

RO-20 AA Ion Chamber



REVISIONS SHEET:

Rev.	Rev. State	Dept. resp.	Name	Rev. page	Cat. *)	Explanation

*) Category C: editorial correction
I: clearing improvement
A: substantial amendment

Explanations must be given, at least with Category A.

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WEEE Compliance:

This product is required to comply with the European Union’s Waste Electrical & Electronic Equipment (WEEE) Directive 2002/96/EC. It is marked with the following symbol:



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1. Introduction

1.1 Instrument Description

The Model RO-20 Ion Chamber (Figure 1-1) is a portable air ion chamber instrument used to detect beta (β), gamma (γ) and x-ray radiation.

The RO-20 has five linear ranges of operation to measure exposure rate for x-ray and gamma radiation. The ion chamber is vented to atmospheric pressure.

The RO-20 is calibrated to γ radiation (^{137}Cs).

A single rotary Function Switch turns the instrument off, provides battery checks, checks the Zero setting, and selects the range of operation.



Figure 1-1: Model RO-20 Ion Chamber

1.2 Measuring Units

The RO-20 has the ranges labeled in exposure rate R/h.

The ranges are 50 R/h, 5 R/h and 500mR/h, 50mR/h, 5 mR/h.

The RO-20 chamber is designed to have a flat energy response in roentgen units.

Use the procedure given in this manual for calibration of the instrument. The calibration controls on the main circuit board are marked from 5 through 50 k, which corresponds to the 5 ranges (expressed in R/h).

1.3 Detector Specifications

1.3.1 Size

2.84-inch inside diam, 13.4 in³ volume (7.21 cm diam, 220 cm³).

1.3.2 Fill

Air, vented to atmospheric pressure.

1.3.3 Wall

0.20 in. (0.51 cm) conductive plastic approximately 640 mg/cm² inside
0.063-in. wall aluminum case, making approximately 1000 mg/cm² total thickness.

1.3.4 Window

Two layers (one on the chamber, one on the can) 0.001-in. (25 micron) mylar, approximately 7 mg/cm² total.

1.3.5 Beta Shield

Sliding shield on bottom of case with positive friction lock. Approximately 1000 mg/cm² (5/16 in. phenolic).

1.3.6 Radiation Detected

Beta, gamma and x-ray.

1.3.7 Photon Energy Response

The nominal photon energy response is shown in [Figure 1-2](#).

In the following examples, the RO-20 had been calibrated to ^{137}Cs (slide closed), with the slide facing the source.

- $\pm 30\%$ from 8 keV to 1.3 MeV, with the open slide facing the source.
- $\pm 15\%$ from 33 keV to 1.3 MeV, with the closed slide facing the source.
- $\pm 15\%$ from 55 keV to 1.3 MeV, through the side of the instrument.

1.3.8 Examples of Beta Response

- Uranium slab: 30% of true mrad/h field behind 7 mg/cm^2 window, with the RO-20 resting on the slab (slide open).
- ^{90}Sr - ^{90}Y : Approximately 93% of true mrad/h field at 30 cm with slide open.

1.3.9 Fast Neutron Response (PuBe)

Reads approximately 8% in mR/h of true neutron field in mrem/h.

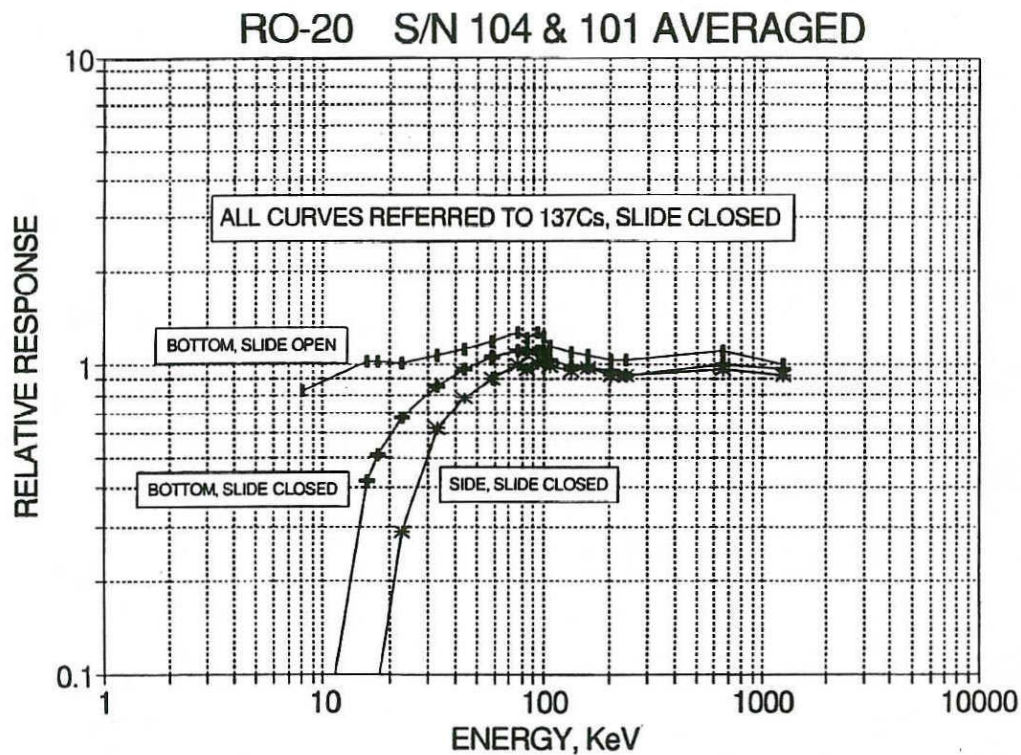


Figure 1-2: Nominal photon energy response

1.4 General Specifications

1.4.1 Ranges Five linear ranges

- 0–5 mR/h
- 0–50 mR/h
- 0–500 mR/h
- 0–5 R/h
- 0–50 R/h

1.4.2 Meter

- Scale length: Approx. 3 in. (7.6 cm)
- 2% accuracy.
- Linear markings: From 0 to 5 in 50 minor increments.
- Back-lighted.

1.4.3 Response Time

Five seconds, 0 to 90% of final reading.

1.4.4 Linearity

- Within $\pm 5\%$ of full scale
- Battery Dependence (**Within $\pm 5\%$**)
- The reading is independent of battery voltage when the battery check indications are in the green arc. In order to achieve, but linearity in the 50R/h Range, it is recommended to exchange the 3 ea 12 Volt batteries (indicated by “Battery 2”) once the needle falls below “4.0”.

1.4.5 Controls

1.4.5.1 External

- Function Switch with Off, Zero, and Battery checking positions.
- The Zero Knob is used to set the meter to zero when the Zero position of the Function Switch is selected, or when the detector is not in a significant radiation field.

- Light Switch, for meter light.

1.4.5.2 Internal

- Five calibration controls, one for each range.

1.4.6 Batteries

- Main power: Five AA cells.
- Chamber bias: 3 ea 12V alkaline batteries = 36V.
- Life: AA cells, widely variable according to RO-20 usage and battery type.
- Typical alkaline: mR/h ranges, 2500 hrs; all other positions, 130 hrs.
- 36 Volt chamber bias battery life: Totally dependent upon the usage of the “Battery 2” position of the range switch. The battery capacity should allow for at least 50,000 five-second battery checks. The battery drain is negligible on all other positions of the Function Switch.

Note: Frequent or continuous use of the light will reduce battery life significantly. ▲

1.4.7 Environment

1.4.7.1 Temperature

Operable from –40 °F to 140 °F (–40 °C to 60 °C). For operation below 0°F (–18 °C), alkaline or nickel-metal-hydride AA cells should be used.

1.4.7.2 Temperature Compensation

The detector is fully compensated over the operational temperature range, for output accuracy within $10\% \pm 0.5$ mR/h.

1.4.7.3 Moisture

Seals used at openings for dust and water resistance. Detector is protected by a silica-gel desiccant.

1.4.7.4 Humidity

Operable from 0 to 95%, no condensing.

1.4.7.5 Weight

Approximately 3.6 pounds (1.63 kg) with alkaline AA cells.

1.4.7.6 Size

4.2 in. wide x 7.9 in. long x 7.7 in. high (10.7 cm x 20.1 cm x 19.6 cm), including handle.

2. Operation

2.1 Description of Controls

2.1.1 Function Switch

The function switch is a nine-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.

2.1.2 Zero Knob

The Zero Knob is used to set the meter to zero when the Zero position of the Function Switch is selected or when the detector is not in a significant radiation field ($< 30\mu\text{R/h}$).

2.1.3 Light Switch

The Light Switch illuminates the meter. It has three positions: Off, Momentary and On.

2.1.4 Calibration Controls (Internal)

Five variable resistors, one for each range, provide internal calibration controls.

2.2 Using the Instrument

The higher radiation field strengths measurable by the RO-20 can cause personal injury in a short time.

Before using the instrument check Battery 1 (AA cells) and Battery 2 (12V alkaline cells). The meter should indicate in the green Battery Check arc. Do not leave the Function Switch in the Battery 2 position for an extended period.

Turn the Function Switch to the Zero position. Check that the meter reads "0." If not, set it to '0' with the Zero Knob.

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

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, press 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.

2.3 Operation the Instrument

2.3.1 Checking the Zero Setting

The zero setting of the RO-20 may be checked in any radiation field by selecting the Zero position of the Function Switch.

If a minor offset from zero exists on the most sensitive range when in a known insignificant field, the Zero Knob may be used to remove the offset. Zero need not be reset when using the higher ranges.

2.3.2 Minimizing Deflection

When switching from the R/h ranges to the mR/h ranges, transient noise may cause a temporary deflection of the meter. The deflection can be minimized by first selecting 500 mR/h, letting the needle settle, and then switching to the lower ranges.

2.3.3 Ion Chamber

The effective center of the ion chamber is marked by dimples at the front and sides of the RO-20.

Because the ion chamber is vented to the atmosphere, it is sensitive to changes in atmospheric pressure. [Table 2-1](#) and [Table 2-2](#) give correction factors to be applied if the RO-20 is used at an elevation other than the elevation at which it was calibrated. Normal atmospheric pressure variations at one location are small enough to be ignored.

The chamber output signal is fully temperature compensated. No additional temperature correction is necessary.

2.3.4 Radiation Overexposure

The RO-20 will not be damaged by exposing it to radiation fields that exceed the full-scale level. Extreme overexposure may cause a minor shift of the Zero position and a small temporary offset on the most sensitive range. Resetting the Zero Knob may be necessary.

2.3.5 Electronic Circuitry

The chamber bias battery holds the electronic circuitry at 36 volts negative with respect to chassis potential. Do not short any part of the circuitry to the chassis parts or damage may occur.

Table 2-1: Altitude Corrections in Feet ⁽¹⁾

		Altitude When Calibrated										
		Sea level (ft)	1000'	2000'	3000'	4000'	5000'	6000'	7000'	8000'	9000'	10,000'
Altitude when used	Sea level (ft)	1	0.96	0.93	0.90	0.86	0.83	0.80	0.77	0.74	0.71	0.69
Altitude when used	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

(1) Multiply reading in feet by correction factor shown.

Table 2-2: Altitude Corrections in Meters ⁽²⁾

		Altitude When Calibrated													
		Sea level (m)	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	3250
	Sea level (m)	1	0.97	0.94	0.91	0.89	0.86	0.83	0.81	0.78	0.76	0.73	0.72	0.69	0.67
Altitude when used	250	1.03	1	0.97	0.94	0.91	0.89	0.86	0.83	0.81	0.78	0.76	0.74	0.72	0.69
	500	1.06	1.03	1	0.97	0.94	0.91	0.89	0.86	0.83	0.81	0.78	0.76	0.74	0.72
	750	1.10	1.06	1.03	1	0.97	0.94	0.91	0.89	0.86	0.83	0.81	0.78	0.76	0.74
	1000	1.13	1.10	1.06	1.03	1	0.97	0.94	0.91	0.89	0.86	0.83	0.81	0.78	0.76
	1250	1.16	1.13	1.10	1.06	1.03	1	0.97	0.94	0.91	0.89	0.86	0.83	0.81	0.78
	1500	1.20	1.16	1.13	1.10	1.06	1.03	1	0.97	0.94	0.91	0.89	0.86	0.83	0.81
	1750	1.24	1.20	1.16	1.13	1.10	1.06	1.03	1	0.97	0.94	0.91	0.89	0.86	0.83
	2000	1.28	1.24	1.20	1.16	1.13	1.10	1.06	1.03	1	0.97	0.94	0.91	0.89	0.86
	2250	1.32	1.28	1.24	1.20	1.16	1.13	1.10	1.06	1.03	1	0.97	0.94	0.91	0.89
	2500	1.36	1.32	1.28	1.24	1.20	1.16	1.13	1.10	1.06	1.03	1	0.97	0.94	0.91
	2750	1.40	1.36	1.32	1.28	1.24	1.20	1.16	1.13	1.10	1.06	1.03	1	0.97	0.94
	3000	1.44	1.40	1.36	1.32	1.28	1.24	1.20	1.16	1.13	1.10	1.06	1.03	1	0.97
3250	1.49	1.44	1.40	1.36	1.32	1.28	1.24	1.20	1.16	1.13	1.10	1.06	1.03	1	

(2) Multiply reading in meters by correction factor shown.

3. Theory of Operation

3.1 General Theory

Figure 3-1 and Figure 3-2 show the basic operation of the circuit. The ion chamber structure is maintained at chassis potential while all the other circuitry is held at -36 volts by the 3 ea 12-volt bias batteries. When the air in the chamber ionizes due to radiation, a minute current flows from the chamber wall to the center electrode, causing the minus input lead of the first operational amplifier to go very slightly positive. This change results in a negative swing of the amplifier output, which is connected to the feedback elements through a temperature-compensating divider circuit.

The feedback elements are connected to the amplifier input and to the ion chamber, and they conduct away all of the current generated in the ion chamber. The second amplifier stage, which is fed from the first amplifier, drives the meter through calibrating adjustable resistors. The gain of the second stage is controlled by the Function Switch so that the full scale output from the second stage is nearly constant for all ranges.

A common line is used as a reference for all the electronic circuits. This common line is held approximately 36 volts negative with respect to the instrument chassis.

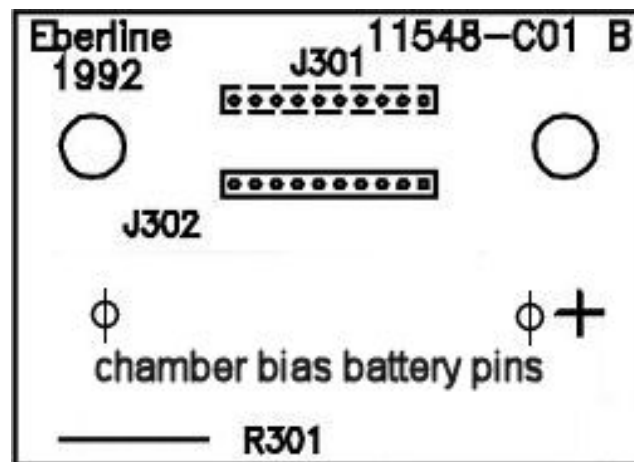


Figure 3-1: Connector board component layout

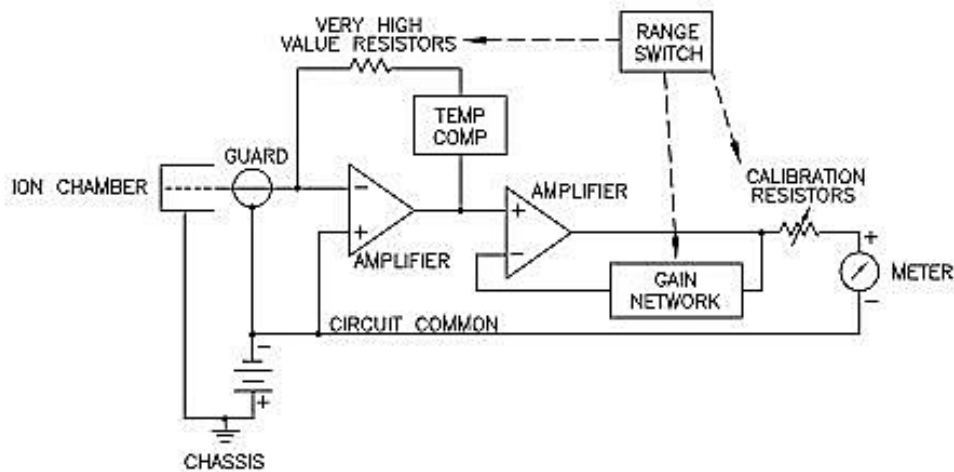


Figure 3-2: Basic operation of the circuit

3.2 Functional Theory

3.2.1 Ion Chamber

The ion chamber is located inside the case below the meter. It consists of the lower two inches of the 3-in.-diam chamber assembly. The remainder of the volume contains electronic components. The chamber wall is 0.20 in. (0.51 cm) thick conductive plastic, and the face is one-mil (25 micron) aluminized Mylar. Another one-mil Mylar layer is glued to the bottom of the case, making the total thickness two mils, a total of approximately seven mg/cm². The active volume of air in the chamber is approximately 220 cm³.

The entire chamber, which is made of conductive plastic, is maintained at chassis potential. The inside of the Mylar face is also at the same voltage. The center electrode is coated with conductive graphite 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 outer ring, to prevent leakage from the chamber voltage to the center electrode. The guard ring and center electrode are maintained at the same (common) potential to prevent leakage from the guard to the electrode.

The chamber is sealed but vented through a plastic tube to a silica gel desiccant package. A small hole connects the chamber to the electronic section above the chamber. In this way, any air drawn into the chamber (e.g., as the result of atmospheric pressure changes, temperature changes, or air transport of the RO-20) must first pass over the desiccant. Dry air in the chamber is essential to help prevent current leakage.

An idealized air chamber, the size of the one used on the RO-20, produces a little over 2×10^{-14} amps per mR/h at the standard temperature and pressure of 0 °C and 760 mm of Hg. At 5 mR/h, it should produce 1×10^{-13} amps and at 50 R/h it should produce 1×10^{-9} amps. It is seen that at full scale on the most sensitive range (5 mR/h), about one-tenth of a micro-microamp is produced in the chamber, which makes protection against leakage currents paramount.

Note The silica gel desiccant should be changed as soon as it shows clear or pink crystals.

The amount of ion current produced depends upon the intensity of the radiation field and the density of the air in the chamber. The density depends on the temperature and pressure of the air. A temperature-sensing compensation circuit corrects for the change in ion current due to temperature changes, leaving only the pressure effects to be considered external to the instrument. [Table 2-1](#) and [Table 2-2](#) show correction factors that are useful when the elevation at calibration is different from the elevation during usage. Normal atmospheric pressure variations at any one location are small enough to be ignored.

A voltage gradient must exist across the ion chamber to move the ions and produce the ion current to be measured. All of the chamber structure is maintained at chassis potential, but the center electrode disk and all the remaining circuitry is biased at -36 volts relative to the chassis. Three 12-V alkaline batteries provides this voltage. Except for insulation leakage and the very few microamps taken during battery check, the alkaline battery (3ea 12V) is essentially open circuited and will last indefinitely.

3.2.2 The Circuit

The first stage of operational amplifier A101 is connected to the ion chamber. (See [Figure 3-3](#) and [Figure 3-4](#).) Also connected to the chamber are the elements in the feedback loop, consisting of two high-value resistors, a reed relay, and a capacitor. The switching in the loop is done by two reed relays. One of the relays is used to short out the components so that any voltage offset may be adjusted out with the Zero Knob. That relay is closed when in the two battery-check positions (to provide maximum battery load), and in the Zero position of the Function Switch. It is open in the other Function Switch positions

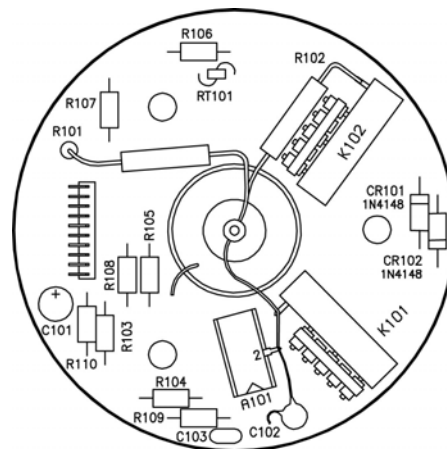


Figure 3-3: Detector board component layout

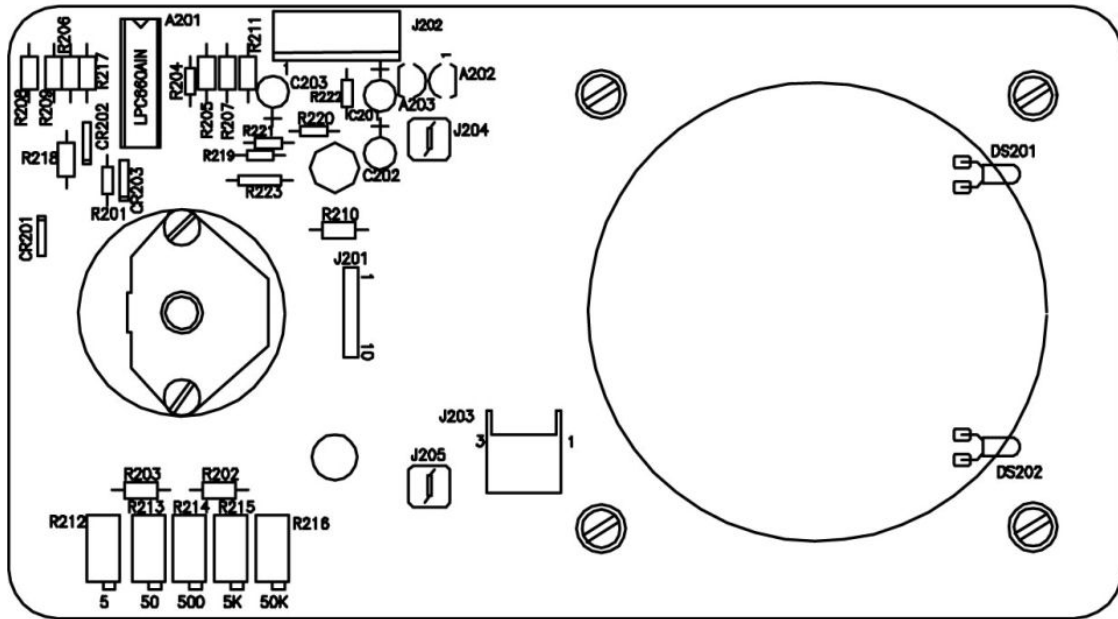


Figure 3-4: Main circuit board layout

When operating on the two R/h ranges, K102 is pulled in to place R102, the 1.5-gigohm resistor, in the circuit. The higher ion currents develop sufficient voltages for operation with this smaller resistor. When using the mR/h ranges, both relays are open, leaving R101 (the 150-gigohm resistor) as the feedback element. The feedback signal to the two high-value resistors comes from the temperature compensation circuit made up of R105, R106, R107 and RT101. C102 is a time-constant component used to set the response time.

The relays consume about 10 times more power than the total of the rest of the circuits, with the exception of the lamps. Because no relays are pulled in on the three mR/h ranges, the battery life is very long if only these ranges are used.

The second stage of A101 amplifies the output of the first stage and then drives the meter circuit. The gain of the second stage is set according to the Function Switch position. Each range has a separate calibration control, an adjustable resistor in series with the second stage output. This circuit then feeds the meter directly through the Function Switch. The Zero Knob provides a slight voltage offset adjustment to the input of the first stage of A101. The amplifiers are DC-coupled and this adjustment is reflected at the meter.

Component A203 is a 5-volt regulator whose output is connected to A202, a component called a *rail splitter*. It produces a voltage exactly one half of that which is impressed across it. The voltage it produces is called *common* and this potential is used as a reference for the rest of the electronic circuits. The negative end of the three 12V batteries is connected to common, holding common 36 volts negative with respect to the chassis. The positive terminal of the meter is connected directly to common so all meter upscale indications must come from a source more negative than common. When checking the AA cells, amplifier A201-8,9,10 is used to reflect the opposite polarity of the AA cell battery's positive end. When checking the three 12V batteries, amplifier A201-12,13,14 is used to reflect the opposite polarity of the input from the more positive chassis potential.

Amplifier A201-1,2,3 is used to hold the relay coils at common potential whenever the relays are not actuated, helping reduce leakage currents when using the mR/h ranges. Amplifier A201-5,6,7 provides a slow reduction of relay coil current when switching to the mR/h ranges in order to minimize transients.

4. Maintenance

4.1 Preventive Maintenance

Refer to [Figure 4-1](#) while performing the procedures described in this chapter

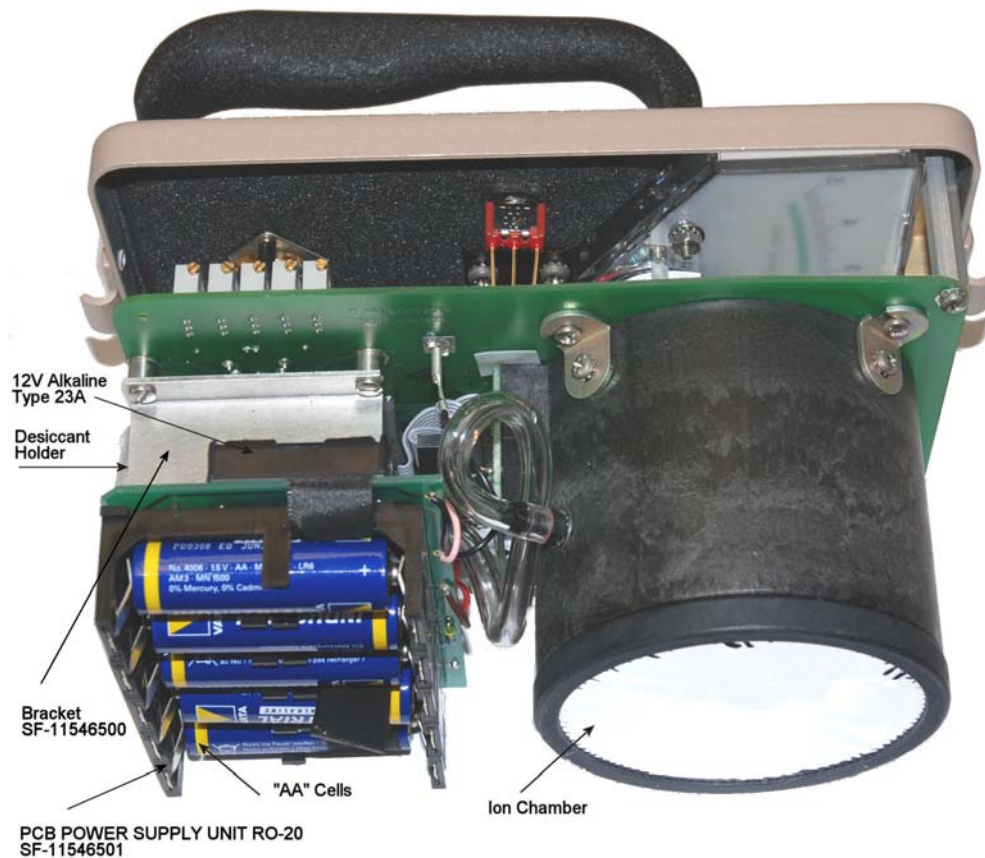


Figure 4-1: Interior View, RO-20

4.1.1 Batteries

Replace the AA cells when Battery 1 check indicates near the left end of the meter's green arc.

Replace the 12V alkaline batteries when Battery 2 check indicates the needle is left "4" in the meter's green arc.

Note The 12V alkaline cells should last several years. They run down exceedingly slowly. ▲

Observe the polarity indicators when installing the batteries.

Remove the AA cells if the instrument is to be inactive for a long period of time.

Caution Many instruments contain alkaline, carbon, lead, nickel cadmium or lithium batteries. All batteries contain small amounts of heavy metals and other hazardous materials and must be handled and disposed of properly. Lithium batteries present fire, explosion and severe burn risk hazards. Do not expose the cell contents to water. Recharge only batteries specifically designated as rechargeable and follow the manufacturers recommendations on recharging. Do not puncture, mutilate or attempt to disassemble, incinerate or heat above 100 °C (212 °F). Thermo Fisher Scientific recommends that all batteries be recycled at appropriate licensed recycling centers or disposed of as required by local ordinances and regulations. ▲

4.1.2 Desiccant

Replace the desiccant package when the crystals begin to turn clear or pink in color. Slip the hose from the fitting on the old desiccant pack and onto the new one.

The used silica gel crystals can be repeatedly dried by heating them to 250 °F (120 °C) for 12 hours or to 400 °F (205 °C) for one hour.

Keep dried crystals in tightly sealed containers until ready for use. The snap-on cap of the desiccant package has a small hole in it to allow the air to move through it. Make sure this hole is not covered or clogged.

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 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. ▲

4.1.3 Calibration

For maximum accuracy, the RO-20 should be calibrated at approximately the same 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 to use. [Table 2-1](#) or [Table 2-2](#) can be used to select the proper offsets in this case. Interpolate where appropriate.

To calibrate,

1. Select the Zero position on the Function Switch and zero the meter.
2. Remove the plastic cover on the side of the can and position the RO-20 so that the ion chamber is in a gamma field of known intensity.
3. Adjust the calibration control (corresponding to the Function Switch position) for the proper meter indication.
4. For best accuracy, choose a calibration field which will cause the meter to read near the "4" mark when calibrated.
5. Repeat the procedure for all five ranges.
6. Reinstall the plastic cover in the side of the can when finished.

Note To avoid errors, the entire ion chamber of the RO-20 must be in the gamma field when calibrating. The effective center of the chamber is marked by indentations at the front and sides of the case. ▲

Caution The higher radiation field strengths required for calibration of the RO-20 can cause personal injury in a short time. Use safe procedures. ▲

4.1.4 Circuit Checks

- Flip the light switch in both directions and observe that the lamps are functional.
- Select Battery 1 position on the Function Switch and measure the voltage of the AA cells. The meter should indicate battery voltage multiplied by 0.6, within 5%.
- Select Battery 2 position of the Function Switch and measure the voltage of the 3 ea 12V alkaline batteries. The meter should indicate battery voltage multiplied by 0.114, within 5%.

4.1.5 Disassembly

The lower case can be separated from the assembly by unfastening the front and rear latches and lifting the instrument from the case.

The chamber face is very thin and easily damaged, and should be protected with a covering when the case will be turned off for an extended period.

Static-sensitive components are used on both the main circuit board and on the chamber board. Use grounding procedures to eliminate static charges when working on the RO-20.

Caution The three 12V alkaline batteries holds the circuit components at 36 volts negative with respect to the chassis. Never short any circuit point to chassis or damaged components may result.

To remove the chamber face:

1. Pry off the clamp ring and lift off the face.
2. To remove the chamber assembly, push the desiccant package toward the rear and separate the hose from the desiccant package.
3. Loosen (or remove) the four screws holding the chamber and rotate it until it is free.
4. Unplug the cable from the chamber. When the chamber's electronic section is exposed, it is best to short the center pin of the guarded feedthrough to the guard ring to prevent static damage to the amplifier.

Caution Never short any part of the chamber circuit to the chamber body or damage to the components may result. ▲

To remove the small battery/connector board from the chamber:

1. Remove the two screws and gently pull the board from the chamber.
2. As soon as the cable connector can be reached, hold it and unplug it from the connector board. (Handle the cable gently.)
3. Remove the board.

To remove the center electrode disk from the chamber:

1. Gently unplug the cable between the chamber board and the small battery board. Unplugging the cable removes the 36-volt bias between the disk and the chamber walls.
2. With pliers, hold the center pin in the electronics section to keep it from turning and unscrew the disk. Two small holes in the disk are provided to help rotate it.

To remove the chamber board assembly:

1. Gently unplug the cable that connects the assembly to the battery board.
2. Unsolder the connections to the guarded feedthrough assembly.
3. Remove the three nuts holding the board and lift it out.

To complete disassembly of the chamber:

1. Remove the three nuts and screws holding the metal cup in place.
2. Lift out the cup and the insulating disk. The three nylon shoulder washers may be pushed out if desired.
3. Unscrew the guarded feedthrough to finish the disassembly.

To remove the battery board and bracket assembly:

1. Remove the batteries (AA cells and 12V cells) and remove the desiccant package.
2. Unplug the two main board connections and unsolder the two wires from the chamber bias supply.
3. Remove the four screws holding the chassis to the board spacers and lift it off.

To separate the main board from the cover:

1. Unplug the cable between the board and the cover.
2. Remove the Knob from the Function Switch and remove the nut from the switch bushing.
3. Remove the two screws from the long standoffs at the front of the board and pull the cover and the board apart. The light switch pins will slip out of the connector.

To remove the meter:

1. Unsolder the wires from it.
2. Remove the two nuts and washers and remove the two long hexagon shaped spacers at the front.
3. Remove the meter retainer and lift out the meter.
4. The slide, the slide holder and the feet may be removed from the can by removing the four nuts and screws which hold them.

4.1.6 Reassembly

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

The aluminized Mylar face on the bottom of the can is one mil (.001 in., 25 microns) thick. It is glued to the can using electrically conductive adhesive. If only one side of the Mylar is coated with aluminum, that side must be positioned against the can.

The slide is not completely symmetrical. When properly installed, the front edge of the slide is even with the edge of the slide holder when the slide is fully closed. When the slide is fully opened, the back of the slide sticks out past the back of the holder.

Adjust the slide release mechanism so that a slight movement of the release button will free the slide. The adjustment is made by moving the two stop nuts (which press against the spring) up or down on the long screw which presses against the slide.

To install a meter, slip it over the studs in the cover, put on the flat washers and the lock washers, and tighten the nuts **lightly** to prevent fracturing the meter plastic. Place the meter retainer over the studs at the front of the meter and, while pressing the retainer back against the meter, tighten the hex spacers on the studs.

When reassembling the cover and main board together, guide the three Light Switch pins into the mating connector. When installing the knob on the Function Switch, make sure it is oriented properly.

The following steps may be used as a guide to resassembling the chamber :

1. Screw in the guarded feedthrough from the top of the chamber assembly.
2. Press the three nylon shoulder washers into the holes in the chamber plate. The widest washer diameter must be on the chamber side.
3. Insert the three screws from inside the chamber up through the nylon washers. Hold them in place.
4. Place the insulating disk over the three screws.
5. Place the metal cup over the three screws. Make sure the opening matches the opening in the chamber.
6. Install lock washers and nuts on the screws. Tighten firmly.
7. With an ohm meter, check that a complete open circuit exists between the metal cup and the body of the chamber.
8. Screw the center electrode disk onto the center pin of the guarded feedthrough. The small diameter hub goes toward the electronic section. Hold the center pin with a pair of pliers and tighten the disk.
9. Install the chamber circuit board and fasten it with lock washers and nuts. Solder in the connections to the guarded feedthrough.
10. Gently plug the cable onto the battery/connector board and fasten the board to the chamber with the screws and lock washers.
11. Use one-mil (0.001 inch, 25 micron) aluminized Mylar for the chamber face. If only one side has aluminum on it, make sure that side is toward the inside of the chamber. Lay the Mylar on the chamber and slip the clamp ring over it, making as smooth a face as possible.

4.1.7 Troubleshooting

The system block diagram shown in [Figure 3-2](#), the general schematic diagram shown in [Figure 4-2](#), and [Chapter 3: “Theory of Operation”](#) are the primary troubleshooting aids.

Check the batteries. The RO-20 has only four active circuit components, amplifiers A101 and A201, the voltage regulator A203 and the reference divider A202. A quick check with a voltmeter will determine whether the outputs of A203 and A202 are proper. The two amplifiers are in sockets for easy substitution. (Pin 2 of A101 is bent outward to avoid touching the socket. Pin 2 is solder-connected; Pin 2 or a new component must be reinstalled the same way for air insulation.)

If substituting new amplifiers does not solve the problem, then track the circuit functions to find the fault. Several components connect to the point in the circuit where the extremely small ion chamber current flows. It is of the utmost importance that they be clean, free of fingerprints, and carefully installed. They include Pin 2 of A101, the two feedback resistors R101 and R102, relays K101 and K102, and C102. The critical leads of these components are not supported on insulators. They are air-insulated at all points.

If leakage currents appear to be a problem, make sure the desiccant is dark blue. Temperature cycling may correct the problem. It may help to use a high-purity, mild Freon solvent spray to clean the high-impedance components. Do not use alcohol spray on the center electrode disk because it will dissolve the conductive Aquadag® coating.

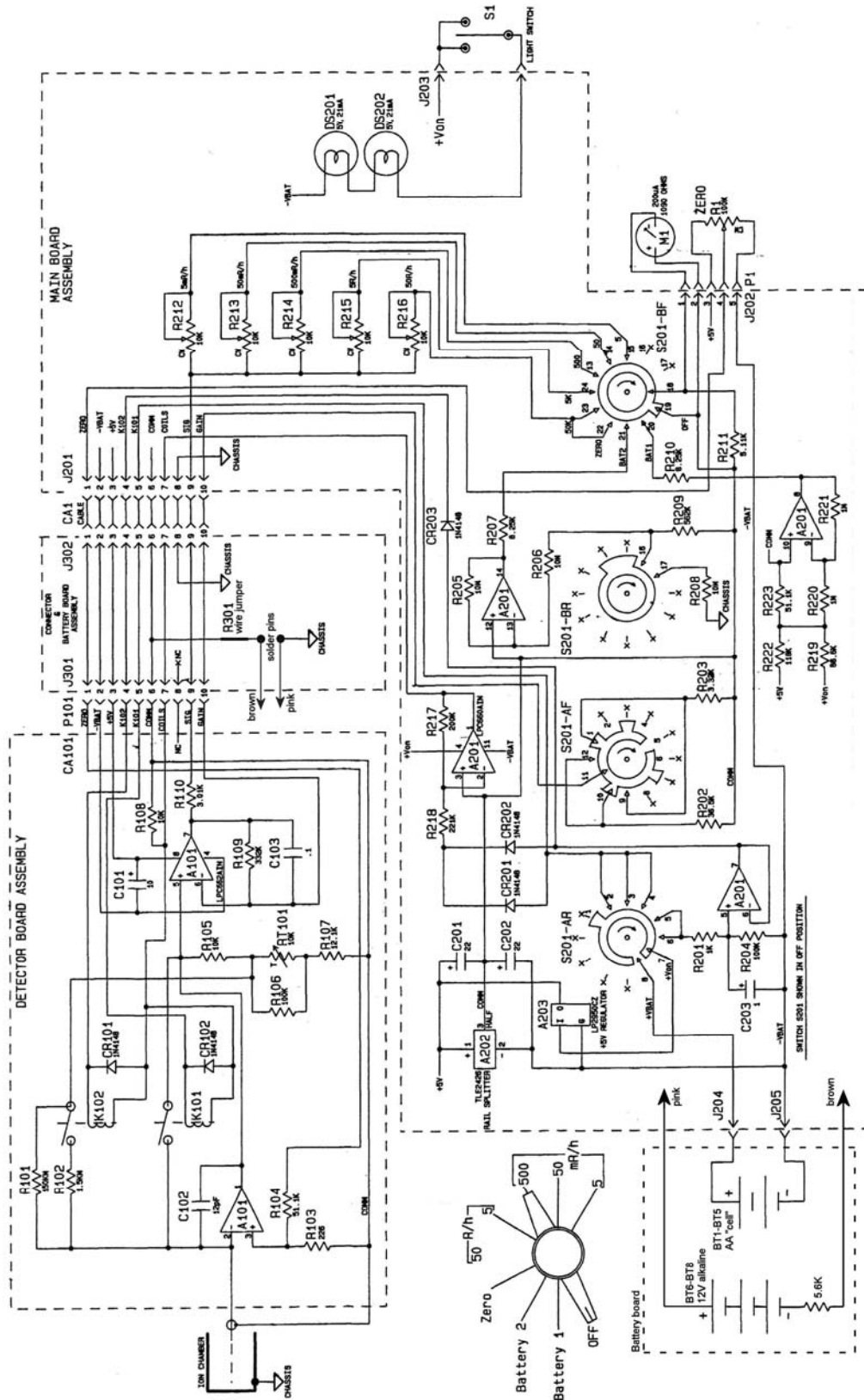


Figure 4-2: General schematic

5. Appendix A - Electronics and Parts List

Table 5-1 lists the electronic items incorporated in the RO-20, and the parts required for normal electronic repair.

When ordering parts from Thermo Fisher Scientific, specify instrument model number, serial number, reference designation, value, and Thermo Fisher Scientific part number.

Table 5-1: RO-20 Electronics and Parts

Part No.	Description
	5 ALKALINE AA-SIZE BATTERIES
	3 ALKALINE 12V BATTERIES FOR CHAMBER BIAS
SF-11546501	1 PCB POWER SUPPLY UNIT RO-20
HDKN25	RANGE KNOB
HDKN4	ZERO KNOB
ICAOALMC662	DUAL MOS INPUT LMC662AIN
MMRU7	RUBBER FEET
MTPA35	METER ASSEMBLY
REHV151G3X	1.5X10/11(150G) OHM 5%
REHV158B2X	1.5X10/9(1.5G) OHM 5%
RLRD1	READ SWITCH
SWRO57	RO20 ROTORY SWITCH
SWTO39	TOGGLE SWITCH
VECA10	FLAT CABLE
YP11498021	RO-20 DESSICANT ASSY, SEALED
YP11500017	RO-20 ION CHAMBER ASSEMBLY
YP11546002	RO-20 MAIN PC BOARD ASSEMBLY
YP11548007	RO-20 CONN/BATTERY BOARD ASSEMBLY

YX11502001	RO20 CAN ASSEMBLY WITH NO CAL HOLE
ZP10448011	HANDLE POWDERCOATED
ZP10894010	RO-20 ZERO KNOB GUARD
ZP11498003	RO20 COVER, PAINTED w/o OVERLAY
ZP11498012	GASKET, COVER, RO-20
ZP11498014	COVER OVERLAY, RO-20
ZP11502004	RO-20 SLIDE

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