UNIVERSAL AVOMETER
D.C. SWITCH
A.C. SWITCH
CUT-OUT
P
R
P.F.
OHMS
ZERO
D.C.
ONLY
CAPACITY
POWER
DECIBELS
VOLTS & AMPS

AVO
REGD. TRADE MARK

Model 7 Universal AVOMETER

WORKING INSTRUCTIONS FOR THE INSTRUMENT AND ITS ACCESSORIES

AVO LTD
AVOCET HOUSE, 92-96, VAUXHALL BRIDGE ROAD, LONDON, S.W.1.


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MODEL 7 MK II
UNIVERSAL
AVOMETER
D.C. SWITCH
A.C. SWITCH


AUSTRALIAN AGENTS
ELECTRICAL EQUIPMENT
OF AUSTRALIA LTD.
75 LIVERPOOL ST., SYDNEY

UNIVERSAL AVOMETER

MODEL 7.

WORKING INSTRUCTIONS.

IMPORTANT.

GENERAL.

To ensure accurate readings, use the instrument face upwards.
If necessary, set the pointer to D.C. zero by means of the screw in the panel. The A.C. switch must be at its D.C. position for this operation. On A.C. ranges the pointer is automatically displaced from D.C. zero to correct for internal losses, the 1½V. cell being employed for this purpose. D.C. tests can only be carried out with the D.C. switch set to the appropriate range and with the A.C. switch at its D.C. position. The reverse procedure applies to A.C. tests.
To prevent damage to the instrument, see that it is set to a suitable range before connecting to the circuit under test. When in doubt set to the highest range and work downwards, there being no necessity to disconnect the leads. Do not however, switch off by rotating the switches to blank positions. The automatic cut-out completely protects the instrument in the case of normal overload by interrupting the main circuit. If it operates DO NOT re-set with the leads connected to the supply, but ensure that the fault is cleared before continuing tests. Since mechanical shock may cause the cut-out to trip, handle the meter carefully. Do not lubricate the plunger.
The ÷ 2 button is for use when measuring current and voltage only, and if the meter is on a normal range, it should never be pressed when the pointer shows more than half scale deflection. The resistance of the meter is the same on a press button range as on the normal one. Press the button firmly.
KNOB "Q" MUST ALWAYS BE REPLACED IN NORMAL POSITION AFTER USE.
A copper oxide rectifier is incorporated for A.C. measurements and the instrument calibrated for sinusoidal input (form factor 1·11).
Special care should be exercised when using high voltages. If the meter is used to measure voltage calling for an external multiplier, or to measure current in such a circuit, it must be used at the earth potential end.

AMPERES.

Ten ranges D.C. and eight ranges A.C. are incorporated. These ranges may be extended by the use of external shunts (100mV.) or transformers (secondary to suit a current range).

VOLTS.

Ten ranges D.C. In addition the 2 mA. range can be used as one of 100 mV. or 50 mV. with the button pressed.
Eight ranges A.C. Suitable for out-put measurements at audio frequency.
All normal ranges of D.C. and A.C. except 10V. A.C. consume 2 mA. at full scale deflection (500 ohms per volt) or 1mA. at full scale for press button ranges (1,000 ohms per volt), the current being proportionately less for smaller deflections. The 10V.A.C. and 5V.A.C. ranges consume 20 and 10 mA. respectively at full scale deflection.

OHMS.

Three self contained ranges and two using external voltage. The press button should not be used on resistance ranges.

10,000 and 100,000 Ohms ranges.

Before commencing tests on these ranges, it is advisable to check, and if necessary, to adjust for both voltage and resistance of the 1½V. cell by means of the potentiometer "P" and resistance "R."
(1) Connect leads together.
(2) With switch at 100,000 ohms position adjust by "P" so that the pointer indicates approximately 0 Ohms.
(3) Adjust by "R" when on 10,000 ohms range until pointer takes up the same position irrespective of whether the switch is on the 10,000 or 100,000 ohms range.
(4) Set accurately to zero ohms by means of "P."

MEGOHM RANGE.

Before testing on this range, it is necessary to adjust as follows:–
(1) Connect leads together.
(2) Set switch to 1 megohm position.
(3) Raise adjusting knob "Q" and rotate in a clockwise direction until the pointer indicates 0 Ohms.
After carrying out tests on this range, return knob "Q" to its normal position in the panel.

BATTERY REPLACEMENT. If it is impossible to obtain zero ohms setting, the internal batteries should be replaced, a 1½V. cell for the two lower ranges and two 4½V. batteries for the high range.

10 & 40 MEGOHM RANGES.

These ranges are available by using the 100 or 400V. A.C. or D.C. ranges respectively in conjunction with a suitable source of voltage. It is safe and correct to use a voltage between ²/₃ to 2½ times that of the range in use, adjustment for zero on the ohms scale being carried out by means of "Q" knob. After adjusting for voltage the test resistance is connected in series, its value being that shown on the ohms scale multiplied by 1,000 or 4,000 as the case may be. With these high voltages the circuit should not be handled while "live."
Return "Q" knob to its normal position in panel after tests.

CAPACITY.

50∼ A.C. Mains supply from 65 to 250V. should be connected to the meter when set to its capacity range, and the "Q" knob should be operated as in the megohm range, to bring the pointer to its infinity capacity position. The unknown condenser should then be connected in series, direct indication of capacity being shown within usual commercial limits of accuracy.
Frequencies other than 50 cycles may be used, but this affects the voltage necessary for adjustment. 250V. A.C. must not be exceeded.
Return "Q" knob to its normal position after tests.

POWER AND DECIBELS.

This range gives a maximum reading of 2 watts, the impedance being 5,000 ohms. The corresponding d.B. scale is calibrated from −15 to +16 d.B., the reference level (O.d.B.) being 50 m.W.
The 10V. A.C. and the 100V. A.C. ranges can be used as power ranges of 200 m.W., the impedance being 500 and 50,000 ohms respectively.
The A.C. switch position marked with a spot (31.5 mA) is for the extension of power and decibels up to 20 watts and +26 d.B. when used in conjunction with external load resistances (see Instruction leaflet M.21).

POWER FACTOR AND WATTAGE. The two sockets, marked "P. F." at the top of the panel are for use with the Model 7 "Power Factor and Wattage Unit." See instruction booklet.

AVO LTD., AVOCET HOUSE, 92/96, VAUXHALL BRIDGE ROAD,
LONDON. S.W.1.
The "AVOMETER" is patented in the principal countries throughout the world. British Patent No's: 200977, 404015, 464867, 476683, 476738.
MADE IN ENGLAND.
The word "AVOMETER" is our registered Trade Mark.

THE
MODEL 7 AVOMETER

WORKING INSTRUCTIONS FOR THE INSTRUMENT AND ITS ACCESSORIES

AVO LTD

AVOCET HOUSE, 92-96, VAUXHALL BRIDGE ROAD, LONDON, S.W.1

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CONTENTS

TABLE OF RANGES

D.C. Current

Range	Value per division and first indication
*0—1 mA.	10 µA.
0—2 mA.	20 µA.
*0—5 mA.	50 µA.
0—10 mA.	100 µA.
*0—50 mA.	500 µA.
0—100 mA.	1 mA.
*0—500 mA.	5 mA.
0—1 A	10 mA.
*0—5 A	50 mA.
0—10 A	100 mA.

D.C. Voltage

Range	Value per division and first indication
*0—50 mV. (1 mA. range)	0·5 mV.
0—100 mV. (2 mA. range)	1 mV.
*0—500 mV.	5 mV.
0—1 V	10 mV.
*0—5 V	50 mV.
0—10 V	100 mV.
*0—50 V	500 mV.
0—100 V	1 V
*0—200 V	2 V
0—400 V	5 V
*0—500 V	5 V
0—1000 V	10 V

A.C. Current

Range	Value per division and first indication
*0—5 mA.	50 µA.
0—10 mA.	100 µA.
*0—50 mA.	500 µA.
0—100 mA.	1 mA.
*0—500 mA.	5 mA.
0—1 A	10 mA.
*0—5 A	50 mA.
0—10 A	100 mA.

A.C. Voltage

Range	Value per division and first indication
*0—5 V	50 mV.
0—10 V	100 mV.
*0—50 V	500 mV.
0—100 V	1 V
*0—200 V	2 V
0—400 V	5 V
*0—500 V	5 V
0—100 V	10 V

Resistance

Range	First Indication	
0—10,000 ohms	0·5 ohms	using internal 1½ volt cell
0—100,000 ohms	5 ,,	using internal 1½ volt cell
0—1 megohm	50 ,,	using internal 9-volt battery
0—10 megohms	500 ,,	using external source of A.C. or D.C. voltage
0—40 megohms	2000 ,,	using external source of A.C. or D.C. voltage

Capacitance

	First indication
0 to 20 mFd.	0·01 mFd.

Power and Decibels

Impedance	Range	First indication	
			0=50 mW.
500 ohms	0 to 200 mW.	0·1 mW.	−25 to + 6 dB.
5,000 ohms	0 to 2 W.	1 mW.	−15 to + 16 dB.
50,000 ohms	0 to 200 mW.	0·1 mW.	−25 to + 6 dB.

* Use ÷ 2 button (*See page* 10)

OTHER "AVO" PRODUCTS

The Model 7x Universal AvoMeter (Panclimatic Model).

The Model 8 Universal AvoMeter.

The Model 8x Universal AvoMeter (Panclimatic Model).

The Model 40 Universal AvoMeter.

The Model 40x Universal AvoMeter (Panclimatic Model).

The Universal AvoMeter Power Factor and Wattage Unit.

The Heavy Duty AvoMeter.

The Multiminor.

The "AVO" Industrial Test Set.

The "AVO" Electronic Multimeter.

The "AVO" Electronic Test Meter.

The "AVO" Valve Characteristic Meter, MK 4.

The "AVO" Valve Tester Type 160.

The "AVO" Signal Generator Type 3.

The "AVO" Wide Band AM/FM Signal Generator, Type AFM 2.

The "AVO" Light Meter.

The "AVO" Electronic Test Unit.

The "AVO" D.C. Amplifier, Type 1388 B.

The "AVO" Transistor Analyser.

A wide Range of Instrument Accessories.

The Company also manufactures a range of Coil Winding Machines, particulars of which will be forwarded upon request.

An illustrated brochure describing all the above products can be obtained free of charge from our Agent on your Territory, or upon direct application to our London Office.

We maintain our own service organisation in London, whilst arrangements have been made for the repair of our instruments in numerous countries throughout the World.

The Braille AvoMeter. A specially adapted version of the Model 7 AvoMeter can be supplied for the use of the blind.

THE

MODEL 7 AVOMETER MK II

WORKING INSTRUCTIONS

Scope of Instrument.

The meter should arrive complete with two connecting leads, two clips and two Prodclips. The plug in leads are designed to facilitate easy connection to the instrument terminals, whilst into the sockets at the remote ends of the leads, either the Prodclips or clips can be fitted. The meter is extremely simple to use ; it has a 5″ hand calibrated scale, together with an anti-parallax mirror to facilitate accurate readings. The instrument incorporates both an "A.C." and a "D.C." switch, whilst the design is such that only two terminals are required. The whole is compact, self contained over wide ranges, readily portable, robust, and automatically protected against reasonable overload. It should be noted that in certain instances, instruments are supplied less internal batteries

The instrument has 50 self contained ranges, as listed upon page 5, covering the measurement of A.C. or D.C. current and voltage, resistance, capacitance, decibels, and audio frequency power.

Although the AvoMeter is, in the main, self contained, it should be noted that the wide ranges of the meter can be even further extended by means of various accessories. Full details of these will be found towards the end of this book.

The highest percentage of accuracy on moving coil instruments, is normally presented towards the higher end of the calibrated scale. By the provision of intermediate ranges between those marked on the switch knobs, it has been possible to offset the disadvantage of reading small pointer deflections. These ranges are shown by asterisks in the table upon page 5.

Limits of Accuracy.

Generally speaking, the highest percentage of accuracy on current and voltage ranges is obtainable at the upper end of the scale, but on resistance ranges, it is better towards the centre of the scale. In the case of voltmeter measurements which are more frequently taken than those of current, successive ranges have been closely chosen to obviate need for taking readings of very small deflections. The instrument will produce its highest degree of accuracy when used face upwards, whilst the anti-parallax mirror fitted to the scale enables readings to be made with great precision.

The instrument meets the requirements laid down in Section 6 of the British Standard Specification 89/1954 for 5″ (127mm.) Scale Length Industrial Portable Instruments. In practice, the calibration of the Model '7' AvoMeter is well within the limits given, due to the great care taken in the manufacture of its various components, and to the fine initial calibration. Although the specification does not include rectifier operated ammeters, the instrument does comply with the same limits as specified for the A.C. voltmeter section.

Scaling.

The scale plate has three main scales, each approximately 5″ in length, the top being for Resistance measurement and marked 0-10,000. The second is for Current and Voltage measurement, both A.C. and D.C. and, is marked 0-100 with divisions approximately 1·25 mm. apart. The third scale is calibrated up to 400 in eight major steps of 50, these again being sub-divided into ten divisions. This scale is only used in conjunction with the 400-volt range marked on the switch knobs. These scales are calibrated to agree with the readings of standard instruments. Three subsidiary scales are provided for Capacitance, Power, and Decibels. The scale markings are 0·01 mFd. to 20 mFd. 1 mW. to 2 watts, and −15 to +16 dB. (about a reference level of 50 mW.).

The " ÷ 2 " Button.

The switch knobs are engraved with sectors enclosing ranges of Voltage, Current, Resistance, etc. In general, the successive ranges shown on the knobs have a 10/1 ratio, but to provide intermediate ranges a divide-by-two button is incorporated on the panel of the instrument, this being operative upon all Current and Voltage ranges.

To deal with mains voltage measurements, the 400-volt " A.C." and " D.C." ranges have been introduced so that they and their associated 200-volt ranges (press button) may be employed for more accurate measurements of mains voltage.

The divide-by-two button is used when measuring Current and Voltage only, and serves to halve the value of any range shown on the switch knob. It should never be pressed if over half-scale deflection is being shown, since twice the length of pointer deflection as normally occurs, is produced on pressing the button. This divide-by-two button is therefore effective in producing the ranges marked with an asterisk in the table of ranges. For example, if the switch knobs are set to give the 0·01A D.C. range, pressing the button will transform it to one of 0·005A D.C. Greater simplicity in manufacture and wider coverage of ranges results from the use of the divide-by-two button in place of intermediate ranges on the switch knobs, but the circuit becomes more complex although the same tappings on the shunt, multiplier or transformer provide two ranges in place of the normal one. Since this device also enables external current and voltage accessories to produce a double range effect, an explanation of its operation might be of assistance to the user.

The relevant portion of the circuit is shown in Figs. 1 and 2, this being connected on D.C. in series with multiplier resistances for voltage measurements, or across a universal shunt for current measurement. It will be noticed that the effective resistance between points A and B is 50 ohms in both conditions, but the current consumption is twice as much in the normal (Fig. 1) as in the divide-by-two condition (Fig. 2).

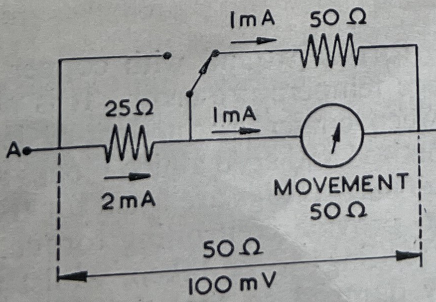


FIG. 1

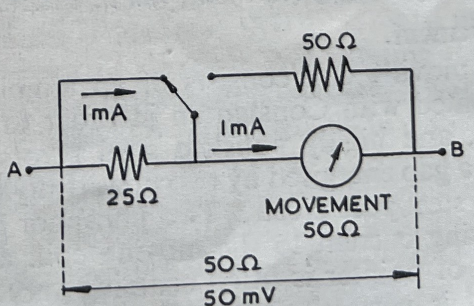


FIG. 2

Since the resistance of a voltmeter is constant for any one switch setting, its range value must be proportional to the current flowing at full scale deflection. *With the ÷ 2 button depressed the application of half the original voltage will bring the pointer to full scale deflection.*

The voltage across A B to give full scale deflection is 100 mV. and 50 mV. in the two cases, so that when shunted for current measurement and when on the ÷ 2 range, only half the normal current is required in the shunt to produce the necessary voltage for full scale deflection.

In the case of A.C., the maintenance of constant resistance is unimportant, but the halving of the current for full scale is reflected from the secondary of the transformer to the primary side and thus affects both voltage and current measurements.

Replacement of Internal Batteries and Cell.

Two 4·5V. batteries and a 1·5V. cell will be found beneath the battery cover. These batteries should be examined from time to time to ensure that their electrolyte is not leaking and damaging the instrument. This condition will generally only occur 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 connections for the 1½ V. cell are obvious, but the 4½ V. batteries must be inserted with their negative poles (the long brass strips) uppermost Markings of polarities will be found inside the battery box.

OPERATION OF INSTRUMENT.

If necessary the pointer should be set to zero by means of the screw head on the face of the panel. Remember that the instrument must be set to a " D.C." range for this adjustment, the meter being unconnected to any external circuit.

The leads fitted with Prodclips or clips as required should now be connected to the meter terminals.

When measuring D.C. Voltage, Current or Resistance, the "A.C." Switch should be set to the position marked " D.C.". Conversely for "A.C." Voltage, or current, the " D.C." Switch should be set to its "A.C." position. The operative range switch should then be set to a suitable value before connecting the meter to the circuit under test. When in reasonable 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 knob marked " Q " gives variable sensitivity to the meter on any range in use and serves for special application, details of which are given later. When not in use, this knob *must* be seated in its normal position in the panel, otherwise false readings may be shown.

Although the instrument is flash tested to 3,000 V. A.C., it should be kept at the low potential end of the circuit (relative to earth) if it is used with accessories on a voltage system over 1,000 V. 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 the case of low voltage heavy current circuits the inclusion of a meter may reduce the current appreciably below the value which would otherwise prevail.

The approximate resistance at the meter terminals on the various ranges is given below, the values being unaffected when the divide-by-two button is pressed.

Normal Range	*D.C.*	*A.C.*
0·002 *A*	50 ohms	—
0·01 ,,	10 ,,	60 ohms
0·1 ,,	1·25 ,,	7·1 ,,
1·0 ,,	0·14 ,,	0·05 ,,
10·0 ,,	0·03 ,,	0·02 ,,

Standard meter leads have a resistance of 0·02 ohm per pair and this value should be added to that of the meter.

In certain cases care should be taken to ensure that a circuit is dead before breaking into it to make current measurements.

VOLTAGE MEASUREMENT.

When measuring voltage, it is necessary to set to 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 rotate the appropriate selector switch, decreasing the ranges step by step, until the most suitable one has been selected. Great care must be exercised when making connections to a live circuit, and the procedure should be entirely avoided if possible.

On every normal " A.C." and " D.C." voltage range except, that for 10 volts A.C., the instrument consumes 2mA. for full scale deflection (500 ohms per volt) and proportionally less current for smaller deflections. When using the press button, full scale deflection is produced by half the current (corresponding to 1,000 ohms per volt) required for the normal range, and since the meter resistance is unaffected, the voltage range is halved. In the case of the " 10 V. A.C." range the consumption at full scale deflection is 20 mA.

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 measurements are to be made, it is possible for the actual voltage to be higher than when the meter is connected. All current consuming voltmeters, however sensitive, draw some current to varying degrees from the circuit under test, thus causing a higher voltage drop in the resistances mentioned and thereby causing the potential to fall at the point of measurement. A practical example of the manner in which errors of this nature can be introduced is given by a typical radio circuit in which a valve anode is fed through a series load resistance from a D.C. source. Under no signal conditions, the valve will have a potential on its anode dependent on the E.M.F. of the source, the actual voltage being a function of the internal impedance of the source, the load resistance and the impedance of the valve. (We have ignored any biasing or other component in the circuit). If now a current consuming voltmeter is introduced across the valve in order to measure the potential which exists between the cathode and anode of the valve, a double effect takes place. The addition of the voltmeter reduces the total resistance of the circuit and therefore slightly increases the current. This increased current passing through the resistance of the source and anode load increases the voltage drop across them, and the sum of these voltages must be deducted from the E.M.F. to give the voltage across the valve. In practice a balance is automatically struck whereby this residual voltage equals the product of the slightly increased current and the reduced resistance (caused by the paralleling of the voltmeter across the valve). Thus, to avoid disturbing the circuit conditions more than absolutely necessary it is advisable to use a multi-range voltmeter on a range sufficiently high to give the maximum practicable resistance, together with reasonable pointer indication. This same principle of using a higher range than apparently necessary should be adopted when measuring values of grid bias produced by the passage of current through a cathode load.

In general, however, if the highest range of the Model 7 AvoMeter is used for this purpose (together with the use of the ÷ 2 button if desired), readings accurate enough for practical purposes can be obtained. When so set, the total resistance of the meter forms a very high resistance path shunted across the valve, thus altering the normal voltage distribution only very slightly, since the valve itself is only a fraction of the total resistance in the circuit.

The distribution of the Model 7 AvoMeter is to-day so wide that many radio manufacturers give in their service sheets the readings which one should obtain at various points of a radio receiver with the instrument set to a given range. The shunting effect of the meter does not therefore now matter, for the manufacturer has taken the actual readings on a Model 7 AvoMeter upon a chassis which is known to be working perfectly.

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

RESISTANCE MEASUREMENT

There are three self contained ranges covering from 0·5 ohms to 1 megohm, whilst two higher ranges are available employing external voltage sources. Generally speaking, the highest accuracy on an ohms range is obtainable about the middle of its scale. Between 20% and 80% of the arc length, the accuracy on the ohms scale will be within ±5% of the indication. Where the value of the unknown resistance to be measured allows a choice of range, that range which gives the most central reading should be employed. Resistance tests should never be carried out on components which are already carrying current. Upon those resistance ranges utilising an internal source of voltage it should be remembered that positive potential appears at the negative terminal of the instrument when set for resistance. 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 condensers and rectifiers.

When measuring the leakage resistance of an electrolytic condenser, the negative lead from the meter should be connected to the positive terminal of the condenser, and the 1 megohm range employed.

The 10,000 ohms and 100,000 ohms Ranges.

These two lower ranges employ a 1½ V. cell (dimensions 1¼″ × 1¼″ × 3½″) such as Siemens type "T." Adjustments for the condition of this cell are made by the potentiometer " P " and the resistance " R ". The former compensates for variations in cell voltage, whilst the latter provides adjustment for changes in the internal resistance of the cell. This " R " adjustment, exclusive to the AvoMeter, enables measurements to be obtained to a greater degree of accuracy than would have been possible without its inclusion. It is of particular value upon the lowest range, which does, of course, when measuring low values, draw appreciable current from the cell.

Before commencing tests on either of these ranges it is advisable to check and, if necessary, to adjust as follows :

(1) Connect the leads together, and set the " A.C." switch to " D.C."

(2) With the " D.C." switch set to 100,000 ohms, adjust control " P " until the pointer indicates approximately zero on the ohms scale.

(3) Switch to the 10,000 ohms range and if the pointer differs from the last setting, adjust by means of " R " so that it just overshoots that position. Since, on the low range, the " R " adjustment causes ten times the change of pointer position that it does on the higher range, the need for just overdoing the apparently correct setting will be obvious. This adjustment should now be checked by comparing it once again with the pointer position on the 100,000 ohms range, and if necessary, the operation repeated. The object is to make the pointer take up the same position on the scale, irrespective of which of the two ranges is selected.

(4) Set to zero ohms precisely, by means of control " P."

After these adjustments, the leads should be connected to the resistance to be tested.

The markings on the resistance scale apply to the 10,000 ohms range, but when using the 100,000 ohms range the indication on the ohms scale should be multiplied by ten.

The Megohm Range.

This range makes use of two $4\frac{1}{2}$V. batteries in series (dimensions $2\frac{7}{16}'' \times \frac{13}{16}'' \times 2\frac{5}{8}''$) such as Siemens " P3 ", or Ever Ready " 1289 ". Before using this range it is necessary to carry out the following adjustments :

(1) Connect the leads together, and set the " A.C." switch to " D.C."

(2) Set the " D.C." switch to the 1 megohm position.

(3) Raise the adjusting knob " Q " from its position in the panel and rotate it in a clockwise direction until the pointer indicates zero.

To test, connect the leads to the unknown resistance, and note the indication on the ohms scale. This value multiplied by 100 will be its actual resistance. Do not hold the clips when carrying out tests on high values or the leakage through the body might cause erroneous indications.

Important. *After carrying out resistance tests on this range, the knob " Q " must be returned to its normal position in the panel.*

Battery Condition.

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 batteries concerned should be replaced. It is important that a discharged battery should not be left in the instrument, since the electrolyte might seep through and cause damage to the meter.

The 10 and 40 megohm Ranges.

These ranges are made available by using the 100 volts and 400 volts A.C. or D.C. ranges respectively in conjunction with a suitable voltage source. It is safe and correct to use a voltage which may be between two thirds and two and a half times that of the voltage range in use (e.g., 230 volts A.C. with 100 volts " A.C." range).

To adjust to ohms zero, the meter must be set to the appropriate range and connected across the source of voltage. The " Q " knob should now be lifted and rotated until the dointer indicates zero on the ohms scale. (*No harm results if the pointer goes beyond full scale deflection on lifting the " Q " knob.*) Switch off the supply to the meter and connect the resistance to be tested in series with the instrument. Reconnect the supply to the meter and the reading shown upon the ohms scale multiplied by 1,000 or 4,000, as the case may be, will give the value of the component under test.

Care should be exercised when using the mains. The article under test should not be handled whilst the current is switched on.

Important. *After carrying out resistance tests on this range, the knob " Q " must be returned to its normal position in the panel.*

CAPACITANCE MEASUREMENT.

Capacitance tests are made with the aid of a 50 c/s A.C. mains supply of between 65 volts and 250 volts. The meter should be set to its capacity range (set the " D.C." switch to " A.C." and the " A.C." switch to " Capacity "), the leads connected to the supply and the " Q " knob raised and rotated until the pointer indicates " INF " on the capacity scale. No harm or damage will result if the pointer goes beyond the limit of marking before the " Q " knob is withdrawn from the panel. The supply should now be removed from the meter, the unknown capacitor connected in series with one of the leads, and the supply reconnected. Direct indication of capacitance will now be shown within the usual commercial limits of accuracy. It is important that neither the capacitor nor the clips should be handled whilst the current is switched on.

Commercial frequencies other than 50 c/s may be used, but in such cases the voltage limits will vary from those given above. It is, however, important that 250 volts A.C. is not exceeded.

At the termination of a test always return the " Q " knob to its position in the panel. It is also desirable that the internal capacitor used on this test should be discharged by shorting the meter terminals, after the source of supply has been disconnected.

Electrolytic capacitors should be polarised before testing. It appears that if an electrolytic capacitor is polarised or has been in use immediately prior to a test being made, it can be checked in exactly the same way as a paper capacitor, if the test is carried out expeditiously, the internal capacitor within the instrument reducing the value of A.C. which is developed across the electrolytic capacitor during test. We do, however advise that an electrolytic capacitor should be polarised while tests are being made upon it and, in order to do this, a choke of at least 20 henries, or a resistance of 50,000 ohms, should be connected in series with a suitable D.C. polarising voltage across the capacitor, taking care to observe correct polarity. The usual connections for making a capacitance measurement are then made as above, the applied A.C. voltage in this case being restricted to 100 V. R.M.S.

Inasmuch as an inverse relationship exists between the magnitude of a capacitor's capacitance and the voltage developed across it, where a voltage is applied from an external circuit to two or more capacitors in series it can be seen that as the value of the capacitor increases, the voltage across it drops. For this reason, therefore, electrolytic capacitors having a capacitance in the order of 20 mF. at 12 V. working can be checked upon the instrument in the manner described above, since not more than their working voltage will be developed across them, by far the greater part of the applied voltage being dropped across the internal capacitor.

AUDIO FREQUENCY POWER AND DECIBEL MEASUREMENTS.

The power and decibel scales of the meter enable tests to be carried out upon amplifiers which are being fed with variable audio frequency voltage.

In the output stage of an amplifier, power is passed to the loudspeaker through a special transformer, the load impedance (which must suit the valve) being that of the loudspeaker itself, multiplied by a square of the transformer ratio. If the secondary feed to loudspeaker is open circuited, the primary will act as a choke to A.C. but pass the D.C. component. A resistance equivalent to the valve load impedance if now connected across the primary will absorb the power previously fed to the loudspeaker. This resistance can be the AvoMeter on one of its three ranges.

It will be seen from the following table, that when the meter is used alone, its application is somewhat restricted upon wattage and impedance measurements.

It is however, possible to extend the wattage ranges by means of external resistances selected to suit the load. A specially calibrated disc is available from the Company, which when attached to the meter around its Q knob, facilitates measurements up to 20W.

AUDIO FREQUENCY POWER MEASUREMENTS.

The following power ranges are obtainable :—

(1) 0—2 watts in 5,000 ohms (2) 0—200 mW. in 500 ohms (3) 0—200 mW. in 50,000 ohms	} using meter alone	{ Details on obtaining these ranges are given below.

Range (1).
Set the " D.C." switch to " A.C." and the " A.C." switch to " Power and Decibel."

Range (2).
Set the " D.C." switch to " A.C." and the " A.C." switch to 10 volts.

Range (3).
Set the " D.C." switch to " A.C." and the " A.C." switch to 100 volts.

DECIBEL MEASUREMENTS.

Four decibel ranges are obtainable about a reference level of 50 mW.

(1) −15 dB. to +16 dB. in 5,000 ohms (2) −25 dB. to +6 dB. in 500 ohms (3) −25 dB. to +6 dB. in 50,000 ohms	} using meter alone

Ranges are set in accordance with instructions given in the previous paragraph relating to power measurements.

If suitable L.F. signals are fed to an amplifier, the meter can now be used to show its frequency response over the audio frequency range. The load must be transferred to the meter as previously described by disconnecting the loudspeaker from the secondary of the output transformer, and connecting the meter across its primary (Fig. 3).

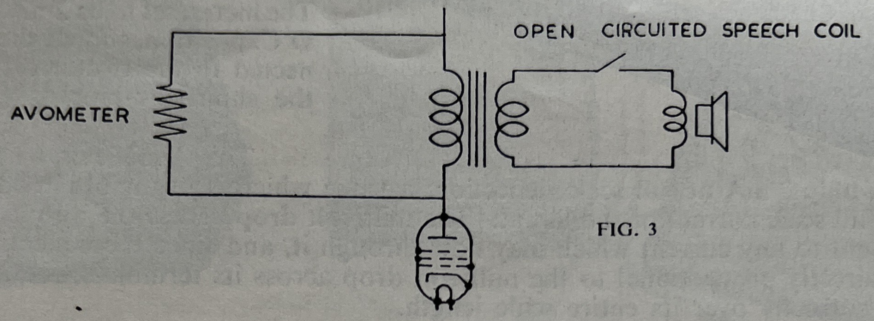


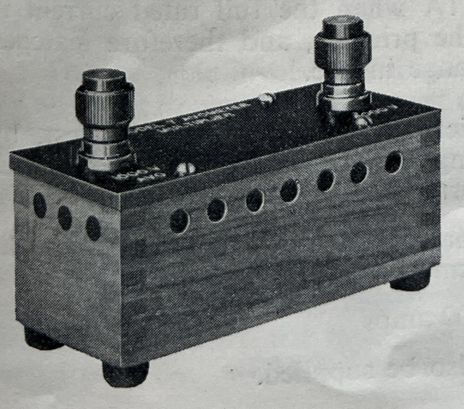
FIG. 3

It is possible to use the decibel scale by simply connecting the meter set to a suitable " A.C." voltage range, across the primary of the output transformer without disconnecting the secondary. It must be understood that in this case the variations in voltage read on the decibel scale give a measurement of relative output under varying conditions.

ACCESSORIES.

To extend the already wide ranges of the meter numerous accessories are available. It should be noted that the divide-by-two feature on the instrument also halves the range of any of the current or voltage extension devices.

Multipliers.



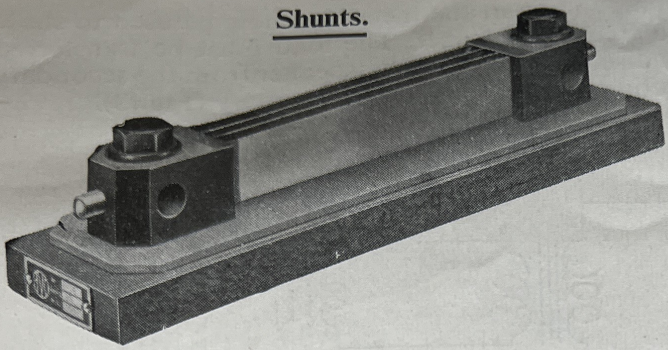
Multipliers are used to extend the voltage range of the instrument upwards and should be connected in series with the meter set to its 1,000V. range. The same multiplier is used for A.C. or D.C. When in use with the multiplier the meter should be kept at the " Earthy " side of the circuit.

The following multipliers are available.

0—2,000 V. (1,000 V. being dropped across Multiplier).

0—4,000 V. (3,000 V. being dropped across Multiplier).

Shunts.



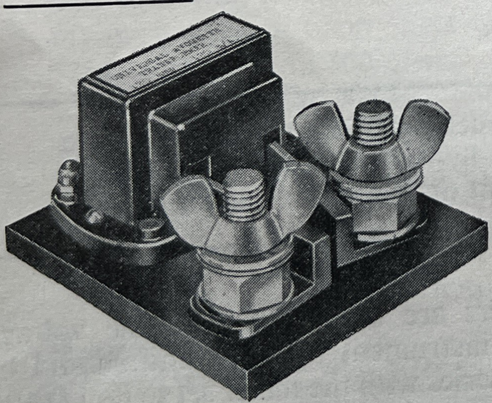
Shunts are available to extend the D.C. current ranges. A Shunt should be connected, by means of its two main terminals in series with the circuit upon which measurements are to be taken. The meter, set to its 2mA. (100mV) D.C. position, should then be connected to the two small studs on the shunt-end-blocks.

The AvoMeter when so set, consumes only 2 mA 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.

When the divide-by-two button is pressed, the meter range is reduced to 50 mV, and therefore any shunt carrying half its rated current is again capable of producing full scale deflection upon the meter. Thus, for example, a 400 amp. Shunt provides an additional range of 0—200 amps.

400 amps   200 amps   100 amps   50 amps

Transformers.



Current transformers are used to extend the A.C. ranges on the meter. Owing to the very high potential which may build up in the secondary circuit of a current transformer if it is left open circuited on load, it is most important to ensure that current is not passed through the primary, unless the meter, set to its correct range, is connected to the appropriate terminals of the transformer. The secondary of the transformer produces 0·1A when the full rated current is flowing in the primary, and therefore matches the meter range in use.

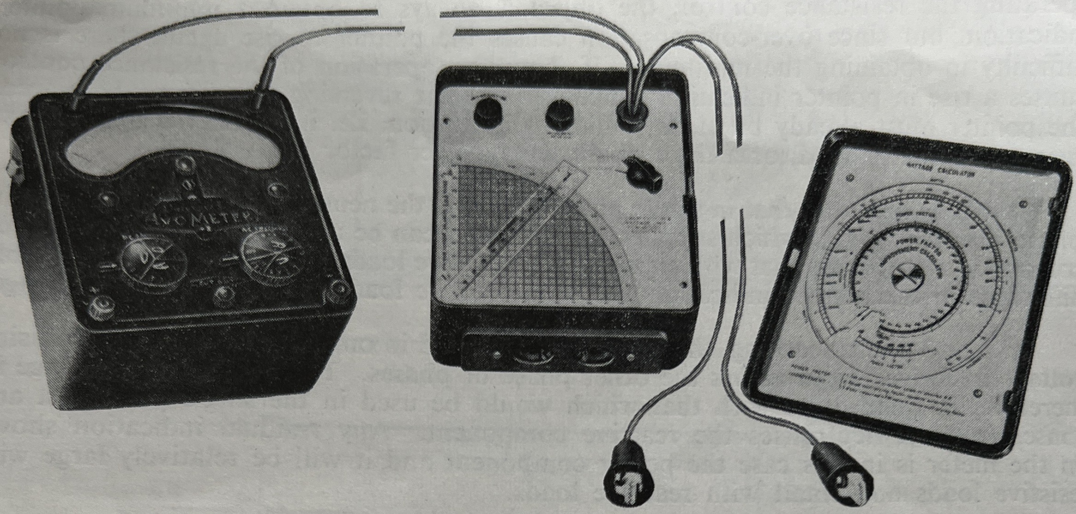
The transformer should be connected in series with the circuit under test, by means of its two terminals. This is done by setting the AvoMeter to its 0·1A A.C. range, and connecting its leads to the two small terminals on the transformer.

The operation of the divide-by-two feature halves the ranges presented by the transformers listed below. The following transformers are available.

400 amps   200 amps   100 amps   50 amps

A double wound 200/50 A. transformer can also be supplied.

The Model 7 AvoMeter Power Factor and Wattage Unit.



The illustration shows a power factor and wattage unit connected up with a Model 7 Avo Meter ready for use.

This device will only operate with a Model 7 AvoMeter fitted with " P.F." sockets in its top panel, and is intended for use on 100-450V, commercial A.C. supplies. A slight modification in procedure does however, enable the apparatus to be used at voltages much below 100 volts. The complete unit is approximately the same size as the AvoMeter.

Readings can be taken on the AvoMeter used in association with the Unit, from which power factor and A.C. power can be determined in single phase, or balanced 2 or 3 phase circuits, provided the current remains constant for two or three seconds, and is of the normal sinusoidal wave form. Unbalanced 2 or 3 phase power can be determined as the sum of the powers in the separate phases. If necessary, external current transformers having small phase angle errors may be included to extend the turrent range of the AvoMeter. The Company can supply a suitable range of transformers up to 400A. Since practically all apparatus which necessitates the use of a power factor indicator works at a lagging power factor, no discriminator is included.

The principle involved is to measure the current in one phase of the circuit under test and then to neutralise its power component in the case of single phase, or its reactive component in the case of balanced 2 or 3 phase circuits. The relationship between the first and second readings in any test, provides the information for power factor determination.

The above operation is performed by connecting the Unit to the mains and tapping off a controlled amount of current by means of a variable resistance, the current being fed to the rectifier in the meter. Since the phase of the neutralising current may be such that it causes a rise instead of a fall in the pointer indication when the control is moved from its " START " position, a reversing switch has been incorporated to save altering the lead connections. To cope with all voltages likely to be encountered a voltage selector switch marked with limits for each setting has been provided. When operating the resistance control, the object is always to obtain a minimum pointer indication, but since over-compensation causes the pointer to rise again, there is no difficulty in obtaining the minimum. If, however, operation of the resistance control causes a rise in pointer indication whichever side the reversing switch may be placed, the pointer must already be at its minimum indication, i.e. it is either a single phase zero power factor load, or a three phase unity power factor load.

It will be apparent that in single phase working, the neutralising current must be in phase with the voltage which supplies the load, and can be used to cancel out its power component. It follows that with substantially resistive loads there will be a considerable difference in the pointer indication and with reactive loads there will be little change.

In 2 or 3 phase working, the current is measured in one phase and the neutralising voltage is derived from across the other phase or phases. This neutralising voltage is, therefore, in quadrature with that which would be used in the single phase test and consequently it neutralises the reactive component. Any residual indication shown on the meter is in this case the power component and it will be relatively large with resistive loads and small with reactive loads.

Should the characteristics of the circuit under test be such that upon switching off, a voltage much in excess of the mains voltage is likely to be generated across the load, it is advisable to disconnect the neutralising voltage leads before switching off.

A summary of the operating instructions, including the use of the calculators, appears below :—

Preliminary Settings of the Unit.

(1) Remove the leads from the drawer in the Unit and plug into the appropriate, socket.

(2) Set the voltage switch at a value to suit the supply. (For voltages below 100V, set to " 100-160V " position).

(3) Set the movement reversing switch at its mid-position.

(4) Set the adjusting knob at the position marked " START."

(5) Connect the short leads to the sockets marked P.F. at the top of the AvoMeter.

(6) Connect the long leads to points which will attain the required voltage when the load is switched on.

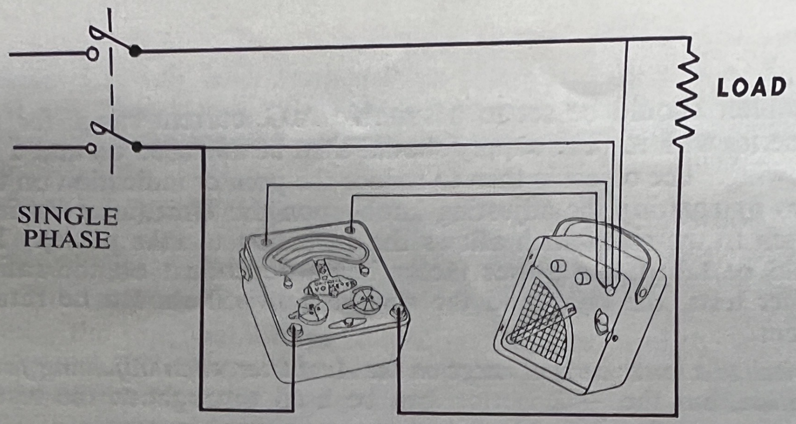
Note.

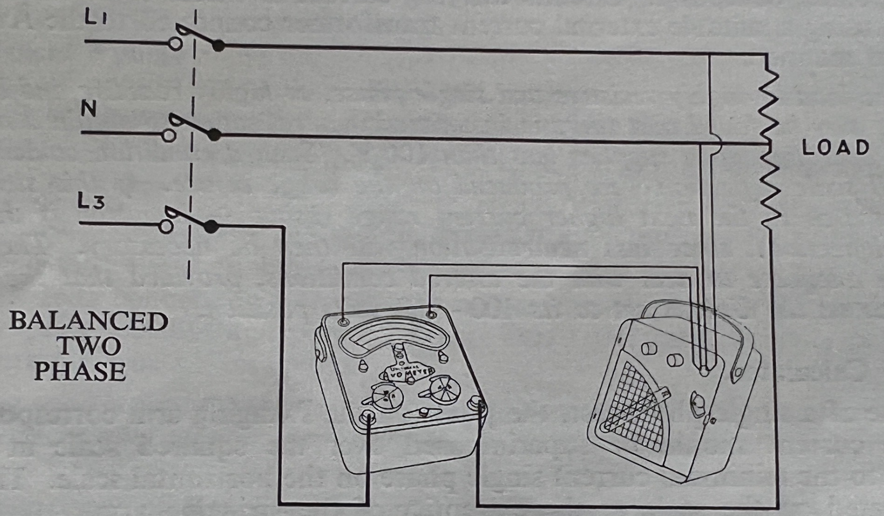
Single phase. The voltage should be taken across the mains.

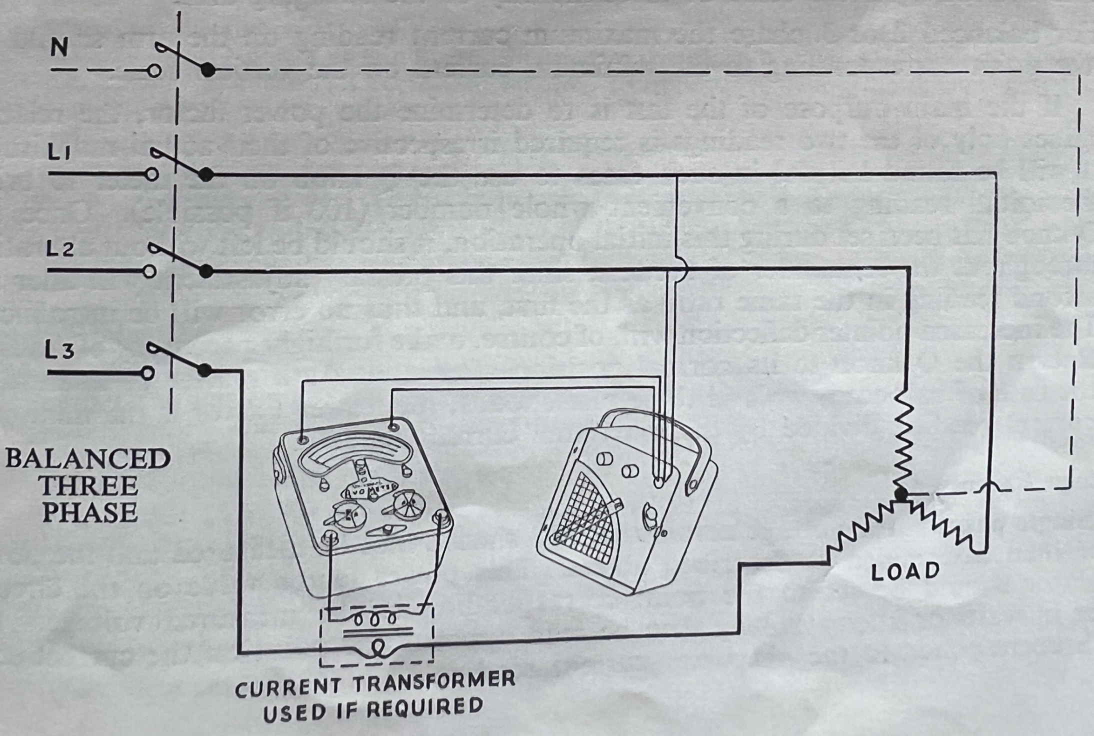
Balanced 2 phase. The current is measured in one line, the voltage being taken from across the other line to the neutral.

Balanced 3 phase. The current is measured in one line and the voltage is taken across the other two lines.

Unbalanced 3 phase. Regard each phase as a single phase test.


LOAD
SINGLE PHASE


L1
N
L3
LOAD
BALANCED TWO PHASE


N
L1
L2
L3
BALANCED THREE PHASE
LOAD
CURRENT TRANSFORMER USED IF REQUIRED

Test.

The AvoMeter should be set to a suitable A.C. current range for the load and connected in series with it. The supply should then be switched on and a note made of the current flowing. The object is then to reduce the pointer indication on the AvoMeter to a minimum by rotating the adjusting knob upon the Unit (after having moved the reversing switch to the side which allows the reduction to take place). The minimum reading should be taken, the power factor being dependent on the ratio of the two readings. After tests, the knob and the reversing switch should be returned to their initial positions.

Never switch to a lower current range on the Avometer when adjusting for the minimum pointer indication, but the ÷ 2 button can be used throughout the test if desired to increase the pointer deflection. Circuits carrying current in excess of 10 amps can be dealt with by using a suitable external current transformer connected to the AvoMeter in the normal manner.

Should the load be highly resistive and single phase, or highly reactive and balanced multi-phase, it may be found that there is insufficient neutralisation to obtain a minimum reading when operating upon supplies less than 100 *V. Such a condition could occur if practically full scale deflection were produced on the range in use. If this situation is encountered, switch to the next higher current range (using* ÷ 2 *button if desired to increase the deflection), since less neutralisation will then be necessary. The voltage should now be adequate to deal with the altered conditions, provided that the Voltage Selector Switch on the Unit is set to its* 100 - 160 *volts position.*

Power Factor Calculator.

In the case of a single phase test, the point on the swinging arm corresponding to the maximum current should be superimposed over the squared scale at a point corresponding to the minimum current single phase on the horizontal scale. The power factor is indicated on the scale at the extremity of the swinging arm.

For balanced 2 or 3 phase the maximum current reading on the arm should lie over the point corresponding to the minimum current on the vertical scale.

Note. If the main purpose of the test is to determine the power factor, the relative values only of the two readings is required irrespective of their actual magnitude. It will be found helpful in such cases to use the Q knob on the meter to bring the initial reading to a convenient whole number (100 if possible). Once the Q knob has been set during this initial operation, it should be left without alteration throughout the remainder of the test, since this primary adjustment will alter the second reading in the same ratio as the first, and thus no error will be introduced. The increased pointer deflection will, of course, make for higher accuracy of reading. Return the Q knob to its normal position after use. As a matter of interest, in the case of balanced two and three phase loads, the Power Factor is the minimum current reading divided by the maximum current reading.

Wattage Calculator.

Single phase : the voltage across the load should first be measured and the power factor then determined as described above. This power factor value on the circular calculator should be set to the point corresponding to the measured voltage. The power in watts or kilowatts may then be read opposite the point on the current scale which corresponds to the *maximum* current reading.

The calculator has only been marked from 10mA and the Power Factor from 0·1 upwards. If at any time values below these are encountered, the calculation can be based on say ten times the current or Power Factor, and the Wattage indication then divided by ten.

Balanced 2 phase : the line/neutral voltage should be measured and the unity (1·0) power factor marked on the calculator set against the voltage value. The wattage *per phase* is then read against the *minimum* current, it being unnecessary to measure the power factor. The total wattage is twice the phase wattage.

Alternatively, the line/line voltage should be measured and the mark V_{L2} on the calculator set against this value. The total wattage is then read against the *minimum* current, there being no necessity to determine the power factor. **Note :** the voltage derived from line to line must not be applied to the Unit, but merely used to facilitate computation on the wattage calculator.

Balanced 3 phase : the line voltage should be measured and the mark V_{L3} on the calculator set against this value. The total wattage is then read against the *minimum* current, it being unnecessary to determine the power factor.

Unbalanced 2 or 3 phase : the power in each phase must be determined as a single phase test, the total power being the sum of the individual phases.

For " star connection " circuits the power in each phase is the product of the phase volts, the line current and the power factor.

For " delta connection " circuits the power in each phase is the product of the line volts, the phase current and power factor. This latter case can only be determined if phase currents can be measured.

Other applications for the device such as the determination of phase angle between two voltage sources may present themselves to the discerning engineer.

The Measurement of Reactive kVA with the Power Factor and Wattage Unit.

Many supply authorities stipulate that a penalty will be imposed if the power factor of a connected load drops below a certain figure. In practice therefore, it is not only desirable to know the power factor, but the amount of correction required to improve it to a given figure. This Unit will provide all the necessary information.

Although " bad power factor " can supply to capacitive loads, it is normally the inductive load which causes trouble in industry, due to the use of motors, transformers and other plant which give rise to inductive " Wattless current." Such current only burdens cables and power stations unnecessarily, and involves supply authorities in expense which many are no longer prepared to except.

The usual method of obtaining the necessary correction, is to connect capacitors in parallel with the inductive load, these capacitors being normally rated by the manufacturer in kVAr.

<u>TO OBTAIN kVAr.</u>

(1) Ascertain the power factor and total wattage of the load.
(2) Set arrow upon the Power Factor Improvement scale to desired power factor.
(3) Read multiplication figure opposite existing power factor.
(4) The kVAr required to correct the circuit is then given by multiplying the wattage of the load by the factor obtainable in (3) above.

If when this kVAr figure has been obtained, it is desired to know the value of the required correction capacitance, it can be found from the following formula :—

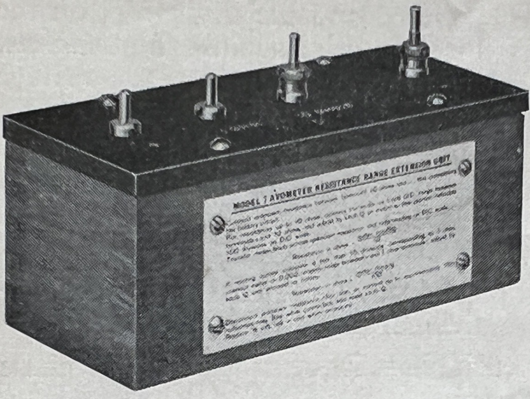
$$\text{Capacitance in } \mu\text{Fds} = \frac{\text{kVAr x } 10^9}{2\text{TTf } (\text{V}^2)}$$

Where :—TT = 3·14. f = frequency of supply. V = voltage of supply.

For balanced three phase working, the capacitance is divided into three equal banks.

Resistance Range Extension Unit.

To obtain even lower readings than those already provided upon the low ohms range of the instrument, a Resistance Range Extension Unit has been developed. This will enable either 10 ohms or 1 ohm to be read at full scale deflection upon the meter. On the 10 ohm range, the unknown resistance is connected across the 10 ohm and negative terminal of the Unit. The meter, set to its " 1 V. D.C." range is connected between the positive and 10 ohms terminal on the unit, the " Q " knob being used to bring the pointer to the 100 mark on the uniformly divided scale. The meter leads should then be transferred across the unknown resistance, and the reading on the 100 division scale noted. This shows the value of the resistance under test as a percentage of 10 ohms, or if the actual readings obtained are divided by 10, direct reading in ohms will be given.



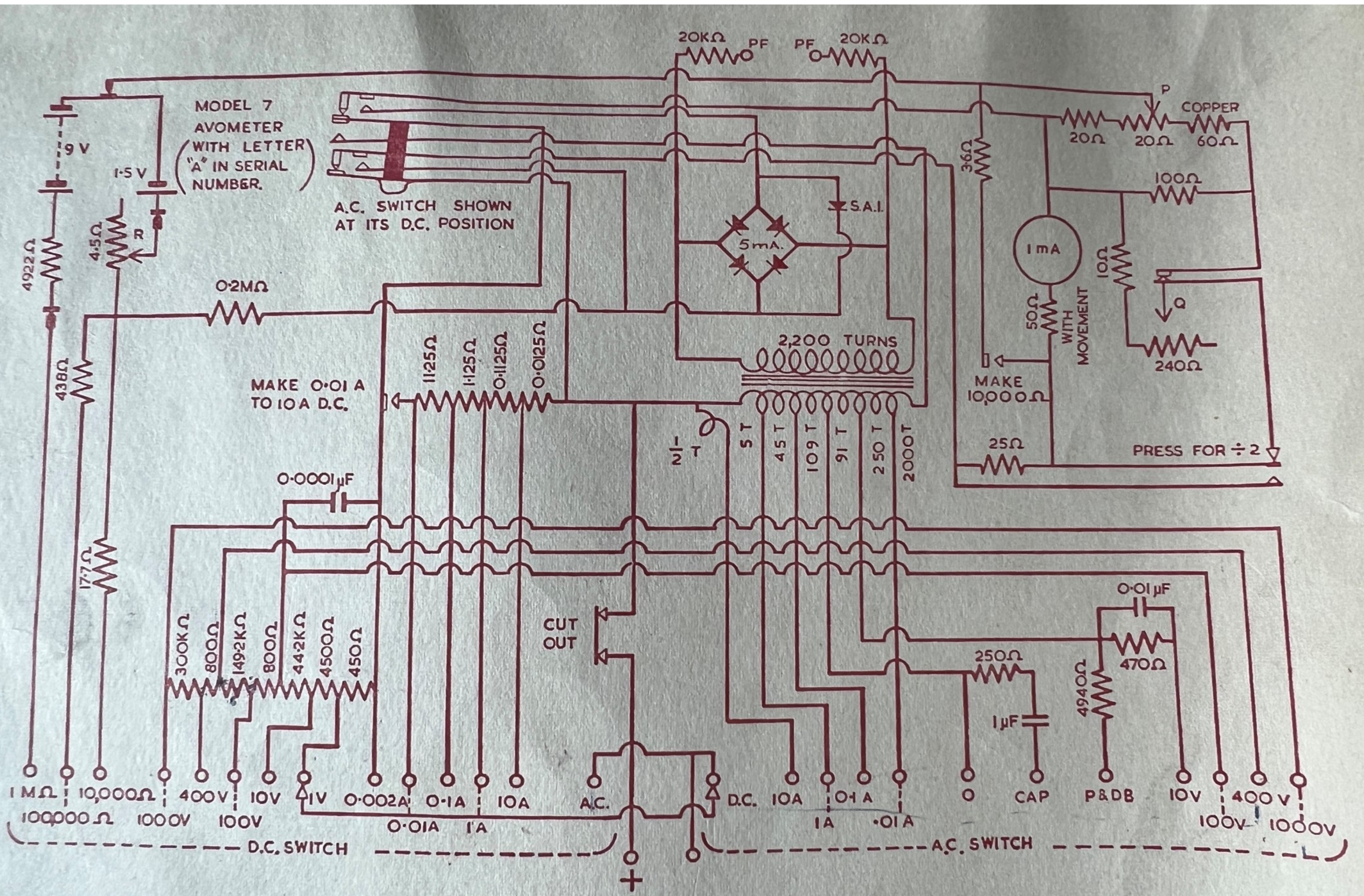
If the reading is less than 1 ohm, a more accurate test can be carried out on the 1 ohm range. The standardising procedure should be repeated with the meter set to its 2mA. range and its leads connected between the positive and 1 ohm stud. The leads should then be transferred across the unknown resistance, the pointer indication on the 100 division scale giving the value of the resistance as a percentage of 1 ohm. If the actual readings obtained are divided by 100, direct reading up to 1 ohm will be given. The procedure outlined above for setting the instrument to full scale deflection by means of its " Q " knob must be repeated for every test.

Immediately tests are complete, disconnect the meter and the tested resistance from the unit to avoid discharging the internal cell. This cell should be examined periodically to ensure that it hasn't become discharged.

The illustration shows the specially designed leather case which can be supplied with the Model 7 Avo-Meter if desired.

Should it ever be your misfortune to have to return the instrument to the Company for repair, pack it carefully and enclose a note informing our engineers of the faults you have found.

Due to high operational standards maintained throughout our works, and the close limits within which we work, breakdowns are comparatively rare. The majority of failures can be traced to damage in transit, or careless handling for which the Company cannot be held responsible except in those cases where the buyer is advised of our liability.



CIRCUIT DIAGRAM OF THE MODEL 7 AVOMETER MK. II