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REMOTE READING INSTRUMENT
FOR FALLOUT SHELTERS

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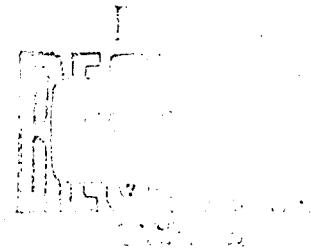


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REMOTE READING RATEMETER
FOR FALLOUT SHELTERS

CONTRACT OCD-OS-62-272

This report has been reviewed in the office of Civil Defense and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Office of Civil Defense.

FINAL REPORT

REMOTE READING RATEMETER

SCOPE: To develop a simple low-cost remote reading ratemeter with a gamma range to 1000 r/hr for use with small fallout shelters. The design objective will be low-cost, small size, light weight, ease of calibration, simplicity of operation, reasonable ruggedness and long shelf life. Remote capability to 100 feet is desired.

INSTRUMENT DESIGN

DISCUSSION: In order to accomplish the above we have evaluated in detail several possible systems for each of the major sub-assemblies, (the readout and power supply unit, the detector and detector housing and the interconnecting cable). The readout and power supply unit have been considered both electrically and mechanically to determine the best possible system of measurement, as well as the most practical method of construction and the best form factor. In the detector, and detector housing, primary emphasis has been placed on ionization chamber performance and the mechanical ruggedness of its housing. Various cables and insulating materials have been evaluated to determine their suitability in an application of this type.

CIRCUIT DESIGN: Since it is desired to have a maximum range of 1000 r/hr, it was decided a four range instrument covering the decades 0-1, 0-10, 0-100 and 0-1000 r/hr would be most suitable. The function of the instrument is similar to that of the CD V-717 with the detector on the end of 100 feet of cable. The circuits used are similar to those used in the CD V-717. The first measurements were made with a circuit consisting of a CK 5886 tube driving a meter. It is found that the necessary sensitivity is obtained if a resistor of 10^{11} ohms is used on the 0-1 r/hr range. Using a

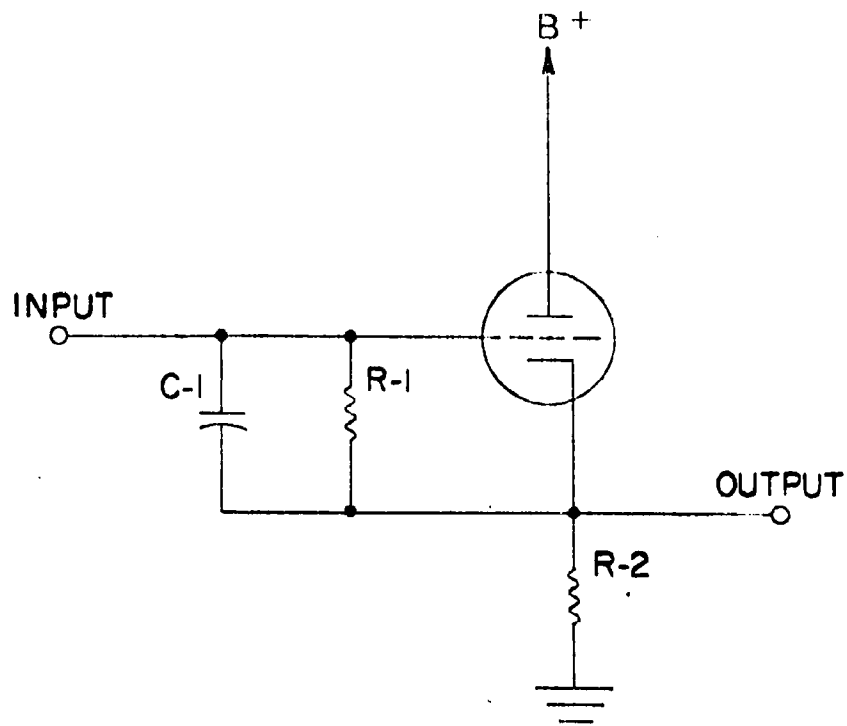
cable which has a capacitance of 30 uuf per foot, an RC time constant of 5 minutes is obtained. A minimum time of 15 minutes is required to reach 95% of final reading. Measurements indicate that this time can, under certain conditions, exceed 1/2 hour. This magnitude of response time would considerably reduce the usefulness of the instrument, particularly since a zero drift of 3 percent per hour is normally permitted in this type of instrument. After checking the zero of the instrument, it will take up to 1/2 hour to obtain a reading on the X1 range. It should be also noted that spurious noise signals, due to any cause, which change the reading on the X1 range will take up to 1/2 hour to bleed off. This could result in serious error in reading.

Since the cable capacitance is always present, the response time can be reduced by one of the following:

- a) Decrease the effect of the capacitance.
- b) Use positive feedback.
- c) Decrease the resistance size.

A circuit of the type shown in figure 1 is commonly used to reduce capacitive effects. If the cathode voltage follows the grid very closely, small signal will be developed across the cable capacitance, and a large signal across the cathode resistor. The shield of the cable is connected to the filament of the tube and the cable capacitance is placed across R1 only. The actual input impedance to the amplifier is greater than R1 by a factor determined largely by the amplification factor (μ) of the tube. Two major limitations exist in the use of this type circuit for the application desired:

- (1) the amplification factor of the electrometer tube is very low.
- (2) although the input resistance is increased, if the tube is to drive the meter directly, a signal current in the tube of 60 micro-amperes will be required. To obtain this change in current, a 0.5



1. $A = \text{Amplification} = \frac{\mu R_2}{r_p + (1 + \mu) R_2}$
2. If $\mu \gg 1$
3. $A \approx \frac{\mu}{1 + \mu}$
4. $R_{\text{INPUT}} = R_1 \left(\frac{1}{1 - A} \right) \approx R_1 (1 + \mu)$

ELECTROMETER CIRCUIT

FIG. 1

volt signal will still be required across R1.

Power supply feedback is accomplished if the voltage supplying the ionization chamber changes as the signal current changes. If the voltage changes in such a way as to increase the signal, positive feedback is present. As an example, if the chamber is exposed to radiation, a signal current will flow. If the chamber voltage increases, due to this flow, the change in voltage is capacitively coupled thru the chamber, thus providing rapid charging of the cable capacitance and a speed up in response time. Using a blocking oscillator power supply, this type of feedback is readily obtained by using a negative chamber voltage. The signal current from the chamber will develop a negative voltage on the grid of the electrometer tube decreasing the tube current and thus causing an increase in the supply voltage due to less loading. As the electrometer tube voltage increases, all other voltages generated by the blocking oscillator power supply increase. The chamber voltage becomes more negative and aids the signal. The use of positive feedback, as described, can reduce response time, but it has the disadvantage of being potentially unstable. If the feedback is too great, the circuit will overshoot and oscillate. To obtain a sizeable reduction in the response time, the feedback factor must be near the point of instability and must be critically adjusted and controlled. It is not desirable to have a critical adjustment of this type in an instrument for use by semi-trained personnel.

The possibility of reduction in the size of the high megohm resistors is particularly interesting, since it automatically decreases the effect of leakage across these resistors, in addition to reducing the response time. Since it is apparent that amplification will be required after the electrometer, it was decided that the most practical

approach to the response time problem was to reduce the high megohm resistors by a factor of approximately 10 and, in addition, to use one of the techniques described above. The natural problem resulting from the use of a D.C. amplifier, after the electrometer tube, is that any changes in the electrometer operating point are also amplified. This results in a rapid zero drift due to changes in heater voltage on the electrometer tube. To reduce the effect of this undesirable characteristic, separate batteries are used for the power supply and the electrometer filament. The power supply battery is used to supply a negative bias for the tube. In this way, as the heater battery voltage is decreasing, the tube current will tend to decrease. The power supply battery voltage is also dropping, and the negative grid bias will thus decrease, causing the tube current to increase. This circuit effectively compensates the zero drift.

As discussed earlier, there is always concern in this type of instrument about the effectiveness of the high megohm circuitry. Since it is not usually checked by the circuit check of the instrument, we, therefore, have no way of knowing if the circuit is able to indicate the presence of radiation. This has been remedied by supplying a signal current of approximately 5×10^{-11} amperes through a 2×10^9 ohm resistor in the grid circuit of the electrometer tube. This current is obtained from a voltage divider in the chamber high voltage circuit. The circuit check position now checks all the circuitry and, it will also check for possible reduction in resistance in the cable, chamber and chamber housing if they are connected to the instrument. When the cable is connected, the circuit check will have a response time of approximately 12 seconds. It should also be

noted that while in circuit check the instrument is capable of reading radiation and the cable should, therefore, be disconnected if the instrument is indicating a radiation level in excess of 0.25 r/hr prior to switching to circuit check. After evaluating all the data taken with the various circuits discussed above, the final circuit as shown in figure 2 was decided upon.

PACKAGING: Concurrent with the circuit analysis several physical configurations were considered. The original intention was to use a drawn aluminum cover and case for the instrument. While the cost of such parts is low, in small quantities, (if standard sizes are selected) the necessity of separate stand-offs and special holding fixtures for the printed circuit board and battery housing is a serious drawback. The use of a die-cast panel, similar to the type used on existing CDV equipment, permits casting in place of stand-offs for mounting, the guard for the zero control and mounting bushings for the meter screws, etc. It was finally decided that a die-cast panel and drawn-aluminum case was the most practical, since it would fit in well with existing designs and permit reduction in the spare parts problem, since the meter would be identical to the existing meters excluding scale and the case would be interchangeable except for the handle. The carrying handle has been removed, and it has been replaced by a handle which is part of the case, and can be used to carry the instrument vertically, and also to support the instrument in a position 45° from vertical on a shelf or table. (See Fig. 3). A water-tight connector is mounted on the panel of the instrument in the lower right-hand corner. The connector is provided with a cap which is used to maintain the water seal of the instrument when the cable is not connected. As mentioned

FORM FACTOR
FOR
RADIOLOGICAL SURVEY METER

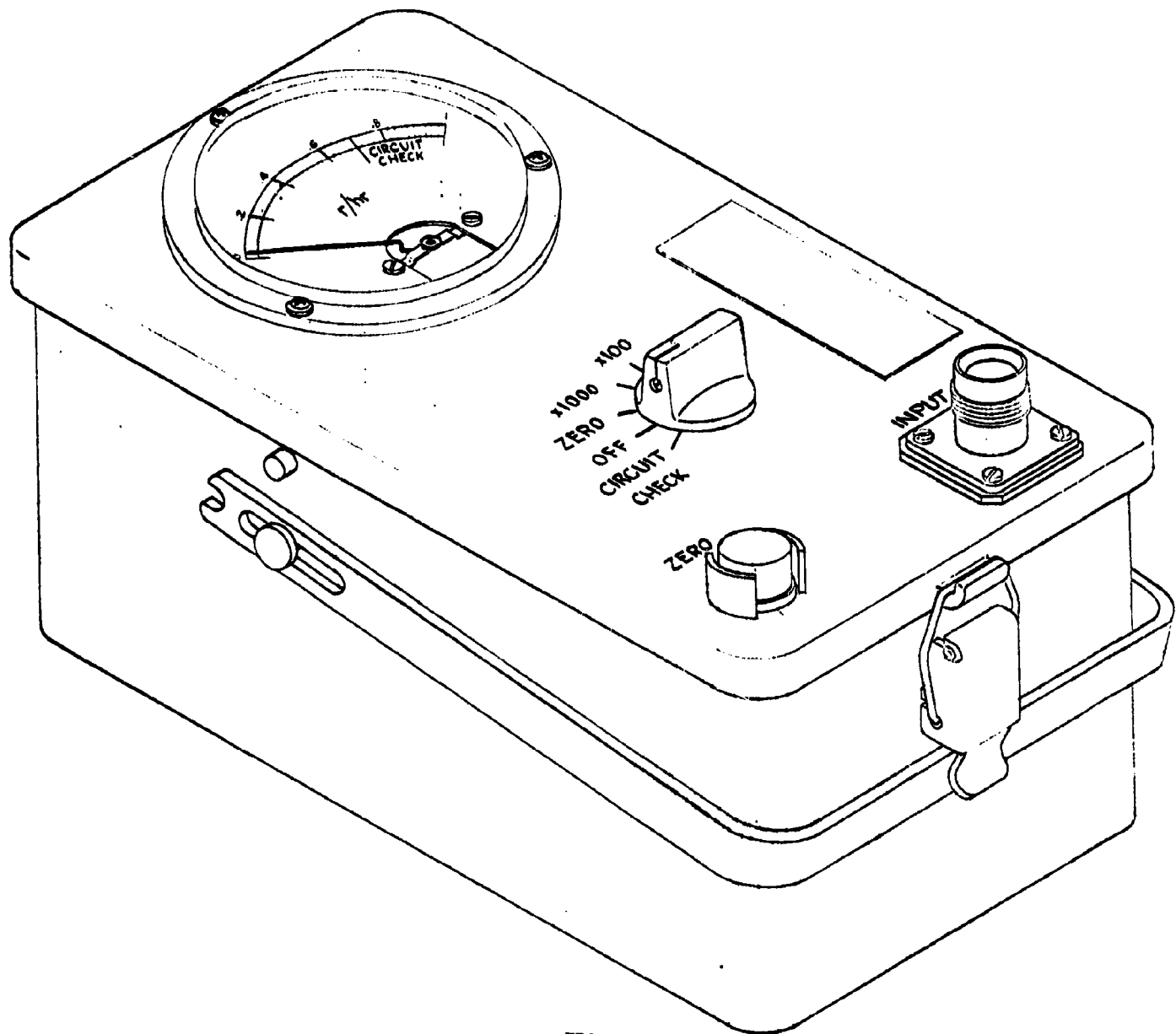


FIG. 3

earlier, the meter is a 3 1/2" round 50 u AMP DC meter, which meets the requirements of meters used on CD V700 and CD V715 instruments, except for the scale markings.

CHAMBER AND CHAMBER HOUSING: The chamber housing and mounting bracket have been designed to provide maximum protection for the chamber. The mounting bracket was constructed so the detector may be screwed to a wall or clamped to a pipe. When the detector is wall-mounted, the pipe clamps may be reversed and stored under the bracket. A cap and chain was provided to cover the detector receptacle when the cable is not connected.

A polyester fiberglass reinforced housing was used on five of the instruments. This material was chosen for its light weight and high strength. An aluminum housing was also used in a shape that may be easily die-cast. The fiberglass housing has the advantage of low mold cost, which is particularly significant, if small quantities are being manufactured.

A breakdown view of the chamber is shown in Attachment "A" of the Specification. It should be noted that a slightly different chamber is used with the fiberglass housing or the aluminum housing. This is necessary in order to meet spectral dependance and directional sensitivity requirements. By assuming that the chamber can be represented by a parallel plate geometry, a theoretical voltage required for 95% of saturation in a 1000 r/hr field can be calculated as approximately 40 volts. If we now apply a 100% safety factor to allow for end effects and corners in the chamber, a voltage of 80 volts is arrived at. The actual saturation data, taken with the chambers in a 100 r/hr field, is included with the test data. The chamber size has been selected to permit use of a voltage of 100 volts or less.

CABLE AND CONNECTORS: The selection of a cable and connectors to perform the necessary functions in the instrument is determined by the following requirements:

- 1) No leakage from high voltage connection to signal.
- 2) Low leakage from signal lead to the ground lead.
- 3) Water proofness.
- 4) Minimum capacitance between the signal lead and both the ground and high voltage leads.
- 5) Low noise characteristics.

Six prototype instruments have been fabricated using two types of connectors and six different cables. The connectors used are twinax and twinax with a shielded pin. The second type can be replaced with an appropriate triaxial connection. In the discussion, the above connectors will be referred to as Connector I and Connector II respectively. The cables used are shown in Table 1 and are designated A thru F.

The connectors performed equally well when tested, but Type I is not an acceptable connector for an application of this type, since there is considerable probability of leakage from the high voltage pin to the signal pin, after the surface of the insulator has become contaminated. The connector with one shielded pin is ideally suited for this application, since the signal lead is shielded by the guard ring around it. The other pin is used for high voltage and the body of the connector is therefore at any desired potential, and the panel and case of the instrument need not be at the high voltage potential. Reference to Table 1 shows that six cable types have been tested. The triaxial types are preferable to the twin-lead shielded since they provide the guard ring effect between the signal and high voltage

leads. It has also been determined that if a cable is not treated to have very low noise characteristics, it will cause a considerable signal to be generated when flexed. The signal introduced is due to static charge generated as the metal conductor rubs against the insulation when the cable bends. This signal is extremely undesirable since it will take up to 1 minute to dissipate on the X1 range. The data of Table 1 shows that some of the cables introduce time constants which require more than 1 minute to reach 95% of final reading. This is due to excessive capacitance between the signal lead and the ground and high voltage leads. Using a triaxial cable, the capacitance between the center conductor and the first shield, must be less than 25 uuf to permit the needed response in 1 minute.

As a result of the test data and the comments above, the cable selected for this instrument must have the following characteristics.

- 1) Triaxial.
- 2) Diameter less than 0.250".
- 3) Capacitance (Signal to first shield) 25 uuf per foot max.
- 4) Low noise characteristics.
- 5) Resistance between signal lead and first shield 10^{15} ohms per linear foot minimum.

TABLE 1
ELECTRICAL PERFORMANCE OF VARIOUS CABLES

<u>CABLE</u>	<u>SUPPLIER</u>	<u>PART NO.</u>	<u>DESCRIPTION</u>	<u>INST. TIME CONST. SECONDS</u>	<u>CABLE DIAM. INCHES</u>
A	Belden	8227	Shielded Twisted Pair	70	
B	Microdot	50-3928	Low Noise Triax	75	.130
C	Amphenol	RG-22/u	Shielded Twin Lead	65	.405
D	"	21-541	Low Noise Coax with external lead	50	.242
E	"	621-106	Polyfoam Triax	45	.245
F	"	21-527	Triax	50	.325

SPECIFICATION

NOMENCLATURE: RADIOLOGICAL SURVEY METER
Remote Indicating, Gamma only, 0-1, 0-10, 0-100 and
0-1000 r/hr

1. SCOPE

1.1 This is a specification for one type of radiation monitoring instrument for use by the general public in measuring radiation dose rate resulting from a nuclear disaster where hazardous conditions may be encountered. It responds to gamma radiation only. Indication is provided by a meter calibrated in roentgens per hour. The instrument is constructed with a separate detector housing which is connected to the indicating unit by 100 feet of cable.

1.2 This specification has a dual purpose: (1) As a basis for government procurement and (2) as a basis for direct sale to the general public. Under (1) above it is required that the instruments meet all items of these specifications; under (2) it required that the equipment meet only those items which are designated with an asterisk.

2. GENERAL PERFORMANCE REQUIREMENTS

* 2.1 The instrument shall respond to gamma radiation over the energy and intensity ranges as specified herein.

* 2.2 The instrument shall be designed for use under conditions of extreme emergency and in any kind of weather, and, therefore, shall incorporate the maximum ruggedness and moisture resistance commensurate with the following detailed requirements.

3. DETECTOR COMPONENT

* 3.1 General Description - The detector component shall be a hermetically sealed ionization chamber containing dry air at atmospheric pressure.

* 3.2 Specification - The chamber shall meet the specifications of Attachment "A", Ionization Chamber Specification".

* 3.3 Beta Shielding - The chamber wall plus the detector housing wall shall total at least 1000mg/cm².

* 3.4 Detector Cable

* 3.4.1 A special triaxial cable shall be furnished which has a maximum capacitance of 25 uuf between the center conductor and its shield, low noise characteristics and max. diameter 0.250 inches. Microdot type 50-3928 or equal.

* 3.4.2 The d.c. resistance of the coaxial cable insulation shall exceed 10¹⁵ ohms at 100 volts at temperatures to 125F.

* 3.4.3 The exposed portion of the cable between connectors shall be between 100 and 100 1/2 feet long.

3.5 Cable Connectors

* 3.5.1 Special triaxial cable connectors shall be furnished to permit the connection of the ion chamber center electrode to the center conductor of the cable, the guard ring of the chamber to the second or middle conductor, and the shell of the chamber to the third or outer conductor.

* 3.5.2 The connectors shall be as shown in Attachment C-4 or equal.

* 3.6 Guard Ring Connection - The guard ring of the chamber feed-through insulator shall be appropriately connected to a low potential point to minimize leakage current.

* 3.7 Instrument case and detector housing shall be connected to a low potential point.

4. CIRCUIT REQUIREMENTS

4.1 Indication

* 4.1.1 Method - The method of indication shall be through the use of a meter with dial markings from 0 to 1 r/hr.

* 4.1.2 Meter Specification - The indicating meter shall meet the specifications of Attachment B, "Meter Specification".

4.2 Sensitivity

* 4.2.1 Range - The instrument shall detect and measure gamma radiation dose rates over the following ranges: 0-1 r/hr, 0-10 r/hr, 0-100 r/hr and 0-1000 r/hr.

* 4.2.2 Response Time - When the instrument is connected for remote use it shall respond so the (after warm-up and zero adjustment) 95% of the final reading is reached as follows:

0-1 r/hr range, no more than 1 min.
0-10 r/hr range, no more than 9 sec.
0-100 r/hr range, no more than 9 sec.
0-1000 r/hr range, no more than 9 sec.

This applies to (1) the instrument, with the range selector switch set on the appropriate range, being abruptly exposed to a radiation field; and (2) the instrument in a radiation field with the selector set on "zero" then abruptly changed to the appropriate range. (Tests shall be made at approximately mid-scale on each range.

4.3 Accuracy

* 4.3.1 Calibration - The instrument shall read correctly within plus or minus 20% of true dose-rate in cobalt 60 and/or cesium 137 gamma radiation fields incident normal to the top and normal to the side of the detector assembly. This shall apply at any time during the specified battery life. (Tests will be made at approximately 20% and 80% of full scale on each range. The "zero" may be adjusted prior to reading).

* 4.4 Spectral Dependence - The error due to energy dependency shall be no greater than plus or minus 15% of the true dose-rate for any gamma radiation energy between 80 Kev effective and 1.2 Mev effective with the radiation incident normal to the top and the side of the

detector assembly. (For tests the dose-rate over the energy spectrum is to be varied to maintain an approximately constant reading on the meter for all energy test points).

* 4.5 Directional Sensitivity - The instrument response shall be such that the difference in the indication for radiation incident normal to the top, and that for radiation incident normal to the side, does not exceed 10% over the photon energy range of 80 Kev to 1.2 Mev. (Tests will be made at approximately 80% of full-scale on the low range).

4.6 Stability

* 4.6.1 Warm-Up - An instrument that has been turned off for two hours or more shall reach 95% of the final reading within two minutes after being turned on at room temperature.

* 4.6.2 Microphonics - The instrument shall be placed in operation and suspended two inches above a concrete surface. When dropped so that one corner strikes first, the meter reading shall not change by more than 1/4 of full-scale and the pointer shall return to its original position within five seconds.

* 4.6.3 Range Switching - After a two minute warm-up and immediately after zeroing a normal radiation background, the selector switch shall be switched to the XI range; within 20 seconds the meter indicator shall be within plus or minus three divisions of zero. Within three additional minutes, the meter shall indicate within one division of zero. For all other ranges the meter indicator must be plus or minus three divisions in 10 seconds. Within three additional minutes the meter shall indicate within one division of zero.

* 4.6.4 Zero Drift - The zero drift due to battery aging or prolonged warm-up shall be less than minus 1% or plus 10% of full-scale during the first hour after new batteries have been installed and less than minus 1% or plus 3% of full-scale per hour thereafter.

* 4.6.5 Damping - When the instrument is abruptly exposed to a radiation field, the over-shoot in reading shall not exceed 20% of the steady state reading.

* 4.6.6 Fluctuations - After warm-up, transient fluctuation due to circuit and component instabilities shall be less than plus or minus 2% of full-scale.

* 4.6.7 Cable Noise - With the remote cable connected for use transient fluctuations caused by flexing the cable shall be less than 10% of full-scale on any range.

* 4.7 Hysteresis - The instrument, indicating 8 r/hr shall then be exposed for at least one minute to a dose rate giving an indication of 1000 r/hr. When returned to the original environment of 10 r/hr, the instrument shall indicate within 20% of the original reading within 20 seconds.

4.8 Jamming - When exposed to radiation dose rates above 1000 r/hr up to 10,000 r/hr with photon energy above 80 Kev, the instrument shall indicate off-scale on the high end of each range.

* 4.9 Accuracy After Overexposure - The instrument, one minute after a one minute exposure to approximately 2000 r/hr, shall read within the accuracy of 4.3 of the high range.

* 4.10 Zero - The instrument shall be designed so that it may be zeroed with one control in all radiation fields up to 1000 r/hr.

* 4.11 Circuit Check - There shall be a provision for an overall circuit check, to include battery supply and all working components. (The ionization chamber and high megohm resistors need not be included).

* 4.12 Calibration - Four independent sensitivity adjustments shall be provided, one for each range. They shall be accessible only when the instrument case is opened and arrange so that clockwise rotation will cause the meter to read up-scale. Factory settings shall be marked.

* 4.13 Location of Calibration Adjustment Potentiometers - The calibration adjustment potentiometers shall be located at the upper rear of the right hand side of the case (when facing the front of the instrument) and shall face the side of the case. The type and location of these potentiometers shall be subject to the approval of the Contracting Officer.

5. ENVIRONMENTAL REQUIREMENTS

5.1 Temperature

* 5.1.1 Operation - The instrument, including battery shall operate over the temperature range of minus 20 F. to plus 125 F. The change in calibration from that at room conditions caused by the change in temperature over this range shall be limited to minus 10% or plus 20% at minus 20 F. and to plus or minus 10% at plus 125 F. The instrument may be zeroed before reading. (Tests shall be made at near mid-scale on each range. The operating instrument at room temperature shall be abruptly inserted into an atmosphere of minus 20 F. for the cold test, and into an atmosphere of plus 125 F. for the high temperature test. Readings shall be taken after the instrument has been in the environment for two hours).

* 5.1.2 Storage - The instrument, exclusive of batteries, shall withstand without damage, storage for 24 hours at minus 50 F. and storage for 72 hours at plus 160 F. (At the conclusion of this test and after reaching room temperature, the instrument shall meet the requirements of Section 5.4).

* 5.1.3 Detector - The instrument at room temperature shall operate when the remote unit and 90 feet of the connecting cable are subjected to temperature extremes of minus 45 F. and plus 145 F. The change in calibration from that at room conditions caused by the change in temperature shall be limited to minus 10% or plus 20% at minus 45 F. and to plus or minus 10% at plus 145 F. The instrument may be zeroed before reading. (Tests shall be made at near mid-scale on each range. The detector and cable of an instrument operating at room temperature shall be abruptly inserted into an atmosphere of minus 45 F. for the cold test, and into an atmosphere of plus 145 F. for the high temperature test. Readings shall be taken after the detector and cable have been in the environment for two hours).

5.2 Atmospheric Pressure

* 5.2.1 Operation - The instrument and detector shall operate within the accuracy specified in 4.3 from the pressure equivalent of sea level to that of 25,000 feet above sea level with the case open, over a period of three hours.

* 5.2.2 Transport - The instrument and detector shall withstand without damage, transportation at the pressure equivalent of elevations of 50,000 feet above sea level for a period of 20 hours with the instrument case closed, and for an additional 20 hours with the case opened.

* 5.3 Humidity - The instrument shall show a variation of no more than plus or minus 10% from the reading at normal room temperature and pressure when exposed with case closed to the humidity test conditions of Military Specification MIL-E-16400E (NAVY). (The instrument may be zeroed prior to reading. Tests shall be made at 20% and 80% full-scale on each range).

* 5.4 Immersion - The instrument shall operate properly immediately following immersion in water to a depth of one foot (as measured from the meter face) for a period of 30 minutes. There shall be no leakage into the instrument case, ionization chamber compartment or connectors. No stopcock grease or similar compounds may be used. The detector assembly and cables shall be immersed to the same depth during this test.

* 5.5 Atmospheric Corrosion - The instrument connected for remote use shall be capable of withstanding a 20 hour salt spray test conducted in accordance with Federal Test Method Standard 151a. There shall be no evidence of corrosion following the test.

* 5.6 Vibration - The instrument and detector shall meet the requirements of 4.3 after being subjected to the vibration tests of Military Standard MIL-STD-167(SHIPS). The instrument shall be turned "on" during these tests.

* 5.7 Tropicalization - It is not required that the instrument be moisture and fungus-proofed. However, if tropicalization is applied, it shall be done in accordance with the requirements of Military Specifications MIL-T-152B and MIL-V-173B.

* 5.8 Electromagnetic Interference - The instrument shall be designed to operate properly in normally encountered electromagnetic fields, and shall be designed to minimize electromagnetic effects of broadcast stations, radars, etc.

* 5.9 Light Sensitivity - The electrometer tube shall be shielded from light so that if clear plastic is used for meters, or, if the instrument is open for calibration, there shall be no discernible change in meter indication when the instrument is alternately subjected to bright sunlight and darkroom conditions of identical dose

rates. (For tests, bright sunlight, or a 300-watt spotlight, six to eight inches from the instrument, may be used to test for light sensitivity).

* 5.10 Drop - The instrument and detector shall be capable of withstanding, without damage, five drops (one on each side and the bottom) from a height of one foot to a hardwood table.

* 5.11 Shock - The instrument and detector shall meet the requirements of 4.3 after being subjected to the shock tests of Military Specification MIL-S-901B(NAVY), except that the five foot drop may be omitted. The instrument shall be turned "on" during these tests.

6. COMPONENTS

6.1 Choice - New components shall be used and only those components commercially available from at least two domestic manufacturers and meeting standard commercial or military tolerances shall be used, unless otherwise noted in these specifications.

* 6.2 Selection - All components shall meet the applicable specifications and there shall be no selection.

* 6.3 Operation - Each component shall be operated only within its specified operational limits.

* 6.4 Design Targets - Design targets for components, with the exception of batteries, shall be a minimum of 5000 hours of operational life without substantial change in characteristics.

* 6.5 Specification - A complete specification for each component shall be supplied with the instruments submitted for preproduction-type approval.

* 6.6 Effect of Replacement - When any component is replaced with another meeting its specification when required in 6.5, it shall be possible to recalibrate the instrument within the accuracy specified in 4.3.

* 6.7 Marking - The values of resistors, capacitors and other standard components shall be marked by means of color-code or other standard commercial practice.

6.8 Variable Elements

* 6.8.1 All variable potentiometers required to adjust calibration and zero shall be of the enclosed type. The variable components required to adjust calibration shall be equipped with slotted shafts for conventional flat-bladed screw-driver adjustment.

6.8.2 All variable components for calibration and zero adjustment shall be tested to withstand rotation of 180 clockwise, then 180 counterclockwise, 5,000 times at rate of approximately two cycles per second.

* 6.9 Electromotor Tube - The electromotor tube shall be EIA type 5886.

* 6.10 Tube Socket - The electrometer tube socket shall be Elco number 770BC or equal. A solder connection for the grid of the electrometer tube is permitted.

6.11 Transformer - The transformer shall be a blocking oscillator type and shall utilize a high permeability ferrite core.

6.12 High Megohm Resistors - The high megohm resistors shall not deviate from their nominal values by not more than $\pm 20\%$ when subjected to any or all of the instrument environmental test conditions in this specification.

7. WIRING AND CABLING

* 7.1 General - Wiring and cabling shall be neat, sturdy and as short as practicable, except that sufficient slack shall be provided (1) to prevent undue stress on cable forms, wires and connections; (2) to facilitate field repair of broken or cut wires and (3) to

enable parts to be removed and replaced during servicing without disconnecting other parts.

7.2 Wire and Cable Runs

* 7.2.1 Wires shall not be bent sharply around corners or edges that might cut or abrade the insulation, nor where the wires enter ceramic, plastic or other insulation material. Where wires run through holes in metal, the insulation shall be protected with suitable grommets or bushings.

* 7.2.2. Wires and cables shall be so located that inductive and capacitive effects will be the minimum practicable. Under no circumstances shall coupling depend primarily on stray capacitance or twisted leads.

* 7.3 Terminations - Wire terminations shall be soldered except that tinned, stranded wires may terminate in solderless connectors, if approved by the contracting officer. Where components do not provide means for mechanical anchorage, connections shall be mechanically secured before soldering by crimping a terminal firmly upon the wire (including insulation where practicable), or the wire upon a terminal, or by other equally effective means. All textile insulation ends shall be treated where necessary to prevent fraying, unless securely clamped by the terminals.

* 7.4 Grounding - Ground connections to shields and other mechanical parts, except the chassis, shall be made only for the purpose of eliminating high-potential points and not for the purpose of completing electrical circuits. Ground connections to the circuit board shall be made mechanically secure by soldering.

* 7.5 Circuit Board - As far as practicable all components shall be mounted on a printed circuit board. Copper-clad fiberglass reinforced epoxy boards NEMA type G-10, 1/16 inch thick shall be used.

At least one ounce copper shall be protected with "seal bright" or tin or solder plating.

* 7.6 Color Code - As far as practicable, the wiring shall be color-coded.

8. BATTERY SUPPLY

* 8.1 Type - The battery complement shall be limited to no more than two size 1.5 volt flashlight cell, NEDA Type 13.

* 8.2 Performance - The performance of the batteries in the instruments supplied shall equal, or exceed, in every respect the performance of batteries meeting Federal Specification W-B-101f (or latest revision). The battery supplied shall appear on the Federal Qualified Products List.

* 8.3 Operational Life - The batteries shall operate the instrument continuously for at least 150 hours. (The instrument, with a fresh battery and operated with the meter reading above mid-scale, shall meet the requirements of 4.3 throughout a 150 hour test period without changing the calibration setting or the battery. The circuit check may be used for the test).

* 8.4 Replacement - It shall be possible to replace the batteries without exposing critical circuit components. No tools shall be required for battery replacement. The batteries shall be restrained, however, bands or straps made of plastic, fabric or rubber shall not be used. The battery connections (8.5) shall be such that all batteries of the appropriate NEDA type listed on the Federal Qualified Products List are mechanically and electrically interchangeable for proper operation of the instrument.

* 8.5 Connections - The connections to the batteries shall be a non-corrosive metal, positive-pressure type. Battery mounting and connections shall be mechanically selective so that the battery may

be installed only in the correct polarity. Battery polarity markings shall be clearly stamped or engraved on or adjacent to the contacts.

* 8.6 Battery Supplied - Batteries no more than three months old on the date the instrument is shipped and meeting the requirements of 8.2, shall be supplied with each instrument. The manufacturer shall submit a certificate of compliance to this effect to the government inspector.

9. INTERNAL CONSTRUCTION

* 9.1 Component Access - All components shall be accessible and replaceable without the use of special tools.

* 9.2 Component Isolation - The high resistance components (electrometer tube, fixed resistors, etc.) shall be separated from the batteries by a gasketed enclosure.

* 9.3 Gasketing - Gaskets, seals and "O" rings shall be of neoprene or other suitable material. The cover gasket assembly shall be affixed to the cover.

* 9.4 Circuit Diagram - A wiring diagram shall be affixed to the inside of the case in a position readily visible when the instrument is open for maintenance. All component values, reference symbols, wire colors, polarities and nominal operating voltages shall be indicated. Voltages shall be measured with a voltmeter having a d.c. sensitivity of 20,000 ohms/volt and the conditions under which these measurements are made shall be stated.

* 9.5 Corrosion Resistance - All ferrous parts must be treated to resist oxidation.

10. PHYSICAL CHARACTERISTICS

* 10.1 General Description - The size and shape of the instrument shall be such as to facilitate its use, decontamination, storage and transport. In the carrying position, the instrument shall present a minimum amount of interference to the body movement of the operator. It shall be so designed that it can be easily and comfortably carried by hand.

* 10.2 Size - The instrument shall be as small as possible, consistent with the design requirements, but shall not exceed a volume of 150 cubic inches excluding the handle. The overall height shall not exceed seven inches.

* 10.3 Weight - The instrument, including batteries less detector, shall weight no more than 5 pounds.

* 10.4 - Case Material and Construction

* 10.4.1 Material - The instrument case and cover shall be alloyed zinc aluminum or steel. The cover shall be die cast, the case may be die cast or drawn. The general construction must be specifically approved by the contracting officer. The case cover shall be as specified in attachments C-2.

* 10.4.2 Closure - It shall be convenient to open and close the case repeatedly for servicing.

* 10.4.3 Form Factor - The form factor, exterior features and marking shall be as shown in Attachment C-1. Any change from the layout illustrated shall not be made without prior approval of the contracting officer.

* 10.4.4 Corners - The corners of the case shall be rounded to a radius of not less than 1/8 inch. All exposed edges shall be smooth and slightly rounded.

* 10.4.5 Chamber Housing and Mounting Bracket - The ionization chamber shall be mounted in a housing and provided with a mounting bracket as shown in Attachment C-3.

* 10.5 Mechanical Balance - When resting on its bottom, the instrument shall withstand a tilt of 35° without overturning.

11. EXTERIOR FEATURES

* 11.1 Indicating Meter - The indicating meter shall be located and oriented as shown in Attachment C-1.

* 11.2 Controls

* 11.2.1 Number - Two external controls shall be provided, a zero adjustment and a selector switch.

* 11.2.2 Location - The controls shall be located as shown in Attachments C-1 and C-2. They shall be capable of operation with gloved hands.

* 11.2.3 Knobs - Each knob shall have 8-32 set-screws with slotted heads for conventional flat bladed screwdrivers. The knobs shall meet the specification of Attachment D-1, "Knob Specification".

* 11.3 Selector Switch

* 11.3.1 Positions - The order of selection shall be CIRCUIT CHECK, OFF, ZERO, X100, X10, X1, X0.1 in clockwise order as seen with the instrument in the reading position.

* 11.3.2 Alignment - In the OFF position, the selector switch knob shall be oriented perpendicular to the long axis of the instrument. The OFF marking shall be on the left side of the instrument as seen with the instrument in the reading position.

* 11.3.3 Detents - All selector switch positions shall have positive detents except CIRCUIT CHECK, which shall have spring loading to return to OFF. The interval between each detent shall be approximately 30 degrees. A slotted or flattened shaft is required for the selector switch.

* 11.3.4 Test - The selector switch shall be tested to withstand rotation through all of its detent positions clockwise and then counterclockwise, 5000 times.

* 11.3.5 Connection - The switch shall be located in the circuit so the battery drain is zero with the switch in the OFF position. When the switch is in the OFF position there shall be a low resistance connection made across the indicating meter.

* 11.3.6 Material - The switch rotor shall be fabricated of a high resistance material.

* 11.3.7 Key - The selector switch shall be secured to prevent rotation of the assembly.

11.4 Zero Adjust

* 11.4.1 Function - The zero adjustment shall cause the meter to read up-scale when rotated clockwise and enable the meter to be set on zero when the selector switch is on the zero position.

* 11.4.2 Guard - A guard shall be provided for the circular zero adjustment knob on two opposite sides so that protection is afforded against accidental movement of this control. See Attachment C-2.

11.5 Handle

* 11.5.1 Construction - A smooth, nonporous handle shall be provided. The handle shall be aluminum or steel. There shall be no sharp edges or corners on the handle assembly, and, no indentations or cavities, where dirt can collect.

* 11.5.2 Clearance - There shall be at least 1 1/4 inch clearance between the underside of the handle in the carry position.

11.6 Fasteners

* 11.6.1 Two snap-type pull-catches shall be provided to hold the lid to the center portion of the case of the instrument. They shall be constructed so that they may be opened with one finger. The fasteners

shall be riveted or spot-welded to the case with corresponding pull-catch strikes cast into the lid. See Attachments C-1 and C-2.

11.7 Exterior Finish

11.7.1 Color - The case of the instrument shall be bright yellow in color (similar to Munsell No. 5Y8/12).

* 11.7.2 Finish - Any paint applied to the surface must be free of sags, runs, blisters, orange peel and other imperfections. After performance and environmental tests described in this specification, there shall be no evidence of embrittlement, loss of adhesion, checking or peeling. If a baked glass enamel is used, it shall conform (with exception of color) to Military Specification MIL-E15090B(SHIPS). If air-dry enamels, lacquer paints or epoxy-base paints are used, they shall have a surface and adhesion equal to that of the paint specified above. A color sample of the finish used will be submitted for approval of the contracting officer.

* 11.7.3 Control Markings - All switch positions shall be legibly marked in black as follows: CIRCUIT CHECK, OFF, ZERO, X1000, X100, X10 and X1. The zero control shall be similarly marked with the word "ZERO". No dial plates may be used. All markings shall be flush-filled indentations or enamel applied in a manner similar to that specified for other paint finish. These markings shall not be removable by operations incidental to the normal use, storage and maintenance of the instrument.

12. INSTRUMENT IDENTIFICATION

12.1 Marking - Each instrument furnished in accordance with these specifications shall bear the following data on the working part of the instrument: "OCD Item No. CD Model No. ____" (to be furnished), and a serial number. Consecutive serial numbers beginning with 1 shall be used. In addition, the contractor's name, city and State shall appear on a conspicuous part of the instrument. The size of

the identification marking should be approximately 1 1/2 X 2 1/2 inches. The character and size of type and spacing may vary to facilitate manufacture. Markings shall conform to 11.73 and shall be submitted to the contracting officer for approval prior to production.

12.2 CD Emblem

12.2.1 The left side of the center section of the instrument shall be marked with the red, white and blue CD emblem of suitable size approved by the contracting officer.

12.2.2 The emblem may be painted on or be affixed with a decalcomania, provided the decalcomania is protected with a clear spar varnish. If painted on, the markings shall conform to 11.8.3.

12.3 Warning Label

* 12.3.1 Each instrument shall have the following warning label approximately 3/4 X 1 3/4 inches in size on the back end of the center portion of the case: "WARNING - PREVENT CORROSION- REMOVE ALL BATTERIES WHEN NOT IN USE".

12.3.2 The label may be painted on or affixed with a decalcomania, provided the decalcomania is protected with a clear spar varnish. If painted on, all markings shall conform to 11.8.3. The label shall be submitted to the contracting officer for approval prior to production.

13. TESTS

* 13.1 Conformance - Conformance with these specifications shall be determined according to the practices of the National Bureau of Standards. Unless otherwise stated, test shall be performed at normal room temperature and pressure. Unless otherwise indicated, tests may be performed in any sequence.

13.2 Damage Resulting from Tests - Instruments damaged incident to test to determine their conformance with the requirements of the specifications will not be accepted by the purchaser, except that

when a sample has satisfactorily passed the test, the manufacture may correct all damage that occurred during the test and resubmit the instrument.

13.3 Preproduction Models

13.3.1 The bidder shall furnish with his bid, three survey meters which will be tested for conformance with these specifications as required by the Invitation for Bids. The preproduction models submitted shall have been subjected to 5.6, 5.11 and, if applicable, 5.7. Test data proving compliance shall accompany the instruments.

13.3.2 One of the preproduction models of a successful bidder who is awarded a contract will become the property of OCD and will be retained as a reference. One of the preproduction models tested shall be retained by the government inspector during the production period and will be returned to the manufacture. All other preproduction models will be returned on request.

13.4 Production Testing - The required test procedure and test schedule is contained in Attachment E.

13.5 Test Costs - The manufacturer shall be responsible for the cost of: tests conducted in his own plant, tests to determine conformance with the pertinent sections of MIL-S-901B (NAVY) and MIL-STD-167 (SHIPS), and, if applicable, MIL-V-173B and MIL-T-152B. The costs of the initial tests under 13.3 will not be borne by the bidder.

13.6 Changes - The manufacturer shall obtain from the contracting officer written authorization to introduce into the production units any change from the approved preproduction model.

* 13.7 Conflicts - In the event there are conflicts between the dimensions and materials specified and the general performance requirements of this specification, the contractor shall resolve the conflicts and the performance requirements shall govern. The written

specifications shall take precedence over the Attachments.

14. INSTRUCTION MANUAL

14.1 Manuals - Two instruction manuals, conforming to Attachment F, shall be supplied with each instrument. The content, format, and materials for these manuals, shall be submitted to the contracting officer for approval before final printing.

15. PACKING AND MARKING

* 15.1 INSTRUMENT CONTAINER - Each instrument shall be boxed individually. The individual container shall be constructed of double-faced corrugated fiberboard, with a bursting strength of not less than 175 pounds, conforming to Federal Specification PPP-B-636b. Two instruction manuals shall be packed in the individual box with each instrument. The batteries shall be removed from the instrument and packed separately in the same box, with sufficient protection to prevent damage to the instrument, batteries or manuals.

* 15.2 SHIPPING CONTAINER - Ten individually boxed instruments shall be over-packaged in a shipping container designed for that purpose. The shipping container will be for domestic use and shall be a standard commercial container of double-faced corrugated fiberboard, with a bursting strength of not less than 275 pounds, conforming to Federal Specification PPP-B-636b.

15.3 CONTAINER MARKINGS - Each instrument box, and each shipping container, shall be marked with the following information: "Radio-logical Survey Meter; OCD Item No. Model No. ____" and the name of the contractor. In addition, each shipping container shall be marked with the contract number, the shipping weight, and the number of instruments in the container.

16. PRODUCTION DRAWINGS AND SPECIFICATIONS

16.1 The contractor shall prepare and furnish, for the approval

of the contracting officer, manufacture's layout and schematic drawings and specifications for all components and materials.

16.2 Drawings and specifications shall be in accordance with standard commercial practices. They shall include reproducible transparencies and five complete sets of prints. Final drawings and specifications shall be delivered within two months from the time of the initial shipment of production instruments, or within four months after the time of notice of award, whichever is sooner.

ATTACHMENT "A"
IONIZATION CHAMBER SPECIFICATION
FOR
RADIOLOGICAL SURVEY METER

A1.1 HEADER - The header shall have 10^9 ohms minimum between mounting ring and guard ring and 10^{13} ohms minimum between guard ring and terminal.

A1.2 CHAMBER TOP - The chamber top shall be made of .015 thick C.R. steel, 3.882 O.D., tin or cadmium plated.

A1.3 COVER LINER - The cover liner shall be 0.177 thick plastic, dag coated with two insulating stand-offs for center electrode support. The stand-offs shall have a combined resistance of not less than 10^{13} ohms.

A1.4 BRASS EYELET - A 1/16 diameter brass eyelet shall be used to make contact to the center electrode.

A1.5 CENTER ELECTRODE - The center electrode shall be .015 thick paper 3.250 inches in diameter, dag coated.

A1.6 SIDE LINER - The side liner shall be .032 thick paper $\frac{51}{64}$ wide by 11 $\frac{3}{4}$ long, dag coated.

A1.7 BOTTOM LINER - The bottom liner shall be .032 thick paper 3 $\frac{3}{4}$ inches in diameter, dag coated.

A1.8 ABSORBER - The absorber shall be .050 thick aluminum 3.886 O.D. by .794 inches outside height.

A1.9 CHAMBER SPACER - The chamber spacer shall be .050 thick aluminum 3.790 inches in diameter.

A1.10 CHAMBER BOTTOM - The chamber bottom shall be .015 thick C.R. steel 3.890 I.D. by 1 $\frac{3}{32}$ outside height, tin or cadmium plated.

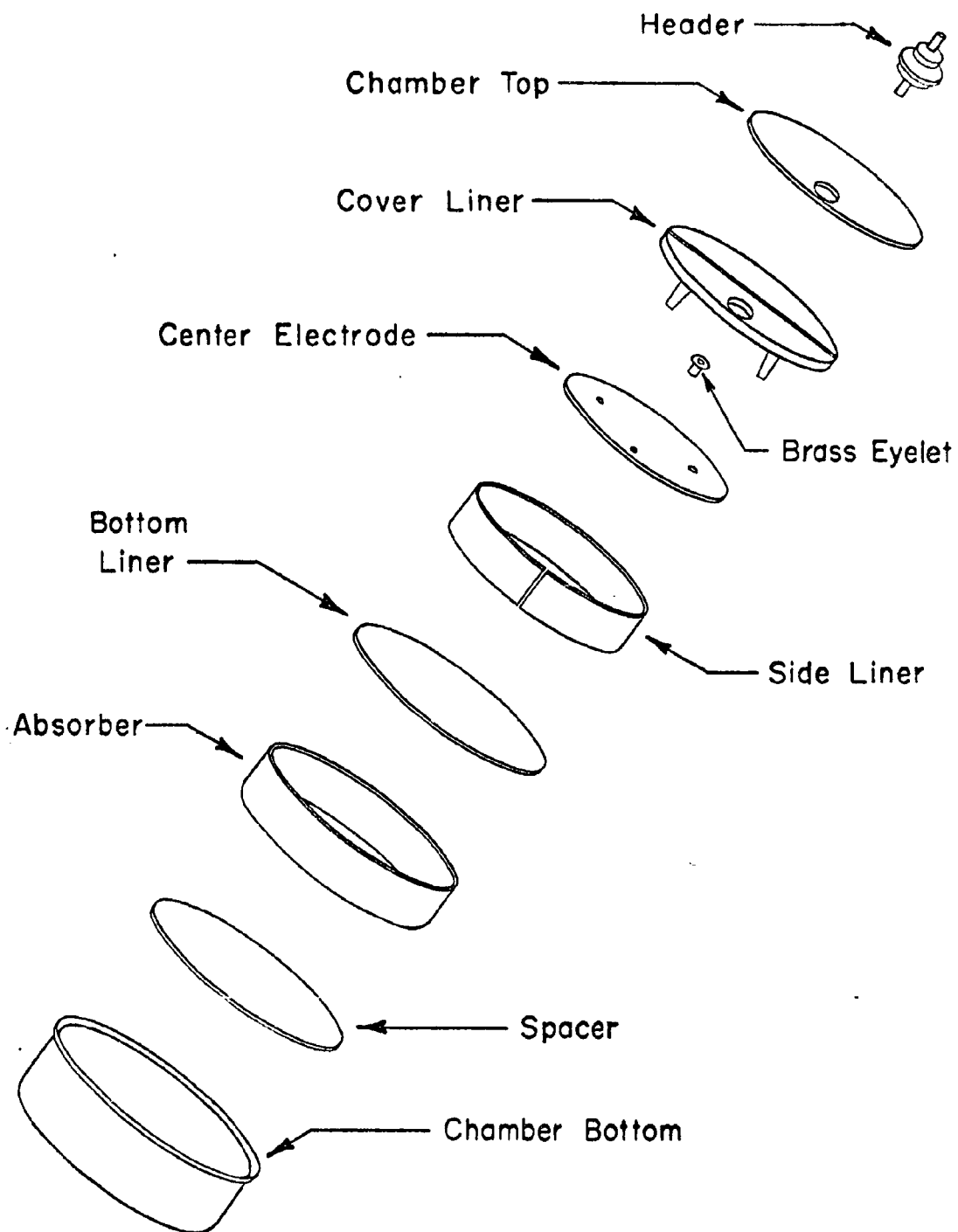
A1.11 PRESSURE - The chamber shall contain dry air at atmospheric pressure, plus or minus 10%.

A1.12 SEAL - The chamber and terminals shall be hermetically sealed. (Hermetic seal is defined as fused, welded, soldered or brazed; metal to metal, glass or ceramic).

A2. SATURATION - The chamber shall be at least 95% voltage-saturated up to 1000 r/hr throughout the battery life as specified in 8.3.

A3. CONFLICTS - In the event there are conflicts between the dimensional, material and other details of Attachment A and the performance requirements (such as Spectral Dependence 4.4), minor adjustments to the design of the chamber should be made, and the performance requirements shall control and take precedence over the Attachments.

ATTACHMENT - A
IONIZATION CHAMBER ASSEMBLY
FOR
RADIOLOGICAL SURVEY METER



ATTACHMENT "B"

METER SPECIFICATION

RADIOLOGICAL SURVEY METER

B1. SENSITIVITY - The sensitivity of the meter shall be 50 microamperes, full scale.

B2. ACCURACY - The accuracy of the meter shall be plus or minus 2% of full scale.

B3. LINEARITY - The meter response shall be linear. Scale division markings shall be equally spaced.

B4. COIL RESISTANCE - The coil resistance shall be 1,850 ohms plus or minus 10%.

B5. DAMPING - The meter movement shall be so damped that overshooting is not more than 20% of the steady state reading.

B6. ZERO SETTING - The zero position of the indicating needle shall be adjustable, the equivalent of one minor scale division from the zero marker on the scale when the meter is held in any position. The adjusting screw shall be located on the rear of the meter. There shall be no external zero adjustment on the face of the meter.

B7. GEOTROPISM AND BALANCE - Under operating conditions, the effects of geotropism and balance shall be such that the indicating needle moves no more than the equivalent of one small scale division, when the meter is rotated around three mutually perpendicular axes. (For tests, a current will be applied to the meter to produce a reading of approximately 1/2 of full scale).

B8. SCALE

B8.1 DIMENSIONS - The meter shall have a scale length of not less than two inches, as measured along an arc passing through the lower ends of the scale divisions.

B8.2 MARKING

B8.2.1 - The meter scale face shall be white with black markings and graduations and the meter needles shall be black. In addition, red markings and lettering shall be used for the circuit check.

B8.2.2 - The scale shall have 50 divisions with five major divisions. Major division marks shall be numbered 0, .2, .4, .6, .8 and 1. There shall be unnumbered minor division marks corresponding to the midpoint between major divisions.

B8.2.3 - The scale shall be labeled "r/hr".

B8.2.4 - Circuit check range shall be marked off below the meter scale by extending the division marks appearing a .7 and 1 and shall be labeled "CIRCUIT CHECK".

B8.2.5 - The required relative size and arrangement for the scale and its markings is shown on page B-4. There shall be no extraneous printing on the meter face.

B8.3 LEGIBILITY - The scale markings shall be readable at a distance of two feet in normal daylight by a person with 20/30 vision.

B9. TESTS

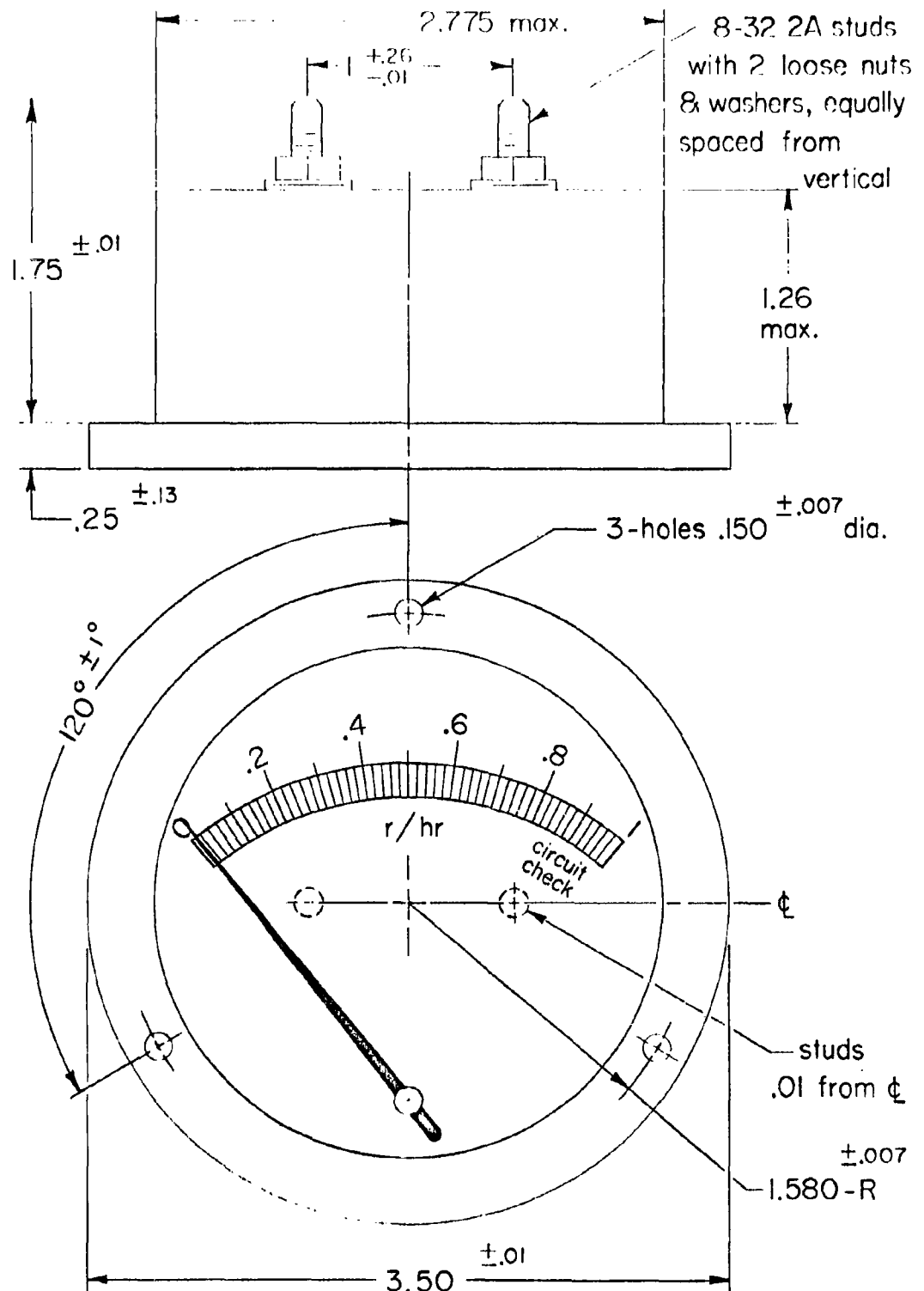
B9.1 VIBRATION - The meter mounted in the normal manner in the case cover of Attachment C-2 shall withstand, without damage, the vibration tests of Military Standard MIL-STD-167 (SHIPS). The meter shall meet all of the specifications following these tests.

B9.2 TEMPERATURE - The meter shall operate properly and meet specifications B6, B7 and B9.1, at any temperature from minus 20F. to plus 125F.

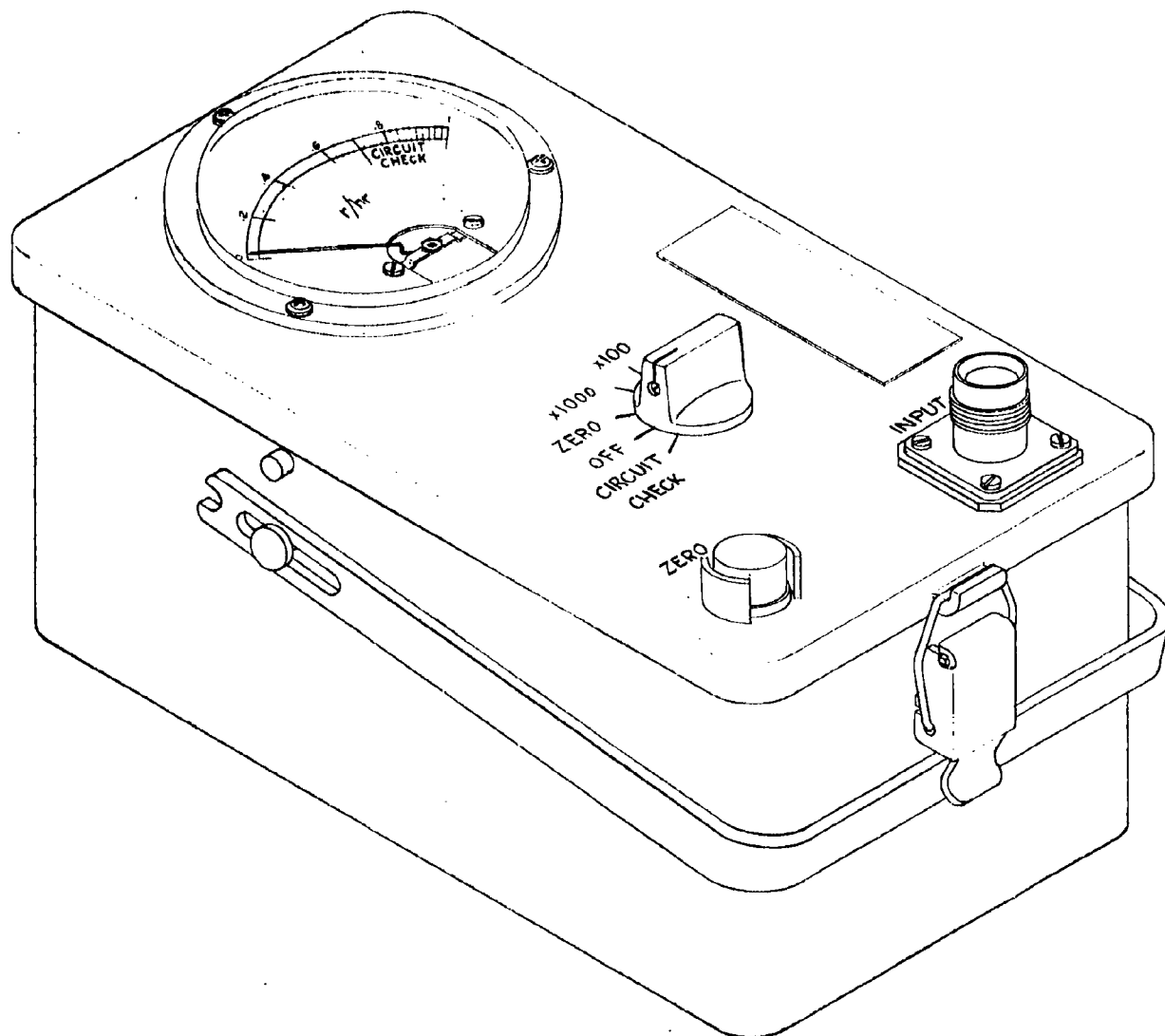
B9.3 IMMERSION - The meter, mounted in a panel with a gasket between the front or back of the flange and the panel, shall withstand immersion in water to a depth of one foot (as measured from the meter face) for a period of 30 minutes with no perceptible leakage to the inside of the meter case.

B9.4 SHOCK - The meter mounted in the normal manner in the case cover of Attachment C-2, shall withstand without damage, the shock tests of Military Standard MIL-S-901B (NAVY), except that the five foot drop may be omitted. The meter shall meet all of the specifications following these tests.

ATTACHMENT - B
METER SPECIFICATION
FOR
RADIOLOGICAL SURVEY METER

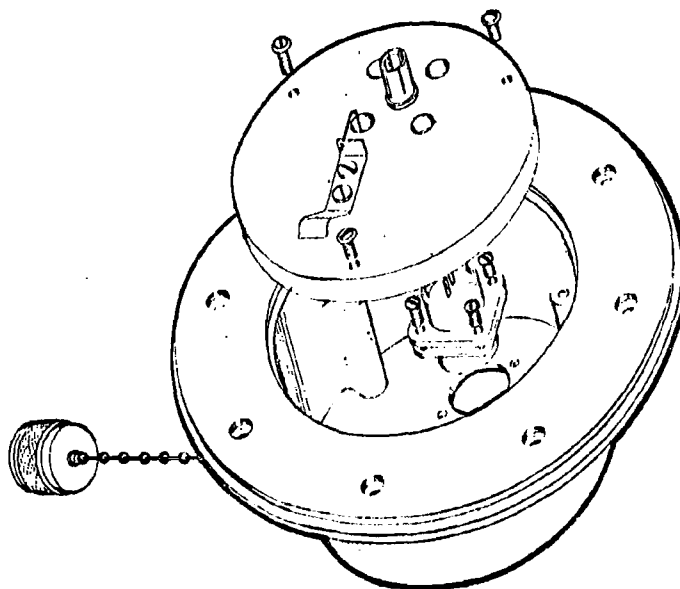


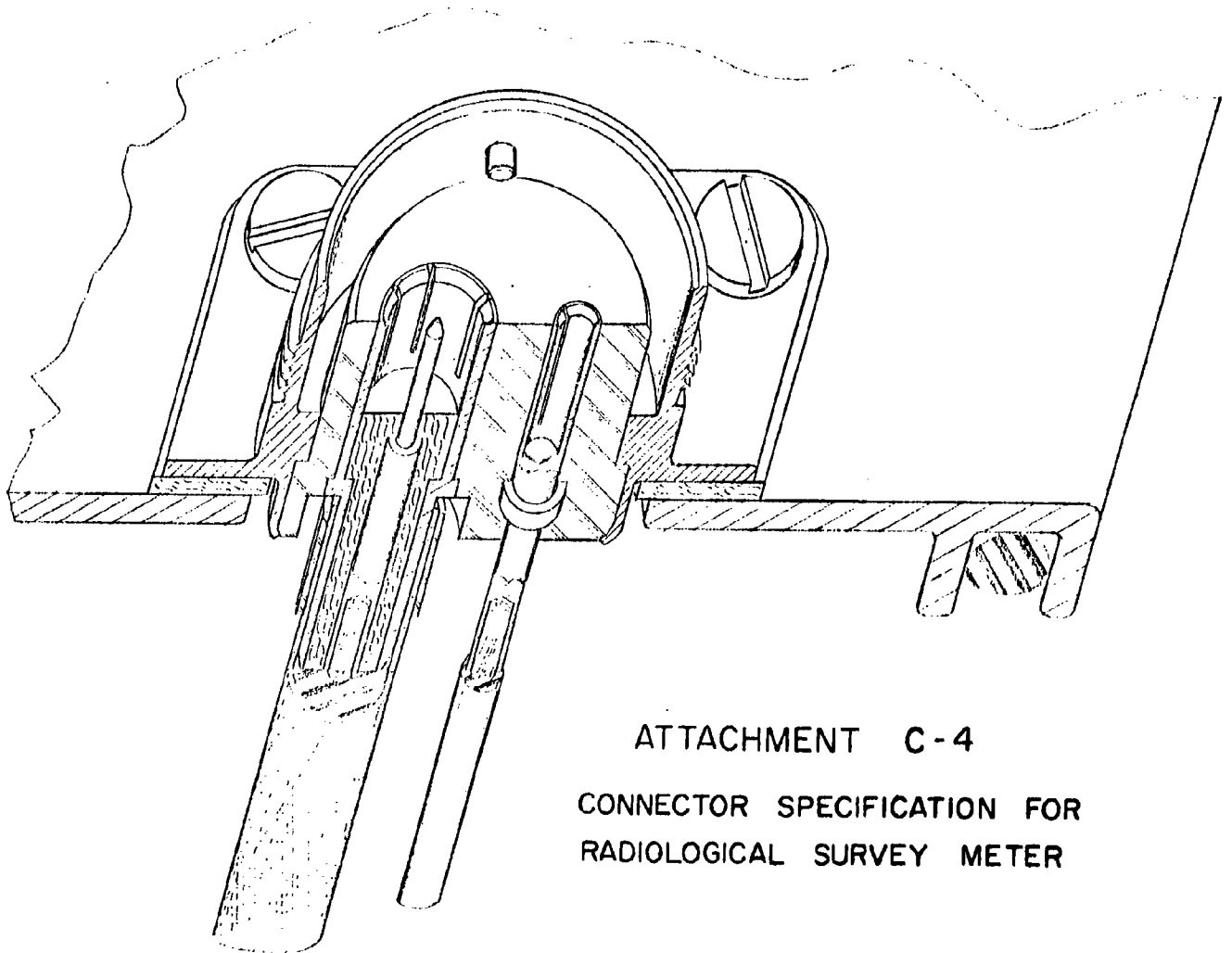
ATTACHMENT C-I
FORM FACTOR
FOR
RADIOLOGICAL SURVEY METER



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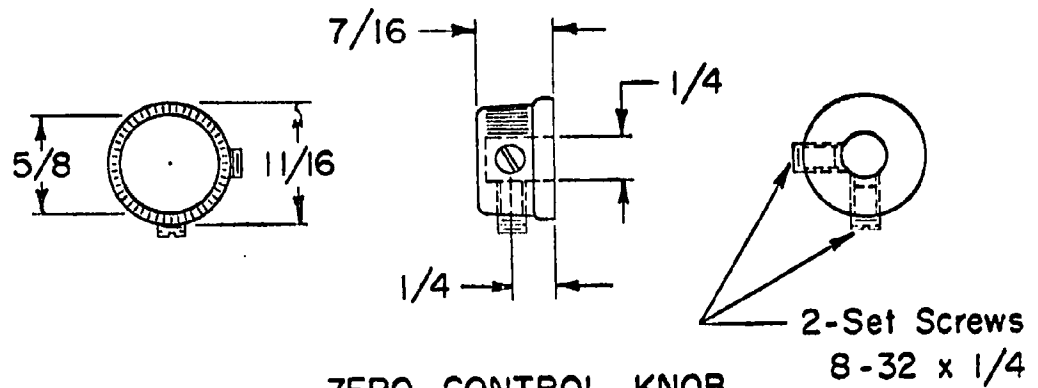
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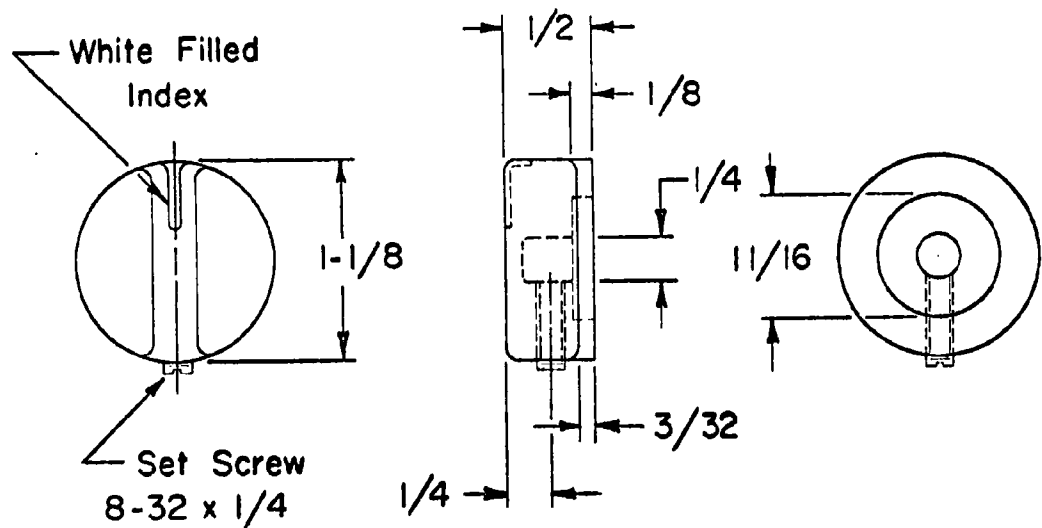


ATTACHMENT C-4
CONNECTOR SPECIFICATION FOR
RADIOLOGICAL SURVEY METER

ATTACHMENT D-1
 KNOB SPECIFICATION
 FOR
 RADIOLOGICAL SURVEY METER



ZERO CONTROL KNOB
 Black Plastic



SELECTOR SWITCH KNOB
 Black Plastic

ATTACHMENT "E"

PRODUCTION SAMPLING INSPECTION & TESTING

FOR

RADIOLOGICAL SURVEY METER

E1. SAMPLING - Sampling shall be in accordance with MIL-STD-105a and the appendix thereto. Level I, Table III shall be used except where appendix levels are specified. (Note exceptions in E3.1).

E2. INSPECTION -

E2.1 Inspection will be made for general workmanship and quality. Acceptance or rejection shall be based on an Acceptance Quality Level (A.Q.L.) of 2.5 defects:

- E2.1.1 Cracked or otherwise damaged case.
- E2.1.2 Loose or inoperable pull-catchfasteners (11.6).
- E2.1.3 Cracked meter glass.
- E2.1.4 Jammed needle, or otherwise damaged meter.
- E2.1.5 Improperly seated meter or meter gasket.
- E2.1.6 Loose control knobs.
- E2.1.7 Loose or inoperable switch or zero adjust.
- E2.1.8 Loose or damaged handle (11.5.1).
- E2.1.9 Broken, loose or defective wiring (7).
- E2.1.10 Improper identification (12).
- E2.1.11 Circuit diagram improperly attached (9.4).
- E2.1.12 Factory settings (4.12 and battery polarity), (8.5) improperly marked.
- E2.1.13 Component marking (6.7).
- E2.1.14 High resistance compartment (9.2) and cover gaskets (9.3) improperly seated.
- E2.1.15 Improper finish (11.7.2).
- E2.1.16 Other visually apparent defects.

E2.2 Inspection will be made for details of packaging, packing and marking (15). Acceptance or rejection will be based on an A.Q.L. of 4.0 d.p.h.u. using the list of defects following and Appendix Level L-7 for normal and L-5 for reduced inspection. Reduced inspection procedure shall be R-1.

- E2.2.1 Damaged container.
- E2.2.2 Insufficient cushioning, blocking or bracing.
- E2.2.3 Marking omitted, illegible, or incorrect (15.3).
- E2.2.4 Defective sealing.
- E2.2.5 Use of improper or defective materials.
- E2.2.6 Quantity of unit package not as specified (15.1 - 15.2).

E3. TESTS - The contractor will be required to furnish all equipment and personnel necessary to perform the tests specified herein.

E3.1 OPERATIONAL - Each instrument shall meet the following requirements. These are 100% production run inspections:

E3.1.1 Zero adjust (11.4.1), Circuit check (4.11), Range switching (4.6.3) and Cable noise (4.6.7), in this order.

E3.1.2 The instrument being tested shall be exposed to a source of ionizing radiation of 0.8 r/hr or more as read on a "Standard" instrument, known to exceed the accuracy requirements of 4.3. The instrument being tested shall read within plus or minus 15% of the reading of the standard instrument.

E3.2 SPECIAL - The instrument shall meet the requirements of the following paragraphs. Acceptance or rejection will be based on an A.Q.L. of 2.5 d.p.h.u., using Appendix Level L-7 for normal inspection and L-5 for reduced inspection.

Reduced inspection procedure shall be R-1.

- E3.2.1 Response Time (4.2.2. modified to test (2) for the lower 3 ranges).
- E3.2.2 Accuracy (4.3.1).
- E3.2.3 Warm-up (4.6.1).
- E3.2.4 Microphonics (4.6.2 modified to a two inch drop on hardwood).
- E3.2.5 Damping (4.6.5).
- E3.2.6 Fluctuations (4.6.6).
- E3.2.7 Cable noise (4.6.7).
- E3.2.8 Jamming (4.8).
- E3.2.9 Immersion (5.4).
- E3.2.10 Drop (5.10 modified to 1 random drop).
- E3.2.11 Cable length (3.4.3).

E3.3 INITIAL PRODUCTION

- E3.3.1 Three instruments selected at random by the inspector from the initial production of 300 units shall be designated for tests to indicate conformance with the following:
3.4.2, 4.2, 4.3, 4.4, 4.5, 4.6.2, 4.6.4, 4.7, 4.9, 4.10, 5.1, 5.2, 5.3, 5.5, 5.6, 5.9, 5.10, 5.11, 6.8.2, 8.3, 8.5, 10.2, 10.3, 10.5, 11.3.4, 11.5.2, A-2.

E3.3.2 The contracting officer shall withhold authorization for delivery pending receipt of test data proving conformance with the above. The instrument serial numbers, date the tests were performed, name of the company and individuals responsible for the tests shall be furnished.

E3.3.3 One of the production instruments tested shall become the property of OCD and shall be retained as a reference. One of the production instruments tested shall be retained by the government inspector during the production period and will be returned to the manufacturer.

E3.4 CERTIFICATION - The manufacturer will be required to certify and, if requested, furnish test data indicating that tests have been made by him, or his supplier, to show conformance of components with the following:: 3.1 (A1.11, A1.12), 3.3, 4.1.2 (B2, B4, B5, B9), 5.7 (if applicable), 6.1, 6.2, 6.3, 6.9, 6.10, 7.5, 8.6 (8.2), 11.3.6, 15.1 and 15.2.

E4 FAILURES - Disposition of rejected lots and defective sample units shall be in accordance with MIL-STD-105a. When resubmitted for acceptance, such lots or sample units shall be suitably tagged or identified by equivalent means to indicate the cause of failure and means employed to correct the fault.

ATTACHMENT "F"
INSTRUCTION AND MAINTENANCE MANUALS
FOR
RADIOLOGICAL SURVEY METER

F1. SCOPE

An instruction and maintenance manual for the survey meter shall be provided. It shall be written, as far as practicable, to enable an inexperienced, non-technical operator to understand in general terms, the instrument's use and theory of operation; and, to enable the operator, by following the instructions, to put the instrument in proper operating condition, operate it, and prevent failure or impairment. In addition, it shall include all necessary information to enable a reasonably competent technician to locate and repair malfunctions of the instrument.

F2. CONTENTS OF THE MANUAL

F2.1 TABLE OF CONTENTS - The table of contents, preceding the text of the manual, shall list all sections and sub-sections, if appropriate, and the illustrations, including photographs, drawings and tables. The page number of each illustration and each sub-section and/or section shall be shown.

F2.2 ILLUSTRATIONS - All illustrations, including photographs, drawings, sketches and tables, if appropriate, or as required below in a particular section, shall be listed in the table of contents. The actual illustration shall be located in appropriate order in the particular section of the text.

F2.3 TEXT OF THE MANUAL - The text of the manual shall include the sections listed below.

F2.3.1 PRECAUTIONS - This section shall spell out in detail any dangers that may exist in using or maintaining the equipment, and will

itemize specific precautions which may or should be taken on all adjustments, alignments, calibration and test methods required to get maximum performance from each instrument. A drawing of the physical layout of the internal construction, with appropriate marking, shall be included. Special high impedance voltage measurements, where appropriate, shall be indicated and the methods and measuring equipment required shall be clearly stated.

F2.3.2 PARTS LIST - This section shall include tables, listing by schematic symbol designations, all electrical and mechanical components considered subject to replacement or maintenance during the normal life of the equipment. Functional descriptions shall be provided for each component and complete information concerning component values, tolerances and other essential characteristics shall be given. In addition, component manufacturer's part numbers, complete information regarding manufacturer's name and address for all items, and appropriate drawing numbers and detailed references shall be listed for unique or modified items. All identical components listed shall be cross-reference. Recommendations shall be made of the quantities of each item considered necessary for plant and also field maintenance for groups of five instruments for yearly periods. When an item is to be used in more than one application, the total quantity of each item for each application is to be stated with the first listing.

F3. FORMAT AND MATERIALS

F3.1 SIZE - The manuals furnished with the instrument shall be approximately 5 1/2 inches by 8 1/2 inches.

F3.2 COVER

F3.2.1 The cover shall be printed in black on a field of yellow.

F3.2.2 The cover shall be marked with the following information. "Instruction and Maintenance Manual, Radiological Survey Meter, OCD Item No. CD V- Model No. ____" (to be furnished), the contractor's name, city and state.

TEST DATA

PAR. 4.2.2 Response Time

INSTRUMENT No.	CABLE	TIME TO REACH 95% OF RDG. ON X1 RANGE.
1	A	55 Sec.
2	B	80 Sec.
3	C	50 Sec.
4	D	40 Sec.
5	E	35 Sec.
6	F	40 Sec.

All other ranges less than 9 seconds.

PAR. 4.3 Accuracy

INSTRUMENT No.	800 r/hr	-200 r/hr	-80 r/hr	-20 r/hr	- 8 r/hr	- 2 r/hr
1	820	210	80	20	8.4	2.1
2	860	210	83	21	8.2	2.1
3	850	220	88	22	8.6	2.1
4	830	210	80	20	8.5	2.1
5	810	200	86	21	8.3	2.0
6	850	210	86	21	8.4	2.1
	-0.8 r/hr- 0.2 r/hr					
1	0.78	0.2				
2	0.84	0.22				
3	0.85	0.21				
4	0.80	0.2				
5	0.83	0.2				
6	0.84	0.21				

PAR. 4.4 and 4.5 Spectral Dependence and Directional Sensitivity
All Data Normalized.

INSTRUMENT NO.	Co 60 SIDE-FRONT		81 Kev SIDE FRONT		103 Kev SIDE-FRONT		161 Kev SIDE-FRONT	
1	1.0	1.05	0.90	0.90	1.00	1.05	1.10	1.12
2	1.0	1.00	0.88	0.90	1.02	1.02	1.03	1.10
3	1.0	1.02	0.92	0.87	0.99	1.02	1.08	1.12
4	1.0	0.96	0.95	0.88	1.00	1.00	1.10	1.10
5	1.0	0.96	0.87	0.88	1.00	1.05	1.10	1.08
6	1.0	1.02	0.88	0.90	0.95	1.00	1.05	1.10

4.6.1 Warm Up. -All Instruments tested OK.

4.6.2 Microphonics

All Instruments Tested OK

4.6.3 Range Switching -All instruments tested OK.

4.6.4 Zero Drift

INSTRUMENT NO.	% DRIFT 1 HR.	% DRIFT 2nd HR.	% DRIFT 24 ADD'L HRS.
1	+3	+1	+15
2	+7	+2	+12
3	-1	-1	-6
4	-2	-1	-10
5	+2	+2	+18
6	+1	+1	+20

4.7 Hysteresis

All Instruments Tested OK.

4.8 Jamming All Instruments Tested OK.

4.9 Accuracy After Overexposure

All Instruments Tested OK.

5.1 and 5.3 Temperature and Humidity

INSTRUMENT NO.	25°C	53°C	25°C	-28°C	25°C
		+95% RH			
1	51.0 r/hr	50.0	53.0	57.0	53.0
2	53.0 r/hr	50.0	53.0	56.0	52.0
3	55.0 r/hr.	52.0	56.0	59.0	55.0
4	50.0 r/hr	46.0	50.0	54.0	51.0
5	54.0 r/hr	51.0	54.0	57.0	54.0
6	55.0 r/hr	51.0	54.0	56.0	55.0

5.2 Atmospheric Pressure All instruments tested OK.

5.4 Immersion -All instruments Tested OK.

5.6 Vibration

Instrument Nos. 2,3,4, and 6 were subjected to the vibration tests. All instruments met the accuracy requirements of this specification before and after the test.

5.9 Light Sensitivity All instruments tested OK.

5.11 Shock

All instruments were subjected to the shock test and all met the accuracy requirements of paragraph 4.3. After the shock test the meter on instrument No. 3 was sticky and was replaced.

8.3 Operational Life

TRUE FIELD R/HR.

	<u>800</u>		<u>200</u>		<u>80</u>		<u>20</u>		<u>8</u>		<u>2</u>		<u>0.8</u>		<u>0.2</u>	
	<u>A</u>	<u>B</u>	<u>A</u>	<u>B</u>	<u>A</u>	<u>B</u>	<u>A</u>	<u>B</u>	<u>A</u>	<u>B</u>	<u>A</u>	<u>B</u>	<u>A</u>	<u>B</u>	<u>A</u>	<u>B</u>
1.	840	760	210	180	86	76	23	19	8.5	8.1	2.2	2.0	0.85	0.79	0.22	0.19
2.	810	750	200	170	84	75	21	17	8.9	8.2	2.3	2.1	0.85	0.81	0.23	0.20
3.	830	780	220	200	81	76	20	18	8.3	7.8	2.1	1.9	0.90	0.82	0.24	0.22
4.	900	830	240	210	83	80	22	19	8.4	7.8	2.3	2.0	0.88	0.80	0.21	0.18
5.	830	750	210	180	84	78	21	18	8.7	7.6	2.3	1.9	0.82	0.74	0.20	0.17
6.	810	710	200	170	83	75	21	17	8.2	7.4	2.1	1.8	0.91	0.83	0.23	0.20

A - with fresh batteries.

B - after 150 hrs. of continuous operation.

SATURATION

CHAMBER NO. 1 X10-12		CHAMBER NO. 2 X10-12		CHAMBER NO. 3 X10-12		CHAMBER NO. 4 X10-12		CHAMBER NO. 5 X10-12		CHAMBER NO. 6 X10-12	
V	I	V	I	V	I	V	I	V	I	V	I
9.0	8.9	9.0	8.2	9.0	9.1	9.0	8.5	9.0	8.1	9.0	8.8
15.0	10.0	15.0	9.3	15.0	10.2	15.0	9.8	15.0	9.3	15.0	10.0
22.5	10.5	22.5	10.0	22.5	10.8	22.5	10.3	22.5	9.9	22.5	10.5
45.0	11.4	45.0	10.6	45.0	11.6	45.0	11.0	45.0	10.6	45.0	11.4
100	11.8	100	10.9	100	12.0	100	11.4	100	10.9	100	11.7

SATURATION VOLTAGE

CHAMBER NO.

1	63v
2	68v
3	59v
4	62v
5	70v
6	65v

MATERIAL LIST AND COST FOR 1000 UNITS

<u>ITEM</u>	<u>SYMB.</u>	<u>DESCRIPTION</u>	<u>FUNCTION</u>	<u>SUPPLIER</u>	<u>QUAN. PER PART NO. INST.</u>	<u>COST PER INST.</u>
1	R1	Resistor, Fixed Comp. 10 ¹¹ ohms 1/2W 20%	Check Ckt. Divider	IRC	1	.30
2	R2	Resistor, Fixed Comp. 6 x 10 ⁹ ohms 1/2W 20%	X1 Signal	IRC	1	.30
3	R3	Resistor, Fixed Comp. 6 x 10 ⁸ ohms 1/2W 20%	X10 Signal	IRC	1	.30
4	R4	Resistor, Fixed Comp. 6 x 10 ⁷ ohms 1/2W 20%	X100 Signal	IRC	1	.10
5	R5	Resistor, Fixed Comp. 6 x 10 ⁶ ohms 1/2W 10%	X1000 Signal	IRC	1	.04
6	R6	Resistor, Fixed Comp. 39 K ohms 1/2W 5%	Check Ckt. Divider	IRC	1	.08
7	R7 & R12	Resistor, Fixed Comp. 20 K ohms 1/2W 5%	Base Return	IRC	2	.16
8	R8	Resistor, Fixed Comp. 4.7 K ohms 1/2W 5%	Collector Load	IRC	1	.08
9	R9	Resistor, Fixed Comp. 43 K ohms 1/2W 5%	D.C. Coupling	IRC	1	.08
10	R10 & R13	Resistor, Fixed Comp. 3 K ohms 1/2W 5%	Emitter Load	IRC	2	.16
11	R11	Potentiometer 2.5 K ohms 2W 10%	Zero Control	A.B. CU2521	1	1.10
12	R14	Quad Potentiometer 4 x 5 K ohms 1/2W 30%	Calib. Adj.	CRL	1	.55
13	R15	Potentiometer 50 K ohms 1/2W 30%	Coarse Zero	CRL	1	.24
14	R16	Resistor, Fixed Comp. 820 ohms 1/2W 5%	Bias Divider	IRC	1	.08
15	R17	Resistor, Fixed Comp. 560 ohms 1/2W 5%	Bias Divider	IRC	1	.08
16	R18	Resistor, Fixed Comp. 390 ohms 1/2W 10%	Filter Resistor	IRC	1	.04
17	R19	Resistor, Fixed Comp. 5.1 Meg. ohms 1/2W 5%	Bleeder Resistor	IRC	1	.08

MATERIAL LIST AND COST FOR 1000 UNITS						QUAN	COST
ITEM	SYMB.	DESCRIPTION	FUNCTION	SUPPLIER	PART NO.	PER INST.	PER INST.
18	R20	Resistor, Fixed Comp. 1 Meg. ohm 1/2 W 5%	Filter Resistor	IRC		1	.08
19	C1	Capacitor, Ceramic 0.01μ f 100 VDC.	H.F. Bypass	CRL		1	.10
20	C2 C3	Capacitor, Electrolytic 5 uf 25 VDC.	P.S. Filter			2	.36
21	C4 C5	Capacitor, Mylar 0.1 uf 100 VDC	P.S. Filter			2	.48
22	Q1	Transistor PNP 2N404	8.0. Transistor			1	.35
23	Q2 Q3	Transistor NPN. 2N1304	D.C. Amplifier			2	.80
24	S1	Switch 3 Pole 7 Pos. One Mom.	On-off and Range Sw.	LEL		1	1.15
25	B1 B2	Battery 1 1/2 volt "D" Size	Battery Supply	NC	950	2	.20
26	CR1	Diode, Silicon, 50 volt Piv. 2 ua leakage	L.V. Rect.			1	.25
27	CR2	Diode, Silicon, 300 volt Piv. 2 ua leakage	H.V. Rect.			1	.55
28	CR3	Zener Diode 8v ± 10%	Voltage Reg. P.S.			1	1.85
29	T1	Transformer B.O.	Power Supply			1	2.20
30	V1	Tube, Vacuum 5886	Electrometer	Ray	5886	1	3.00
31		Panel	Inst. Panel	LEL	D-6003-528	1	2.35
32		Cover Liner	Chamber Liner	LEL	B-6003-520	1	.33
33		Chamber Bottom		LEL	B-6003-518	1	.50
34		Chamber Absorber		LEL	B-6003-519	1	.37
35		Chamber Spacer		LEL		1	.16
36		Chamber Bottom Liner		LEL		1	.14

ITEM	SYMB.	DESCRIPTION	FUNCTION	SUPPLIER	PART NO.	QUAN. PER INST.	COST PER INST.
37		Chamber Side Liner		LEL		1	.23
38		Chamber Center Electrode		LEL		1	.17
39		Chamber Header		LEL		1	.32
40		Guard Ring Contact		LEL	B-6003-507	1	.93
41		Insulating Plate		LEL	B-6003-508	1	.24
42		Contact Spring		LEL	B-6003-515	1	.17
43		Handle		LEL	B-6003-525	1	.43
44	M1	Meter .0-50 ua.S.P.	Indicating	LEL	B-6003-530	1	4.25
45		Cover	Chamber Housing	LEL	C-6003-516	1	1.35
46		Bottom Housing	" "	LEL	C-6003-509	1	1.10
47		Detector Bracket		LEL	C-6003-511	1	1.45
48		Case		LEL	C-6003-531	1	1.10
49		Catch (Cad. Plate)		LEL	HC-200 CE	2	.20
50		Rivet (1/8 Dia. x 1/4 Semi Tub)		SIM		4	.02
51		Shoulder Rivet		LEL	A-6003-524	2	.12
52		" "		LEL	A-6003-522	2	.12
53		"CD" Label		LEL	A-106-123	1	.03
54		Flt. Washer No. 10x .032				2	.01
55		Connector Male		LEL		2	6.00
56		" Female		LEL		2	6.00
57		Cable Triax				100	10.00

COST ANALYSIS

As seen in the material list, the material cost per instrument in a manufacturing lot of 1000 is approximately \$54.00. The labor required to manufacture and test the instrument will then be approximately 2 1/2 hours.

With these basic costs a final price can be obtained from the following:

Material Cost	\$54.00
Direct Labor - 2 1/2 hrs. @ \$2.00	5.00
Overhead on Labor - 180%	<u>9.00</u>
	68.00
General and Administrative Costs - 20%	<u>13.60</u>
	81.60
Profit - 7%	<u>5.72</u>
Final Price	\$87.32

The purchase price determined above is obviously a function of the overhead and government and administration weighing factors. The end price of approximately \$85.00 does not include cost of tools which would be necessary. Tooling of the case, panel, printed circuit board and battery box will cost approximately \$23,000, resulting in an additional cost of \$23.00 per instrument, in a 1000 quantity. The resulting price of between \$100.00 and \$110.00 per instrument would be reduced by between 35% and 40%, if the quantity is increased to 10,000 instruments.

PRODUCTION AND MANUFACTURING

When considering a quantity of 1000 instruments, it is not possible to use complete mass production and automatic handling techniques. Some of these methods such as dip-soldering printed circuit boards will, however, be applicable. The material list and drawings, included as part of this report, describe quite thoroughly the details of the various parts, such as the die-cast panel and the drawn aluminum case.

A breakdown of the assembly and testing procedure follows:

1. Prepare all components for insertion into the printed circuit board. This includes bending and trimming of leads.
2. Sub-assemble the rotary switch. Wire and solder all components and leads which require connection to the switch wafer except the electrometer tube.
3. Insert the rotary switch and its components into the printed circuit board.
4. Insert all other components. A fixture will be required to maintain proper location of switch shaft and the zero potentiometer shaft.
5. Dip-solder the entire P.C. board. Automatic soldering equipment will usually provide more uniform soldering and it is desirable though not essential.
6. Clean and trim P. C. board.
7. Eyelet the transformer and transformer bracket to the P.C. board and solder the transformer leads in place.

8. Place the dust-cover housing gasket on top of the printed circuit board.
9. Insert the electrometer tube in its socket and solder the grid lead in place.
10. Install the dust-cover over the switch and electrometer tube and fasten it in place.
11. Test printed circuit board. A test fixture should be used which provide a test of the P.C. board as it is used in the instrument.
12. Sub-assemble the battery box.
13. Prepare panel box cementing the panel gasket, mount meter and connector with their respective gaskets.
14. Install P.C. board in panel, fasten it and the battery box to panel, solder battery leads to P.C. board, secure meter leads to the meter lugs and connect the leads from the connector.
15. The panel assembly is now complete and it is calibrated using a constant current generator simulating the signal current from the ionization chamber.
16. The header is inserted into the chamber cover and the cover liner is placed over it.
17. The center electrode is fastened to the feet of the liner and soldered to the center pin of the header.
18. The chamber spacer, chamber liner and chamber absorbers are inserted in to the chamber bottom.
19. The chamber cover is soldered to the chamber bottom and the header is simultaneously soldered into the cover.

20. After the chamber has had sufficient time to cool to room temperature the hole in the center of the cover is soldered.

21. The chamber is installed in chamber housing as shown in the detector assembly drawing C-3.

CONCLUSION

As required six pre-production prototypes have been manufactured and completely tested. As the data indicates these instruments meet or exceed all the requirements of the CDV-717 specification. The use of 100 feet of cable with a considerable reduction in response time constant rather than the expected increase is of considerable importance. All six units are identical with respect to circuitry but different connector and cable combinations have been employed. In addition one of the six sample has been supplied with an aluminum housing instead of the fiberglass enclosure. The chamber absorbers have been modified in the chamber used with the aluminum housing to account for differences in energy dependence characteristics.

The specification for this instrument is patterned after the CDV-717 specification with the changes and additions shown in the specification section of this report.

The cost this instrument in small quantities (approximately 1000 units) will be approximately \$85.00 per instrument, but as earlier mentioned this price will drop considerably if the quantity is increased. The end price (should the quantity approach 100,000 units) will almost certainly be less than \$40.00.

The instrument as designed and fabricated can become a useful addition to the OFFICE OF CIVIL DEFENSE INSTRUMENT LINE. To facilitate evaluation and procurement, if desired, complete specification changes, manufacturing and production information, parts list and manufacturing drawings are included in this report.