INSTRUCTION MANUAL

FOR THE

STARK

MODEL ND-3A

CIRCUIT ANALYZER

22 RANGE

STARK

CANADA

PART No. 119T1

STARK ELECTRONIC INSTRUMENTS LIMITED manufacture a complete line of Electrical Indicating Meters, Tube Testers and Circuit Analyzers, in sizes and ranges to suit every purpose.

TUBE TESTERS are modern and up-to-date, accurate, and easily operated.

CIRCUIT ANALYZERS can be had in many designs from the handy pocket size to large de-luxe models. They cover an extremely wide range of all electrical measurements.

ELECTRICAL INDICATING METERS incorporated in Stark Tube Testers and Circuit Analyzers are completely manufactured in our own plants.

All meter needs for AC or DC voltage and current measurements, both Panel Mounting and Portable, can be supplied in five distinctive styles, in round or rectangular, from 2" to 9" sizes.

See inside back cover for further details.

STARK TUBE TESTERS:

(PACKED)

Model 9-11—Approx. 10½"x 9"x5"— 9 lbs.
Model 9-55—Approx. 13½"x12"x5"—11 lbs.
*Model 9-44—Approx. 10½"x 9"x5"— 9 lbs.
*Model SY —Approx. 10½"x 9"x5"— 9 lbs.

*SELF POWERED - INDEPENDENT OF EXTERNAL POWER SUPPLY.

Model SY also provides DC Voltage Range 0-10-300 and Ohms 0-100,000-1 Meg.

STARK ANALYZERS:

(PACKED)

DC 1,000 Ohms per Volt.
Model AF-2 —Approx. 6½"x3¼"x3½"—1½ lbs.

AC & DC 1,000 Ohms per Volt.
Model RP —Approx. 8¾"x3¼"x5¾"—3½ lbs.

AC & DC 20,000 Ohms per Volt.
Model KM —Approx. 15"x 10"x 5"—10 lbs.

AC & DC 400 or 1,000 Ohms per Volt.
Model ND-3—Approx. 5"x5½"x5½"—3½ lbs.

MODEL ND-3A "UNIVERSAL" CIRCUIT ANALYZER

I N D E X

1. GENERAL

The Stark Model ND-3A Circuit Analyzer is a multi-range voltmeter, milliammeter and ohmmeter, designed to cover a range of measurements most useful in the testing of communications and other electronic equipments. Special consideration has been given to ruggedness and portability in the design of this instrument.

2. GENERAL DESCRIPTION

2.1 CIRCUITS: The instrument provides for a total of 22 ranges of measurement, which are as follows::

0-3-15-60-150-300-600-1500-3000 volts DC
0-3-15-60-150-300-600-1500-3000 volts AC
0-3-15-150-600 milliamperes DC
0-20,000-200,000 ohms.

A desired range is chosen by the insertion of test leads in appropriate pinjacks, and by the proper positioning of two switches on the panel. An additional adjustment is provided to compensate for changes in the voltage of the battery used in the ohmmeter circuits.

The circuit components are arranged and connected in a manner which minimizes the possibility of breakdown or of errors due to wear or changes in the characteristics of components.

2.2 METER: The meter used in this instrument is completely manufactured in our own plant, and is especially designed for

this service. It has a D'Arsonval type of movement, requiring 800 microamperes of current for full scale deflection. The accuracy of the meter is guaranteed to be within 2% of full scale deflection at any point on the scale.

2.3 RESISTORS: All critical resistors of 50,000 ohms or less are wire wound in our own plant, and are impregnated and annealed to ensure stability against the effects of humidity and time. They are calibrated to a value within 1% of their designated value, and will maintain their accuracy indefinitely.

Where wire wound resistors are impractical, metallized resistors are used. They are completely sealed against the effects of humidity, and are only slightly affected by age or temperature.

2.4 RECTIFIER: This component is a high quality copper oxide unit, of the full wave type. It is capable of rectifying voltages at frequencies as high as 1000 cycles per second with negligible error, and may be used as an indicator of voltage at any audio frequency. It can withstand current overloads of 500% for short periods without harmful effect.

2.5 OTHER COMPONENTS: The switches employed are the best obtainable for use in test instruments of this type. The contact resistance is extremely low, and the contacts themselves are well insulated and mounted on a thoroughly impregnated bakelite punching.

The potentiometer and other components are standard units with well-known characteristics, and have been proven well suited for use in test instruments.

3. CIRCUIT DESCRIPTION

3.1 DC VOLTAGE MEASUREMENT.

3.11 CIRCUIT: Referring to Fig. 1, it will be seen that this circuit consists of Resistors R3 to R10 and the meter, and that connection is made to the meter and pinjacks through the AC-DC switch and the top deck of the selector switch.

3.12 APPLICATION: The voltmeter circuit has a sensitivity of 1000 ohms per volt, which is ample for the majority of measurements, including measurements of grid bias and plate voltage, power supply voltage and battery voltage. In high resistance circuits, however, the loading effect of the voltmeter may result in an indicated voltage which is somewhat lower than the actual voltage after removal of the voltmeter from the circuit. This error can be negiected in many cases or correction can be made when necessary by reference to Fig. 2 and the following formula:

$$V1 = KV2.$$

where V1 = actual voltage across R2.

V2 = indicated voltage across R2.

$$K = 1 + \frac{R1 \quad R2}{R3\ (R1 + R2)}$$

R1 + R2 = total resistance in series with voltage source.

R2 = portion of total resistance across which the measurement is to be taken.

R3 = resistance of voltmeter. Since the voltmeter sensitivity is 1000 ohms per volt, the voltmeter resistance on the 60 volt range, for instance, would be 60 x 1000 =60,000 ohms.

3.2 AC VOLTAGE MEASUREMENT.

3.21 CIRCUIT: Reference to Fig. 1 shows that this circuit is comprised of Resistors R1, R2, R4 to R10, the full wave rectifier, and the meter, and connections are made to the meter and pin-jacks through the AC-DC switch and the top deck of the Selector Switch. Resistor R1 across the output of the rectifier has a value which reduces the sensitivity of the circuit to a uniform level of 1000 ohms per volt. R1 varies in value with the efficiency of the rectifier and in general is calibrated to each individual rectifier. Resistor R2 must also be individually calibrated, since its value depends on the effective resistance of the rectifier.

3.22 APPLICATION: The relatively high sensitivity of this circuit enables the operator to make accurate measurements of audio frequency amplifier gain, transformer turns ratio, etc., at any frequency in the range 25-1000 cycles per second, and to make comparative measurements at higher audio frequencies. The actual signal voltage may be traced step by step through the equipment under test, thus decreasing the time required for trouble shooting. The usual power transformer and line voltage measurements can also be made effectively with this circuit.

3.23 LIMITATIONS: The use of any rectifier of this type in voltage measuring circuits introduces possible sources of error, which can be compensated for if they are understood and recognized.

All copper oxide rectifiers exhibit a change in effective resistance due to a change in temperature. This is equivalent to changing the total series resistance of the voltmeter circuit, and has its greatest effect where this series resistance is a minimum, since the variable resistance of the rectifier is then a considerable proportion of the total series resistance. For this reason the possible error on the 3 volt range, due to temperature change alone, is several times as great as the error on the remaining ranges.

This type of rectifier is also subject to errors if the wave form of the voltage under test is not sinusoidal. As examples of the error to expected for serious distortion of the wave form, the following may be cited. If the voltage wave contains a 50% second harmonic, the error may be in the range 0 to 10 per cent, and if it contains a 50% third harmonic the error may be —10 to +16 per cent, the actual error depending on the relative phase of the harmonic and fundamental waves. In general, such acute distortion is not experienced and the error will thus be proportionately less.

3.3 DIRECT CURRENT MEASUREMENT.

3.31 CIRCUIT: For current measurements, a ring type shunt is used. This is shown as Resistors R11 to R14, Fig. 1. Connections are completed to the meter and pinjacks through the AC-DC switch and both decks of the selector switch. In this type of shunt the resistors are permanently soldered together and con-

nections are made in such a manner that variations in switch contact resistance, or poor connections at the pinjacks, do not materially affect the accuracy of the circuit.

3.32 APPLICATION: This circuit provides sufficient range for the majority of current measurements in radio and allied equipment. Determination of plate and screen currents, filament current, and others which will suggest themselves to the operator, can readily be made.

3.4 RESISTANCE MEASUREMENT.

3.41 CIRCUIT: As may be seen from Fig. 1; the circuit used for this function is comprised of Resistors R16 to R18, the potentiometer R19, the battery B, and the meter. Connections are made to the meter and pinjacks through the AC-DC switch and both decks of the selector switch.

A typical circuit, the "R" range for example, includes the meter, the battery B, the potentiometer R19 and the resistor R17, connected in series with the pinjacks. When the pinjacks are short circuited, the current flowing through this circuit is limited by resistor R17 to approximately one milliampere, and is adjusted by rotation of R19 to exactly one milliampere as indicated by full scale deflection of the meter. If then, the short circuit is removed and replaced by a resistance, the meter deflection will be somewhat less than full scale due to the added resistance in the circuit. The scale of the meter is calibrated in terms of this added resistance.

To obtain a lower resistance range (the "R ÷ 10" Range) the meter sensitivity is reduced by shunting it with resistor R16 so that 10 milliamperes is required for full scale deflection. This reduces the range of measurement by a factor of 10. For an increased range of measurement, it is quite possible to use the "R" range and add an externally connected battery and resistor in series with the pinjacks. For example, the "R" range will be multiplied by 10 if the total battery voltage is multiplied by 10, and an external resistance is added to limit the current to one milliampere. That is, a total voltage of 15 and resistance of approximately 15,000 ohms is required, but since 1.5 volts and approximately 1500 ohms are already connected in the circuit, the external battery should be 13.5 volts and the external resistance approximately 13,500 ohms. The external components are connected in series with the pinjacks. The circuit may be opened at any point to connect in any unknown resistance which it is desired to measure.

3.42 APPLICATION: The lowest resistance which can be measured conveniently with this instrument is 5 ohms, while the highest resistance marked on the scale is 200,000 ohms. This range permits the operator to determine the resistance of many communications equipment components, including resistors, radio and audio frequency coils, transformers, and loudspeaker voice and field coils. In addition this circuit may be used for conventional continuity testing.

Should it be found convenient to increase the range of measurements, this can be done readily as described in paragraph 3.41. By increasing battery voltage to 15, 150, etc., and adding the appropriate series limiting resistors, the "R" range may be multiplied by 10, 100, etc.

The circuit depends for its accuracy upon the battery voltage, and upon the accuracy of the meter. However, the accuracy of measurements is also affected by the care with which the preliminary adjustment to full scale deflection is made, and by the accuracy with which the meter is first set at its zero deflection position.

4. BATTERY REPLACEMENT

4.1 BATTERY: The battery required for this instrument is an Eveready No. 915 or Burgess No. 9 cell.

4.2 REPLACEMENT: This battery should be replaced when it is no longer possible to obtain a proper adjustment of the "ZERO OHMS" knob as described in paragraph 6.4 (d). To replace the battery, remove the four corner screws in the panel, and lift the instrument out of its cabinet. Remove the screw holding the battery mounting bracket to the bakelite sub-panel, and lift out the battery. In replacing with a new battery, correct polarity must be observed.

5. METER SCALES

5.1 GENERAL: The following information is provided to explain the reasons for the arrangement of the scales on the meter, and the methods used for correctly interpreting them.

Obviously it is not possible to provide on the meter scale plate a separate scale for each of the 22 ranges contained in the instrument. Some method of condensing must therefore be employed and actually two methods are used.

First, the ranges are chosen in a manner such that each range is a simple multiple, say 2, 4, or 10, of another range. It is then possible to use a single scale but provide sets of figures associated with this scale for the various ranges. The scale shown in Fig. 4, by proper choice of ranges, is thus used for 19 ranges.

Second, the 19 sets of figures which might be associated with this scale are reduced to three sets by (a) using multiples of one set of figures to designate other ranges and (b) using one set of figures to designate the same numerical range, whether the units for that range be AC volts, DC volts, or milliamperes.

Thus, in Fig. 4 for example, the one set of figures 0-150 is used also for ranges 0-15 and 0-1500, and may refer to AC volts, DC volts or milliamperes, depending upon the positions of the switches and test leads in the instrument.

5.2 SCALES: As a guide to those who may desire information concerning the proper scale to use when making a particular measurement each paragraph in Section 6 describing a method of measurement also makes reference to the scale associated with that measurement, and the method of reading it.

5.3 SCALE READING: The following comments on the reading of scales may be of assistance:

1. Wherever possible, an instrument range should be chosen which causes the meter needle to deflect into the upper half of the scale. This makes for greater accuracy and ease of reading.

2. To avoid parallax, the operator should stand directly in front of the meter when reading, and preferably not closer than necessary for good readability.

3. The operator should become familiar with the quantity represented by each division on each scale. The scale shown in Fig. 4, for example contains 60 divisions. When taken in conjunction with the associated figures 0-600, every division then has a value of 10. If the 0-300 or 0-150 scale were used, then each division would represent a value of 5 or 2.5 respectively.

6. OPERATING INSTRUCTIONS

6.1 DC VOLTAGE MEASUREMENT

6.11 LOW DC VOLTAGE MEASUREMENT

See paragraphs 3.11 and 3.12.

Range 0-3-15-60-150-300-600 volts.

Sensitivity 1000 ohms per volt.

(a) Set AC-DC switch in "DC" position.

(b) Set selector switch on suitable voltage range. If in doubt as to magnitude of voltage to be measured, set in "600 V" position.

(c) Insert test leads in pair of pinjacks marked "DC RANGES", with red wire lead in "+" pinjack.

(d) Connect test prods to voltage source under test, with red wire prod on positive terminal.

(e) Read voltage on meter scale marked "VOLTS & MA". Use scale shown in Fig. 4 as follows:

If selector switch in "3 V" position, use 0-300 figures and divide by 100.

If selector switch in "15 V" position, use 0-150 figures and divide by 10.

If selector switch in "60 V" position, use 0-600 figures and divide by 10.

If selector switch in "150 V", "300 V" or "600 V" position use 0-150, 0-300 or 0-600 figures respectively, and read directly.

6.12 HIGH DC VOLTAGE MEASUREMENT.

See paragraphs 3.11 and 3.12.

Range 0-1500-3000 volts.

Sensitivity 1000 ohms per volt.

(a) Set AC-DC Switch in "DC" position.

(b) Set selector switch on any voltage range.

(c) Insert black wire test lead in "—" pinjack of pair marked "DC RANGES", and red wire test lead in "1500 V" or "3000 V" pinjack.

(d) Connect test prods to voltage source under test, with red wire prod on positive terminal. **Use extreme care in handling of all high voltage connections.**

(e) Read voltage on meter scale marked "VOLTS & MA". Use scale shown in Fig. 4 as follows:

If red wire test lead in "1500 V" pinjack use 0-150 figures and multiply by 10.

If red wire test lead in "3000 V" pinjack use 0-300 figures and multiply by 10.

6.2 AC VOLTAGE MEASUREMENT

6.21 LOW AC VOLTAGE MEASUREMENT.

See paragraphs 3.21, 3.22 and 3.23.
Range 0-3-15-60-150-300-600 volts.
Sensitivity 1000 ohms per volt.

(a) Set AC-DC switch in "AC" position.

(b) Set selector switch on suitable voltage range. If in doubt as to magnitude of voltage to be measured, set in "600 V" position.

(c) Insert test leads in pair of pinjacks marked "AC VOLTS".

(d) Connect test prods to voltage source under test.

(e) Read voltage on meter scale marked "3 V AC ONLY" (see Fig. 5) if selector switch is in "3 V" position, or on scale marked "VOLTS & MA" (see Fig. 4) if selector switch is in any other voltage position. Scale shown in Fig. 5 is direct reading. When scale shown in Fig. 4 is used, read scale as follows:

If selector switch in "15 V" position use 0-150 figures and divide by 10.

If selector switch in "60 V" position use 0-600 figures and divide by 10.

If selector switch in "150 V", "300 V" or "600 V" position, use 0-150, 0-300 or 0-600 figures respectively and read directly.

6.22 HIGH AC VOLTAGE MEASUREMENT.

See paragraphs 3.21, 3.22 and 3.23.

Range 0-1500-3000 volts.
Sensitivity 1000 ohms per volt.
(a) Set AC-DC switch in "AC" position.
(b) Set selector switch on any voltage range.
(c) Insert black wire test lead in black pinjack of pair marked "AC VOLTS" and red wire test lead in "1500 V" or "3000 V" pinjack.

(d) Connect test prods to voltage source under test. **Use extreme care in handling of all high voltage connections.**

(e) Read voltage on meter scale marked "VOLTS & MA". Use scale shown in Fig 4 as follows:

If red wire test lead in "1500 V" pinjack, use 0-150 figures and multiply by 10.

If red wire test lead in "3000 V" pinjack, use 0-300 figures and multiply by 10.

6.3 DIRECT CURRENT MEASUREMENT.

See paragraphs 3.31 and 3.32.

Range 0-3-15-150-600 milliamperes.

(a) Set AC-DC switch in "DC" position.

(b) Set selector switch on suitable current range. If in doubt as to magnitude of current to be measured, set in "600 MA" position.

(c) Insert test leads in pair of pinjacks marked "DC RANGES", with red wire lead in "+" pinjack.

(d) Connect test prods in series with circuit in which current is to be measured, with red wire prod on positive terminal.

(e) Read current in milliamperes on meter scale marked "VOLTS & MA". Use scale shown in Fig. 4 as follows:

If selector switch in "3 MA" position, use 0-300 figures and divide by 100.

If selector switch in "15 MA" position, use 0-150 figures and divide by 10.

If selector switch in "150 MA" or "600 MA" position, use 0-150 or 0-600 figures respectively and read directly.

6.4 RESISTANCE MEASUREMENT.

See paragraphs 3.41, 3.42 and 4.2.

Range 0-20,000-200,000 ohms designated "R÷10" and "R" respectively.

(a) Set AC-DC switch in "DC" position.

(b) Set selector switch on suitable "R" range.

(c) Insert test leads in pair of pinjack marked "DC RANGES".

(d) Connect free ends of test prods together, causing meter needle to deflect, then adjust knob marked "ZERO OHMS" until meter reads exactly full scale (zero ohms on scale marked "OHMS". (See Fig. 3). If another range is used, the "ZERO OHMS" knob must be re-adjusted.

(e) Connect test prods to resistance to be measured.

(f) Read resistance value in ohms on meter scale marked "OHMS". Use scale shown in Fig. 3 as follows:

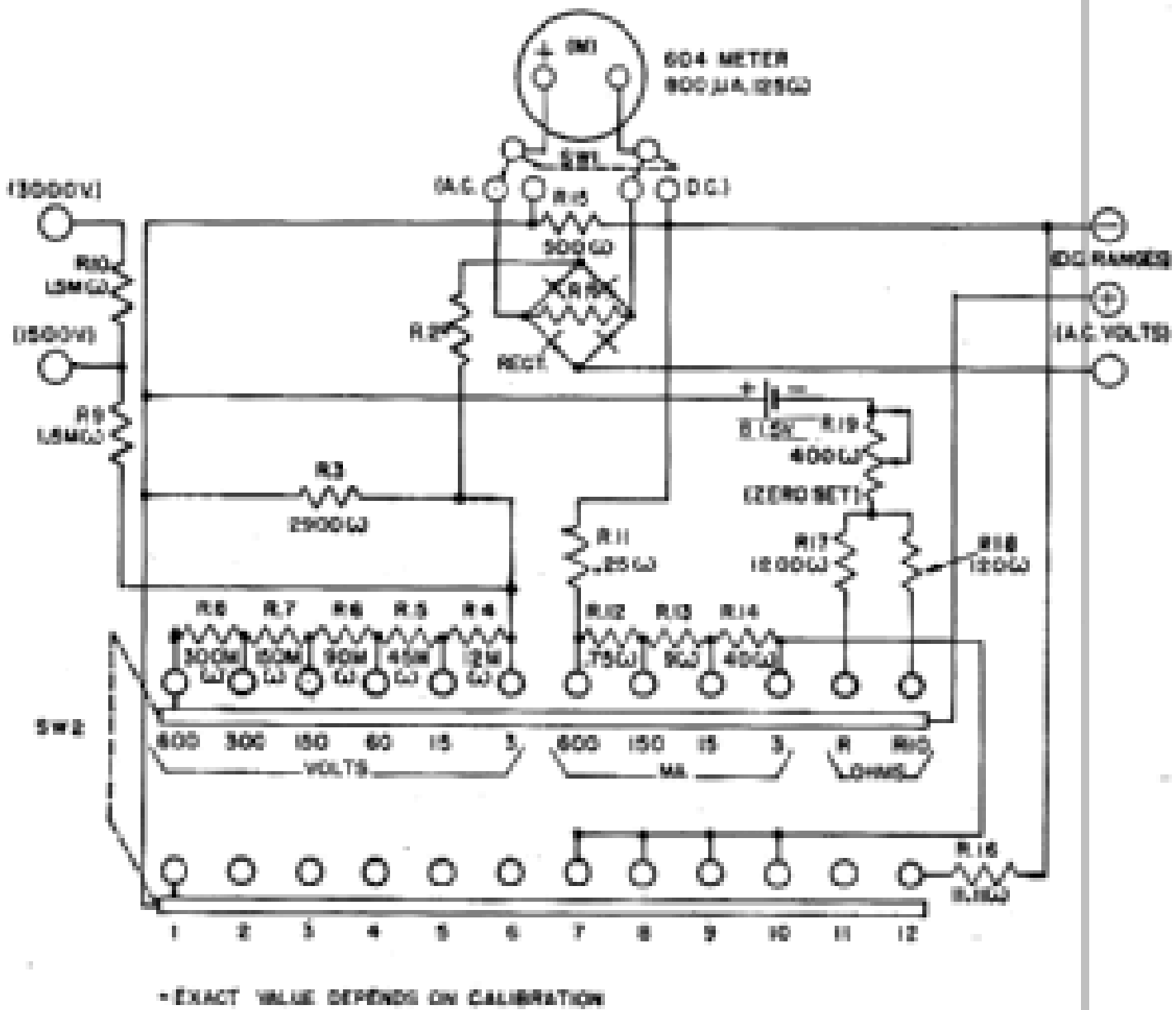
If selector switch in "R" position, read scale directly.

If selector switch in "R÷10" position divide scale reading by 10 to obtain the actual resistance in ohms.

7. MAJOR PARTS LIST

Description	Part No.
Battery; Eveready No. 915 or equivalent	101D1
Bracket, Battery holding	104B5
Cabinet	107A9
Clip, for battery connections	104D4
Knob, 1¼" pointer	121A9
Knob, ¾" round	121B2
Manual, Instruction	119T1
Meter, complete	M6037
Panel	128B14
Pinjack, black	132A2
Pinjack, red	132B2
Potentiometer	134A8
Rectifier	138A8
Resistor, .25 ohm, spool	R11
Resistor, .75 ohm, spool	R12
Resistor, 9 ohms, spool	R13

Resistor, 11.11 ohms, spool	R16
Resistor, 40.0 ohms, spool	R14
Resistor, 120 ohms, spool	R18
Resistor, 500 ohms, spool	R15
Resistor, 1200 ohms, spool	R17
Resistor, 2900 ohms, spool	R3
Resistor, 12,000 ohms, spool	R4
Resistor, 45,000 ohms, spool	R5
Resistor, 90,000 ohms, metallized	R6
Resistor, 150,000 ohms, metalliezd	R7
Resistor, 300,000 ohms, metallized	R8
Resistor, 500,000 ohms, metallized	R9A, R9B, R9C, R10A, R10B, or R10C
Resistor, calibration, spool	R1
Resistor, calibration, spool	R2
Sub-panel, for resistors	115R3
Switch, 2 position, single deck	144G2
Switch, 12 position, 2 deck	144B2
Test lead set, complete	151G1



* EXACT VALUE DEPENDS ON CALIBRATION

FIG. 1

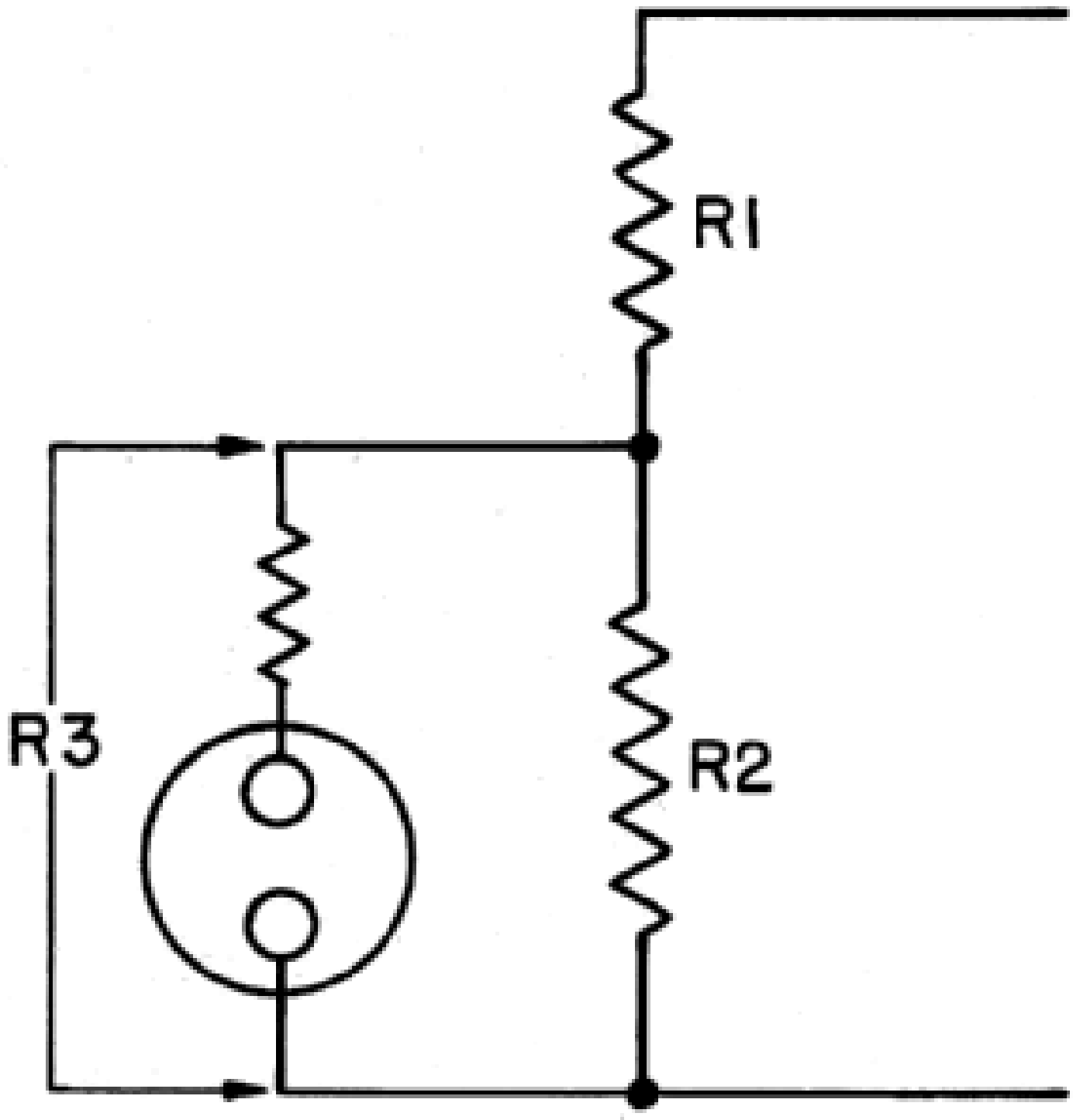


FIG.2

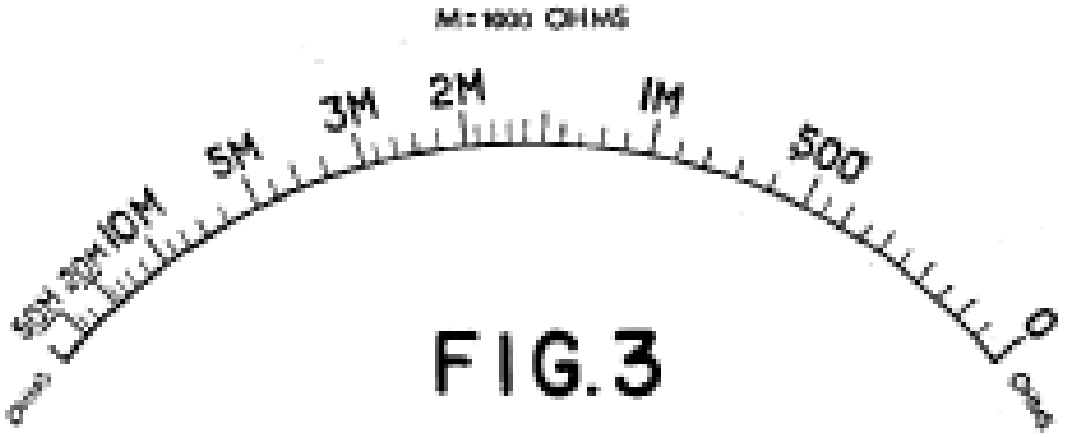


FIG.3

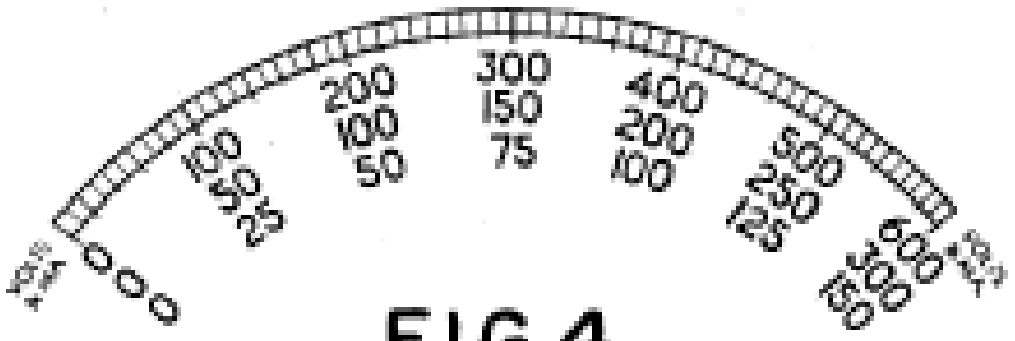


FIG.4

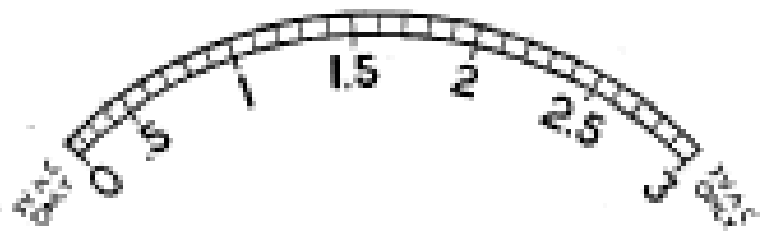


FIG.5