactivity produce a weak response in the counter as though the rays from the actual ore body were penetrating the intervening amount of soil or overburden. In one case, by careful measurements and the use of contour maps, a large body of uranium ore was discovered 200 feet below the surface. The radioactivity at the surface of the earth over the ore was only twice that of the surrounding area. Upon drilling a test hole down to the ore, it was found that the telltale radioactivity was located entirely in the top five or six feet of earth. At a distance of 100 feet below the surface (and 100 feet from the ore body) there was actually less radioactivity than occurred on the surface.

Experiences of this kind are common enough to say that there is no simple answer to the question, "How deep may buried ore be detected?" It can be shown that a very few feet of barren quartz or limestone can almost completely absorb the rays from a large body of uranium beneath it. But it is also true that telltale traces of uranium are often found at large distances from the parent body and these traces often enable the prospector to locate the real vein.

VI. Assaying With a Geiger Counter

Geiger Counters respond only to radioactive materials such as uranium and thorium. The reading will not be affected by any metal or mineral that is not radioactive. A Geiger Counter can be used to determine the uranium content of a piece of ore in percent of U_3O_8

only by comparative methods. To do this it is necessary to obtain a sample of ore that has been assayed and has a known uranium content. Place this sample at a particular distance from the probe and observe the meter reading. Then take a sample of the ore of unknown value and place it at the same distance from the probe. If the ore is of the same physical size and shape as the assayed sample, and has the same uranium content, it will give the same reading on the meter. If it has twice the uranium content, it will give twice the reading and so forth. In order to obtain samples of the same size and shape, it is desirable to have both the known and unknown ore samples ground into a powder and placed in small bottles of equal size. If the ore in question contains thorium, the readings of the Counter will represent the sum total of uranium and thorium. Typically, a pound of ore containing only 1 % of uranium and no thorium will give a reading of somewhat more than .1 MR/HR when held close to the Counter's sensitive area. When applying these tests the shield on the Model 107B probe should be closed.

A simple bead test can be of some value for determining if there is any thorium in the ore. A loop of wire is dipped into Sodium Floride and then heated over a small hot flame until a bead is formed. When the bead is brought in contact with the finely ground ore sample, grains from the sample attach themselves to the bead. The bead is then reheated until the grains are melted into it. After cooling, the bead is examined under ultraviolet light. Uranium will fluoresce to a brilliant lemon yellow. If there is only thorium present, no fluorescence will be indicated on the bead.

VII. Special Factors Affecting Results

The air and all rocks and soils are radioactive to some extent. Their radioactivity is due to the presence of minute traces of relatively small numbers of radioactive elements including uranium (the radioactivity of the air is due to two gases, radon and thoron, and traces of radioactive elements in dust). Because the radioactivity in rocks and soils is generally due to traces or "impurities," only general statements can be made concerning the amount of radioactivity associated with particular types of rock. Furthermore, since the chemical behavior of the radioactive elements is frequently different from that of the other elements with which they occur, the distribution of radioactivity of the surface layers of rocks and soil may be influenced by the presence of percolating ground waters.

In general it may be said that granite, pegmatite and shale are likely to be more radioactive than limestone, quartzite, or sandstone. But there will be many exceptions to this rule; for example, the highly radioactive carnotite is often found in sandstone.

Because of the effect of local topography (drainage ditches, rock outcrops, bogs, road cuts, etc.) on radioactivity distribution, care must be used in interpreting radioactivity readings if precise readings are desired. In areas where shale may be near or on the surface, the radioactivity will usually be high. Lakes, swamps, and rivers usually produce low values of radioactivity. The radioactivity over a fresh road cut will frequently be abnormal (either high or low). Radioactivity readings frequently show a characteristic change over faults, being higher on one side than the other.

Geiger Counters do not respond to any ore that is not radioactive. In taking readings for uranium, it should be remembered that there are other elements, notably thorium, which are also radioactive. There is no convenient way to distinguish between the readings obtained from uranium and thorium bearing ore (other than chemical analysis) . Since thorium is also a valuable mineral this is not a serious disadvantage.

Prospectors are occasionally misled by the "mass effect" and believe they have found a valuable uranium deposit, when actually they are in the presence of a large body of very low grade ore which is valueless. In general, readings of several times background are not significant unless a small sample which gives a good reading can be found either at the surface or below the surface. If good readings can be obtained in an area, but not from an individual ore sample this indicates that either the ore body is deeply buried or that the reading is due to the "mass effect." Another situation in which "mass effect" becomes an important factor is when the probe is placed in a hole in the ground. If the soil is even slightly radioactive, the measurement taken is the *total* of the radiation coming from the soil all around the probe and will therefore produce a higher reading than when the probe is at the surface and is being influenced only by radioactivity coming from the surface.

Readings with the instrument will be affected by the presence of ice and snow on the ground. Ice is a particularly efficient absorber of gamma radiation. Most of the gamma rays will be absorbed by the ice if it is three or four feet thick. The extent that snow will absorb the gamma radiation depends upon the thickness of the layer of snow and how closely it is packed.

VIII. Preventive Maintenance and Field Adjustment

If the instrument is stored for long periods such as one year, the batteries should be removed. The instrument should be given the same care as would be given a portable radio and should be protected as much as possible from rough handling. No servicing should be attempted by unqualified persons except for battery replacement and setting of the calibration control. The radioactive sample provided with the Model 107B is calibrated. It is stamped with its value in milliroentgens. It will give a reading equal to this value when held flat against the face of the Geiger tube with the shield in the open position. The sample should be moved about to the position where it gives the maximum reading. The calibration can be adjusted by removing the cap nut on the calibration control and turning the control to the point where the meter reading is approximately equal to the value stamped on the sample. Sensitivity falls off as the batteries wear out and may be reset by adjusting the calibration control. "A" batteries should be replaced when they fall below 1.10 volts; "B" batteries should be replaced when they fall below 35 volts.

Batteries should always be tested under load. It is therefore desirable to have the instrument turned on when battery voltages are measured. The instrument should be turned off at all times when not in use to conserve the batteries. Geiger tubes are extremely fragile and can be easily broken if improperly handled, although they will stand considerable jarring when mounted in the instrument. We do not recommend replacing or handling of Geiger tubes by other than experienced personnel.

IX. Battery Replacement

Both models use two 45 volt "B" batteries (Eveready #455 or equivalent), one 22 1/2 volt "C" battery (Eveready #412 or equivalent) and two flashlight batteries. We recommend the Eveready #D99 flashlight battery as it has far better life and performance than other types tested.

The batteries can be serviced by unhooking the latch fasteners at each end of the case and lifting the instrument out of the case. The "A" and "C" batteries can be replaced simply by pulling them out of their holders. To replace the "B" batteries, disconnect the snap fasteners by pulling them loose from the batteries and then slide the batteries out of their compartment. The "A" batteries require replacement almost twice as often as the "B" batteries. The "C" battery needs to be replaced only about once a year. Batteries can be purchased from most radio and hardware stores, etc., and no experience is required for their replacement.

X. Theory of Operation

The instrument contains three tubes. A 1U5 tube together with its associated circuit is used to obtain the nine hundred volts necessary to operate the Geiger tube from the battery supply used. An NE7 neon bulb operates as a relaxation oscillator to provide the basic frequency of about one hundred cycles. This frequency is amplified by the 1U5 tube and a high voltage is developed across the choke coil in its plate circuit. This is coupled to the diode section of the tube which rectifies the high voltage. An NE2 neon bulb is used in conjunction with a bleeder consisting of a string of 22 megohm resistors in an automatic voltage regulating circuit.

Two 1AF4 tubes are used in a multivibrator type amplifier circuit which drives the indicating devices and provides a means of range changing.

XI. Corrective Maintenance

Failure can be due to the common faults of electronic circuits such as burned out resistors, shorted condensers, *etc.* Standard servicing techniques may be used with one major exception. The 900 volts across the Geiger tube can be measured accurately only with an electrostatic voltmeter. Any ordinary meter even of the vacuum tube voltmeter type will load the circuit sufficiently to cause a drop in voltage of 100 volts or more. When replacing the 1U5 tube it may be necessary to reset the high voltage. The high voltage can be decreased by reducing the number or value of resistors in the string of 22 meg resistors. The high voltage can be increased by adding resistance to this string.

XII. Laboratory Calibration Procedure

(For authorized service shops only)

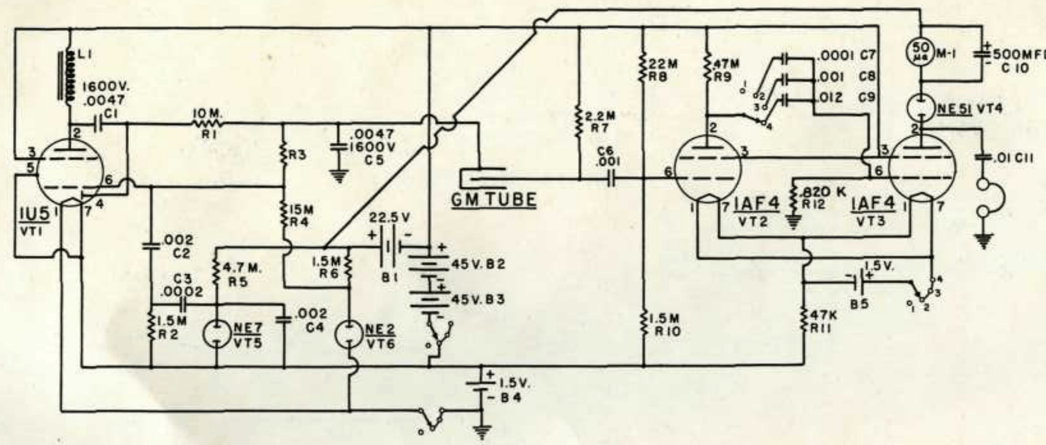
Before calibrating, close the shield on the probe and make sure 900 to 940 volts is being obtained at the Geiger tube. Expose the probe to a source of .2 MR/HR and turn the range switch to XI. Set the calibration control on the top panel to obtain a meter reading of .2 MR/HR. Then remove the instrument from its case and expose the probe to a source of 2 MR/HR. Turn the range switch to X10 and adjust the trimmer marked X10 located under the top panel to obtain a reading of 2 MR/HR. Next use a source of 10 MR/HR and turn the range switch to X100. Adjust the X100 trimmer to obtain a 10 MR/HR reading.

XIII. Guarantee and Factory Service

All parts except the batteries are guaranteed for a period of ninety days from date of purchase against defects in workmanship and material. The batteries cannot be guaranteed as they may be easily damaged by misuse. Always check the batteries before returning the instrument for factory service. To obtain service, pack the instrument carefully, and return it insured and prepaid to the factory. If you prefer to use a local repair shop write us and we will advise you of the name of the closest factory authorized service shop. The instrument should be covered on all sides with a thick layer of soft packing material. Enclose a note stating exactly in what way the instrument has not been performing properly, from whom it was purchased and the date of purchase. Ship to:

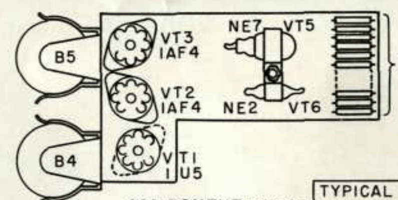
PRECISION RADIATION INSTRUMENTS, INC.
2235 S. LA BREA AVENUE LOS
ANGELES 16, CALIFORNIA

World's Largest Manufacturer of Portable Radiation Instruments



NOTES:

1. SWITCH POSITIONS. 1 OFF
   2 20 MR/HR(X100)
   3 2 MR/HR(X10)
   4 .2 MR/HR(X1)
2. R3 (APPROX. 200 MEGOHMS) ADJUST SO VOLTAGE ACROSS GM TUBE TERMINALS IS 900 TO 940 VOLTS, MEASURED WITH ELECTROSTATIC VOLTMETER.



COMPONENT BOARD
BOTTOM VIEW

TYPICAL VOLTAGES TO GROUND
(SWITCH IN X 100 POSITION; ~ MEASURE WITH VACUUM TUBE VOLTMETER.)

PIN	1U5(VT1)	1AF4(VT2)	1AF4(VT3)
1	0	10	12
2	95	20	75
3	95	95	100
4	(NOTE 2)		
6	-2.0	5.5	0
7	1.5		

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-GEIGER COUNTER-
MODELS 106B
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JAN. 1955
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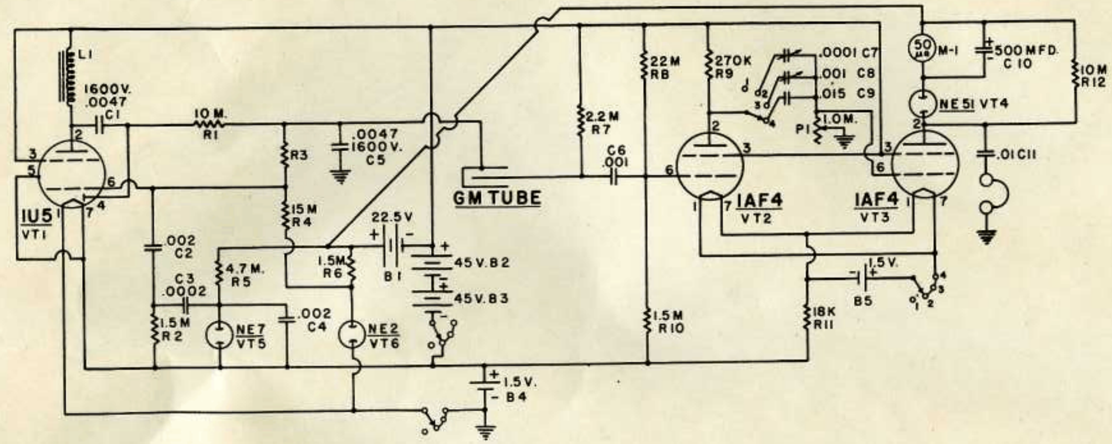

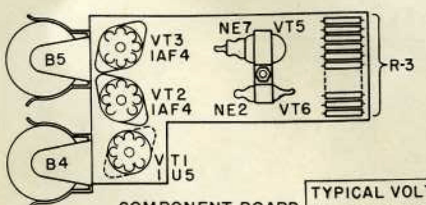

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1. SWITCH POSITIONS: 1 OFF
2 20 MR/HR (X100)
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2. R3 (APPROX. 200 MEGOHMS) ADJUST SO VOLTAGE ACROSS GM TUBE TERMINALS IS 900 TO 940 VOLTS, MEASURED WITH ELECTROSTATIC VOLTMETER.

3. SOME MODEL 107B INSTRUMENTS USE GM TUBE PART NO. V-71, OTHERS USE PART NO. V-73. TYPE V-73 BASE CONNECTIONS: PIN 1 CONNECTS TO CENTER WIRE; PIN 3 TO SHELL.

TYPICAL VOLTAGES TO GROUND
(SWITCH IN X 100 POSITION; ~ MEASURE WITH VACUUM TUBE VOLTMETER.)

PIN	IU5(VT1)	IAF4(VT2)	IAF4(VT3)
1	0	10	12
2	95	20	75
3	95	95	100
4	(NOTE 2)		
6	-2.0	5.5	0
7	1.5		

PRECISION RADIATION INSTRUMENTS, INC.
~ GEIGER COUNTER ~
MODELS 107B
DRAWN BY H.D.
CHECKED BY
JAN. 1955
D-3