# OPERATING MANUAL

# FOR THE

# CDV-765 GAMMA

# RADIATION TRANSFER STANDARD

OFFICE OF CIVIL DEFENSE
DEPARTMENT OF THE ARMY

# OPERATING MANUAL

# FOR THE

# CDV-765 GAMMA RADIATION TRANSFER STANDARD

OFFICE OF CIVIL DEFENSE

DEPARTMENT OF THE ARMY

TABLE OF CONTENTS

A. GENERAL DESCRIPTION: The CDV-765 Gamma Radiation Transfer Standard was developed for the Office of Civil Defense by the Victoreen Instrument Division of VLN Incorporated under Contract No. OCD-PS-65-182. This device was developed to provide a means of calibrating the CDV-794 Model 2 Calibrator and various other gamma radiation sources used in the OCD Maintenance and Calibration Program against the primary gamma standard located at the RADEF Instrumentation Test Facility. In this way, the roentgen can be standardized throughout the Civil Defense RADEF system.

B. UNPACKING: When unpacking the CDV-765 Transfer Standard for the first time note the position and orientation of the various parts in order to repack the device in the same way. This packing orientation provides the best fit as well as maximum protection against rough handling. The unpacking procedure is as follows:

1. Remove the foam pads on top of the instrument housing and the detector unit.

2. Remove the detector by grasping the handle and slowly pulling straight up.

3. Remove the instrument from the shipping case, hold the shipping container down by placing one foot across the left front corner, hold the lid with the left hand, and with the right hand grasp the instrument case handle and pull straight up until the

instrument clears the shipping container. Store all padding in the shipping case. If difficulty is encountered in remembering the packing position of various components when repacking, refer to Figure No. 1.

C. PRECAUTIONS:

1. The $^{226}Ra$ check source located in the CDV-765 Ion Chamber Detector is leak tested during the semi-annual calibration check of the device and should not be wipe tested by the individual users. Excessive or improper wipe testing of this source can destroy its usefulness. Because $^{226}Ra$ is not a radionuclide controlled by the Atomic Energy Commission, an AEC Byproduct License is not required for possession. However, in some States where radionuclides are licensed by the State, $^{226}Ra$ requires a State License for possession. Individual State licensing agencies should be checked on this matter.

2. High Voltage (200 VDC) is present in the high voltage supply of the console. The "Detector High Voltage" switch on the front of the console should be turned off whenever the high voltage cable is not connected.

3. This device is designed to operate from 105-125 VAC, 50 to 60 Hz power lines. Connecting the instrument to any power source not within these requirements will result in faulty operation and can produce permanent damage.

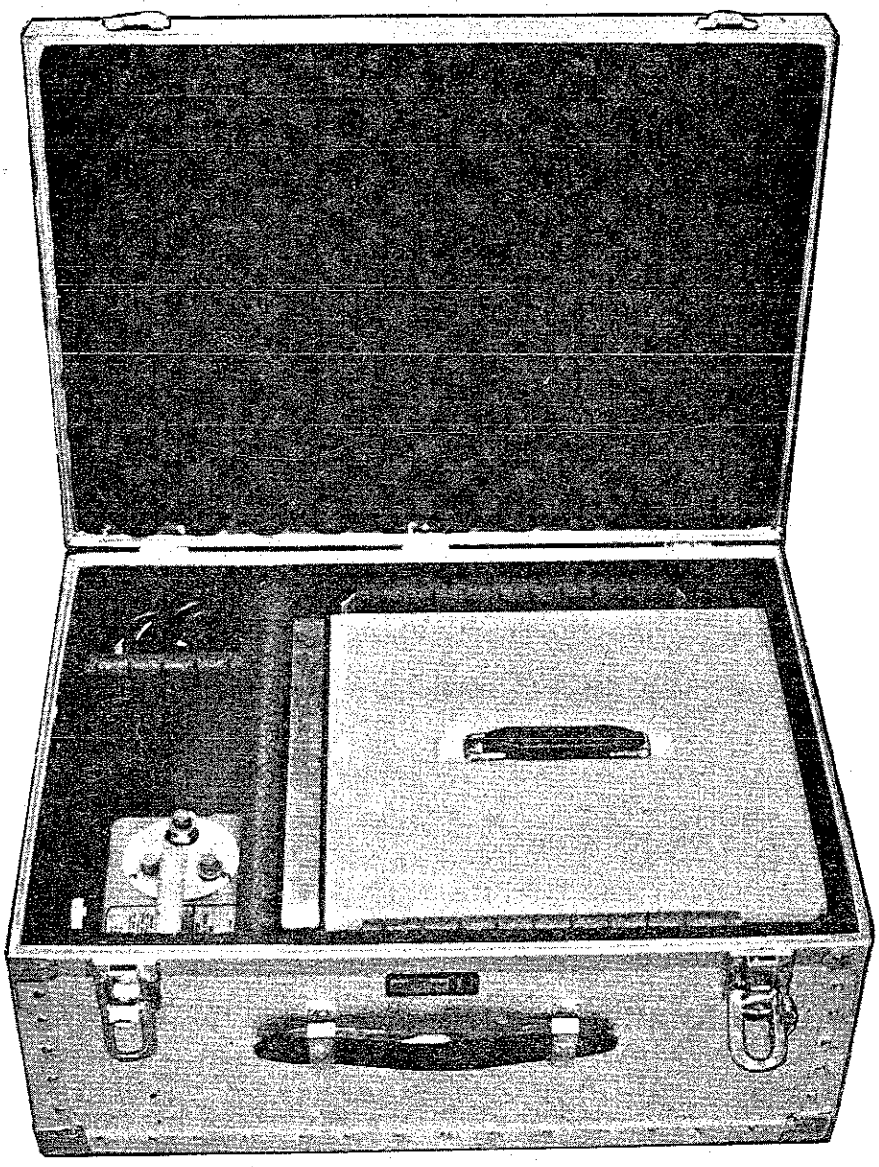

Figure No. 1: CDV-765 Transfer Standard Complete With Carrying Case

4. Do not attempt to repair the electronic circuitry of this device. If improper operation or any defects other than those described in the Maintenance and Calibration Section, are observed by the user, return the complete unit to the RADEF Instrumentation Test Facility for repair with a written description of the malfunction.

5. This instrument is an extremely sensitive device and must be recalibrated every six months. Check the Calibration Log on page 24 to determine the last time the device was calibrated. If the calibration is more than six months old return the unit to the RADEF Instrumentation Test Facility.

6. Radiation exposures to the detector must only be made from the lowest rate to the highest rate. The reason for starting with the lowest rate in calibration is that after the detector is exposed to gamma exposure rates of several hundred R/h; there is a slight hysteresis effect which will produce slightly higher readings on the more sensitive detection ranges. While the error produced is small ( $\sim$ 2% of the final reading) it can be avoided by starting with the low exposure rates and working up. If the detector is inadvertently exposed to a high exposure rate, just before making a low exposure rate measurement, allow the instrument to idle for $\sim$ 5 minutes. At the end of this time period most of the hysteresis effect will have dissipated.

7. The total gamma exposure received by the detector in one (1) day should be limited to $\leq$ 1,000R. Exposures in excess of this limit will produce excessive leakage in the ion chamber insulators resulting in a shift in the gamma response. Should this occur, the detector will recover from this radiation damage effect in approximately a week.

8. When the moisture indicator on the detector unit becomes pink in color, remove the dessicant from the case and dry it in accordance with the procedure described in the Maintenance and Calibration Section of this manual.

## D. OPERATING PROCEDURE FOR THE CALIBRATION OF THE CDV-794 MODEL 2 CALIBRATOR:

Refer to Figure No. 2, page 6 for a visual presentation of the controls and lights used in the procedure.

1. After unpacking the instrument, inspect it for obvious damage. Turn the "Main Power" switch to "Off".

2. Connect the signal and high voltage cables to the rear of the instrument cabinet and to the ion chamber detector unit. The larger cable with the BNC connectors is the signal cable and must be connected to the check source position on the detector.

3. Connect the AC line cord to the male connector on the rear of the cabinet and a power supply outlet of 115 volt, 60 Hz.

4. Turn the "Test Selector" switch full counter clockwise. Set the "Test Cycle Mode" switch to "Auto". Set the "DVM" switch

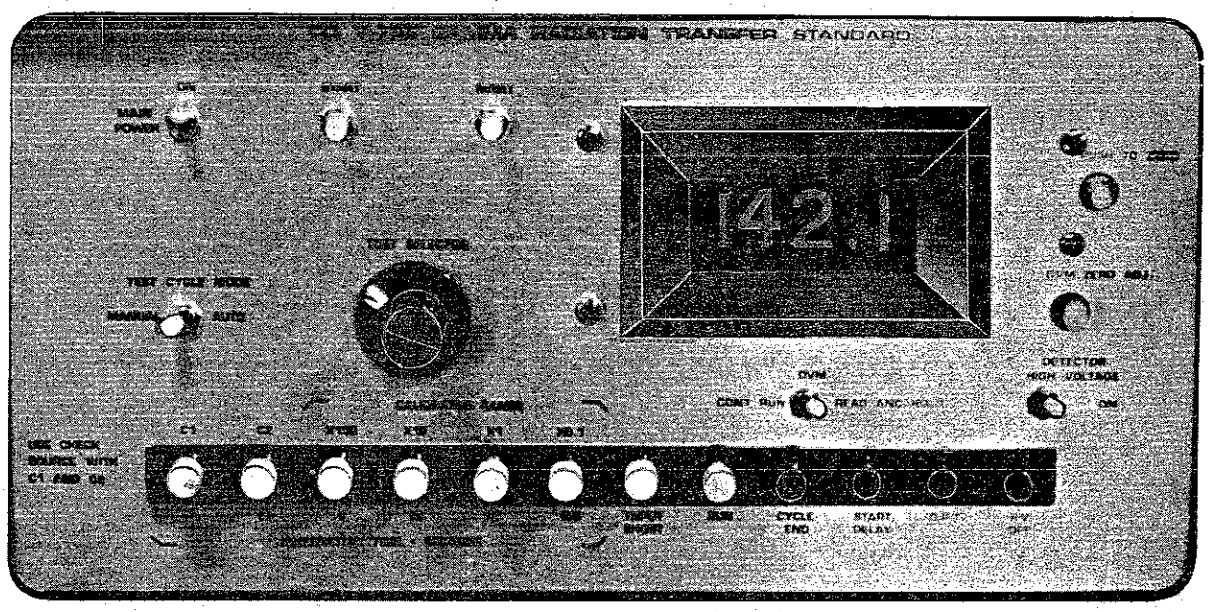


Figure No. 2: Front Panel

to "Cont. Run". Turn the "Detector High Voltage" switch "On".

5. Turn "On" the "Main Power" switch.

6. The following lights should then be "On".

(a) The digitec readout numerals should be illuminated.

(b) The yellow lamp marked "Cl".

(c) The yellow lamp marked "Input Short".

(d) The yellow lamp marked "Run" should be dimly lit.

7. No red lights should be on. The logic behind this is that normal cycling of the instrument should not occur with a red panel light showing.

8. Allow the unit to warm up for 15 minutes.

9. At the end of the warm up period check the zero reading of the Digitec Voltmeter. It should read zero, but if not, use the "DVM Zero Adj." to reduce the reading to zero. Do <u>not</u> press "Push to Zero" button. A slight offset voltage present in the electrometer will not affect the reading accuracy to any noticeable degree as long as the DVM reading can be set to zero.

10. Set the "DVM" switch to "Read and Hold."

11. To obtain a reading from the check source press the "Start" button. The rest of the cycle is automatic.

12. The yellow "Input Short" light will go out and the yellow "Run" light will flash on and off.

13. When 50 seconds has passed the red "Cycle End" light will

turn on; the yellow "Run" light will stop flashing and go dim; and the Digitec Voltmeter will automatically indicate the collected voltage.

14. After approximately 10 seconds from the turn on of the red "Cycle End" light the red "Start Delay" and the yellow "Input Short" lights will turn on and the red "Cycle End" light will turn off.

15. After an additional 15 seconds the automatic cycle will repeat.

16. Readings obtained from the Digitec Voltmeter must only be taken during the automatic cycling at the point in time when the "Start Delay" light is on. The first three (3) readings may have some drift and must be ignored. Take the average of the next three (3) successive readings. Compare this average to the "C1" check source data given in the calibration table page 24. This average must be within the tolerances given. If not, the unit must be considered defective.

17. Switch the "Test Selector" switch to the "C2" position. The "C1" yellow lamp will go out and the "C2" yellow lamp will come on.

18. Switch the "Test Cycle Mode" switch to the "Manual" position and the "DVM" switch to "Cont. Run". Push the "Reset" button and re-zero the Digitec Voltmeter if necessary. Do not push the "Push to Zero" button.

19. Turn the "Test Cycle Mode" switch back to the "Auto" position and the "DVM" switch back to "Read and Hold."

20. Press the "Start" button.

21. The automatic cycle for "C2" is essentially the same as with the "C1" check given in Item Nos. 12 through 16, except that the yellow "Run" lamp will be on for only 2.5 seconds. Again the first three (3) readings must be ignored. The average of three (3) additional readings must be compared to the "C2" check source data given in the calibration table page 24 . This average must be within the tolerances given or the unit is to be considered defective.

22. Repeat Item #18.

23. Turn the "Detector High Voltage" switch off, note that the "HV Off" red light is on.

24. Disconnect the cables from the detector and feed the ends into the access hole in the rear of the CDV-794 Model 2 Calibrator.

25. Place the detector on the instrument jig/holder of the CDV-794 calibrator and reconnect the CDV-765 cables to the detector. Note that the signal cable must be connected to the "Detector Output" jack. Dress the two leads so that the CDV-794 test chamber door does not rub on them when closed.

26. Turn the "Detector High Voltage" switch to "On". The "HV Off" red light will go out.

27. Turn the "Test Selector" switch to the full clockwise position. The "C2" yellow light will go out and the "X0.1" white light will come on.

28. Adjust the "DVM" for zero if necessary.

29. Repeat Item #19.

30. Turn the CDV-794 Model 2 calibrator wheel directly to X0.1 position. CAUTION: Do not turn the calibrator wheel through the X100, X10, X1 positions to obtain the X0.1 position.

31. Press the CDV-765 "Start" button.

32. The "Input Short" yellow lamp will go out and the yellow "Run" lamp will flash on and off for a period of 100 seconds. The red "Cycle End" lamp will then come on, the "Run" yellow lamp will go dim, and the Digitec Voltmeter will indicate the stored voltage. After 10 seconds the red "Cycle End" light will go out and the red "Start Delay" and yellow "Input Short" lights will come on. After an additional 15 seconds the automatic cycle will repeat.

33. Readings obtained from the Digitec Voltmeter must only be taken during that point in time of the automatic cycle when the red "Start Delay" light is on. The first three (3) readings must be ignored. The average of the next three (3) successive readings is used for determining the CDV-794 Model 2 exposure rate for the X0.1 range. Refer to Item #53 for computation of this exposure rate.

34. Turn the "Test Selector" switch to the "X1" position. The white "X0.1" light will go out and the white "X1" light will come on.

35. Repeat Item #18.

36. Repeat Item #19.

37. Place the CDV-794 Model 2 calibrator wheel in "X1" position.

38. Press the CDV-765 "Start" button.

39. The X1 automatic cycle is essentially the same as with the X0.1 check given in Item #32 except that the yellow "Run" lamp will flash for only 20 seconds. Again the first three (3) readings must be ignored. The average of three (3) additional readings will be used for determining the X1 exposure rate. Refer to Item #53 for this computation.

40. Turn the "Test Selector" switch to the "X10" position. The "X1" white light will go out and the "X10" white light will come on.

41. Repeat Item #18.

42. Repeat Item #19.

43. Place the CDV-794 Model 2 calibrator wheel in the X10 position.

44. Press the CDV-765 "Start" button.

45. The X10 automatic cycle is essentially the same as with the X0.1 check given in Item #32, except that the yellow "Run" lamp will flash for 50 seconds. Again the first three (3) readings are to be ignored. The average of three (3) additional readings is to be used for obtaining the exposure rate of the X10 range, Refer to Item #53 for this computation.

46. Turn the "Test Selector" switch to the "X100" position. The "X10" white light will go out and the "X100" white light will come on.

47. Repeat Item #18.

48. Repeat Item #19.

49. Place the CDV-794 Model 2 calibrator wheel in the "X100" position.

50. Press the CDV-765 "Start" button.

51. The X100 automatic cycle is essentially the same as with the X0.1 check given in Item #32 except that the yellow "Run" lamp will flash for 5 seconds. Again the first three (3) readings are to be ignored. The average of three (3) additional readings is to be used for obtaining the exposure rate for the X100 range. Refer to Item #53 for this computation.

52. This completes the operation of the CDV-765 Transfer Standard. Turn the "Main Power" switch off. Disconnect the cables. Refer to Item F. for packing and shipping instructions.

53. Using the average output voltage readings and the calibration factor for each selector range (refer to calibration table page 24 ) the gamma exposure rate can be determined using the following formula:

$$R = VF$$

where: R = the gamma exposure rate in R/h

V = the CDV-765 reading in volts

F = calibration factor given in the calibration log for each range.

The accuracy of these measurements are within $\pm$5% of the true gamma

exposure rate as determined by the National Bureau of Standards, providing the calibration is performed as instructed.

E. CALIBRATING OTHER GAMMA SOURCES: Although the CDV-765 was designed primarily as a device for calibrating the CDV-794 Model 2 Calibrator, it can be used to determine gamma exposure rates from any gamma radiation source in free air; providing the proper geometrical considerations are made. In addition, the gamma or X-ray energies must fall between 0.08 and 1.33 Mev; the exposure rates must fall between 0.1 and 500 R/h, and the scatter radiation contributions must be considered in any such measurements. Since the detector responds like a typical OCD Ion Chamber Survey Meter, detectors with different geometries, sizes or energy response characteristics, will not give the same results. However, for the gamma calibration of the CDV-715 and CDV-717 instruments this device is ideal. For example, a CDV-793 Calibrator (AN/UDM-1A) can be accurately calibrated with this device, providing the gamma beam is uncluttered with steel, iron or other efficient gamma radiation scattering materials. The detector must be positioned with the handle away from the source and the case bottom positioned at a 45° angle from the horizontal. The radiation field at positions > 1.5 meters from the source can be determined within approximately the same accuracies as the CDV-794 calibration. Other wide beam sources can be calibrated in much the same manner

G. THEORY OF OPERATION:

G.1 - Circuit Description: The CDV-765 Gamma Radiation Transfer Standard consists of an ion chamber detector mounted in a case resembling a CDV-715 Ion Chamber Instrument. This detecting element is shown in Figure No. 3. The detecting element is a hermetically sealed, air filled ionization chamber consisting of a steel cylindrical shell and a thin aluminum disc for a collector located in the center of the shell. The shell is the positive electrode and the collector the negative electrode. The collector is insulated from the shell by three (3) styrene pillars projecting from the chamber lid and by an extremely high resistance triaxial feedthrough. The feedthrough is mounted in the chamber shell by a glass-to-metal seal and the center contact of the feedthrough serves as the external connection to the collector. The intermediate ring electrode in the feedthrough is connected to ground as a guard ring to prevent leakage currents across the glass insulator. A voltage of $\sim$ 200 VDC positive is applied to the shell with respect to the collector assuring adequate chamber saturation at gamma exposure rates well over 500 R/h. This collection voltage causes ions produced by the secondary electrons to be attracted to the chamber electrode having the opposite charge. The collection of these ions on the electrodes produces a small current which is proportional to the number of ions collected. Therefore, the gamma radiation intensity

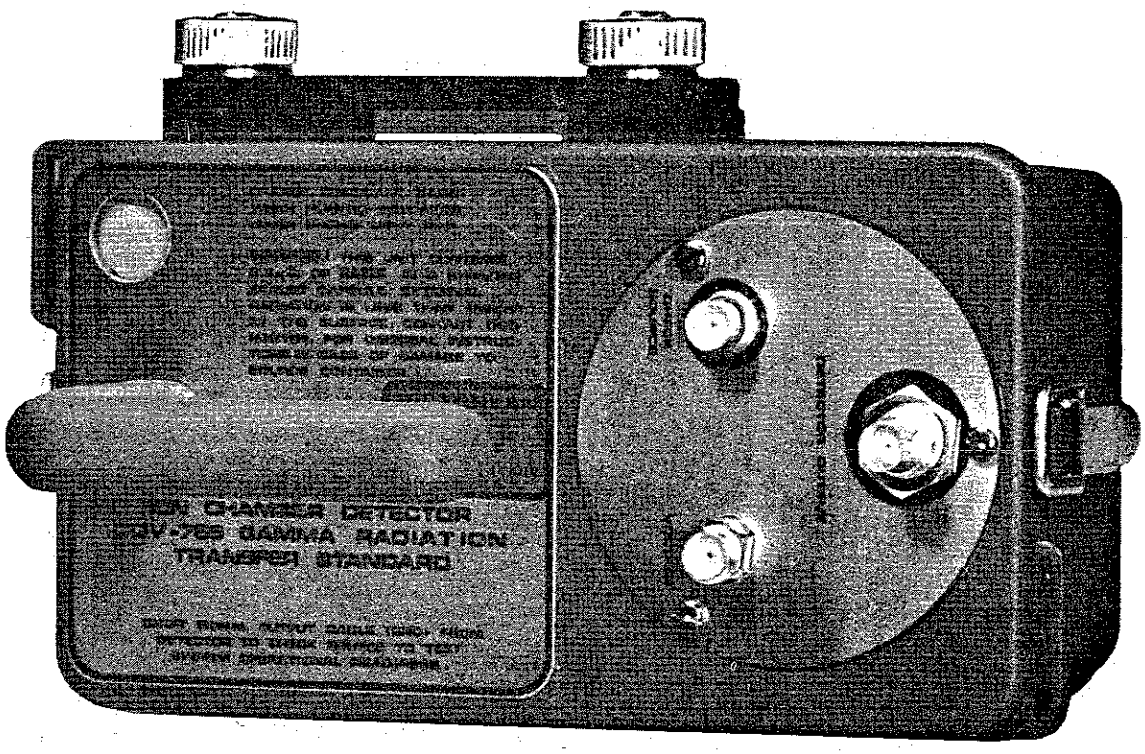


Figure No. 3: Detector Unit

of the field impinging on the ion chamber is proportional to the amount of current produced.

The ion chamber feeds its output current to the main amplifier through a low noise, low capacity double shielded cable. The high voltage is supplied from the console to the detector unit through a separate shielded PTFE cable. The small current output ( $\sim$ 5.8 pA at 0.4 R/h) of the ion chamber is used to develope a charge on a stable capacity of extremely high leakage resistance. This rate of charge measurement is made with a feedback stabilized vibrating capacitor electrometer. During operation, a charge on the vibrating capacitor will produce a 300 Hz sinusoidal voltage at its terminals. This AC signal is coupled to the grid circuit of an electrometer where it is amplified. In this case, the electrometer tube is used as a high impedance input, low noise, AC amplifier. A discriminator compares the phase and amplitude of the amplified 300 Hz signal from the vibrating capacitor with a reference signal from an oscillator. A DC voltage output is thus obtained which is proportional to the amplitude and polarity of the charge on the vibrating capacitor. This output voltage is fed back to one terminal of an integrating-storage capacitor. Any steady current flow into the input will cause the input-output capacitance of the integrating capacitor to charge steadily. This charge is indicated by a Digitec Voltmeter as a

steadily rising voltage opposite in polarity to that of the input current. Reed relay switches are used to select the value of the integrating capacitor, to open the input circuit at the end of the fixed integration period, and to restore the input circuit to near zero before starting a new measurement. The logic and switching control circuits were designed to control the operation of the electrometer-integrator input relay switches, length of the integration period, value of the integrating capacitor and the operation of the readout, with an automatic repeating cycle if desired. These functions are carried out by a multiple binary counter, control flip-flops, switches, time delay circuits and control gates. The electrometer-integrator, voltmeter, and other control circuitry are all located in the instrument console.

G. 2 - Operating Sequence: The "Start" button will operate only when the circuits are ready to accept a start signal. This is when all delay cycle red lamps are out, the "Input Short" lamp is on, and the "Run" lamp is dim. If the "H.V. Off" lamp is lighted, the operating cycle may be run, but no valid data will be obtained. It should be remembered that if the "Run" lamp is flashing in a normal manner after a manual or automatic cycle start has been made, and any red light shows, an abnormal condition exists and the readout numbers should be ignored. The "Reset" switch is operative at all time and may be used to reset the cycle at will. The reset function

includes the "Cycle End" period, and the mandatory "Start Delay" period which allows the input circuit capacitance to discharge to near zero, so that consistent output readings will be obtained when taking repeat readings of the same input signal. Pressing the "Reset" button during one of the delay periods will restart the first delay cycle and probably increase the total delay time before a new start is possible. As soon as the "Start" button is pressed, the "Input Short" lamp goes out and the "Run" lamp begins to flash, indicating that the built-in timer is operating. The integration times are all preset and are indicated below the test position lamps. The "C1" check period is 50 seconds and the output voltage at the end of this period should be in the range of 11.2 ±.8 volts, for all instruments. Each instrument has been calibrated with its own detector and check source, and this voltage has been determined very closely. The exact calibration figures for this instrument with its own check source and the roentgens per hour per volt conversion constant for each range is given in the Calibration Log of this manual.

The basic timing accuracy of the integration periods is better than 0.2% for all except the two shortest periods. The precision of the 2.5 second "C2" test period is limited to ±1 part in 150, while the precision of the 5 second X100 integration period is ±1

part in 300. This means that the "C2" check is a rough check on the condition of the low level ranges, while the "C1" test position, with timing accuracy better than 1 part in 1,000, is much more precise.

At the end of the integration period, the "Run" lamp stops flashing and the "Cycle End" lamp comes on. The DVM reads the final output voltage only for the duration of the "Cycle End" delay period. At the end of this period, the "Cycle End" lamp goes out, and the "Start Delay" and "Input Short" lamps are lighted. The electrometer output voltage runs to zero when the input is shorted, and the DVM reads the electrometer output voltage only during the "Cycle End" period, and at the end, the output reading is stored until it is updated by the next reading or reset to zero by operation of the "Reset" switch. The "Start Delay" period is 24 ±9 seconds for all instruments. In any one instrument, the cycle time duration repeats closely. At the end of the "Start Delay" period, an output pulse is generated which starts the "Run" cycle unless the "Test Cycle Mode" switch is on "Manual", in which case the operation stops with the circuits ready to go whenever the "Start" button is pushed.

After the first three (3) cycles are completed, at least three (3) more readings should be taken to make sure that the instrument has stabilized and is giving output readings which track each other within less than 1%. The range of "C2" voltages is 15.2 ±.8 volts for all instruments. Again, the exact output of the check source

for this instrument is given in the Calibration Log of this manual.

Four (4) red lights indicate respectively (a) the "HV Off;" (b) the "Cycle End" of the integration period; (c) the "Start Delay" period during which the start of a new measurement cycle is held off until the charge previously stored in the integrating capacitor has been dissipated; (d) the "ORT" (Over Range Trip) a protective shutoff circuit which stops the run cycle and cancels the input signal whenever the output voltage rises above the normal full scale output voltage of the electrometer. If the "ORT" acts, the normal cycle is interrupted and the "ORT" lamp stays on, stopping the automatic cycle and disabling the manual start switch in the manual mode. The "ORT" must be reset by pressing the "Reset" switch. If the cause of the excessive output voltage is not corrected, the "ORT" will interrupt each time until the fault is cleared. The "ORT" will also interrupt operation of the instrument if the detector input is connected to the check source and the X1 or X0.1 range is selected.

A small (5.5 μCi) $^{226}Ra$ check source is located in the detector case which can be used to determine instrument operability.

G. 3 - Mechanical Features: The entire system is housed in an aluminum clad, plywood carrying case. The case is lined with foam and equipped with locks. The carrying case is shown opened with the device properly packed inside in Figure No. 1 on page 3 of this manual.

The CDV-765 Detector Unit is equipped with a holding fixture on the case bottom identical to the jig used to mount instruments for calibration in the CDV-794 Test Chamber. This has been provided so that the ion chamber detector and check source can remain in a sealed case at all times. Dessicant bags are placed in the sealed case and a plastic color-change indicator shows when the dessicant requires re-activating or changing.

H. MAINTENANCE AND CALIBRATION: Because the CDV-765 Transfer Standard is an extremely sensitive device, no attempt should be made to repair or adjust it if abnormal operation or trouble is encountered. The exceptions, to this statement are the inspection and cleaning of plugs, jacks, and line connections. If the moisture indicator on the detector unit turns pink, the dessicant should be removed from the detector case and dried in an oven as described on page 9 in the Maintenance and Calibration Memorandum, M&C No. 71-6, dated April 27, 1971. When removing the dessicant from the oven, place it in the detector case and seal, immediately. If the restoration of the dessicant is successful, the indicator should turn blue. Any other trouble or problem encountered should be referred to the RADEF Instrumentation Test Facility or the Nucleonics Division of OCD Headquarters.

Each CDV-765 Transfer Standard must be returned to the RADEF Instrumentation Test Facility every six (6) months for periodic maintenance and calibration. A Calibration Log is provided at the end of this manual which gives the date of the last calibration of the device, as well as the calibration factors and the readings to be obtained from the check source. If this date is more than six (6) months old, the device should be packaged as described in Section F above and shipped by UPS, REA or truck freight to:

RADEF Instrumentation Test Facility
Bldg. #22, Paulding Street
Washington Navy Yard
Washington, D.C. (Southeast)

Upon the completion of maintenance and calibration, the device will be returned to the sender unless otherwise instructed.

# I. CALIBRATION LOG

CDV-765 GAMMA RADIATION TRANSFER STANDARD

SERIAL NO. _____

| CALIBRATION DATE | BY | CHECK SOURCE CALIBRATION | | CALIBRATION FACTORS | | | |
|---|---|---|---|---|---|---|---|
| | | C1 | C2 | X100 | X10 | X1 | X0.1 |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |