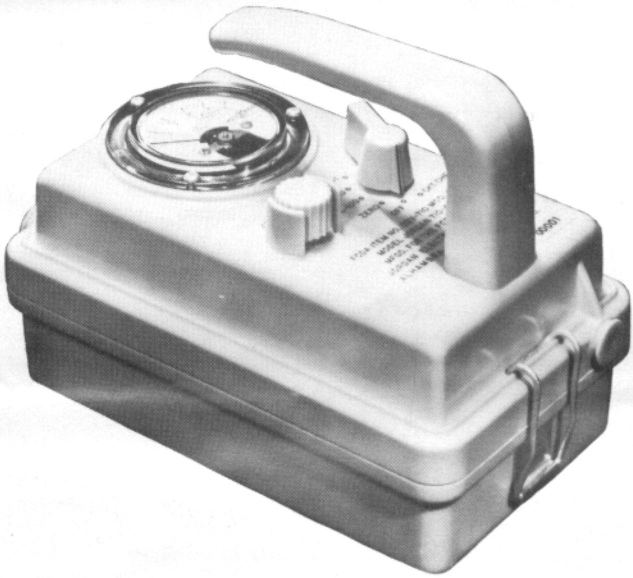
operating
and maintenance
INSTRUCTIONS



Radiation Survey Meter
Jordan Model 710-4

FCDA Item No. CD V-710—Model No. 4

Jordan Electronics, Inc.
3025 West Mission Road
Alhambra, California

TABLE OF CONTENTS

operating and maintenance instructions

1.0 GENERAL DESCRIPTION

1.1 ranges

The *Jordan 710-4* measures the intensity of gamma radiation up to 50 roentgens per hour (r/hr). Three ranges are provided, 0-.5, 0-5 and 0-50 r/hr. On the lowest (0-.5 r/hr) range, the small division on the scale is .02 r/hr and, by interpolation, measurements can be made in increments of .01 r/hr. Intensities higher than 50 r/hr are indicated by the meter reading off scale, and the instrument is not harmed.

1.2 ionization chamber

The sensing element in the *Jordan 710-4* is an air equivalent plastic ionization chamber in an hermetically sealed steel enclosure. All the desirable qualities of the usual plastic chamber are maintained, while sealing the chamber minimizes the effects of temperature and eliminates the altitude and moisture effects.

1.3 spectral response

The accuracy of this instrument is not affected by changes in energy level from .08 Mev (Million electron volts) to 1.2 Mev. This is the range required to measure gamma radiation of the various energies encountered in fission products.

1.4 accuracy

The accuracy of this instrument is ± 20% when used in temperatures from −20°F to +125°F. The accuracy is not affected by altitude, and the instrument will not respond to light or radio frequency radiations. The case is watertight to withstand immersion, and the housing containing the critical measuring components is gasketed to prevent any effects of moisture. Under normal operating conditions the measuring error is less than 10%.

1.5 controls

Two controls are provided. (See figure 1.) The RANGE SWITCH is used to turn on the instrument, check its proper functioning, and select the required range. The ZERO CONTROL is used to adjust the circuit to insure correct readings.

1.6 circuit check

The proper functioning of the measuring circuit including the batteries may be checked by setting the range switch to CIRCUIT CHECK and observing the meter reading. The limits of acceptable indication cover the top 40% of the scale, and a reliable indication of the condition of the instrument is available.

1.7 batteries

Two "D" size flashlight cells, NEDA type 13 and one 22.5 volt "B" battery, NEDA type 215 are used. The operating life for continuous duty is 200 hours and, for intermittent use, about twice this figure.

1.8 meter

The meter in the *Jordan 710-4* uses the new core magnet movement. It will withstand the shock and vibration of rough field use, and it is sealed in a plastic case to prevent damage from dust and moisture.

1.9 physical features

The instrument is approximately 4″ wide, 7″ long and 3″ high, excluding the handle. The instrument weighs only 2 lbs. 4 oz. The case and handle are molded of tough, durable plastic and are reinforced to withstand high impact shock and rough treatment. A separate battery compartment is molded into the lower case to prevent leaky batteries from damaging other components. The *Jordan 710-4* has passed a rugged military shock test (MIL-T-17113) and will withstand considerable abuse without loss of accuracy.

2.0 THEORY OF OPERATION

2.1 ionization chamber

The sensing element of the *Jordan 710-4* is an hermetically sealed ionization chamber with air equivalent plastic walls. This comprises a cylindrical air container called the sháll and a disc, centrally located within it, called the collector. The collector is insulated from the shell which is operated at a potential of approximately 22.5 volts positive with respect to the collector.

Gamma rays passing through the chamber shell cause the air molecules to become charged positively and thus become ions. Having a positive charge, the ions are repelled from the positive (+22.5V) shell, and they go to the collector. The number of ions thus formed is proportional to the intensity of the radiation.

The collection of these positive ions creates a current that flows from the chamber collector to the measuring circuit where it is amplified to operate the meter.

2.2 electrometer tube

The very small ionization current from the chamber collector (.000003 microampere at .5 r/hr) flows through an extremely high resistor (160,000 megohms) and develops a measurable voltage across this "high-meg" resistor. This voltage is applied to the grid of a vacuum tube which is called an electrometer tube because it is capable of measuring voltages at extremely small current values. The electrometer tube is connected as a triode. Its three elements are the **filament** which when heated by current from the "D" cell emits electrons, the **grid** which controls the flow of these electrons according to the voltage applied to it, and the **plate** which receives the electrons and passes them to the circuit in the form of a measurable current.

2.3 measuring circuit

A current i_1, flowing from the "B" battery B_3 through resistors R_a, R_b, R_c and R_d produces the voltages necessary to operate the circuit. From the positive terminal of B_3, the voltage e_s is connected to the shell of the ionization chamber. A lower voltage e_p supplies the **plate** of the electrometer tube VT. The **filament** (cathode) of the electrometer tube is operated at the voltage e_g while the **grid** operates at the CHASSIS GROUND potential.

This supplies the required negative grid voltage. The meter M is connected in the cathode circuit of the electrometer tube. Changes in the grid voltage of the electrometer tube cause changes in the current flowing through the meter, thus producing the required indication.

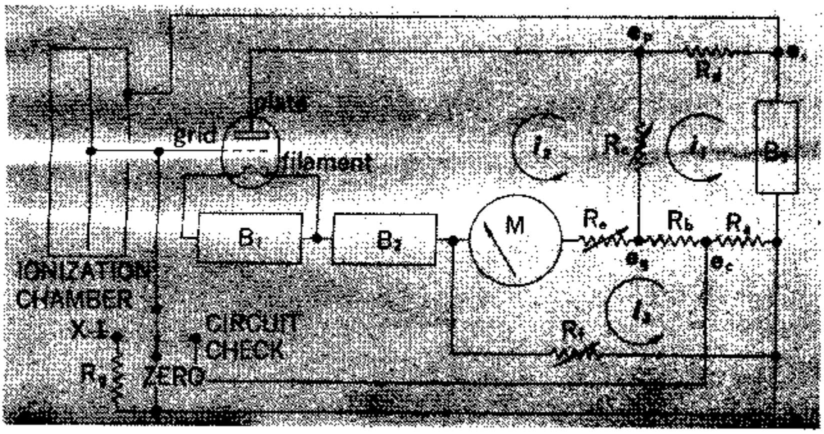


Figure 1 — The Basic Circuit

2.4 circuit check

A very small portion e_c of the voltage from the "B" battery B_3 is impressed on the grid of the electrometer tube VT when the switch is turned to the circuit check position. This voltage e_c is selected to make the meter read approximately full scale. Deterioration of any of the components or batteries in the circuit will change this reading. This voltage can, therefore, be used to check the entire circuit with the exception of the ionization chamber and high-meg resistor.

2.5 zero controls

The voltage e_g developed across resistors R_a and R_b produces a current i_3 through R_e, the meter M, and R_f. The variable resistor R_f (COARSE ZERO control) is adjusted at the factory to make the current i_3 equal and opposite to the plate current i_2 when the grid voltage is zero. Thus, the meter reads zero when there is no radiation. Small adjustments to zero the instrument in a radiation field are made by turning the range switch to the ZERO position to ground the current from the ionization chamber and thus simulate the "no radiation" condition. The variable resistor R_c (ZERO) is then adjusted to make the meter read zero.

3.0 INSTALLATION

3.1 inspection

The instrument is shipped with the batteries packed separately to prevent damage to the instrument from battery leakage.

Inspect the instrument carefully for any signs of damage in shipment. If any damage is apparent, the batteries should not be installed until an electrical check is made to prevent a short circuit causing further damage.

3.2 batteries

Remove the toggle clamps holding the lower case and open the case. Note that compartments molded into the lower case locate and hold the batteries. The batteries must be installed in their proper positions to permit replacing the lower case.

Observe the polarity markings at each battery contact.

Install the batteries in their proper positions and check to see that the battery contacts apply pressure to the battery terminals. If the pressure appears insufficient to insure good contact, remove the battery and squeeze the contacts together slightly to increase the contact pressure.

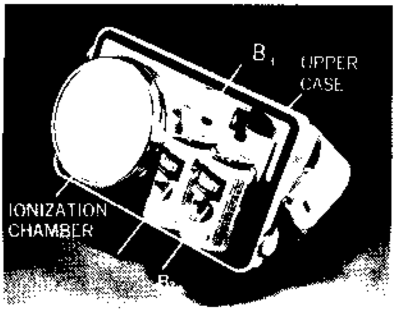


Figure 2 — The Jordan 710-4 with lower case removed

When the batteries are installed, turn the range switch to the ZERO position and adjust the ZERO control to make the meter read zero. Turn the range switch to the CIRCUIT CHECK position and see that the meter reads within the red circuit check markings. If these indications can not be obtained, refer to section 7.5 for trouble shooting procedures.

If the circuit check indication is proper, replace the lower case and fasten the toggle clamps.

The instrument is now ready for operation. If the shoulder strap is required, snap the metal fasteners onto the buttons provided on each end of the instrument and adjust the buckle to the desired length.

4.0 OPERATION

4.1 operational checks

Turn the range switch to the ZERO position, wait a minute or two for the electrometer tube to warm up and adjust the ZERO control to make the meter read zero.

Turn the range switch to the CIRCUIT CHECK position. The meter should read within the red band marked CIRCUIT CHECK. If it does not, the batteries may be dead, or trouble may exist in the circuit. See sections 5 and 7 for maintenance procedures. When the batteries are new, the meter should read near the top of the circuit check band. When the reading nears the bottom of the band, the batteries should be replaced.

The CIRCUIT CHECK does not test the chamber or the high-meg resistors.

4.2 taking readings

Turn the range switch to the X-100, X-10 or X-1 range as required and read the radiation intensity indication on the meter. The meter readings must be multiplied by the factor for the range being used. For example, a meter reading of .35 on the X-10 range indicates 3.5 r/hr. On the X-100 range the intensity would be 35 r/hr.

When several readings will be taken in an hour, or the instrument will be used frequently during a day, it is advisable to leave it turned on during the entire period of use.

The instrument is equally sensitive to radiation from the sides, front and bottom.

5.0 OPERATOR'S MAINTENANCE

5.1 battery replacement

The batteries should be replaced when the CIRCUIT CHECK setting on the range switch makes the meter read near the low end of the CIRCUIT CHECK band.

To replace batteries, remove the toggle clamps and the lower case and remove the old batteries. These should be discarded immediately to prevent their being inadvertently re-used. Inspect the battery contacts and clean if necessary. Install new batteries as described in section 3.2.

If the batteries are to be removed and reinstalled, be sure that B_1 and B_2 are not interchanged. A voltmeter check will show that the voltage of B_2 is always higher than that of B_1.

5.2 cleaning

WARNING: *Do not use cleaning solvents on the plastic parts.*

To clean the case, use soap and water. If the batteries have leaked, remove the lower case and fill only the battery compartment with warm water. The battery "goo" will be loosened in a short while and can be easily rinsed out. Be careful not to soak off the circuit diagram or the CD decal.

6.0 PREVENTIVE MAINTENANCE

Preventive maintenance is required once every six months of storage, once every month of occasional use, or prior to any critical period of use.

The batteries should be removed and checked for corrosion and cleaned if necessary. The battery contacts in the instrument should be carefully cleaned if necessary. Any leaking batteries should be discarded and replaced.

Check the calibration against a standard gamma source and adjust if necessary according to the instructions in section 7.

If the instrument is to be stored for more than a few weeks, the batteries should be removed and stored separately.

7.0 CORRECTIVE MAINTENANCE

7.1 tools required

Two tools are required to disassemble the instrument partially for minor maintenance:

A ½" nut driver for the switch and zero control nuts, and
a 3/16" nut driver to remove the high-meg compartment.

For complete maintenance, the following should be available:

a. A 5/16" nut driver for the meter terminals.
b. A small Phillips screwdriver for the screws that mount the meter.
c. A 20,000 ohm per volt multimeter such as the Simpson 260.
d. A small soldering iron and solder.
e. A pair of diagonal cutters and small long-nose pliers.

7.2 disassembly

The instrument may be partially or completely disassembled in the following steps:

a. Remove the toggle clamps and the lower case.
Pull off the switch knob and remove the nut holding the switch.
DO NOT LOOSEN ANY SCREWS.
b. Hold the handle and press down on the switch shaft to remove the chassis from the upper case.
c. Place the chassis in the lower case to hold the batteries in position and place the upper case next to it as shown in figure 3.

The instrument is now sufficiently disassembled to make voltage checks and inspect some of the components. Place the instrument with the ionization chamber on the left and all circuit components will be located as shown in the circuit diagram figure 4.

To remove the high-meg housing, remove the two small nuts on the switch mechanism, lift out the switch mechanism and remove the two spacers below it. Now lift off the high-meg housing.

NOTE: *Because the electrometer tube is sensitive to light, the instrument will not measure radiation accurately when the high-meg housing is open.*

To re-assemble the instrument, follow the above steps in the reverse order. When replacing the switch mechanism, be sure the switch rotor is in the position that it was in when the switch mechanism was removed.

7.3 calibration

A calibrated source of radioactive material should be used to calibrate the instrument. Cobalt-60 and Radium sources are most commonly used. If the radiation intensity of the source is unknown, a secondary standard instrument such as a Condenser R Meter can be used to calibrate the source.

The *Jordan 710-4* can be calibrated on any of its three ranges and the other two will automatically be calibrated. A convenient radiation intensity to use is 0.35 r/hr. A 20 mc. Radium source will produce this intensity at 8.62 inches. All measurements must be made from the center line of the chamber, the location of which is indicated by a small raised line on each side of the lower case. The source should be no closer than 6 inches from this mark.

Prior to recalibrating the instrument, install a new set of batteries. Set the range switch to the ZERO position, turn the ZERO control clockwise to the stop and adjust the COARSE ZERO control to make the meter read 0.4. Re-zero the instrument with the ZERO control.

Check the calibration with the instrument in the case. Remove the instrument and adjust the CALIBRATE control as required. Replace the instrument in the case and check the reading. Repeat this procedure until the correct reading is obtained. If a large source is available, the high ranges should also be checked.

7.4 batteries

The "B" battery and "D" cells are tested by use of the circuit check feature. If trouble occurs, however, the batteries should be tested separately with a voltmeter. The voltages should be as follows:

	New	*After 200 Hours*
B_1	1.55V	1.25V
B_2	1.55V	1.55V
B_3	23V	15V

7.5 trouble shooting

Seven of the eight significant voltages in the circuit can be measured by removing only the lower case. Voltages can be measured from the chassis to each of the battery contacts. The plate of the electrometer tube is connected to the small washer under the center of B_2. Measurements can be made at this point by moving B_2 in its contacts about ¼" to the back of the instrument. It is recommended that these measurements be made before the instrument is disassembled for further trouble shooting.

All components with the exception of the high-meg resistors and the electrometer tube are similar to parts used in radio and television sets and most radio servicemen and radio amateurs can test them.

Voltages can be checked with those shown on the circuit diagram. Batteries must be removed before making resistance or continuity checks.

The high-meg resistors cannot be checked with standard radio test equipment but can be assumed to be functioning properly if they are not dirty or damaged.

CAUTION: *Do not handle the high-meg resistors, the ceramic switch deck, or the electrometer tube. Touch them only with clean tools.*

Do not unsolder the red wire from the shell connection of the ionization chamber. This will destroy the hermetic seal. Disconnect the other end of this wire if necessary.

The following symptoms and suggested corrective procedures will be helpful in trouble shooting the *Jordan 710-4*.

will not zero	CORRECTIVE PROCEDURE
Dead batteries	Replace all batteries
Dirty battery contact	Inspect and clean battery contacts
Loose battery contact	Check contact pressure and squeeze battery contacts together to increase pressure if necessary
Coarse zero control disturbed	Readjust according to instructions in section 7.3
Electrometer tube filament open	Remove batteries, set range switch to ZERO, measure resistance between battery contacts. Should be approximately 150Ω.
Open potentiometer	Check potentiometers with ohmmeter
Open resistor	Check resistors with ohmmeter
Open connection	Inspect all solder joints and wiring
Open switch contact	Check switch contacts, clean and, if necessary, adjust contacts
Short circuit	Inspect for mechanical damage

no reading	CORRECTIVE PROCEDURE
Dead batteries	Replace batteries
Dirty battery contact	Inspect and clean battery contacts
Loose battery contact	Check contact pressure and squeeze battery contacts together to increase pressure if necessary.
Meter damaged	Replace meter
Open connection	Inspect all solder joints and wiring

reads low

Calibration control disturbed	Check calibration as outlined in 7.3
Calibration control open	Check calibration control with ohmmeter
Dead electrometer	Replace with new 5886
Dirty high-meg components	Clean the high-meg resistors, ceramic deck, electrometer tube, and chamber insulator with pure dry alcohol
Meter damaged	Replace meter

reads high

Calibration control improperly adjusted	Check calibration as outlined in 7.3
If high reading is on only one range, a high-meg resistor may be damaged.	Replace suspect high-meg resistor

Figure 3 – The Jordan 710-4 Disassembled for Servicing

8.0 REPLACEABLE PARTS

8.1 mechanical components

No. Req'd	*Description and Function*	*Jordan Part No.*
1	Case assembly, upper	AP-0006
1	Case assembly, lower	AP-0005
1	Knob assembly, switch	AP-0010
1	Knob, zero	MP-0016
2	Clamp, toggle	AA-0001
1	Shield, high-meg	MS-0255
1	Gasket, case	HG-0039
1	Gasket, meter	HG-0043
1	Strap assembly, shoulder	AP-0011

8.2 maintenance supply parts

Suggested supply for five instruments for one year of operation:

Qty.	*Circuit Symbol*	*Description and Function*	*Jordan Part No.*
5	B_1	"D" cell, filament supply	BA-0005
5	B_2	"D" cell, bias supply	BA-0005
5	B_3	"B" battery, plate supply	BA-0006
1	VT	Vacuum tube, electrometer, 5886 . .	VT-5886
1	M	Meter, indicating	EI-0013
1	R_1	Resistor, high-meg, Range X-1 . . .	RX-0007
1	R_2	Resistor, high-meg, Range X-10 . . .	RX-0008
1	R_3	Resistor, high-meg, Range X-1000 . .	RX-0009
1	R_7	Potentiometer, zero control	RP-0103
1		Case assembly, upper	AP-0006
1		Case assembly, lower	AP-0005
1		Knob assembly, switch	AP-0010
1		Knob, zero	MP-0016
2		Clamp, toggle	AA-0001

8.3 names and addresses of manufacturers

NATIONAL CARBON CO.
30 East 42nd Street
New York 17, N. Y.

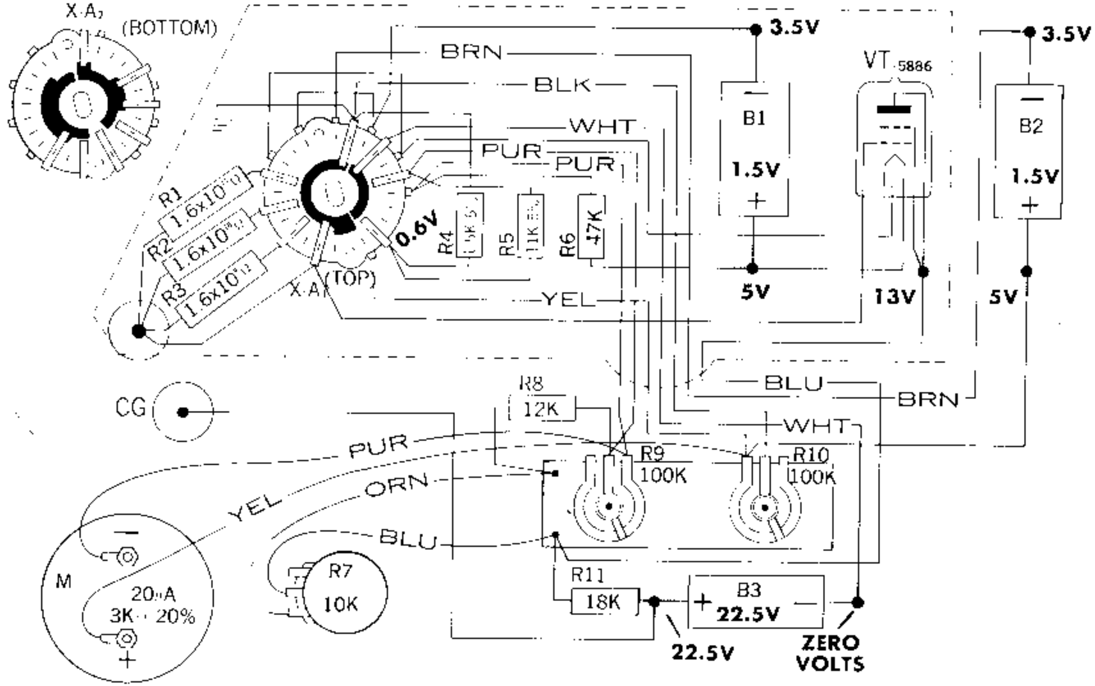
RESISTANCE PRODUCTS COMPANY
914 South 13th Street
Harrisburg, Pennsylvania

INTERNATIONAL RESISTANCE CO.
401 North Broad Street
Philadelphia, Pennsylvania

CENTRALAB
900 E. Keefe Ave.
Milwaukee 1, Wisconsin

P. R. MALLORY & CO., INC.
3029 E. Washington
Indianapolis 6, Indiana

PHAOSTRON INSTRUMENT AND
ELECTRONIC CO.
151 Pasadena Ave.
South Pasadena, California



Resistors ±10%. Controls +20% unless otherwise noted. Switch shown in OFF position.

Shaded terminals available inside lower case.

Voltages shown are nominal and are measured from the chassis with a 20,000 ohms per volt meter set to the lowest practical range. Set switch to ZERO position.

Figure 4 — Wiring Diagram

8.4 electrical components

Circuit Symbol	*Description and Function*	*Manufacturer*	*Mfr's Type No.*	*Jordan Part No.*
B_1	1.5V "D" cell, filament supply	National Carbon Co.	950	BA-0005
B_2	1.5V "D" cell, bias supply	National Carbon Co.	950	BA-0005
B_3	22.5V "B" battery, plate supply	Jordan	J-15	BA-0006
R_1	Resistor, high-meg 160,000 meg 10%, Range X-1	RPC	BBF	RX-0007
R_2	Resistor, high-meg 16,000 meg 10%, Range X-10	RPC	HBF	RX-0008
R_3	Resistor, high-meg 1,600 meg 10%, Range X-100	RPC	HBF	RX-0009
R_4	Resistor, carbon 1.5K 5% ½W circuit check	IRC	BTS	RC-0152C
R_5	Resistor, carbon 11K 5% ½W bias	IRC	BTS	RC-0113C
R_6	Resistor, carbon 47K 10% W shunt	IRC	BTS	RC-0473
R_7	Potentiometer, carbon 10K 20% ½W zero control	Centralab	Model 2	RP-0103
R_8	Resistor, carbon 12K 10% ½W plate load	IRC	BTS	RC-0123
R_9 R_{10}	Potentiometer, carbon 100K 20% ½W calibrate adj. Potentiometer, carbon 100K 20% ½W coarse zero adj.	Mallory	ECD	RX-0010
R_{11}	Resistor, carbon 18K 10% ½W plate dropping	IRC	BTS	RC-0183
CG	Ionization chamber assembly	Jordan		AE-0026
M	Meter, indicating 20 μa 3000Ω	Phaostron	220	EI-0013
VT	Vacuum tube, electrometer, 5886	Raytheon	5886	VT-5886
X-A X-A_2	Switch deck, ceramic, range switch	Jordan		SD-0019