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Serial No. 3759

INSTRUCTION & MAINTENANCE MANUAL

Model 115

SBX-18A

PRECISION RADIATION INSTRUMENTS, INC

# INSTRUCTION AND MAINTENANCE MANUAL

for

# MODEL 115 "SUPER SCINTILLATOR"

## I. GENERAL DESCRIPTION

Precision Radiation Instruments Model 115 is a completely portable instrument which detects radio active materials and indicates the intensity of the rays which these materials emit. The detecting element in the 115 is a Thallium activated Sodium Iodide crystal. It is sensitive only to gamma rays; such as those emitted by Uranium. This crystal detecting element, which is optically coupled to a Photomultiplier tube, is 100 times more sensitive to gamma rays than is the standard geiger tube. When gamma rays strike the crystal it gives off light pulses or "Scintillations" which cause the Photomultiplier to generate electrical pulses. These pulses are fed to a ratemeter circuit which converts them into a meter reading.

The ratemeter circuit in the model 115 has an especially fast response which offers a quick meter indication of increases in radiation intensity. Because of the extreme sensitivity of the detecting element, more counts or pulses are obtained from a given amount of radioactive material. A greater number of pulses produces a more stable meter indication, thus enabling the user to read smaller changes in intensity. Great sensitivity and quick response allow the user to detect radioactive materials from a vehicle or airplane even when travelling at high speeds.

Provision has been made for the use of a strip chart recorder to be used with the model 115. When used, the recorder offers a permanent record of a survey. This is particularly desirable for aerial surveys.

The battery power supply virtually eliminates warm up time. A calibration check source, mounted in the case, provides an easy check of overall operation and accuracy at any time. Complete with probe and portable carrying case, the model 115 weighs only 16 pounds.

Designed primarily for prospecting for radioactive minerals and oil fields, the model 115 is an extremely accurate and sensitive detecting in-instrument with many other applications.

## II. DEFINITION OF TERMS AND THEIR USE

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.

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.

Measurement; we shall use the term "measurement" as meaning a measurement of radiation intensity. This measurement is taken directly from the 4 inch meter mounted on the panel of the 115, and will be expressed in milliroentgens per hour (MR/HR).

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. DESCRIPTION OF CONTROLS

### A. "ON-OFF-RANGE" control.

This control is mounted on the probe. With the knurled knob any one of eight positions can be selected; 1, "OFF"; when the knob is turned to this position, the entire instrument is turned off. 2. "ZERO"; when in this position the instrument can be electronically zeroed. 3. "5"; when in this position, the instrument is set at the highest range. A full scale indication on the meter means the instrument is exposed to radiation intensity of 5 milliroentgens per hour. 4. All succeeding positions on the range control, 2.5, .5, .25, .05, .025, mean that when the range control is set to one of these values a full scale reading indicates an intensity in MR/HR equal to the value selected on the control.

### A-1, METER READINGS.

The meter, in order to accommodate a greater number of ranges, has been divided into two separate scales. Each scale is read from left to right, is divided by five major divisions and fifty minor divisions.

The first scale, at the top of the meter face, reads from 0 to .25. When a range is selected with the range control, the user must naturally read from the meter scale which corresponds to this range. The 0 to .25 scale can be read with three separate ranges, as selected with the range control. These ranges are "2.5 MR/HR", ".25 MR/HR", and ".025 MR/HR". When using the 2.5 MR/HR range, each major division is equal to 1/5 of the full scale reading, or .5 MR/HR; the first major division reading being .5 MR/HR; the second, 1 MR/HR, and so on. When using the .25 MR/HR range, the only difference in readings taken is the placement of the decimal point; the first major division reading would be .05 MR/HR; the second, .1 MR/HR, and so on up to .25 MR/HR. The same rule applied when the .025 range is used; the only difference being in the placement of the decimal point. The first major division would then be equal to .005 MR/HR; the second, .01 MR/HR, and so on, up to .025 MR/HR.

EXAMPLE:
Range control set at "2.5".
Meter needle deflected to read ".15" on the top scale
MR/HR intensity 1.5 MR/HR.

Range control set at ".25".
Meter needle deflected to read ".15" on the top scale
MR/HR intensity .15 MR/HR.

Range control set at ".025".
Meter needle deflected to read ".15" on the top scale
MR/HR intensity .015 MR/HR.

The second scale is printed on the meter face just below the first scale and reads from 0 to 5. Here, each major division is equal to 1/5 the full scale reading as in the previous scale. The ranges, as selected with the range control, which can be read from this scale are "5", ".5" and ".05". When the range control is in the "5" position, all readings on this scale can be taken directly with each major division representing 1 MR/HR. The first major division (marked "1") equals 1 MR/HR; the second, 2 MR/HR, and so on up to 5 MR/HR. When the range control is in the ".05" position, the scale should read as follows: the first major division (marked "1") is equal to .01 MR/HR; the second, .02 MR/HR, and so on up to .05 MR/HR.

EXAMPLE:
Range control set at ".5"
Meter needle deflected to read "3" on the second scale
MR/HR intensity .3 MR/HR

The instrument is calibrated in MR/HR rather than counts per minute because this is a much more meaningful and reliable method of measurement. The reading in courts per minute may vary widely in a given field of radiation whereas the intensity in MR/HR is a constant value.

B. "TIME CONSTANT" control

There are two time constant controls in the model 115. The two controls provide three different time constants. Their function is to slow down the meter response. If a fast time constant is in use, the meter will respond very quickly to any change in radiation intensity. Since the gamma rays do not occur at evenly spaced intervals, the fast time constant allows the meter indication to fluctuate, especially if the intensity is very low. The slower time constants slow down the meter reaction to changes in intensity, thus giving a more stable, easier to read indication.

One of the time constant controls is on the panel of the instrument. This control is marked "normal" and "slow". When this switch is in the "slow" position, the other control has little effect. This switch is usually used in the "normal" position. The slowest time constant is obtained when this switch is turned to "slow". This should be done if the instrument is being carried at a slow speed or is stationary and a very acccurate reading is desired

The other time constant control is mounted on the probe and is marked "fast" and "slow". In the "fast" position an instantaneous reading is obtained (with the panel switch on "normal"), but the reading will be quite erratic. This position should be used for checking the approximate level of radiation and for deciding which position to set the range switch on. It can also be used for making surveys when traveling at high speed provided the average of the fluctuations is taken as the reading. The probe switch should be set on the slow position (with the panel switch on "normal") for making most surveys.

C. "ZERO" control

This control is mounted on the probe and is one of the two controls which are covered by cap nuts. The instrument can be electronically zeroed with this control by first turning the "ON-OFF-RANGE" control to the "ZERO" position. The meter will momentarily give a reading and then return to zero; if the meter does not return to zero, remove the cap from the control and adjust this control until the meter does indicate zero.

D. "VERNIER CALIBRATE" control

This control is used to compensate for changes in the battery voltage as the batteries wear out. A calibrated radium check source is provided so that the user can conveniently check the instrument for such changes. This source should, when it's radioactive rays are impressed upon the detecting element, cause the instrument to give a certain reading. If it does not, the "VERNIER CALIBRATE" control should be adjusted until the meter gives the proper reading.

E. "CALIBRATION ADJUST" control

This control is one of the two controls which are covered by cap screws and is mounted on the probe next to the "ZERO" control. This control has the same function as the vernier calibrate control, but has a much greater effect on the instrument. It should be used to recalibrate the instrument when the vernier control no longer will bring the meter reading to the desired level. For the procedure on recalibration, refer to the paragraph headed "RECALIBRATION PROCEDURE".

IV EXTERNAL CONNECTORS

A. There are two pin jack connectors, one red and one black, mounted on the meter panel and marked "RECORDER PREAMP". These connectors are provided so that a pre-amplifier (model 116) can be attached. By using this preamplifier, the model 115 can drive a 1 milliampere Esterline Angus recorder. The recorder, used in this fashion, would give the user a permanent record of the results of his work.

B. OPERATION

A. The model 115 consists of two separate parts, which are connected by a cable. One portion of the instrument contains most of the electronic components and the detecting element; this portion is the "probe". The other parts of the instrument are built into the carrying case; the meter, batteries, etc. For survey work the probe does not necessarily have to be removed from the case. If the probe is not removed from the case, however, the radioactive checking sample should be removed from the case so that it does not affect the readings.

The probe may be removed from the case and placed in any position which will offer greater sensitivity; i.e., in surveying from aircraft, the probe end is sometimed thrust through a hole in the bottom of the plane and its sides surrounded by lead shielding 3/4" thick and 4 or 5 inches high. This practice eliminates any absorption of rays by the plane's structure and cuts down the effect which cosmic rays have on survey readings. Good results can also be obtained without this procedure.

Since the detecting element, the sodium iodide crystal, is mounted in the end of the probe opposite the end where the cable enters, there should be as little obstruction as possible between this portion of the probe and the area being surveyed.

B. Turn the "ON-OFF-RANGE" control to "zero". There will be a momentary meter reading and the needle will then return to zero; if it does not return to zero, remove the cap from the ZERO control and adjust until it does indicate zero.

C. Turn the "ON-OFF-RANGE" control to the "5 MR/HR" range and bring the probe to the point from which you wish to measure the sample. If the meter reading is below 2.5 MR/HR, turn the control to the next lowest position ("2.5"). If the meter reading is below .5 MR/HR, turn the control to the next lowest scale (".5") and so on. When measurements are taken, the user should always turn the range control to the lowest possible range upon which he can still obtain a reading. The range should only be increased if the needle goes off scale to the right on the range being used. If the 5 MR/HR, or highest range, is used and the meter is still off scale to the right, the probe end may be moved back away from the activity until a reading can be made. If the probe does have to be moved back from the sample to acquire a reading, and the intensity of the sample is to be compared with the intensity of another sample, caution should be taken to make sure that the distance from the samples is the same in both readings. The "INVERSE SQUARE" law applies here. That is, the intensity of the radiation decreases in proportion to the square of the increase in the distance from the sample.

EXAMPLE:
Reading from sample at 1 inch distance - .2 MR/HR
Reading from same sample at 2 inch distance - .05 MR/HR

By taking a reading from this sample at 2 inches, we have doubled the distance from which the first reading was taken, i.e., we have multiplied the distance by 2.

Since the radiation intensity decreases in proportion to the square of the increase in the distance, the reading at 2 inches must be 1/4 of the reading at 1 inch, i.e., factor of increase in distance is 2; 2 squared is four, so we divide our first reading (.2 MR/HR) by four when we have doubled the distance from the sample. Our reading at this distance for the sample is .05 MR/HR.

From this example, it is apparent that, if readings are taken from two samples to determine the relationship between the amount of radioactivity in each, any difference in the distance at which these readings are taken, can cause a large error if the inverse square law is not taken into consideration.

D. CHANGING TIME CONSTANT settings will be necessary during a measurement if it is desirable to eliminate meter needle fluctuation. In most cases, the panel mounted time constant switch should be left in the "NORMAL" position. The probe mounted time constant control can be used to acquire "quick" readings on the "FAST" position or may be changed to the "SLOW" position if the needle fluctuation is too great to allow an accurate reading. It is important for the user to remember that when a long time constant is used, the meter takes longer to reach its final reading, and he should wait until the needle has reached the end of its travel.

E. Occasionally, it is desirable to check the calibration of the instrument. The procedure for checking calibration is as follows: A calibrated radium sample is clip mounted in the case near the end of the probe. It is marked with its value in MR/HR. Turn the range control to be the .25 range and push the end of the probe against the sample. The meter should indicate the value stamped on the sample. If it does not, turn the VERNIER CALIBRATE control until it does indicate this value. The side of the calibrated sample which gives the highest reading should be facing toward the end of the probe. This procedure need be repeated only occasionally, but especially after the instrument has been in long, continuous use, or has been out of use for some time. After the instrument has been in use for some time, the vernier calibration control will no longer bring the meter to the desired reading. At this time the procedure in the paragraph headed RECALIBRATION PROCEDURE should be followed.

## VI 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 model 115 Super Scintillator has been used in mines of known value to determine what happens when a deposit of radioactive material has been encountered.

It has been established that the normal background reading for the model 115 will fall somewhere between .005 and .02 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 usually good practice since any deposit may be buried under some rock or soil overburden which would reduce the intensity reading at the surface or in the air above it.

If the survey is conducted from a moving vehicle, the location where an increase in meter reading is encountered should be noted. If possible, a survey should be made from the vehicle, or on foot, 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 find 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 so as to make sure that as much of the area as possible is surveyed.

Aerial surveys require more careful planning because of the greater speed at which an aircraft travels. It is customary to mark a rectangular area on a map, then fly over the area from one end to the other as one would plow a field If a continuous strip chart recorder is used, the chart is marked at the end of each run or pass over the area; if a high reading is encountered, the spot may be easily found by referring to the chart. Sometimes easily located objects such as long streamers are dropped on locations where high readings are noted and these locations are later surveyed from the ground.

Samples should be collected from the area of high radioactivity and should be checked by holding them against the sensitive end of the probe 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 Ave., New York 23, N. Y., Attention: Raw Materials Operations.

A Scintillation Counter can be used to determine the uranium content of a piece of ore in percent of U308 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.

For additional information on prospecting, we recommend the book "PROSPECTING FOR URANIUM", for sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., price 45 cents.

Be sure to read section VII B. "HAZARDS TO CONSIDER" in the following text before making surveys.

## VII. PROSPECTING FOR OIL FIELDS

### A. PROCEDURE

Airborne surveys for locating oil fields with a scintillation counter have shown great promise and are now an accepted technique with many companies. (See Popular Mechanics Magazine, June 1953 and Fortune Magazine, June 1952). This method detects radiation associated with the oil itself rather than geological structure. The phenomena is not fully understood but it has been well established that an oil field, (not an individual well) is surrounded by a "halo" of radiation substantially higher than the radiation level in the adjoining area. It has also been well established that the area directly over an oil field is lower than normal in radioactivity.

A recommended procedure is to fly over a suspected oil field in a series of parallel lines about 300 feet apart and then fly another series at right angles to the first series. Radioactivity readings should be logged every few seconds or a strip recorder should be used. If this "grid pattern" assumes a significant form, it should be checked by repeating the procedure on the ground or with a helicopter at a distance of a foot or two above ground. In making aerial surveys, the plane should fly at the lowest speed and altitude consistent with safe flying.

### B. HAZARDS TO CONSIDER

The readings are affected by radon gas. This gas is emitted by radioactive minerals which exist everywhere throughout the surface of the earth in minute amounts. When barometric pressure is high, the gas (being almost as heavy as dust) does not rise. This is a good time for making surveys. If the barometric pressure is low, the radon gas rises and the effect may be great enough to make any survey meaningless. If radon gas is influencing the readings to any extent, even a small breeze may distribute the gas unevenly, giving rise to false interpretations. It is therefore advisable to make surveys in the early morning hours before breezes start or on calm days.

Shale has a higher natural radioactivity than other types of surfaces. In areas where shale outcrops exist, radiation highs will be found over such outcrops and must be discounted.

Large differences in readings due to the presence of oil fields, (or even uranium deposits except under ideal conditions) should not be expected. A significant set of readings might look like this:

EXAMPLE:
Normal background varying from .012 to .016 MR/HR.
Reading over oil field varying from .008 to .012 MR/HR
Reading over halo varying from .018 to .022 MR/HR.

It should be expressly understood that the 115 is not offered as an instrument that will locate oil wells or oil fields, but only as an instrument that will provide valuable clues as to their possible location.

## VIII. THEORY OF OPERATION.

The "Scintillator" employs a sodium iodide crystal optically coupled to an RCA 5819 photomultiplier tube. The tube is enclosed in a magnetic shield to prevent defocusing by the earth's magnetic field. When gamma rays penetrate the crystal they cause it to scintillate or throw off minute flashes of light. The light flashes are converted to electrical pulses by the photomultiplier tube and the photo tube greatly amplifies these pulses. The voltage pulses developed across the load resistor of the photomultiplier actuate VT1 and VT2 which are used as a univibrator. This circuit converts all pulses received to pulses of equal shape and amplitude to produce an indication that is proportional only to the counting rate. The steady signal voltage obtained from the plate circuit of VT2 is used to drive the meter through VT3 which acts as a vacuum-tube voltmeter. A relaxation oscillator power supply is used to obtain the thousand volts required for the photomultiplier tube. An NE7 neon bulb provides the basic frequency of about one hundred cycles per second. This frequency is amplified by VT4 and a high voltage is developed across the choke coil in its plate circuit. The diode tube VT5 rectifies the high voltage. The voltage regulator tube VT6, together with a compensating circuit is used to stabilize the voltage.

## IX PREVENTIVE MAINTENANCE AND BATTERY REPLACEMENT.

An occasional calibration check assures the user that batteries and other electronic components in the model 115 are in proper working order. The first indication of weak batteries is an inability to recalibrate the instrument. The batteries are located beneath the meter panel and can be checked or replaced by removing this panel.

Battery complement:

4 Eveready #467 - 67½ volt or equivalent
2 Eveready #412 - 22½ volt or equivalent
8 Eveready #D99 - 1½ volt or equivalent

The 1½ volt D99 batteries should be replaced only by new D99 batteries, or equivalent leakproof cells.

In the event the instrument is stored for long periods, such as one year, the batteries should be removed.

Replacing the batteries is easily accomplished by removing the meter panel, removing the old batteries, and putting the new ones in. Care should be taken to make sure that negative and positive terminals are properly connected. The 1½ volt (flashlight type) batteries are mounted on a removable panel. This panel may be lifted out for more convenient replacement of these batteries after removing the screws which hold it to the back of the case.

The batteries last much longer under intermittent use than when used continuously. Under intermittent conditions, a complete replacement of the batteries should only be necessary approximately once a year.

Although ruggedly constructed, the Model 115 is an electronic instrument and should be treated accordingly. It can be damaged by improper or rough treatment.

CAUTION: DO NOT ALLOW THE TEMPERATURE OF THE INSTRUMENT TO BE IN EXCESS OF 110 DEGREES FAHRENHEIT, AT ANY TIME. HIGH TEMPERATURES WILL PERMANENTLY DAMAGE THE DETECTING CRYSTAL.

## X. CORRECTIVE MAINTENANCE.

Access can be gained to the circuit components by simply pulling the two halves of the probe apart. The crystal is hermetically sealed to the photomultiplier tube and this assembly should never be opened as even minute amounts of moisture will damage the crystal. Failure can be due to the common faults of electronic circuits such as burned out resistors, shorted condensers, tubes, etc. Standard servicing techniques may be used with certain exceptions. The 900 volts across the photomultiplier 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. An oscilloscope with a fast preamplifier and triggered sweep not slower than five microseconds may be required for some servicing functions. Ordinary service shops do not have such equipment and an otherwise qualified service man, inexperienced with Scintillation Counters, could seriously damage the photomultiplier assembly. It is advisable, therefore, for servicing to be performed by a shop experienced with Scintillation Counters.

## XI. RECALIBRATION PROCEDURE

A gamma ray source of known value (in MR/HR) must be used to recalibrate the Model 115. It is desirable to use a radium source for this purpose. A source which will produce an intensity of 1 MR/HR is necessary for most accurate calibration. A radium source of one millicurie equivalent radium strength will produce an intensity of .9 MR/HR at a distance of one meter. Intensities at other distances can be computed from the inverse square law.

Place the source at a distance from the center of the crystal so that the calculated intensity at the center of the crystal will equal 3/4 full scale deflection on the range being used. Remove the cap nut from the probe mounted "CALIBRATION ADJUST" control. Adjust this control until the meter reads the calculated intensity plus background intensity (for 'background' see Section II). The instrument will then be properly calibrated.

## XII. GUARANTEE AND FACTORY SERVICE

All parts except the tubes, batteries and crystal are guaranteed for a period of ninety days from date of purchase against defects in workmanship and material. The tubes, batteries and crystal 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. 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

Tentative

WTA
FCL 2ex



**Precision Radiation Instruments**
2235 So. La Brea Ave.
Los Angeles 16, California

INSTRUCTION AND MAINTENANCE MANUAL FOR THE
MODEL 111 "SCINTILLATOR"

attached circuit is for model 115
SBX-18A

1. General information and operation.

The presence of gamma radiation can be determined by taking a reading with a Geiger Counter or a Scintillation Counter. The two types of instruments are used in a similar manner. The major difference between them lies in the detecting element. The Geiger Counter uses a Geiger-Mueller tube which is filled with a gas, whereas the Scintillation Counter uses a Sodium Iodide crystal, which is very dense, as its detecting element. The crystal, if sufficiently large, intercepts practically every gamma ray that passes through it, whereas the Geiger tube reacts to less than 1% of the gamma rays that penetrate it. As a result, the Scintillation Counter records many times as many rays as the Geiger Counter from the same source. This makes the "Scintillator" a more sensitive instrument than the Geiger Counter. Another important result is that a steadier meter reading for a given field of radiation if obtained, because the "Scintillator" is averaging many times as many counts per time interval as the Geiger Counter. This effect is particularly important when measuring small amounts of radiation. As a result, a small difference in intensity can be read easily on the "Scintillator" when the same difference would not be recognizable on the Geiger Counter due to its erratic meter movement. This is the factor that makes the "Scintillator" so valuable for uses such as prospecting where a small indication is sometimes very important. The "Scintillator" is also differentially sensitive to scattered gamma rays of low energy, which are usually most important in prospecting and cannot be detected with a Geiger Counter. The "Scintillator" will normally read about .01 to .02 milliroentgens/hour more or less depending on location. This count is caused by cosmic rays, internal contamination and normal radioactivity of the immediate surroundings. This measurement is called the background count. Since the count varies by locality the background for each locality must be determined. After taking the background count this count should be deducted from the reading for the net reading. Some geologists, however, prefer to report total gross radio-activity in milliroentgens/hour, as measured in the field.

General information and operation (continued).

The instrument has six ranges, .025, .05, .25, 1, 5 and 25 milliroentgens/hour full scale as well as a zero and off position. The instrument should first be turned to the zero position and the meter reading should be observed. If it does not read zero the cap nut should be unscrewed from the zero adjust control and the control should be adjusted until the meter reads zero. It is normal for the meter needle to go off the scale and remain there for a few seconds before dropping back when the instrument is first turned on. The switch should then be turned to the .025 or .05 range. These are the most sensitive ranges and are the ones most used for prospecting. When the meter goes off scale the switch should be turned to a less sensitive range. It should always be turned to the "Off" position when the instrument is not actually in use.

The time constant control is used to control the response time of the ratemeter. In the "slow" position it will take the meter about twenty seconds to reach its final reading, but the reading will be much steadier and more accurate than in the "fast" position. For quick checks and when prospecting from a moving vehicle the "fast" position should be used and for exact readings the "slow" position should be used.

2. Battery replacement.

The batteries can be serviced by pressing the button on the side of the battery box and at the same time pulling the lid away from the box. The lid can then be disengaged from its hinges and removed. The entire battery assembly will slide out of the box. No tools are needed as all batteries snap into position. Care must be taken to put the new battery in exactly the same position as the old one. The batteries will last in excess of two hundred hours with intermittent use.

3. Preventive maintenance and field adjustment.

If the instrument is stored for long periods 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 and zero adjustments. Batteries last very much longer with intermittent use than they do with continuous use. Turn the switch off whenever the instrument is not in actual use. As the batteries wear out the sensitivity of the instrument will fall off. A sample is provided to check the sensitivity. This is a small plastic disk clipped to the battery case and it has its value in milliroentgens/hour stamped on it. This disk, when placed flush against the end of the probe, will cause the meter to read approximately the value stamped on the plastic. It will make a difference which side of the plastic is placed against the probe. If desired, the sensitivity can be reset by removing the cap nut from the calibration adjustment and turning the adjustment to the desired reading. This will provide only an approximate setting. For an exact calibration see calibration procedure.

The crystal will be permanently damaged by temperatures in excess of 110°F. It is therefore essential not to expose the instrument to high temperatures.

4. Theory of operation.

The "Scintillator" employs a sodium iodide crystal optically coupled to an RCA 6199 photomultiplier tube. The tube is enclosed in a magnetic shield to prevent defocusing by the earth's magnetic field. When gamma rays penetrate the crystal they cause it to scintillate or throw off minute flashes of light. The light flashes are converted to electrical pulses by the photomultiplier tube and the tube greatly amplifies these pulses. The voltage pulses developed across the load resistor of the photomultiplier actuate VT1 and VT2 which are used as a univibrator. This circuit converts all pulses received to pulses of equal shape and amplitude to produce an indication that is proportional only to the counting rate. The steady signal voltage obtained from the plate circuit of VT2 is used to drive the meter through VT3 which acts as a vacuum-tube voltmeter. A relaxation oscillator power supply is used to obtain the nine hundred volts required for the photomultiplier tube. An NE7 neon bulb

Theory of operation (continued).
provides the basic frequency of about one hundred cycles per second. This frequency is amplified by VT4 and a high voltage is developed across the choke coil in its plate circuit. The diode tube VT5 rectifies the high voltage. The voltage regulator tube VT6, together with a compensating circuit is used to stabilize the voltage.

5. Corrective maintenance.

Access can be gained to the circuit components by simply pulling the two halves of the probe apart. The crystal is hermetically sealed to the photomultiplier tube and this assembly should never be opened as even minute amounts of moisture will damage the crystal. Failure can be due to the common faults of electronic circuits such as burned out resistors, shorted condensers, tubes, etc. Standard servicing techniques may be used with certain exceptions. The 900 volts across the photomultiplier 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. An oscilloscope with a fast preamplifier and triggered sweep not slower than five microseconds may be required for some servicing functions. Ordinary service shops do not have such equipment and an otherwise qualified service man inexperienced with Scintillation Counters could seriously damage the photomultiplier assembly. It is advisable, therefore, for servicing to be performed by a shop experienced with Scintillation Counters.

6. Calibration procedure.

Calibration should be accomplished with a radium needle. The "Scintillator" is sensitive to gamma rays of energy as low as .02 Mev. Therefore, it is essential to allow for the scattering effect when calibrating as the room scattering may effect the reading by as much as 100% at low levels of radiation. To calibrate, place the center of the crystal at a distance from the radium needle to produce a field intensity of 3/4 full scale (preferably on the 5 milliroentgens/hour range). A radium source of one millicurie equivalent radium strength will produce a gamma-ray flux of 0.9 milliroentgens/hour at a distance of one meter. (The exact value is computed from the formula:

$$S = 8.98(1-0.13t)m$$

Where S = intensity of radiation at a hypothetical distance of 1 cm.
t = thickness (in mm) of the platinum-iridium capsule wall,
m = actual radium content of the capsule)

Fluxes at other distances can be computed from the inverse-square law. The reading obtained will be somewhat higher than the true value. This is called the gross reading. Next, interpose a lead shield eight inches or more thick halfway between the crystal and the source. This will eliminate almost all of the direct radiation and the reading obtained will be due mainly to scattering and background count. Deduct this reading from the gross reading for the net or true reading. Adjust the calibration control until the net reading indicated by the meter corresponds to the calculated intensity for the particular radium needle. The instrument will then be correctly calibrated for all scales to within plus or minus 5% of the 3/4 full scale reading.

7. Guaranty and factory service.

All parts except the tubes, batteries and crystal are guaranteed for a period of ninety days from date of purchase against defects in workmanship and material. The tubes, batteries and crystal 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. The instrument should be covered on all sides with a thick layer of soft packing material. Enclose a note stating 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, 2235 S. La Brea Avenue, Los Angeles 16, California.

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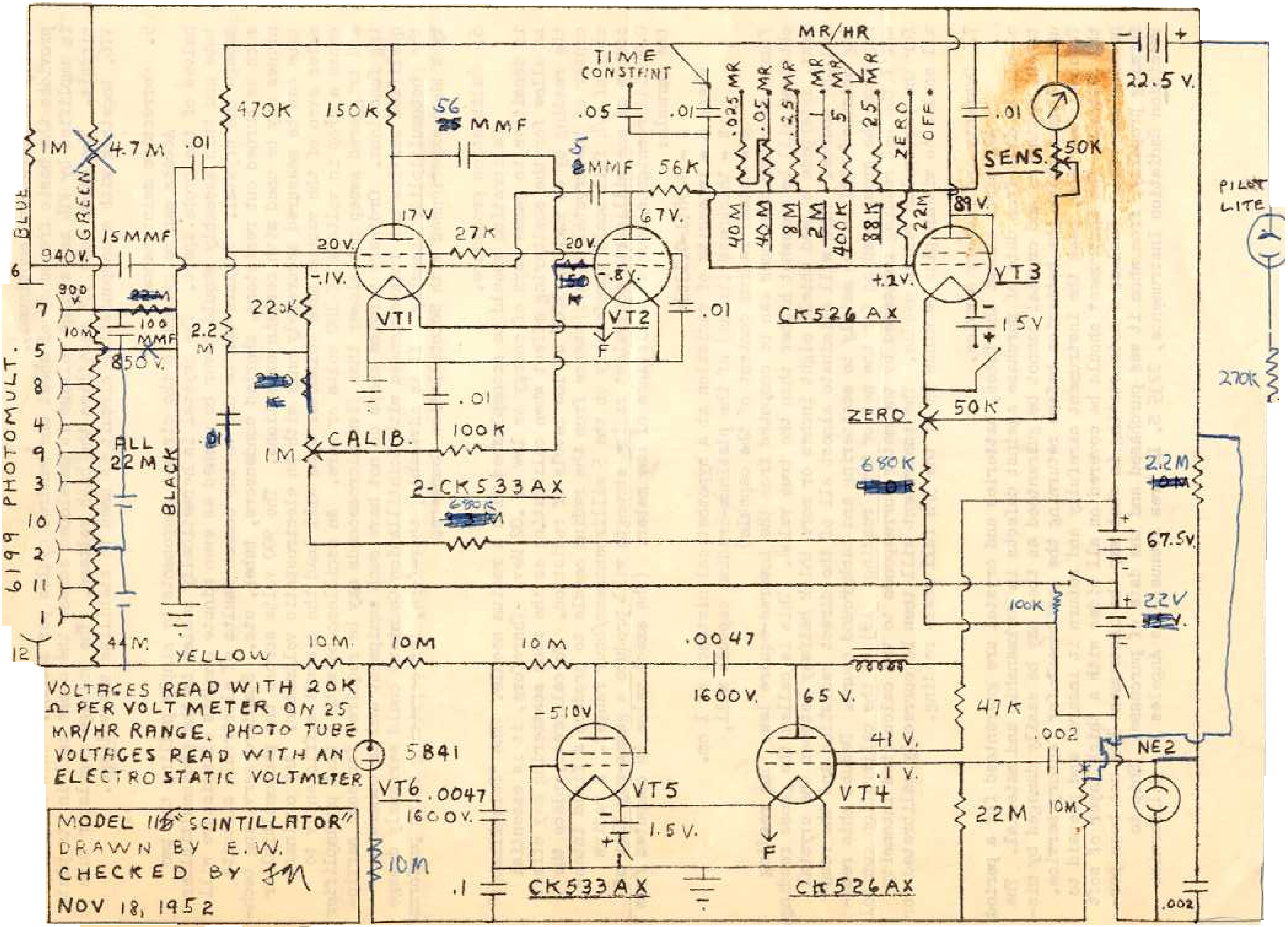


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