VTVM
&
UNI-PROBE

MODEL
222

INSTRUCTION
MANUAL

ELECTRONIC INSTRUMENT CO. INC.
3300 NORTHERN BLVD., L. I. CITY 1, N. Y.

VACUUM TUBE VOLTMETER

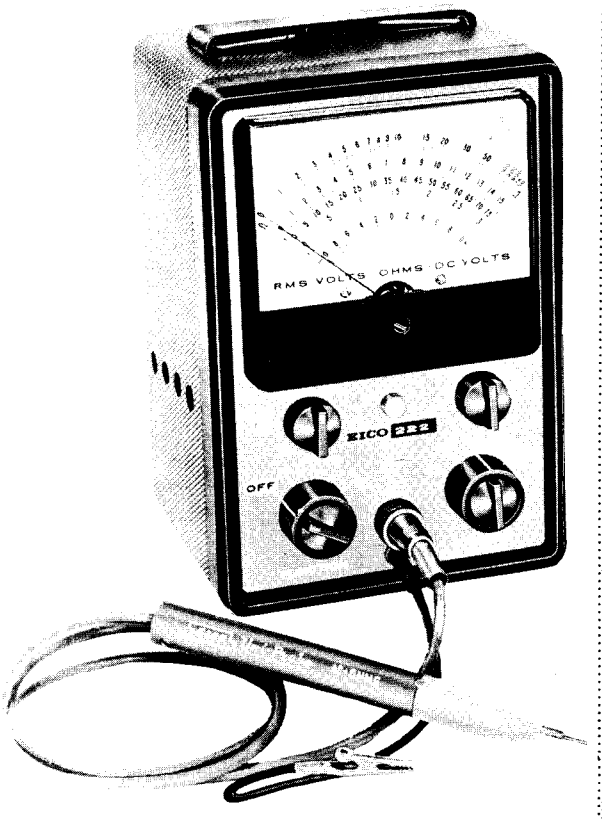

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FIGURE

ELECTRONIC INSTRUMENT CO., INC.
33-00 NORTHERN BLVD., L.I.C. 1, N.Y.

SECTION I. GENERAL DESCRIPTION AND SPECIFICATIONS

1-1. GENERAL DESCRIPTION

The EICO Model 222 is a remarkably efficient VTVM design, wherein significant performance and quality improvements are obtained over previous models in the same price bracket. A 400uA meter, separate +DC and -DC volts calibration adjustments, more accurate low voltage measurement plus measurement to higher voltages than ever before, and vastly improved appearance all contribute to making this instrument the finest value possible.

The Model 222 is an excellent general purpose VTVM for service work, industrial testing, school and home laboratories. Three probe types are available to extend its usefulness: Model HVP-1 or Model HVP-2 High Voltage Probe to extend the DC voltage ranges by a factor of 100; Model PRP-11 RF VTVM Probe for RF voltage measurements up to 250mc; Model PTP-11 Peak-to-Peak VTVM probe for reading the peak-to-peak voltage of complex waveforms.

The Model 222 provides complete electronic protection against meter over-load or burn-out; adjustment of all calibration controls without cabinet removal; and UNI-PROBE, a single unit probe used for all functions (a half-turn of the probe tip inserts the isolating resistor for DC voltage measurements). For use of the instrument as a null detector, or for f-m detector alignment, a zero center scale is provided. A 1-1/2 volt battery is used for resistance measurements to avoid danger to delicate apparatus that may be tested with the instrument. The meter is 2% accurate and multiplier resistors are 1% accurate.

1-2. SPECIFICATIONS

DC Voltmeter
Ranges: 0 to 3,15,75,300,1500 volts
Input Resistance: 11 megohms
Accuracy: ± 3% of full-scale

Models HVP-1 or HVP-2 High Voltage Probes with 1090 megohm resistor provide a scale multiplication factor of 100. Up to 7500 volts can be read on the 75 volt range, and up to 30,000 volts can be read on the 300V range.

AC Voltmeter
Ranges: 0 to 3,15,75,300,1500 RMS volts
Input Resistance: 1 megohm
Accuracy: ± 5% of full-scale
Frequency Response: 30 cps to 3 Mc (source impedance 100 ohms or less)

Model PRF-11 VTVM Probe permits RF voltage measurement to 250 Mc, read on DC voltmeter scales, with an accuracy of ± 10%.

Model PTP-11 Peak-to-Peak VTVM Probe permits accurate peak-to-peak reading of complex waveforms, also on the DC voltmeter scales.

Ohmmeter
Ranges: RX1 (0-1K ohm, 10 ohm center), RX10 (0-10K ohm, 100 ohm center), RX1K (0-1 megohm, 10K ohm center), RX10K (0-10 megohm, 100K ohm center), RX1M (0-1000 megohm, 10 megohm center)

Tube Complement: 1-12AU7, 1-6AL5
Power Requirements: 105-125VAC, 60/50 cps; drain: 5 watts
Size (HWD): 8 1/2 x 5 3/4 x 5 1/8 inches
Weight: 5 lbs.

SECTION II. OPERATING INSTRUCTIONS

2-1. CONTROLS AND TERMINALS

FUNCTION selector

At the OFF position, the instrument is disconnected from the AC power line. At all other positions, power is on, indicated by the pilot lamp. The AC position is used for a-c voltage measurement. The +DC position is used for d-c voltage measurement where the voltage measured is positive with respect to ground. The -DC position is used for d-c voltage measurement where the voltage measured is negative with respect to ground. The OHMS position is used for resistance measurement.

UNI-PROBE switch

Set the UNI-PROBE at DC for all d-c voltage measurement and at AC-OHMS for all a-c voltage and resistance measurements. Turn the UNI-PROBE tip a half-turn to change the selected position.

RANGE selector

Provides selection from 5 ranges for a-c voltage measurement, d-c voltage measurement, and resistance measurement. The outer circle on the dial is the resistance ranges, denoted by the multiplying factor to be used on the reading made on the ohms scale at the range selected. The inner circle on the dial is the voltmeter ranges, denoting the value of a full-scale reading on the appropriate volts scale for either d-c or a-c voltage measurement at the range selected.

ZERO adjust

Used to adjust the meter pointer to zero indication in all functions during and/or after warm-up, and to set the meter pointer to zero on the zero-center scale when this is required.

OHMS adjust

Used to adjust the meter pointer to the extreme right-hand graduation — ∞ (infinity) — on the OHMS scale with the UNI-PROBE and ground lead separated (open circuit). This control permits prolonged use of battery.

CO-AX connector

Male co-axial connector to which UNI-PROBE lead is connected for all functions.

G terminal

Ground terminal (banana jack) to which ground lead is connected.

FUSE

An extractor post fuseholder on the rear apron contains a cartridge fuse in the primary circuit of the power transformer. The fuse is a standard type, rated 0.5 ampere.

CAUTION

The blocking capacitor in the instrument circuit on a-c voltage measurement is rated at 1000 VDC. Do not measure a-c voltages in the presence of a d-c voltage much in excess of 600 VDC to avoid the possibility of breaking down this capacitor.

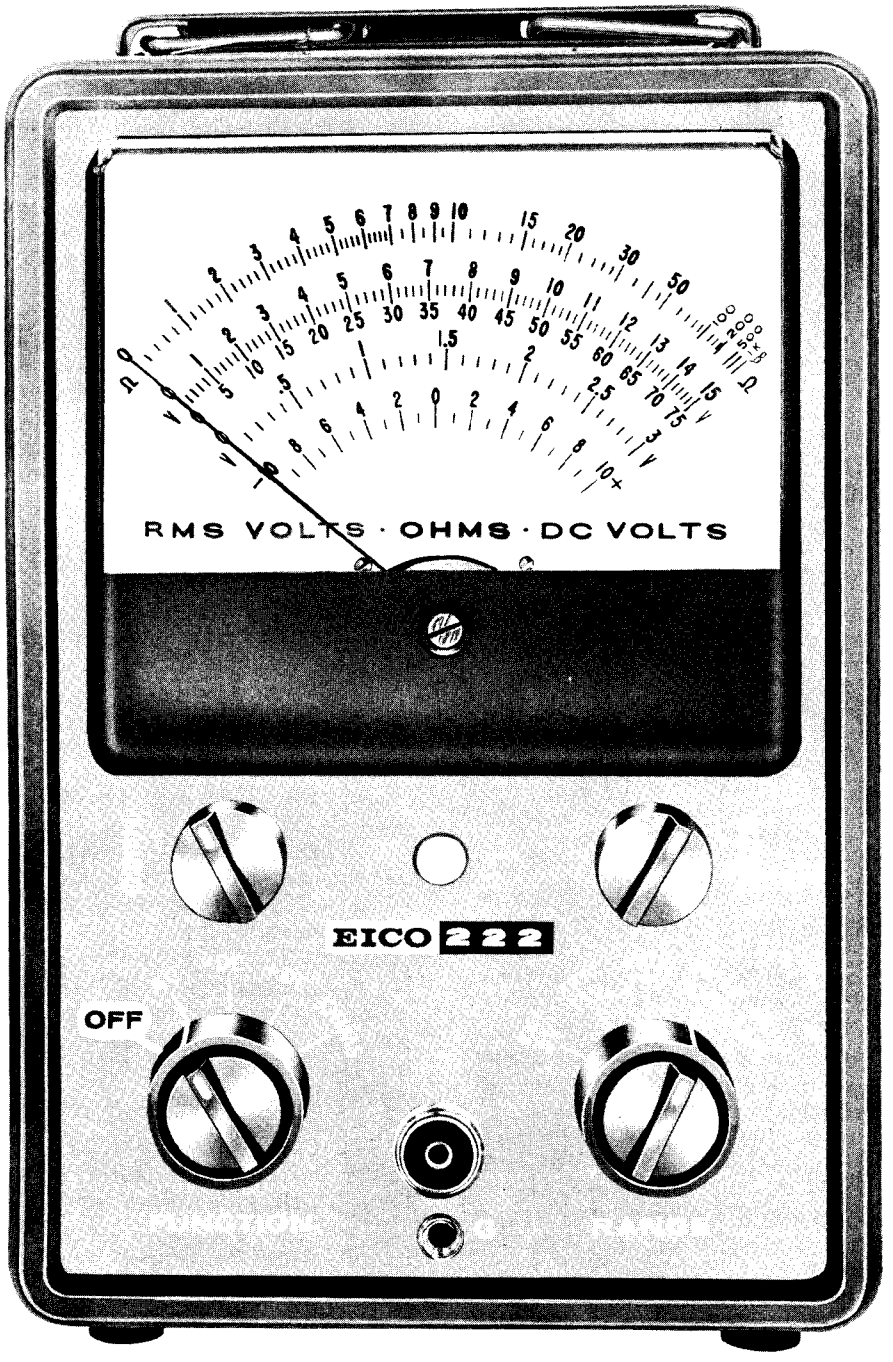


Figure 2-1. Front Panel Controls and Terminals

2-2. OPERATION

VENTILATION

Adequate ventilation is necessary for proper operation of the instrument and to avoid the possibility of heat damage. The use of a perforated case permits convective movement of air through the unit to remove the heat generated by tubes and other components. The air movement consists of cool air drawn through the sides of the case being heated and escaping through the top. Take sensible measures to avoid impeding the required air flow.

NOTES

When the instrument is turned off, the meter pointer should be at zero. If not, see Section 5, paragraph 3, "Meter Mechanical Zero Adjust".

On a-c voltage measurement, the instrument responds to the peak value of the waveform and reads in RMS value of a sine wave having this peak value. Non-sinusoidal waveforms will not be read accurately. Use the accessory PTP-11 Peak-to-Peak Voltmeter Probe for measuring complex waveforms.

The meter scales are either black or red to permit rapid scale identification. There is no special significance to a scale being red rather than black. The top scale (ohm) is for all resistance readings. The three middle scales (V) are for d-c or a-c voltage readings used as follows: 0-75 for the 75V range only; 0-3 for the 3V and 300V ranges; 0-15 for the 15V and 1500V ranges. The lowest scale is for zero-center use; it is merely a logging scale and is arbitrarily numbered from -10 to +10.

Although the meter is protected against burn-out under ordinary overloads, repeated overloads may impair the accuracy of the movement. For this reason, in the following instructions the operator is advised to first make a trial measurement at a range setting higher than the voltage expected.

a. PRELIMINARY ADJUSTMENTS

1. Connect the UNI-PROBE to the CO-AX terminal, and the ground lead to the G (ground) terminal.

2. Plug the line cord into an outlet supplying 105-125 volts AC, 50-60 cps.

3. Set the FUNCTION selector at the desired function, and the UNI-PROBE to correspond. Allow several minutes for the instrument to warm up. If necessary, use the ZERO adjust to set the meter pointer within scale limits during the warm-up.

4. Short the UNI-PROBE to the ground lead and set the meter pointer at the left-hand zero with the ZERO adjust.

b. DC VOLTAGE MEASUREMENT

1. Set the UNI-PROBE at DC and the FUNCTION selector at either +DC or -DC, depending upon the polarity of the voltage to be measured with respect to ground.

2. Set the RANGE selector at a position considerably higher than the voltage to be measured.

3. If necessary, use the ZERO adjust to set the meter pointer at the left-hand zero with no voltage applied.

4. Connect the ground lead to the ground side of the voltage being measured and touch the UNI-PROBE to the high side.

5. Reset the RANGE selector to the position which gives a reading nearest to full scale and read the dc voltage on the meter.

c. ZERO CENTER INDICATION

Zero-center indication permits observation of either positive or negative voltage excursions without resetting of the FUNCTION selector. To prepare the instrument for zero-center indication, simply set the FUNCTION selector at +DC and turn the ZERO adjust (with no voltage applied) until the meter pointer is set at 0 on the -10 to +10 scale. The range selector should be set first to a position at least twice the highest anticipated voltage and then to the lowest position which permits the meter pointer to remain on the scale. The meter pointer will deflect to the right of zero-center for a positive voltage and to the left for a negative voltage.

d. RESISTANCE MEASUREMENT

Remove all power from the equipment under test before making resistance measurements so that no voltages are present.

1. Set the UNI-PROBE at AC-OHMS and the FUNCTION selector at OHMS.

2. Set the RANGE selector at RX10.

3. Short the UNI-PROBE to the ground lead. The meter pointer should be at the left-hand zero. Use the ZERO adjust to reset the pointer at the left-hand "0", if necessary.

4. Separate the UNI-PROBE from the ground lead. The meter pointer should deflect to the extreme right-hand graduation (∞) on the OHMS scale. Use the OHMS adjust to set pointer at the ∞ (infinity) graduation, if necessary.

5. Connect the clip on the ground lead to one terminal of the resistance to be measured and touch the UNI-PROBE to the other terminal.

6. Reset the RANGE selector to give a convenient deflection and multiply the reading on the OHMS scale by the factor indicated at the RANGE selector setting.

CAUTION

In measuring the resistance of delicate low-current devices, such as meter movements, it is essential to

keep in mind the current that may be drawn in the measurement. The short circuit currents that will be drawn at each resistance range is given below:

Rx1	150ma
Rx10	15ma
Rx1K	150uA
Rx10K	15uA
Rx1M	0.15uA

e. RESISTANCE MEASUREMENT ABOVE 1000 MEGOHMS

The upper limit of direct resistance measurement with this instrument is 1000 megohms. The leakage resistance of small paper and mica capacitors usually exceeds the value. To measure resistance values above 1000 megohms, an external dc voltage source between 20 and 500 volts can be used to obtain a measurable pointer deflection. The circuit connections are shown in Fig. 2-2 and the procedure is as follows:

1. Set the FUNCTION selector at + DC and the UNI-PROBE at DC.

2. Measure the voltage at point A and then the voltage at point B.

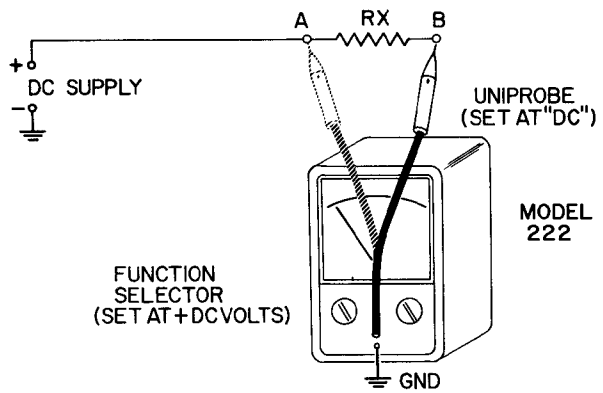


Figure 2-2. Resistance Measurement Above 1000 Megohms

3. Compute the resistance from the following formula.

$$Rx = (\text{megohms}) = \frac{11\,[(\text{Volts at "A"}) - (\text{Volts at "B"})]}{(\text{Volts at "B"})}$$

Example: In measuring a resistance by the method of Fig. 2, the external dc voltage supply is 300 volts. The instrument measures 300 volts at point A and 1.1 volts at B. Then,

$$Rx = \frac{11\,(300 - 1.1)}{1.1} = 3000 \text{ megohms (approx.)}$$

f. AC VOLTAGE MEASUREMENTS

1. Set the UNI-PROBE at AC-OHMS and the FUNCTION selector at AC.

2. Set the RANGE selector at a position considerably higher than the voltage to be measured.

3. If necessary, use the ZERO adjust to set the meter pointer at the left-hand zero with no voltage applied.

4. Connect the ground lead to the ground side of the voltage source to be measured and touch the UNI-PROBE to the high side.

5. Reset the RANGE selector to the position which gives a reading nearest to full scale and read the ac voltage.

NOTE: The Model 222, of itself, responds to the peak value of the value of the waveform in AC voltage measurements, and reads in the RMS value of a sine wave having the corresponding peak value.

SECTION III. APPLICATIONS

This instrument may be used to maintain and service television receivers, FM-AM and communication receivers, transmitters, audio equipment, and pulsed electronic and electro-mechanical equipment. Indicative of its versatility are some of the special applications described below.

a. OSCILLATOR GRID-BIAS MEASUREMENT: The negative dc voltage developed on the oscillator grid is always directly proportional to the strength of oscillation. This voltage can be measured very readily at the oscillator grid while the band switch is turned to the various bands, and in each of its positions the main tuning condenser is rotated from minimum capacity. This will give an indication of the strength of oscillation at all frequencies within the oscillator's range.

b. AVC-VOLTAGE MEASUREMENTS: The automatic volume control voltage developed by the incoming signal can be measured at a number of places in the receiver. This negative voltage first appears across the diode load resistor. It may also be measured along the AVC bus and at the grids of the RF tubes being controlled. The dc voltage measured at the diode load resistor is a very convenient output indication during receiver alignment.

Owing to the high input resistance of this instrument, it is possible to measure bias (AVC) voltage on the grid of RF and if amplifier tubes without disrupting the signal.

c. DC SUPPLY VOLTAGE MEASUREMENTS: Power supply dc voltages can be measured at the rectifier filaments and in the filter circuits. Plate, screen, and cathode dc voltages can be measured at the corresponding pins of the tube sockets.

d. BIAS CELL VOLTAGE MEASUREMENTS: This instrument will accurately measure the voltage of a bias cell. Current drawing voltmeters are not capable of making this measurement and in many cases will damage the cell.

e. DETECTION OF GASSY TUBES: One effect of a gassy tube is to reduce the normal negative grid bias, or even make the grid positive. This instrument is ideal for measuring the voltage directly at the control grid of any tube in order to determine whether or not this effect is present. Excessive gas will cause the tube to cease operating normally, and in an audio amplifier will usually cause the volume control to become noisy. This amount of gas will not always produce a noticeable change in the operation of the radio receiver. Consequently, if repeated difficulty is experienced with volume controls becoming noisy in this type of circuit, this instrument should be used to check for incorrect bias.

f. OUTPUT INDICATION: To measure output in the alignment of AM and TV receivers, the instrument is prepared for dc voltage measurement and usually connected to the load resistor of the second detector while the circuit components are adjusted for optimum output. In an FM receiver, the instrument is connected across the limiter load resistor. The zero-center feature is very useful for the alignment of FM discriminators.

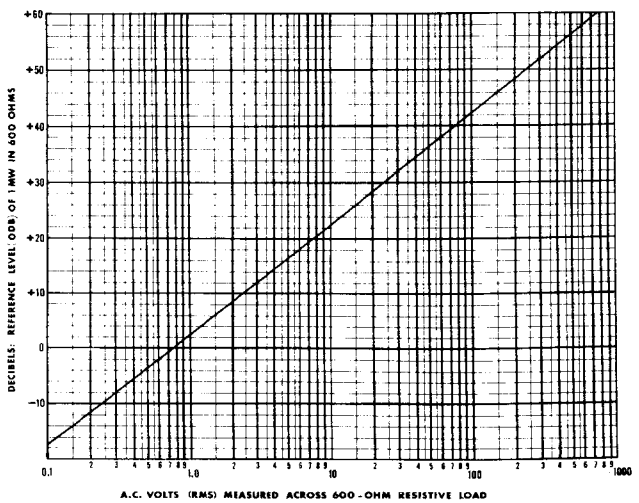


Figure 3-1. Decibels vs. AC Volts (RMS)

g. DB MEASUREMENTS: In order to avoid crowding of frequently used scales, there is no db scale on the meter. Another reason for the absence of this scale is that there are many different reference levels in use and each reference level results in a different scale. Fig. 3-1 is a graph for one accepted reference level, namely 0.775 volts across 600 ohms resistive load (1 milliwatt), with which rms ac voltage readings can be converted to db readings. However, the db value read from the chart is correct only when the voltage reading has been taken across a 600 ohm resistive load. If the reading has not been taken across a 600 ohm load, the db value read from the chart must be corrected by adding algebraically to it the correction increment specified in the chart of Fig. 3-2 for the particular resistive load. If the resistive load is not included in the chart, the correction increment may be calculated from the following formula.

$$\text{Correction Increment} = 10 \log \frac{600}{R}$$ (where R is the resistive load)

It should be noted that decibel measurements must be made with a sine waveform to avoid waveform error and that the correlation between decibels and ear response is greatest at 1000 cycles.

Load Res.	DB Added
600	0
500	+ 0.8
300	+ 3.0
250	+ 3.8

Load Res.	DB Added
150	+ 6.0
50	+ 10.8
15	+ 16.0
8	+ 18.8
3.2	+ 22.7

Figure 3-2. Table

SECTION IV. CIRCUIT DESCRIPTION

The central circuit in the operation of this instrument is a vacuum-tube bridge circuit using a 12AU7 twin-triode. When the bridge is balanced by the ZERO adjust R22, the voltages at the two cathodes will be equal and the meter connected across them will read zero.

a. DC VOLTMETER OPERATION: When a positive dc voltage is applied, a fraction (depending on the range setting) is taken from the range voltage divider (R10-R15) and applied to the grid of V2A. This causes the current through V2A to increase and consequently, the cathode voltage of V2A to increase. Concurrently the voltage on the arm of R22 tends to increase, which since it tends to make the cathode of V2B more positive, causes a decrease in the plate current and hence in the cathode of V2B. This push-pull action provides highly linear and stable operation. The meter circuit is connected across the two cathodes, and the difference in potential across the meter causes current to flow through the meter from the cathode of V2A to the cathode of V2B.

b. AC VOLTAGE MEASUREMENTS: The applied voltage is first applied to the a-c bleeder (R2-R4) and diode V1A, which shunts the positive half of applied a-c waveform to ground. Capacitor C3 is charged to the peak value of the negative half of the waveform. The contact potential of diode V1A (negative) is counteracted by positive voltage from the B+ supply obtained from the divider composed of R26 and R25 (A.C. Balance) and applied to C3 through isolation resistor R24. Resistor R18 and the range voltage divider (R10-R15) divide the peak voltage so that only 70% is applied to the range voltage divider, permitting the same scales to be used for both d-c voltage and rms a-c voltage readings. The operation thereafter is similar to d-c voltage measurements.

c. OHMMETER OPERATION: The voltage of the internal battery divides across the ohms range resistor selected (R5-R9) and the resistance being measured. At open circuit, the full battery voltage is applied to the grid of V2A. The OHMS adjust control R30 in the meter circuit is adjusted to set the meter pointer to the extreme right-hand graduation — ∞ (infinity) — on the OHMS scale in this condition. At short circuit,

zero voltage is applied to the grid of V2A for a zero reading. Intermediate values of resistance being measured cause intermediate values of voltage applied to the grid of V2A, and therefore intermediate readings on the OHMS scale, which is calibrated to read the actual resistance. The operation from the grid of V2A is similar to d-c voltage measurements.

SECTION V. MAINTENANCE

5-1. GENERAL

Your instrument will normally require little service outside of the tube replacement. The performance of the instrument is not dependent on tube selection and all of the types employed are available nationally.

All of the required adjustment procedures are described in this section. Trouble-shooting information is provided also. Operating voltages and transformer winding resistances are shown on the schematic diagram.

5-2. CASE REMOVAL

Loosen and remove the two sheet metal screws at the rear. Slide the case out of the panel frame and off the instrument.

5-3. METER MECHANICAL ZERO ADJUST

The meter pointer should rest directly over the zero of the voltmeter scales when the FUNCTION switch is at OFF (power off). If the meter pointer comes to rest at a deflected position, adjust it to zero by turning the slotted screw directly beneath the meter face.

5-4. WARM-UP

Insert the leads and plug the line cord into an outlet supplying 105-125 volts AC, 50-60 cps. Turn the unit on and allow a minimum of 2 hours for the warm-up preliminary to calibration. For maximum stability of calibration, a 36 hour warm-up period is desirable. If necessary, use the ZERO ADJ. control to set the meter pointer within scale limits during the warm-up period.

5-5. AC BALANCE ADJUSTMENT

Set the FUNCTION selector at AC, the RANGE selector at 1500V, and the UNI-PROBE at AC-OHMS. Short the UNI-PROBE to the ground lead and use the ZERO adjust to set the meter pointer exactly at the left-hand zero. Keeping the leads shorted, reset the RANGE selector at 3V and use the AC Balance potentiometer, R25, to reset the meter pointer at the left-hand zero.

5-6. AC VOLTMETER CALIBRATION

Set the FUNCTION selector at AC, the RANGE selector at 300V, and the UNI-PROBE at AC-OHMS. Connect the UNI-PROBE and the ground lead across the 117 volts a-c supply. Adjust the AC Calibration potentiometer, R28, until the meter reads 117 rms volts. If the maximum accuracy of which the instrument is capable is desired (5% of full scale), apply exactly 300 volts (60 cps) on the 300V range (or 75 volts on the 75V range) and adjust R28 for exactly full-scale deflection.

5-7. DC VOLTMETER CALIBRATION

Set the FUNCTION selector at +DC, the RANGE selector at 3V, and the UNI-PROBE at DC. Connect the UNI-PROBE to the positive terminal and the ground lead to the negative terminal of a single flashlight cell, which will provide a voltage of 1.55 volts when fresh. Adjust the +DC Calibration potentiometer, R29, until a 1.55 volt reading is obtained on the meter. Now remove the leads from the battery and reset the FUNCTION selector at -DC. Connect the UNI-PROBE to the negative terminal and the ground lead to the positive terminal of the flashlight cell. Then adjust the -DC Calibration potentiometer, R31, until a 1.55 volt reading is obtained on the meter.

5-8. OHMMETER CALIBRATION

No separate calibration is required.

NOTE: Access to the four calibration controls can be obtained by the holes on the side of the cabinet. Fig. 5-1 shows the location of each control in Model 222.

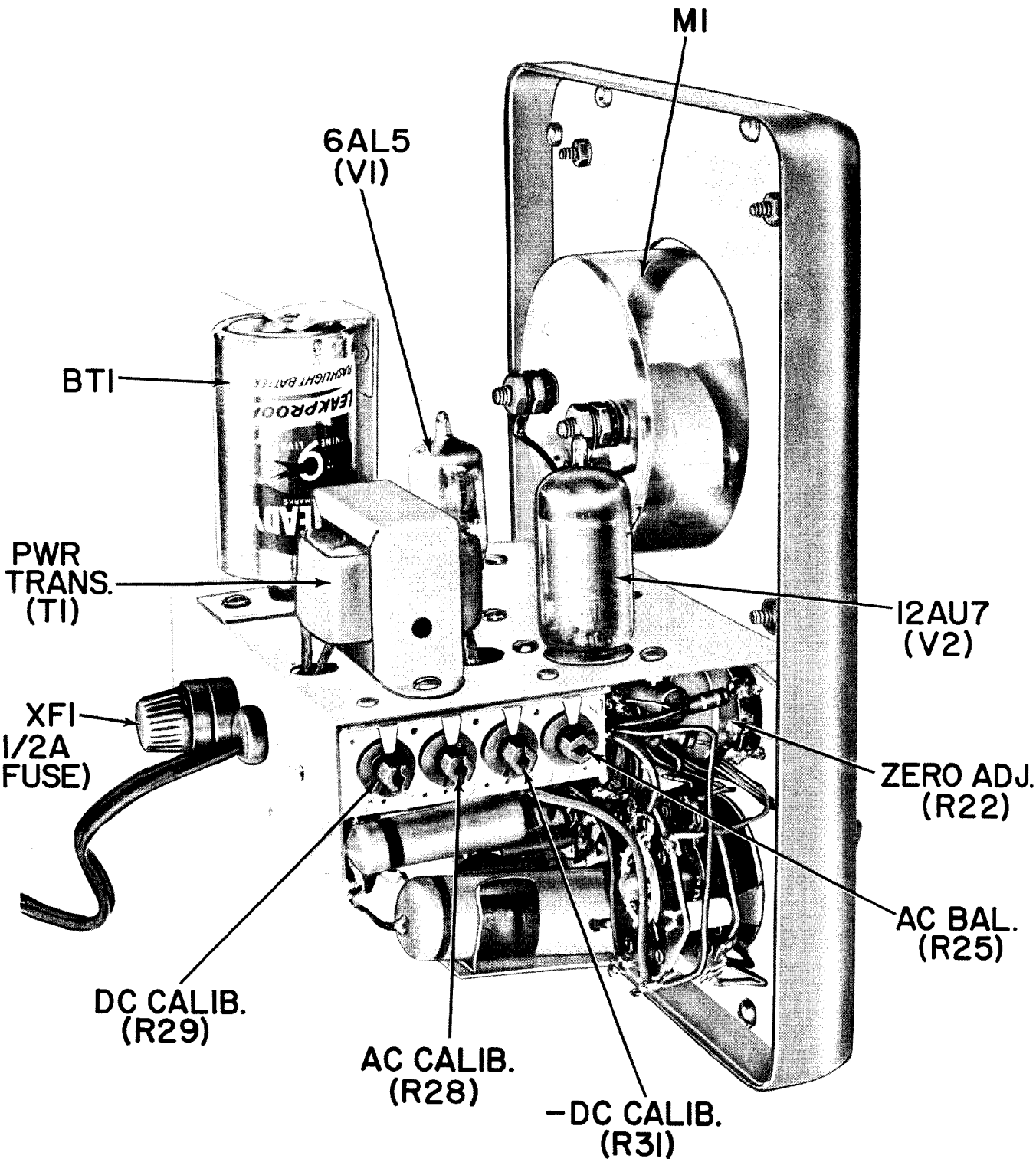
5-9. SERVICE

If trouble develops in your instrument which you can not remedy yourself, write to our service department listing all possible indications that might be helpful. List, also, any code numbers in red under the words INSTRUCTION MANUAL on the cover. If desired, you may return the instrument to our factory where it will be placed in operating condition for $7.00 plus the cost of parts replaced due to their being damaged in the course of construction. NOTE: Before returning this unit, be sure all parts are securely mounted. Attach a tag to the instrument, giving your home address and the trouble with the unit. Pack very carefully in a rugged container, using sufficient packing material (cotton, shredded newspaper, or excelsior), to make the unit completely immovable within the container. The original shipping carton is satisfactory, providing the original inserts are used or sufficient packing material inserted to keep the instrument immovable. Ship by prepaid Railway Express, if possible, to:

Electronic Instrument Co., Inc.
33-00 Northern Blvd.
Long Island City 1, N.Y.

Return shipment will be made by express collect. Note that a carrier cannot be held liable for damages in transit if packing IN HIS OPINION, is insufficient.

Figure 5-1. Calibration Potentiometers and Tube Layout



5-10. TROUBLE-SHOOTING CHART

SYMPTOM	POSSIBLE CAUSE
Instrument inoperative on all Functions	
1) Tubes and pilot light do not light	1) Defective line cord; S1D switch; blown fuse
2) Fuse blown	2) Short in T1 windings; C5 shorted, T1 defective
3) Pilot lights; tubes do not light	3) Open filament winding on T1
Instrument operative but improperly on all ranges	
1) ZERO ADJ. inoperative a) METER pointer does not move b) METER pointer bangs to right or left	1) No B+ and/or B-; S1C; V2, R22, M1 open or defective, V2 circuitry (check out all voltages)
2) ZERO ADJ. works but unit intermittent on all functions	2) a) Loose or bad connections in probe or cable b) Wiper contacts on S1 dirty or defective c) Loose or bad connections in V2 circuit d) V2, V1B, C5 defective
Instrument fails to operate properly on DC	
1) Meter does not read	1) a) UNI-PROBE resistor R1 open b) Open contacts in DC path. (See switching table) c) Loose or open connections
2) Meter reads inaccurately on "+DC"	2) a) Calibration resistor R29 out of adjustment or defective b) One or several resistors in the S2A network R10 through R15 off value or defective c) R1 shorted (10% higher reading)
3) Meter reads inaccurately or "-DC"	3) Calibration resistor R31 out of adjustment or defective
Instrument operates improperly on OHMS; works correctly on AC and DC	
1) Meter pointer does not move at all	1) a) Battery exhausted or not making contact b) Defective contact on S2C and/or S1C (See switching table) c) Defective R30
2) Meter pointer deflects but can not be set to infinity on scale with OHMS adjust	2) a) Battery failing b) R30 defective
3) RX1 range reads high	3) Faulty or "high-resistance" connection in ohms defective
4) RX1M " reads erratically	4) Excessive leakage or dirt in wafers S1-A,B,C or S2C
5) Resistance reading faulty on one range	5) Resistor from R5-R9 group for the particular range defective
Instrument fails to operate properly on AC; works normally on Ohms and DC	
1) No indication on meter	1) a) V1A defective b) C1, C2 or R18 open; C3 shorted c) One or more switch contacts in AC path do not make contact. (See switching table)
2) Meter pointer moves off zero when ranges are changed	2) a) "AC Balance" R25 out of adjustment b) R24 or R18 defective
3) Meter reads inaccurately	3) a) Calibration resistor R28 out of adjustment b) V1A defective; C2 and/or C3 leaky c) R18 and/or R24 off value d) Switch contacts in the AC path dirty. (See switching table)
4) Meter intermittent	4) a) Intermittent and/or cold connections in AC circuitry. Dirty switch contacts in AC path. (See switching table) b) V1A defective

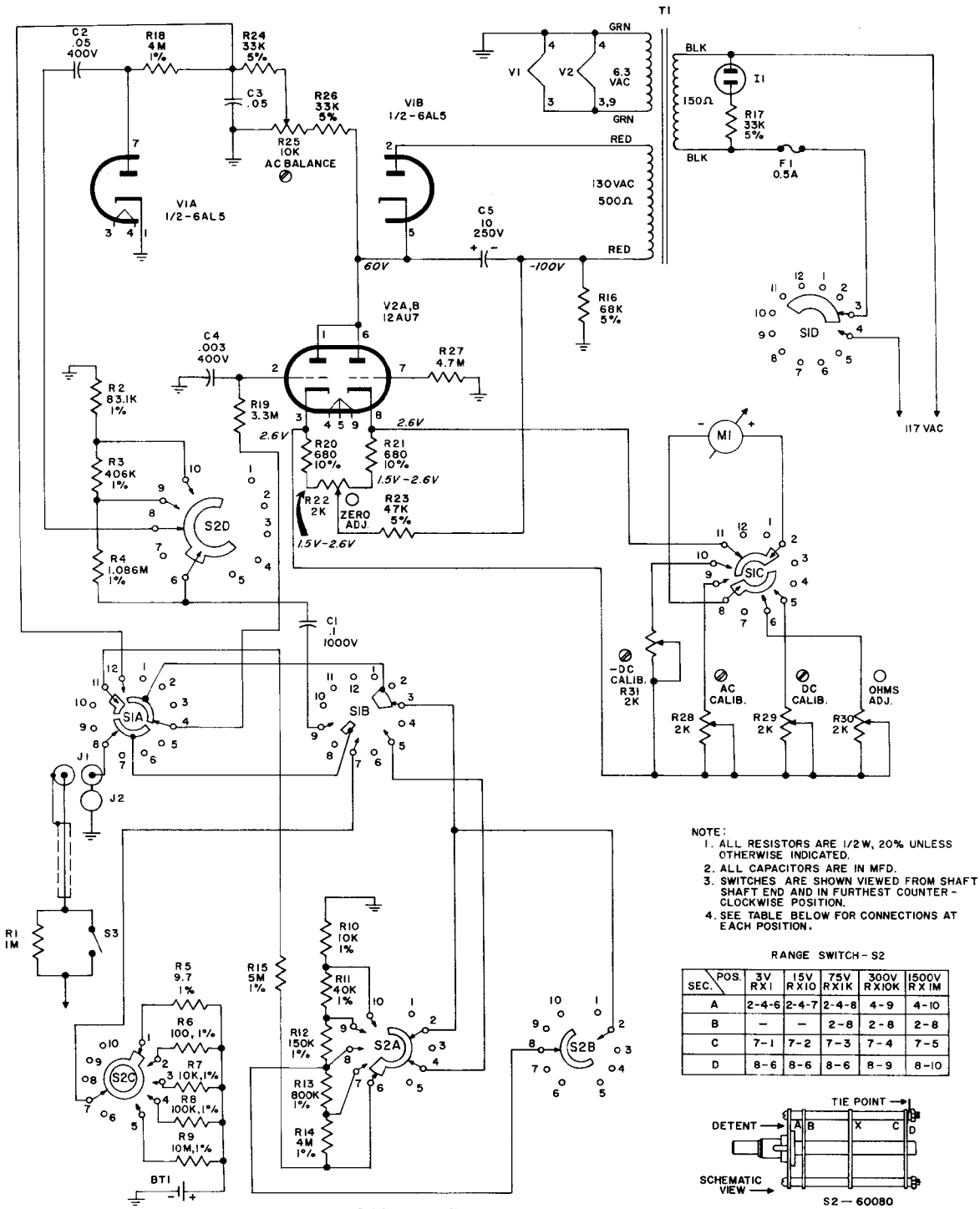
SECTION VI. REPLACEMENT PARTS LIST

SYM.#	STOCK#	AM'T.	DESCRIPTION
BT1	56000	1	battery, 1-1/2 volts
C1	20003	1	capacitor, paper, .1mfd, 1000V
C2,3	20001	2	capacitor, paper, .05mfd, 400V
C4	20007	1	capacitor, paper, .003mfd, 400V
C5	23028	1	capacitor, elec., 10mfd, 150V
E1	89517	1	rotor contact
E2	89518	1	contact, left
E3	89519	1	contact, right (with hole)
E4	89659	1	probe body
E5	89520	1	contact holder
E6	44003	1	spacer, large diameter fiber
E7	44002	1	spacer, small diameter fiber
E8	42021	1	washer, large diameter fiber
E9	42020	1	washer, small diameter fiber
E10	47002	1	spring
E11	88521*	1	metal tip
E12	89658*	1	nosepiece
F1	91007	1	fuse, 1/2 Amp
I1	97715	1	pilot light
J1	50002	1	connector, male
J2	50008	1	jack, banana
M1	72008	1	meter, 400uA
R1	10407	1	resistor, 1M ohm, 1/2W, 10% (brown,black,green,silver)
R2	11086	1	resistor, 83.1K ohm, 1/2W, 1%
R3	11076	1	resistor, 406K ohm, 1/2W, 1%
R4	11077	1	resistor, 1.086M ohm, 1/2W, 1%
R5	11043	1	resistor, 9.7 ohm, 1/2W, 1%
R6	11005	1	resistor, 100 ohm, 1/2W, 1%
R7	11051	1	resistor, 10K ohm, 1/2W, 1%
R8	11079	1	resistor, 100K ohm, 1/2W, 1%
R9	11078	1	resistor, 10M ohm, 1/2W, 1%
R10	11051	1	resistor, 10K ohm, 1/2W, 1%
R11	11020	1	resistor, 40K ohm, 1/2W, 1%
R12	11025	1	resistor, 150K ohm, 1/2W, 1%
R13	11030	1	resistor, 800K ohm, 1/2W, 1%
R14	11032	1	resistor, 4M ohm, 1/2W, 1%
R15	11034	1	resistor, 5M ohm, 1/2W, 1%
R16	10520	1	resistor, 68K ohm, 1/2W, 5% (blue,grey,orange,gold)
R17	10503	1	resistor, 33K ohm, 1/2W, 5% (orange,orange,orange,gold)
R18	11032	1	resistor, 4M ohm, 1/2W, 1%
R19	10033	1	resistor, 3.3M ohm, 1/2W, 20% (orange,orange,green)
R20,21	10406	2	resistor, 680 ohm, 1/2W, 10% (blue,grey,brown,silver)
R22	16000	1	potentiometer, 2K ohm, linear
R23	10521	1	resistor, 47K ohm, 1/2W, 5% (yellow,violet,orange,gold)
R24	10547	1	resistor, 43M ohm, 1/2W, 5% (yellow,orange,blue,gold)
R25	18090	1	potentiometer, 10K ohm, linear (part of assembly R25,28,29,31)
R26	10503	1	resistor, 33K ohm, 1/2W, 5% (orange,orange,orange,gold)
R27	10034	1	resistor, 4.7M ohm, 1/2W, 20% (yellow,violet,green)
R28			potentiometer, 2K ohm, linear (Part of 18090)
R29			potentiometer, 2K ohm, linear (Part of 18090)
R30	16000	1	potentiometer, 2K ohm, linear
R31			potentiometer, 2K ohm, linear (Part of 18090)
S1	60104	1	switch, rotary, 5 position
S2	60080	1	switch, rotary, 5 position
T1	30012	1	transformer, power
TB1	54042	1	terminal strip, 4 post right
TB2	54018	1	terminal strip, 4 post with ground
V1	90017	1	tube, 6AL5

*Factory Assembled

REPLACEMENT PARTS LIST (Cont'd.)

SYM.#	STOCK#	AM'T.	DESCRIPTION
V2	90013	1	tube, 12AU7
XF1	97804	1	fuseholder
XV1	97024	1	socket, 7 pin miniature
XV2	97025	1	socket, 9 pin miniature
	40000	10	nut, hex, No. 6-32
	40001	5	nut, hex, 3/8"
	40004	2	nut, hex, No. 2-56
	40007	8	nut, hex, No. 4-40
	40016	1	nut, hex, 1/2"-24
	40036	1	nut, hex, 1/4"-32
	41008	1	screw, No. 6-32 x 1/2
	41024	1	screw, No. 8-32 x 1/4, set screw
	41047	2	screw, No. 8 PK (self tapping)
	41061	1	screw, No. 8-32 x 3/16, set screw
	41063	4	screw, No. 6-32 x 1/4, Flat Head
	41086	4	screw, No. 6-32 x 5/16
	41089	10	screw, No. 6-32 x 3/16, Round Head
	41090	8	screw, No. 4-40 x 5/16
	41095	2	screw, No. 2-56 x 1/4
	42000	3	washer, lock, 3/8"
	42001	4	washer, flat, 3/8"
	42002	8	washer, lock, No. 6
	42005	4	washer, flat, No. 6
	42006	2	washer, fiber shoulder, No. 6
	42007	8	washer, lock, No. 4
	42022	1	washer, metal cup
	42023	1	washer, lock, 1/4"
	42024	1	washer, split, No. 6
	42029	1	washer, rubber, 1/2"
	42049	1	washer, flat, 1/4"
	42053	2	washer, lock, No. 2
	42511	1	retainer, flat spring
	43000	1	lug, No. 6
	46013	4	foot, rubber
	51000	1	connector, female
	51005	1	plug, banana
	51502	1	clip, alligator
	53036	2	knob, large
	53037	2	knob, small
	56503	1	battery holder
	56517	1	clip, Tinnerman
	57004	1	line cord
	58004	length	wire, hook-up
	58300	length	spaghetti tubing
	58425	length	cable, grey co-ax
	58424	length	cable, grey kinkless
	58501	length	wire, bare
	80088	1	panel
	81250	1	chassis
	81916	1	bracket, capacitor
	82104	1	strain relief
	86005	1	frame, rectangular
	87006	1	handle with rings
	88074	1	cabinet
	89249	1	nomenclature label
	89649	2	handle mounting bracket
	66108	1	manual of instructions (wired)
	66361	1	manual of instructions (kit)



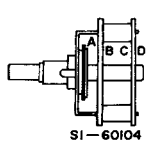
NOTE:
1. ALL RESISTORS ARE 1/2W, 20% UNLESS OTHERWISE INDICATED.
2. ALL CAPACITORS ARE IN MFD.
3. SWITCHES ARE SHOWN VIEWED FROM SHAFT SHAFT END AND IN FURTHEST COUNTER-CLOCKWISE POSITION.
4. SEE TABLE BELOW FOR CONNECTIONS AT EACH POSITION.

RANGE SWITCH - S2

SEC. \ POS.	3V RX1	15V RX10	75V RX1K	300V RX10K	1500V RX1M
A	2-4-6	2-4-7	2-4-8	4-9	4-10
B	—	—	2-8	2-8	2-8
C	7-1	7-2	7-3	7-4	7-5
D	8-6	8-6	8-6	8-9	8-10

S2 — 60080

FUNCTION SWITCH - S1

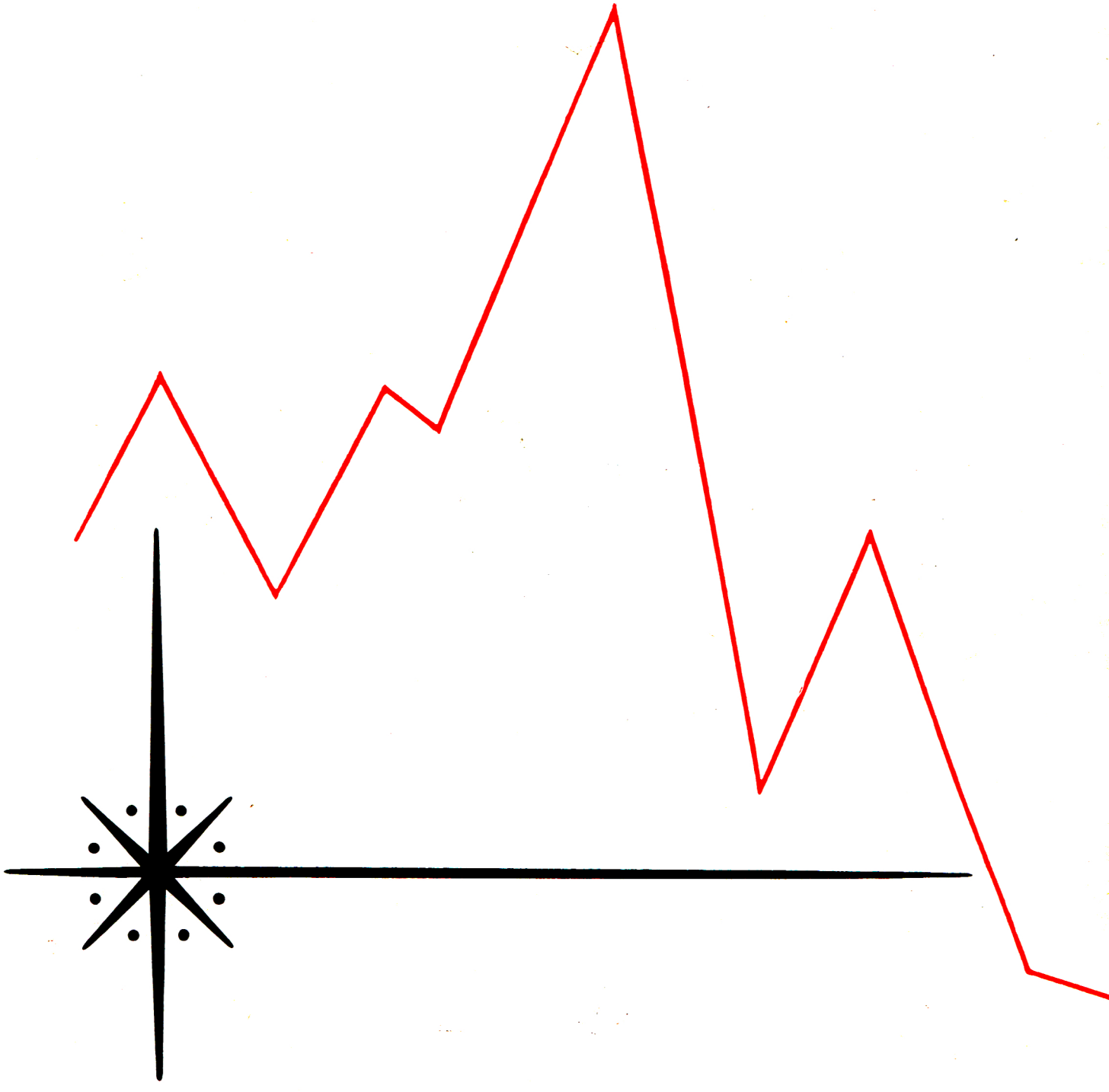


S1 — 60104

SEC. \ POS.	OFF	AC VOLTS	-DC VOLTS	+DC VOLTS	OHMS
A		11-12	8-11	8-11	4-8
A TO B INTERCON*	A4B3	A8-B9, A4-B3	A4-B5	A4-B4	A4,8-B7
C	2-11	8-9, 2-11	8-10, 2-11	2-5, 8-11	2-6, 8-11
D		3-4	3-4	3-4	3-4

*SOME WIPERS ON THE A & B WAFER ARE INTERNALLY CONNECTED.

Figure 5-2. Schematic Diagram & Switching Table for 222



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ANOTHER PERFORMANCE PROVEN PRODUCT