# *AVOMETER*

# Service Manual

## Models 8, 8x and 9 Mark 4

This manual has been produced primarily to aid our friends and associates overseas, and it is hoped that it will form a useful guide to the trained engineer who has the task of servicing *AVO* products. The instrument has not been dealt with in absolute detail (to do so would be beyond the scope of this publication), although it is assumed that the engineer undertaking the work has a good knowledge of the principles governing moving coil multi-range instruments.

The instrument has been 'broken down' in such a manner that an engineer with a limited amount of tools and test gear, can take *AVO* components and spare parts and fit them into the instrument, which will then only require a minimum degree of calibration and test.

No attempt should be made to service an *AVOMETER* unless the full range of test equipment (as detailed in this booklet) is available. In the event of a major overhaul, the instrument should be returned to Avo or to the *AVO* local representative.



AVO LIMITED · DOVER · KENT · ENGLAND

# Contents

## Test Facilities & Equipment Required



## Preliminary Procedure



## The Supply of Interchangeable Parts & Sub-Assemblies



## Fault-Finding & Servicing Information



## Dismantling, Replacement & Re-Setting Instructions



## Final Procedure



## Suggestions for Ordering Spare Parts

# *AVOMETER* Service Manual for Models 8, 8x and 9 Mark 4

# Test Facilities & Equipment Required

## 1. Essential Test Facilities, Equipment & Conditions

Certain facilities and equipment are absolutely essential before any consideration can be given to the possibility of undertaking the repair of *AVO* meters. To assist in deciding whether the facilities and equipment available are adequate, a short list of tools and test gear which will form the minimum requirements, is given below, assuming that the suggestion made in the Introduction to fit new sub-assemblies is adopted. If it is decided to undertake the more complicated tasks, then very much more equipment will be required and for certain fine operations, good sight and a steady hand are essential.

The room in which repairs are to be carried out should preferably have air filtering and be temperature controlled. The bench tops should be covered with plain light coloured linoleum or similar material. Good daylight, but shielded from direct sunlight is satisfactory, but in any case it should be supplemented for certain operations by light from tungsten lamps with suitable shades. Care should be taken not to create dazzle or excessive lighting contrast, and it is suggested that when dependent on artificial lighting, a general bench illumination of 75 lumens per square foot (foot candles) is satisfactory. Do not smoke — this is particularly important when inflammable or cleaning fluids are exposed.

## Instruments and Test Gear

Suitable precision voltmeters d.c. and a.c.
Accuracy ± 0·3% d.c. ± 0·75% a.c.

Suitable precision ammeters d.c. and a.c.
Accuracy ± 0·5% d.c. ± 0·75% a.c.

Flash Testing Equipment

An ohmmeter or a spare *AVOMETER*

A substitute movement encased and with flying leads (37·5μA f.s.d. 3333Ω)

Resistance Box

A Wheatstone Bridge, complete with galvanometer.

Microscope with 16mm objective and X10 or X15 eyepiece.

Controlled voltage and current supplies.

Thermometer.

Draught Proof Box with mountings for movement and having a glass cover and connections for test purposes.

A simple variable current supply.

A simple potential divider for checking scale shape linearity.

NOTE: If precision grade instruments are used as standards, then actual calibration errors should be known for all points down the scale. In the case of a.c. measurements, if the standards are true r.m.s. instruments, it is most important that the supplies are of sinusoidal waveform. The control means should not distort the waveform and in this connection we do not recommend the use of variac transformers at settings where the output voltage differs appreciably from that of the input.

If a rectifier type of instrument having a known scale characteristic is used as a standard and is properly calibrated to agree with a sinusoidal waveform, it can then be used for checking other rectifier instruments even if the waveform is distorted.

## Tools and Other Aids

De-soldering equipment with solder removal facilities
A small soldering iron
Lightweight soldering iron for movement repairs
Screwdrivers for 2BA, 4BA and 6BA screws
Torque screwdriver 8BA, 3 to 4 in. lb.
A set of watchmaker's screwdrivers
A set of BA box spanners
5/16 in. BSF box spanner
A set of open ended BA spanners
Tweezers suitable for light work on moving coil hairsprings, etc.
Pliers, various sizes
A pair of circlip pliers
A pair of side cutters
A hand drill
A set of twist drills from ¼ in. diameter (6mm) approx. downwards
One each of the following taps: 2BA, 4BA, 6BA, 8BA and tap wrench
A ¼ in. UNF ring spanner for terminal nuts with a ⅛ in. gap in the ring to clear connections
A pin or tack hammer
Pencil brushes
½ in. brushes
An eye glass
Bellows or air blast

## Spare Parts

A stock of *AVOMETER* spares
A stock of recently manufactured appropriate cells (1·5V) and batteries (15V).

## Miscellaneous Items

Some small receptacles to hold piece parts
Small glass jars with lids for fluids containing methylated spirit, switch cleaning fluids such as Carbon Tetrachloride or Electrolube and de-greasers such as Trichlorethylene or Genklene.
A reel of good quality cored solder (60% tin, 40% lead) in 16 s.w.g. or 1·5mm such as Ersin Multicore
A reel of good quality solid solder wire (60% tin, 40% lead) in 20 s.w.g. or 1mm for soldering hairsprings
Tinned copper wire 18 s.w.g. and 22 s.w.g.
Sleeving for tinned copper wire
Some small sticks of orange wood
A bundle of pith or clean cork
A number of steel needles
A mapping pen and Indian ink
White cellulose paint
Cellulose thinners
Tubes of adhesive such as Bostik Type 299 White
Tubes of Bostik black, or similar glazing compound
Thin mineral oil (use only to polish the outside of the meter)
Vaseline or similar grease
Loctite retaining compound (green)
Wash leather
Cleaning cloths

# Preliminary Procedure

## 2. Suggested Repair Procedure

When the instrument arrives for repair, examine it carefully and note any signs of damage which might have been caused whilst the instrument was in course of transit (it is assumed that the instrument has not been brought by hand). Apart from internal inspection, do not proceed with any repairs until (a) the customer's observations regarding the failure of the instrument have been received and (b) it is certain that the instrument has not suffered damage in transit. Severe transit shocks can sometimes damage instruments internally although externally they appear to be perfect. Always give the customer full details of any suspected transit damage, particularly when the damage to the instrument is more serious than that reported by him. The customer may wish to claim financial damage from the carrier who shipped the instrument and because of this, the packing material in which the instrument arrived, should be retained. It is important that the carriers should be informed of the damage without delay.

If the customer has not advised that the repair may be proceeded with irrespective of your charge, we strongly advise that the instrument should be examined and an estimate submitted before any work is carried out. (Do not overlook the condition of the leads, prods, clip, cell and battery when quoting). This procedure and the acceptance of the estimate will provide a safeguard against disputes arising over the charge for the work after the necessary repairs have been completed.

## 3. Consideration of the Customer's Report

If the customer has complained about trouble on the resistance ranges only, examine the cell and battery, which are located beneath the Instruction Plate, before opening the instrument, for meters requiring no more than the replacement of batteries are often returned for repair. Take particular note of Section 14 (h) which deals with the state of the 15V battery. If the cell or battery is found to be exhausted, the instrument should, nevertheless, be tested throughout before being returned to its owner to ensure that there is no other failure not reported by him.

It may be found that a fault exists which bears no relation to the complaint received. If so, the instrument should be opened (See Section 6) and the full extent of the fault reported to the customer before proceeding with the repair.

Should the cause of the reported fault not be apparent, it may be one of an intermittent nature and if it cannot be located the fullest information should be obtained from the customer as to the symptoms and then concentrate on the likely portions of the circuit. Intermittent faults which can suddenly appear or vanish and vary in intensity from slight to severe, can be very misleading during diagnosis and difficult to locate. Intermittent faults can often be traced by changing the instrument operating temperature by $\pm$ 10° from ambient temperature.

The customer may occasionally insist that a fault is due to defective manufacture, for example, in the cut-out, but investigation will frequently show that damage has been caused by misuse. The customer should be informed if this is the cause before commencing any work on the instrument. As regards the movement, even if it appears to be reasonably free from fault, it should nevertheless be carefully examined both for pivot and other stick and also to ensure that the balance is satisfactory.

## 4. Fault Diagnosis

A visual examination of the interior (Read Section 6 before opening the instrument) will probably show where the fault lies, but do not dismantle any parts before examination or test. Provided the movement appears to be in order a few well chosen tests will almost certainly determine the extent of the fault (See Section 13). If the movement is suspect, it should be disconnected and a substitute one connected to the appropriate points to facilitate diagnosis.

It is very rare for any instrument to be returned on the score of inaccuracy, but if so, it should be tested on all ranges in comparison with a high accuracy instrument, which could be a Precision *AVOMETER* or another *AVOMETER* which has recently been calibrated against a sub-standard.

For electrical tests, a source of variable voltage and current (both a.c. and d.c.) sufficient to cover all ranges of the instrument, will be required together with resistance standards. Current, voltage and resistance tests at full scale, should be made on successive ranges commencing with the lowest range as far as faults present will permit.

## 5. Accuracy

The standard required after repair calls for the following accuracies when the instrument is tested in the horiontal position:

| | |
|---|---|
| D.C. Voltage: | $\pm$ 2% of indication between full scale and half scale deflection. $\pm$ 1% of the full scale value below half scale deflection. |
| D.C. Current: | $\pm$ 1% of full scale value. |
| A.C. Voltage & Current: | $\pm$ 2·25% of full scale value over effective range. |
| Resistance: | $\pm$ 3% of reading at centre scale. |

## 6. Removal of the Panel from the Case

If it is necessary to open the instrument (see notes which follow regarding fault finding) it should be placed on the bench and the *AVO* seal removed from its side. A heated screwdriver will facilitate this operation. The head of the sealing screw is located beneath the wax seal.

With the instrument face upwards on the repair bench, remove the six screws round the edge of the case. If the front panel has to be prised off, use a broad-bladed screwdriver so as to avoid damage to the rubber sealing gasket and to the top of the case. Ease the whole panel evenly and vertically upwards until it is clear of the case and then place it face downwards on the bench. Since this is the position which the instrument will occupy for some time on the work bench, it is advisable to place small pieces of adhesive tape over the switch and terminal knobs beforehand to avoid their becoming defaced. Care should be taken not to lose the sealing gasket as this will be required when replacing the panel in the case.

It will now be possible with the aid of the circuit diagram (and making use of any information obtained from the preliminary tests or the details in Section 13) to check the suspected part of the circuit wiring by means of an ohmmeter or another *AVOMETER* until the fault is located.

## 7. Removal of the Component Board

Having removed the panel from the case, lay it face downwards on the bench and disconnect the high voltage resistors connected to the two high voltage terminals at the top of the panel. Remove nuts and screws securing the board. These are the large slotted screw and Dubo ring at the centre of the board, a 4BA nut on the left-hand side of the board and a 4BA screw/4BA nut from the right-hand side of the board. Place these in a safe place as they will be required when re-assembling. Unsolder connecting wires from the board taking particular note of the connections. Remove potentiometer knobs when the whole component board assembly complete with transformer board assembly can then be lifted free from the pillar/pillars and eased carefully off the main switch spindles. (This may prove to be a tight fit and care is required).

## 8. Removal of the Movement from the Panel

For simple repairs it may not be necessary or even desirable to remove the movement from the panel, but if it interferes with other work and is likely to become damaged or become dirty during repairs, it should be removed as follows:

It is advisable to trip the cut-out before removing the movement. Unsolder the connections to the movement. Holding a piece of $\frac{1}{8}$ in. thick non-magnetic material between the magnet and a 2BA screwdriver, remove each fixing screw. (Note: if the screwdriver is drawn by magnetic attraction into contact with the side of the magnet, permanent loss of magnetic strength will result).

The complete movement assembly may now be carefully lifted from the panel. To replace the movement the above procedure should be reversed. Care must be taken to ensure that the elongated slot in the zero adjuster passes over the zero pin. After replacing a movement in the panel it is always necessary to re-set the cut-out mechanism. (See Section 16).

For earlier models having a printed circuit board which covered the movement, it will be necessary to first release the printed circuit board and fold this back to enable the movement to be removed as detailed above.

# The supply of Inter-Changeable Parts and Sub-Assemblies

## 9. Sub-Assemblies

Reference to the Parts List will show that the instrument has been 'broken down' in such a manner that parts which may suffer electrical or physical damage can be replaced. Replacements are not available for every small component for many items seldom suffer damage. Particular note should be taken of the following sub-assemblies:

(a) The component board assembly

(b) The Movement

(c) The cut-out mechanism

The first item incorporates many components and if any of these become damaged it is possible for individual components to be replaced by components obtained from the company. However, if damage is extensive, it may be preferable to replace the complete board, particularly if it was one of the early models having a printed circuit board.

The other two items (b) and (c) are not only carefully made (and precision calibrated) but they contain many parts which may present mechanical as well as electrical problems if individual parts are replaced. If all the necessary apparatus and skill are not available to carry out repairs to these assemblies, replace the whole unit. It is particularly recommended that a seriously faulty movement is replaced with a new one for so many difficulties can arise without the skill and equipment for this work. The factory employs special jigs, fixtures and tools for assembly and without their aid some repair tasks become most difficult. A faulty movement may be sent to the factory for repair or replacement.

The following notes will assist you in deciding how to proceed:

## 10. Component Board

Individual components on this board can be readily replaced after identification from the diagram. Various electrical components are calibrated on assembly. If these are replaced and the instrument is not re-calibrated there is a possibility that the instrument will not meet the original specification. If a printed circuit board is fitted, some form of solder removing iron will be required. When servicing a printed circuit board great care is necessary to ensure that the minimum of solder is used, as excessive solder may cause short circuits. After any repair work on a printed circuit board all residue flux and dirt must be cleaned off.

## 11. The Movement

The movement is such a specialised item, that in the event of defects of more than a minor nature, complete replacement is recommended. Such a replacement is provided with facilities for adjustment to its correct resistance. See Instructions for removal from the panel before commencing any work. (See Section 8).

If adequate skill and facilities are available for major movement repair certain spares are available, but reference should be made to Section 18 before dismantling. Repairs to the movement will, in many cases, demand not only the adjustment of sensitivity to 37·5μA and re-calibration, but also possible replacement of the scaleplate, in order to regain the original accuracy. The fitting of a new moving coil will necessitate the re-balancing of the movement, whilst the magnet may have to be re-magnetised and aged before the sensitivity of 37·5μA can be met. In view of the difficulties the desirability of fitting a complete replacement movement is self-apparent. The defective movement can be returned and allowance made for any useful component parts.

## 12. The Cut-Out Mechanism

Re-building of this mechanism is not as easy as it would first appear and it is often more economical to purchase a new assembly, than to repair the old.

# Fault-Finding and Servicing Information

## 13. Fault-Finding Table

The following table is given to assist in the rapid location of a fault. Comprehensive servicing details follow. See Section 14 (a) to (s) inclusive.

| | SYMPTOMS | PROBABLE FAULT |
|---|---|---|
| (a) | No reading on any range or intermittent reading only. | Leads open circuit or intermittent, switch or circuit fault. Cut-out contacts burnt. Moving coil open-circuit or stuck. It is useful to note whether current flows when no pointer indication is given. Another movement will be required for this test. |
| (b) | No reading on an isolated current voltage or resistance range. | Suspect a faulty connection between the switch contact and the shunt, multiplier or transformer concerned. |
| (c) | One or more d.c. ranges inoperative and lower ranges incorrect. | One or more shunt sections open circuit. |
| (d) | No d.c. voltage readings (or erratic readings) in excess of a particular range. | An open circuit in a resistor beyond the last working range. |
| (e) | Reads approximately 33% high on d.c. volts. | Shunt open circuit. |
| (f) | Low, or fails to read on a.c., but is correct on d.c. | Suspect a faulty diode or transformer open circuit. |
| (g) | Ohms range inoperative, intermittent or incorrect. | Battery or cell not making satisfactory contact. Zero Ω potentiometer or fuse faulty. |
| (h) | Inability to attain ohms zero setting or ohms zero drifts shortly after being set. Low readings on Ω × 100 range. | Cell or battery deterioration. |
| (j) | Instability of reading in general. | Examine leads and switches, cut-out and reverse moving coil contacts. |
| (k) | Cut-out fails to re-set. | Mechanism set too finely. Bent spindle or ruptured lock lever. |
| (m) | Cut-out fails to operate on moderate overloads. | Cut-out mechanism set too coarsely, operating rod bent. Bent spindle or dirt in re-set housing. |
| (n) | Low readings on all current and voltage ranges. | Hairspring turns caught up or stuck together. This fault is sometimes associated with change of zero. Partial short circuit in moving coil. |
| (p) | Pointer stick at one particular point. | Dust, hair or foreign body fouling the movement. It may be possibly be in the gap, on the scaleplate or on the window glass. |
| (q) | Slight uniform pointer stick over whole scale. | Tight in jewels, blunted pivots, dirt in jewels or possible damaged jewels. |
| (r) | Pointer stuck firmly. | Pivot out of jewel. |
| (s) | Pointer moves from position of rest by more than 1% of the maximum scale value when the instrument is held in any position within 45° from horizontal. | Movement out of balance. |

To enable the most suitable method of repair to be selected the information obtained from the above table should be carefully considered together with the servicing information in Section 14 and the details given in Sections 9-12 regarding the supply of sub-assemblies.

Details regarding the removal and re-setting of main assemblies are given in Sections 15 to 18.

## 14. Servicing Information

The information in this section is cross-referenced to the alphabetical sequence in the fault-finding table, i.e. if the symptom and possible fault appear at (f) in the fault finding table, the relevant servicing information will be found at (f) in this section.

(a) **No reading on any range or intermittent reading only.**

Using another meter, check whether current flows in the circuit on both current and voltage ranges in spite of no pointer indication. If current flows the fault is possibly in the moving coil and this should be checked for open circuit.

If no current flows on any voltage or current range, the leads should be checked for open circuit and the cut-out examined. If current flows on some ranges and not on others, a circuit fault should be suspected and the components associated with the range on which no current flows should be checked and any faulty component replaced. If current flow is intermittent faulty switches may be the cause.

(b) **No reading on an isolated Current, Voltage or Resistance Range.**

If only one range is found to be at fault the circuit, and in some cases the components associated with that particular range should be checked. The connection between the relevant switch contact and the shunt, multiplier or transformer concerned should be checked with an ohmmeter to see if there is a dry joint and correction made as necessary.

(c) **One or more d.c. current ranges inoperative and lower ranges incorrect.**

One or more shunt sections may be open circuit and these should be checked.

(d) **No d.c. Voltage reading (or erratic reading) beyond a particular range.**

The fault will almost certainly be an open circuit resistor connected in the circuit following the last working d.c. voltage range. It will therefore, be necessary to check the resistors on the first non-working d.c. voltage range.

(e) **Reads approximately 33% high on d.c. volts.**

This will almost certainly be due to an open-circuited shunt. The faulty component should be replaced by one of the same value, or alternatively, if the damage is extensive, the complete shunt should be replaced. After this has been carried out and the movement refitted, the instrument sensitivity should be checked by switching the meter to its 50μA d.c. range, passing 50μA d.c. through the instrument and making slight adjustment as necessary.

(f) **Low, or fails to read on a.c. but is correct on d.c.**

This fault may be due to faulty diodes. Replace each diode in turn and re-test. If the fault still persists then the transformer should be replaced.

If the transformer has to be replaced, take careful note of the transformer connections before removal. (See Section 15 for replacement instructions).

(g) **Ohms range inoperative, intermittent or incorrect.**

If the ohms range is inoperative or erratic, the connections to the cell should be checked by connecting a voltmeter to the battery contact pins which connect the panel and then tapping the case sharply. If trouble exists or is suspected, the battery contacts should be cleaned and this will probably clear the fault. If the fault still persists, check the fuse and replace if necessary. Should the fault not be cleared the ohms range potentiometer should be checked and replaced if defective.

(h) **Inability to attain ohms zero setting or ohms drifts shortly after being set — low readings on × 100 range.**

If the pointer cannot be brought up to zero ohms or fails to hold its ohms zero for a reasonable period with the leads shorted together when on the low range the 1·5V cell requires replacement. If other ranges are affected replace all batteries.

**15V battery.** It can so happen that the 15V battery may age in such a manner that although it has an e.m.f. of 15V, its internal resistance has increased so much that some loss of accuracy and zero drift can occur. If the battery has been in use for some time, or if a low ohms indication is suspected on the high resistance range in spite of correct zero setting, it is worth while removing the battery and momentarily checking its short circuit current on the 100mA d.c. range. Although with a good battery up to 200mA will flow, no harm will result. It is desirable that the 100mA range should be used in order that a readable indication is obtained if the current is very low. If the battery fails to give a reading greater than 25mA it should be discarded.

(j) **Instability of reading in general.**

This is usually due to dirty switch contacts. General cleaning of all switch contacts will probably remove the instability. Ensure that the bi-metal contacts are working freely on the switch arms of the range switch assemblies. Any damage to the switches will require complete replacement of the main switch assembly board.

The reverse moving coil contacts should also be examined. These may need cleaning with a suitable fluid or re-setting. It may that general cleaning of all contacts would remove the instability, particularly if there are signs of gross overloading.

(k) **Cut-out fails to re-set.**

If the cut-out mechanism has been set too sensitively (See Section 16) the cut-out button may refuse to stay set. The mechanism will only re-set when the instrument is lying face uppermost and before steps are taken to make adjustment always place the instrument in this position and carry out tests of your own. Ensure that the lock lever spring is returning right home and the turned over end is not fouling the groove in the table.

(m) **Cut-out fails to operate on moderate overload.**

Before carrying out any adjustments to the cut-out ensure that the spindle is not bent. The cut-out mechanism may be set too coarsely. For test and re-setting instructions see Section 16.

Failure of the cut-out mechanism to operate in use may have been due in many instances to the fact that the instrument has not only been severely overloaded as

regards the range, but has also had a.c. applied when set to d.c. and vice versa. Burnt out fixed or moving contacts will sometimes result from this cause. Some users imagine that the cut-out should protect the instrument fully in all circumstances in spite of warnings given to the contrary by the company.

### (n) Low readings on all current and voltage ranges.

When an instrument is subjected to severe shock (such as it may receive during transit) it sometimes happens that individual turns of the hairsprings become caught up one upon another causing the instrument to read low. Upon opening the instrument, the confused appearance of the hairspring(s) will at once be apparent. A fine needle should be inserted between the turns of the hairspring nearest its centre and guided to follow the turns outwards in a rotary motion towards the periphery of the spring. The turns will automatically be released unless the hairspring has become badly deformed by accidental bending of the outer soldered joint. A slightly damaged hairspring can sometimes be restored with the aid of a pair of fine tweezers and a needle, but if the spring is badly deformed, it will be necessary to replace (see section 18).

Low readings may also be caused by hairs on the hairspring, or individual turns of the hairspring sticking together, due to the presence of dirt or some viscous substance. The offending deposit should be removed by lightly brushing with Trichlorethylene or Carbon Tetrachloride, care being taken to ensure that drops of the liquid do not fall upon the scaleplate where they may cause discolouration. After brushing the springs, wipe the brush dry in order to remove any dissolved substance, (a piece of clean white paper, free from fluff is ideal) and repeat the process. Finally examine the spring in strong light with an eye glass to make sure that all dirt is removed and that the turns can no longer be made to stick together.

A partially short-circuited moving coil will cause an instrument to read low on all ranges, a possible indication of this being increased damping of the movement. If the resistance of the movement circuit at 20°C is much below 3333Ω and in addition, the full scale current is in excess of 37·5μA, this would confirm a fault of this nature.

### (p) Pointer stick at one particular point.

This symptom usually indicates that dust, a small piece of iron or some other foreign body is possibly fouling the moving coil former. Specks of dust, or even a hair, if present, can be removed with a fine needle.

A minute hair on the window or scaleplate, or in the moving coil could cause sticking and this may show up in a bright light. In all such cases sticking might also be dependent upon a slight tilt of the instrument associated with the small but essential pivot play. Never dismantle the movement unless attention to the faults mentioned fail to clear the fault (see section 18 if it is necessary to dismantle the movement).

### (q) Slight uniform pointer stick over the whole scale.

This may be due to a slight tightening of the moving coil between the spring mounted jewels. With the movement horizontal a minute clearance between the top jewel and pivot should permit a slight sideways rock. The jewel assembly will show a sideways rock if adjustment is too tight, due to the jewel being raised from its seating. The movement in such a case would show a perculiar change of swing just before coming to rest and furthermore, the instrument held on its side might also show complete instability of zero reading. Slightly easing the top jewel screw will indicate if this is the cause of friction and effect a cure. If this type of stick cannot be cured by jewel screw adjustment it will be necessary to dismantle the movement for repair or replace it completely.

### The following information is given for those who feel that they have the facilities and skill to repair the movement itself.

Sticking can be due to dust or a rustlike deposit which sometimes forms on the tip of the pivot and in the jewel and it may be worth while seeing if its removal cures the stick rather than replace the movement. After removing the frame from the magnet and pole piece assembly (See Section 18) unsolder the hairsprings. Unscrew the bottom jewel screw and then the bridge together with the top jewel, zero adjuster etc. after which the coil can be removed and the jewels inspected. If a microscope is available (having a magnification of × 10 or better) place the jewel screw on the table with the jewel uppermost, illuminate well and examine. It is very difficult to diagnose small mechanical damage optically, but the presence of foreign matter such as red deposit arising from wear is readily apparent.

The jewels can be cleaned using a piece of pegwood cut with a very sharp knife or razor blade to a diameter which will enter the end of the jewel screw. The tip must be brought to a very fine point and there must be no loose fibres left. Soak the stick in Trichlorethylene and holding the jewel downwards, wipe the interior. Brush the jewel, still inverted, with a fine dry clean pencil brush and then examine the jewel under the microscope in good light to ensure that all rustlike deposit or other foreign matter has been removed. If cracks are detected the jewel must be replaced.

Sticking could also be caused by a damaged pivot. The pivot should be examined under a microscope and if it should require cleaning this can be carried out by rotating the end of a piece of impregnated pegwood on the pivot tip and then pressing it into a piece of cork or pith. Re-examine the pivot to see if it can be used or if it should be replaced. An undamaged tip should have spherical radius of less than one fiftieth that of the pivot diameter i.e. 0.020 in. If any departure from the spherical shape is evident, or if its radius has become excessive, the pivot should be replaced by one inserted to exactly the same distance. If a jewel screw assembly is rested on the tip of the pivot, the clearance between the end of the screw and the pivot holder should be in the order of 0·012 in. This can determine the maximum jewel retraction under the influence of impact.

A damaged jewel, (which is a most infrequent occurrence) must always be replaced by a similar one supplied in its spring mounting.

If the above treatment to overcome stick has been tried without success a replacement movement should be fitted. It should be mentioned that dismantling a movement to replace pivots, hairsprings or even a moving coil is almost always accompanied by some loss of accuracy.

### (r) Pointer stuck firmly.

It can occasionally happen that severe mechanical shock can cause a pivot to leave its jewels and become lodged in the end of a jewel screw, which would result in the pointer becoming firmly stuck. Do not try to push the pivot back as damage will occur. A slight re-adjustment of both top and bottom jewels screws may cure the fault, but if it persists, the moving coil assembly will have to be replaced.

(s) **Movement out of balance.**

The moving coil is balanced when the instrument leaves the factory, but a very severe overload, mechanical shock or pivot damage may cause it to become unbalanced. The balance limit permitted in BS 89 allows a pointer change of $\pm$ 1% of maximum scale values when the instrument is held in any position within 45° from horizontal.

If the movement needs re-balancing, it should be mounted in a draught proof box and tested in four positions with the axis horizontal for tests 2, 3 and 4:

(1) Set the pointer to zero with the instrument in a horizontal position.

(2) Check zero position with pointer horizontal and pointing left.

(3) Check zero position with pointer horizontal and pointing right.

(4) Check zero position with the pointer vertical upwards.

The balancing box should be tapped lightly during balancing operations to ensure that pivot friction does not interfere with the balance effect. If a satisfactory balance cannot be achieved, the pivots will almost certainly be defective.

If a new coil is fitted major balancing is called for. The balancing of an instrument calls for a high degree of skill and once again, we advise that if the trouble is difficult to cure, the whole movement assembly should be replaced.

# Dismantling, Replacement and Re-Setting Instructions

If removal of one of the main assemblies is necessary the following instructions should be carefully studied in order that assemblies are removed without further damage and to ensure that the re-setting operations necessary for correct functioning are carried out satisfactorily.

## 15. Replacement of Transformer Assembly

To remove the transformer assembly remove the four spring retaining clips. Unsolder all connections to the transformer and note their position. The transformer assembly can then be carefully eased away from the board.

Take the new transformer unit and carefully fit the transformer to the board. Fit the *new* spring fixings making sure that the transformer is seated firmly in the moulding. Re-solder all connections and trim any surplus length of tag.

## 16. Re-Setting the Cut-Out Mechanism

The replacement of burnt-out contacts is simple, but in the case of the moving contact assembly, care is necessary to avoid bending the spindle. The cut-out should be in its open position when the fixing collar or circlip is being attached and care should be taken not to bend the cut-out spindle.

As the tripping value may have been disturbed by the replacement of fixed or moving contacts, or by having removed the movement for servicing, the cut-out setting should be checked. A new cut-out was introduced for the Models 8 and 9 Mark 4 which can be identified by the two horizontal coil springs mounted on the cut-out table. For this new cut-out the setting operations are as follows (See diagram opposite).

Adjust the main contact pressure (600-800 grams measured on the top of the re-set button) by setting the contact carrying springs.

Slack off the adjusting screw (Item 2) until the movement push rod has visible end float.

Adjust the eccentric stud (Item 1) to make the lever (Item 3) engage with the crank (Item 4). The lock should be just positive. (Cut-out cocked).

Re-position the adjusting screw (Item 2) to remove all end float from the movement push rod, when the cut-out is cocked.

The cut-out sensitivity can be adjusted by the final delicate positioning of the adjuster screw (Item 2). Confirm this final setting with several tests. The cut-out must trip at 20:1 overload and must not trip at 4:1 overload.

## 17. Replacement of Range Disc Assemblies

The Range Disc Assemblies are mounted on the underside of the main component board and are readily visible when the board is removed from the front panel. To replace the range wafers remove the moulded bars carrying the contact fingers and unsolder the wire connections. Take particular care to observe the position of the contacts and the wafer before removing them. Remove the circlip, wafer and bush. The circlip and bush can be disposed of as replacements are provided with the new wafer. When replacing the wafer ensure that it is correctly positioned. Replace the moulded bars carrying the contacts, ensuring that the contact fingers are pressed down firmly to ensure good contact.

Replacing the Range switch knobs is more easily undertaken with the component board removed, or at least raised enough to enable the circlip on the switch spindle to be removed. This circlip may be cut and disposed of. The knob can then be lifted off and the new switch knob assembly (which comprises knob, balls, spring and circlip) replaced.

## 18. Dismantling the Movement

If adequate facilities and skill are available for major movement repair certain spares are available. Repair will necessitate adjustment of the sensitivity to 37·5$\mu$A, re-calibration and also the possible replacement of the scaleplate in order to re-gain the original accuracy. The fitting of a new moving coil will necessitate re-balancing of the movement whilst the magnet may have to be re-magnetised and aged before the sensitivity of 37·5$\mu$A can be met.

The following notes are given to assist in the dismantling and repair of the movement:

First remove the movement from the panel (See Section 8). Be most careful to ensure that ferrous objects such as screwdrivers are not allowed to come in contact with magnets, nor must the strip securing the magnets to the pole pieces be removed. Failure to observe these precautions will result in a loss of magnetic flux. The frame carrying the moving coil should be prepared for withdrawal from the magnetic system in order that the moving coil can subsequently be extracted from the assembly for any necessary attention. To do this unsolder the lead from the bottom hairspring adjuster and turn it into line with the bracket holding the jewel screw. Finally remove the two 8BA screws securing the frame to the pole pieces and if the magnet is held in the right hand with the scale pointing downwards the concentrator assembly is best removed by the left hand holding the frame just below the scaleplate. Great care is necessary in this operation, to guard against the pull of the magnet. If the hairsprings are now unsoldered, the bottom jewel screw locking nut and the two screws securing the bridge piece which carries the top jewel screw slacked off considerably but not removed, the moving coil can now be taken away from the frame.

To remove a scaleplate it will be necessary to break the locking varnish on the 6BA nuts. A soldering iron can be held on the nuts or a soaking in thinners will loosen the nuts.

The reversal of the dismantling will enable the movement to be rebuilt, but the following points should be observed. Before mounting the moving coil, the pivots and jewel screw should be cleaned as recommended in Section 14(q). If new hairsprings have been fitted, it is most important that they are oriented correctly. The spring must only be just strong enough to return the bell cranks after displacement.

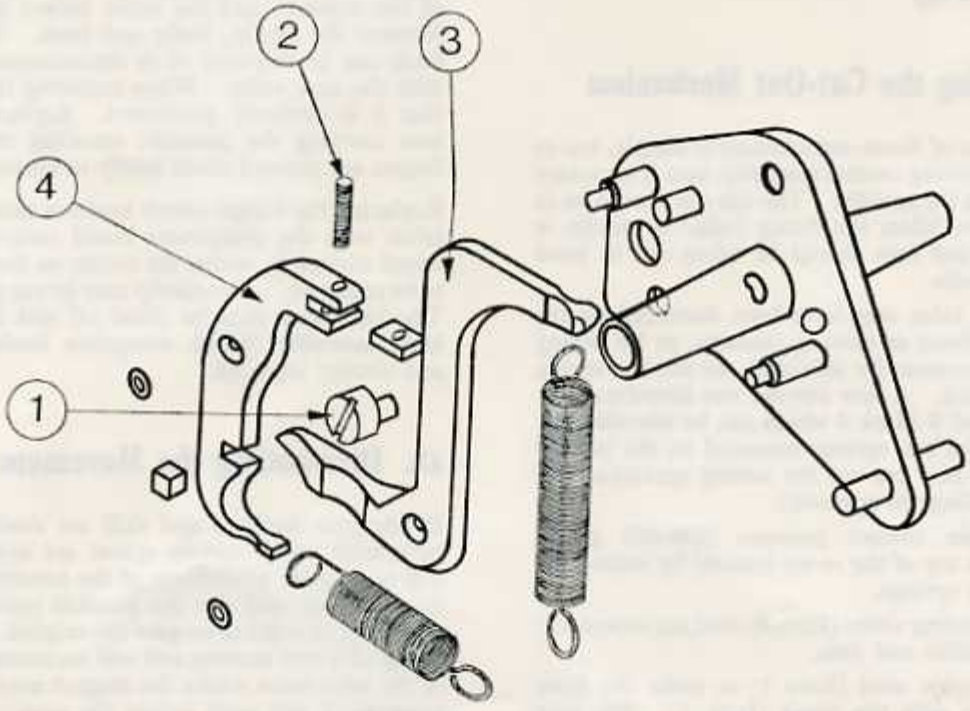
When replacing the movement ensure that the elongated slot in the zero adjuster passes over the zero pin. After replacing a movement in the panel it is always necessary to re-set the cut-out mechanism. (See Section 16).

The bottom zero adjuster should be set so that the external screw gives about equal pointer adjustment above and below scaleplate zero. Clockwise rotation should produce forward rotation of the pointer and it is advisable that having obtained exact zero setting the screw is rotated a *minute* amount in the opposite direction, so that the pin ceases to bear on the slot of the top zero adjuster, thus making displacement of the pointer during transit unlikely.

NOTE:

Hairsprings should always be freshly tinned for 3/32 in. at their ends ensuring that the solder does not run along the hairsprings, and degreased before mounting. For colletted springs, it is only the outer which requires tinning. Never use a flux paste, resin or resin-cored solder since flux deposits will eventually cause hairspring turns to stick together in service. If trouble due to sticky hairsprings does make itself apparent they can be cleaned with Trichlorethylene or Carbon Tetrachloride, using a fine pencil brush.

When re-fitting great care must be taken to ensure that the hairsprings and pivots are not damaged. The coil should be correctly positioned as the jewel screws are tightened, the final setting being such that there is just a perceptible movement at the tip of the pointer. The position of the coil about the concentrator should be such that on depressing the coil in either direction it cannot leave the spring jewels. The clearance between the pointer and the scaleplate should be uniform and slight adjustment of this can be made if necessary by the bridge piece position. Before replacing the movement on the panel ensure that the cut-out crank levers are free to operate under the retaining plate and will fully return to rest under light spring pressure, also that the spring does not foul the thrust rod. Hold a piece of 1/16 in. of non-magnetic material between the magnet and 2BA screwdriver while tightening the screws which must be carried out firmly.




Re-setting Cut-out Mechanism

# Final Procedure

## General

It is most important that every effort is made to ensure cleanliness during repair. It is almost certain however, that dust will settle on the instrument during repair unless it is carried out in a Clean Air zone. Brushing where applicable and the use of bellows or an air blast are invaluable for cleaning the panel. Do, however, keep the movement under cover until it is ready to be fixed to the panel and take all steps to keep it dust free until it is finally encased.

When all faults have been satisfactorily cleared and the meter meets the accuracy requirements outlined in Section 5 the following procedure is recommended.

## 19. The Appearance of the Repaired Instrument

Having ensured that the instrument is perfect electrically and mechanically do not be content to return it to the customer in a dirty condition. Wipe or brush out the inside of the case, taking particular care that no small particles of iron, solder or other foreign substances are left within the instrument. Fit the case to the panel using the original screws and place your own seal in the recess provided. When re-boxing the instrument after repair, particular care must be taken to ensure that the screws are no greater in length than those which were originally supplied. The use of screws of incorrect length can cause breakdown of an instrument on flash test.

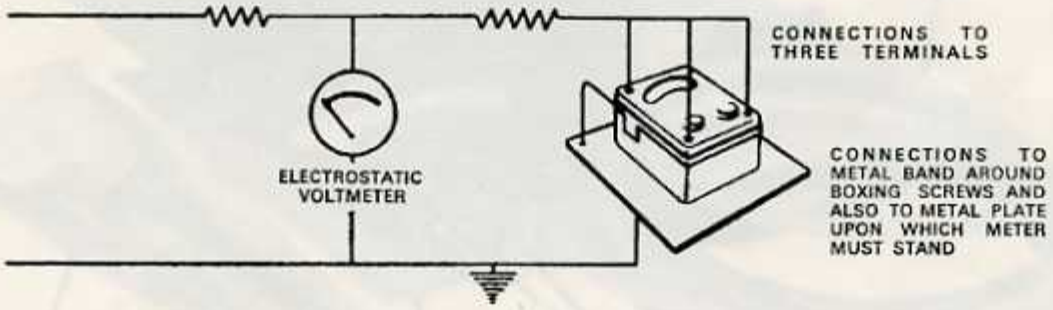
The general brightening up of an instrument will usually have a most profound psychological effect on the owner of the instrument and immediately conveys to him the correct impression that his meter has received careful and pains-taking attention.

## 20. Flash Test

Before leaving the factory every instrument is subjected to a flash test of 6000V 50Hz for one minute between the terminals and the case fixing screws. It is advisable that a corresponding test should be given to the instrument after repair, and a suitable circuit which will not cause damage in the event of failure is given below:

The fixing screws should all be simultaneously in contact with the metal plate, so that capacitative sparking cannot occur. The flash test box should have safety switch in the primary circuit to the transformer. (See diagram below).

The test voltage should be raised and lowered gradually. Indication of breakdown will be given by the failure of the pointer of the electrostatic voltmeter to rise, or actually falling whilst a fixed voltage is applied. It is essential to ensure that the voltmeter is of the type which draws negligible current. If the meter under test shows a pointer deflection it is usually caused by static charge on the meter window. This may be disregarded providing the electrostatic meter gives a steady indication.




# Suggestions for Ordering Spare Parts

If you will kindly follow the procedure set out below, delays will not occur due to the exchange of unnecessary correspondence.

Where assemblies on the illustrations refer to 'see breakdown', a breakdown of the assembly will be found on a subsequent illustration.

## 1. Identify Parts

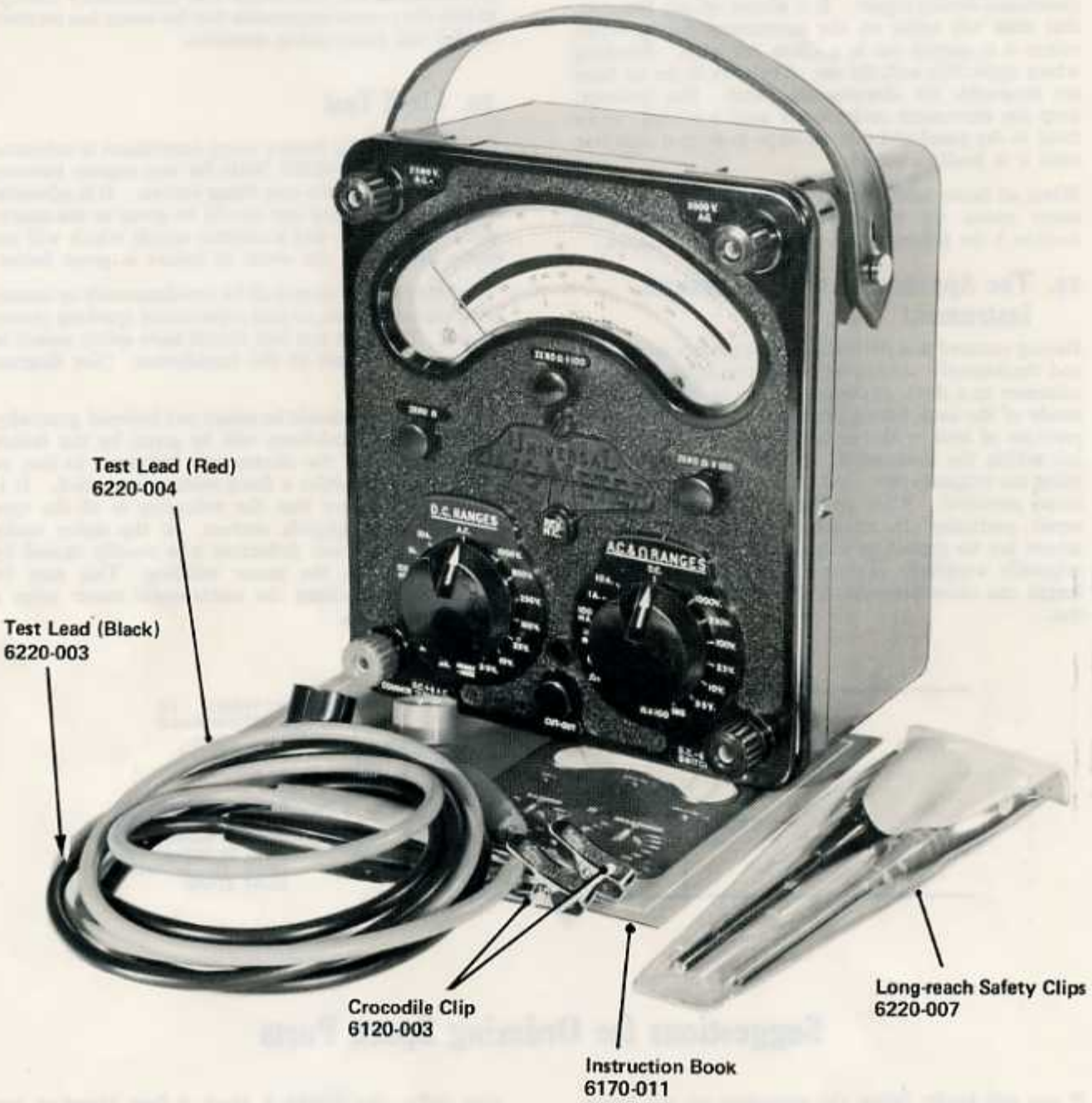
Study the illustrations carefully and identify the part(s) required. The items which have been annotated are the only parts which can be supplied as spares.
The illustrations are annotated with the Part Numbers for the Model 8 Mark 4. In most cases, the Part Numbers for the Model 9 Mark 4 are identical; where they differ, the Model 9 Mark 4 Part Numbers are detailed below the illustration.

## 2. Detail Required

When ordering, state the Model Number of the instrument for which the spares are required, the Part Number and description of the item required, its location in the instrument (and of course the quantity needed) as well as the *AVOMETER* Serial Number.

## 3. Ordering

Overseas users should send requirements to the Avo Representative on their territory. If the parts are required in the United Kingdom, application should be made direct to Avo Limited.




MODEL 9 MARK 4:

Instruction Book — 6170 - 012

**Plate 1: Complete Station**

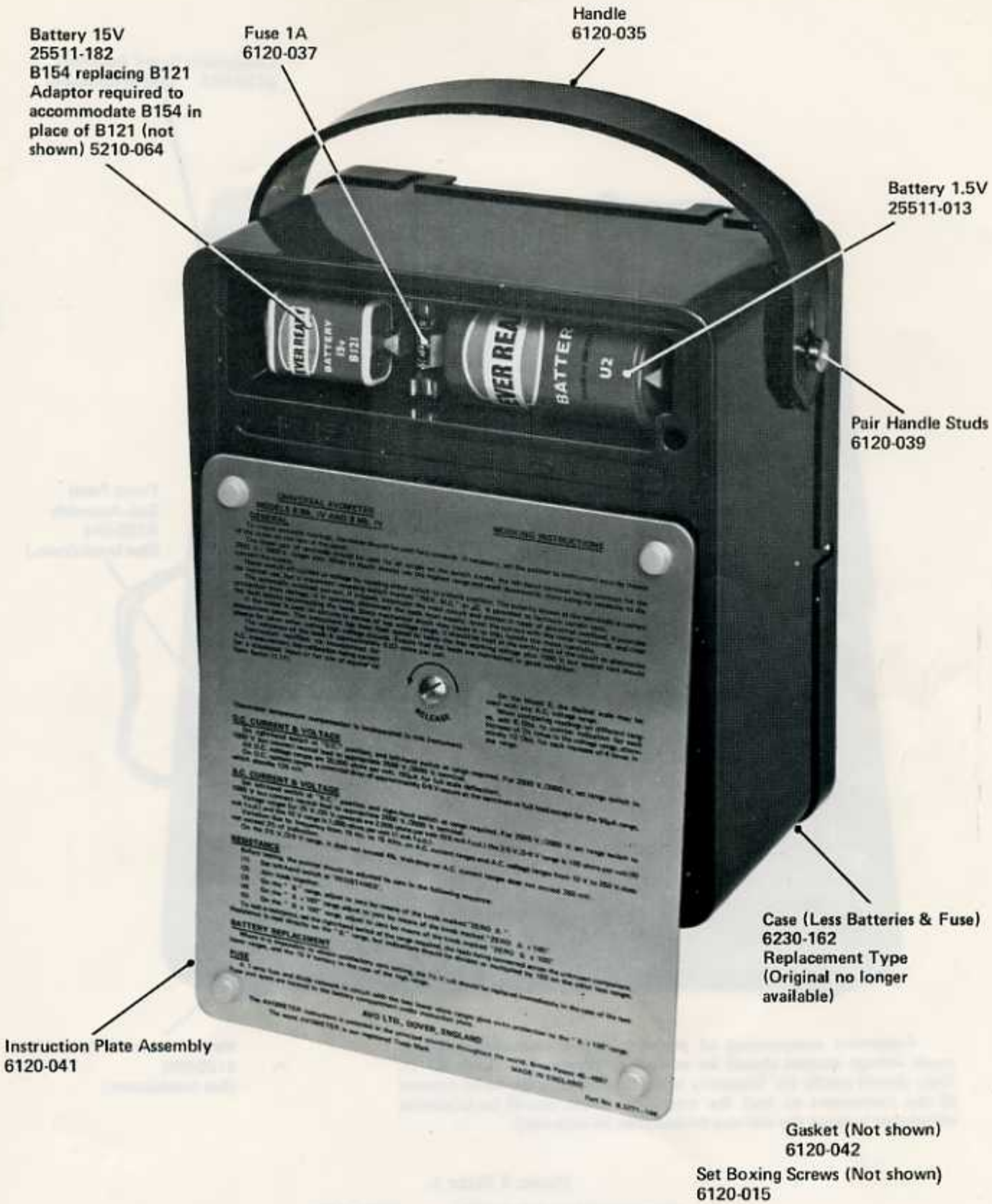
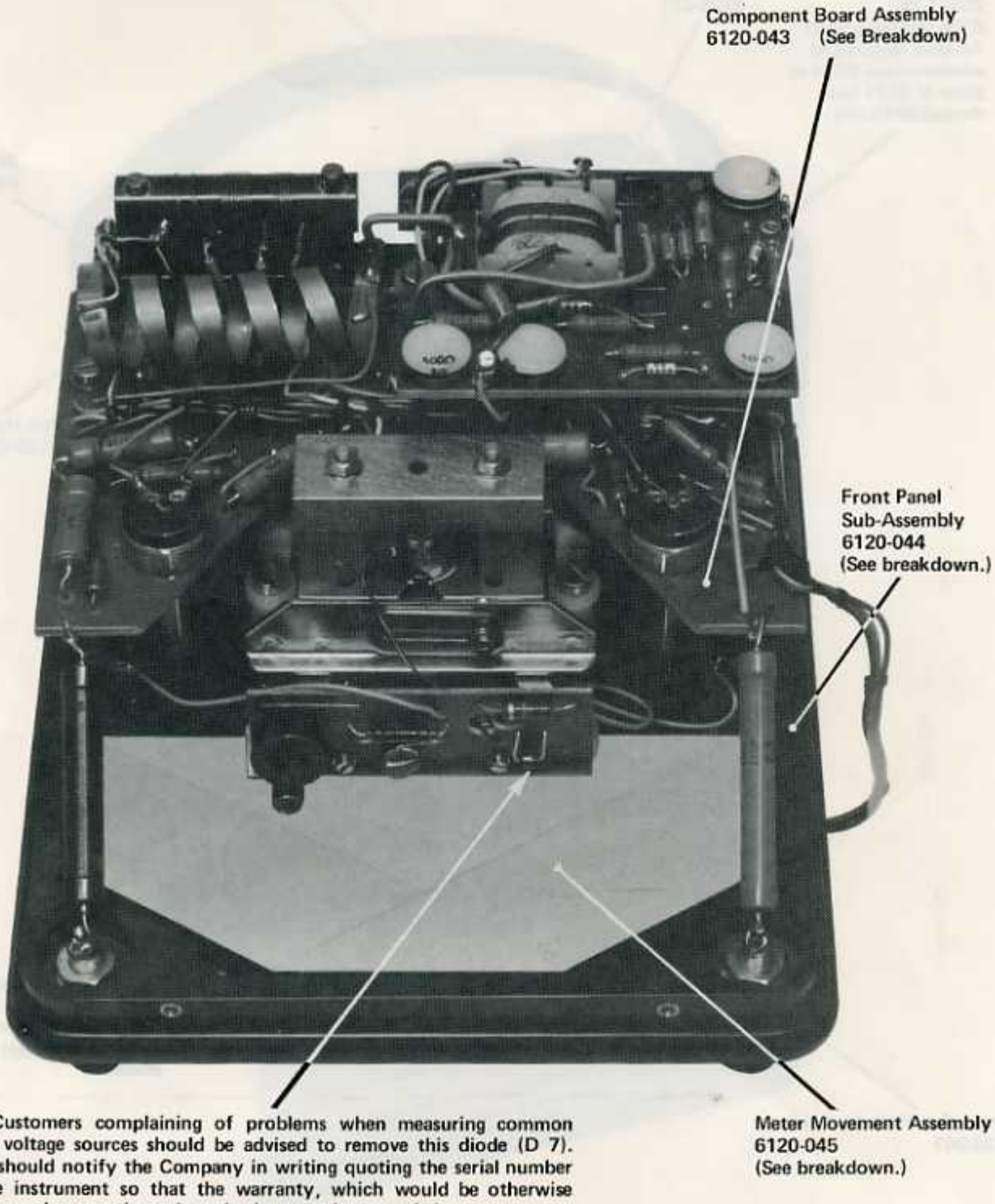



**Plate 2: Case Assembly**



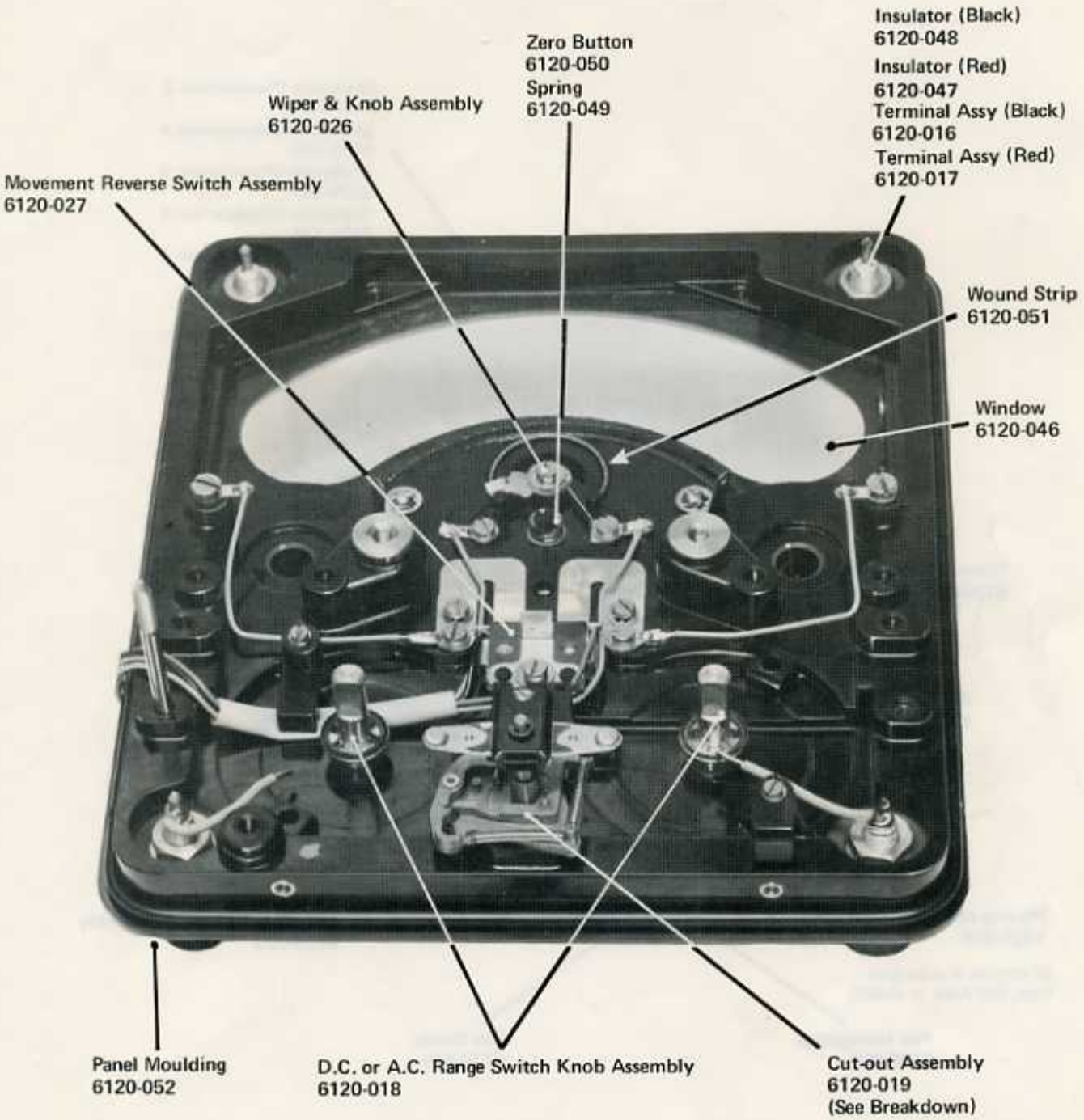

Customers complaining of problems when measuring common mode voltage sources should be advised to remove this diode (D 7). They should notify the Company in writing quoting the serial number of the instrument so that the warranty, which would be otherwise withdrawn because the seal was broken, can be extended.

MODEL 9 MARK 4:

| | | |
|---|---|---|
| Component Board Assembly | — | 6120 - 143 |
| Front Panel Sub-Assembly | — | 6120 - 144 |
| Meter Movement Assembly | — | 6120 - 145 |

## Plate 3: Front Panel Assembly

Note: **Terminal Assembly** comprises: Socket, nut, collar and either red or black insulator.
**Wiper and Knob Assembly** comprises: Knob, contact arm, two washers and screw.
**Movement Reverse Switch Assembly** comprises: both pairs of upper and lower contact assemblies.
**D.C. and A.C. Range Switch Knob Assembly** comprises: Knob, spring, ball and circlip.

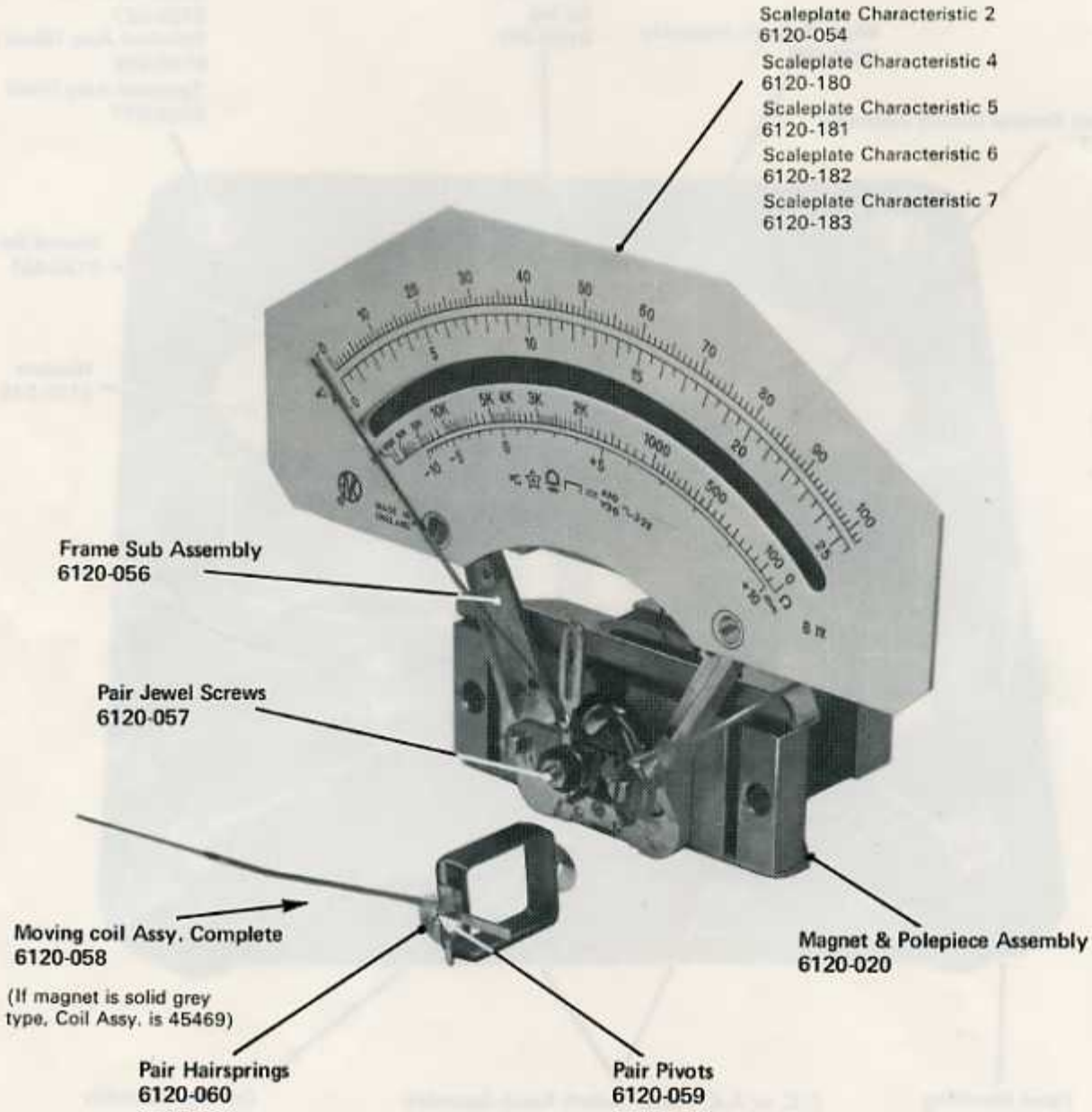



Push-on Knob, Ohms & ohms x100 not shown
6120-025

MODEL 9 MARK 4:
Panel Moulding — 6120 - 152

## Plate 4: Front Panel Sub-Assembly

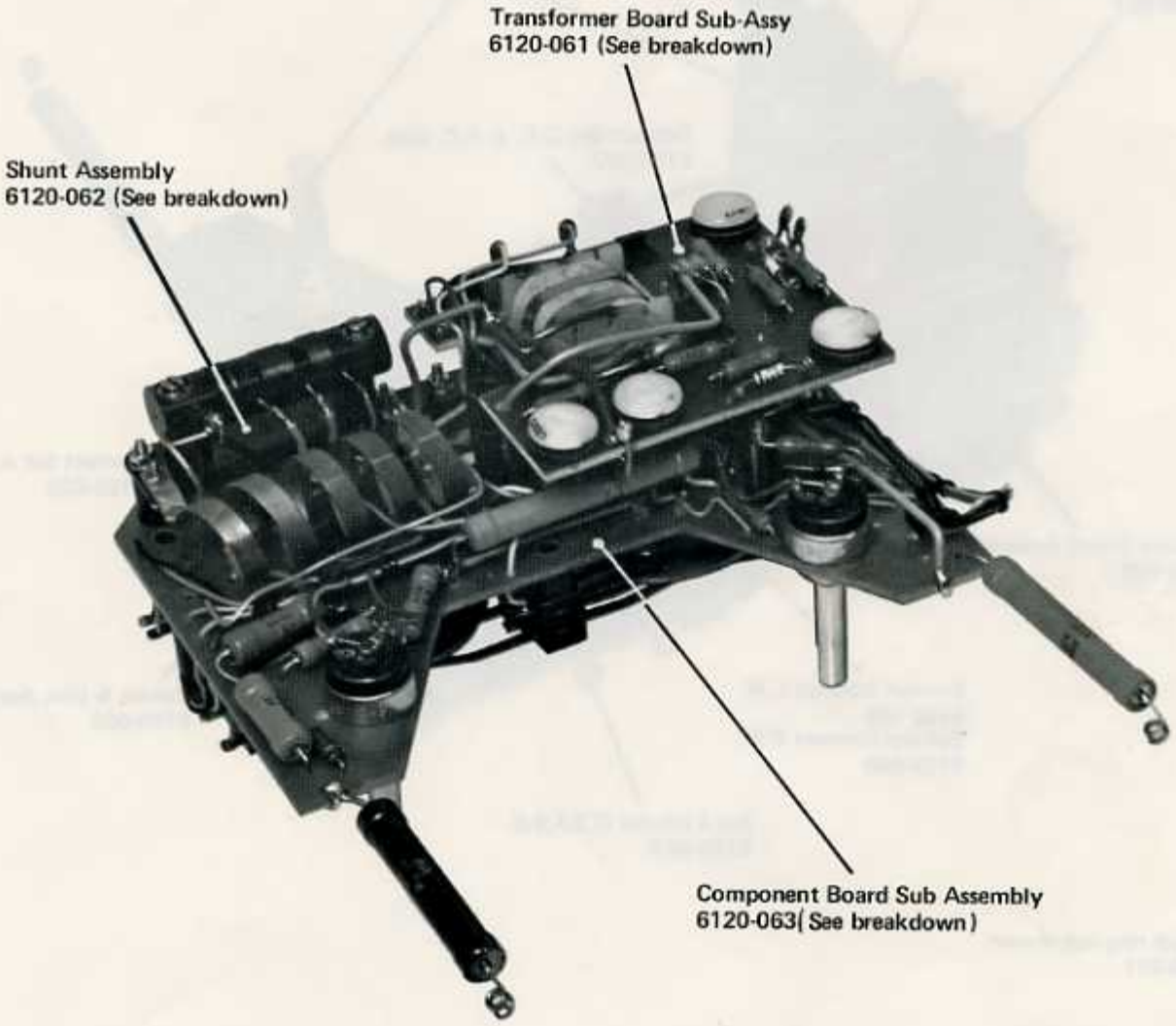
Note: Movements have scaleplates selected during calibration, which give the most accurate scale shape. If magnets, moving coils or hairsprings are changed, it may be necessary to use a scale having a different characteristic.




MODEL 9 MARK 4:

| | | |
|---|---|---|
| Scaleplate — Characteristic 1 | — | 6120 - 153 |
| Scaleplate — Characteristic 3 | — | 6120 - 155 |
| Scaleplate — Characteristic 4 | — | 6120 - 176 |
| Scaleplate — Characteristic 6 | — | 6120 - 178 |
| Scaleplate — Characteristic 7 | — | 6120 - 179 |

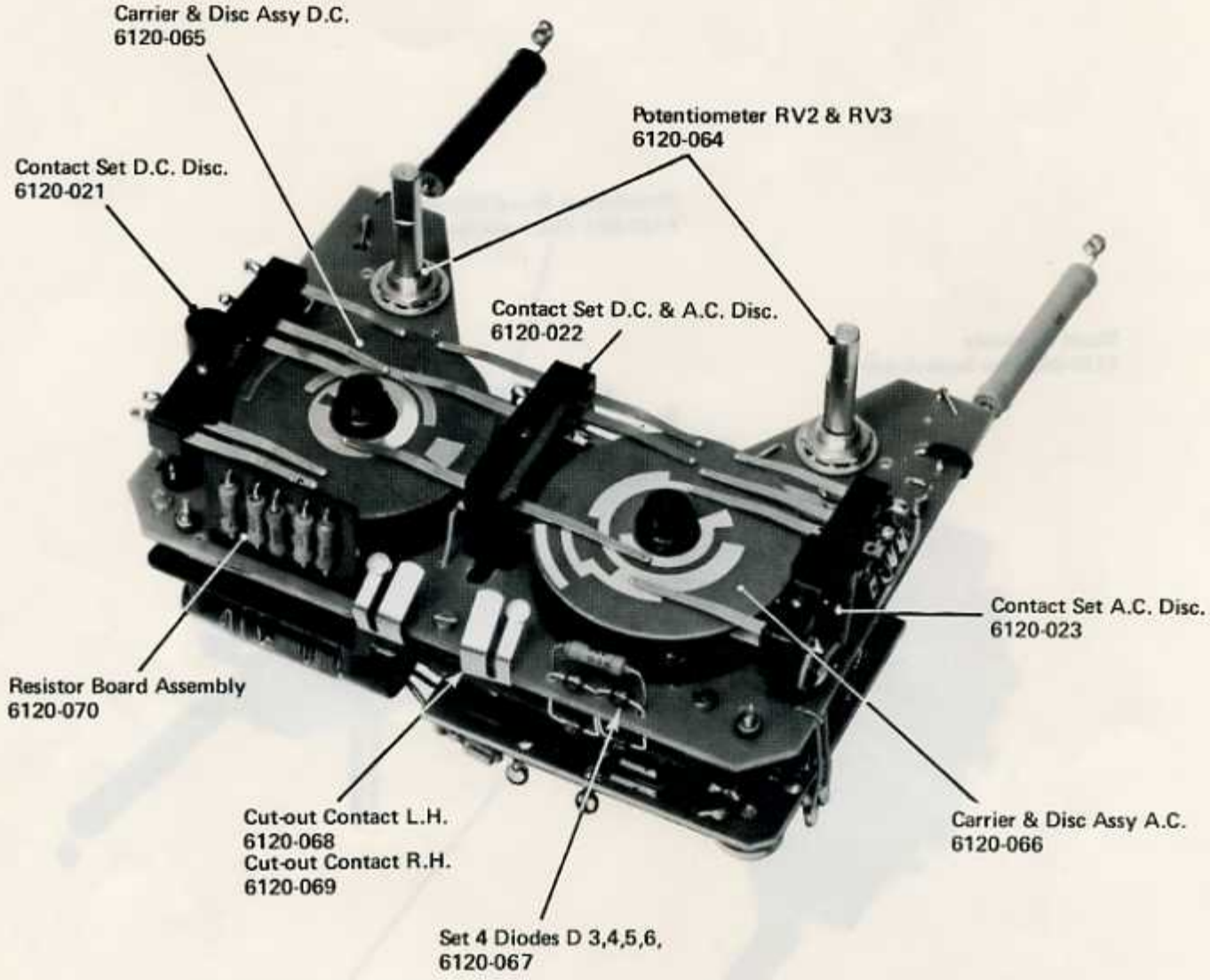
## Plate 5: Meter Movement Assembly




MODEL 9 MARK 4:

Transformer Board Sub-Assembly — 6120 - 161
Component Board Sub-Assembly — 6120 - 163

## Plate 6: Component Board Assembly




Switch ring not shown
6120-071

Pair Wipers not shown
6120-072

MODEL 9 MARK 4:
Resistor Board Assembly — 6120 - 171

## Plate 7: Component Board Sub-Assembly

Note: Alternative diodes 28421-802 or 28421-804.

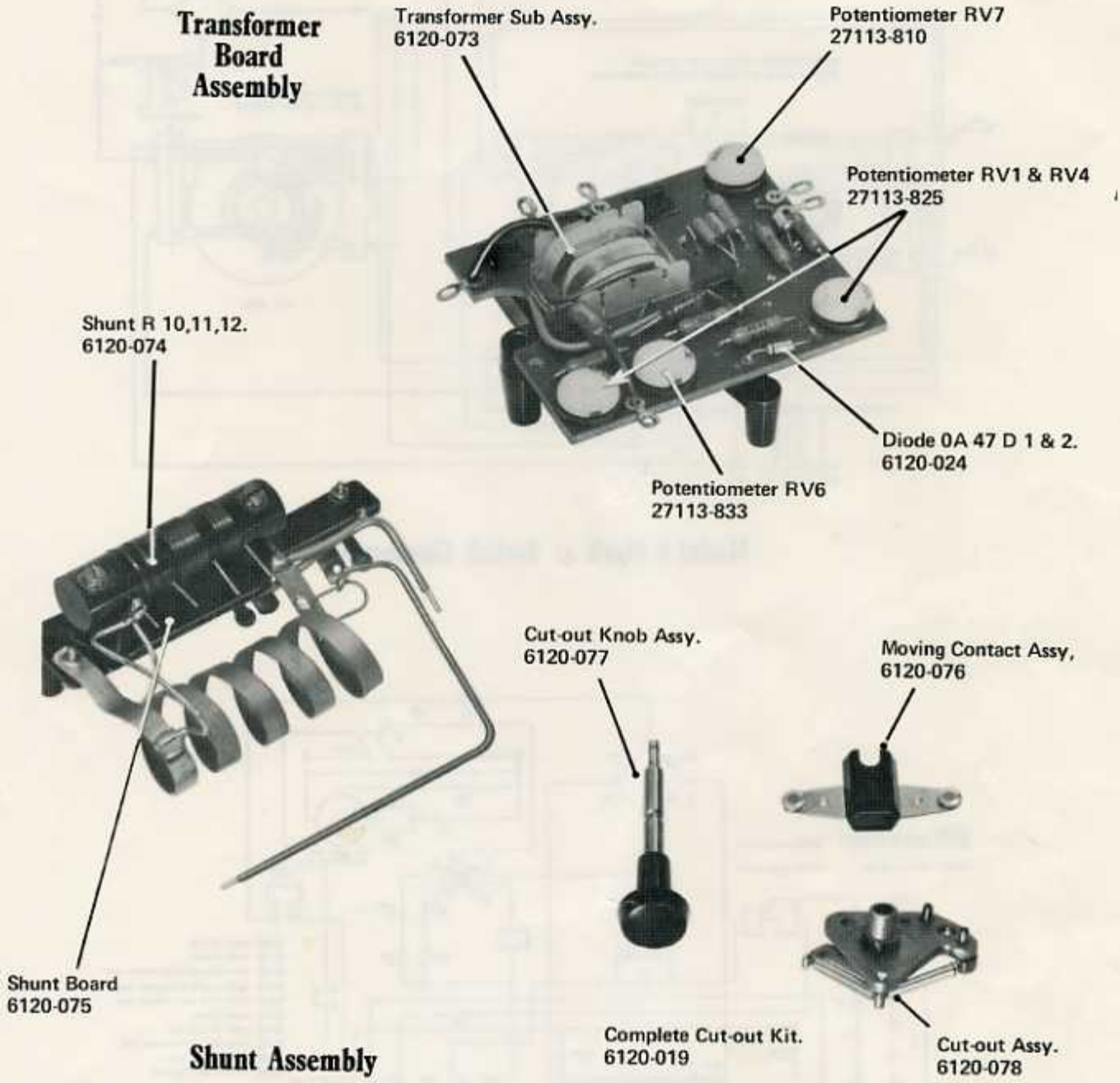
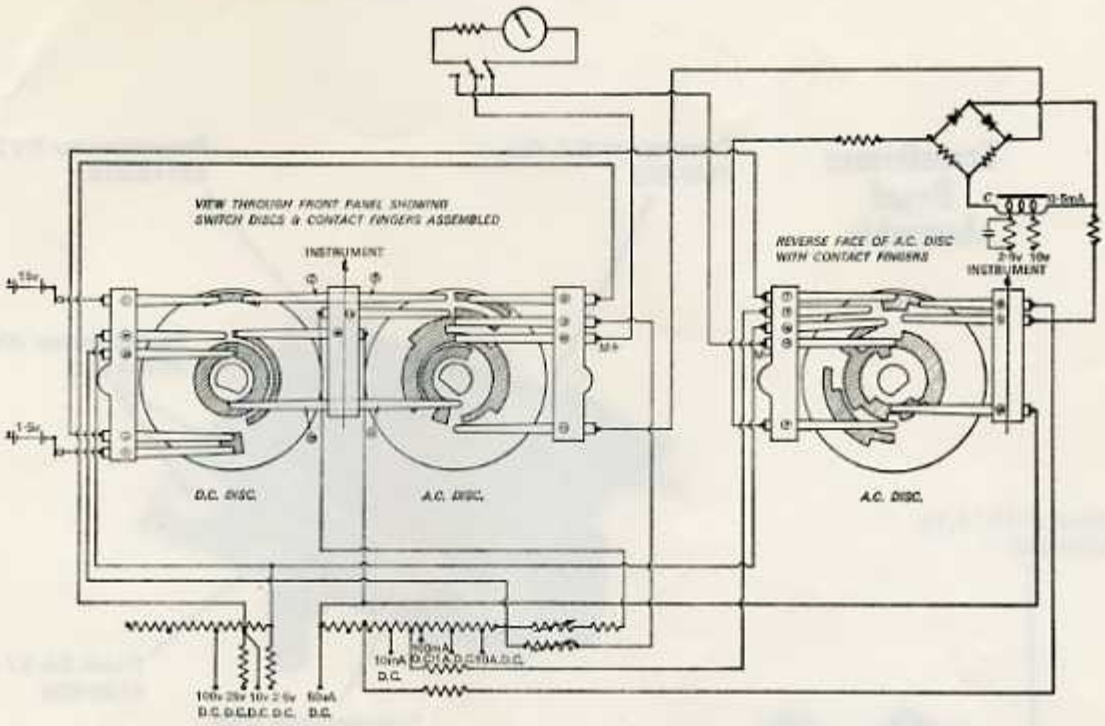
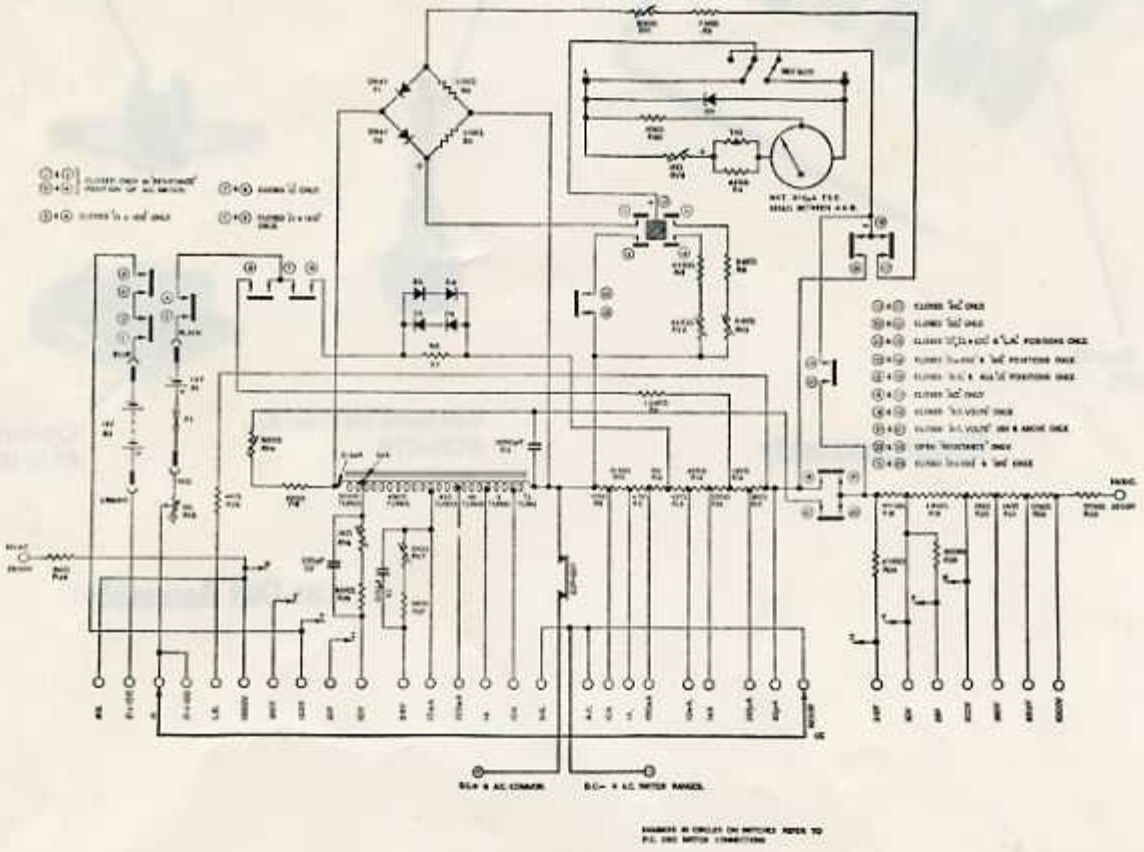


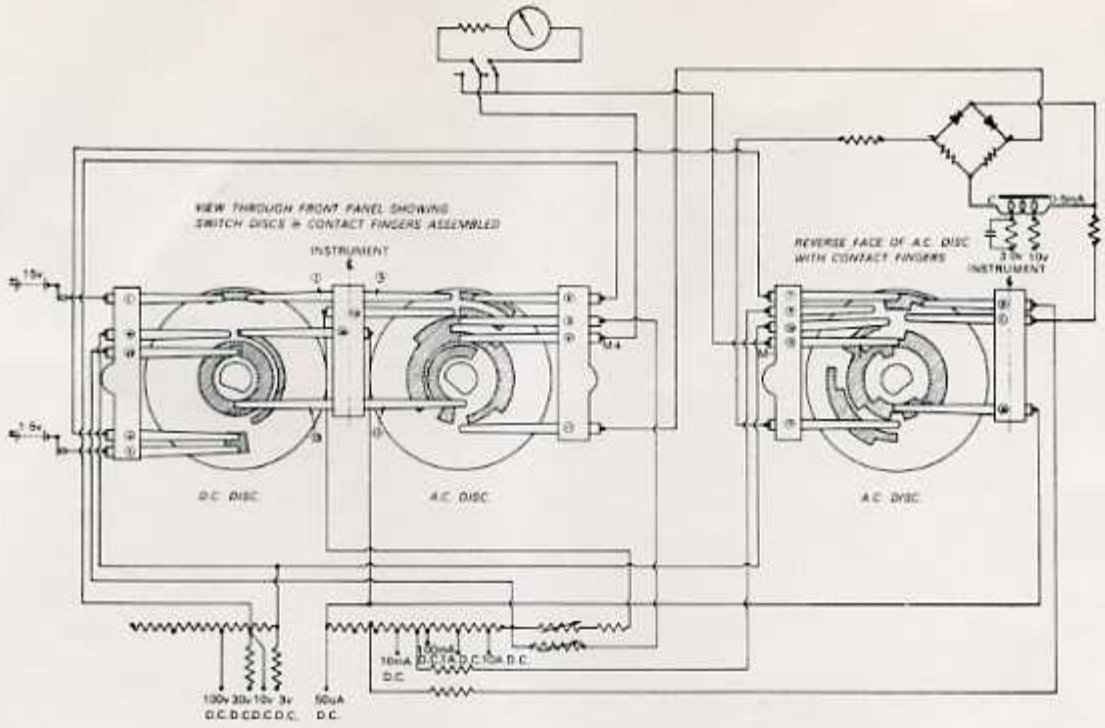

**Plate 8: Assemblies**



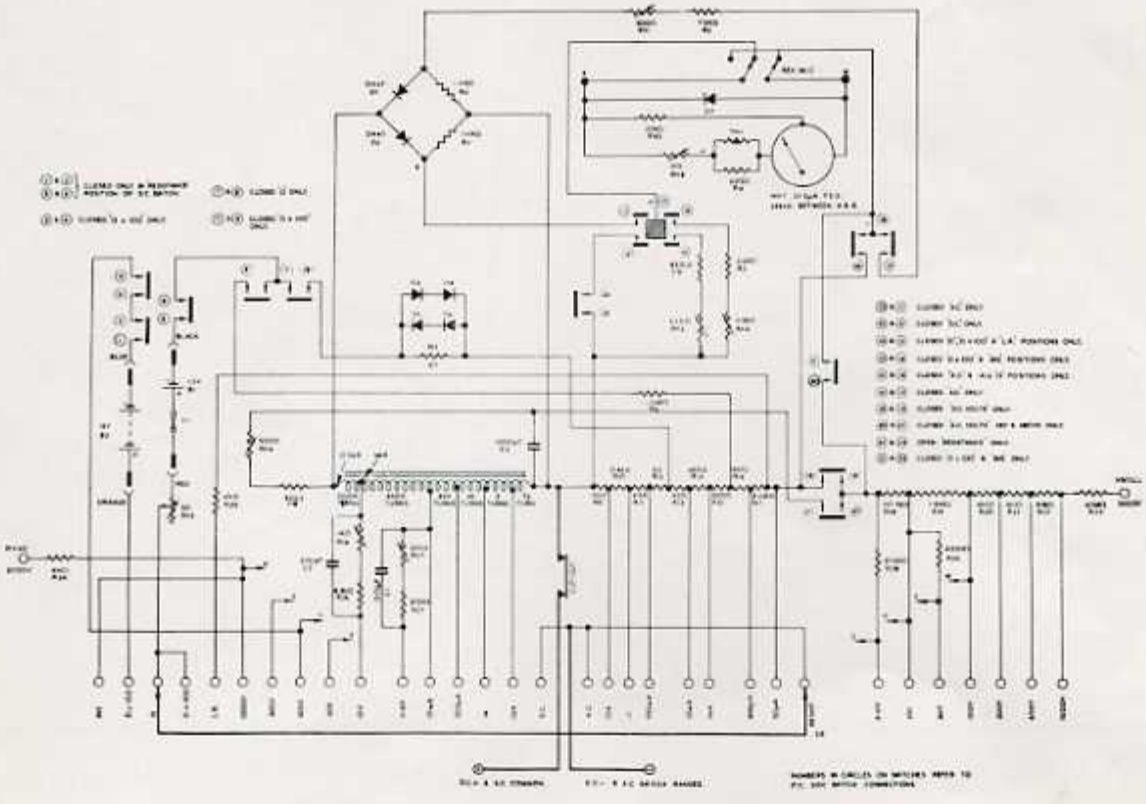

**Model 8 Mark 4: Switch Connections**



**Model 8 Mark 4: Circuit Diagram**




**Model 9 Mark 4: Switch Connections**



**Model 9 Mark 4: Circuit Diagram**