

**Model RM-20**

**Radiation Monitor  
Technical Manual**

**Thermo**  
ELECTRON CORPORATION

## MODEL RM-20

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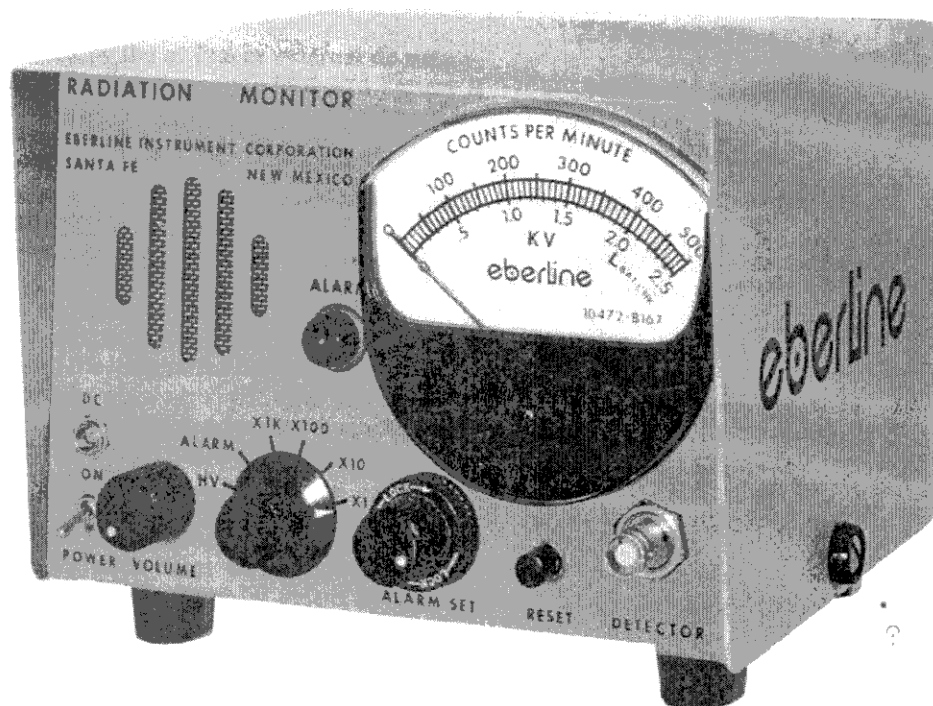


Figure 1-1. Model RM-20 Radiation Monitor

## MODEL RM-20

### SECTION I GENERAL

#### A. PURPOSE AND DESCRIPTION

The RM-20 series Radiation Monitor is a compact, versatile, alarming count rate meter with a charge-sensitive input and variable high voltage, suiting the unit for use with most Geiger-Mueller (GM), scintillation, and proportional detectors.

Power is supplied by the ac line or external dc supply. An internal 12 V gelled electrolyte lead-acid battery is optional, and is float-charged when the unit is operating from the ac line.

Four linear count rate ranges are indicated by the meter. The ranges are selected by the *X1*, *X10*, *X100* and *X1K* positions of the range switch. The alarm set point and the high voltage output are also read out on the meter when selected by the range switch. The high voltage is adjusted by an internal control, and the alarm set point is adjustable over the scale of the meter by a front panel control. The alarm, when actuated, does not interrupt or affect meter reading and is a locking type which will continue to provide a loud tone on the speaker until the reset switch is depressed.

Under non-alarm counting conditions, the speaker produces one click for each event detected, with volume variable from zero to maximum by means of a front panel control.

All individual units in the RM-20 series of instruments are identical except for the meter faces and name tags. Specific model numbers presently assigned are as follows:

##### 1. RM-20-1

- a. Meter Scale: 0 to 500 counts per minute (cpm).
- b. Ranges: 0-500, 0-5k, 0-50k and 0-500k cpm.

##### 2. RM-20-5

- a. Meter Scale: 0 to 10<sup>6</sup> counts per second (cps).
- b. Ranges: 0-10, 0-100, 0-1k, and 0-10k cps.

#### B. SPECIFICATIONS

##### 1. Meter

- a. Scale Length: 3.3 inches (8.4 cm).

- b. High Voltage Scale Marking: 0 to 2.5 kV in 50 V increments.

- c. Battery Check: All meter faces have a battery check mark which is used only when the optional internal battery is installed.

##### 2. Response Time

Adjustable by internal control from approximately 2 seconds to 20 seconds, measured from 0 to 90 percent of final reading.

##### 3. Linearity

Within  $\pm 5$  percent of full scale, typically  $\pm 2$  percent of full scale.

##### 4. Alarm Point

Adjustable from zero to greater than full scale by a front panel control, displayed when the range switch is in the *ALARM* position.

##### 5. Alarm Indication

Front panel alarm light (red) and approximately 1 kHz tone on speaker, independent of volume control.

##### 6. Speaker

Two-inch-diameter. One click for each event counted. Volume adjustable from zero to maximum.

##### 7. High Voltage

Adjustable by internal control from less than +300 V to +1800 V with a 100 M $\Omega$  load and to +2500 V on a proportional chamber (no load).

##### 8. Input Sensitivity

Selectable by an internal switch from approximately  $2 \times 10^{-13}$  C to  $3 \times 10^{-12}$  C. (Approximately equivalent to 1 mV to 15 mV.)

##### 9. Threshold

Adjustable from 0 to approximately 3 V.

##### 10. Power

a. Alternating Current: 105-125 V, 50/60 Hz at less than 0.1 A. (A 230 V, 50/60 Hz option is available.)

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b. Direct Current: 10 to 20 V (12 Vdc nominal) at approximately 25 mA dc (no alarm). Up to 400 mA dc under alarm conditions with high count rates.

c. Optional internal battery life approximately 10 hours on one full charge (no alarm).

d. Mating connector to front panel dc connector is Switchcraft No. 760. The center conductor is positive.

### 11. Temperature

The instrument is operational from -20 °F to +140 °F (-29 °C to +60 °C) with less than  $\pm 10$  percent of full scale change in calibration or alarm point, and less than 1 percent change in high voltage.

12. Detector Connector: MHV coaxial.

### 13. Detector Requirements

a. Operating Voltage: Any positive voltage from 300 to 1800 V with a 100 M $\Omega$  load and up to 2500 V for a proportional chamber.

b. Impedance: 100 M $\Omega$  minimum dc resistance.

c. Pulse Height: At least 1.0 mV (negative going) with a rise time of 1 microsecond ( $\mu$ s) or less.

### 14. Mechanical

a. Size: 5½ inches high x 6½ inches deep x 7½ inches wide (14 cm x 16.5 cm x 19 cm).

b. Weight: 2¾ pounds (1.25 kg). [4¼ pounds (1.9 kg) with optional battery installed.]

## SECTION II OPERATION

### A. DESCRIPTION OF CONTROLS AND CONNECTORS

#### 1. External (See Figures 1-1, 2-1, and 2-2)

a. **Switch:** A six-position rotary switch selects readout of the high voltage, alarm set point, and one of the four scale multipliers: *X1*, *X10*, *X100* and *X1K*. This number must be multiplied by the meter reading to obtain the proper count rate.

b. **POWER:** A toggle switch turns the instrument **ON**.

c. **DC:** Connector jack which accepts external dc power. Mates with Switchcraft No. 760. Center pin positive.

d. **VOLUME:** Varies loudness of speaker clicks from zero to maximum.

e. **ALARM SET:** Sets the point on the meter scale at which the alarm will actuate.

f. **RESET:** Unlatches the alarm, if actuated, and returns the meter reading to zero.

g. **DETECTOR:** Connection to detector. MHV coaxial. Center pin positive.

h. **Line Filter and ac Connector:** Mates with the power cord for ac input.

#### 2. Internal (See Figure 2-1)

a. **1, 10, 100, and 1K Controls:** One control for each range, which individually calibrates that range.

b. **Response:** Adjusts the meter response time for compromise between speed and fluctuation of reading.

c. **HV CAL:** Calibrates the *HV* readout to indicate the actual high voltage.

d. **GM/P Switch:** Selects low gain (*GM*) amplifier configuration for the Geiger tube and high gain scintillation detectors, or the high gain (*P*) configuration for gas proportional and low gain scintillation detectors.

e. **DISCR:** Discriminator control which sets the threshold level between 0 and 3 V, approximately.

f. **HV ADJ:** A control which adjusts the high voltage applied to the detector.

### B. PREPARATION FOR USE

#### 1. Inspection

The instrument should be checked for physical damage.

#### 2. Connections

Plug the ac cord into a 115 V, 60 Hz line or connect 10 to 20 Vdc to the dc connector and turn the **POWER** switch **ON**. (If the optional internal battery is installed, the unit will operate without an external power connection.)

### C. USING THE INSTRUMENT

#### 1. Starting

Turn the switch to *HV* and verify that the high voltage is suitable for the detector to be used. If in doubt about this, refer to the calibration procedure in the maintenance section.

#### 2. Operation Check

With the detector connected and the range switch in the appropriate range, place a check source in a repeatable position adjacent to the detector, and note that a suitable reading is obtained.

Push the **RESET** button. The reading should drop to zero rapidly, then climb back to the source reading when the **RESET** is released.

The **RESPONSE** control (internal) may be adjusted for the best compromise between fast response and steady reading.

Rotate the **ALARM SET** counterclockwise until an alarm occurs as indicated by the **ALARM** light and a 1000 Hz squeal on the speaker. Push the **RESET** button; the alarm should desist until the reading again reaches the alarm set point.

#### 3. Interpretation of Indications

The meter reading must be multiplied by the scale switch setting to obtain the proper number. The fluctuation of the meter is normal and is caused by the random nature of radioactive decay.

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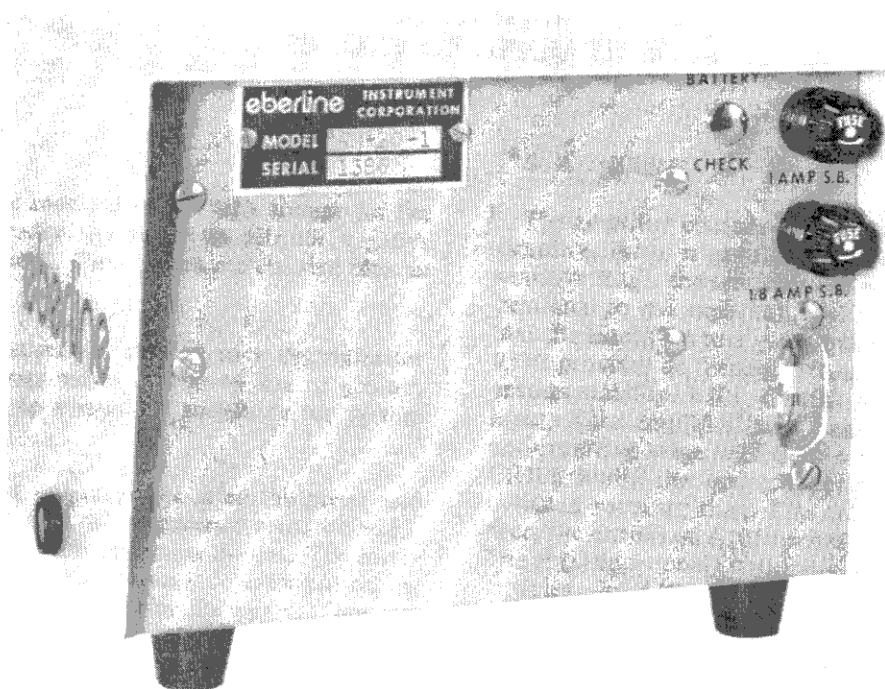


Figure 2-1. Model RM-20 Rear View

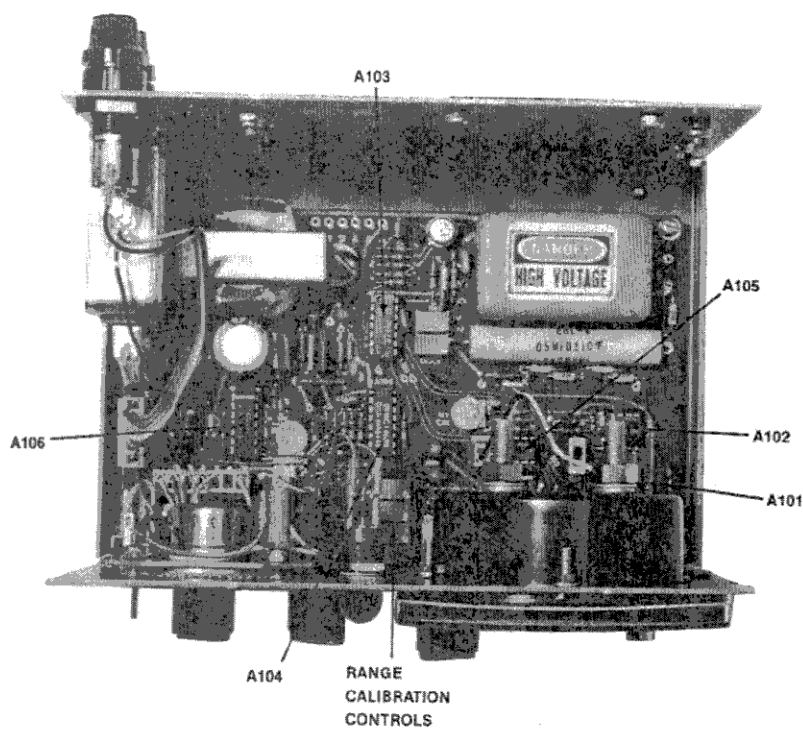


Figure 2-2. Model RM-20 Top View

## SECTION III THEORY OF OPERATION

### A. GENERAL

The high voltage supply develops high voltage for the detector. When radiation reacts in the detector, negative pulses are generated. These pulses are coupled into an amplifier.

The amplified pulses are applied to a discriminator circuit which passes pulses of a given size or greater, converting them to a standard amplitude for further processing.

The discriminator output pulses drive the meter and speaker trigger circuits, which generate standard width pulses for input to their respective drivers. The meter driver converts the trigger pulses to current pulses, integrates the current, and drives the meter. Thus the meter reading is proportional to the average rate of radiation at the detector.

The meter drive voltage is applied to a comparator which has a reference voltage controlled by the *ALARM SET* control. When the meter drive voltage exceeds the reference voltage, the circuit recognizes an alarm condition, which turns on the alarm oscillator and couples its frequency to the speaker.

### B. FUNCTIONAL THEORY (See Figure 6-1)

#### 1. High Voltage Supply

This unit consists of controlled oscillator Q101, voltage step-up and rectification T102, high voltage division for feedback R138-R142, feedback buffer amplifier A105, and the oscillator control comparator A103.

The *HV ADJ* control R149 sets a reference voltage at one input of A103, and the buffered feedback from the high voltage output drives the other input. The regulation circuit is in balance when these voltages are approximately equal. If the reference voltage is increased, by adjusting *HV ADJ* clockwise, comparator A103's output, pin 14, goes low, gating oscillator Q101 on, increasing the high voltage output and the feedback voltage until the comparator output gates the oscillator off again.

A heavier load tends to lower the high voltage, unbalancing the comparator. This tends to increase the duty cycle of the oscillator to maintain the desired output.

#### 2. Amplifier

The amplifier consists of A101, A102, and associated circuitry. A101 is configured as an inverting charge-sensitive stage, the sensitivity of which is inversely proportional to the capacitance of C102. R109 and R110 bias the amplifiers to a +4 V quiescent operating point. R102 provides dc feedback around the stage and C103 ensures stability. R101, CR101, and CR102 protect the input of the amplifier from transient spikes. A102 is a non-inverting stage with a gain of 20, approximately. CR105 limits the undershoot amplitude to improve overload recovery time. The *GM/P* switch S103 connects the output of A101 or A102 to the discriminator. The *P* (proportional) position utilizes the gain of A102 in series with A101 to provide the greater sensitivity required with gas proportional detectors. The Geiger-Mueller (*GM*) position uses A101 only, providing lower gain and better overload recovery for better performance with Geiger tube detectors. Most scintillation detectors will work satisfactorily with either gain configuration; the only operating difference being the different high voltages required.

#### 3. Discriminator

The discriminator consists of one-fourth of a quad comparator, A103, and associated circuitry. The *DISCR* control R107 sets a reference voltage at the positive input to the comparator. When the positive-going amplifier output pulse at the negative input to the comparator exceeds the reference voltage, the comparator output switches to ground. C106 provides positive feedback for jitter-free switching. When the amplifier pulse returns to baseline, the comparator output returns to +8 V through pull-up resistor R108.

#### 4. Trigger Circuits

The triggers consist of A104 and associated circuitry. A104 is a dual monostable multivibrator, one section of which is the meter circuit trigger and the other half is the speaker circuit trigger. The width of the pulse out of the meter trigger is controlled by the R-C time constant at pins 14 and 15, which is selected by the range switch S102. Each of the range positions (*X1*, *X10*, *X100*, *X1K*) incorporates its own R-C network so that the pulse width for each range is individually adjustable for calibration.

The speaker trigger pulse width is fixed at approximately 250  $\mu$ s. The circuit between pins 6 and 4 sets a maximum speaker rate of about 1000 pps.



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### 5. Meter Integrator-Driver

The negative meter trigger pulse out of A104 pin 9 causes Q108 to conduct a given current for the duration of the trigger pulse. C108 integrates this charge and discharges through R115, the *RESPONSE* control, and R116.

The voltage developed across R116 drives the input of A105, the meter drive amplifier, which provides meter current proportional to this voltage. The *RESPONSE* control varies the R-C time constant of the discharge circuit, which essentially filters the voltage to the operational amplifier, smoothing or speeding up the meter response.

When the range switch is in the *HV* position, the high voltage feedback signal, through the high voltage calibration control R147, is connected to the meter drive amplifier so that the meter indicates the high voltage.

When the range switch is in the *ALARM* position, the alarm reference voltage, which is selected by the alarm set control R135, is connected to A105, indicating the alarm set point on the meter.

### 6. Speaker Driver

The 250  $\mu$ s speaker trigger pulse from A104, pin 6, is amplified by Q107 and Q106 to drive the *VOLUME* control R125 and the speaker coil through isolating diode CR107. One click is heard for each event counted.

The 1 kHz alarm tone is amplified by Q104 and Q105 to drive the speaker voice coil, with CR107 providing isolation from the volume control so that the alarm tone is not affected by the volume setting.

### 7. Alarm Circuit

The alarm circuit consists mainly of A103, A106, and associated circuitry.

The meter drive signal on R116 is connected to A103, pin 6. The *ALARM SET* R135 reference voltage is applied to the other input of the same comparator, pin 7. When the meter signal becomes greater than the reference, the output, pin 1, goes to ground, causing the other comparator output, pin 2, to switch to ground also, latching the alarm condition. This low signal turns on Q102 and Q103, causing the *ALARM* light to come on. If the *RESET* switch S104 is pushed after the alarm-causing high reading has gone away, the comparators will unlatch, allowing pins 1 and 2 to rise to +8 V again.

During the alarm condition, the low output from the comparator gates the 1 kHz tone oscillator A106 into operation. A high output disables the oscillator. The frequency is determined by R129 and C115.

### 8. Power Circuitry

The ac line voltage is stepped down by T101, full wave rectified by CR109-CR112, and filtered by C120. A107 provides a regulated +14.5 V line for the speaker

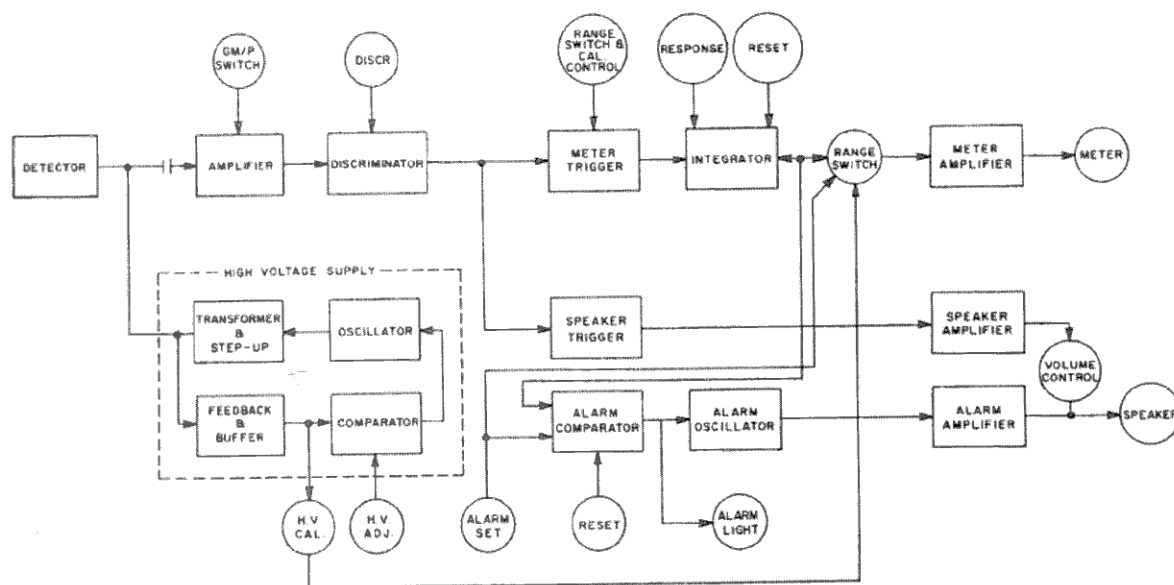


Figure 3-1. RM-20 Block Diagram (11068-C21A-1)

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amplifiers and for battery charging if the optional internal battery is installed or an external 12 V battery is in use. A108 provides a regulated +8 V line for all the remaining circuitry. The design is such that T101 limits the current available for heavy alarm and charging loads, allowing A107 to pull out of regulation without affecting the +8 V line.

The dc connector J3 on the front panel permits the instrument to be powered by an external dc source, such as an automobile battery. In this case (or if the internal battery is installed) the +14.5 V line will be approximately +10 V, resulting in somewhat less audio from the speaker.

### C. OPTIONS AND MODIFICATIONS

#### 1. Internal Battery Option

This option includes a 12 V gelled-electrolyte, sealed, lead-acid type battery. This will provide more than 40 hours of normal operation (no alarm) on one recharge. The battery is continuously float-charged while the instrument is turned on and operating from the ac line. A discharged battery will recharge in 8 hours or less. Actuating the **BATTERY CHECK** pushbutton S105 on the rear panel causes the meter to read above the **BAT CHK** mark if the battery is charged.

#### 2. 230 Vac Option

This option permits the instrument to be operated from a 230 V, 50 or 60 Hz line. The only component change is that a 230 V transformer is substituted for the 115 V version of T101.

#### 3. Non-Locking Alarm

When this modification is made, the alarm will end any time the input signal rate falls below the alarm set point.

To make this modification, locate the upper outside lead on the back of the **RESET** switch (the lead nearest A101) and cut it in two.

#### 4. Modifications

The circuit board terminals, numbered 1 through 6, shown at the lower left corner of Figure 6-1, provide for possible modifications. Terminal 6 is forced low during an alarm condition. Terminal 1 provides a positive pulse (for counting by an external scaler) each time a count is registered by the RM-20. Terminals 2, 3, and 4 may be used to adjust the high voltage externally.

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### SECTION IV MAINTENANCE

#### A. DISASSEMBLY AND REASSEMBLY

1. To remove the cover, remove the 10-32 screw from each side of the unit and lift the cover off.

2. To remove the circuit board, unplug the three nylon connectors and the two tab connectors near the *DETECTOR* connector. Remove the knobs and nuts from the board-mounted components which protrude through the front panel; that is *POWER*, *VOLUME*, range switch, *ALARM SET*, and *RESET*. Unscrew the ac input connector and line filter assembly from the rear panel. Remove the two 4-40 screws at the rear corners of the board and slide the board back and out to the side. (If the battery is installed, it will have to be removed first.)

#### B. PREVENTIVE MAINTENANCE

Keep the instrument clean and dry. There is no scheduled preventive maintenance.

#### C. CALIBRATION

##### 1. High Voltage Indication

Calibration of the high voltage readout requires the use of a very high impedance voltmeter (1000 M $\Omega$  or more) capable of measuring up to 2500 V.

a. Connect the positive side of the high voltage voltmeter to the outboard end of C117, the high voltage filter capacitor. Connect the reference side to chassis ground at the lug on the *DETECTOR* connector. Set the range switch to the *HV* position.

b. Adjust the *HV ADJ* potentiometer R149 until the high voltage meter reads 2000 V. Adjust the *HV CAL* potentiometer R147 until the front panel meter also indicates 2.0 kV.

c. Set the *HV ADJ* potentiometer for 2500, 1500, 1000, and 500 V. The front panel meter should agree with each setting within 50 V.

##### 2. Calibration to True Frequency

If calibration to true incoming pulse rate is appropriate, a pulse generator such as the Eberline Model MP-2 or equivalent is necessary. The pulser must produce negative-going pulses with a rise time of 1  $\mu$ s or less. The pulser should be

connected to the instrument through a 0.001  $\mu$ F, 3 k V capacitor to block the dc high voltage at the *DETECTOR* connector. (The MP-2 pulser has this capacitor built in.)

a. Set the RM-20 *DISCR* control for 1 V between pins 10 and 11 of A103. Set the *ALARM SET* control fully clockwise. Set the *GM/P* switch to *P*.

b. Connect the pulser to the *DETECTOR* connector on the front panel. Set the pulse amplitude at 10 mV.

c. Set the range switch to *X1K* and the pulser for approximately 80 percent of full range. Adjust the 1k range potentiometer until the meter reads the input pulse rate.

d. Calibrate the remaining (*X100*, *X10*, *X1*) ranges in a similar manner.

e. Set the range switch to *X100* and set the pulser for approximately 80 percent of full scale.

f. Turn the range switch to the *ALARM* position, and adjust the *ALARM SET* control for a reading of one minor division below the meter indication of step e. above.

g. Set the range switch back to *X100*, and verify that the alarm actuates within one minor division of the alarm set position.

h. Press the *RESET* switch. The alarm should stop and the meter reading should go toward zero.

i. Set the *ALARM SET* control fully clockwise and disconnect the pulser.

j. Set the function switch to the *HV* position, and adjust the high voltage to suit the intended detector. (If this voltage is not known, follow steps 3.a. and 3.b. following.)

k. Connect the detector to the RM-20 with the cable to be used in actual operation (if possible). Expose the detector to a source of radiation to assure that the system is operational.

##### 3. Calibration to Detector Response

If it is appropriate to calibrate the instrument to the response of a detector (instead of counts per minute) such as mR/h, for example, proceed as follows.

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a. For GM detectors, set the *GM/P* switch to the *GM* position. For scintillation detectors use the *GM* position unless more than 1500 V is required, in which case the *P* position should be used. For gas proportional detectors, *P* position gain and higher detector voltages are required. The *DISCR* control may be set lower, which simulates increased gain, but care must be exercised to avoid setting the sensitivity below the level of internal noise generated by the alarm and speaker circuits.

b. Before connecting the detector, make sure the high voltage is not set excessively high. If the proper voltage is known, set the controls for that output. If the proper high voltage is not known, set the voltage low, connect the detector, and plot a voltage plateau curve (count rate versus detector voltage) for both background radiation and for the radiation of interest. Use the curves to select the best operating voltage and set the high voltage to that value.

c. If facilities are available, expose the detector to four different known radiation intensities to allow

calibration of all four ranges (*X1k*, *X100*, *X10*, *X1*) in the upper half of the meter scale. If facilities are limited, calibrate as many ranges to radiation as is possible. The other ranges may be roughly calibrated by using a pulser to ratio a pulse rate up or down by a factor of 10 for adjacent ranges.

d. Check the operation of the alarm controls in a manner similar to steps 2.e., f., g., and h. above.

### D. TROUBLESHOOTING

Typical voltages and waveforms are given on the schematic Figure 6-1, and component locations are shown in Figure 6-2.

Voltages are measured with a digital voltmeter with 10 M $\Omega$  or higher input impedance. High voltage is best measured with an electrostatic voltmeter or DVM with high voltage probe having 1000 M $\Omega$  impedance or higher.

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## SECTION V PARTS LIST

The following table lists the electronic items incorporated in the RM-20 and should contain any part necessary for normal repair. Unless otherwise specified, callouts of manufacturers and manufacturers' part numbers are to be considered typical examples only and not restrictions against using equivalent parts with the same operating characteristics. When ordering parts from Eberline, specify model number, serial number, reference designation, value, Eberline part number, or a word description if the part has no reference designation. Eberline will automatically substitute equivalent parts when the one called out by the manufacturers' part number is not available.

| REF DESIG   | PART   | DESCRIPTION                              | MANUFACTURER AND PART NUMBER | EBERLINE PART NUMBER |
|---|--|--|------------------------------|----------------------|
| <b>1. Chassis and Miscellaneous</b>   |  |  |                              |                      |
| DS1   | Power Cord                                   | 3-wire, #18                              | Belden 17250                 | WRAC4 (4)            |
| DS2   | Speaker                                      |  | Lafayette S-433              | ADSP3 (6)            |
| F1  | Lamp   | 14 V, 0.08 A                             | No. 330                      | LPBU6 (5)            |
| F2  | Fuse   | 3 AG, 1/8 A, Slo Blo                     |                              | FUSB2 (1)            |
|   | Fuse   | 3 AG, 1 A, Slo Blo                       |                              | FUSB12 (1)           |
|   | Fuseholder                                   |  | Littelfuse 342022            | FUHO3 (5)            |
| J1  | Connector                                    | MHV                                      | Amphenol 27025               | CXMH2 (7)            |
| J2  | Line Filter/<br>Connector                    |  | Corcom 1ED1                  | MEVE102 (3)          |
| J3  | Connector                                    | dc                                       | Switchcraft 712A             | COAF16 (5)           |
| M1**  | Meter  | 0-50 $\mu$ A dc                          | Jewell MM3T                  | MTPA29 (8)           |
| ** When ordering a replacement meter, specify complete instrument model number, scale labeling (cpm, cps, mR/h, etc.), full scale value and meter face identification number (10472-_____). |  |  |                              |                      |
| P101  | Connector                                    | 5-pin                                    | Molex 09-50-7051             | COMR205 (6)          |
| P102 (Partial)  | Connector                                    | 4-pin                                    | Molex 09-50-7041             | COMR104 (1)          |
| P103  | Connector                                    | 2-pin                                    | Molex 09-50-7021             | COMR902 (8)          |
|   | Crimp Terminals<br>(for P101, P102,<br>P103) |  | Molex 08-50-0106             | COHD11 (7)           |
| R1  | Resistor                                     | 15, $\pm$ 5 percent, 2 W,<br>Carbon Film |                              | RECC150B25 (0)       |
| <b>2. Circuit Board YP11068004 (8)</b>  |  |  |                              |                      |
| A101  | Op-Amp                                       |  | RCA CA3130AE                 | ICAOC3130S (2)       |
| A102  | Op-Amp                                       |  | RCA CA3160E                  | ICAOA03160 (9)       |
| A103  | Quad Comparator                              |  | National LM339N              | ICACA0339N (8)       |
| A104  | Dual Monostable                              |  | Motorola MC14538BCP          | ICCMA4538B (9)       |
| A105  | Dual Op-Amp                                  |  | National LM358N              | ICAOA00358 (7)       |

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| REF DESIG  | PART                               | DESCRIPTION                            | MANUFACTURER AND PART NUMBER             | EBERLINE PART NUMBER             |
|--|------------------------------------|--|--|----------------------------------|
| A106<br>A107, A108                                       | Quad NOR Gate<br>Voltage Regulator | CMOS, 14-pin DIP<br>Programmable       | RCA CD4001BE<br>National LM317T          | ICCMA4001B (8)<br>ICAVA0317T (1) |
| C101   | Capacitor                          | 220 pF, 3 kV,<br>20%, X5F              | Sprague 30GAT22<br>or equivalent         | CPXX4 (4)                        |
| C102, C106   | Capacitor                          | 4.7 pF, 1 kV                           | Sprague 10TCC-V47<br>or equivalent       | CPCE472F2U (2)                   |
| C103   | Capacitor                          | 20 pF, 1 kV,<br>10%, S2L               | CRL DD200<br>or equivalent               | CPCE200P3U (3)                   |
| C105   | Capacitor                          | 0.01 $\mu$ F, 50 V,<br>20%, X7R        | AVX SR155C103KAA<br>or equivalent        | CPCE103P3N (9)                   |
| C107, C122,<br>C123                                      | Capacitor                          | 39 $\mu$ F, 10 V, Tantalum             | Sprague 199D396X9010DA1                  | CPTA390M3F (5)                   |
| C108   | Capacitor                          | 68 $\mu$ F, 10 V, Tantalum             | Sprague 150D686X9010R2                   | CPTA680M3F (9)                   |
| C109   | Capacitor                          | 100 pF, 500V, 10%,<br>COG (NPO)        | AVX SR155A101KAA                         | CPSP101P3N (8)                   |
| C110   | Capacitor                          | 0.001 $\mu$ F, 50 V, 10%,<br>COG (NPO) | CRL CY15C102M                            | CPSP102P3N (6)                   |
| C111   | Capacitor                          | 0.01 $\mu$ F, 50 V, 10%,<br>COG (NPO)  | AVX SR305A103KAA                         | CPSP103P3N (4)                   |
| C112, C113,<br>C115, C116,<br>C125, C126,<br>C128        | Capacitor                          | 0.1 $\mu$ F, 50V,<br>10%, X7R          | CRL CW20C104K<br>or equivalent           | CPCE104P3N (7)                   |
| C118   | Capacitor                          | 0.22 $\mu$ F, 50 V, 20%                | Centralab CW30C224M                      | CPCE224P4N (1)                   |
| C114   | Capacitor                          | 220 pF, 1 kV, 10%, Z5F                 | CRL DD221 or equivalent                  | CPCE221P3U (9)                   |
| C117   | Capacitor                          | 0.047 $\mu$ F, 4.0kV, 10%              | American Shizuki<br>X675HV.047104000V020 | CPPF503PXY (9)                   |
| C119   | Capacitor                          | 1.0 $\mu$ F, 50 V, 10%,<br>Tantalum    | CS13                                     | CPTA105P3N (4)                   |
| C120   | Capacitor                          | 470 $\mu$ F, 50 V                      | Sprague<br>513D-477M063EK4               | CPAL471M3N (8)                   |
| C121   | Capacitor                          | 15 $\mu$ F, 20 V<br>Tantalum           | Sprague type 196D                        | CPXX10 (0)                       |
| C124   | Capacitor                          | 120 $\mu$ F, 10 V, 10%,<br>Tantalum    | CS13                                     | CPTA121M3F (4)                   |
| C127   | Capacitor                          | 0.001 $\mu$ F, 1 kV,<br>10%, Z5R       | CRL DD-102                               | CPCE102P3U (1)                   |
| CR101, CR102,<br>CR104,<br>CR114                         | Diode                              | Silicon                                | 1N4148                                   | CRSI1N4148 (7)                   |
| CR105  | Diode                              | Germanium                              | 1N34A                                    | CRGE1N0034 (9)                   |
| CR106  | Diode                              | Silicon, HV                            |  | CRSIVA0025 (3)                   |
| CR107, CR108,<br>CR109, CR110,<br>CR111, CR112,<br>CR113 | Diode                              | Silicon                                | 1N4002                                   | CRSI1N4002 (2)                   |
| J101   | Connector                          | 5-pin, male                            | Molex 09-60-1051                         | COMR305 (4)                      |
| J102 (Partial)   | Connector                          | 4-pin, male                            | Molex 09-60-1041                         | COMR304 (7)                      |

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| REF DESIG  | PART          | DESCRIPTION                         | MANUFACTURER AND PART NUMBER | EBERLINE PART NUMBER |
|--|---------------|-------------------------------------|------------------------------|----------------------|
| J102 (Partial)   | Connector     | 3-pin, male                         | Molex 09-60-1031             | COMR803 (8)          |
| J103   | Connector     | 2-pin, male                         | Molex 09-60-1021             | COMR802 (0)          |
| P102 (Partial)   | Connector     | 3-pin, female                       | Molex 09-50-7031             | COMR703 (0)          |
| Q101   | Transistor    | PNP, silicon                        | 2N4234                       | TRSP2N4234 (7)       |
| Q102, Q108   | Transistor    | PNP, silicon                        | 2N4126                       | TRSP2N4126 (8)       |
| Q103   | Transistor    | NPN, silicon                        | 2N4401                       | TRSN2N4401 (6)       |
| Q104, Q107   | Transistor    | NPN, silicon                        | 2N4124                       | TRSN2N4124 (2)       |
| Q105   | Transistor    | PNP, silicon                        | 2N4403                       | TRSP2N4403 (2)       |
| Q106   | Transistor    | PNP, silicon                        | 2N6124                       | TRSP2N6124 (5)       |
| R101, R105, R113   | Resistor      | 1k, 5%, 1/4 W, Carbon Composition   |                              | RECC102B22 (4)       |
| R102   | Resistor      | 510k, 5%, 1/4 W, Carbon Composition |                              | RECC514B22 (0)       |
| R103, R106, R112, R109, R110, R123, R130, R145, R146, R150 | Resistor      | 10k, 5%, 1/4 W, Carbon Composition  |                              | RECC103B22 (2)       |
| R104, R133, R131, R144                                     | Resistor      | 20k, 5%, 1/4 W, Carbon Composition  |                              | RECC203B22 (0)       |
| R107, R118, R119, R120, R121                               | Potentiometer | 100k, multiturn, PC mount           | Bourns 3299W-1-104           | PTCE104B03 (5)       |
| R108   | Resistor      | 39k, 5%, 1/4 W, Carbon Composition  |                              | RECC393B22 (9)       |
| R111, R122, R136, R158                                     | Resistor      | 1M, 5%, 1/4 W, Carbon Composition   |                              | RECC105B22 (7)       |
| R114   | Resistor      | 820, 5%, 1/4 W, Carbon Composition  |                              | RECC821B22 (9)       |
| R115   | Potentiometer | 100k, PC mount                      | CTS 375Y-104B                | PTCE104B04 (4)       |
| R116   | Resistor      | 12k, 5%, 1/4 W, Carbon Composition  |                              | RECC123B22 (0)       |
| R117, R156   | Resistor      | 10k, 1%, 1/4 W                      | RN55D                        | RECE103B12 (2)       |
| R124   | Resistor      | 120, 5%, 1/4 W, Carbon Composition  |                              | RECC121B22 (4)       |
| R125   | Potentiometer | 100, PC mount                       | Bourns 81J1AB20A05           | PTXX101B0X (7)       |
| R126   | Resistor      | 430, 5%, 1/4 W, Carbon Composition  |                              | RECC431B22 (7)       |
| R127, R129   | Resistor      | 5.1k, 5%, 1/4 W, Carbon Composition |                              | RECC512B22 (4)       |
| R128   | Resistor      | 22k, 5%, 1/4 W, Carbon Composition  |                              | RECC223B22 (8)       |
| R132   | Resistor      | 2k, 5%, 1/4 W, Carbon Composition   |                              | RECC202B22 (2)       |
| R134   | Resistor      | 33k, 5%, 1/4 W, Carbon Composition  |                              | RECC333B22 (5)       |

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| REF DESIG                                 | PART   | DESCRIPTION   | MANUFACTURER AND PART NUMBER     | EBERLINE PART NUMBER   |
|---|--|---|----------------------------------|--|
| R135<br>R137, R138,<br>R139, R140<br>R141 | Potentiometer<br>Resistor                    | 2.5k, PC mount<br>20M, 1%, 1/4 W  | Bourns 81A1AB20A12<br>RN55D      | PTXX252B0X (8)<br>RECE206B12 (3)                                     |
| R142<br>R147<br>R148                      | Resistor<br>Potentiometer<br>Resistor        | 20k, 1%, 1/4 W<br>10k, PC Mount<br>100k, 5%, 1/4 W,<br>Carbon Composition                                 | RN55D<br>CTS 375Y-103B           | RECE203B12 (0)<br>PTCE103B04 (6)<br>RECC104B22 (0)                   |
| R149                                      | Potentiometer                                | 10k, multiturn,<br>PC mount   | Bourns 3299W                     | PTCE103B33 (1)   |
| R151                                      | Resistor                                     | 470, 5%, 1/4 W,<br>Carbon Composition   |                                  | RECC471B22 (3)   |
| R152, R154<br>R153<br>R155<br>R157        | Resistor<br>Resistor<br>Resistor<br>Resistor | 243, 1%, 1/4 W<br>2.55k, 1%, 1/4 W<br>1.3k, 1%, 1/4 W<br>340, 1%, 1/4W                                    | RN55D<br>RN55D<br>RN55D<br>RN55D | RECE241B12 (0)<br>RECE252B12 (7)<br>RECE132B12 (1)<br>RECE341B12 (8) |
| S101                                      | Switch                                       | Toggle, DPDT,<br>PC mount   | C&K 7201 SDAV2BE                 | SWTO22 (5)   |
| S102                                      | Switch                                       | 2 pole, 6 pos./pole,<br>PC mount, non-shorting  | Grayhill<br>71BF30-01-2-6N       | SWR013 (5)   |
| S103                                      | Switch                                       | Slide, SPDT, PC mount   | Alco TSS11DG-PC                  | SWSL6 (3)  |
| S104                                      | Switch                                       | Momentary PB,<br>PC mount, DPDT   | C&K 8225DAV2                     | SWPB13 (4)   |
| T101                                      | Transformer                                  | 117/12 Vac, 350 mA<br>(Note: 230 Vac option<br>requires Stancor P8721,<br>Eberline Part Number<br>TFPO34) | Stancor P8391                    | TFPO10 (2)   |
| T102                                      | HV Assembly                                  |   | Eberline                         | YP10931000 (2)   |

3. Battery Option YP11138000

|              |                             |                    |                    |             |
|--------------|-----------------------------|--------------------|--------------------|-------------|
|              | Battery                     | 12 V               | Powersonic PS-1212 | BTGC6 (4)   |
| Part of P102 | Connector                   | 3-pin              | Molex 09-50-7031   | COMR703 (0) |
|              | Crimp terminals<br>for P102 |                    | Molex 08-50-0106   | COHD11 (7)  |
| S105         | Switch                      | Momentary PB, SPDT | C&K 8121-S-Y4-Z-GE | SWPB14 (3)  |



## SECTION VI

### DIAGRAMS



Figure 6-1. RM-20 Schematic (11068-D20G)

# MODEL RM-20

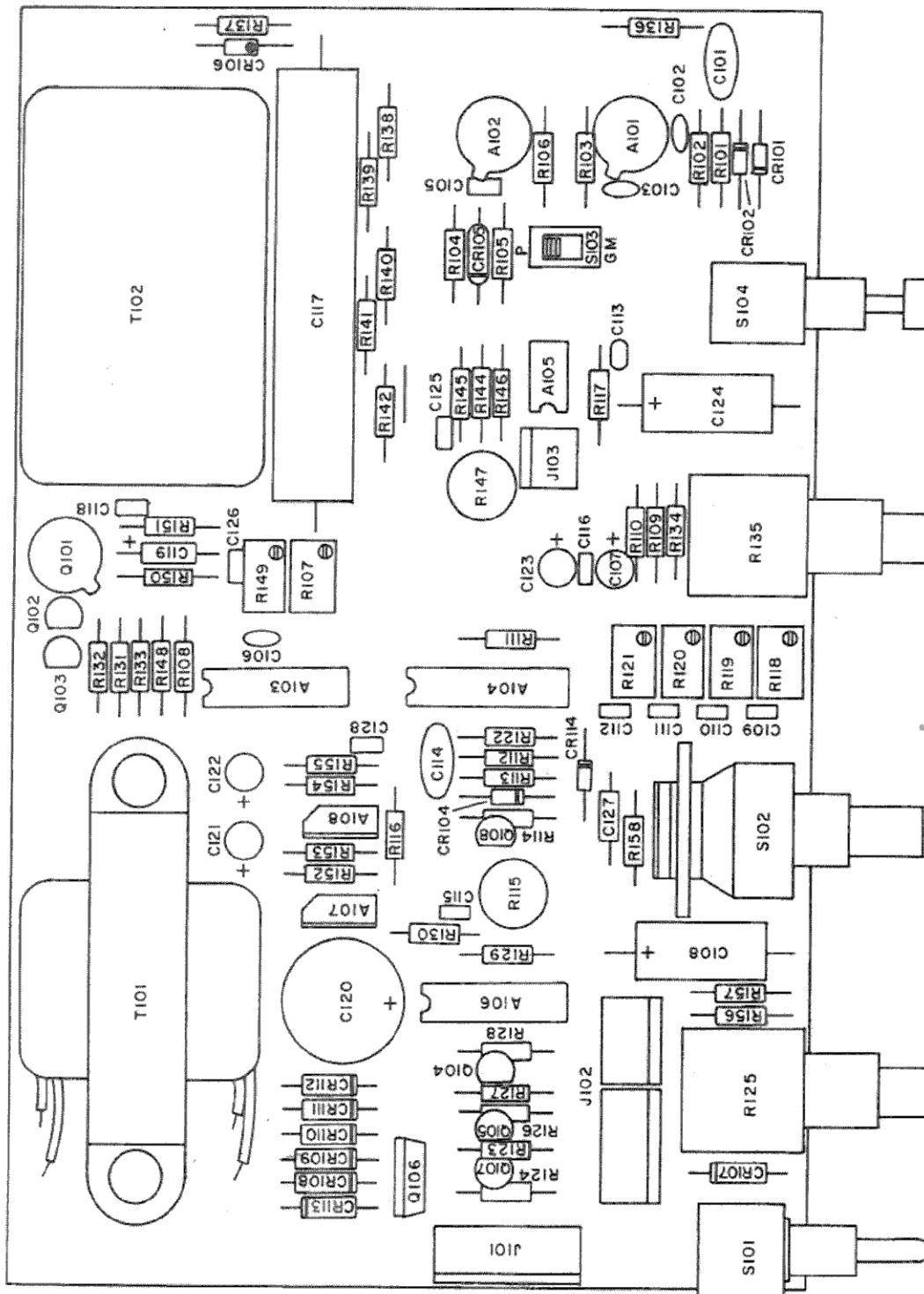


Figure 6-2. RM-20 Component Layout of Circuit Board (11068-C19C)