Model RO-2

Ion Chamber Technical Manual

John Witzell

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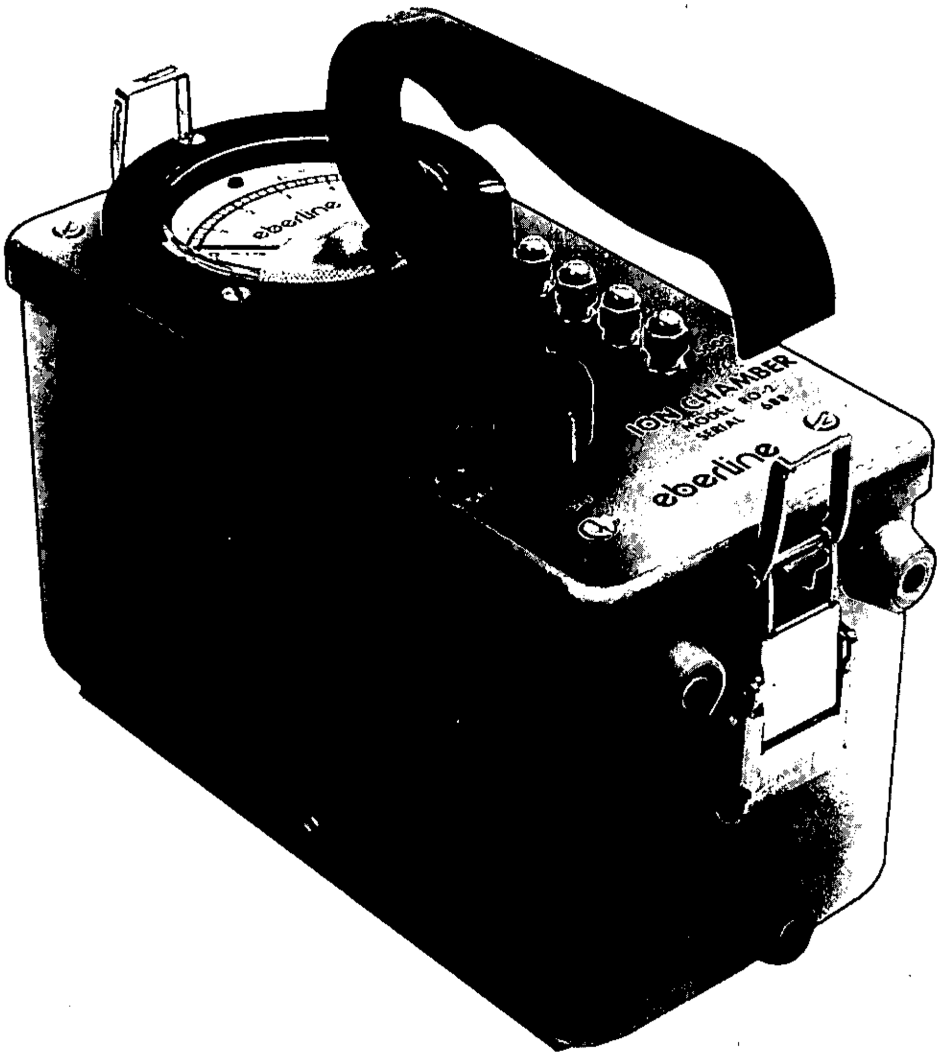

Figure 1-1. Ion Chamber, Model RO-2

SECTION I
GENERAL

A. PURPOSE AND DESCRIPTION

The Model RO-2 is a portable air ion chamber instrument used to detect beta (β), gamma (γ), and x-ray radiation. The RO-2 has four linear ranges of operation to measure dose rate for x-ray and γ radiation. The ion chamber is vented to atmospheric pressure and is specifically designed to have flat energy response into the x-ray region. The Model RO-2 is sensitive to β, γ, and x-ray and is calibrated to γ radiation (^{137}Cs). A single rotary switch turns the instrument off, provides a battery check, checks the zero setting, and selects the range of operation.

B. SPECIFICATIONS

1. Detector

a. Size: 3 inch diameter, 12.7 in³ volume (7.62 cm, 208 cm³).

b. Fill: Air, vented to atmospheric pressure.

c. Wall: One-sixteenth inch phenolic, approximately 200 mg/cm² inside 0.050 inch wall aluminum case.

d. Window: Two layers 0.001 inch mylar, approximately 7 mg/cm² total.

e. Beta Shield: Sliding shield on bottom of case with positive friction lock. Approximately 400 mg/cm² (1/8 inch phenolic).

f. Radiation Detected: Beta, gamma, and x-ray.

g. Photon Energy Response: Nominal ±15 percent from 12 keV to more than 1.3 MeV. (See Figure 1-2.)

h. Example of Beta Response

(1) Uranium Slab: 33 percent of true mrad/h field behind 7 mg/cm² window with RO-2 resting on slab, slide open.

(2) ^{90}Sr-^{90}Y: 75 percent of true mrad/h field at 40 cm with slide open, 8 percent with slide closed.

i. Fast Neutron Response: Reads approximately 10 percent in mR/h of true neutron field in mrem/h.

2. General

a. Ranges: Four linear ranges: 0-5, 0-50, 0-500 and 0-5000 mR/h.

b. Meter: Ruggedized, sealed, 2.38 inch (6.04 cm) scale length, 2 percent accuracy. Linear markings from 0 to 5 in 25 minor increments.

c. Response Time: 5 seconds, 0 to 90 percent of reading.

d. Linearity: Within ±5 percent of full scale.

e. Battery Dependence: No calibration shift with battery voltage change. (Down to battery *[BATT]* check mark on meter.)

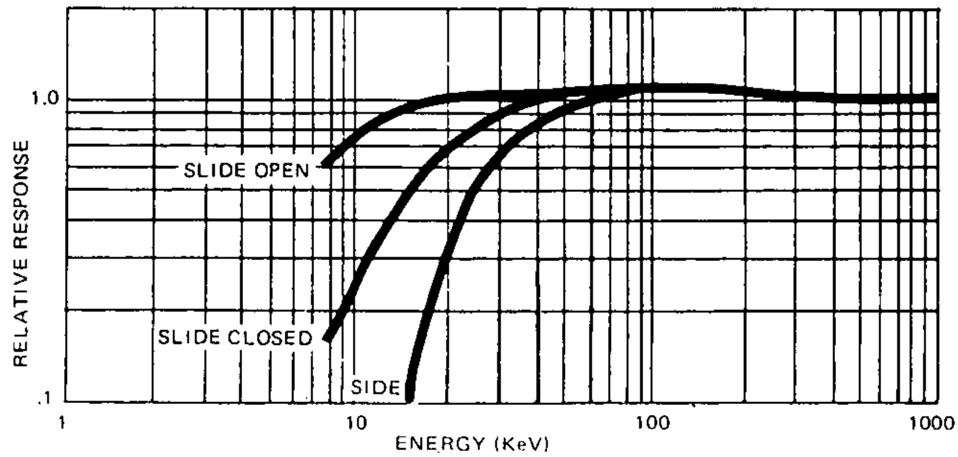

Figure 1-2. Nominal Photon Energy Response

f. Controls

(1) Range switch with *OFF, ZERO,* and *BATT* checking positions.

(2) *ZERO* knob used to set meter to zero when *ZERO* position of range switch is selected or when in no significant radiation field.

(3) Calibration controls, one for each range.

g. Batteries

(1) Type: Three NEDA 1604, 9 V type, 10 to 5.4 V per battery.

(2) Life: Two batteries approximately 200 hours C-Zn, 330 hours alkaline, 330 hours mercury. Third battery is shelf life.

h. Environment

(1) Temperature: Operable from -40 °F to 140 °F (-40 °C to 60 °C). (Operation at low temperatures may be limited by battery performance.)

(2) Moisture: Seals used at openings for dust and water resistance. Detector is protected by a silica-gel drying box.

(3) Radio Frequency Sensitivity: Reading unaffected by radar fields up to 20 mW/cm^2.

i. Weight: Approximately 3.8 pounds (1.7 kg), including C-Zn batteries.

j. Size: $3^{15}/_{16}$ inches wide x $8^{5}/_{16}$ inches long x $7^{7}/_{16}$ inches high (10 cm x 21.1 cm x 18.9 cm), including handle.

SECTION II
OPERATION

A. DESCRIPTION OF CONTROLS

1. Function Switch: Eight-position rotary switch that turns the instrument *OFF,* checks the condition of the batteries, checks instrument *ZERO,* and selects the range of operation to be used.

2. ZERO Knob: Used to set the meter to zero when the *ZERO* switch position is selected or when in an insignificant radiation field.

3. Calibration Controls: Four variable resistors, one for each range.

B. USING THE INSTRUMENT

1. Turn the function switch to *BAT 1* and then to *BAT 2* positions. The meter should read above the *BATT* cut-off line in both cases.

2. Turn the function switch to *ZERO* position. Check that the meter reads zero. If not, set it to zero with the *ZERO* knob.

a. Due to a change in manufacturing of the operational amplifier, A1, the zero control will work in reverse for instruments with the new manufacturer's amplifier. These devices can be identified by the description "DAWN" indicated on the part. This should pose no problem, simply turn the zero control in either direction. To zero the meter as appropriate.

3. Set the function switch to the desired range of operation. The switch position selected is the full scale reading of that range.

4. When measuring β, low energy γ, or x-ray emissions, open the sliding β shield on the bottom of the case and face the bottom of the instrument toward the radiation source. To open or close the shield, depress the friction release button on the left side of the case and manually move the slide, or let it fall due to gravity. When the shield is open, protect the thin face against puncture damage.

NOTES

a. The zero setting of the instrument may be checked in any radiation field by merely selecting the *ZERO* position.

b. When selecting the most sensitive range (5 mR/h), switching transient noise may cause a temporary deflection of the meter. This can be avoided by first selecting 50 mR/h, letting the needle settle, and then switching to 5 mR/h.

c. The effective center of the ion chamber is marked by dimples at the front and sides of the instrument case.

d. Since the ion chamber is vented to atmospheric pressure, it is sensitive to changes in both air pressure and temperature. Tables 2-1 and 2-2 give correction factors to be used if the use conditions are different from the calibration conditions. If both pressure and temperature are different, multiply the meter reading by both factors.

e. Do not expose the instrument to fields significantly above full scale for the range selected or amplifier gate stress and possible damage may result.

		ALTITUDE WHEN CALIBRATED										
		SEA LEVEL	1000'	2000'	3000'	4000'	5000'	6000'	7000'	8000'	9000'	10,000'
ALTITUDE WHEN USED	SEA LEVEL	1	0.96	0.93	0.90	0.86	0.83	0.80	0.77	0.74	0.71	0.69
	1000'	1.04	1	0.96	0.93	0.90	0.86	0.83	0.80	0.77	0.74	0.71
	2000'	1.08	1.04	1	0.96	0.93	0.89	0.86	0.83	0.80	0.77	0.74
	3000'	1.12	1.08	1.04	1	0.96	0.93	0.89	0.86	0.83	0.80	0.77
	4000'	1.16	1.12	1.08	1.04	1	0.96	0.93	0.89	0.86	0.83	0.80
	5000'	1.20	1.16	1.12	1.08	1.04	1	0.96	0.93	0.89	0.86	0.83
	6000'	1.25	1.20	1.16	1.12	1.08	1.04	1	0.96	0.93	0.89	0.86
	7000'	1.30	1.25	1.20	1.16	1.12	1.08	1.04	1	0.96	0.93	0.89
	8000'	1.35	1.30	1.25	1.21	1.16	1.12	1.08	1.04	1	0.96	0.93
	9000'	1.40	1.35	1.30	1.25	1.21	1.16	1.12	1.08	1.04	1	0.96
	10,000'	1.45	1.40	1.35	1.30	1.26	1.21	1.17	1.12	1.08	1.04	1

Multiply Meter Reading By Given Correction Factor

Table 2-1. Altitude Corrections

			TEMPERATURE WHEN CALIBRATED																		
	°C		-40	-34.4	-28.9	-23.3	-17.8	-12.2	-6.7	-1.1	4.4	10	15.6	21.1	26.7	32.2	37.8	43.3	48.9	54.4	60
		°F	-40	-30	-20	-10	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140
TEMPERATURE WHEN USED	-40	-40	1	0.98	0.95	0.93	0.91	0.89	0.87	0.85	0.84	0.83	0.81	0.79	0.78	0.76	0.75	0.74	0.72	0.71	0.70
	-34.4	-30	1.02	1	0.98	0.95	0.93	0.92	0.89	0.88	0.86	0.84	0.83	0.81	0.79	0.78	0.77	0.75	0.74	0.73	0.71
	-28.9	-20	1.05	1.02	1	0.98	0.96	0.94	0.92	0.90	0.88	0.86	0.85	0.83	0.81	0.80	0.79	0.77	0.76	0.75	0.73
	-23.3	-10	1.07	1.05	1.02	1	0.98	0.96	0.94	0.92	0.90	0.88	0.87	0.85	0.83	0.82	0.80	0.79	0.78	0.76	0.75
	-17.8	0	1.10	1.07	1.05	1.02	1	0.98	0.96	0.94	0.92	0.90	0.88	0.87	0.85	0.84	0.82	0.81	0.79	0.78	0.77
	-12.2	10	1.12	1.09	1.07	1.04	1.02	1	0.98	0.96	0.94	0.92	0.90	0.89	0.87	0.85	0.84	0.82	0.81	0.80	0.78
	-6.7	20	1.14	1.12	1.09	1.07	1.04	1.02	1	0.98	0.96	0.94	0.92	0.91	0.89	0.87	0.86	0.84	0.83	0.81	0.80
	-1.1	30	1.17	1.14	1.11	1.09	1.07	1.04	1.02	1	0.98	0.96	0.94	0.92	0.91	0.89	0.87	0.86	0.85	0.83	0.82
	4.4	40	1.19	1.16	1.14	1.11	1.09	1.06	1.04	1.02	1	0.98	0.96	0.94	0.93	0.91	0.89	0.87	0.86	0.85	0.83
	10	50	1.21	1.19	1.16	1.13	1.11	1.09	1.06	1.04	1.02	1	0.98	0.96	0.94	0.92	0.91	0.89	0.88	0.86	0.85
	15.6	60	1.24	1.21	1.18	1.16	1.13	1.11	1.08	1.06	1.04	1.02	1	0.98	0.96	0.95	0.93	0.91	0.90	0.88	0.87
	21.1	70	1.26	1.23	1.20	1.18	1.15	1.13	1.10	1.08	1.06	1.04	1.02	1	0.98	0.96	0.95	0.93	0.91	0.90	0.88
	26.7	80	1.29	1.26	1.23	1.20	1.17	1.15	1.13	1.10	1.08	1.06	1.04	1.02	1	0.98	0.96	0.95	0.93	0.92	0.90
	32.2	90	1.31	1.28	1.25	1.22	1.20	1.17	1.15	1.12	1.10	1.08	1.06	1.04	1.02	1	0.98	0.96	0.95	0.93	0.92
	37.8	100	1.33	1.30	1.27	1.24	1.22	1.19	1.17	1.14	1.12	1.10	1.08	1.06	1.04	1.02	1	0.98	0.97	0.95	0.93
	43.3	110	1.36	1.33	1.30	1.27	1.24	1.21	1.19	1.16	1.14	1.12	1.10	1.08	1.06	1.04	1.02	1	0.98	0.97	0.95
	48.9	120	1.38	1.35	1.32	1.29	1.26	1.23	1.21	1.18	1.16	1.14	1.12	1.09	1.07	1.05	1.04	1.02	1	0.98	0.97
	54.4	130	1.41	1.37	1.34	1.31	1.28	1.26	1.23	1.20	1.18	1.16	1.13	1.11	1.09	1.07	1.05	1.04	1.02	1	0.98
	60	140	1.43	1.40	1.36	1.33	1.30	1.28	1.25	1.22	1.20	1.18	1.15	1.13	1.11	1.09	1.07	1.05	1.03	1.02	1

MULTIPLY METER READING BY GIVEN CORRECTION FACTOR

Table 2-2. Temperature Corrections

SECTION III
THEORY OF OPERATION

A. GENERAL

Refer to Figure 3-1, a block diagram representing the basic operation of the circuit. The ion chamber has battery potential between the inside wall and the center electrode. When the air in the chamber ionizes due to radiation, a minute current flows through the chamber causing the minus input lead of the operational amplifier to go very slightly positive. This results in a negative swing of the amplifier output which is connected to the feedback elements through a divider circuit. The feedback elements are connected to the amplifier input and ion chamber and they conduct away all of the current generated in the ion chamber. The meter is also tied to the output of the amplifier and indicates in proportion to amplifier output voltage. Range changing is done by selecting different feedback elements and by selecting different points on the feedback divider.

B. FUNCTIONAL THEORY

1. Ion Chamber

The ion chamber is located inside the case below the meter. It consists of the lower two inches of the three-inch diameter chamber assembly. The remainder of the volume contains electronic components, including the amplifier A1. The chamber wall is one-sixteenth inch phenolic and the face is one mil aluminized Mylar®. Another one mil Mylar® layer is glued to the case, making total thickness of two mils. The active volume of air in the chamber is 208 cm^3.

The inside of the chamber has a conductive coating of graphite aquadag which is maintained at positive battery voltage. The inside of the Mylar® face is also at the same voltage. The outside of the chamber is coated with aquadag and is maintained at ground potential to provide electrostatic shielding. The center electrode is coated with conductive aquadag and is supported on the center conductor of the guarded feedthrough at the top of the chamber. The guard ring of the guarded feedthrough is positioned on insulators between the center conductor and the positive outer ring to prevent possible leakage from the chamber voltage to the center electrode. The guard ring and center electrode are maintained at the same potential (ground potential) so no leakage from the guard to the electrode will occur.

The chamber is sealed, except for a small hole in the top wall which vents it to the electronic section immediately behind the chamber. This section is vented to the inside of the main instrument case through a plastic

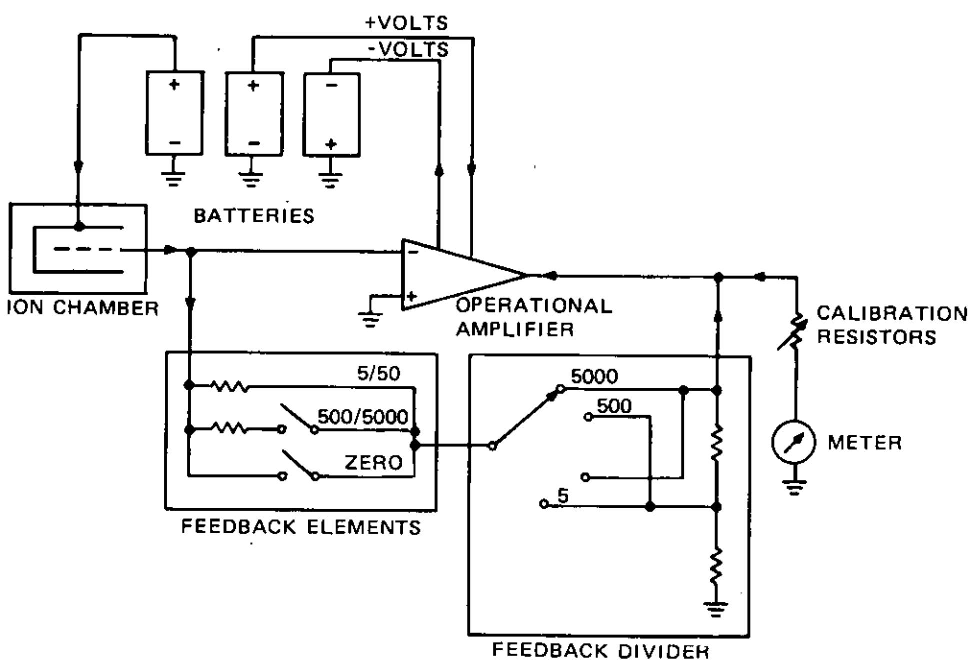

Figure 3-1. System Block Diagram

hose connected to a drying box filled with silica gel desiccant. In this way, any air drawn into the chamber (caused by atmospheric pressure changes, temperature changes, transporting RO-2 by air, etc.) must first pass over the drying desiccant. Dry air in the chamber is necessary to help prevent leakage.

An idealized air chamber, the size of the one used on the Model RO-2, produces approximately 1.93 x 10^{-14} A per mR/h at standard temperature and pressure. (STP is 0 °C and sea level pressure of 760 mm of Hg.) At 5 mR/h it should produce 9.65 x 10^{-14} A and at 5000 mR/h it should produce 9.65 x 10^{-11} A. It is seen that at full scale on the most sensitive range (5 mR/h), less than one-tenth of a micro-microamp is produced in the chamber, which makes protection against leakage current paramount. The silica gel desiccant should be changed as soon as it shows any clear or pink crystals.

The positive voltage supplied to the inside chamber wall is provided by a separate battery, BT3. This battery does not power any other circuit but the chamber and, therefore, its current drain is insignificant and its life is indefinitely long (shelf life). For this reason, it is not checked by the battery checking circuits.

2. Operational Amplifier (See Figure 6-1)

Operational amplifier A1 is contained in a single T0-5 size transistor package located in the top of the chamber assembly. It has dual MOS FET inputs which result in a very high input impedance on the order of 10^{15} Ω. Noninverting input pin 3 is connected to ground and the other input, pin 2, is connected to the ion chamber center electrode and the feedback elements. The output of amplifier pin 6 feeds the meter circuit and the feedback circuit.

When ion chamber current flows toward the amplifier input at pin 2, the input becomes slightly more positive which causes the output to go more negative. This negative output of the amplifier draws a current from one of the feedback elements to exactly match the amount of current the ion chamber is contributing. If a higher ion chamber current occurs, the amplifier must produce a higher voltage across the feedback element to draw off the current. In this way, the amplifier voltage output is proportional to the rate of radiation in the chamber.

3. Meter Circuit

The meter is driven directly from the output of amplifier pin 6, through dropping resistor R8 and one of four calibrating resistors R9 through R12. Nominally, the meter reaches full scale on all ranges at approximately the same voltage output from the amplifier. The four calibrating resistors allow for manufacturing tolerances in various components and provide for calibration at various elevations and temperatures. Function switch S1, section C, determines which calibration resistor is in the circuit. Capacitor C4 sets the time constant for the meter circuit.

4. Range Switching

The range that the Model RO-2 is operating on depends entirely on the feedback circuitry between the output of the amplifier and the amplifier input, pin 2, which is connected to the ion chamber. Table 3-1 shows the nominal current and voltage condition of the circuit when at full scale on the four ranges (sea level, 0 °C).

Feedback resistor R1 is connected to the circuit at all times. When using the 500 and 5000 mR/h ranges, S3 closes and R2 is put into the circuit. Since R2 has 100 times less resistance than R1, the effect of R1 is negligible. When on the *ZERO, BAT 1, BAT 2,* or *OFF* positions of the range switch, S1 closes and shorts out the feedback resistors so that the feedback current cannot generate any voltage across the resistors. When this occurs, any voltage remaining on the amplifier output and showing on the meter is zero offset error. This offset can be removed with *ZERO* control R3 which rebalances the amplifier with both inputs of A1 at zero potential.

Switches S2 and S3 are glass encapsulated magnetic

RANGE SETTING	ION CHAMBER CURRENT, AMPS FULL SCALE	FEEDBACK ELEMENT	VOLTAGE ON FEEDBACK ELEMENT	VOLTAGE OUT OF AMPLIFIER
5 mR/h	9.65 x 10^{-14}	R1, 3 x 10^{12} Ω	0.29	2.9
50 mR/h	9.65 x 10^{-13}	R1, 3 x 10^{12} Ω	2.9	2.9
500 mR/h	9.65 x 10^{-12}	R2, 3 x 10^{10} Ω	0.29	2.9
5000 mR/h	9.65 x 10^{-11}	R2, 3 x 10^{10} Ω	2.9	2.9

Table 3-1. Full Scale Currents and Voltages

reed switches with a very high open circuit impedance. They are activated by a permanent magnet which moves on a swinging arm on the outside of the chamber assembly. S2, the shorting switch, is located in the right side of the chamber assembly. The magnet is over S2 when the range switch is at *OFF, BAT 1, BAT 2,* or *ZERO.* S3, the switch that places R2 in the circuit, is located in the left side of the chamber assembly. The magnet is over S3 when the range switch is at the *5000* or *500* mR/h positions. When using the *50* or *5* mr/h positions, the magnet is over the center of the chamber and neither S2 nor S3 is pulled in. This leaves R1 as the active feedback resistor.

The second section of S1 (S1-B) selects full amplifier output voltage, or one-tenth of the voltage to supply the feedback elements. Full amplifier voltage is used on the *5000, 50, BAT 1,* and *BAT 2* positions. One-tenth output voltage is used on the *500, 5,* and *ZERO* positions.

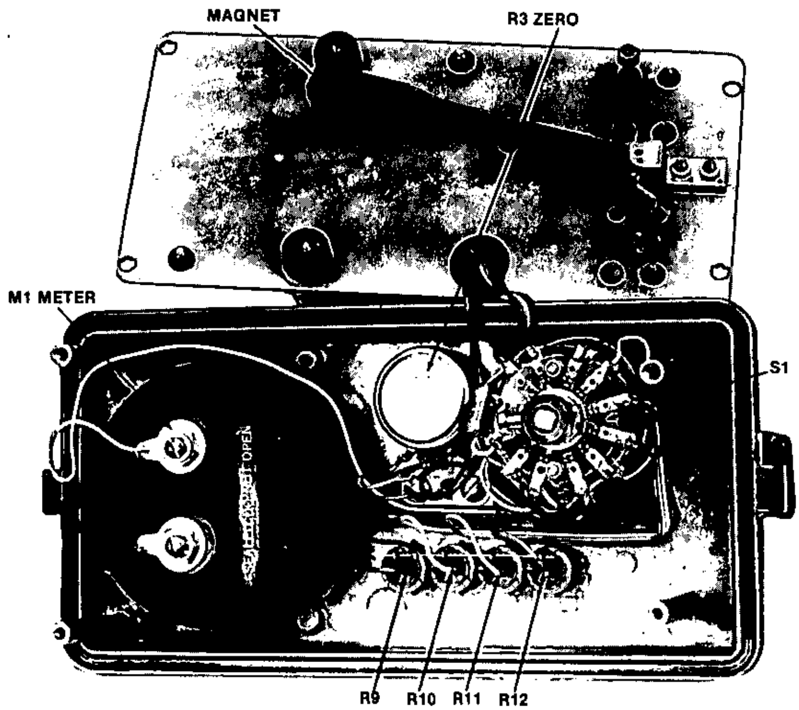

Figure 4-1. Interior View, Cover, Model RO-2

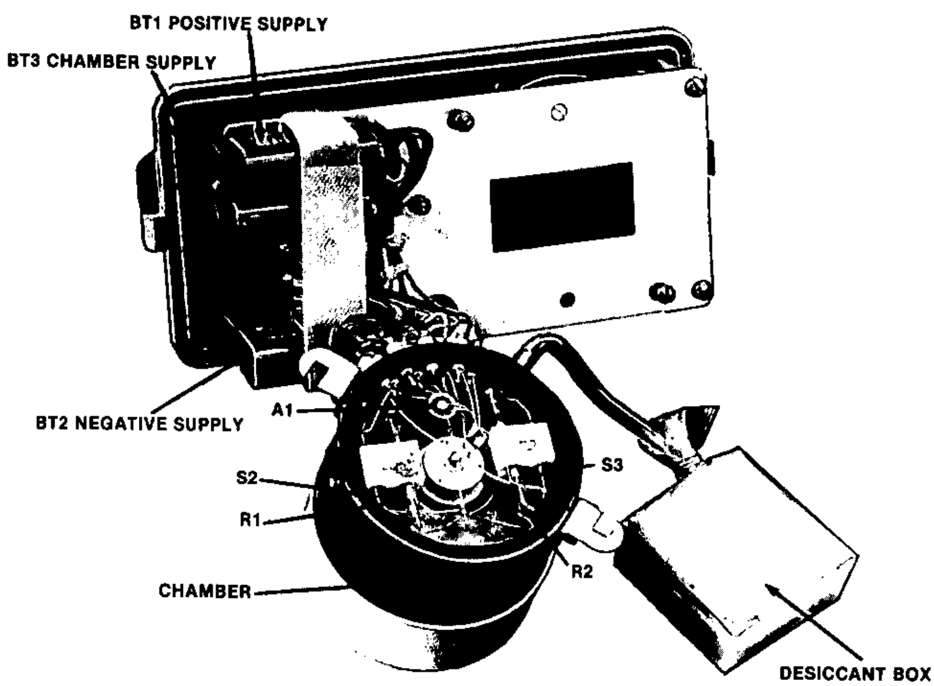

Figure 4-2. Interior View, Detector, Model RO-2

SECTION IV
MAINTENANCE

A. PREVENTIVE MAINTENANCE

1. Replace the batteries when, during battery check, the meter indicates at or below the left end of the *BATT OK* line on the meter face. The batteries are accessible when the cover assembly is separated from the case and the desiccant box is unstrapped. The batteries may be changed separately or in pairs. *BAT 1* checks the right hand battery and *BAT 2* checks the left hand battery (viewed from the top). Center battery BT3 powers the ion chamber current only and, therefore, lasts for an indefinite amount of time (shelf life). It is not checked by the internal battery checking circuits. It is a good practice, whenever a new battery is required for BT1 or BT2, to move the center battery to that position and install the new battery in the center position. In this way, the full power available from fresh batteries is utilized (no shelf life decay) and a fresh battery always powers the chamber. Turn the RO-2 off before changing batteries.

2. Remove the batteries if the instrument is to be inactive for a long period.

3. Dry or replace the desiccant crystals when they first begin to turn clear or pink in color. To remove the desiccant box, separate the cover assembly and case and open the nylon retaining straps that hold the box. Remove the tape from around the box lid. When new or dried crystals are in place in the box, retape the lid to the box and reinstall. Do not seal the box completely with tape. Leave a small space so that air can enter and leave the box. The desiccant crystals can be repeatedly dried by heating to 250 °F for twelve hours or to 400 °F for one hour. Do not heat the plastic box. The desiccant life will be prolonged if the box is placed in a small plastic bag with a rubber band closing the bag around the plastic hose.

NOTE

It is very important that the inside of the chamber assembly be kept dry to avoid leakage currents due to moisture. If the desiccant becomes saturated and the unit becomes erratic due to moisture, renew the desiccant crystals and cycle the instrument between room temperature (or lower) and +140 °F three or four times to flush the chamber air across the desiccant.

B. CALIBRATION

For maximum accuracy, the RO-2 should be calibrated at approximately the same temperature and air pressure as is expected for its use. If the conditions for calibration and for use are necessarily different, an offset may be used during calibration so that the instrument will read properly when put in use. Tables 2-1 and 2-2, Section II, may be used to select the proper offset in this case.

To calibrate, remove the calibration control locks and position the RO-2 so that the ion chamber is in a gamma field of known intensity. The effective center of the chamber is marked by case indentations. Adjust the calibration control (corresponding to the range switch position) for the proper meter indication. For best accuracy, choose a calibration field strength that will cause the meter to read around the four mark when calibrated. Repeat the procedure for all four ranges.

To avoid errors, the entire ion chamber of the RO-2 must be in the γ field when calibrating. The effective center of the chamber is marked by indentations at the front and sides of the case.

WARNING

The γ field intensities required for the complete calibration of the RO-2 are potentially hazardous to personnel. Observe proper precautions to prevent injury.

C. DISASSEMBLY

1. The cover assembly and the case may be separated by unfastening the front and rear latches and lifting the instrument from the case.

NOTE

The chamber face is very thin and easily damaged. If the case is to be off for an extended period, protect the face with cardboard or other covering.

CAUTION

Amplifier A1 is highly susceptible to damage from static charges. When the cover is removed, take care that no item, including batteries, be brought in contact with the RO-2 assembly that has not first been grounded to the chassis of the RO-2. Grasping the chassis of the RO-2 with one hand and touching the item concerned with the other should eliminate any static charge. Soldering irons must be clipped to the chassis prior to touching any part of the RO-2. For added protection when working on the instrument, remove batteries and clip chamber terminals 1, 3, 4, 7 and 8 (counting clockwise with the chamber face toward viewer) together. Remove the clips before re-installing batteries.

2. To remove the desiccant box, pull open the nylon retaining straps and slip the plastic tube off the pipe at the side of the chamber assembly.

3. To separate the chassis plate from the cover, remove the four screws at the corners of the chassis plate and lay the plate over to the side. With this done, access to the range switch, the calibration potentiometers, zero control, meter, and magnet swing arm are provided.

4. To remove the meter, remove the instrument handle, the wires to the meter, and the three screws in the meter bezel. This frees the meter.

5. To gain access to the detector electronics, loosen the two screws holding the chamber mounting brackets to the chassis plate. Rotate the chamber assembly slightly to allow the assembly to come free. Observe caution paragraph above. Cleanliness inside the chamber assembly is of the utmost importance.

6. The inside of the ion chamber can be reached by removing the ring which clamps the Mylar® face and then removing the face. Once the face is removed, the center electrode may be removed by unscrewing it from the center pin. If the pin starts to rotate, hold it with pliers in the electronic section.

7. Removal of the four screws in the corners of the slide holder on the bottom of the case will remove the slide and the holder.

D. REASSEMBLY

1. In general, for reassembly reverse the procedure used in disassembly.

2. The chamber face and the thin window under the slide are both 1-mil-thick (0.001-inch) aluminized Mylar® film. The window on the can is glued to the aluminum surface with electrically conductive adhesive, and the window on the chamber is clamped against a conductive rubber gasket so that proper electrostatic fields can be maintained, especially inside the chamber. If only one side of the Mylar® is aluminized, make sure that the aluminized side is toward the inside of the chamber in both cases. To replace the chamber face, lay the Mylar® over the rubber gasket and press on the clamp ring evenly to avoid large wrinkles. In very moist conditions it may be advisable to flush the chamber with dry nitrogen just prior to closing it with the face. If this is not done, it may be necessary to temperature cycle the unit later as described in part A of this section.

3. The magnet swing arm assembly should be adjusted so that it is against the right hand stop when the range switch is at *OFF* through *ZERO*, is against the left hand stop when the switch is at *5000* and *500*, and should be centered when the switch is at *50* and *5*. The magnet should just clear the meter insulators as it swings past. The swing arm operation is adjusted by moving its mounting bracket, moving the switch cam assembly, and by bending the arm where necessary. Make sure the magnet cannot contact the meter case under any conditions of movement.

E. TROUBLESHOOTING

The schematic diagram Figure 6-1, the system block diagram Figure 3-1, and Section III "Theory of Operation" are the primary aids to troubleshooting.

1. The instrument has no active electronic components except for amplifier A1. Then, the most likely sources of trouble would be the amplifier, a broken wire, poor batteries, or leakage in the high impedance areas of the chamber assembly.

2. If the meter remains pegged and will not zero when the *ZERO* position is selected, check for proper battery voltages. Try pressing the magnet down against the chassis plate to make sure that S2 is pulled in. Using the schematic Figure 6-1 as a guide, check for proper voltages at the chamber assembly terminals. Terminal 1 should be at plus battery voltage, terminal 2 should be slightly less negative than the negative battery voltage, terminal 3 should be ground, etc. If these voltages appear normal, but terminals 5 and 8 are of the same polarity, the amplifier is probably defective and should be changed. Observe how the old amplifier was installed and install the new one the same way.

3. Since the amplifier can be completely destroyed by as insignificant an act as touching it improperly, every possible precaution should be taken to make sure that all static charges are eliminated around the unit. Do not remove the shorting device shipped with the new amplifier until other shorting clips are in place. Leave the clips in place until the amplifier is soldered in. Then transfer the clip to the terminal or other place where the lead was soldered until installation is complete. Make sure that the soldering iron is grounded not only to instrument chassis ground but also to the shorting clip around the amplifier when soldering first starts.

4. High Impedance Components

Several components connect to the point in the circuit where the extremely minute ion chamber current flows. It is of utmost importance that they be clean, free of fingerprints, and carefully installed. They include pin 2 of A1, the two feedback resistors R1 and R2, and the two reed switches S2 and S3. The leads of these components are not supported on insulators. They are air insulated at all points. All wiring in the chamber assembly should be dressed away from the high impedance components.

If leakage currents appear to be a problem, make sure the silica gel in the desiccant box is dark blue. Temperature cycling, as described in the note in part A of this section, may correct the problem. The use of a high purity, mild, Freon® solvent spray to clean the high impedance components may help. Do not use alcohol spray since it will dissolve the aquadag coating used in the assembly.

REFERENCE DESIGNATION	VALUE	LOCATION ON SWITCH (TOP VIEW, METER FORWARD)
C4	33 μF	Front (upper)
C5	15 μF	Front (lower)
R4	1 MΩ	Right rear
R5	110k	Right rear
R6	430k	Left front
R7	430k	Right side
R8	68k	Left side

Table 4-1. Range Switch Component Locations

SECTION V
PARTS LIST

The following table lists the electronic items incorporated in the RO-2 and should contain any part necessary for normal electronic repair. Unless otherwise specified, callouts of manufacturers and manufacturers' part numbers are to be considered typical examples only. There are no 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
A1	Amplifier			ICAOC07463
BT1, BT2, BT3	Battery	NEDA 1604 Type	Eveready 216 or equivalent	BTCZ1
C1, C2	Capacitor	0.1 μF, 10%, 80 V	Sprague 192P1049R8	CPPF104P3O
C3, C4	Capacitor	33 μF, 10%, 10 V	CS13	CPTA330M3F
C5	Capacitor	15 μF, 10%, 10 V	CS13	CPTA150M3F
M1	Meter	20 μA		MTPA7
	Meter Face			ZP10472065
R1	Resistor	3×10^{12}, 10%	Victoreen RX-1 HI-MEG	REHV302G3X
R2	Resistor	3×10^{10}, 10%	Victoreen RX-1 HI-MEG	REHV300G3X
R3	Potentiometer	5k, 10%, Linear	AB JAID040S502UA	PTCC502B05
R4	Resistor	1M, 5%, 1/4 W		RECC105B22
R5	Resistor	110k, 5%, 1/4 W		RECC114B22
R6, R7	Resistor	430k, 5%, 1/4 W		RECC434B22
R8	Resistor	68k, 5%, 1/4 W		RECC683B22
R9, R10, R11, R12	Potentimeter	100k, 10%	AB WA2M028S104UA	PTCC104B13
S1	Rotary Switch			SWR036 ZP10603039
S2, S3	Reed Switch		Hamlin MARR-15-17.5/22.5	SWRD1
		Desiccant, Indicating Silica Gel	No. 6-16B Eagle Chemical Co. P.O. Box 107 Mobile, Alabama 36601	HDMI103
		Conductive Coating Aquadag Dispersion	No. 154 Acheson Colloids Co. Port Huron, Michigan 48060	
		Conductive Adhesive 2 part	Tecknit 72-00008X	HDMI137
		Aluminized Mylar® 1-mil-thick (0.001-inch) Aluminized on both sides	Alexander Vacuum Type C14 Greenfield, MA 01301	MMMY6

SECTION VI
DIAGRAMS

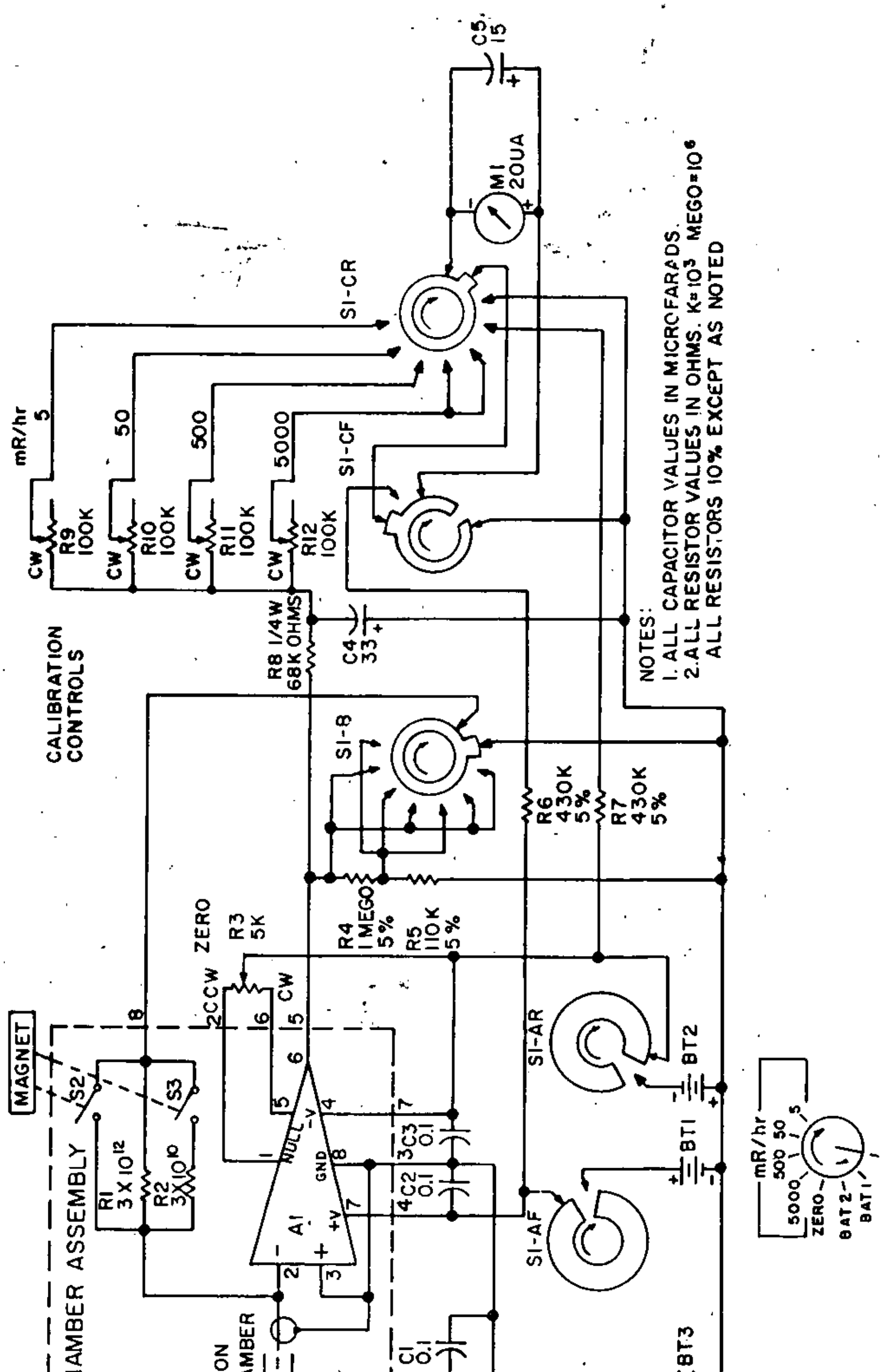

Figure 6-1, RO-2 General Schematic, (10603-B24G)

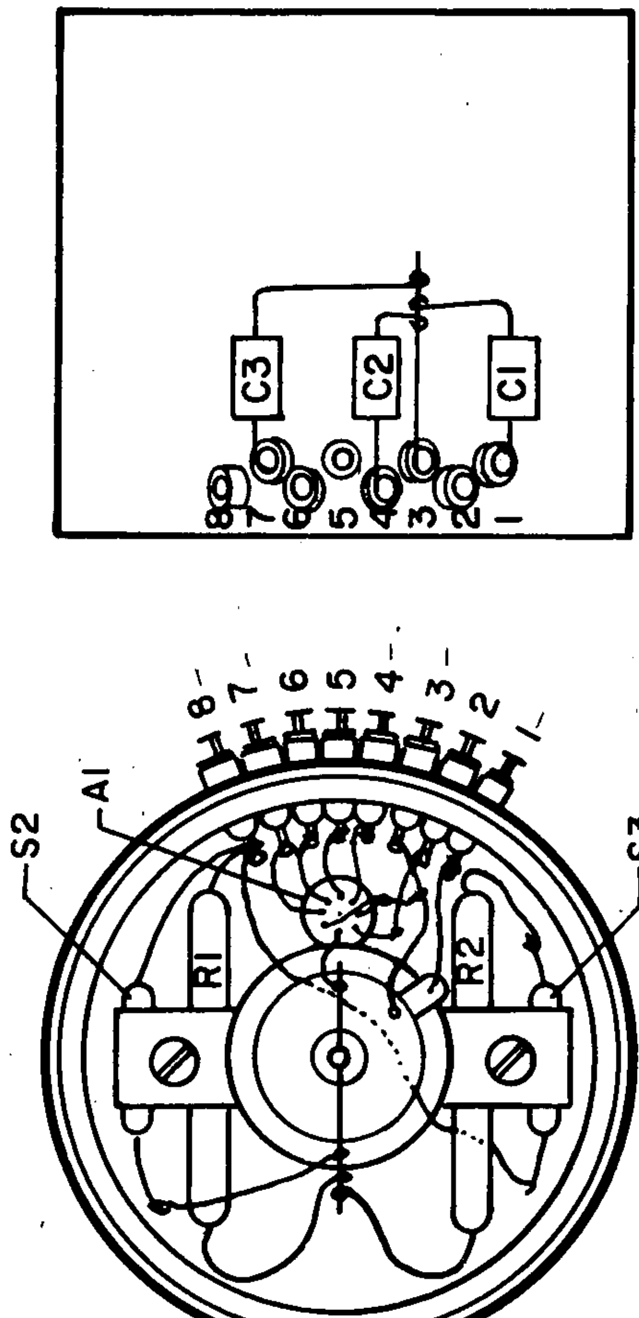

Figure 6-2. Model RO-2 Chamber Component Layout (10603-A63)