



Operating Instructions Avometer Model 9 Mk.4



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SWITCH TRANSIT POSITION.

During transit, the right-hand switch should be set to 'D.C.' and the left-hand switch to any position except 'A.C.' or 'RESISTANCE.'











Symbol	Definition
	Alternating Current (a.c.)
	Direct Current (d.c.)
	Cut-out
	Movement reverse control REV.M.C.
	Ohms
	Moving Coil
	Rectifier instrument
	For horizontal use
	For a.c./d.c. use
	Flash tested at 6kV

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TABLE OF RANGES

D.C. Voltage	D.C. Current	A.C. Voltage	A.C. Current
3,000 V.	10 A.	3,000 V.	10 A.
1,000 V.	1 A.	1,000 V.	
600 V.	100 mA.	300 V.	1 A.
300 V.	10 mA.	100 V.	100 mA.
100 V.	1 mA.	30 V.	10 mA.
30 V.	300 μ A.	10 V.	
10 V.	50 μ A.	3-0 V.	
3-0 V.			

Resistance

0-200 megohms-with external voltage or external unit
0-20 megohms, (200,000 ohms mid-scale) } self-
0-200,000 ohms (2,000 ohms mid-scale) } contained
0-2,000 ohms (20 ohms mid-scale)
0-2.5 ohms (with external unit)

A range of accessories is available to extend the normal ranges of measurement. These include d.c. voltage multipliers (up to 30kV) d.c. current shunts (125mV drop), current transformers and a resistance range extension unit.

GENERAL DESCRIPTION

The Avometer is extremely simple to use, range selection in general being accomplished by means of two switch knobs. All tests, except those on the 3,000 V. ranges, make use of the pair of terminals at the base of the instrument.

A clearly marked 5 in. (127 mm.) scale has uniformly divided graduations to match 100 and 300 scale markings, and in addition there is an ohms scale. An anti-parallax mirror permits readings of the knife edge pointer to be made with great precision.

The meter is supplied complete with a pair of special rubber-covered leads. The remote ends of the leads are fitted with spring clips, which may be interchanged with the Avo Long Reach Safety Clips Mk. 2 supplied with the instrument.

Avo Long Reach Safety Clips Mk. 2 have been introduced to enable connections for test purposes to be made at what are normally inaccessible points on a chassis. Examination will show that they are completely insulated with the exception of the jaws at one end, which can be opened by compressing the stem into the body of the clip. Rigid connections to wiring can thus be made by this insulated device in complicated wiring systems where other types of larger clip could not be attached, or if fixed might cause short circuits. It should be noted that they are not suitable for high current.

OPERATING INSTRUCTIONS

LIMITS OF ACCURACY

The instrument will produce its highest accuracy when used face upwards, in which position it has been calibrated.

In the case of voltage measurements, successive ranges have been chosen to obviate the need for taking readings on very small deflections.

D.C. Voltage. 2% of indication between full-scale and half-scale deflection. Below half-scale deflection. 1% of the full-scale value.

D.C. Current. 1% of full-scale value.

A.C. Voltage*. Up to 300 V. 2.25% of full-scale value over effective range. (25–2,000 Hz.).

A.C. Current*. 2.25% of full-scale value over effective range.

Resistance. 3% of reading at centre scale.

The 'effective range' in accordance with British Standard Specification 89/1954 is:

D.C.—from 0.1 of scale-range to full-scale value.

A.C.—from 0.25 of scale-range to full-scale value.

It will be noted that with the exception of the d.c. voltage ranges, the instrument meets the requirements laid down in Section 6 of the British Standard Specification 89/1954 for 5 in. (127 mm.) scale-length Industrial Portable Instruments.

*The instrument is calibrated for use at 50 Hz but the change in readings, due to variation in frequency (between 15 Hz and 15 kHz) should not exceed 2% on a.c. current ranges or on a.c. voltage ranges between 10V and 300V. On the 3V a.c. range the change should not exceed 4%.

Inasmuch as rectifier moving coil instruments give readings on 'a.c.' proportional to the mean and not the r.m.s. value of the wave form which they are presented, they depend for their accuracy not only upon their initial calibration, but also upon the maintenance of a sinusoidal wave form. Since the form factor (r.m.s. value divided by mean value) of a sine wave is 1.11, this has been taken into account in calibrating the meter which does, therefore, indicate r.m.s. values on the assumption that the normal sine wave will be encountered. Generally speaking, considerable wave form distortion can occur without appreciably affecting the form factor and resulting accuracy of measurement, but the user should recognise the possibility of some error when using distorted wave forms, squarish wave shapes producing high readings, and peaky ones, low readings.

OPERATING INSTRUCTIONS

DESIGN AND CONSTRUCTION

The instrument consists of a moulded panel on the inside of which is mounted the whole of the switching apparatus, resistors, shunts, transformer, rectifier, etc., together with the movement. The panel fits into a robust moulded case, the joint being rendered dust proof, whilst a carrying strap is provided to facilitate portability. The main switching is accomplished automatically by means of two knobs which indicate on the engraved panel, the range in use. These switches are of generous and robust design, the contacts being arranged to 'make' before 'break' on adjacent ranges; a feature which provides a factor of safety in use. When the instrument is set for operation on d.c., the moving coil is associated with a universal shunt and series multipliers, whilst on a.c., diodes and a transformer are also introduced.

RANGE CONTROLS

The left-hand knob provides all the d.c. current and voltage ranges (except 3,000 V.) and the right-hand knob the a.c. ranges (except 3,000 V.) and also the resistance ranges. These knobs are electrically interlocked so that d.c. readings can only be made after the right-hand switch has been set to d.c., and the left-hand switch to the range selected, a.c. readings call for the left-hand switch to be set for a.c. (it must not be left at RESISTANCE) and the

right-hand switch at the range required. Resistance tests require the left-hand switch to be set to RESISTANCE and the right-hand one to the desired range.

If the switches are inadvertently left to actual ranges simultaneously, there is no circuit through the meter, and it is thereby safeguarded against accidental damage or misleading readings.

The main ranges are engraved on the panel around the switches, and arrow heads on the knobs indicate the actual range selected. The 3,000 V. a.c. and d.c. ranges are available by means of the two special terminals so marked.

Wide coverage in resistance has been achieved by having a fundamental range as marked on the scale, together with ranges of $\times 100$ and $\div 100$ to supplement it.

In addition, a 200-megohm range marked 'INS' is available, using an external d.c. voltage source or the Resistance Range Extension unit described on page 13.

THE MOVEMENT

The moving coil consists of an aluminium alloy former wound with copper wire and supplemented with Constantan in order to reduce temperature error. Additionally compensation is provided by a thermistor. The moving coil is pivoted on hardened and highly polished steel pivots between conical spring-loaded jewels, and swings in a gap

energised by two magnetised and aged Hycamax blocks associated with mild steel pole pieces. Two phosphor bronze hair springs are fitted for the purpose of carrying current to the moving coil, and to provide controlling torque. A knife edge type of pointer is fitted enabling very fine readings to be taken, whilst the whole movement is balanced and damped so that the pointer quickly comes to rest.

SCALING

The scale plate has three main sets of markings, each of approximately 5 in. (127 mm.) length, the one being for resistance measurement and is marked 0–200,000 ohms. The second is for current and voltage (both a.c. and d.c.) and is marked 0–100 with divisions approximately $1\frac{1}{2}$ mm. apart. The third scale, calibrated 0–300 has 60 divisions, is used for current and voltage measurements.

MOVEMENT REVERSE CONTROL

It sometimes happens that d.c. voltages may be required both positive and negative to a reference point, or the direction of flow may be reversed. In order to simplify the matter of lead alteration, a movement reverse press button (REV. M.C.) is provided. It should be noted that the polarity marked on the terminals is for normal use and does not apply when the button is pressed.

OVERLOAD PROTECTION

Apart from the ability to do its job, one of the most attractive features of the instrument is the provision of an automatic cut-out which gives a very high degree of overload protection to the whole of the instrument. The incorporation of this device will be found to be of particular value when conducting experimental work, for it imparts to the user the feeling of mental ease and confidence. When conducting experimental work with conventional moving coil meters, these can be easily ruined by inadvertently applied overloads, whereas the Avometer is so well protected that it can withstand considerable mishandling.

If an overload is applied to the meter, the cut-out knob springs from its normal position in the panel, thus breaking the main circuit, and this knob has only to be depressed to render the instrument again ready for use. It is important to note that the cut-out should never be reset when the instrument is connected to an external circuit, whilst the fault which caused the overload should be rectified before the meter is reconnected.

The mechanism is brought into operation by the moving coil coming into contact with a trigger just beyond its full-scale position. There is, in addition, a second release at the zero end, so that the cut-out is tripped if the meter is overloaded in reverse. Although the overload mechanism gives almost complete protection to the meter, it cannot be guaranteed to fulfil completely its function in the very

OPERATING INSTRUCTIONS

worst cases of misuse, such as the mains being connected across the meter when set to a current range. It should be noted that mechanical shock to the instrument will sometimes trip the cut-out mechanism. The cut-out should be reset, using direct pressure and without twisting the button, the instrument lying face upwards. Additional protection is provided on resistance ranges by a fuse connected in the Ω and $\Omega \div 100$ ranges and protective diodes connected in the $\Omega \div 100$ range. A diode connected across the movement provides further protection should a.c. be applied when the instrument is connected to a d.c. range.

REPLACEMENT OF INTERNAL BATTERY, CELL AND FUSE

In the battery compartment under the instruction plate, which can be removed by means of a single DZUS fastener, is mounted a 15 V. battery and a $1\frac{1}{2}$ V. cell together with a 1A fuse and a spare fuse. The batteries should be examined from time to time to ensure that the electrolyte is not leaking and damaging the instrument. This condition will generally occur only when the cells are nearly exhausted. If it is known that the meter is going to stand unused for several months, it is preferable that these batteries should be removed to prevent possible damage.

When replacing batteries, the $1\frac{1}{2}$ V. cell and the 15 V. battery must be inserted with the poles to match the markings of polarity inside the battery box.

REPLACEMENTS

1.5 V. cell, $1\frac{3}{8}$ in. dia. \times $2\frac{3}{8}$ in., such as Ever Ready (or overseas, Berec) U.2. 15 V. battery, $1\frac{3}{4}$ in. \times $\frac{5}{8}$ in. \times $1\frac{1}{2}$ in., such as Ever Ready B.121. If B121 is unobtainable a B154 is a suitable replacement. This requires an Avo adaptor Part No. 5140—015/016 for satisfactory fitting.

PLUG-IN TYPE LEAD

When ordering replacements, the following description and part numbers should be quoted:

	Part No.
Connector No. 2 (Black)	20913F*
Connector No. 2 (Red)	20913E*
Clip	12381B
Long Reach Safety Clip Mk. 2 (Red)	21443B

**If these part numbers are not quoted, the older type of leads (with hook terminations) will automatically be supplied.*

WARNING

*Special care must be taken when using the instrument to service television receivers or other apparatus employing capacitors of large capacitance, for the inclusion of such components in a circuit may mean that **very heavy peak currents** may flow when the apparatus is switched on. Such surges produce a peaky wave form, and although these peaks are of only a few milli-seconds duration, they may never-the-less, puncture the instrument rectifiers*

OPERATION OF INSTRUMENT

The meter is intended for use horizontally. Should it happen by any chance that the pointer is not on zero, it may be so set by means of the screw head on the panel.

The leads fitted with Long Reach Safety clips Mk. 2 or clips, as required, should be connected to the lower pair of meter terminals in all cases except when measuring voltages over 1,000 V.

When measuring current or voltage, ensure that the instrument is set to match the type of source to be measured (either a.c. or d.c.) and then choose a suitable range before connecting up to the circuit under test. When in doubt, always switch to the highest range and work downwards, there being no necessity to disconnect the leads as the switch position is changed.

Do not, however, switch off by rotating either of the knobs to a blank position.

The instrument is flashed tested at 6,000 V. a.c., but should the meter be used with accessories on circuits in excess of 3,000 V., it should be kept at the low potential end of the circuit (near earth potential). If this procedure cannot be adopted other suitable safeguards must be applied.

CURRENT MEASUREMENT

To measure current, the instrument should be set to a suitable a.c. or d.c. range, and then connected in series with the apparatus to be tested.

Generally speaking, the power absorbed in the instrument is negligible, but in cases of low voltage heavy current circuits, the inclusion of a meter may reduce the current appreciably below the value which would otherwise prevail. The potential drop at f.s.d., across the meter terminals is in the order of 500 mV. on all d.c. ranges, except the 50 microamp range which has a drop of 125 millivolts. In the case of a.c., it is less than 350 mV. on all ranges. Standard meter leads have a resistance of 0.02 ohm per pair. Care should be taken to ensure that the circuit is 'dead' before breaking into it to make current measurements.

VOLTAGE MEASUREMENT

When measuring voltage, it is necessary to set the appropriate range of 'a.c.' or 'd.c.' and connect the leads across the source of voltage to be measured. If the expected magnitude of the voltage is within the range of the meter, but its actual value is unknown, set the instrument to its highest range, connect up and if below 1,000 V. rotate the appropriate selector switch, decreasing the ranges step by step, until the most suitable range has been selected. If the voltage should exceed 1,000 V., the instrument should be set to measure 1,000 V. as described above, but the negative lead should be transferred to the appropriate 3,000 V. terminal. Great care must be exercised when making connections to a live circuit, and the procedure should be entirely avoided if possible.

OPERATING INSTRUCTIONS

When measuring high a.c. and d.c. voltages (say above 800 V.) unless the common positive terminal is either earthy or connected to earth, errors will be introduced if the instrument is touched during a reading.

On d.c. ranges, the meter consumes only 50 microamps at full scale deflection, this sensitivity corresponding to 20,000 Ω/V . In the case of a.c. ranges above 10 V., full scale deflection is obtained with a consumption of 0.5mA. (2,000 Ω/V .) The 10 V. range is 1000 Ω/V . The 3 V. a.c. range consumes 10 mA. at full scale deflection. The meter maintains a high degree of accuracy for audio frequency tests up to 15 kHz on ranges up to 300 V. a.c. Whilst discussing the problem of measuring voltage, it would be well to draw attention to the fact that in certain circuits where the current is limited because of the presence of a resistance between the source and the point at which a measurement is to be made, it is possible for the actual voltage to be higher normally than when the meter is connected. All current consuming voltmeters, however sensitive, draw current to varying degrees from the circuit under test, thus causing a higher volts drop in the resistances mentioned, and thereby causing the voltage to fall at the point of measurement.

Owing to the high sensitivity of the Model 9 on d.c. ranges, this effect is unlikely to be of importance except in a very few instances. A practical example of where it might be taken into account is in the measurement of e.h.t. voltage on a television set or the tapping on a potential divider,

where the resistances are so high as to be comparable with the resistance of the meter on the range in use. It is generally possible to use a meter on a higher range than absolutely necessary, and in such a case the higher meter resistance causes less disturbance than would otherwise be the case. At the same time adequate pointer deflection for reasonable accuracy should be attained.

When it is essential to obtain an accurate indication of the voltage developed across a high resistor it is sometimes preferable to insert the meter in series with it, and to measure the current flowing. The reading given upon the meter, in milliamps, multiplied by the value of the resistance in thousands of ohms, will give the developed voltage.

RESISTANCE MEASUREMENT

There are three self-contained ranges covering from 0.5 ohms to 20 megohms, and provision is also made for both upward and downward extension of these limits. The self-contained ranges make use of the usual series circuit, and successive ranges are on 100:1 ratio, which permits of very wide coverage with three ranges.

On resistance ranges, the meter must not merely start from its normal instrument zero, but must have, in addition a resistance zero corresponding to the full scale deflection of the meter. Before carrying out tests for resistance a check and, if necessary, adjustment should be carried out to

ensure that when the leads are joined together the meter actually indicates zero ohms, irrespective of the condition of the battery (within the limits of adjustment). The method of adjustment is described later.

Owing to the nature of the scale, it is not easy to define the accuracy, but it should be within 3% of the reading about centre scale, increasing up to about 10% of the indication around deflections corresponding to 10% and 90% of full scale deflection.

Resistance test should never be carried out on components which are already carrying current.

On three ranges which utilise the internal source of voltage, it should be remembered that a positive potential appears at the negative terminal of the instrument when set for resistance tests. This fact may be important because the resistance of some components varies according to the direction of the current through them, and readings, therefore, depend upon the direction in which the test voltage is applied, quite apart from its magnitude. Such cases include electrolytic capacitors and rectifiers.

When measuring the leakage resistance of an electrolytic capacitor the negative lead from the meter should be connected to the positive terminal of the capacitor, and the ohms $\times 100$ range employed.

Before making resistance tests the pointer should be adjusted to zero in the following sequence:

1. Set left-hand switch at 'RESISTANCE'.

2. Join leads together.
3. On the Ω range, adjust to zero by means of the knob marked 'ZERO Ω '.
4. On the ' $\Omega \div 100$ ' range, adjust to zero by means of the knob marked 'ZERO $\Omega \div 100$ '.
5. On the ' $\Omega \times 100$ ' range, adjust to zero by means of the knob marked 'ZERO $\Omega \times 100$ '.

To test a resistance, set the right-hand switch at the range required, the leads being connected across the unknown component.

Resistance is read directly on the ' Ω ' range, but indications should be divided or multiplied by 100 on the other two ranges.

If on joining the leads together it is impossible to obtain zero ohms setting, or if furthermore the pointer position will not remain constant, but falls steadily, the internal battery or cell concerned should be replaced. It is important that a discharged unit should not be left in the instrument, since the electrolyte might seep through and cause damage to the meter. If it is impossible to obtain readings on the $\Omega \div 100$ range, the 1A fuse located in the battery box should be checked.

NOTE. It can so happen that a 15-volt battery may age in such a manner that although it indicates a potential of 15 volts, its internal resistance has increased so much that some loss of accuracy can occur on the high resistance

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range ($\Omega \times 100$). If the battery has been in use for some time, or if errors are suspected on the high resistance range, it is worth while *removing* the battery and checking its short circuit current on the 100 mA. d.c. range. If the battery fails to give a reading greater than 25mA. it should be discarded.

INSULATION RESISTANCE MEASUREMENT

Two courses are open, the first merely calling for a battery or other source of d.c. voltage in the order of 130 V. to 160 V. The left-hand switch should be set at 'RESISTANCE' with the right-hand switch at 'INS' and the meter leads should be connected to the battery. The pointer should be brought to zero on the ohms scale by means of the adjuster marked 'ZERO $\Omega \times 100$ '. To test, connect the unknown resistance in series with the meter and its value will be that shown on the ohms scale multiplied by 1,000. Resistances up to 200 megohms can, therefore, be read on this range.

The alternative method makes use of the 'Resistance Range Extension Unit', described later.

LOW RESISTANCE MEASUREMENT

The meter setting marked L.R. is for use with the Resistance Range Extension Unit. The method of use is described in the section covering accessories.

A range of accessories is available to extend the normal ranges of measurement. These include d.c. voltage multipliers (up to 30kV.) d.c. current shunts (125mV. drop), current transformers and a resistance range extension unit, as follows:

D.C. VOLTAGE MULTIPLIERS

General Note: When measuring high a.c. and d.c. voltages (say above 800V.) unless the common positive terminal is either earthy or connected to earth, errors will be introduced if the instrument is touched during a reading.

Combined 10kV. and 30kV. d.c. Voltage Multiplier

A combined 10kV. and 30kV. d.c. multiplier is available for use with the instrument. The Multiplier should be connected to the Avometer set to the 10V. d.c. range. It is recommended that the meter is kept as near earth potential as possible and the Multiplier used at the high potential end, e.g. when measuring an e.h.t. voltage when the negative line is earthy, the Multiplier should be connected between the point of positive potential and the positive terminal of the meter. In addition, the low potential end of the meter must be connected to the low potential of the supply being measured using the low potential lead provided. A cap is provided which should always be in position over the high voltage terminal not in use. It is recommended that neither the meter, multiplier nor leads are handled whilst high voltage tests are in progress. Protection is provided by a resistor connected permanently

across the multiplier terminals thus preventing the full voltage being present should the meter be disconnected.

30kV. D.C. Multiplier

A 30kV. d.c. Multiplier is available for use in series with the meter set to its 1,000 V. d.c. range, readings being made direct in kV. on the 0–100 scale and multiplied by 300. It is *most* important to ensure that the meter is kept in the earthy end of the circuit and the multiplier connected to either the positive or negative terminal whichever is at high potential. This method of connection to get forward pointer indication with the meter earthy is recommended as we do not think it desirable to use the moving coil reverse button when measuring high voltage.

In general we recommend that neither the meter, multiplier nor leads are handled whilst high voltage tests are in progress, and a special lead is provided with the multiplier for connection to the high potential point.

CURRENT TRANSFORMERS

Transformers are available to extend the a.c. current ranges when set to 100mA. a.c. It is necessary to connect the meter set to its 100mA. range to the secondary of the transformer before current is passed through the primary, and care should be taken that the cut-out is in position. If this course is not followed, quite a considerable voltage will appear at the secondary terminals, if current passes through the primary. Transformers for 30, 100, and 300 amp. are now replaced by current Ratio Transformer.

ACCESSORIES

CURRENT RATIO TRANSFORMER

This transformer replaces the 30A, 100A, and 300A transformers previously manufactured to extend the ranges of a.c. current measurement. It may be used on any a.c. current range up to 1.5A to provide a comprehensive range of full scale values up to 600A a.c. (see operating instructions packed with each transformer).

D.C. SHUNTS

The Shunt should be connected by means of its two main terminals in series with the circuit to be measured. The meter, set to its $50\mu\text{A}$ (125mV.) d.c. position should then be connected to the two small studs on the shunt end blocks.

The Avometer when so set, consumes only $50\mu\text{A}$ at full-scale deflection, a value which is negligible in comparison with the full-scale current of the shunt. The millivolt drop across the shunt is directly proportional to any current which may flow through it and since the deflection on the meter is directly proportional to the millivolt drop across its terminals, the instrument indicates correctly over its entire scale length.

Shunts available: 30, 100 and 300 amp.

RESISTANCE RANGE EXTENSION UNIT

This accessory enables the meter to be used for both high and low resistance measurements. It is complete with

batteries (except in some instances) and switching to facilitate tests. The device should be connected to the lower terminals on the meter. For high resistance the meter is set to the ' $\Omega \times 100$ ' position, the Unit switch at the 'SET' position and the unknown resistance should then be connected to the 'High' terminals. Adjustment to full scale deflection should be performed by means of the ' $\text{ZERO } \Omega \times 100$ ' knob. The Unit switch should then be rotated to 'TEST', and the reading on the ohms scale noted. Its value is that shown multiplied by 1,000 corresponding to a range of 200 megohms.

For low resistance measurements the Avometer should be set to position 'L-R' and the Unit switch should be placed at 'SET', the unknown resistor connected to the 'Low' terminals and adjustment to full scale deflection carried out by means of the ' $\text{ZERO } \Omega$ ' knob. The Unit switch should then be moved to position marked 'TEST' and the pointer deflection on a uniformly divided scale noted. Full scale deflection corresponds to $2\frac{1}{2}$ ohms. In order to avoid discharging the batteries, immediately tests have been completed the resistor should be removed from the unit, its switch set to the 'low set' position, and the unit disconnected from the meter.

REPLACEMENT BATTERIES

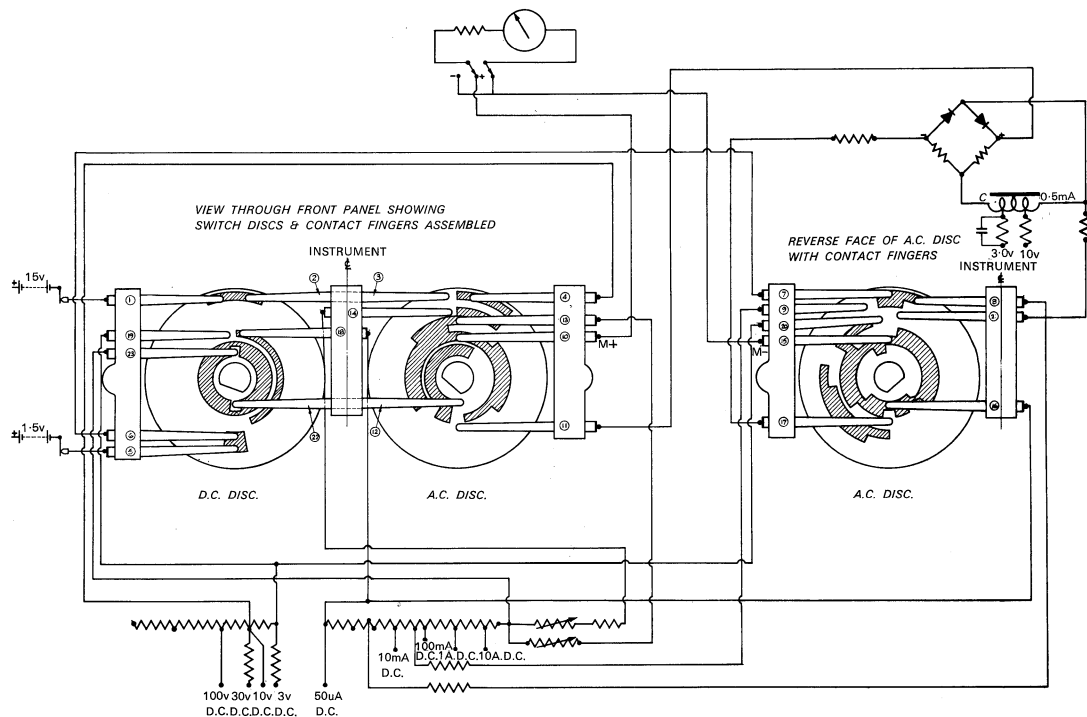
Replacement batteries 1.5 V. cell— $1\frac{3}{8}$ in. dia. \times $2\frac{3}{8}$ in. such as Ever Ready (or overseas, Berek) U.2 Four 30 V. batteries— $1\frac{1}{2}$ in. \times $\frac{5}{8}$ in. \times $2\frac{9}{16}$ in., such as Ever Ready B.123.

Due to the high operational standards maintained throughout our organisation, and the close limits within which we work, breakdowns are comparatively rare, and can often be traced to transit damage or careless handling, for which the Company cannot be held responsible. If, however, your instrument should require servicing or a calibration check, we at Avo have the knowledge and equipment to repair your instrument to the highest possible standard.

For those customers who feel they have the necessary skill and equipment to carry out their own servicing requirements, spares are available from Avo Limited. To obtain the correct spares item, identify the component required and state its position in the instrument. Where applicable state the circuit reference number. Should you at any time have to return your instrument to the Company for repair, pack it carefully and enclose a note informing our engineers of the faults which you have found. Customers outside the U.K. should contact the Avo representative for their territory.

R1	1.11k Ω	R27	200 Ω
R2	1.11k Ω	R28	57.5k Ω
R3	7.5k Ω	R29	400k Ω
R4	620 Ω	R30	10k Ω
R5	3.6k Ω	RV1	500 Ω
R6	1.24k Ω	RV2	5.5k Ω
R7	9 Ω	RV3	5.5k Ω
R8	820 Ω	RV4	500 Ω
R9	0.05 Ω	RV5	5 Ω
R10	0.45 Ω	RV6	1k Ω
R11	4.5 Ω	RV7	100 Ω
R12	3.0 Ω	RV8	1k Ω
R13	42 Ω	D1	OA47
R14	450 Ω	D2	OA 47
R15	300 Ω	D3	BY 124
R16	867 Ω	D4	BY 124
R17	8.33k Ω	D5	BY 124
R18	197.5k Ω	D6	BY 124
R19	1.8M Ω	D7	BY 124
R20	4M Ω	C1	0.02 μ F \pm 5%
R21	6M Ω	C2	270pF \pm 5%
R22	8M Ω	C3	1000pF \pm 5%
R23	40M Ω	Th1	Va 1039
R24	4M Ω	F1	Fuse 1 amp
R25	4k Ω	B1	Battery 1.5 V.
R26	8.2k Ω	B2	Battery 15 V.

SWITCH CONNECTIONS

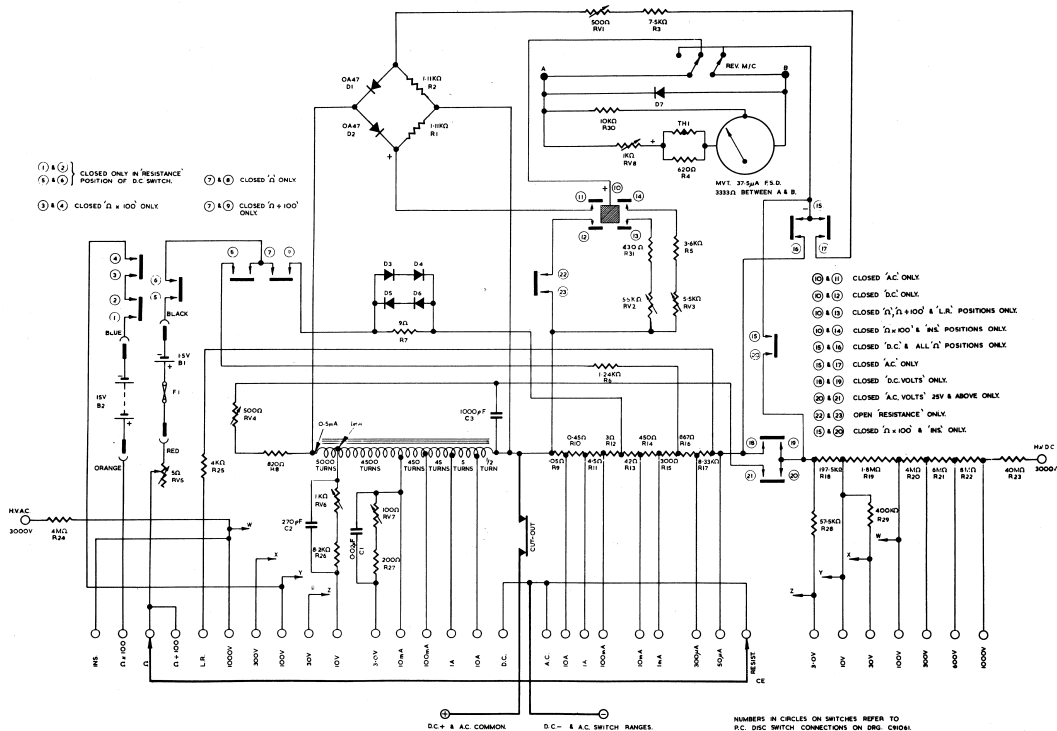


(1) & (2) } CLOSED ONLY IN 'RESISTANCE'
 (5) & (6) } POSITION OF D.C. SWITCH.

(7) & (8) CLOSED '1' ONLY.

(3) & (4) CLOSED ' $\Omega \times 100$ ' ONLY.

(7) & (8) CLOSED ' $\Omega + 100$ ' ONLY.





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