Testing Section.
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UNIVERSAL MEASURING BRIDGE

TYPE 1

WORKING INSTRUCTIONS

THE AUTOMATIC COIL WINDER & ELECTRICAL EQUIPMENT CO. LTD.
AVOCET HOUSE, 92-96, VAUXHALL BRIDGE ROAD, LONDON, S.W.1.

THE

"AVO"

UNIVERSAL MEASURING BRIDGE

TYPE I

THE AUTOMATIC COIL WINDING & ELECTRICAL EQUIPMENT CO., LTD

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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 field of radio and electronics.

The success of our steadfast policy of maintaining high standards of performance in instruments of such wide versatility, 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.

THE "AVO" UNIVERSAL MEASURING BRIDGE - TYPE 1.

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THE

AVO

UNIVERSAL MEASURING BRIDGE
TYPE I

INTRODUCTION

The "AVO" Universal Measuring Bridge Type I is one of the most easily and rapidly operated instruments of its type yet produced. Measurements of inductance, capacitance, resistance and insulation are made over 76 ranges, giving wider scope than hitherto found on instruments of this calibre.

The leading design features are as follows:—

1. The instrument has been designed in such a manner that the point of balance can be found extremely quickly. One sweep of the main calibrated dial covers four decades and assures a rapid search over the ranges provided. An automatic scale expansion device selects either of the two lower accuracy decades of the main scale, thus enabling measurements at these parts of the scale to be reproduced at the full scale accuracy. Thus, by using only two multiplier ranges for both resistance and capacitance, the following extremely wide ranges of measurements are encompassed:—

$0{\cdot}1\Omega$—$1{,}000M\Omega$. $1pF$—$1{,}000\mu F$.

2. The instrument measures resistance using D.C., and capacity and inductance using 1,000 c/s signal generated by an internal oscillator.

3. Inductance measurements can be made without consequential balancing difficulties resulting from the sequential use of the Balance and "Q" controls. On this Bridge, initial balance can be obtained for inductance and final balance given by the calibrated "Q" Balance control.

4. An extremely sensitive Valve Voltmeter is used as the Bridge Indicator, feeding a moving coil meter and provided with a Variable Sensitivity control, in order that balance sensitivity can be varied to suit the degree of out of balance condition of the Bridge. When measuring resistance, the meter assumes a centre zero position at balance and when off-balance the indicator shows the direction in which the main Potentiometer control must be moved to bring the Bridge into balance.

5. A wide range of extremely useful insulation (leakage) ranges are incorporated, leakage currents being directly indicated on the moving coil meter.

Insulation test voltages can be obtained from 5—450V D.C., the moving coil instrument giving a first indication of 0·01µA (0·1 of full scale deflection). This represents an ability to read resistances up to 45,000MΩ.

6. The internal capacity of the instrument has been eliminated electronically, thus enabling capacitors down to a few pF to be measured without the necessity of subtracting the value of the internal strays from the reading given by the instrument.

7. External resistance, capacitance and inductance standards, can be used in conjunction with the Bridge circuit. Two ranges are available, viz., ±10 per cent. of the value of the external standard, and a wide range enabling comparisons to be made up to 100 or down to 0·01 of the value of the external standard. The comparator scale (±10 per cent. of external standard) will be found to be most useful. A divergence of 1 per cent. represents approximately 0·5 in. (1·25 cm.) on a linear scale.

RANGES AND ACCURACY

Resistance Ranges: 6 calibrated ranges covering 0·1Ω—1,000MΩ.
(Accuracy ±1 per cent. at mid-scale.)

Capacity: 6 calibrated ranges covering a nominal 1µµF—1,000µF.
(Accurancy ±1 per cent. at mid-scale.)

Inductance: 6 calibrated ranges covering 1mH—1,000H.
(Accuracy ±2 per cent. at mid-scale.)

TECHNICAL DESCRIPTION

1. The Bridge incorporates standard arms of resistance for resistance measurements, and capacitors for capacity and inductance measurements, a Maxwell network being employed in the latter case. D.C. is used for the measurement of resistance against both internal and external standards, an internal source of 1,000 c/s being used for the measurement of capacity and inductance. The balancing potentiometer comprises a wiper arm (which is rigidly connected to the indicating pointer) traversing a precision wound resistance, thus endowing the instrument with a linear scale, free from backlash and slip.

Indication of balance and the reading of leakage current is given by means of a sensitive valve voltmeter which is switched to respond to either A.C. or D.C. inputs, dependent on the range in use. The employment of a valve voltmeter enables a high degree of discrimination to be maintained when measuring high value resistors which will not, of course, normally pass enough current to operate a less sensitive form of indicating device.

2. The Measurement of Resistance using Internal Standards

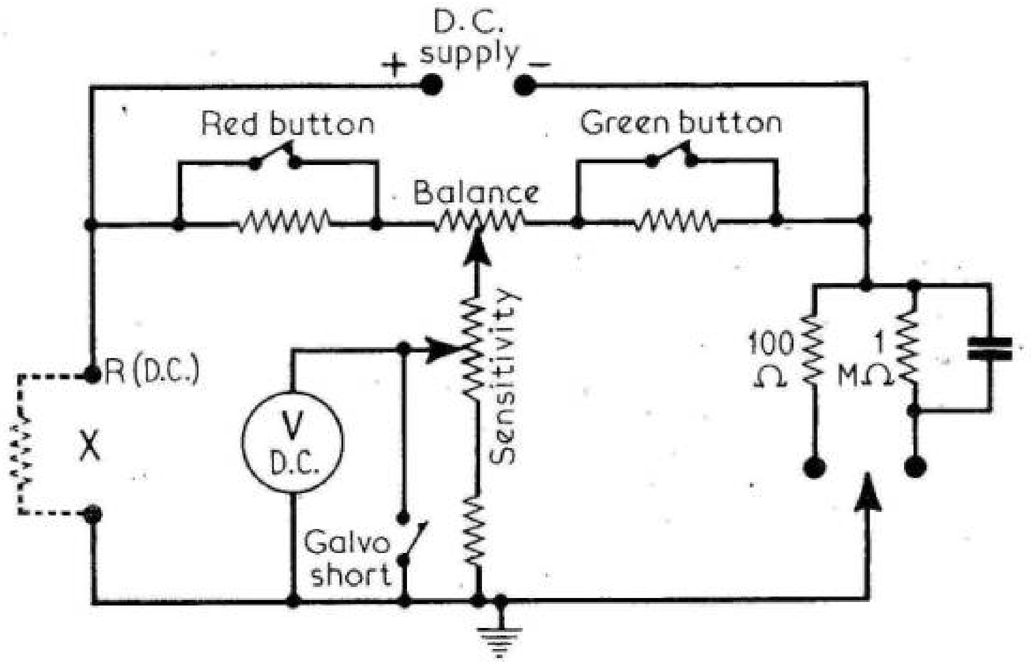


Fig. 1

This circuit is basically a D.C. working Wheatstone Bridge using a valve voltmeter as the balance indicator, and clearly illustrates the operation of the range expansion system,* in that when the switch marked "red" is opened, a resistance approximately nine times the value of the calibrated potentiometer is introduced into the circuit as an additional ratio arm, causing the Bridge to balance at values more than ten times that of the standard. In a similar manner when the red switch is closed and the green switch is opened, the Bridge will balance at values less than one-tenth of the standard. The condenser across the 1MΩ standard is inserted to keep the A.C. input impedance of the valve voltmeter low to avoid errors which might otherwise be introduced, due to stray A.C. pick-up.

* See fold-out sheet at the end of the book.

3. The Measurement of Resistance using an External Standard

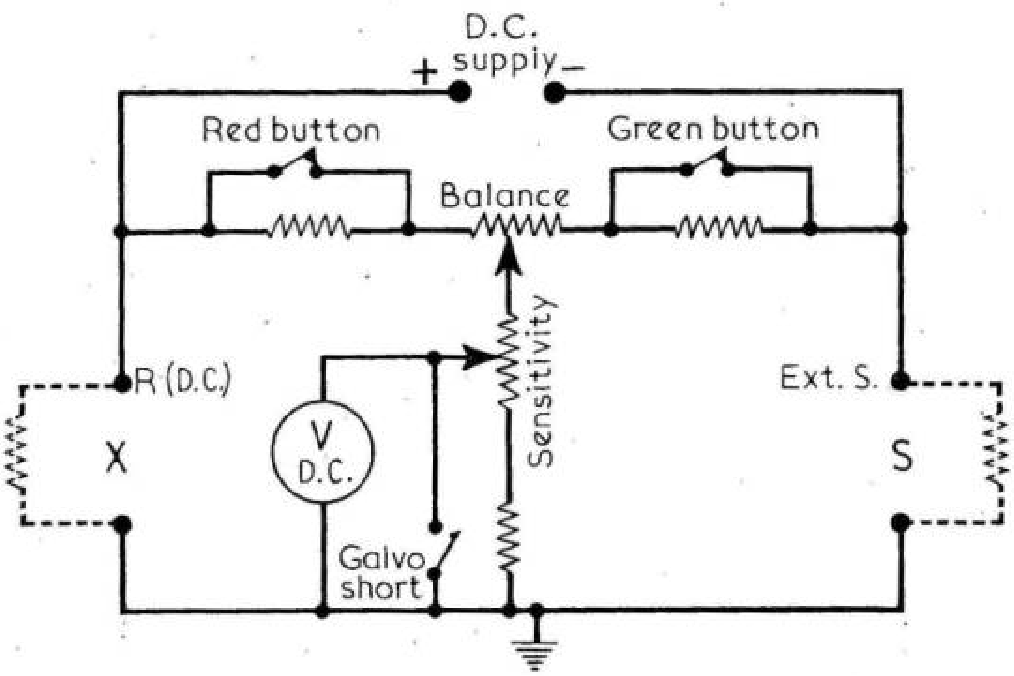


Fig. 2

This circuit is identical with that shown in Section 2, except that the standard is now provided externally by the user.

Note.—Where external standards in excess of 100,000 Ω are used, it is desirable to add a condenser of 0·05 μF in parallel with the standard.

When both the red and the green switches are opened, equal resistances of approximately nine times the variable are introduced on each side, thus giving balance within values of ±10 per cent. of the standard. This range does, therefore, become the very useful comparator range.

4. The Measurement of Capacity using Internal Standards

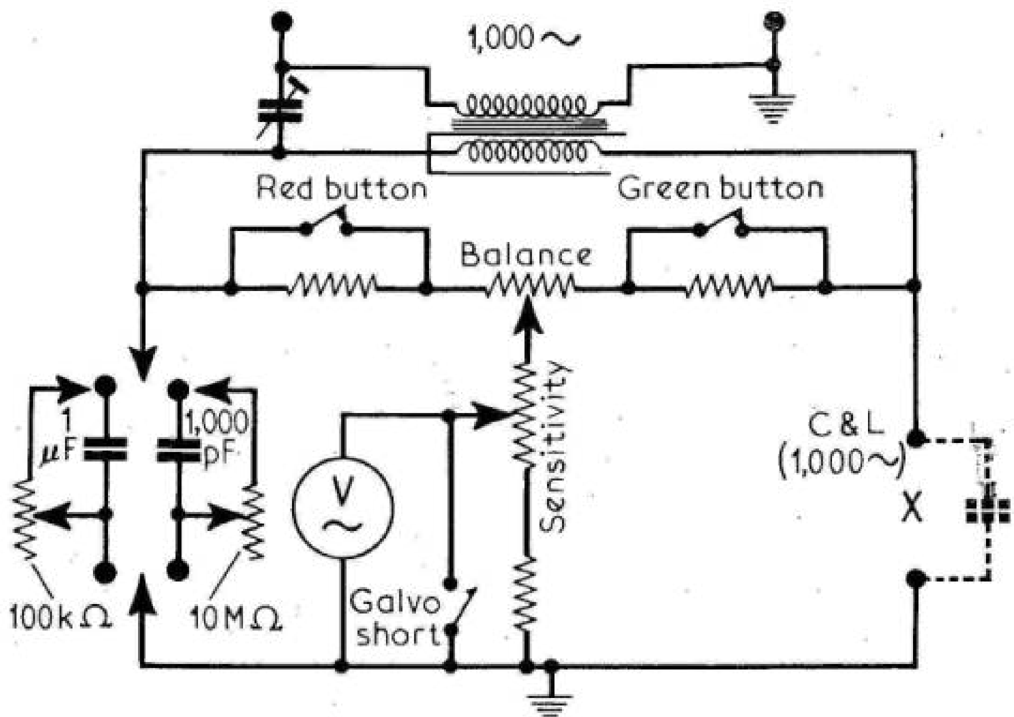


Fig. 3

This circuit will be seen to be very similar to the Wheatstone Bridge layout in Section 1, for the measurement of resistance, but it will be noted that the unknown and standard arms have been interposed. If this was not done, capacity and resistance could not be read on a common scale since the reactance of a capacitor is inversely proportional to its value and would require a mirror image scaled to that provided for a resistance. It will also be noted that the source and detector now work at 1,000 c/s instead of D.C. A small trimmer condenser forms part of the source and provides a voltage of phase and magnitude to nullify the effect of stray internal capacitance.

Note.—The values of the "Q" controls do not bear the same relationship to the impedances of the standard across which they are connected, for they have been chosen to cover a range of control appropriate to the conditions most likely to be encountered. This results in the necessity of multiplying the "Q" calibration indication by ten when using the μF (and H) range.

5. **The Measurement of Capacity using an External Standard**

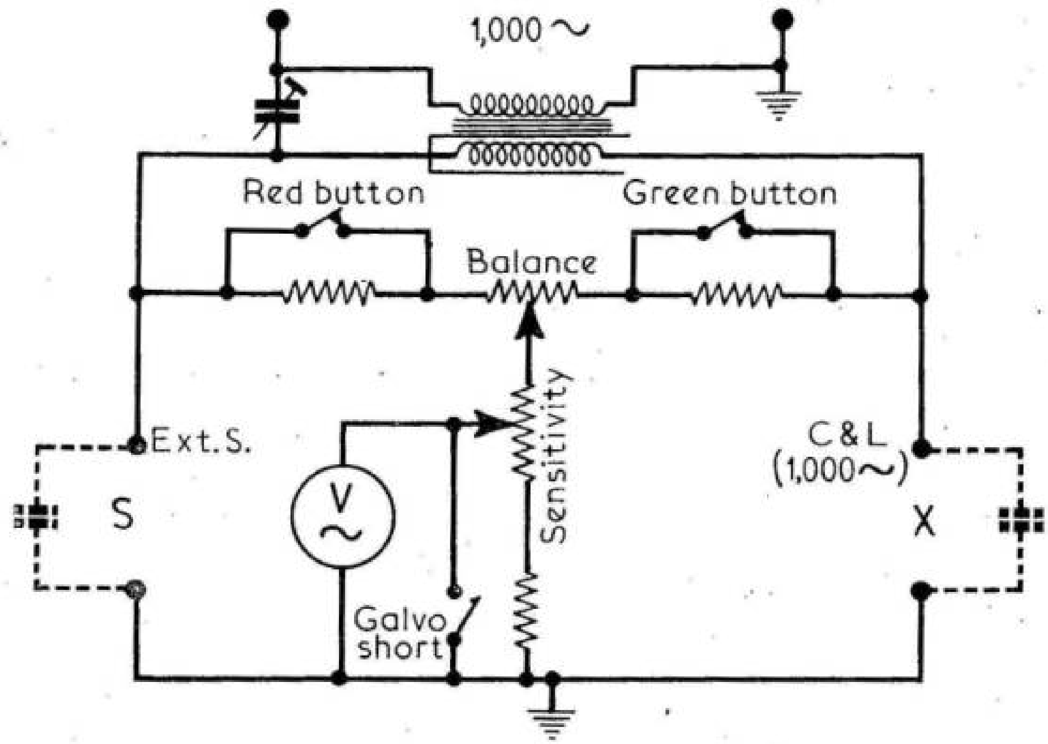


Fig. 4

This circuit is identical to that in Section 4, except that the standard is now provided by the user. When both the red and the green switches are open, equal resistances of approximately nine times the variable are introduced in each side, thus giving balance within values of ± 10 per cent. of the standard. Thus, this range can be used as a comparator range.

6. The Measurement of Inductance using Internal Standards

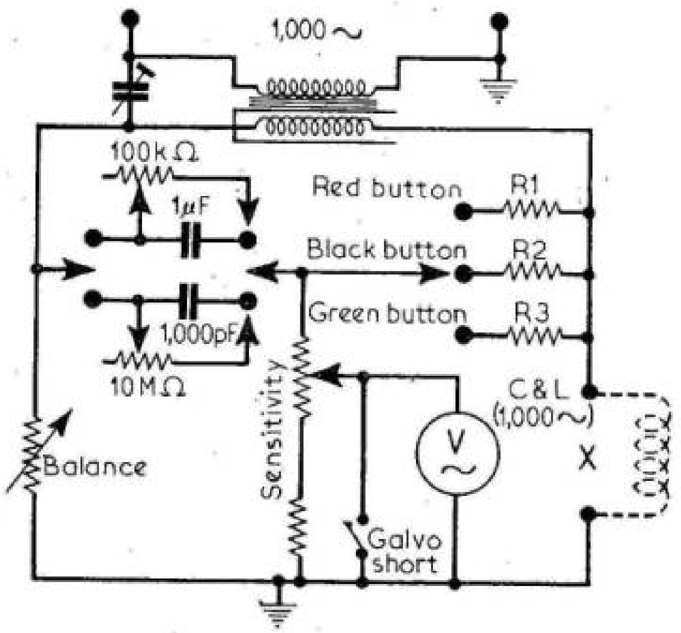


Fig. 5

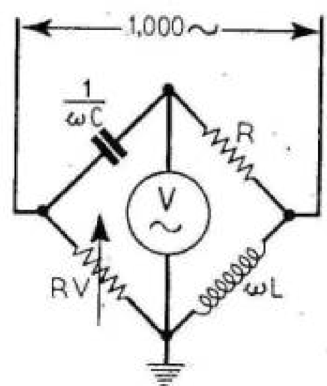


Fig. 6

This circuit is basically a Maxwell Bridge, using the same internal condensers which are employed as standards for the capacity ranges, but the potentiometer strip is now used as a variable resistor. Referring to the symbols on the sketch above, condition of balance is given when $RV.R = \frac{\omega L}{\omega C} = \frac{L}{C}$. Three ratio arms, R1, R2 and R3, are provided and are introduced by the red, black and green push-buttons.

7. **The Measurement of Inductance using an External Standard**

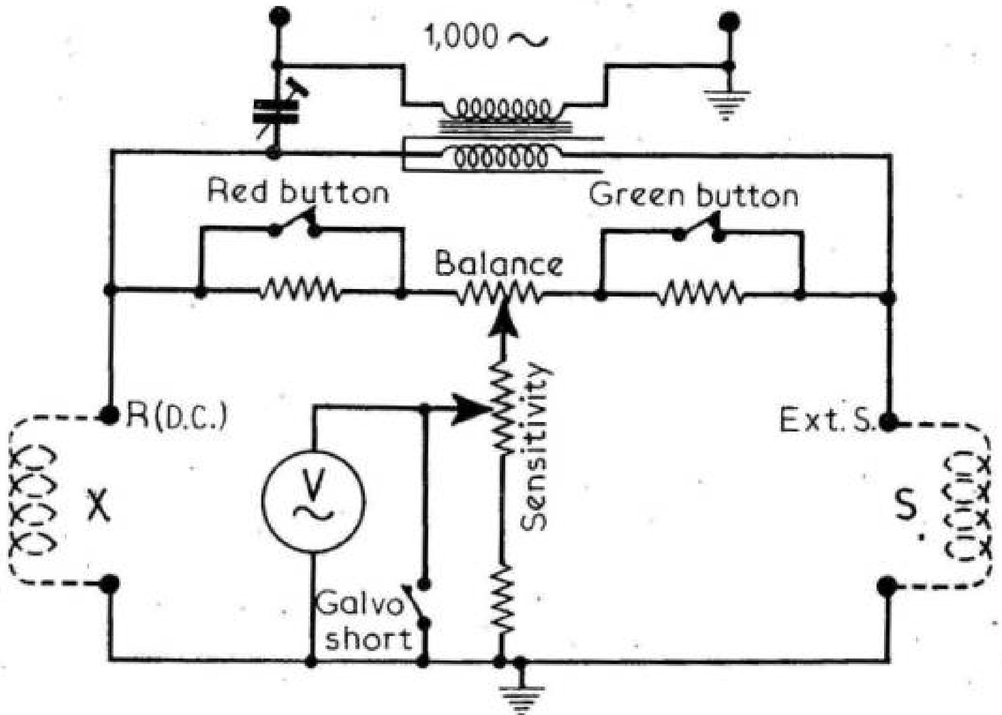


Fig. 7

Since the standard is now an inductance, the circuit employed is similar to that used for an external resistance standard (see Section 2) and the comparator scale can be used in exactly the same manner.

8. The Measurement of Insulation (or Leakage Currents in Condensers, etc.)

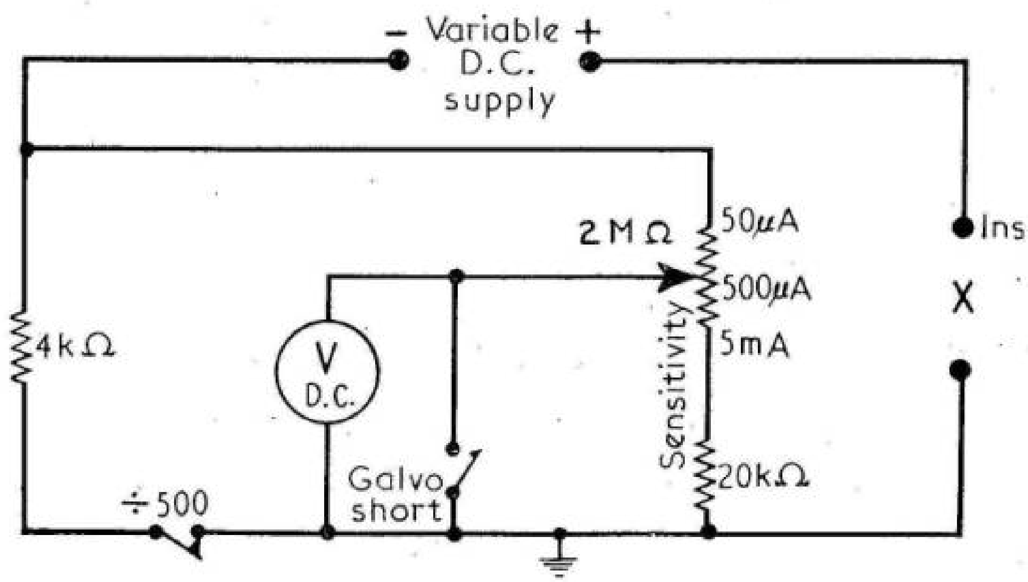


Fig. 8

In the circuit above the D.C. test voltage is selected by the insulation voltage switch and applied directly to the high potential insulation terminal. Any leakage current passing through the component under test will develop a voltage across the 4KΩ resistor which is applied to the valve voltmeter via the calibrated Sensitivity control. When the ÷ 500 switch is depressed the 4KΩ resistor is open-circuited and the whole current flows through the calibrated Sensitivity control. The instrument is now in its most sensitive condition.

OPERATING INSTRUCTIONS

These instructions assume that the user has only a slight knowledge of the use of this type of instrument and has no indication of the approximate value of the components to be measured. A more experienced user having some idea of the value of the components he intends to measure, will be able to dispense with a great deal of the procedure set out below.

Important Note.—When changing ranges or connecting or disconnecting components, the Sensivity control should always be set at its 5mA position.

9. The Expanded Scales for the Measurement of Resistance and Capacity

A very large number of Bridges produced hitherto suffer from two defects:—

(*a*) It is often difficult to find the point of balance when the operator has no idea of the value of the unknown component to be measured.

(*b*) The extremities of range scales are usually cramped and not only is it difficult to make readings at these points, but the instrument will not normally give the same degree of accuracy which it will present towards centre scale.
Bearing these short-comings in mind, a great deal of thought has gone into the design of the scales of this instrument which are shown in detail in the fold-over leaf at the end of this publication.

The scale expansion system only affects the three upper scales and therefore only these need now be considered. The second scale from the top is the basic scale, the centre point of which corresponds with the Range switch positions 1,000pF, 1μF, 100Ω and 1MΩ. If, therefore, we consider the 1,000pF range (the argument following applies to all ranges to which reference has just been made) readings can be taken direct from this scale between 100pF and 1,000pF and 1,000pF and 0·01μF. If, however, balance is obtained at the extremities of this scale, i.e., between 10pF and 100pF, or 0·01μF and 0·1μF, then these sections of the scale can be immediately expanded by pressing

(*a*) The green button, to expand the first section, and

(*b*) The red button, to expand the latter section to which we have referred.

If, for instance, we press the green button, having obtained balance between 10pF and 100pF, not only will we immediately expand this portion of the scale, but will also enable balance to be obtained between 1pF and 10pF, should the unknown be of this magnitude. (See operating notes which follow.)

10. The Inductance Scale

Readings can be taken direct on this scale in mH and in H, the two ranges being selected by means of the Range Selector switch.

11. Comparison Scale

This range will be found to be most useful when it is desired to compare newly produced components against a known standard. For instance, a motor manufacturer may wish to check the inductance of a new winding against one which is known to be perfectly operational, or it may be necessary to balance two resistors or two condensers, etc. All these tasks can easily be undertaken by this Bridge, which will present any deviation up to ±10 per cent. on a linear scale approximately 8¾ in. (19 cm.) long. Full details for using this range are given in the Working Instructions which follow.

Note.—When measuring low value resistors or capacitors and test leads are employed, the resistive or capacitive value of the leads must be measured and deducted from the value given by the Bridge for the component under test.

12. To Connect the Instrument to a Mains Supply (105–115, 200–260v. 50 c/s A.C.)

Before attempting to connect the instrument to the mains for the first time, remove the small plate at the back and ensure that the fuse is inserted between a suitable pair of clip contacts to match the A.C. supply voltage to be employed. The plate should then be replaced and the instrument connected to the mains by means of the leads provided. If not already supplied, a suitable mainsplug should then be fitted to the mains lead, the black and red leads being connected to "neutral" and "line" respectively and the green (or yellow) lead connected to "earth".

The instrument may now be switched on by means of the Toggle switch provided, and the red indicator should become illuminated. Allow the instrument a few minutes to warm up before undertaking any tests.

13. To Measure Resistance using Internal Standards

(*a*) Connect unknown between terminals ⏚ and R (D.C.).

(*b*) Depress the black scale selector button.

(*c*) Set the Range switch to 100Ω.

(*d*) Check that the Sensitivity control is in its 5mA position.

(*e*) Press the Galvo short button and adjust the balance indicator to the centre zero by means of the Centre Zero control. Release Galvo short button.

(*f*) Turn the Balance control until the scale cursor is at the left-hand end of its traverse.

(*g*)† Note the position of balance indicator which will normally be to the left of the centre. (For resistances in excess of 1Ω.)

† Should the balance indicator read to the right when the cursor is to the extreme left of its traverse, the value of the unknown is less than 1Ω, and therefore, the green button should be pressed and balance sought on the green range between 0·1Ω and 1Ω. Where the unknown resistance is less than 10Ω the ⏚ and R (D.C.) terminals should be shorted and the internal resistance (this is normally about 0·1Ω) determined, and deducted from the balance reading of the unknown.

(*h*) Traverse the scale cursor to the right by means of the Balance control, continuously noting the position of the balance indicator needle, for if it passes through its centre position this is indicative of the Bridge passing through its condition of balance. Having found this condition of balance by turning the Balance control one way and then the other until the balance indicator needle is in its central position, increase the sensitivity of the valve voltmeter by means of the Sensitivity control, maintaining the needle at its central position by means of the Balance control. When the Sensitivity control is set to 50µA obtain final balance and then depress the Galvo short button. This operation should cause no further movement of the indicating needle. If it does, however, check once more the zero setting of the indicator by adjusting the Centre Zero control and then re-balance the Bridge.

(*i*)* If balance is not obtained during the traverse of the cursor from left to right, change the Range switch to its 1MΩ position. The balance indicator will now normally change from left of centre to right of centre indicating that the value of the unknown is less than 100MΩ.

* Should the balance indicator read to the left when the cursor is at the extreme right of its traverse, the value of the unknown is greater than 100MΩ, and therefore the red button should be pressed and balance sought on the red scale between 100MΩ and 1,000MΩ. If the balance indicator still remains to the right it is indicative that the value of the unknown is greater than 1,000MΩ or is open circuited.

(*j*) Traverse the cursor from the right to the left by means of the Balance control and determine point of balance as in (*h*).

(*k*) At the point of balance, the value of the unknown can be read directly from the calibrated scale, but should the balance point fall within the green or the red sections where discrimination and accuracy are slightly reduced, the appropriate green or red button should be pressed and the Bridge re-balanced as in (*h*). The value of the unknown can now be read directly from the appropriate expanded green or red scale.

14. To Measure Resistance using External Resistance Standard

Employing the Ratio Scales

(*a*) Connect unknown between terminals ⏚ and R (D.C.).

(*b*) Connect standard between terminals ⏚ and EXT. S.

(*c*) Depress black scale selector button which gives balance over the limits of 0·1—100 times the value of the external standard.

(*d*) Set the Range switch to EXT. R.

(*e*) Use the Balance, Sensitivity, Centre Zero and Galvo short controls as for finding balance using internal resistance standards. (Section 13 (*h*)).

Employing the Comparison Scale

(*f*) If balance is obtained within 0·9 and 1·1 of the value of the standard, the red and green buttons should be pressed and engaged simultaneously, thus enabling the comparator scale to be used. This is the bottom linear scale calibrated ±10 per cent.

Note.—If it is desired to use the comparator scale immediately to check components which should be within very close tolerances, these should be connected to the Bridge as already described, the red and green buttons pressed and engaged simultaneously enabling balance to be immediately obtained on the comparator scale.

15. To Measure Capacity using Internal Standards

(*a*)† Connect unknown capacitor between terminals C and L (1,000 c/s) and ⏚

† Electrolytic condensers must be "formed" before being tested. See Section 20.

(*b*) Depress black scale selector button.

(*c*) Set Range switch to 1,000pF.

(*d*) Switch off the "Q" control.

(*e*) Check that the Sensitivity control is set to its 5mA position.

(*f*) Turn the Balance control until the scale cursor is at the left-hand end of its traverse.

(*g*) Traverse the scale cursor to the right by means of the Balance control, continuously noting the position of the balance indicator needle, for the Bridge will be balanced when this needle falls to its furthest position in an anti-clockwise direction. Having found this condition of balance by moving the Balance control one way and then the other until the indicator is in its most anti-clockwise position, increase the sensitivity of the valve voltmeter by means of the Sensitivity control, maintaining the needle at its most anti-clockwise position by means of the Balance control.

(*h*) When the Sensitivity control is finally set to its 50μA position, turn the "Q" control clockwise and adjust both it and the Balance control to bring the indicator needle into its furthermost anti-clockwise direction. The Bridge will now be correctly balanced and the value and "Q" (also power factor) of the component under test can now be obtained from the instrument. Power factor is approximately equal to $\frac{1}{\text{"Q"}}$ for large values of "Q".

(*i*)* If balance is not obtained during the traverse of the cursor from left to right, change the Range switch to its 1μF position.

* *Note.*—The user may find it impossible to find balance anywhere on the basic scale, for if the value of the component under test is between 1pF and 10pF or 100μF and 1,000μF, it will only be possible to balance the Bridge at the extremities of the green and red scales with the appropriate buttons depressed.

(*j*) Traverse the cursor from right to left by means of the Balance control, and determine point of balance as in (*g*).

(*k*) At the point of balance, the value of the unknown can be read directly from the calibrated scale, but should the balance point fall within the green or the red sections where discrimination and accuracy are slightly reduced, the appropriate green or red button should be pressed and the Bridge rebalanced as in (*g*). The value of the unknown can now be read directly from the appropriate expanded green or red scale.

16. To Measure Capacity using an External Standard Capacitor

Employing the Ratio Scales

(*a*)† Connect the unknown between terminals ⏚ and C and L (1,000 c/s).

† Electrolytic condensers must be "formed" before being tested. See Section 21.

(*b*) Connect standard between terminals ⏚ and EXT. S.

(*c*) Depress the black scale selector button which gives balance over the limits of 0·1—100 times the value of the external standard.

(*d*) Set the Range switch to EXT. C.

(*e*) Switch off the "Q" control and check that the Sensitivity control is set to its 5mA position.

(*f*)‡ Obtain point of balance on basic scale as set down in Section 15 (*g*).

‡ The procedure for balancing the Bridge when using an external standard capacitor varies very slightly from the procedure employed when using an internal standard, for when the range switch is set to its EXT. C. position the "Q" control is no longer operative and the instrument is therefore balanced by means of only the Balance Control.

It should also be realised that there is an unavoidable internal capacitance (about 100μμF) across the EXT.S. terminal and earth which could cause an appreciable comparison error. When making capacity comparisons, therefore, below approximately 0.05μF, it is suggested that this internal capacitance is balanced by an external variable air condenser connected across the C and L (1,000 c/s) and earth terminals before the comparison standard and the un-known are connected.

Employing the Comparator Scale

(*g*) If balance is obtained within 0·9 and 1·1 of the standard, the red and green buttons should be pressed and engaged simultaneously, thus enabling the comparator scale to be used. This is the bottom linear scale calibrated ±10 per cent.

Note.—If it is desired to use the comparator scale immediately to check components which are known to be within very close tolerance, these should be connected to the Bridge as already described, and the red and green buttons pressed and engaged simultaneously enabling balance to be immediately obtained on the comparator scale.

When using this method of comparing one external condenser with another, particularly when large condensers (paper or electrolytic) or silver ceramic condensers having a bad power factor at 1,000 c/s are being used, it is desirable to introduce a subsidiary power factor balancing circuit by connecting the low potential sides of the standard and the unknown, to the ends of a potentiometer of a suitable value, the slider of which is connected to the earthy terminal (see sketch below). The potentiometer should, of course, be of a suitable value to suit the likely power factor and reactance of the component under test, and will generally require to be large enough to more than compensate for the difference in ohms between the two reactances, caused by their individual power factors/capacity.

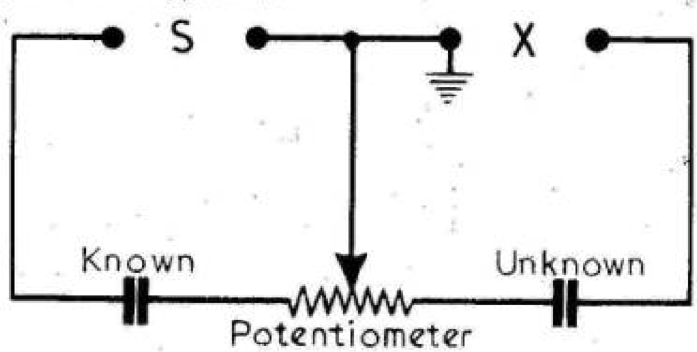


Fig. 9

17. To Measure Inductance using Internal Standards

(*a*) Connect the unknown inductance between terminals C and L (1,000 c/s) and ⏚

(*b*) Depress the green L ÷ 10 selector button.

(*c*) Set Range switch to mH.

(*d*) Switch off the "Q" control.

(*e*) Check that the Sensitivity control is set to its 5mA position.

(*f*) Turn the Balance control until the scale cursor is at the left-hand end of its traverse.

(*g*) Traverse the scale cursor to the right by means of the Balance control, continuously noting the position of the balance indicator needle, for the Bridge will be balanced when this needle falls to its furthermost position on an anti-clockwise position. Having found this condition of balance turn the "Q" control clockwise and adjust both it and the Balance control to bring the indicator needle into its furthermost anti-clockwise position.

(*h*) Increase the sensitivity of the valve voltmeter by means of the Sensitivity control maintaining the needle at its most anti-clockwise position by means of the Balance and "Q" controls. The Bridge will now be correctly balanced and the value and "Q" of the component can now be obtained from the instrument.

*If balance is not obtained during the traverse of the cursor from left to right, depress the black L × 1 button and traverse the cursor to the left. If balance is still not obtained, depress the red L × 10 button and traverse the cursor to the right. If it is impossible to find a balance point, set the range switch to the position H and repeat the whole procedure using the three scale selector buttons consecutively. If it is still impossible to find the balance point the inductance of the component under test will be outside the measuring limits of the instrument.

* Inductance measurements are read directly from the scale marked $L \frac{mH}{H}$

If the L × 1 selector button is depressed readings are given directly from this scale. The L ÷ 10 and the L × 10 buttons, when depressed require readings on the scale to be divided by 10 in the case of the former, and to be multiplied by ten in the case of the latter.

18. To Measure Inductance using an External Standard Inductance

Employing the Ratio Scales

(*a*) Connect the unknown between terminals ⏚ and R (D.C.).

(*b*) Connect standard between terminals ⏚ and EXT. S.

(*c*) Depress the black scale selector button which gives balance over the limits of 0·1—100 times the value of the external standard.

(*d*) Set the Range switch to EXT. L.

(*e*) Switch off the "Q" control, and check that the Sensitivity control is set to its 5mA position.

(*f*) Obtain balance on the basic scale as set down in Section 17 (*g*).

Note.—The procedure for balancing the Bridge when using an external standard inductance varies very slightly from the procedure employed when using an internal standard, for when the Range switch is set to its EXT. L. position the "Q" control is no longer operative, and the instrument is therefore balanced by means of only the Balance control.

EMPLOYING THE COMPARISON SCALE

(*g*) If balance is obtained within 0·9 and 1·1 of the standard, the red and green buttons should be pressed and engaged simultaneously, thus enabling the comparator scale to be used.

This is the bottom linear scale calibrated ±10 per cent.

Note.—If it is desired to use the comparator scale immediately to check components which are known to be within very close tolerances, these should be connected to the Bridge as already described and the red and green buttons pressed and engaged simultaneously, enabling balance to be immediately obtained on the comparator scale.

When comparing one external inductance with another, it is desirable to introduce a subsidiary power factor balancing circuit by connecting the low potential sides of the standard of the unknown to the ends of a potentiometer of a suitable value, the slider of which is connected to the earthy terminal (see the sketch below). The potentiometer should, of course, be of a suitable value to suit the likely power factor and reactance of the component under test, and will generally require to be large enough to more than compensate for the difference in ohms between the two reactances, caused by their individual power factors/reactances.

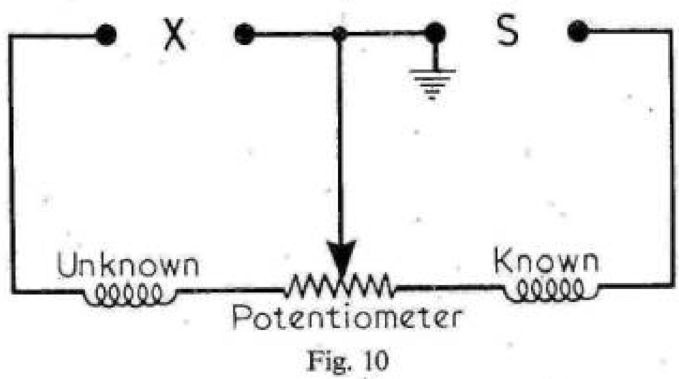


Fig. 10

Due to the self capacitance of some chokes above 100H it will sometimes be found to be impossible to balance the inductance bridge, due to the choke running into resonance at the testing frequency of 1,000 c/s and thus altering the phase relationships in the Bridge network.

19. **The Measurement of Insulation (or Leakage Currents) in Condensers, etc.**

NOTE.—THIS TEST EMPLOYS D.C. VOLTAGES UP TO 450V, AND SINCE A SHOCK AT THIS VOLTAGE COULD PROVE TO BE FATAL THE USER IS ADVISED TO TAKE THE UTMOST PRECAUTIONS HIMSELF AND TO ENSURE THAT THE INSTRUMENT IS NOT USED BY UNSKILLED PERSONNEL. THE PROCEDURE WHICH FOLLOWS ENSURES THAT A CONDENSER UNDER TEST IS DISCHARGED BEFORE IT IS REMOVED FROM THE INSTRUMENT. IF, FOR ANY REASON, A CONDENSER IS REMOVED FROM THE INSTRUMENT IN A CHARGED STATE, ITS TERMINALS SHOULD BE IMMEDIATELY SHORTED TO AVOID AN ACCIDENT.

(*a*) Turn the INS. V. D.C. control to position 5.

(*b*) Set the Range switch to INS.

(*c*) Turn the Sensitivity control to its 5mA position.

(*d*) Connect component to be tested between terminals ⏚ and INS. The INS. terminal is positive (it is important to note this point when checking polarity conscious components such as electrolytic condensers and rectifiers).

(*e*) Turn the INS. V. D.C. control to the required test voltage.

(*f*) Check that the indicator is at its centre zero position by depressing the Galvo short button and adjusting the Centre Zero control.

(*g*) Immediately the Galvo short button is released, the indicator will indicate a leakage current of 0—5mA. (Zero is at mid-scale.) To make the indicator more sensitive, turn the Sensitivity control to its 500μA position; the indicator will now indicate 0—500μA. To increase the sensitivity still further, turn the Sensitivity control to its 50μA position. The indicator will now indicate leakage current of 0—50μA.

(*h*) If it is still not possible to obtain an indication of leakage current, return the Sensitivity control to its 5mA position and depress the leakage ÷ 500 button to indicate leakage currents of 0—10μA. To increase sensitivity still further, release the leakage ÷ 500 button, change the Sensitivity control to its 500μA position, depress the leakage ÷ 500 button to indicate leakage currents of 0—1μA. To operate the indicator in its most sensitive position, release the leakage ÷ 500 button set the Sensitivity control to its 50μA position and depress leakage ÷ 500 button to indicate leakage currents of 0—0·1μA. When using this latter range the zeroing of the indicator should be re-checked as described in Section (*f*) before the reading is finally taken.

Note.—When using the leakage indicator in its most sensitive condition to measure leakage currents in high value paper condensers, the user may obtain continuous flickering of the needle due to the effect of slight changes in mains voltage charging and discharging the condenser when operating in this state of extreme sensitivity.

THE USER MUST NOT CHANGE THE POSITION OF THE SENSITIVITY CONTROL WHILST THE LEAKAGE ÷ 500 BUTTON IS DEPRESSED, FOR IF THIS IS DONE, CHARGING CURRENTS ARE LIKELY TO DAMAGE THE INDICATOR.

(*i*) At the termination of the test, release the leakage ÷ 500 button, turn the Sensitivity control to its 5mA position, turn the INS. VOLTS D.C. control to position 5 and wait a few moments for the component to discharge before removing it from the terminals of the instrument.

We have only just been able to give the general outline of testing components *in situ*. There are a number of limitations which the user must learn to appreciate. It will invariably be essential for him to be provided with a circuit diagram of the apparatus he is testing and when, in particular, checking older electronic apparatus, one cannot always assume that the D.C. leakage current of capacitors can be ignored.

20. "Forming" Electrolytic Condensers

Before an electrolytic condenser can be tested or used as an external standard it must be "formed" by subjecting it to the leakage test set down in Section 19. Care must be taken to increase the test voltage in steps from 5V, constant watch being kept to ensure that the "leakage" current does not overload the indicator. When the working voltage of the condenser has been reached, it should be kept in circuit until the leakage current ceases to fall. This may take a few moments for a component which has been in recent use, but many minutes for a component which has been in store.

The component should then be removed from the Bridge as described and immediately tested for capacity or used as an external standard. If it is desired to use the polarised capacitor as an external standard for a long period arrangements should be made to supply a suitable polarising voltage from a D.C. source via a high value resistor as shown in Fig. 11.

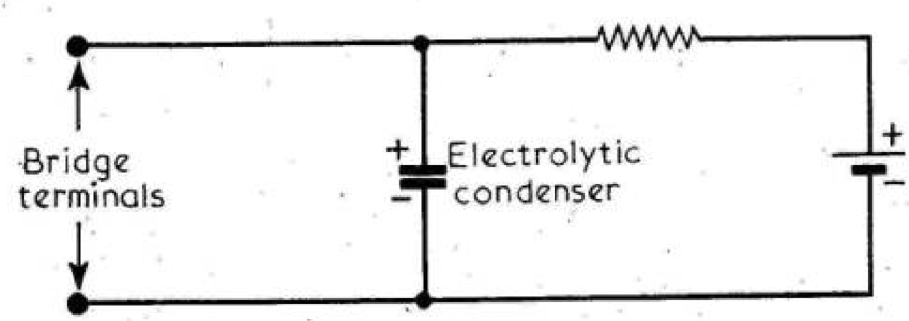


Fig. 11

21. The Measurement of Components in situ

The "AVO" Universal Measuring Bridge does, as already described, use D.C. for the measurement of resistance and A.C. at 1,000 c/s for the measurement of capacitance and inductance. It will thus be appreciated that on resistance tests the D.C. test voltage will be isolated by paper or mica condensers in good condition, which happen to be in the circuit under test.

The problem of measuring components *in situ* revolves around the ability of the Measuring Bridge to pass current through only that component, the value of which we desire to measure. Referring to the Fig. 12 below and assuming that C1 and C2 are good quality paper or mica condensers, the Universal Measuring Bridge can be used to measure the D.C. resistance of the choke AB and the resistance AC by placing test leads across these appropriate points, for there is no circuit through the condensers as far as D.C. is concerned. Thus the user will realise how advantageous it is that this particular Bridge uses D.C. and not A.C. to make resistance measurements, for otherwise tests of this type would be impossible due to the passage of the A.C. test voltage through the condensers.

It may not be possible to carry out tests in this way if C1 and C2 are electrolytic condensers, for they may pass a leakage current which will produce erroneous results.

To check the capacitance of either C1 or C2, one side of the component must be isolated, and, in a similar manner, one side of the inductance L1 will have to be disconnected before an inductance check can be made (except in those cases where C1 and C2 are so small, and therefore their reactances at 1,000 c/s so high, that their presence can be ignored). In some circuits where a capacitor is shunted by a resistance it may be possible to balance out the effect of this shunt resistance by means of the "Q" control on the instrument.

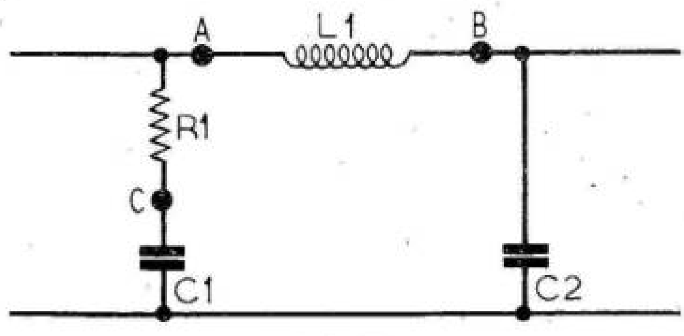
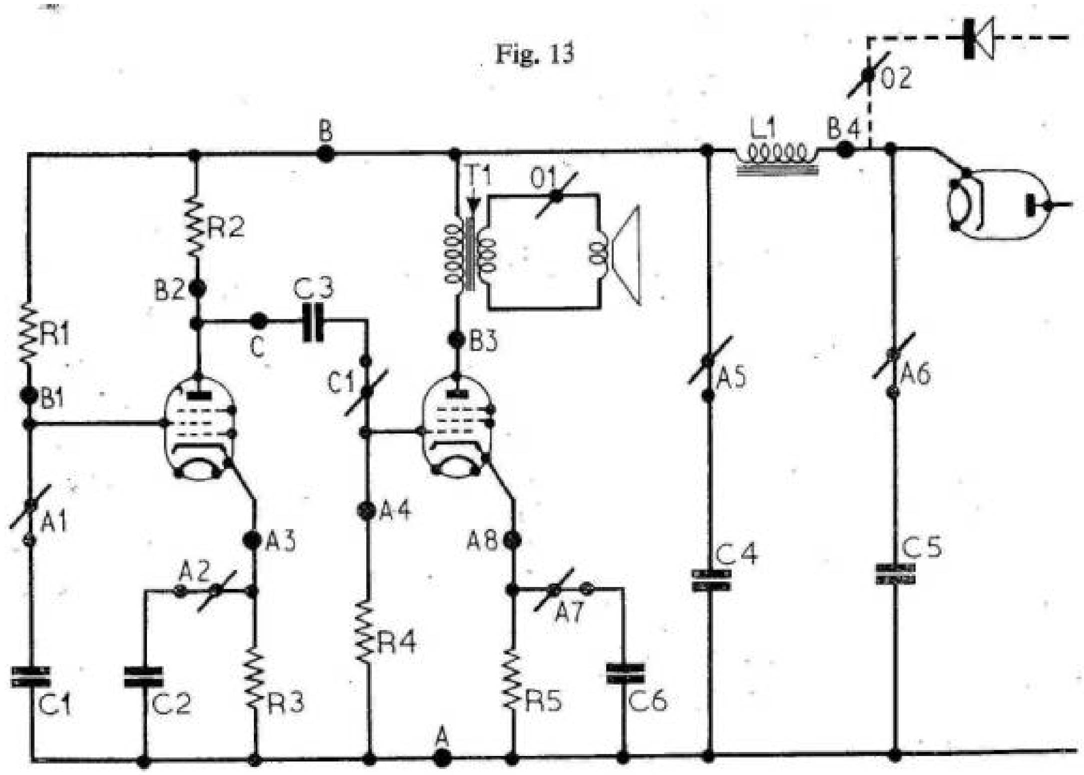


Fig. 12

Now that we have discussed the theory of checking components *in situ*, we may consider the simple circuit shown in Fig. 13. The table shows against each of the components, the points at which connections should be made to check certain components, the terminals to be used on the instrument, and also where components are to be disconnected before a test is made. It should be noted that the secondary of T1 should be open-circuited (at position O1) before taking inductance measurements on the primary. If the circuit employs a metal rectifier and it is desired to make tests using test point B, then one side of the rectifier must be open-circuited (position O2) to avoid the possibility of erroneous readings being introduced due to the test voltage leaking through the rectifier.

Fig. 13



•Connection points. ø • Disconnection and connection points—connection made to circuit at dot. øO1 Disconnect when measuring primary of T1. ø O2 Disconnect for tests using point B if metal rectifier is employed.

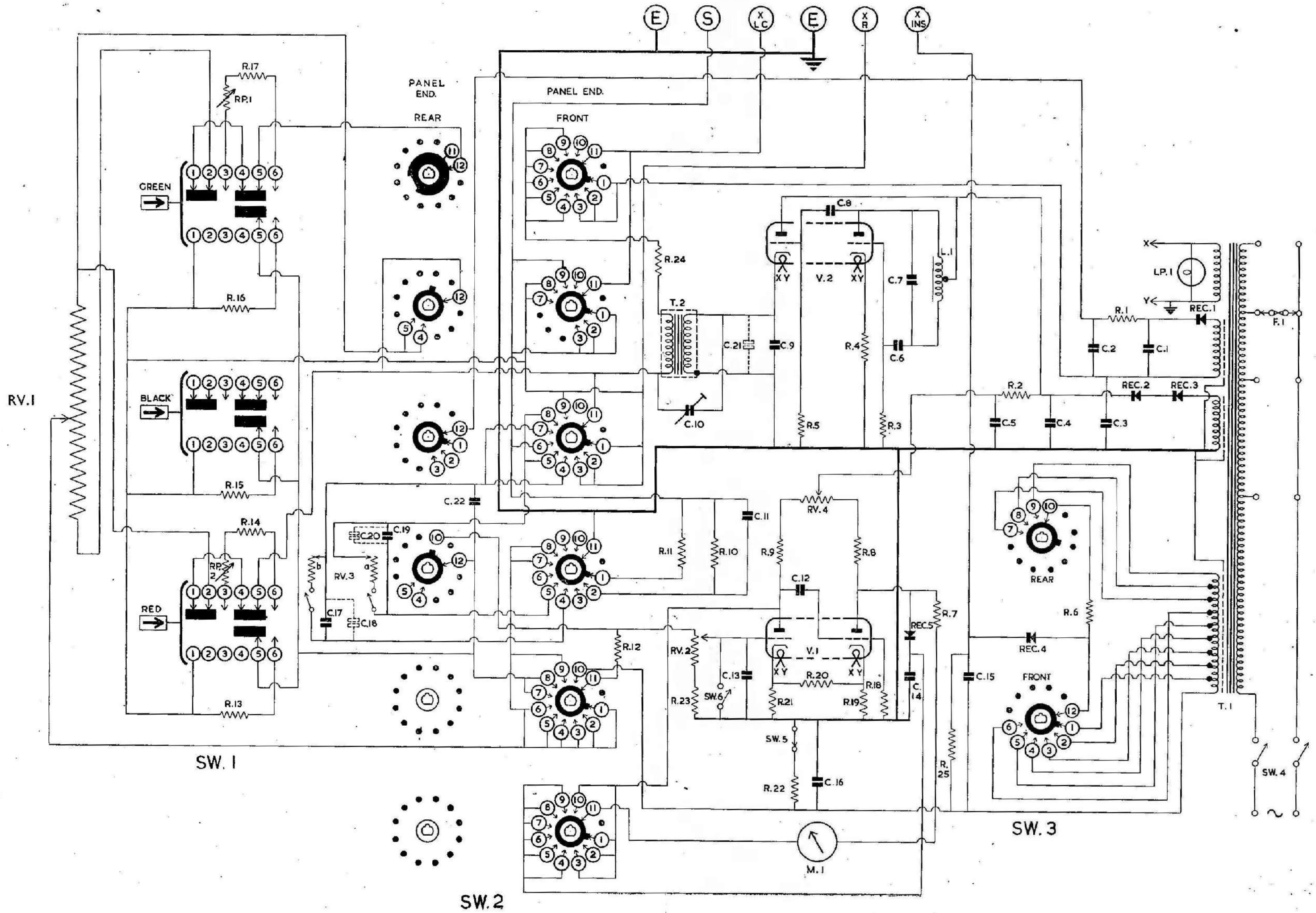
	Terminal —	*Terminal R (D.C.)*	*Terminal C and L (10,000 c/s)*	*Remarks*
C1	A		A1	
C2	A		A2	
C3	C		C1	
C4	A		A5	Not necessary to disconnect if reactance of L1 is very high.
C5	A		A6	Not necessary to disconnect if reactance of L1 is very high.
C6	A		A7	
R1	B	B1		
R2	B	B2		
R3	A	A3		
R4	A	A4		
R5	A	A8		
T1	B	B3		To measure resistance.
T1	B		B3	To measure inductance.
L1	B	B4		To measure resistance.
L1	B		B4	To measure inductance.

Cir. Ref.	*Value Ω*	*Tol.*	*Type*
R.1	680	±5%	AW3115
R.2	10 K.	±5%	8
R.3	50 K.	±5%	8
R.4	1·5 K.	±5%	9
R.5	510 K.	±20%	16
R.6	7·5 K.	±20%	9
R.7	30 K.	±1%	C.23
R.8	50 K.	±1%	C.22
R.9	50 K.	±1%	C.22
R.10	1 M.	±1%	C.22
R.11	100	±1%	C.23
R.12	47 K.	±10%	9
R.13	200 K.	±1%	C.23
R.14	50 K.	±1%	C.22
R.15	20 K.	±1%	C.23
R.16	2 K.	±1%	C.21
R.17	50 K.	±1%	C.22
R.18	47 K.	±10%	9
R.19	2 K.	±2%	C.21
R.20	7·5 K.	±1%	C.22
R.21	2 K.	±2%	C.21
R.22	3·9 K.	±5%	16
R.23	20 K.	±5%	8
R.24	390	±10%	8
R.25	510 K.	±20%	16

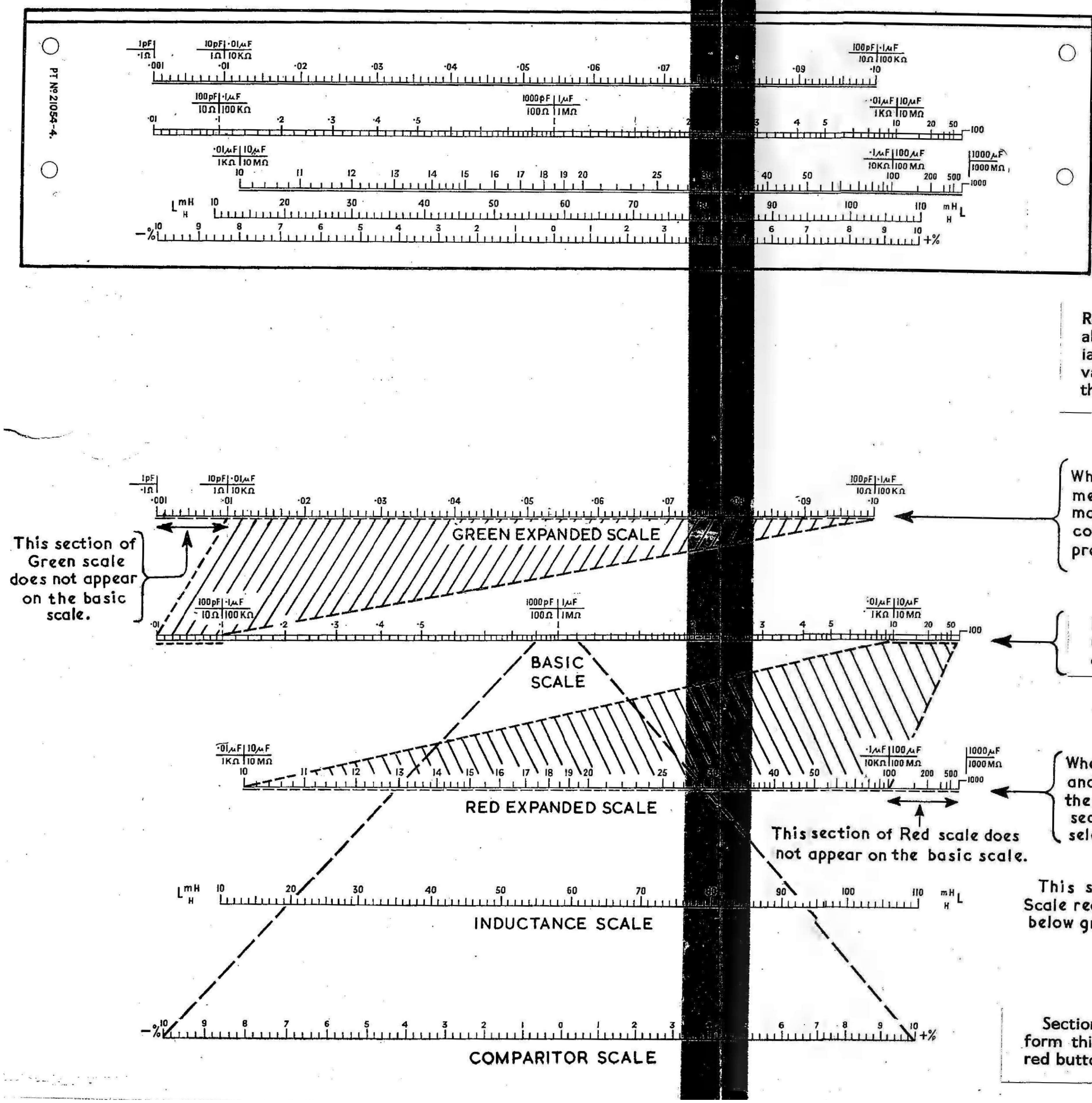
Cir. Ref.	*Value*	*Tol.*	*Working Volts*
C.1	16μfd	—	
C.2	+16μfd	—	350
C.3	·05μfd	±20%	350
C.4	16μfd	—	
C.5	+16μfd	—	350
C.6	·01μfd	±20%	350
C.7	·02μfd	±20%	500
C.8	·01μfd	±20%	350
C.9	·05μfd	±20%	350
C.10	1pfd to 8 pfd	Trimmer	—
C.11	·05μfd	±20%	350
C.12	·01μfd	±20%	350
C.13	2200pfd	+50% —0%	500 503
C.14	·1μfd	±20%	
C.15	8μfd	—	450
C.16	·25μfd	±25%	150
C.17	850pfd	±2%	350
C.18	5pfd to 60pfd	±5%	—
C.19	1μfd	±1% —10%	400
C.20	·05μfd to ·01μfd	±5%	350
C.21	·003μfd to ·01μfd	+80% —20%	—
C.22	100pfd	±5%	—

Cir. Ref.	*Type*
REC.1	R.M.I. S.T.C.
REC.2	R.M.O. S.T.C.
REC.3	R.M.O. S.T.C.
REC.4	K.8-20 S.T.C.
REC.5	GEX.34
LP.1	6·5V. ·3 amp. MES.
SW.1	Push Button (ganged)
SW.2	Range Switch
SW.3	Insulation Switch
SW.4	D.P.D.T. Toggle
SW.5	Insulation ÷ 500
SW.6	Galvo Short
T.1	Mains Transformer
T.2	Amplifier Transformer
L.1	Oscillator Inductance
M.1	Movement
F.1	1 Amp.
V.1	12AU7
V.2	12AU7
RV.1	5850 Ω ± 50 Ω
RV.2	2M Ω Log Law
RV.3	Ganged a = 0·1M Ω, b = 10M Ω
RV.4	5K Ω ± 10%
RP.1	2K Ω
RP.2	2K Ω

CIRCUIT DIAGRAM FOR "A.V.O." UNIVERSAL MEASURING BRIDGE TYPE 1



THE SCALEPLATE OF THE AVO UNIVERSAL M[illegible]ING BBRIDGE



Method of scale calibration

RANGE SWITCH SET TO 1,000pF

RANGE SWITCH SET TO 1μF

·01μF	10μF
1 kΩ	10MΩ

RANGE SWITCH SET TO 100Ω

(A)

RANGE SWITCH SET TO 1MΩ

Reference points on the scaleplate are marked as above and relate to the calibration point immediately below the vertical line A. The four values of the position indicated relate back to the setting of the Range switch.

When making resistance or capacity measurements and balance is obtained in the section marked of the basic scale, this expanded scale, covering that section can be obtained by depressing the green selector button.

Basic scale for resistance and capacity measurements. Also acts as comparator scale in conjuction with bottom percentage scale.

When making resistance or capacity measurements and balance is obtained in the section marked of the basic scale, this expanded scale, covering that section can be obtained by depressing the red selector button.

This scale is only used for Inductance readings. Scale readings must be multiplied by factor given below green, black and red scale selector buttons.

Section shown of basic scale can be expanded to form this ± 10% comparator scale when green and red buttons are depressed and engaged simultaneously.