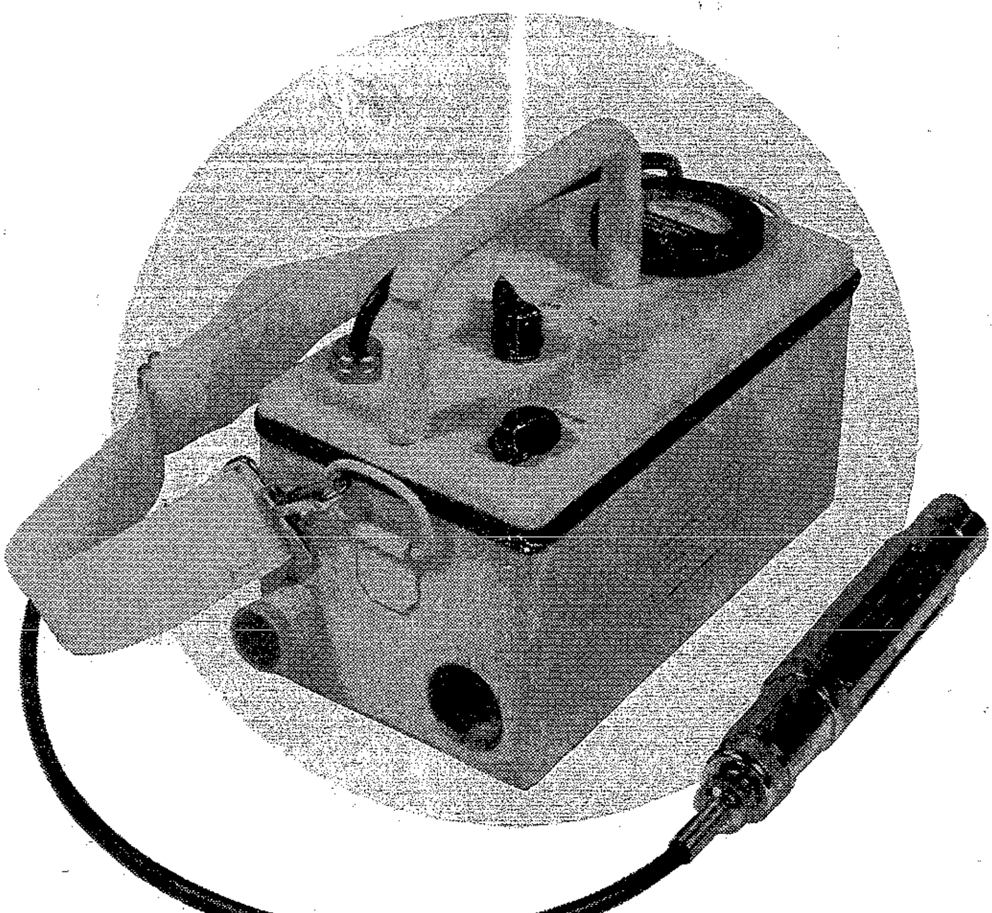
Instruction Manual

for

RADIATION SURVEY METER
SM-5A

[redacted]



nuclear research corp.

2563 Grays Ferry Avenue • Philadelphia 46, Pa.

Table of Contents

1.0 SPECIFICATIONS

RANGES RCA VS144 1,34 Volts

0.5, 5.0, 50.0 mr/hr, read on 50 μa—2½" meter.

INSTRUMENT ACCURACY

±10% of full scale.

CALIBRATION

Internal provision for calibrating one range, other ranges adjusted concurrently.

CONTROLS

"Off-mr/hr" switch on exterior of cabinet, and two internal controls for calibration and pulse height selection.

TUBE COMPLEMENT

2 each—CK503AX
1 each—CK1038
1 each—Geiger Tube, CK1043
1 each—1AD5
1 each—CK5785

BATTERY LIFE AND COMPLEMENT

A—1 each, Mallory mercury cell battery pack #302476
B—1 each, RCA #VS016, 67.5 volts, dry bat.
B—2 each, RCA #VS084, 22.5 volts, dry bat.
Life over 130 hours/8-hour per day operation.

TIME CONSTANT

12 seconds to reach 95% of the final reading.

SIZE

4¾" H. x 4⅞" W. x 8⅞" L.

WEIGHT

6 lbs.

FINISH

Bright yellow enamel, with black lettering.

2.0 GENERAL DESCRIPTION

The SM-5A [redacted] is a portable radiation survey meter for the detection and measurement of low-intensity beta-gamma radiation. The instrument is especially intended for civil defense use, for monitoring personnel, food and water, and for other applications where low-level measurements must be made.

The instrument is comprised of a geiger tube probe, an electronic pulse shaper, and a counting rate circuit. The counting rate is indicated visually on a panel meter. Individual pulses may be detected audibly through the use of headphones.

The geiger tube, which is sensitive to beta and gamma radiation, delivers electrical pulses at a rate proportional to the radiation intensity. These pulses are amplified and shaped and fed into the counting rate circuit. The output of the counting rate circuit, a d.c. current proportional to the pulse rate and hence the radiation intensity, is read on the panel meter.

3.0 THEORY OF OPERATION

3.1 GEIGER TUBE[1,2] (V-1)

When a beta particle traverses the sensitive volume of a geiger tube, or when a gamma photon reacts with the molecules of the tube gas, or with molecules in the tube wall ejecting an electron into the tube's sensitive volume, ionization of the gas, with the liberation of electrons, occurs. These free electrons gain sufficient energy from the electrical field between the anode and cathode to ionize additional neutral gas molecules. The free electrons thus liberated in turn gain energy and produce further ionization. This cumulative ionization (avalanche) builds up in a very short time, creating a greatly amplified current surge through the geiger tube. The external circuit converts the current pulse to a voltage pulse, which actuates the counting system.

Following the initial surge of current, a quenching process occurs so as to prevent further cumulative ionization. When quenching is complete, and most ions are neutralized, the tube is ready to accept a new ionizing event.

3.2 AMPLIFIER[3] (V-2, V-3)

The voltage pulses from the geiger tube are used to drive a one shot multi-vibrator. This circuit converts pulses of different shapes and amplitudes to pulses of constant shape and amplitude.

The output pulses of this circuit are integrated and actuate a meter. Since the pulses have been shaped, the meter reading gives a direct indication of pulse rate.

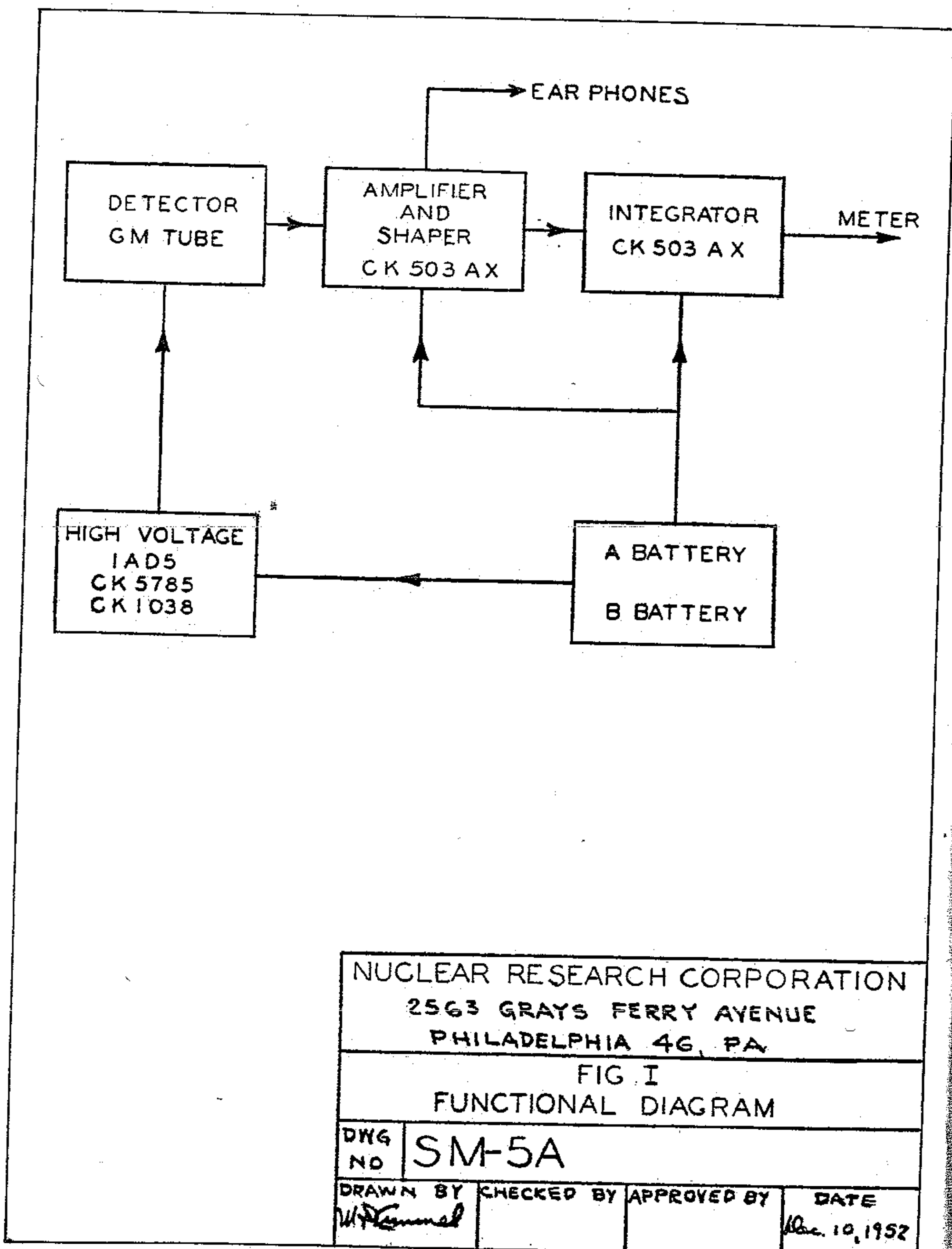

EAR PHONES
DETECTOR
GM TUBE
AMPLIFIER
AND
SHAPER
CK 503 AX
INTEGRATOR
CK 503 AX
METER
HIGH VOLTAGE
1AD5
CK 5785
CK 1038
A BATTERY
B BATTERY
NUCLEAR RESEARCH CORPORATION
2563 GRAYS FERRY AVENUE
PHILADELPHIA 46, PA
FIG I
FUNCTIONAL DIAGRAM
DWG NO
SM-5A
DRAWN BY
CHECKED BY
APPROVED BY
DATE
Dec. 10, 1952

Figure 1

Calibration of each range is accomplished by varying the pulse width in each range.

3.3 HIGH VOLTAGE SUPPLY[4, 5] (V-4, V-5, V-6)

In the high voltage supply, voltage pulses from a neon oscillator are used to drive an amplifier having a high plate impedance. The current pulses, through the high impedance coil in the plate circuit, create a correspondingly high voltage pulse from plate to ground. These high voltage pulses are then rectified, filtered, and stabilized. The polarity of the voltage thus produced is positive with respect to ground.

3.4 INDICATORS[6]

The rate at which beta particles or gamma photons are incident upon the geiger tube is converted by the geiger tube and electronic system into a corresponding d.c. level. This level is proportional, for a given gamma ray energy, to the intensity of the gamma ray flux in milliroentgens per hour. The meter scale is therefore marked directly in mr/hr.

In addition to visual meter presentation, the intensity of beta-gamma radiation present can be determined with the aid of earphones. The voltage pulses that appear across the cathode resistors, R5R6, are coupled to a jack which will accommodate a pair of earphones.

4.0 INSTALLATION

Note: Immediately following receipt of the instrument, check thoroughly for any damage that might have occurred in shipping. Particular attention should be paid to any possible damage to the geiger tube.

4.1 BATTERY INSTALLATION AND REPLACEMENT

(Switch in "off" position.) The instrument can be opened by first removing the geiger tube probe from its cabinet housing, and then removing two screws from the bottom of the case. The top panel can then be separated from the bottom section of the cabinet. The A battery leads are next connected to the 6-lug, screw-type binding post (observe color code of wires and post screws). The A pack is recessed between the bottom angle bracket and the wiring chassis. (See Figure III.)

The B batteries are assembled in the order: 67.5-volt battery, 22.5-volt batery, 22.5-volt battery. The appropriate battery plugs must be used. The B batteries fit into the recess of the same side of the unit as the A pack. (See Figure III.)

The top and bottom of the case may now be screwed together. It is important that the rubber "H" seal around the bottom portion of the cabinet fit snugly around the bottom lip of the top of the cabinet. The fit can be made with the aid of a dull blade instrument, such as a screwdriver, thin coin, or fingernail file. Care should be taken not to scratch the paint and to make certain that the inside of the "H" is completely inside the cabinet and that the outside of the "H" is completely outside the cabinet.

5.0 OPERATION

5.1 SWITCH SETTINGS AND WARM-UP

Following installation, the "off-range" switch should be turned to the 50 mr/hr range for an indication of the radiation field present. If the meter indication on the 50 mr/hr scale is not sufficient, then the range switch may be turned to the next range–5.0 mr/hr. For background and very weak fields, the 0.5 mr/hr range is applicable.

5.2 INDICATOR OPERATIONS—Readings, Accuracy, and Stability

The time constant on each range allows reasonably rapid readings, which are important when varying intensities are present. For accurate measurements, an average of the fluctuating meter readings should be taken as the correct value. However, even including the statistical fluctuations, a reading to within ±15% of the average can be obtained with a single reading. An average meter reading will remain constant to within ±5% of full scale for 8 hours of continuous use of the instrument. For intermittent use, the drift, due to all causes, is within ±10% of full scale, for approximately 130 hours. Battery life is the main limiting factor.

5.3 INDICATOR OPERATION—Calibration

This instrument may be calibrated with a National Bureau of Standards calibrated radium needle. Separation distance should be taken as the distance between the needle and the long axis of the geiger tube. The probe shield should be closed. The separation distance should be that distance which will give 3.5 mr/hr at the geiger tube, and calibrations should be performed with the instrument set on the 5.0 mr/hr scale. The calibrating element is R_7. For a standard radium needle, the following formula should be used:

$$S = \frac{8.98\,(1 - 0.13t)M}{D^2}$$

Where S = Roentgens/hour
t = Thickness of platinum filter in mm
M = Actual radium content of the needle measured in mg

The value of M is obtained by correcting the equivalent value as indicated on the Bureau of Standards certificate by the correction factor listed at the bottom of the certificate.

D = The distance from geiger tube to source in centimeters.

For a coarse calibration, the small source that is plugged into the cable end of the case can be used. This source is approximately .25 microcuries of a hard beta emitter (Strontium 90). With the smaller end of the source container resting on the open shield, a reading of approximately 20 mr/hr should be obtained on the 50 mr/hr range.

6.0 OPERATOR'S MAINTENANCE

6.1 After 100 hours of operation of the instrument, all batteries should be checked. (See Section 4.1, Battery Installation and Replacement.)

6.2 The geiger tube is capable of over 500 hours of operation at an average radiation of 0.5 mr/hr. When the geiger tube has ended its useful life, it, of course, must be replaced. This is done by first rotating the entire probe shield ⅛th of a turn, with respect to the probe's cable connector, and then carefully slipping the shield from the cable connector. Next, the knurled water seal nut, at the geiger tube end of the cable connector, is unscrewed and removed. The geiger tube may now be removed by carefully pulling the tube (fingers on base of tube) from the cable connector. When inserting the new geiger tube, the reverse procedure is used, except that it is best to place the rubber "O" ring and washer around the geiger tube base first, and then press the tube into the socket, followed by pressing the "O" ring into place. The use of Stopcock grease (or equivalent) is an aid in the water seal, and is therefore recommended.

7.0 PREVENTIVE MAINTENANCE

7.1 All tubes are rated conservatively for more than 500 hours of operation. However, tubes could be checked at periodic intervals to preclude failure of the instrument during operation.

7.2 Periodically, a complete visual and electrical check of the instrument should be made. This check includes inspection of all solder and mechanical points, the appearance of all components, particularly the range switch and meter.

This check includes a complete voltage analysis of the system. (See Section 11.0, Circuit, for voltage values.)

8.0 CORRECTIVE MAINTENANCE

Note: Figure II shows the parts layout for the amplifier section of the instrument (V_2 and V_3). Figure III shows the parts layout for the high and low voltages supplies of the instrument (V_4, V_5, V_6).

	Symptom	Check
5.1	Meter reading low on each scale (radiation field present), not possible to calibrate.	Batteries, vacuum tubes, geiger tube (geiger tube is best checked by replacing with a tube known to be good).
5.2	Meter reads on 50mr/hr scale with no radiation present.	Reset R_5 (See Section 5.0, Operation).
5.3	Meter reads continuously (possibly off scale), no radiation present.	Geiger tube, vacuum tubes, R_5 setting, C_8.
5.4	No reading at all on meter.	Geiger tube, C_1, H.V. supply (V_3, V_4, V_5); batteries; amplifier circuit (V_1, V_2); C_7.
5.5	Meter reads with geiger tube out.	Reset R_5, batteries C_8, amplifier tubes and circuits.

9.0 REFERENCES

1. Korff, S. A. *Electron and Nuclear Counters,* Van Nostrand, 1946.
2. Lapp, R. E. and Andrews, H. L. *Nuclear Radiation Physics,* Prentice Hall, 1950.
3. Mather, N. W. "Multivibrator Circuits," *Electronics,* October 1946.
4. Brainerd, J. R., et al. *Ultra High Frequency Techniques,* Van Nostrand, 1942.
5. Massachusetts Institute of Technology, Radar School Staff. *Principles of Radar,* McGraw-Hill, 1946.
6. Lapp, R. E. and Andrews, H. L. Loc. cit.

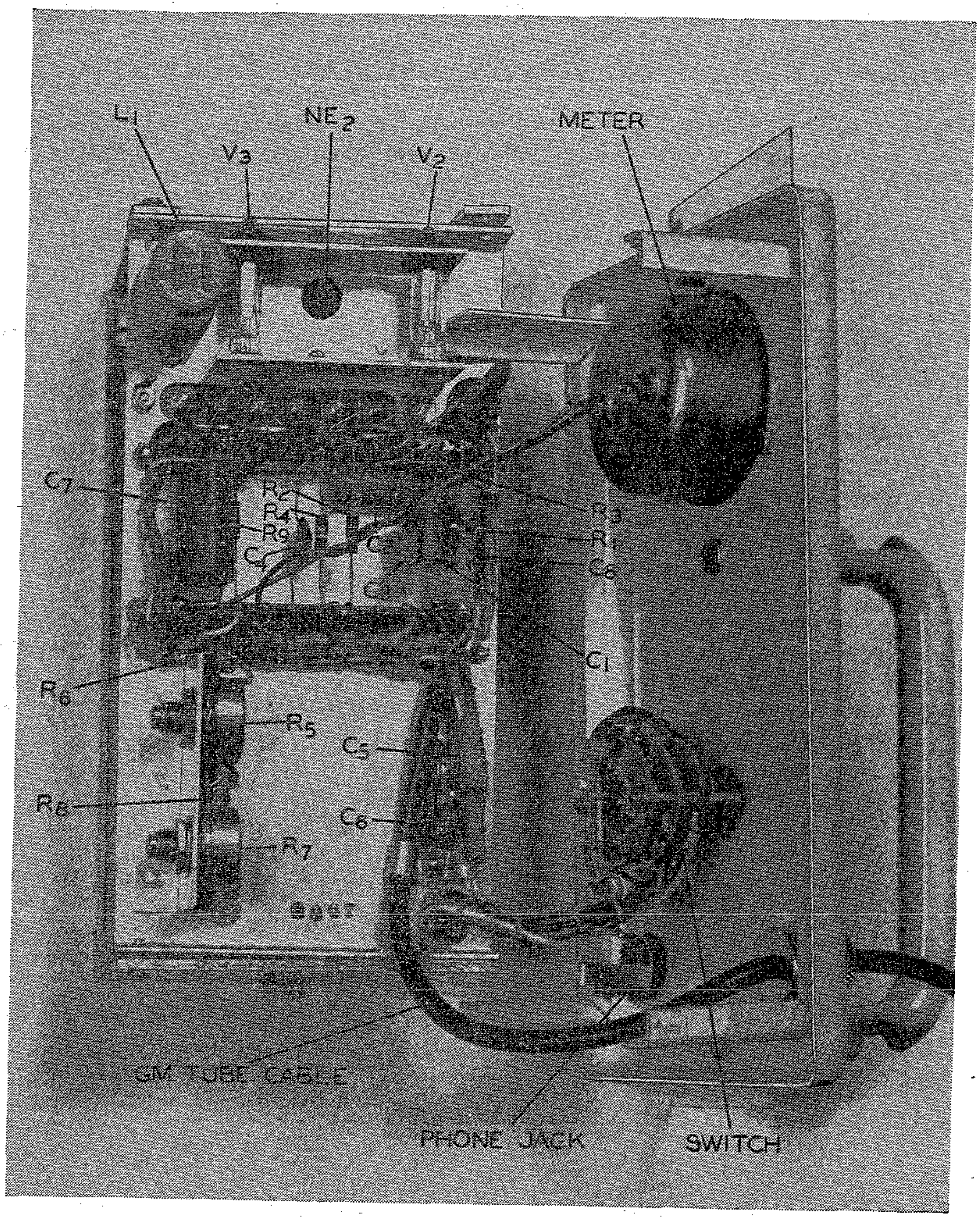

L1
NE2
METER
V3
V2
C7
R2
R4
R9
R3
R1
C8
C1
R6
R5
C5
R8
C6
R7
GM TUBE CABLE
PHONE JACK
SWITCH

Figure II

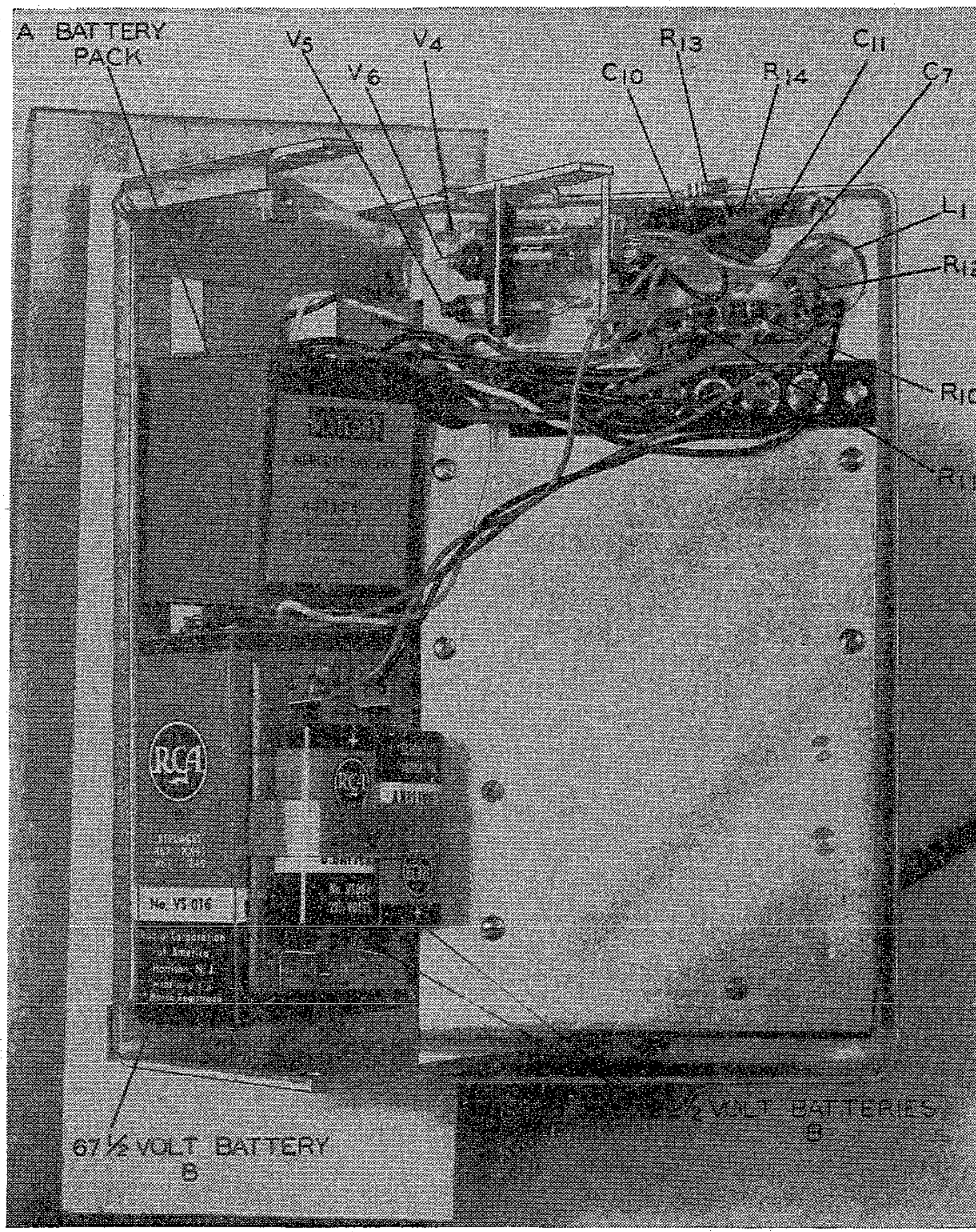

A BATTERY PACK
V5
V4
V6
R13
C10
R14
C11
C7
L1
R12
R10
R11
RCA
67½ VOLT BATTERY B
VOLT BATTERIES B

Figure III

10.0 PARTS LIST

Part	*Type*	*Manufacturer*	*Function*
V1	Tube G.M.	Raytheon #CK1043	Detector Beta/Gamma Radiation
V2	Tube Vacuum	Raytheon #CK503AX	Pulse Amplifier
V3	Tube Vacuum	Raytheon #CK503AX	Pulse Amp. & Integrator
V4	Tube Gas	Raytheon #CK1038	Voltage Regulator
V5	Tube Vacuum	Raytheon #CK5785	Voltage Rectifier
V6	Tube Vacuum	R.C.A. #1AD5	Pulse Amplifier
A1	Battery 1.3 V. Mercury cells	Mallory Pack #302476 6 cells in 3 sections.	Power Supply for vacuum tube filament.
A2	Battery 1.3 V. Mercury cells		
A3	Battery 1.3 V. Mercury cells		
B1	Battery 22.5 V. Dry	R.C.A. #VSO84	Power supply for neon oscillator. Power supply for plates and screens of vacuum tubes.
B2	Battery 22.5 V. Dry	R.C.A. #VSO84	
B3	Battery 67.5 V. Dry	R.C.A. #VSO16	
R1	Resistor Carbon 10M ±10%, ½W	Allen Bradley #EB1061	G.M. tube load
R2	Resistor Carbon 360K ±5%, ½W	Allen Bradley #EB3645	V2 screen voltage drop
R3	Resistor Carbon 820K ±10%, ½W	Allen Bradley #EB8241	V2 grid leak
R4	Resistor Carbon 510K ±5%, ½W	Allen Bradley #EB5145	V2 plate load
R5	Res. Variable 10K pot., ½W	Clarostat #CM12101	V3 bias control
R6	Res. Carbon 27K ±	Allen Bradley #EB2731	V3 bias control limit
R7	Res. Variable 1M pot., ½W	Clarostat #CM12100	Pulse width control
R8	Resistor Carbon 820K ±10%, ½W	Allen Bradley #EB8241	Pulse width con. & limit
R9	Resistor Carbon 22K ±10%, ½W	Allen Bradley #EB2231	Pulse rate integrator
R10	Resistor Carbon 1M ±10%, ½W	Allen Bradley #EB1051	H.V. Filter
R11	Resistor Carbon 10M ±10%, ½W	Allen Bradley #EB1061	H.V. Filter
R12	Resistor Carbon 15K ±10%, ½W	Allen Bradley #EB1531	V6 screen voltage drop
R13	Resistor Carbon 390K ±10%, ½W	Allen Bradley #EB3941	V6 grid leak

10.0 PARTS LIST—Contd.

Part	Type	Manufacturer	Function
R14	Resistor Carbon 3.3M ±10%, ½W	Allen Bradley #EB3351	Ne2 current limit
C1	Cond. Mica 390 $\mu\mu$f, 2000V ±20%	Arco-VCM-20-B-391	V1 coupling
C2	Cond. Paper .05 μf, 200V +40% −20%	Cornell-Dubilier, P3255	V2 screen by-pass
C3	Cond. Mica 250 $\mu\mu$f, 500V ±20%	Arco-CM-20-251	Head set coupling
C4	Cond. Disc. Ceramic .01 μf 500V +20% −80%	Erie #811-01	V2-V3 coupling
C5*	Cond. Mica 510 $\mu\mu$f, 500V ±5%	Arco-CM-20-511	V2-V3 coupling
C6	Cond. Mica 62 $\mu\mu$f, 500V ±5%	Arco-CM20-620	V2-V3 coupling
C7	Cond. Electrolytic Dry 100 μf, 6V	Cornell-Dubilier, BRH601	Pulse integrator
C8	Cond. Paper .007 μf, 1500V	Mallory PT1627	H.V. Filter
C9	Cond. Paper .007 μf, 1500V	Mallory PT1627	H.V. Filter
C10	Cond. Disc. Ceramic .005 μf, 500V +100 −0	Centralab DD502	Ne2 coupling
C11	Cond. Disc. Ceramic .002 μf, 500V +100 −0	Centralab DD202	Pulse Rep. rate control
L1	Choke 50H at 3 ma 6000 ohms	Crest #M 13	V9 plate load
M	Meter 0-50 μa 2½" rd, scale 0-.5 mr/hr, Hermetically sealed	Burlington Mod. #321	Visual presentation of radiation flux
Ne	Lamp Neon	General Electric, Ne2	Pulse generator
S1-S6	Switch 6 pole 4 pos.	Centralab #PA-022-119	Switch power & ranges
H.S.	Earphones 2000 DC ohms	Trim #27, Acme	Aural presentation of count rate
	Shoulderstrap	N.R.C. #SS-2	Carrying instrument
	Radioactive source, 0.25 μc. Sr 90	N.R.C. BS-1	Course calibration of unit
	Instruction manual	N.R.C. #SM-5A	

10.0 PARTS LIST—Contd.

PROBE SECTION—SM-5A-5C

1 each—"O" ring	Linear Inc. #1820-12	G.M. tube seal
1 each—"O" ring	Linear #1820-5	Cable seal
1 each—Fiber Washer	Penn Fibre—25/32" OD x 21/32" ID x 31/64" TH	G.M. tube seal
1 each—Metal Washer St. plated 3/16" ID x 1/2" OD x 3/64" TH		
1 each—Nut (cable)		N.R.C. SM-5A-5C-10A
1 each—Nut (G.M.)		N.R.C. SM-5A-5B-9A
1 each—Spring		From Amp. #91MC3F
1 each—Socket		From Amp. #91MPF3S
1 each—Socket spacer		N.R.C. SM-5A-21-11A
1 each—Socket retainer		N.R.C. SM-5A-5A-8C
1 each—G.M. tube shield		N.R.C. SM-5A-5D-11C & SM-5A-5-7C

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1 each—"O" ring	Linear #1820-5
1 each—"O" ring	Linear #1820-10
2 each—"O" ring	Linear #1820-6
2 each—"O" ring	Linear #1820-2
2 each—"O" ring	Linear #1820-3
2 each—Fiber Washer	Penn Fibre—½" ID x 11/16" OD x 1/32" TH
2 each—8/32, 1/2" screws slotted, bind. head, tapered, plated	
1 each—Water seal bushing	N.R.C. SM-5A-22-4B
4 ft. cable, Coaxial	Chester Cable, RG62/U
4 each—Socket, 5 pin min.	Cinch, 54A11953
4 each—Socket ring	Cinch, 20K12446
1 each—Socket 8 pin min.	Cinch, 54A13686
1 each—Socket ring	Cinch, 20K13702
1 each—Knob—long pointer, brass bushing	H. Davies, #2110
1 each—Socket bat.	Cinch 5M
1 each—Socket bat.	Cinch 5F
1 each—Phone jack	Switchcraft 2J-1065
1 each—Phone plug, bakelite, black	Trimm, type BL55
1 each—Rubber Ear (for Earphones)	Carron Prod. #S-3 BLK Rubber Bulb
1 each—Bracket	N.R.C. SM-5A-5-5C
1 each—Chassis	N.R.C. SM-5A-12-6B
2 each—Terminal boards, 11 lug	Cinch, 2011
2 each—Terminal boards, 4 lug	Cinch, 2004
1 each—Terminal boards, 3 lug	Cinch, 2003
1 each—Terminal boards, 6 screw binding post	Cinch, 1776
1 each—Cabinet	N.R.C. SM-5A-3-2C & SM-5A-2-3B
1 each—Phone cover	JAN Hardware #J-1301
1 each—Grommet	General Cement, 1041E
4 each—Grommets	General Cement, 1042E
2 each—Grommets	General Cement, 1043E
1 each—Battery Retainer and Spring Clip	N.R.C. SM-5A-B

PARTS RECOMMENDED FOR FIVE UNITS FOR ONE YEAR BASED ON ESTIMATED 500 HR. OPERATION

Qty.	*Item*	*Part*
5 –	V1	CK1043
4 –	V2, V3	CK503AX
3 –	V4	CK1038
2 –	V5	CK5785
2 –	V6	1AD5
20 –	A1, A2, A3	A battery packs
40 –	B1, B2	B battery 22.5V
20 –	B3	B battery 67.5V
5 –	Condenser	C7, 100μf, 6V
1 –	L1	Choke
1 –	M	Meter
5 –	Ne2	Neon Lamp
1 –	S1-S6	Switch
2 –	R.S.	Earphones
2 –		Shoulderstrap
2 –		Radioactive Sources
2 –		Instruction Manuals
1 –	Probe section–SM-5A-5C	
2 –	"O" ring, Linear 1820-12	
2 –	Washer Fiber, 25/32″ ID x 21/32″ OD x 31/64″ TH	
2 –	Nut (G.M.)	
1 –	Socket (G.M.)	
4 –	"O" ring, Linear 1820-2	
4 –	8/32, ½″ screws slotted, bind. head, tapered, plated	

11.0 CIRCUIT

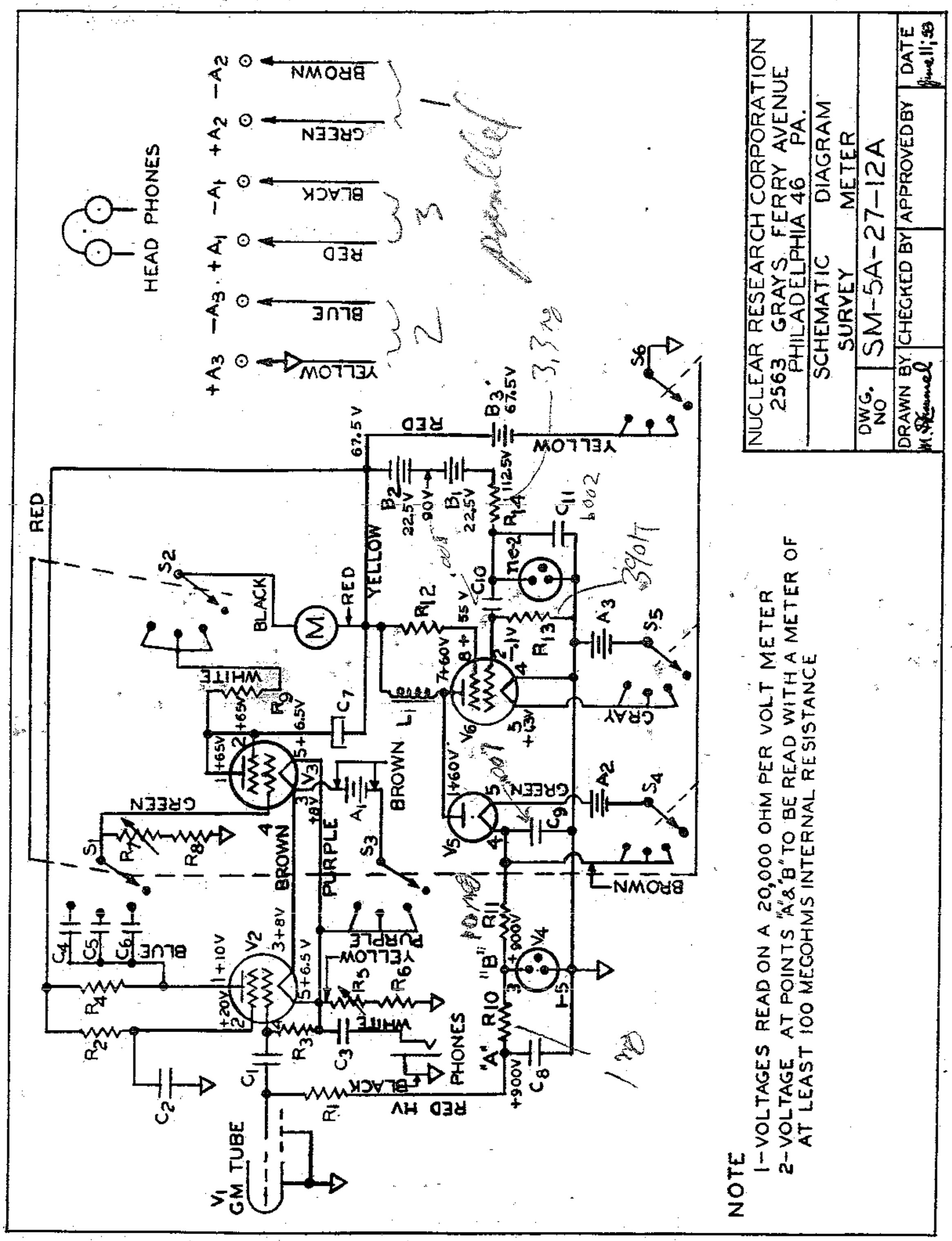

Figure IV

12.0 MANUFACTURERS' NAMES AND ADDRESSES

Allen Bradley Company, 136 W. Greenfield, Milwaukee 4, Wisconsin

American Phenolic Corporation (Amphenol), 1830 S. 54th St., Chicago 50, Ill.

Arco Electronic Co., 103 Lafayette St., New York 13, N. Y.

Burlington Instrument Co., Burlington, Iowa

Carron Products Inc., 331 N. Lawrence St., Philadelphia, Penna.

Centralab, Inc., 914 E. Keefe St., Milwaukee 1, Wisconsin

Chester Cable Corp., Chester, N. Y.

Cinch Inc., 1026 S. Homan Avenue, Chicago 24, Ill.

Clarostat Mfg. Company, Dover, New Hampshire

Cornell-Dubilier Company, South Plainfield, New Jersey

Crest Laboratories, Far Rockaway, New York

H. Davies Molding Company, 1428 N. Wells St., Chicago 10, Ill.

Erie Resistor Company, 644 W. 12th Street, Erie, Pa.

General Cement Company, 919 Taylor Avenue, Rockford, Ill.

General Electric Co., Div. 1, River Road, Schenectady 5, New York

Insuline Company, 1 Broadway, New York

Linear, Inc., Brightwater Place, Massapequa, New York

Mallory & Company, 3029 E. Washington St., Indianapolis, Indiana

Nuclear Research Corp., 2563 Grays Ferry Ave., Phila. 46, Penna.

Penn Fibre & Specialty Co., 2020 E. Westmoreland St., Phila. 34, Penna.

Radio Corp. of America, Tube Division, Harrison, New Jersey

Radio Corp. of America, Battery Division, Harrison, New Jersey

Raytheon Manufacturing Co., 55 Chapel Street, Newton 58, Mass.

Switchcraft Inc., 1328 N. Halsted Avenue, Chicago 22, Ill.

Trimm, Inc., 400 W. Lake Street, Libertyville, Illinois