Model 7 Universal AVOMETER

WORKING INSTRUCTIONS

THE

AUTOMATIC COIL WINDER & ELECTRICAL EQUIPMENT CO., LTD.,

WINDER HOUSE, DOUGLAS STREET, LONDON, S.W.1.

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INSTRUCTIONS FOR USE

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FOREWORD

For more than a quarter of a century we have been engaged in the design and manufacture of " AVO " Electrical Measuring Instruments. Throughout that time we have consistently pioneered the design of modern multi-range instruments and have kept abreast of, and catered for, the requirements of the epoch-making developments in the fields of radio and electronics.

The success of our steadfast policy of maintaining high standards of performance in instruments of unexcelled accuracy, and making such instruments available at reasonable cost, is reflected in the great respect and genuine goodwill which " AVO " products enjoy in every part of the World.

It has been gratifying to note the very large number of instances where the satisfaction obtained from the performance of one of our instruments has led to the automatic choice of other instruments from the " AVO " range. This process, having continued over a long period of years, has resulted in virtual standardisation on our products by numerous Public Bodies, The Services, Railway Systems, and Post Office and Telegraph Undertakings throughout the world.

Our designers have thereby been encouraged to ensure that new instruments or accessories for inclusion in the " AVO " range fit in with existing " AVO " apparatus and serve to extend the usefulness of instruments already in being. Thus, the user who standardises on " AVO " products will seldom find himself short of essential measuring equipment, for, by means of suitable accessories, his existing equipment can often be adapted to meet unusual demands.

It is with pleasure that we acknowledge that the unique position attained by " AVO " is due in no small measure to the co-operation of so many users who stimulate our Research and Development staffs from time to time with suggestions, criticisms, and even requests for the production of entirely new instruments or accessories. It is our desire to encourage and preserve this relationship between those who use " AVO " instruments and those who are responsible for their design and manufacture, and correspondence is therefore welcomed, whilst suggestions will receive prompt and sympathetic consideration.

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INTRODUCTION

Since its conception in 1923, the AvoMeter has maintained a distinct lead upon all its competitors. It can to-day, quite rightly, be termed the most popular instrument of its type in the World, for in no other instrument can one find such a unique combination of ranges, and comprehensive automatic overload protection, in addition to a high degree of accuracy, reliability and simplicity of use.

During World War II, tens of thousands of these meters were produced for the Armed Forces, Research Laboratories, Factories, etc., and it is largely due to the unparalleled service which they gave in the most arduous conditions that the same type of instrument is to-day selling so well throughout the globe.

The manufacture of so comprehensive an instrument in such a compact form and produced at a moderate price is a major achievement. The Model 7 AvoMeter incorporates a very large number of useful ranges, but if tests outside the already wide limits of the instrument are required it will generally be found possible to extend the scope of the instrument by means of one of the many accessories which are available.

Although the instrument is widely noted for its ability to withstand hard usage, remember that its mechanism deserves the careful treatment which one would extend to any valuable apparatus. Given a reasonable amount of care and attention, not forgetting the removal of exhausted batteries, this instrument will give years of lasting satisfaction.

TABLE OF RANGES

D.C. Current		D.C. Voltage		A.C. Current		A.C. Voltage	
Range	Value per division and first indication	Range	Value per division and first indication	Range	Value per division and first indication	Range	Value per division and first indication
*0–1 mA.	10 μA.	*0–50 mV.	0.5 mV.	*0–5 mA.	50 μA.	*0–5 volts	50 mV.
0–2 mA.	20 μA.	(1 mA. range)		0–10 mA.	100 μA	0–10 volts	100 mV.
*0–5 mA.	50 μA.	0–100 mV.	1 mV.	*0–50 mA.	500 μA.	*0–50 volts	500 mV.
0–10 mA.	100 μA.	(2 mA. range)		0–100 mA.	1 mA.	0–100 volts	1 volt
*0–50 mA.	500 μA.	*0–500 mV.	5 mV.	*0–500 mA.	5 mA.	*0–200 volts	2 volt
0–100 mA.	1 mA.	0–1 volt	10 mV.	0–1 Amp.	10 mA.	0–400 volts	5 Volt
*0–500 mA.	5 mA.	*0–5 volt	50 mV.	*0–5 Amp.	50 mA.	*0–500 volts	5 Volt
0–1 Amp.	10 mA.	0–10 volt	100 mV.	0–10 Amp.	100 mA.	0–1000 volts	10 Volt
*0–5 Amp.	50 mA.	*0–50 volt	500 mV.				
0–10 Amp.	100 mA.	0–100 volt	1 volt				
		*0–200 volt	2 volt				
		0–400 volt	5 volt				
		*0–500 volt	5 volt				
		0–1000 volt	10 volt				

Resistance

Range	First Indication	
0–10,000 ohms	0.5 ohms	using internal 1½ volt cell
0–100,000 ohms	5 ,,	
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 ,,	

Capacity

Range	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.

THE

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WORKING INSTRUCTIONS

Scope of Instrument.

The meter should arrive complete with two connecting leads, two clips and two prods (held upon the battery cover). The hook ends fitted to the leads are designed to facilitate easy connection to the instrument terminals, whilst into the sockets at the remote ends of the leads, either the prods or the 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, also an " A.C." and a " D.C." switch, whilst the design of the instrument is such that only two terminals are required. The instrument 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 ranges, as listed upon page 6, covering the measurement of " A.C." or " D.C." current and voltage, resistance, capacity, decibels, and audio frequency power.

Although the AvoMeter is, in the main, self contained as far as the coverage of the ranges given in the table upon page 6 are concerned, it should be noted that the wide range 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 short pointer deflections. These ranges are shown by asterisks in the table upon page 6.

Limits of Accuracy.

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.

Accuracy is to British Standard First Grade limits on " D.C." and on " A.C." from 25–2,000 c/s. Sufficient accuracy for most practical purposes can, however, be obtained over the audio frequency band. The limits laid down by BS89/1937 for first grade " D.C." multi-range moving coil instruments, permit errors up to 1.2% of the indication from full scale to half scale deflection. Below half scale deflection a constant error equal to that at half scale is allowed, this being equivalent to 0.6% of full scale deflection. On " A.C." the corresponding limits laid down for multi-range rectifier moving coil volt meters are 3.5% of indication, and 1.75% of full scale deflection respectively.

In practice AvoMeters are very well within these limits due to the great care taken in the manufacture of the various components used within them, and the fine initial calibration.

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 with 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.

Design and Construction of the AvoMeter.

The instrument consists of a moulded panel, on the inside of which are mounted the whole of the switching apparatus, resistances, shunts, transformer, rectifier, etc., together with the moving coil. The panel fits into an attractively finished robust case, the joint having been rendered completely dust proof, whilst a leather carrying strap is provided to facilitate portability. The entire switching of the multipliers, shunts, transformer, etc., is accomplished automatically by means of two switch knobs on the panel, each plainly marked so that the range in use appears opposite an arrowhead.

These switches are of generous and robust design, contacts being arranged to make before break, on adjacent ranges (a feature which provides a further factor of safety to the user). When the instrument is set for operation on " D.C." the moving coil employs universal shunts and series multipliers, whilst on " A.C." the moving coil is associated with a rectifier and tapped transformer system in addition to series multipliers.

Range Controls.

The left hand knob governs " D.C." ranges and the right hand knob the " A.C." ranges, the switching being interlocked in such a manner that it is only possible to obtain " D.C." readings by setting the " D.C." switch to a range and rotating the " A.C." switch to the position marked " D.C." A similar procedure is necessary when making an " A.C." measurement, and the instrument is therefore protected from damage in the event of both switches being left on ranges when making a test, for in this condition there is no circuit through the meter. Should " A.C." be passed through the instrument when it is set to a correct " D.C." range or vice versa, no pointer indication will be produced, and no damage will result, provided that the meter is not overloaded on the range selected. It is possible to determine whether a source is " A.C. " or " D.C." since pointer deflection can only be produced with switches set for the same type of measurement as the supply.

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 completely eliminates the inconvenience and expense of replacing fuses. 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 inadvertantly 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 re-set 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 functions on moderate overloads if the moving coil hits the forward or reverse end stops, whilst should the acceleration of the moving coil, due to overload, be excessive, a different portion of the mechanism comes into play and the breaker contacts may even be released before the pointer has traversed one-third of the scale length.

The user is, however, warned against gross negligence, for although the overload mechanism gives almost complete protection to the meter, it cannot be guaranteed to fulfil completely its function in the very worst cases of overload, 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 normally be reset with the instrument lying face upwards.

The Movement.

The moving coil consists of an aluminium former wound with copper wire and supplemented with Constantan in order to reduce temperature error. It is pivoted on hardened, and highly polished steel pivots between conical spring-loaded jewels, and swings in a gap energised by two powerfully magnetised and aged alnico blocks associated with mild steel pole pieces. Two phosphor bronze hair springs are fitted for the purpose of conveying 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 perfectly balanced and reasonably damped so that the pointer quickly comes to rest.

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 Capacity, 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.).

Ranges.

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 the 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, to obtain the 5 mA. D.C. Current range, the " A.C. " switch is set to its " D.C." position, the " D.C." switch set to 0.01 amps. and the divide-by-two button depressed. 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 provides 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).

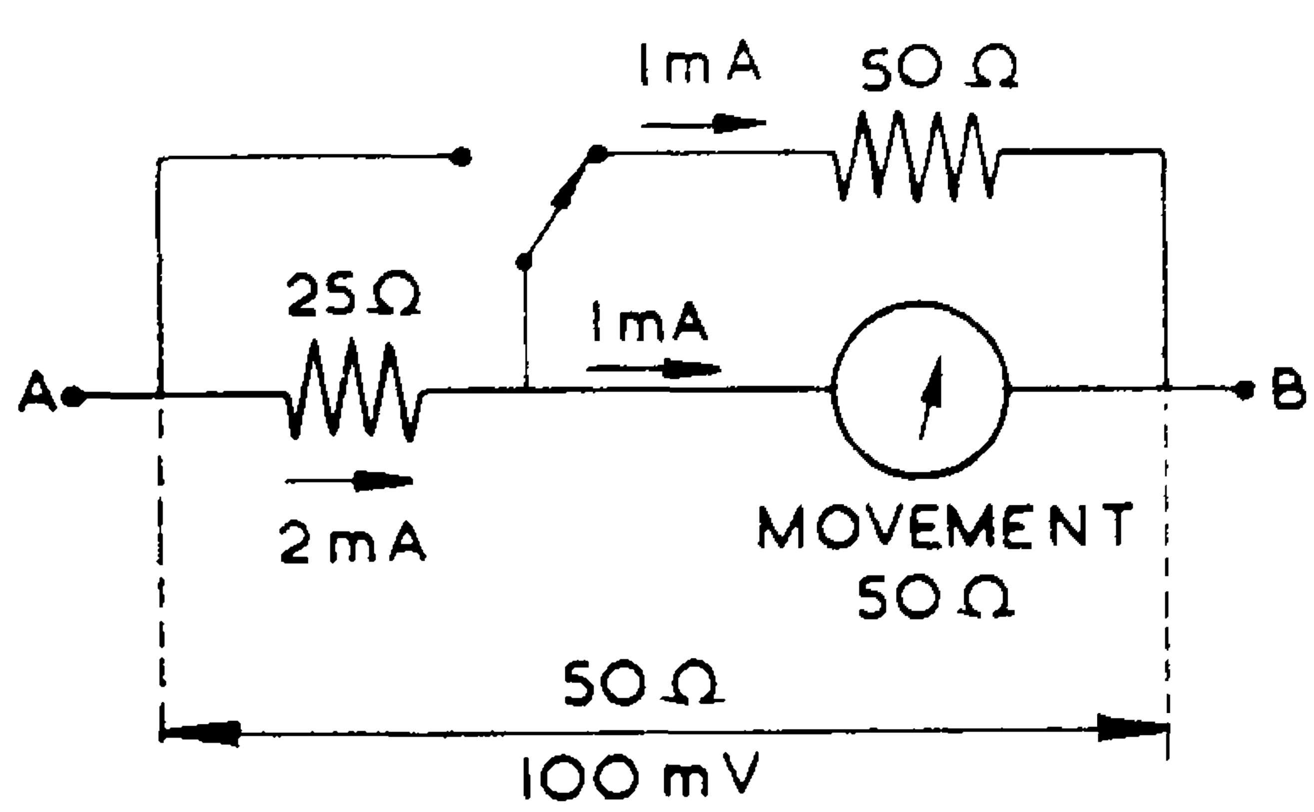


FIG. 1

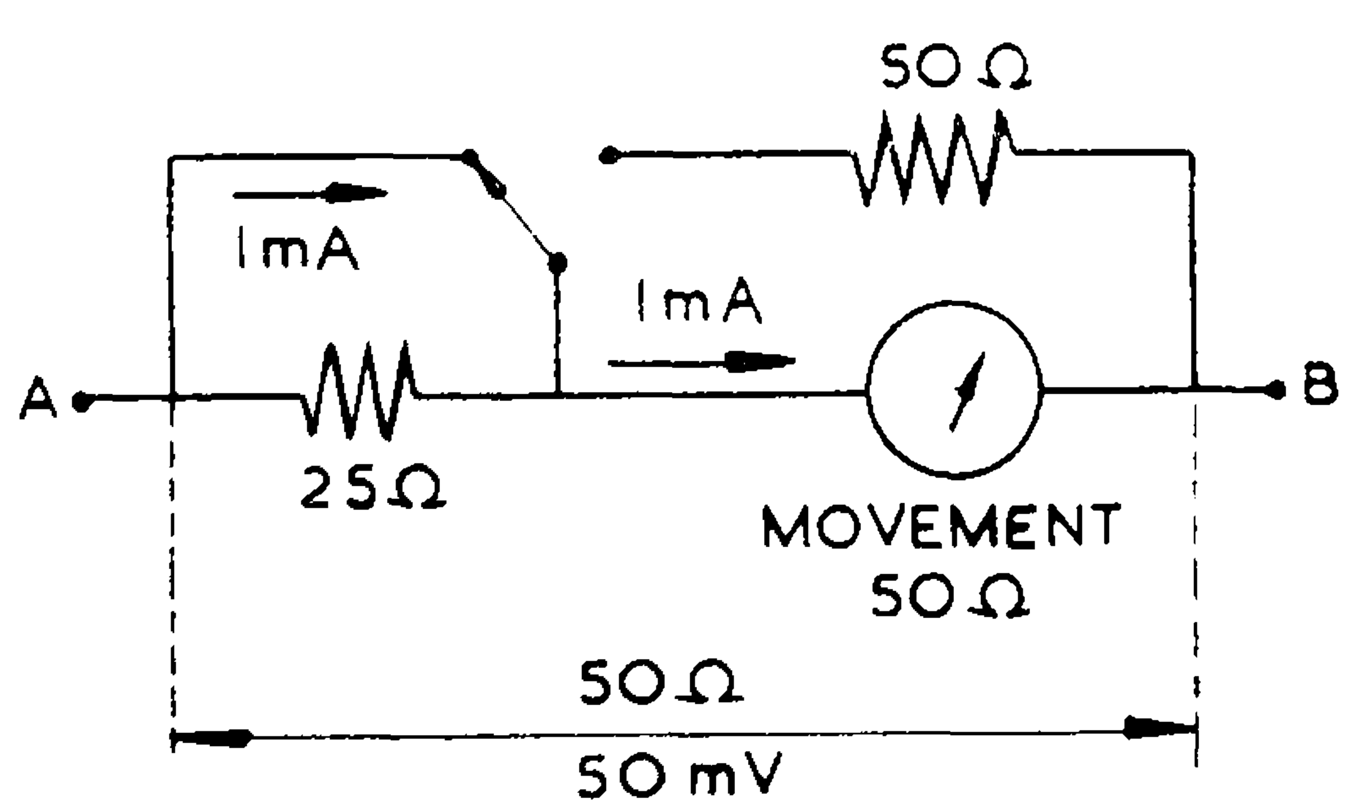


FIG. 2

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 $\div 2$ 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 $\div 2$ range only half the normal current is required in the shunt to produce the necessary voltage for full scale deflection.

In this meter, 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 effects both voltage and current measurements.

The knobs marked " P," " Q," and " R " are of use in conjunction with the resistance ranges, etc., and full details of their functions will be given in a later section of this book.

If at any time it becomes necessary to re-set the pointer to Zero, the slotted zero adjusting screw should be used, and this *must* be done whilst the instrument is set to a " D.C." range, the meter not being connected to any external circuit. The reason for this procedure is that in order to compensate for small inevitable errors on " A.C." the pointer is slightly displaced from zero when set to " A.C." To produce this deflection, a minute current is drawn from the $1\frac{1}{2}$ V. cell used for resistance measurements, whilst the normal setting for cell deterioration on resistance tests is such as to maintain the correction on " A.C."

Replacement of Internal Batteries and Cell.

Inside the cover, under the carrying strap, two 4.5 V. batteries and a 1.5 V. cell will be found. 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 $1\frac{1}{2}$ V. cell are obvious, but the $4\frac{1}{2}$ V. batteries must be inserted with their negative poles (the long brass strips) uppermost. Markings of cell 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 prods or clips as required should now be connected to the meter terminals.

Ensure that the instrument is correctly 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 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 the 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.", if it is used with accessories on a voltage system over 1,000 V. it should be kept at the low potential end of the circuit (relative to earth). 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 amps.	50 ohms	—
0.01 ,,	10 ,,	60 ohms
0.1 ,,	1.25 ,,	1.7 ,,
1.0 ,,	0.14 ,,	0.05 ,,
10.0 ,,	0.03 ,,	0.02 ,,

Standard meter leads have a resistance of 0.02 ohms per pair and the value of lead resistance should be added to the meter resistance.

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 range 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 2 mA. for full scale deflection (500 ohms per volt) and proportionally less 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 volts drop in the resistances mentioned and thereby causing the voltage 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 proportional to the E.M.F. of the source, the actual voltage being dependent upon the internal impedance of the source, the load resistance and 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 upon the highest range which gives the highest resistance coupled 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, since 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 MEASUREMENTS.

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. 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 a current. Upon those 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 Range.

These two lower ranges employ a $1\frac{1}{2}$ V. cell (dimensions $1\frac{1}{4}'' \times 1\frac{1}{4}'' \times 3\frac{5}{8}''$) such as Siemens type " T." Adjustments for the condition of this cell is made by the potentiometer " P " and the resistance " R." The former compensates for variations in cell voltage, whilst the latter provides adjustment to allow for changes in the internal resistance of the cell, thereby enabling 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 "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 than 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 exactly by means of control " P."

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

Readings are direct on the low 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 $4\frac{1}{2}$-volt batteries in series (dimensions $2\frac{7}{16}'' \times \frac{13}{16}'' \times 2\frac{5}{8}''$) such as Siemens " P3." Before using this range it is necessary to carry out the following adjustments :

(1) Connect 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.

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 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 pointer indicates zero on the ohms range. **(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.

CAPACITY MEASUREMENT.

Capacity 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, 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 condenser connected in series with one of the leads, and the supply reconnected. Direct indication of capacity will now be shown within the usual commercial limits of accuracy. It is important that neither the condenser 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 condenser used on this test should be discharged by shorting the meter terminals, after the source of supply has been disconnected.

Electrolytic condensers should be polarised before testing. It appears that if an electrolytic condenser 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 condenser, if the test is carried out expeditiously, the internal condenser within the instrument reducing the value of " A.C." which is developed across the electrolytic during test. We do, however, advise that an electrolytic condenser should be polarised whilst 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 condenser, taking care to observe correct polarity. The usual connections for making a capacity 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 condenser's capacity and the voltage developed across it, where a voltage is applied from an external circuit to two or more condensers in series it can be seen that as the value of the condenser increases, the voltage across it drops. For this reason, therefore, electrolytic condensers 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 condenser.

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 loud speaker 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 ranges, if of suitable value, or if it is desired to cover a greater range the meter should be used in conjunction with its Power and Decibel Extension Unit described later.

POWER MEASUREMENTS.

The following power ranges are obtainable :—

(1)	0–2 watts in 5,000 ohms	Details on obtaining these ranges given are below.
(2)	0–200 mW. in 500 ohms	
(3)	0–200 mW. in 50,000 ohms	
(4)	0–200 mW. 0–2 W. 0–20 W. in 500–15,000 ohms (using Power and Decibel extension unit)	

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.

Range (4).

Set the " D.C." switch to " A.C." and the " A.C." switch to appropriate current range or " spot (31.5 mA.)." For further details see section upon Power and Decibel Extension Unit.

DECIBEL MEASUREMENTS.

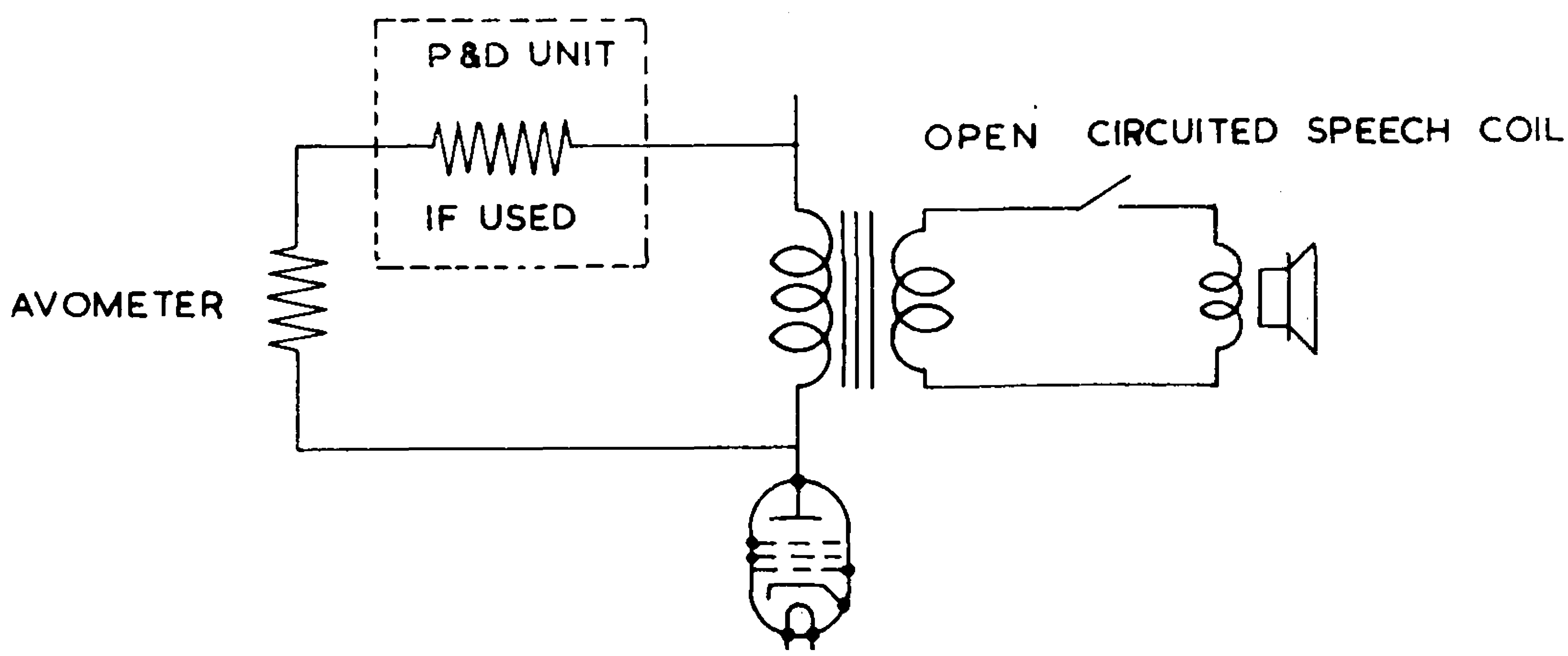
Four decibel ranges are obtainable about a reference level of 50 mW.

(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

(4) −25 db. to +6 db.
−15 db. to +16 db.
−5 db. to +26 db.
in 500–15,000 ohms (using Power and Decibel unit).

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

If suitable LF. signals are fed in, the meter can now be used to show the frequency response of an amplifier over the audio frequency range. The load must be transferred to the meter as previously described (either direct or via the extension unit described in the section upon accessories) by disconnecting the loudspeaker from the secondary of the output transformer, and connecting the meter across its primary (Fig. 3).



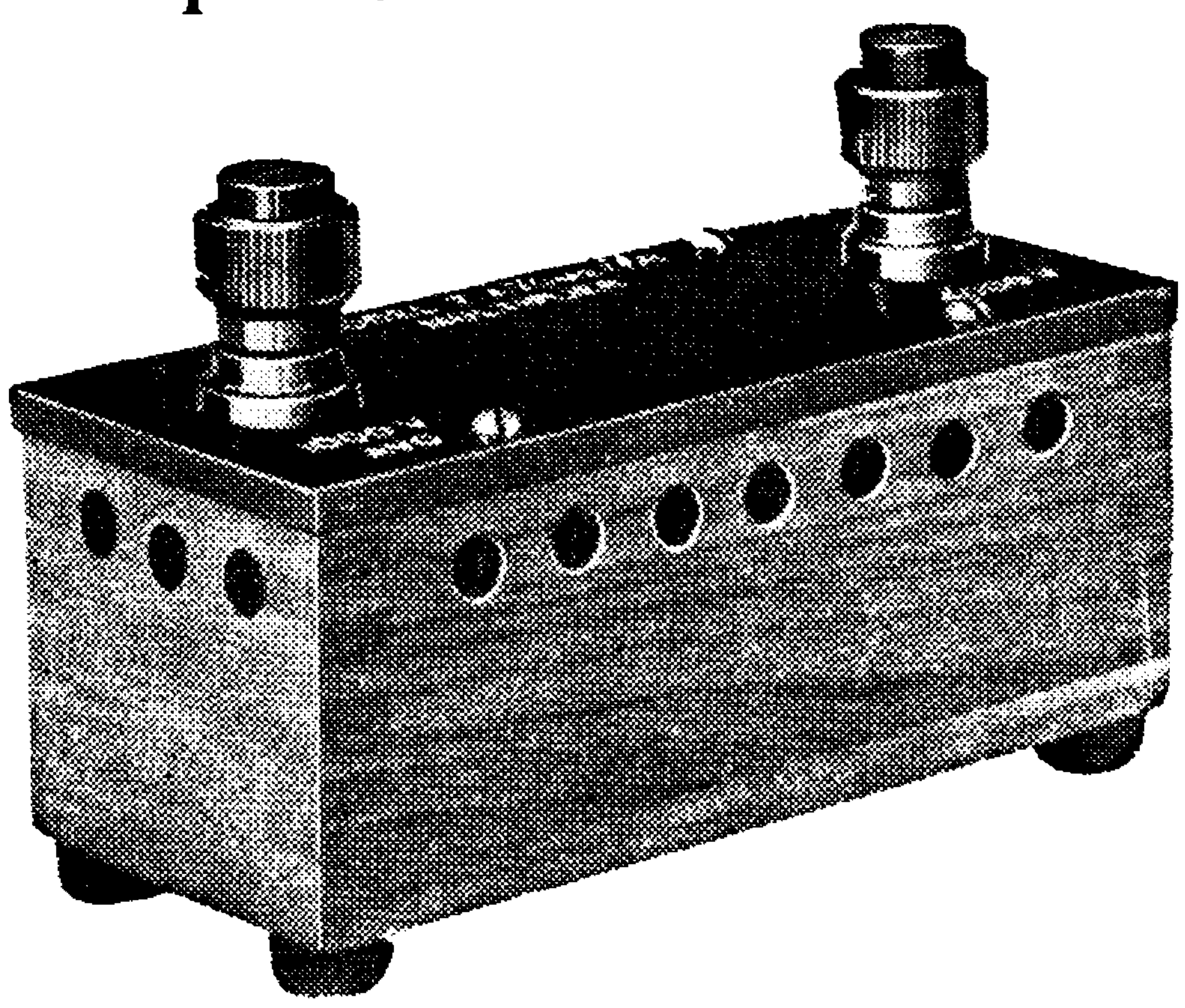
(FIG. 3)

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.

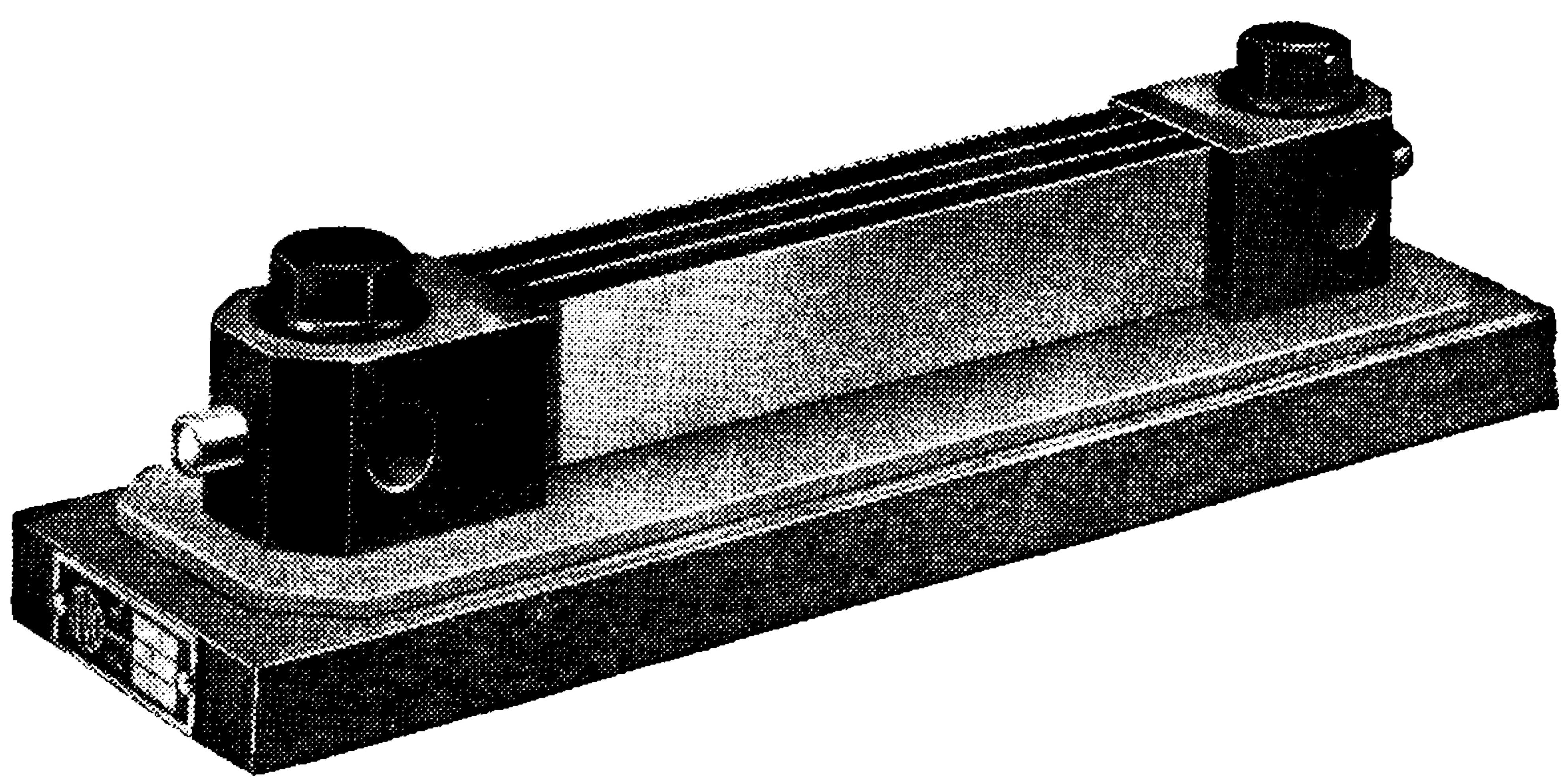


Multipliers are used to extend upwards the voltage range of the instrument and should be connected in series with the meter set to its 1,000 V. range. The same multiplier is used for " A.C." or " D.C." When in use with the multiplier the meter should be kept at the " Earthy " side of the circuit.

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. The shunt should be connected in series with the circuit upon which measurements are to be taken, by means of its two main terminals, and the meter, set to its 2 mA " D.C." position, connected to the two small studs on the shunt end blocks.

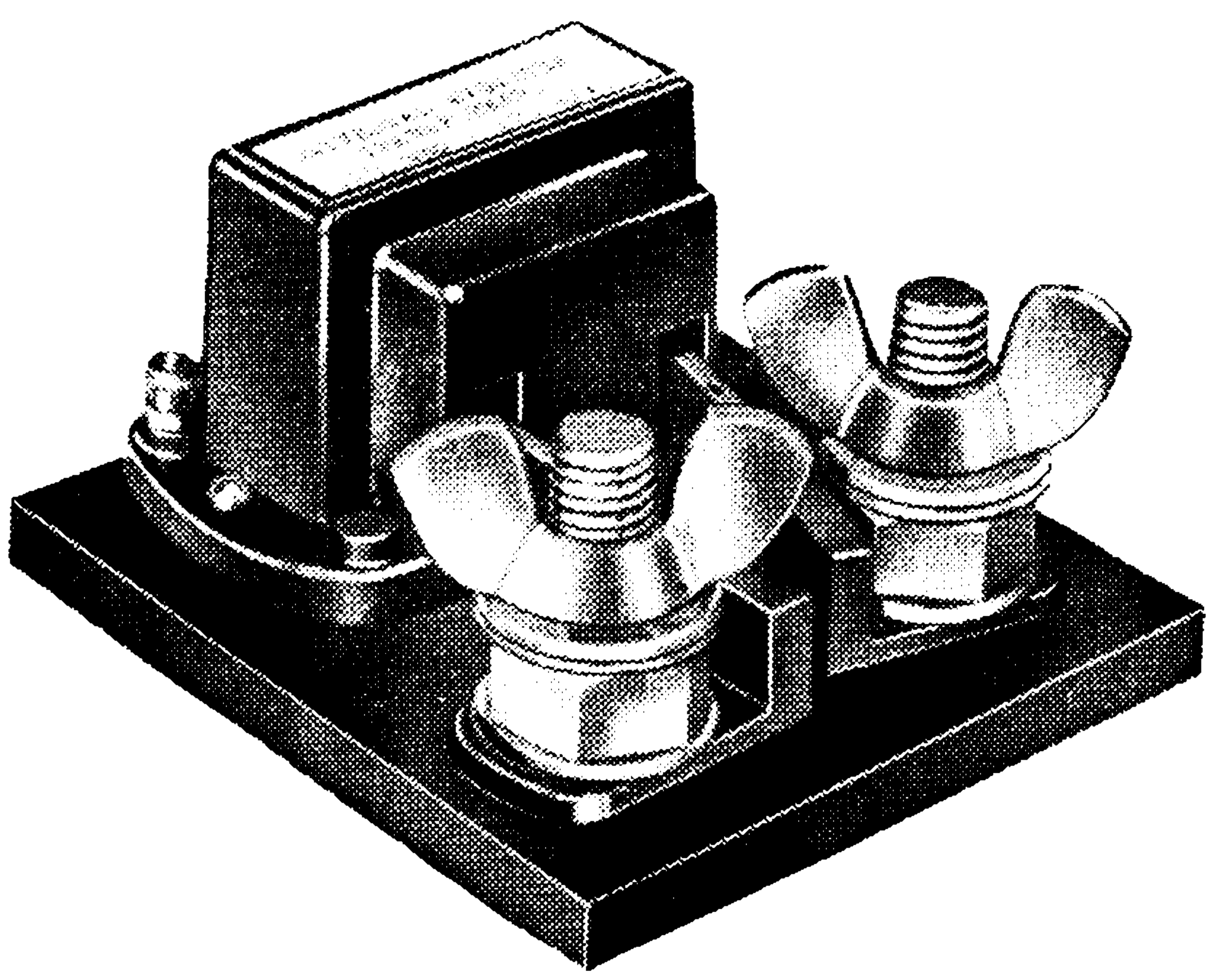
The resistance of the meter when set to its 2 mA. " D.C." range is 50 Ω, 100 mV. therefore being required to give full scale deflection. The resistance of the shunt is such that at its full rated current 100 mV. is developed, and thus the instrument set to its 2 mA. range and connected across the shunt will indicate full scale deflection.

The following shunts are available :

400 amps.
200 amps.
100 amps.
50 amps.

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.

Transformers.



Current transformers are used to extend the " A.C." current ranges on the meter. The transformer should be connected in series with the circuit under test, by means of its two large terminals.

The meter set to its 100 mA. " A.C." current range should be connected to the two small terminals upon the transformer.

Owing to the very high potential which may build up in the secondary circuit of a current transformer if left open circuited, it is most important to ensure that current is not passed through the primary, unless the meter, set to its correct range and with the cut-out properly set, is connected to the appropriate terminals of the transformer. The following transformers are available :

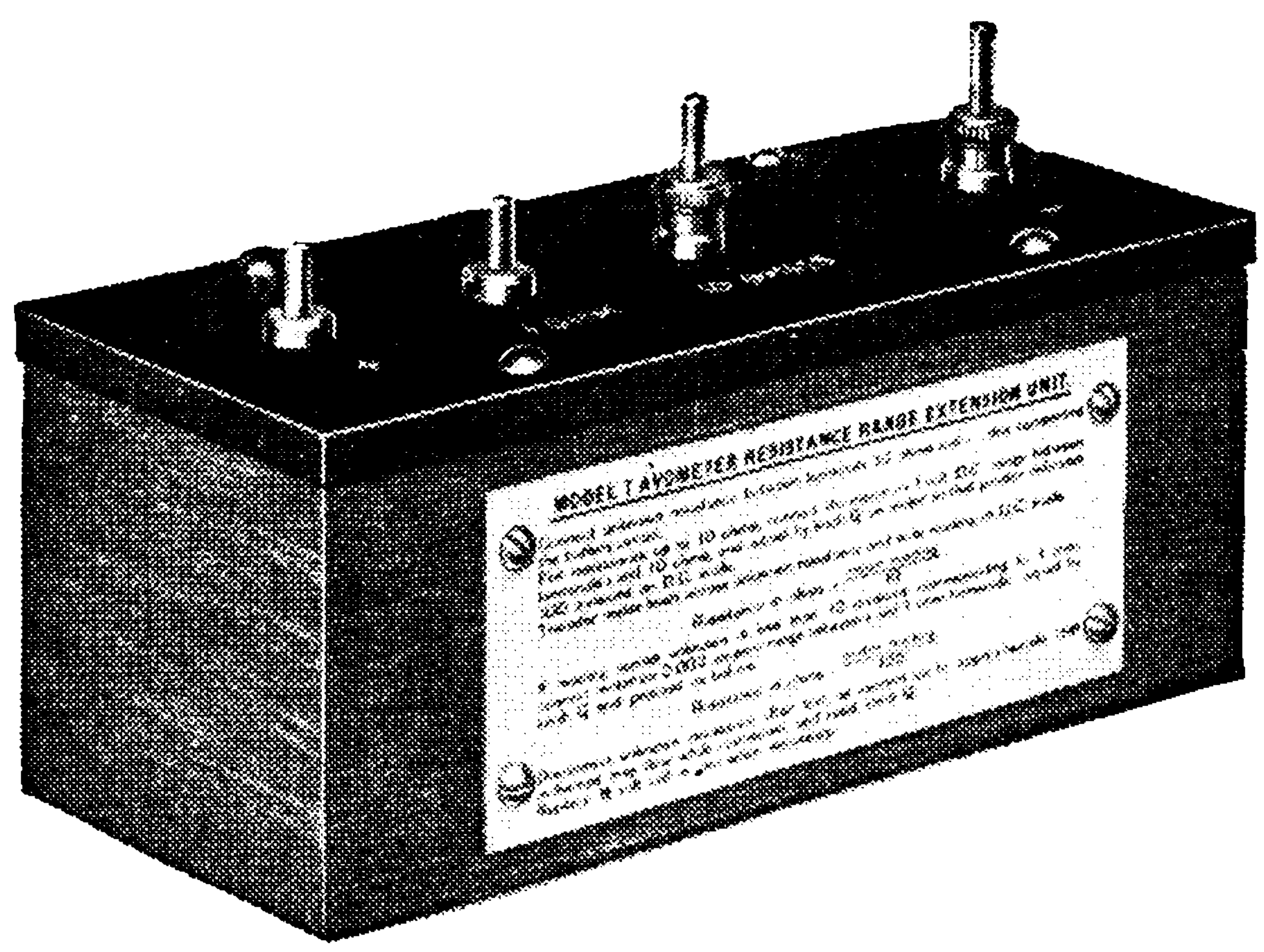
400 amps.
200 amps.
100 amps.
50 amps.

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

The operation of the divide-by-two feature halves the ranges presented by the transformers listed above.

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 2 mA. 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.

It should be noted that this accessory contains a $1\frac{1}{2}$ V. cell similar to that housed in the meter. This cell should be examined periodically to ensure that it hasn't become discharged.

THE POWER AND DECIBEL EXTENSION UNIT

THIS Unit is only applicable to Model 7 AvoMeters described in this booklet, or to an earlier pattern having the power scale 0–2 watts. It comprises two parts, these being a resistance box permitting values from 500 to 15,000 ohms to be obtained, and a calibrated disc for use in association with the " Q " knob on the meter.

It is first necessary to affix the disc to the panel in the correct position, this being done with a suitable glue or cellulose adhesive. The " Q " knob must be slightly withdrawn from the panel to permit the disc being slipped over the pointer on the knob.

The position in which to affix the disc is determined by taking any reading of current or voltage on a normal range and then rotating the " Q " knob until the pointer indicates the same position as on the normal reading.

Set the 20 mark on the disc opposite the indicator on the " Q " knob and allow adhesive to harden.

Instructions for Using Meter for Power and Decibel Measurement.

Knowing the load impedance of the output circuit to be measured, the equivalent or near value may be made up by connecting appropriate resistances (possibly singly or with series or parallel arrangements), see Table 1.

TABLE I.

Resistance (approx.)	**Power Box Connection**
500 ohms	A
650 ,,	B & C in parallel.
800 ,,	B & D ,,
1000 ,,	B
1300 ,,	C & D ,,
1600 ,,	C & E ,,
2000 ,,	C
2500 ,,	A & C in series.
3000 ,,	B & C ,,
4000 ,,	D
5000 ,,	B & D ,,
6000 ,,	C & D ,,
8000 ,,	E
10000 ,,	C & E ,,
12000 ,,	D & E ,,
15000 ,,	B, C, D & E in series

Bearing in mind the anticipated wattage, the "Q" knob should be set to a value equal to $\frac{\text{impedance}}{\text{factor chosen}}$ the factor being obtained from Table II. The A.C. switch knob must be set to the appropriate position for the wattage range chosen

Meter and resistance connected in series constitute the impedance which must be substituted for the load in output measurements, this being accomplished by connecting across the output transformer primary and open circuiting the secondary.

For use on push-pull circuits, the resistance box should be set to match the specified anode to anode load of the valve circuit, and connected across the whole of the transformer primary. The speech coil should of course be disconnected.

To obtain the correct " Q " knob setting. it is first necessary to determine a factor which is dependent on the range of wattage desired and also on the current range in use on the meter. This factor is obtained upon table II. below.

TABLE II.

Meter Range	200 mW.	2 W.	20 W.
10 mA. A.C.	100	1000	—
Spot (31.5 mA. A.C.)	10	100	1000
100 mA.	—	10	100

The Q setting of the knob should be at the value $\frac{\text{impedance.}}{\text{factor.}}$

For the 200 mW. and 20 W. ranges, subtract or add 10 db. respectively to the decibel indication on the scale plate.

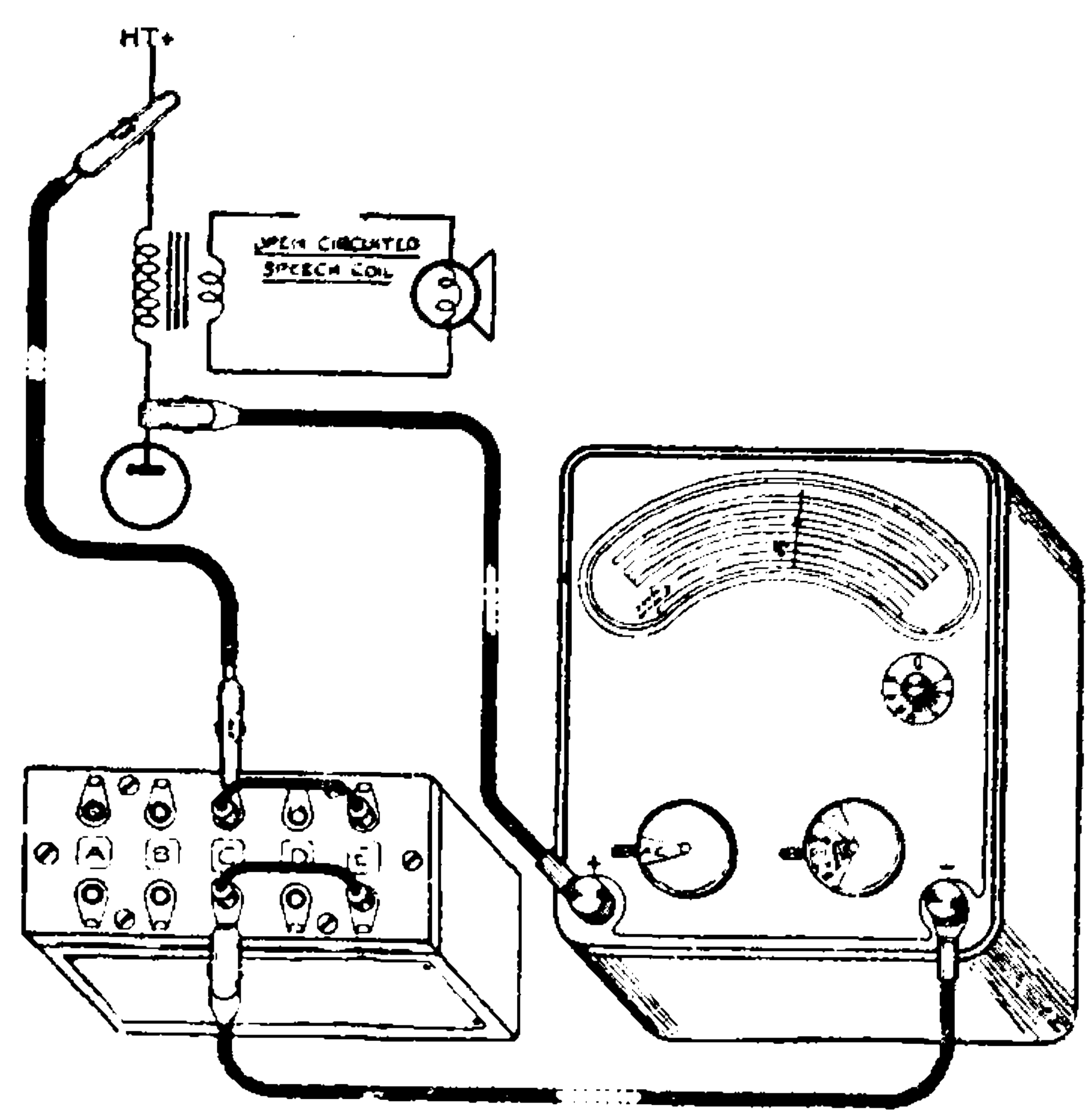
Example.

Suppose the loudspeaker impedance is 1500 ohms, and the power expected is in excess of 2 watts.

From Table I the nearest impedance available in the box is 1600 ohms, obtained by connecting C and E in parallel, this being sufficiently close for all practical purposes.

From Table II, ascertain the " Q " setting to be employed by looking down the 20 Watt column and choosing a suitable factor such that " Q " equals $\frac{\text{impedance}}{\text{factor chosen.}}$

The factor 1000 is impracticable, in this case, as " Q " $=\frac{1600}{1000}=1.6$ which is lower than the lowest mark on the disc. The factor 100 corresponding to " Q " $= \frac{1600}{100} = 16$ can be employed, this being for use with the 100 mA. A.C. range of the meter. The meter, therefore, should be set to 100 mA. A.C., the " Q " knob set to 16, the meter and power box being connected in series across the primary of the output transformer. In order that the load may be transferred from the speaker to the power box the speech coil must be open circuited.



Supposing the meter pointer indicates 600 mW. on the 2 watt scale, the actual power in this case will be 6 watts, as the range chosen corresponds to 20 watts.

The decibel indication on the scale, at the above point, would be approximately + 11, but as the 20 watt power scale is in operation instead of 2 watt, 10 should be added making + 21 db., the reference level of 0 db. being still 50 mW.

Power measurements up to about 50 watts, if of short duration, may be made. This value corresponds to half scale deflection on a theoretical range of 200 W., or about 1/6th scale on one of 2kW.

Settings are as follows :—

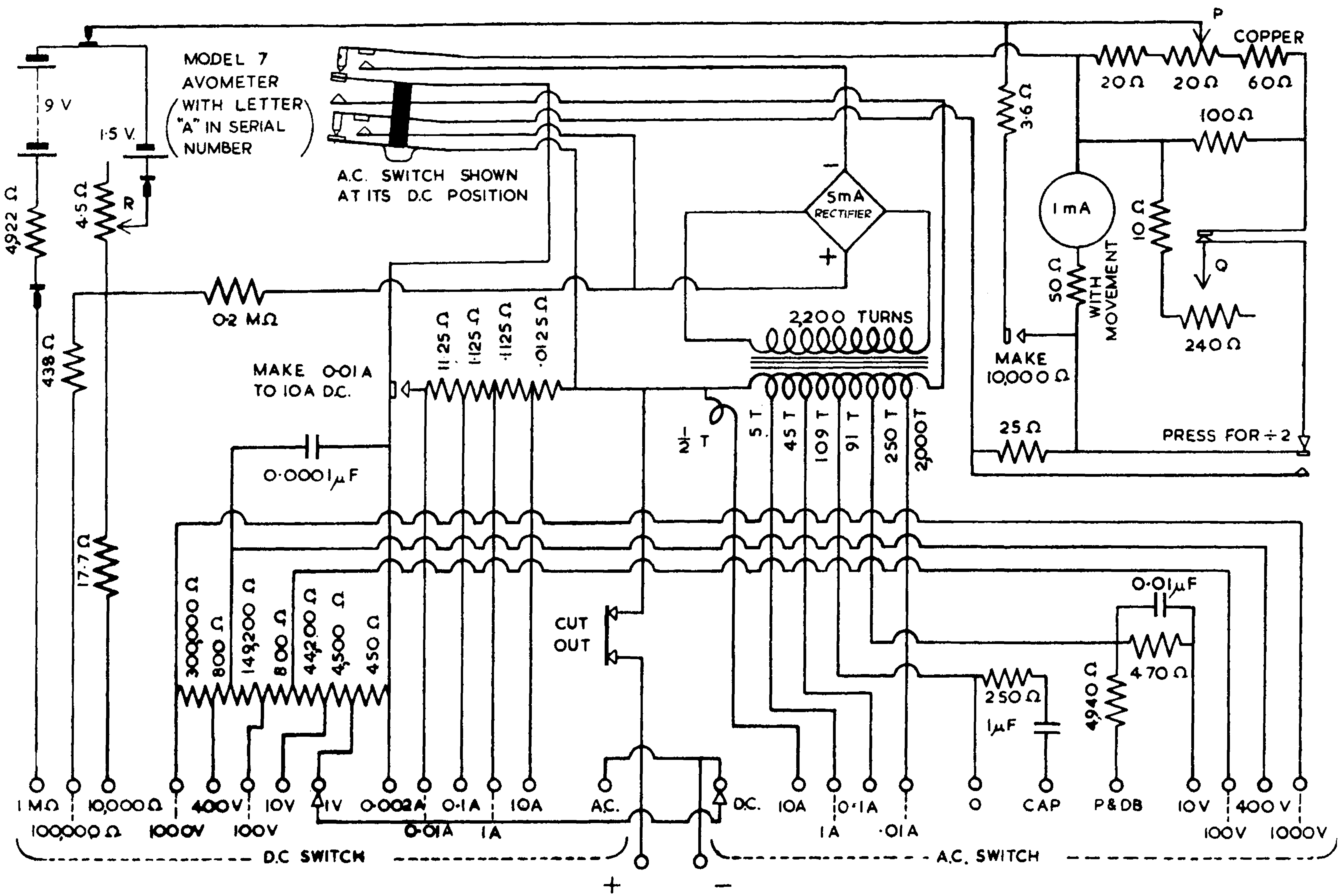
Theoretical 200 W., use 100 mA range and factor of 1000.
Theoretical 2 kW., use 1 amp. range and factor of 100.

The illustration shows the specially designed leather case which can be supplied with the Model 7 Avometer 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.

E. & O. E.



CIRCUIT DIAGRAM OF THE MODEL 7 AVOMETER