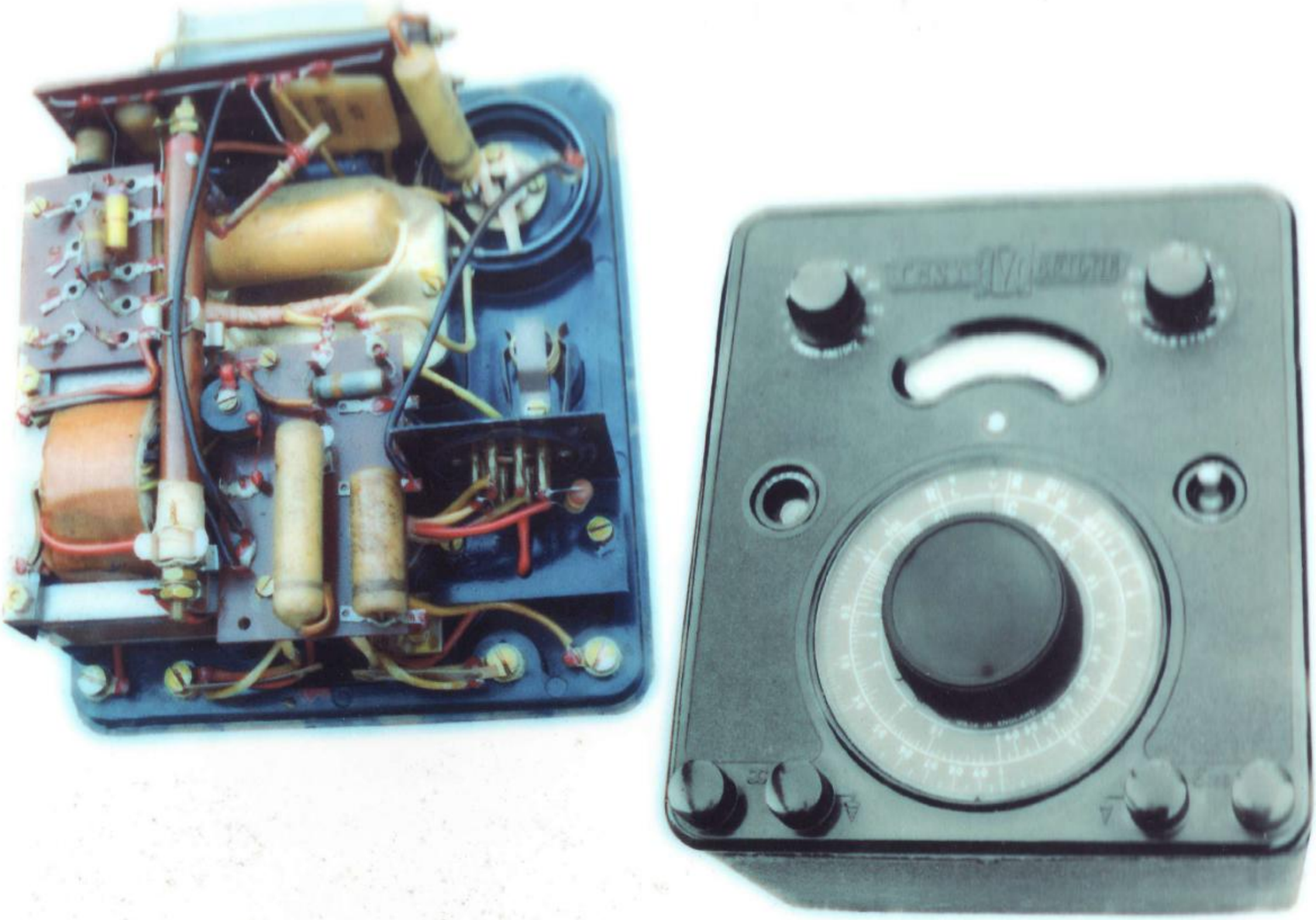
Restoration Manual

AVO Test Bridge

Peter Wotton



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AVO Test Bridge

1. Introduction

This Manual is concerned with restoring the small, bench, AVO Test Bridge (ATB) manufactured from about 1936 to 1947.

The contents include: The full text of the original manual issued with each unit; the original circuit diagram, cleaned up, with all components re-labelled and values added; an illustration identifying and locating all the main component positions; a full technical breakdown of the circuit; and details on restoration and fault finding.

These ATBs, some sixty years old (the one on the cover is dated 1947), have existed on a rapidly-advancing technical market and are now usually seen as Collectors' items. Nevertheless the design was so sound that the AVO B150 Bridge, issued some 30 years later, is essentially the same Bridge. When restored, the ATB is still and excellent piece of gear, accurate and with a wide range; for anybody interested in using different bridge methods, it is also most flexible.

Some word about the conventions adopted. For Frequency, Cycles has been used instead of Hertz. For Resistors: the omega symbol has been omitted on the circuit diagram and parts list; values such as 250Ω are shown as 250; values such as 1,200Ω, often shown as 1.2k, are given the modern 1K2 — and similarly throughout. For capacitors the terminology of the day, as folloed by AVO has been used. At the time of the ATB the word micro (a millionth, 10^{-6}, nowadays μ) was abbreviated to m, hence microFarad became mF or mfd (AVO used both). The modern pF (10^{-12}, as with nF, 10^{-9}, unknown at this time) was therefore mmfd or mmF.

Finally, safety: the ATB's metal case is connected internally to the circuit's earth and this must be connected to mains earth; the metal of the on/off switch is isolated, check with a high voltage Megger to ensure that there is no leakage to the mains leads.

2. AVO Test Bridge
Working Instructions

Mains Supply

The instrument is normally suitable for use on 50 cycles A.C. mains supply of 220-240 volts, unless otherwise stated on Meter scale plate.

Range of Measurement

Condensers from 5 mmF-50 mF can be measured and resistance measurements can be made from 5 ohms-50 megohms. Except at the extreme ends of the ranges, the accuracy of measurement is within 5%. Whilst the logarithmic nature of the scales allows roughly constant percentage discrimination for all values of resistance and capacity. The bridge is also suitable for measurements against external standards.

The indicating valve voltmeter can be used as a sensitive measuring device for external alternating voltage up to medium broadcast frequencies with reasonable accuracy, the logarithmic nature of the scale shape giving a wide range of 0.1V-15V

General Instructions

Connect the unknown condenser or resistance to the 'X' terminal and set the SELECTOR switch to the correct range, which will depend on the approximate capacity or resistance of the sample to be tested. Rotate the calibrated dial until the meter indicates minimum deflection, showing that the bridge is balanced. The value of the unknown will then equal the value of the internal standard capacity or resistance, depending on whether a condenser or resistance is being tested, multiplied by the reading on the calibrated scale. When testing components with one connection 'earthy,' such as condensers with one side connected to a shielding case, etc, the earthy connection should be made to the terminal marked ⏚.

To Measure Capacity of Unknown Condenser

Proceed as above, using the selector ranges. Cl, C2 or C3 and reading on the calibrated scale C. For capacities from 5 mmF (.000005 mF) to 1000 mmF (.001 mf) use range C1, the internal standard on this range being 100 mmF (.0001 mF). For capacities front 1000 mmF (.001 mF) to 100,0000 mF (.1mF) use range C2, the internal standard on this range being 10,000 mmF (.01 mF) For capacities 0.1mF to 50 mF use range C3, the internal standard on this range being 1 mF.

Example

Using range C1, balance is obtained with a reading 2.4 on the calibrated scale C. The unknown therefore equals 100 mmF x 2.4 = 240mmF (.00024 mF)

To Measure Value of Unknown Resistance

Proceed as general instructions. using selector ranges RI, R2 or R3 and read on the calibrated scale R. For resistances from 5 ohms-1000 ohms, use range R1, the value of the internal standard being 100 ohms. For resistances from 1000 ohms-100,000 ohms, use range R2, the value of the internal standard being 10,000 Ohm. For resistances from 100,000 ohms-50 megohms use range R3, the value of the internal standard being 1 megohm.

Example

A nominal ¼ megohm resistance, when measured on range R3, might give balance with a reading of 0.28 on the calibrated scale R. The actual value of the resistance is therefore 1 megohm x 0.28 = 280,000 ohms.

Power Factor Measurements

When testing large value Condensers, especially electrolytics, on range C3 balance will often be indicated without the needle reaching its proper minimum reading. This is caused by condenser losses which may be balanced out by rotating the POWER FACTOR control until balance is obtained with meter needle at proper minimum. The reading of this control then indicates directly the percentage power factor of the unknown. When making normal measurements on range C3 this control should be left set at 0.

Leakage of Condensers

To test for leakage, leave the condenser connected to the terminals 'X' as for capacity tests, and rotate the calibrated dial to the "click" position L. Set the SELECTOR switch to position L. The rate of flashing of the neon lamp will then indicate the amount of leakage I n the condenser. It must he noted that for a given amount of leakage, in the rate of flashing will be greater and the amount of glow will become less as the capacity of the unknown decreases. As the condenser charges up an initial flash will be noticed but after this the lamp should remain unlighteded for a perfect condenser.

Measurements Against External Standards

If desired, measurements of resistance, capacity and inductance may be made against external standards by connecting the unknown to the 'X' terminals and the standard to the terminals marked 'ext.' The SELECTOR switch should be set to E and the dial rotated for balance in the normal way. The value of the unknown will be the reading on the dial multiplied by the value of the standard. Dial readings should be made on Scale C for condensers and scale R for resistances or inductances. Owing to the low test frequencies large errors may be caused if the inductance being tested has a high D.C. resistance compared with its reactance (low Q) For this reason, the Bridge is most suitable for measurements of inductance above 0.1 H

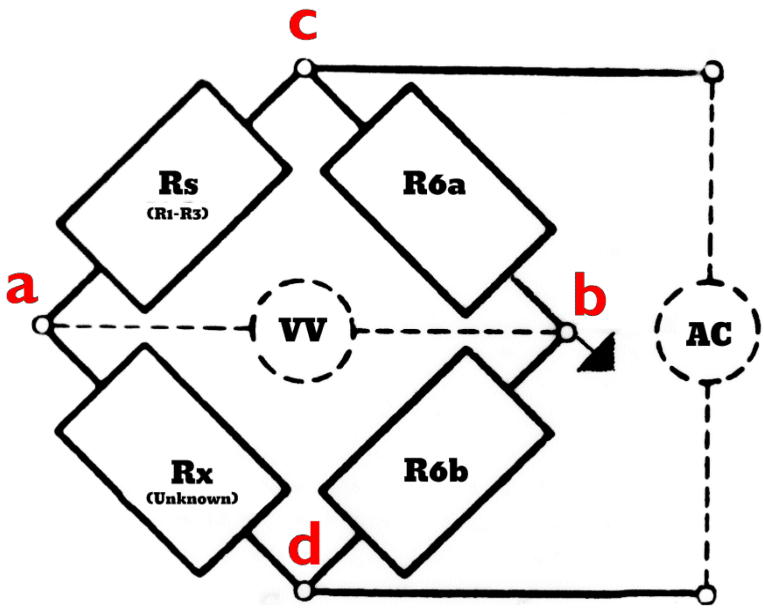
Use of Valve Voltmeter for External Voltage Measurements

To use the indicating valve voltmeter for external voltage measurements, set the dial to "click" position V and the SELECTOR switch to V. The voltage to be read should be applied to the terminals 'ext,' the terminal marked ⏚ being earthy. The voltage is then indicated directly in volts on the meter scale

3. Circuit Breakdown

The AVO Test Bridge (ATB) is essentially a simple AC Bridge using a Valve Voltmeter (VV) as a balance detector.

Bridge



The Bridge principle was first introduced by S. H. Christie in 1833 but was neglected until 1843 when Sir Charles Wheatstone drew attention to Christie's idea. In 1891, following the lead of Oberbec (1892), Max Wein produced his alternating current bridge. The first AC power plant in the UK wasn't opened until 1895; hence the methods used by Wein for producing AC were fairly basic. The Bridge illustration above, as used in the ATB, is essentially Wein's development of the Wheatstone Bridge.

Relating the Bridge illustration above to the ATB circuit diagram: AC is the 50V applied across R5/R6; R6a and R6b, their values controlled by the wiper position (b), are the upper and lower resistance arms of R6 with the ratio being displayed on the Calibrated Dial; Rs represents the switched, internal standard resistors (or capacitors) R1 to R3 (or C1 to C3 plus C8 and R4), the common point of which joins R6 at a; Rx is the unknown resistor (or capacitor) across c & d; d (via selector switch S1) connects through S2 to the non-earth side of of X while the earth side of X connects to c; balance is detected by the VV. Note here that the wiper of the R6 pot (b) is earthed. Although and Earth symbol is moulded below the X and EXT terminals (the earth symbol has been added to the circuit diagram), these terminals are only actually at earth potential when the Dial is set at V (EXT only) or L (X only).

When the ratio of R6a and R6b is the same as the ratio of Rs to Rx then the voltage across b & d is zero; this is shown by the minimum reading on the VV. The Calibrated Dial is rotated to achieve this, indicating the value of Rx, the unknown, in the process.

The Calibrated Dial markings are shown in the illustration left. The main dial readings (R6) are from **0.1** at the white arrow to **10**, counter-clockwise to the black arrow. The Dial's **1** represents balance for an Rx equal to Rs. Note that the design of the ATB is based on a 10:1 ratio either side of the Rs value. For an Rs which is a multiple of 10 the dial therefore becomes easy to read. With Rs=100 ohms, for example, the Bridge will have a range of 10 to 1,000 ohms; any scale reading obtained being multiplied by 100 for the value of the unknown, Rx. The ATB uses three internal standard resistors, 100, 10,000 & 1 megohm allowing continuous Bridge readings from 10 ohms to 10 megohms. In addition, there are extrapolated readings available from the less accurate parts of the scale giving the ATB an effective range of 5 ohms to 50 megohms. It is extremely simple to increase the range of the Bridge by making up standard 1 ohm and 10 megohm resistors (using, say, the Bridge to obtain these values). These

resistors would be connected across EXT when the Bridge's overall range would be 0.05 ohms to 500 megohms.

How accurate is the ATB? Testing with the accurate AVO standard, Rs, against a standard resistance box over the calibrated 0.1 to 10 range, the dial calibration was found to be well within the 5% quoted by AVO.

Valve Voltmeter

The Valve Voltmeter consists of two components, an Amplifier and a Diode Detector (rectifier); these functions are contained within one valve, a double-diode pentode (6B8G). The Amplifier magnifies the balance reading between b & d (see Bridge illustration), while the Detector turns the amplified AC reading into DC to operate the meter — note AVO refer to the meter (M1) as the movement.

Amplifier

At a basic level, the valve (Anode, pin 3, and Cathode, pin 8) represents a Variable Resistor connected between R10 and earth. The Value of this resistor is controlled by the voltage on the Grid (top cap). Large changed in the variable Resistor are obtained with small, low power, voltage variations at the Grid. The initial value of the Variable Resistor is fixed by a small bias applied to the Grid (the purpose of R12). R10 and the Variable Resistor (valve) are connected in series across a voltage approaching 300V DC; any signal at the junction of R10 and the Variable Resistor is applied to C5. The wiper of R6, b, connects to earth. The other side for reading the Bridge null is at d, which connects to the Grid of the valve through C6. Any reading at d therefore appears, amplified, at C5.

Diode Detector

The Anodes (pins 4 & 5) of the valves two diodes are joined to produced a single diode (in conjunction with a common Cathode, pin 8). The amplified null reading transmitted through C5 is rectified and shows on the Movement, M1.

Other Features

The ATB is adapted for further usage: as an AC Valve Voltmeter 0-15V (usable up to broadcast frequencies and with an expanded lower scale); Power Factor indicator; Leakage Detector.

Voltmeter

There were a number of different principles for meter design available at the time of the ATB. The moving coil meter, as used here and in all Universal AVO and Taylor Meters, had become a market standard for a fuller explanation see the broken-down example illustrated on page 11. In its basic form the meter is linear but the diode curve is not.

Power Factor

Ideally, a capacitor absorbs no power. The reality is much more involved; while its inductance can often be disregarded, the resistance (leads and foil) represents power wastage. The effect of the capacitor's electrical resistance, which equates to, say, mechanical friction losses experienced in mechanisms, results in a Power Factor (R/X) term. At the frequency of test, only the larger capacitors are of concern — electrolytics in particular. The value of the PF pot (1,900 ohms) is such that at 50(%) it is approximately half the value of the reactance (X) of the standard 1 mF capacitor.

Leakage Detector

Turning the Calibrated Dial to L earths one end of the X terminals, it also engages S2 which connects the non-earth X terminal to the Neon tube, N1. The unknown Rx (a capacitor in this case), in series with a neon tube and a high resistance (R7), is therefore connected between earth and nearly 300V, similar to a mains testing screwdriver (though nowadays the Neon would be replaced by an LED).

Notes

There were only two important modifications to the circuit:—

1 In 1942 the dual voltage model was introduced (see the A, B, C & D tappings on the primary of the mains transformer — for connections see Chapter 2).

2 The ATB version in this Manual uses a 6B8G valve (double-diode-pentode), being in use from about 1941 or a little earlier. Previously the circuit used an L63 valve (triode) with a separate 'Westector' as the diode detector. The 6B8G version added R12 which provides both grid bias and some negative feedback.

To find the ATB's date of manufacture see the last three numbers on the Movement's dial — on page 11, the 6844-947 on the dial indicates September 1947.

A useful website for anyone wish to explore bridge methods, and technical background in general, would be: www.AllAboutCircuits.com.

4. Restoration

Restoration is seen here in terms of: Opening the ATB; Case Restoration; Circuit testing and repair.

Opening the ATB

Like an AVO 8, round the top of the case there are some 6 screws to be removed. These are brass screws and the screwdriver slot is easily damaged. If stuck, first try screwing a touch further in to break any lock. If the slot becomes damaged, slowly side-drilling a deeper slot and half-drilling out the centre of the screw will usually allow removal without damaging the screw thread of the Bakelite front panel.

With screws removed, insert a sharp, wide-bladed surface between the Bakelite front and the metal case; lever up gradually and evenly all the way round the join.

Case Restoration

The smooth parts of Bakelite are most easily cleaned and polished with Duraglit (Brasso) polish wadding. Scratches are easily removed with very fine sandpaper followed by a genuine Polishing Sandpaper. Finally, hard polishing with Duraglit will eventually return the original shine. For Polishing Sandpaper try a jewellery/watch supplier — for example, Walsh Bros at Beckenham; 243 Beckenham Rd or 118/120 High St (shop). For the textured Bakelite surface a toothbrush loaded with diluted washing-up liquid (not too wet), or for a very greasy surface Meths, should be effective

Circuit Testing and Repair

The illustration on the back cover is of an ATB that was difficult to open and had not been opened for some decades. Inside, all manufacturing inspection paint was untouched and with the original components. Note particularly: the large wax-dipped capacitors; the old three-number resistor colour coding — body colour, then end ring, then centre ring for number of noughts; the Systoflex covered wiring, bare wire was cut to length and sleeved with Systoflex (long-lasting, excellently insulated sleeving, which resists soldering iron temperatures); old copper rectifier, Wl, (usually still in excellent working order); the early variable capacitor for trimming, C8; the board holding C3 which also holds the full complement of standard resistors and capacitors.

In an unit of this age it is essential to test every component, particularly the capacitors. Unsolder the connection to M1 (the X the Component Positions illustration on page 12) and one end of C5, this will allow nearly all the components to be tested in isolation. It is usually essential to replace capacitors C4 to C6 — 400v Polyester ones are ideal. C7, the electrolytic, should also be replaced — do not increase the value and use 400v working or higher. Although not shown on the diagram C3 may as in the illustration, have a second capacitor across it — beware, this will have been carefully selected for C3 to exactly 1mF. If there is continuity across the valve filaments (pins 2 & 7) the valve will usually be working but replacements are not difficult to find (EBay).

Check the pots, R4 and R6, separately. A break is serious, however it is possible to disassemble, separate any molten ends and blob solder to hold the wires and connect the tips — neither an elegant nor an ideal solution but practicable. Note, modern enamelled wire is self-fluxing whereas old enamelled wire was scraped or dipped before tinning. Insulate and fix the result with Shellac (French Polish). To reduce wear, put a coat of Vaseline on the track travelled by the wiper.

One other extreme fault is mould due to damp. This is usually confined to the silk covering on resistors R1, R2 & R5. Dry brush and blow away as much as possible; brush with Meths and allow to dry, seal with a couple of coats of Shellac.

Movement (Meter)

The aim here is not the complete repair and adjustment of a moving coil meter. However, with the details provided it should be possible to safely part-strip the Movement, locate the fault and in some cases cure it.

Before disassembly, connect an ohmmeter quickly between earth and the disconnected meter terminal. This should allow, first, if the Movement's coil has continuity and second, from the way the needle flicks across, if foreign matter is impeding the coil's rotation.

To disassemble: Remove the two screws (one beneath W1 and hard to access) holding the brass or aluminium plate (both are used). The two large screws revealed should then be removed and the wire to the earth side (left) disconnected. A non-magnetic screwdriver is essential — make one up from stainless steel (old thin-bladed knife), a brass one will probably not be strong enough. It should now be possible to carefully extract the movement.

Refer to the Movement Diagram illustration, p11, showing a broken-down Movement: A moving coil meter is merely a current carrying coil pivoted between the specially shaped pole-pieces of a magnet. The principle of operation at the pole-pieces may be seen at A while an ATB's stripped Movement is shown in C. B the Coil Assembly but with the coil (minus hairspring and pointer) detached separately from the frame (left) on which it is pivoted and rotates.

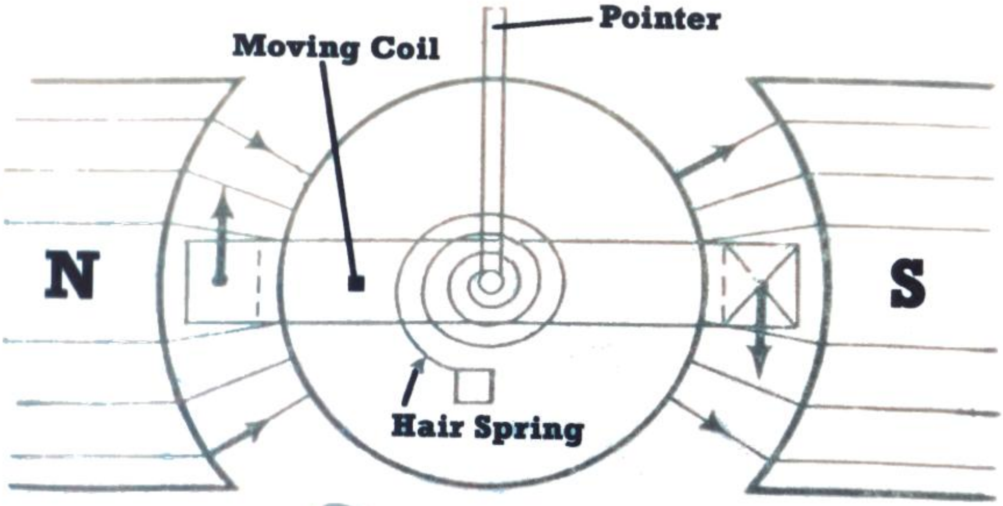
Screws pass from me bottom of the Coil Assembly frame, B, through the magnet, **c** (C — screw holes at **d**) and into a tapped brass plate, **b**. These screws should not be loosened. Above the brass plate, and screwed on to the brass plate from below, is a small adjustable iron 'keeper', **a**, which is used to control the accuracy of the Movement's setting — again, this should not be touched.

A caught hairspring (due possibly to dropping the ATB) may be freed with a sliver of wood. Assuming the coil is sound and moving, the most common fault is due to damp having rusted the magnet resulting in rust particles migrating into the Coil Assembly space. A small Blower is useful — as used for lens cleaning and watch repair. Check with an ohmmeter to ensure free movement of the coil and then re-assemble. A thin coat of Shellac is useful to stabilise surfaces.

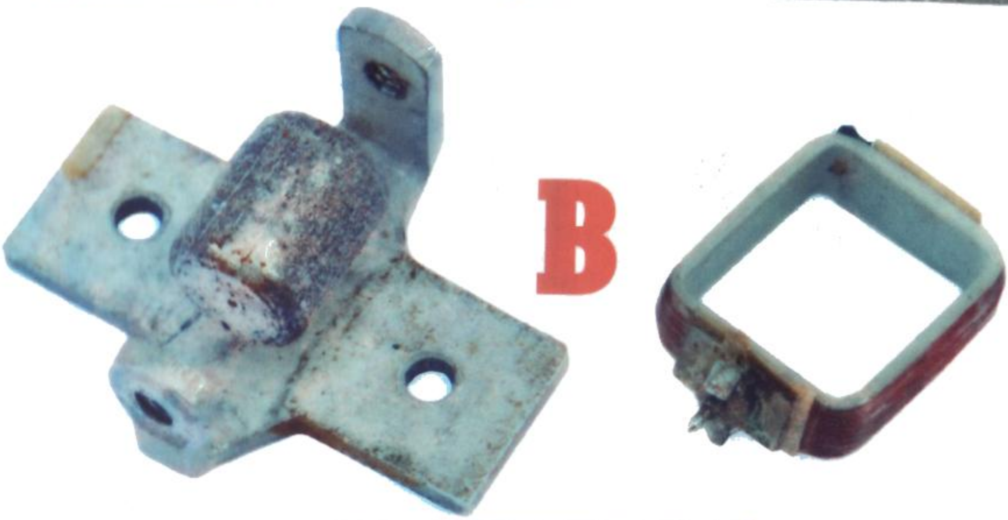
As a quick final test — using the ATB as an AC voltmeter tests most of the circuit and this is complemented by operation of the various bridge ranges; complete testing however will depend on the equipment available. As mentioned previously, where possible a check on every component is recommended.

5. Movement Diagram

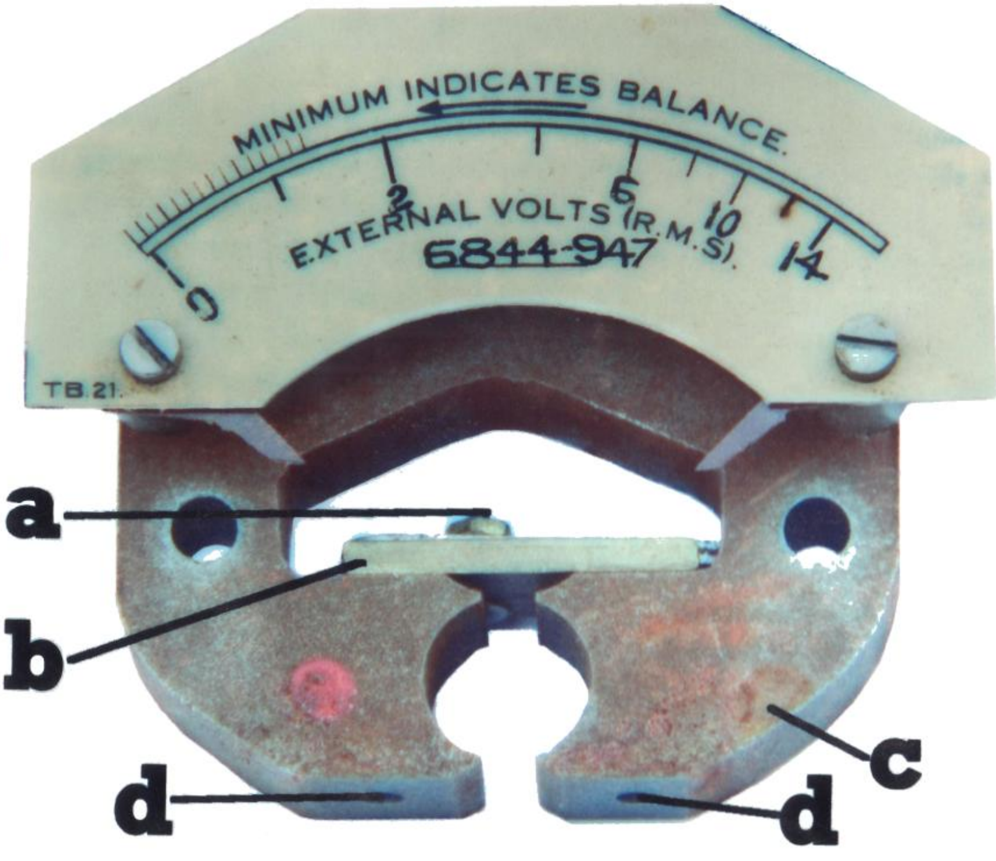
A



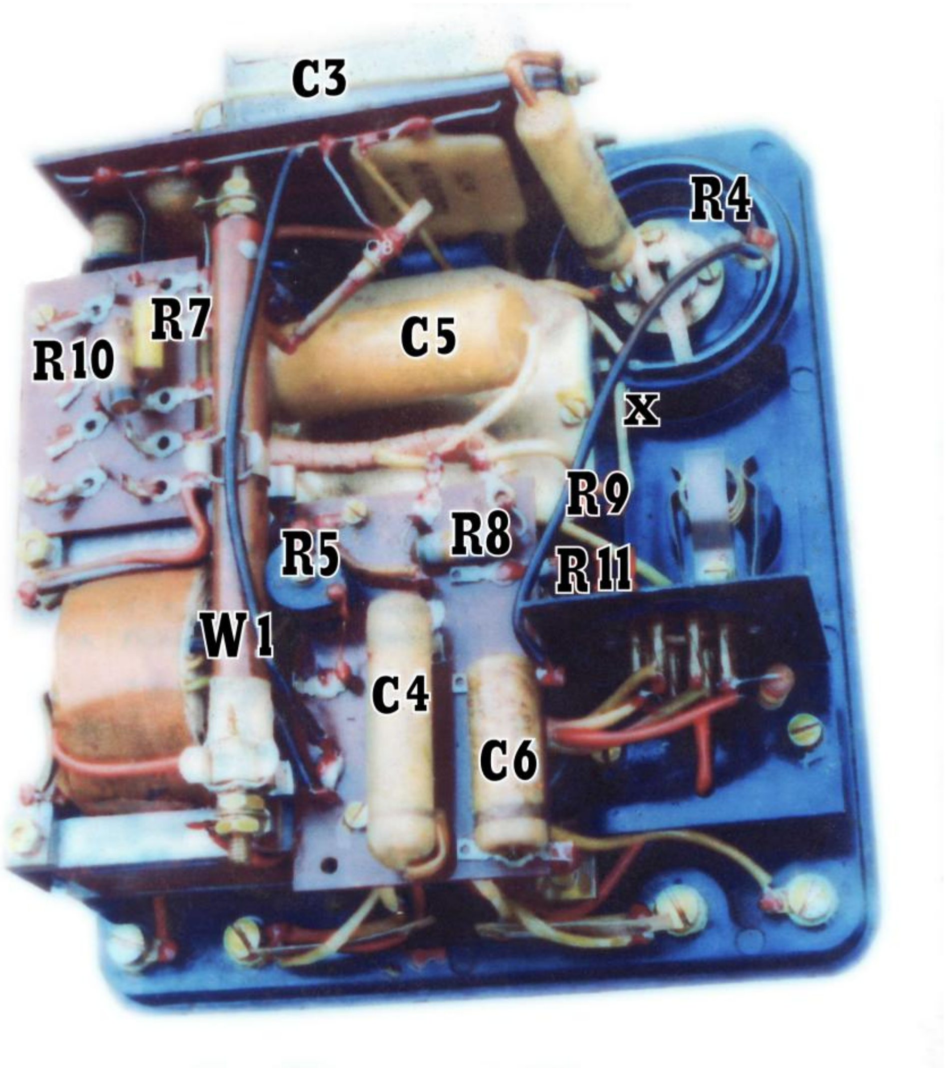
B



C



6. Component Positions



R1	100	½%	C1	85mmfd ½%
R2	10k	½%	C2	.01mfd 1%
R3	1M	2%	C3	1mfd +2-10%
R4	1K9	(PF)	C4	.02mfd
R5	350	10%	C5	.25mfd 400V
R6	1K	Dial	C6	.05mfd
R7	50K	20%	C7	4mfd 400V
R8	96K	10%	C8	3-30mmfd
R9	2M2	20%	W1	Metal Rectifier
R10	100K	10%	N1	Neon Lamp
R11	5M	20%	M1	Movement
R12	250	20%	V1	6B8G Brimar

7. Circuit Diagram