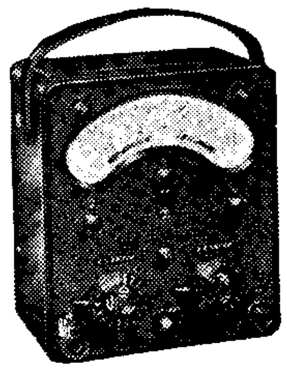


AVOMETER SERVICING INFORMATION

AVOMETER SERVICING INFORMATION

These instructions have been written to provide a general guide to the Servicing of Avometers. The instructions regarding the particular model under test can be readily ascertained and other instructions applicable to other models in the range can be ignored.

An abbreviated specification and recommended spares list covering an individual instrument is provided in the pocket on the inside back cover. If additional Spares Lists are required, the Part No. allocated to the particular model should be quoted.

No attempt should be made to service an Avometer unless the full range of test equipment, as shown on pages 6 and 7 is available. In the event of a major overhaul the instrument should be returned to Avo Limited. The average time to effect a complete overhaul is seven days and the repair carries a year's guarantee.

AVO LIMITED · AVOCET HOUSE · DOVER · KENT · ENGLAND

CONTENTS

SERVICING INFORMATION

INTRODUCTION

Throughout the past decade, the Avometer has built for itself an unrivalled reputation for reliability and service. It is, however, inevitable that instruments fail from time to time, mainly due to accidental misuse, and when they do, we are most anxious to ensure that they are repaired to the highest possible standard. We have therefore produced this booklet primarily to aid our friends and associates overseas, and we hope that it will form a useful guide to the trained engineer who has the task of servicing our products. We have not dealt with the instrument in absolute detail, for to do so would be beyond the scope of this publication although we have 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 test-gear and tools, can take factory pre-calibrated parts and fit them into the instrument, which will then only require a minimum degree of calibration and test.

We would ask you particularly to note the advice which we have given throughout this booklet, regarding the use of complete sub-assemblies. We strongly advise you to keep in stock a number of key items, in order that they can be immediately available when required.

Procedure 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:-

(1) Study this manual carefully, and identify the part(s) required.

(2) State the reference number of the part(s) required, the location in the instrument and the quantity required.

(3) State the serial number of your instrument, if known. This will be found on the instrument scale plate.

Overseas users of our instruments should send their requirements to our Representatives on their territory. If the parts are required in Great Britain, application should be made direct to Avo Limited.

TEST FACILITIES AND EQUIPMENT REQUIRED

1. ESSENTIAL TEST FACILITIES, EQUIPMENT AND CONDITIONS

Certain facilities and equipment are absolutely essential before any consideration can be given to the possibility of undertaking the repair of Avometers. To assist you in deciding whether the facilities and equipment available are adequate, we give below a short list of tools and test gear which will form your minimum requirements, assuming that you adopt our suggestion made in the Introduction to fit new sub-assemblies. If you decide 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 we have found that when dependent on artificial lighting, a general bench illumination of 75 lumens per square foot (ft. candles) is satisfactory. Do not smoke - this is particularly important when inflammable or cleaning fluids are exposed.

INSTRUMENTS AND TEST GEAR

Precision voltmeters a.c. and d.c. } Accuracy ± 0.3% D.C. Voltage ± 0.75% A.C.
Precision ammeters a.c. and d.c. } ± 0.5% D.C. Current

Flash testing equipment.
An ohmmeter or spare Avometer.
A substitute movement of each type encased and with flying leads.
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 ac 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

A small soldering iron.
Lightweight soldering iron for movement repairs.
Screwdrivers for 2BA, 4BA and 6BA screws.
A set of watchmakers screwdrivers.
A set of BA box spanners.
Tweezers suitable for light work on moving coil hairsprings etc.
Pliers, (various sizes).
A pair of duck-bill pliers.
A pair of side cutters.
A hand drill.
A set of twist drills from 1/4 in. diameter (6mm) approximately downwards.
One each of the following taps: 2BA, 4BA, 8BA and tap wrench.
A 1/4 in. UNF ring spanner is required for terminal nuts, with a 1/8 in. gap in the ring to clear connections.
A pin or tack hammer.
Pencil brushes.
1/2 in. brushes.
An eye glass.
Bellows or air blast.

SPARE PARTS.

A stock of Avometer spares.
A stock of recently manufactured appropriate cells and batteries.

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 degreasors 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.
Manganin wire 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.
Sticks of permanent white wax crayon.
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.
Wash Leather.
Cleaning Cloths.

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 to you (we assume here that the instrument has not been brought to you by hand). Apart from internal inspection, do not proceed with any repairs until, (a) you have received your customer's observations regarding the failure of the instrument, and (b) you are quite sure that the instrument has not suffered damage since it left your customer. Severe transit shocks can sometimes damage instruments internally, although externally they appear to be perfect. Always give your customer full details of any suspected transit damage, particularly when the damage to the instrument is more serious than that reported by him. Your customer may wish to claim financial damages from the carrier who shipped the instrument, and in order to assist him you should retain the packing material in which the instrument arrived. It is also most important that the carriers should be informed of the damage without delay.

If your customer has not told you specifically to go ahead with the repair, irrespective of your charge, we strongly advise that you should examine the instrument and submit an estimate before any work is carried out. (Do not overlook the condition of the leads, prods, clips, cell and batteries when quoting). This procedure, and the acceptance of your estimate will safeguard you against disputes arising over your charge for the work, after the necessary repairs have been completed.

3. CONSIDERATION OF THE CUSTOMER'S REPORT

If the customer has complained about troubles on the resistance ranges only, examine the batteries before opening the instrument, for testmeters requiring no more than the replacement of batteries, are often returned for repair. Take particular note of Section 14 (j) which deals with the state of the 15 volt battery (where applicable). If the battery or cell 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 be 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 you are unable to locate it, you should obtain the fullest information from your customer as to the symptoms, and then concentrate your efforts on the likely portions of the circuit or mechanism. 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 located by changing the instrument operating temperature by ± ten degrees from ambient temperature.

The cause of variation in readings if continuously present when testing electrically or during continuity tests can be diagnosed without much trouble.

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

4. FAULT DIAGNOSIS

A visual examination of the interior (read Section 6 before opening the instrument), will probably show where a 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 the substitute one should be connected to the appropriate points by means of its flying leads, to facilitate diagnosis.

It is very rare for an 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 and voltage tests at full scale should be made on successive ranges commencing with the lowest as far as the faults present will permit. (See abbreviated specification in the appropriate Parts List).

5. ACCURACY

The standard required after repair should be as specified for a new instrument. (See abbreviated specification).

6. REMOVAL OF THE PANEL FROM THE CASE

If one is assured that the instrument does require opening (see the notes which follow for your guidance in fault finding), it should be placed on the bench before you, and the 'AVO' seal removed from its side, a heated screwdriver facilitating 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.

7. REMOVAL OF MOVEMENT FROM 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 be 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 1/16 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).

Raise the movement carefully from the panel and place it in a suitable covered receptacle for cleanliness.

After withdrawing the movement from the panel, damage may be more easily detected by signs of scorched windings, burnt contacts, etc. Intermittent contact troubles or component failures may be more difficult to locate. One should, therefore, with the aid of the circuit diagram, and making use of any information obtained from the preliminary tests or the detail in Section 13, trace through the suspected part of the circuit wiring by means of an ohmmeter or another Avometer until the fault is located.

Particular attention should be paid to the operation of the leaf switches to ensure that there is a reasonable factor of safety in the making and breaking of the various contacts (See Section 16).

THE SUPPLY OF INTERCHANGEABLE PARTS AND SUB ASSEMBLIES

8. SUB-ASSEMBLIES

We would ask you to take particular note of the following sub-assemblies:-

(a) The Bottom Resistance Board.

(b) The Top Resistance Board.

(c) The Cut-out Table Mechanism.

(d) The Movement.

The first two items (a) and (b) incorporate numerous resistors which have been carefully calibrated well within the limits shown in the publication. If any of these resistors become damaged individual components can be replaced. In earlier models if it is necessary to replace one of the high stability carbon resistors, the associated supplementary resistor must also be replaced. In more recent models metal film resistors are used and supplementary resistors are not required. It is preferable to replace faulty resistors with the appropriate value obtained from the company, or even the complete board if damage is extensive, rather than to try to rectify damage with the type of component normally available.

The latter two items (c) and (d) are not only carefully made (and precision calibrated in the case of the movement), but they contain many matched parts which may present mechanical, as well as electrical problems if individual parts are replaced. If you have not all the necessary apparatus at your disposal and skill to carry out the repairs to either assembly, replace the whole unit. A faulty movement may be sent to the factory for repair or replacement. We do in particular, recommend you to replace a seriously faulty movement with a new one, for so many difficulties can arise if you are not fully equipped and skilled in this delicate work. The factory employs special jigs, fixtures and tools for the assembly of the two sub-assemblies (c) and (d) enumerated above, and without their aid, some repair tasks become most difficult.

The notes which follow regarding these particular components will enable you to decide how to proceed.

9. THE BOTTOM RESISTANCE BOARD

Where windings or bobbins are burnt out it will be necessary to replace these either with factory pre-calibrated components or alternatively it is recommended that the whole board is replaced. If there is a fault on the shunt windings it will be necessary to check the instrument sensitivity after replacement. Adjustment may be required for individual ranges if re-winding has been carried out. Thus, unless all the necessary equipment is available to carry out these tests and adjustments satisfactorily, we suggest you replace the board complete.

10. THE TOP RESISTANCE BOARD

This board carries most of the voltage multipliers. The multipliers employ metal film resistors of high accuracy but earlier models used high stability carbon resistors supplemented by low value wider tolerance resistors to obtain the required accuracies. It is essential that if a high stability carbon resistor is replaced the associated supplementary resistor is also replaced. Damage in this multiplier network can be made good either by replacing the whole board, or by the insertion of factory pre-calibrated resistors or bobbins.

11. THE CUT-OUT MECHANISM

Individual mechanical spare parts for the cut-out table mechanism can be fitted if the necessary skill and facilities to carry out the work are available, but it must be stressed that the rebuilding of this mechanism is not as easy as it would at first appear, and it is often more economical to purchase a new assembly, than to repair the old.

Where a completely new cut-out assembly is supplied a design change may cause some difficulty on very early models as regards the cut-out table locking screw and guide pillar. Modern assemblies use 6BA threads in these positions, whereas older models use 8BA threads. If the original pillar and screw have been retained, they can usually be fitted to the new assembly, but if the holes in the panel have been stripped they would have to be re-drilled and tapped 6BA before the new assembly can be fitted.

12. 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 a swamp bobbin for adjustment to the correct resistance. See instructions concerning removal from the panel before commencing any work (See Section 7).

If adequate facilities and skill are available for major movement repair, certain spares are available, but reference should be made to Section 18 before dismantling. Spare hairsprings and pivots can be supplied, but we would stress that the latter item is difficult to fit, and such work should not be attempted unless adequate facilities, tools, jigs, fixtures and the necessary skill are all available. Some loss of accuracy is probable and remagnetisation may be required if the springs are replaced. The moving coil complete with hairsprings and pivots can also be supplied but the replacement of such a unit in the movement is difficult and will demand not only the adjustment of sensitivity to the correct value and re-calibration of the swamp resistance but possible re-writing of the scaleplate, in order to regain the original accuracy. The latter is hardly possible without special facilities and skill. The fitting of a new moving coil will also necessitate the re-balancing of the movement whilst the magnet may have to be re-magnetised and aged before the sensitivity can be set.

In view of the difficulties set out above the desirability of fitting a complete movement is self-apparent. When a movement is changed, always ensure that the serial number marked on its scale plate is transferred to the scale plate of the replacement movement.

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 (u) 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. On socket type terminals ensure that sockets are clean.
(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. current ranges inoperative and lower ranges incorrect.	One or more shunt sections open circuit.
(d) No dc voltage readings (or erratic readings) in excess of a particular range.	An open circuit in a resistor beyond the last working range.
(e) No ac readings (or erratic readings) in excess of a particular range over 100V.	An open circuit in a resistor beyond the last working range.
(f) Low, or fails to read on ac, but is correct on dc.	Suspect a faulty rectifier, or transformer. Insufficient pressure on leaf contacts.
(g) Reads approximately 33% high on d.c. volts.	Shunt open circuit.
(h) Ohms range inoperative, intermittent or incorrect.	Battery or cell not making satisfactory contact. Rheostat windings tarnished or faulty. Burnt out resistors or leads intermittent. Faulty potentiometers or fuses.
(j) Inability to attain ohms zero setting or ohms zero drifts shortly after being set. Low readings on Ω x 100 range.	Cell and battery deterioation.
(k) Instability of reading in general.	Examine leaf switch contacts, main switch contacts and cut-out. Also ÷2 contacts or reverse moving coil contacts as applicable.

(m) Cut-out fails to re-set.	Mechanism set too finely, or jewel in bell-crank chipped. Bent spindle or ruptured lock lever.
(n) Cut-out fails to operate on moderate overloads.	Cut-out mechanism set too coarsely, operating rod bent. Bent spindle or dirt in reset housing.
(p) 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
(q) Pointer stuck at one particular point.	Dust or other foreign body fouling the movement. It may possibly be in the gap, on the scaleplate or window glass.
(r) Slight uniform pointer stick over whole scale.	Tight in jewels, blunted pivots, dirt in jewels or possible damaged jewels.
(s) Pointer stuck firmly.	Pivot out of jewel.
(t) Movement out of balance.	Pointer moves from position of rest by more than 1% of the maximum value when the instrument is held in any position within 45° from horizontal.
(u) Where applicable: Normal current and voltage ranges incorrect, but ÷ 2 ranges correct.	Q control left in contact with variable resistance or not making contact with strip. Open circuit in network connected to above strip or ÷ 2 button.

To enable you to decide on the most suitable method of repair 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 8 to 12 regarding the supply of sub-assemblies.

Details regarding the removal and resetting of main assemblies are given in Section 15 to 18 inclusive.

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

Ensure that the movement swings freely. 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 current or voltage range, the leads should be checked for open circuit and the cut-out examined. If the instrument has socket type terminals check that the sockets are clean using the terminal nuts to connect the instrument to the supply. 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. (See Section 14 (k).

NOTE: Check that the appropriate leaf contact cam screw is locking and the cam correctly positioned before (b), (c), (d), (e) and (f).

(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 dc Voltage readings (or erratic readings) beyond a particular range.

The fault will almost certainly be an open circuit resistor connected in the circuit beyond the last working dc voltage range. It will therefore be necessary to check the resistors on the first non-working dc voltage range. The faulty resistor together with its supplementary resistor, if present, should be replaced by one from the company.

(e) No ac Voltage readings (or erratic readings) beyond a particular range over 100V.

Once again this fault will almost certainly be an open-circuited resistor connected in the circuit following the last working ac voltage range. It will, therefore be necessary to check all resistors in the first non-working ac voltage range. The faulty resistor, together with its supplementary value where applicable, should be replaced.

(f) Low, or fails to read on ac, but is correct on dc.

This fault may be due to high resistance or insufficient force on the leaf contacts. The complete bank should be checked, cleaned with switch cleaning fluid and re-set if necessary (See Section 16). (Under no circumstances should abrasive material be used to clean contacts). If the contact settings are satisfactory the bridge circuit should be checked and replaced if necessary.

If the fault still persists the transformer should be replaced. Further testing will then show whether the original bridge circuit is also defective. The transformer can be removed by unsoldering its connections, and removing the bolt which runs through its centre.

Should the transformer have to be replaced careful note should be taken of the transformer connections before removal.

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

This will almost certainly be due to an open-circuited shunt. Where windings or bobbins are burnt out they should be replaced by components of the correct value or alternatively the complete shunt should be replaced. After this has been carried out and the movement refitted the instrument sensitivity should be checked. Slight adjustment may be necessary to the magnetic shunt. If in spite of our recommendation, windings are replaced, the appropriate range should be checked and the windings adjusted as required.

(h) Ohms range inoperative, intermittent or incorrect

If the reading is erratic remove the case and connect a voltmeter to the battery contact strips. If the voltmeter reading is unsteady the battery contacts should be cleaned and this should clear the fault. If the lower ranges are inoperative the fuse or P & R resistors as appropriate to the particular instrument should be checked and replaced if necessary. If the fault still persists other components in the relative circuit should be checked and the leaf contacts cleaned with switch cleaning fluid or re-set if necessary (See Section 16). Under no circumstances should abrasive material be used to clean switch contacts.

(j) Inability to attain ohms zero setting or ohms zero drifts shortly after being set Low readings on X100 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. 15 volt battery (where applicable. It can so happen that the 15 volt battery may age in such a manner that although it has an e.m.f. of 15 volts, 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 indications 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 is 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.

(k) Instability of reading in general

If there are any signs of burnt out components all leaf contacts, the cut-out and switch contacts should be cleaned before any further testing is carried out.

The individual springs of the leaf switches sometimes fail to make contact correctly. Should the application of switch cleaning fluid be of no avail they should be adjusted by bending their extremities up or down by means of a pair of duck bill pliers (See Section 16). If this fails to cure the fault the main switch contacts and the cut-out contacts should next be examined. There may be deposits of soot or condensed vapour from a burnt out component causing intermittent contact or even complete failure. The contacts should be cleaned by brushing with a switch cleaning fluid, but if this is ineffective the switch may have to be removed from the panel. (See Section 15).

If the fault has not yet been located the ÷ 2, Q or reverse moving coil contacts should be examined. These may need cleaning with a suitable fluid or re-setting. It may be that general cleaning of all the contacts would remove the instability, particularly if there are signs of gross overloading.

(m) Cut-out fails to re-set

Ensure first that the spindle is not bent, that the lock lever spring is returning right home and the turned-over-end is not fouling the groove in the table.

If the cut-out mechanism has been set too sensitively (See Section 17) or the pallet stone which is fitted into the crank has broken, the cut-out button may refuse to stay set. In the latter case, either the whole cut-out table mechanism will have to be replaced or a new crank fitted, provided that adequate facilities are available for its final adjustment. 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.

If the cut-out leaf spring on the movement has been removed, it should, on refitting, be adjusted to a strength which only just restores the bell-crank after displacement.

(n) 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 or the leaf spring on the movement may be set too strongly. For test and re-setting instructions (see last paragraph of Section 14 (m) and Section 17). The thrust rod if bent during re-fitting of the movement might be tight in its guide and cause trouble.

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

(p) Low reading 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 upon one 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 a badly deformed spring should be replaced (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 scale plate where they may cause discolourisation. 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 could also 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 coil and swamp together with the shunted thermistor (where fitted) at 20°C is much below the specified figure and in addition the full scale movement current is in excess of the correct value this would almost certainly confirm a fault of this nature.

(q) Pointer stick at one particular point.

This symptom usually indicates that a small piece of iron or some other foreign body has found its way into the magnetic gap or on to the concentrator and is fouling the moving coil former. The movement should be withdrawn from the panel and with a piece of white paper inserted between the two magnets to improve visibility, the gap should first be examined in good light. Specks of dust or even a hair if present, can be removed with a fine needle. Magnetic particles may have to be coaxed towards the edge of the gap with a fine needle before they can be extracted. Ensure that the gap is completely clean before checking further.

A minute hair on the scaleplate or window could cause sticking and this may only show up in a bright light. In all such cases sticking might also be dependent on a slight tilt of the instrument associated with the small but essential pivot play.

Note: Never dismantle the movement for cleaning unless attention to the above points fail to clear the fault. (See Section 18 if it is necessary to dismantle the movement).

(r) Slight uniform pointer stick over 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 of a slight sideways rock. Slightly easing the top jewel screw will show if this is the cause of excessive friction and effect a cure.
Note: Instruments fitted with the most recent type of spring jewel assembly will also 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 peculiar change of swing just before coming to rest and furthermore the instrument held on its side might also show complete instability of zero reading.

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.

Note: 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 or parts. After removing the frame from the magnet and pole piece assembly (see Section 18) unsolder the hairsprings. Unscrew the bottom jewel screl and then the bridge together with the top jewel, zero adjuster etc., after which the coil can be removed and jewels

inspected. If a microscope is available (having a magnification of x100 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 done 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 a spherical radius of less than one fiftieth that of the pivot diameter, i.e., .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 .012in. This can determine the maximum jewel retraction under the influence of impact.

A damaged jewel, (which is a most infrequent occurence) must always be replaced by a similar one supplied in its spring mounting. Care must be taken on reswinging the movement to ensure that the jewel setting is correct, i.e., that only a minute degree of pivot side play is present and one has not over tightened it and passed the conditions of zero play to where it reappears.

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, hair-springs or even a moving coil complete is almost always accompanied by some loss of accuracy.

(s) Pointer stuck firmly

It can occasionally happen that severe mechanical shock can cause a pivot to leave its jewel and become lodged on the end of the jewel screw. If this has happened do not try to push the pivot back as damage will occur. The bridge piece screws should be eased off, the pivots replaced and the bridge re-tightened. A slight re-adjustment of both top and bottom jewel screws might help to avoid the recurrence of such a mishap.

(t) Movement out of balance

The moving coil is balanced when the instrument leaves the factory, but very severe overload, mechanical shock or pivot damage may cause it to become unbalanced. The balance limits permitted in BS89 allow a pointer change of $\pm$ 1% of maximum scale value when the instrument is held in any position within 45° from horizontal.

If the movement needs rebalancing it should be mounted in the draught proof box (see Section 1) 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 the zero position with the 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 and metal balance weights will have to be wound and firmly stuck in position. After drying out, re-balancing will be called for as above.

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 assembly should be replaced and the original unit returned to the factory for servicing or replacement.

(u) Normal Current and Voltage Ranges incorrect but ÷2 ranges correct (where applicable)

This will almost certainly be due to the Q control being left in the wrong position and making contact with the rheostat or the spindle not contacting with the spring strip. It could also be due to a fault in the resistor network associated with the ÷ 2 circuit.

If the Q control has been left in contact with the variable resistance, restore the control to the correct position. If the indication on a normal range of 10V upwards is twice its correct value, it is possible that the Q arm is not making contact with the strip or the ÷ 2 contact is not making in the normal position. Should it read 33% high one of the resistors which shunts the movement on normal ranges is probably open circuit.

DISMANTLING AND RE-SETTING INSTRUCTIONS FOR SWITCHES, CUT-OUT MECHANISM AND MOVEMENT

If removal of the main switch assemblies, leaf switches, cut-out mechanism or the movement is necessary the following instructions should be carefully studied in order that the assemblies are removed without further damage and to ensure that the re-setting operations necessary for correct functioning are carried out satisfactorily. Under no circumstances should lubricating oil be applied to either cut-out, pivots, switch rings or switch contacts.

15. MAIN SWITCHES

If a broken knob has to be replaced, the instructions below should be followed. If however, a switch ring or the wiper arm are burnt it will first be necessary in the case of the AC switch to remove the two resistance boards, the transformer and the leaf switch assembly.

AC Switch

Remove the 4BA screw from the cam which can then be withdrawn from the spindle. Set the switch to the 100V position and push the pin through the carrier. Turn the switch through 180° and if the pin is not dislodged remove it with a pair of pliers.

Place the panel on the bench with its face uppermost. If the 'a.c.' switch knob is now gently lifted, the click ball will remain supported in its spring whilst the cam and arm assembly will fall away from the inside of the meter towards the bench.

To replace the switch, place wiper arm assembly together with the cam loosely in the correct position within the instrument in the centre of the switch ring, and place the meter on the bench with the panel uppermost. Place a little mineral jelly on the click ball spring and insert it into its hole in the panel. Place a similar dab of jelly into one of the slots on the underside of the switch knob and press the click ball into the jelly. Turn the panel again face downwards holding it in one hand, and push the spindle of the knob into the panel carrier and cam, ensuring that the click ball seats down on its spring and compresses it correctly. Turn the switch knob to its 10A (100mA Models 7 & 40) position and place the panel face downwards on the bench with the cut-out assembly towards you. Turn the wiper arm assembly until the arm points away from you. Take the carrier pin, and place it in the hole in the brush arm carrier and press it home. The cam, with its washer should be set and firmly tightened as detailed in Section 16.

DC Switch

The procedure for the removal of the 'd.c. Ranges' switch is similar to that out-lined for the 'a.c. Ranges' switch, but when replacing the switch assembly the rotary contacts should be pointing towards you when the switch has been set to the line between volts and ohms. The carrier pin should now be inserted and the cam replaced and set as explained in Section 16.

16. LEAF SWITCHES

The individual springs of these switches sometimes fail to make contact correctly. Leaves can be adjusted by bending their extremities up or down by means of a pair of duck bill pliers. The adjustment of these leaf switches sometimes proves to be rather difficult and in some cases it is more economical to replace the whole contact assembly rather than spend time on the adjustment of the old one.

Cam Setting (Models 7 and 40)

(a) A.C. Switch when set to D.C., all contacts should be lifted to their fullest extent. The cam should be turned until this occurs, and the cam locking screw then tightened securely.

(b) D.C. Switch. With the knob set to 10,000 ohms the outer cam should raise the contacts nearest the movement to the maximum extent, and the cam should be tightened securely in this position. On rotating the knob, the other pair of contacts should make on the positions 0.01A to 10A, but must be open on 0.002A. Ensure that the leaves are truly positioned laterally so that they do not catch on a wrong 'lift'.

Cam Setting - other models

(a) 'A.C. and ohms range' switch. When set to the Ω ÷ 100 both contacts of the set of leaf contacts nearest to the cut-out should be lifted to their fullest extent. The cam should be turned until this occurs. The cam should then be set tentatively at the centre of the rise and fall of the contacts and the cam locking screw then tightened. After ensuring that the contact clearances of the leaf switch are correct tighten the cam screw securely.

In order to confirm that the movement is smooth and that there is a reasonable factor of safety at all positions of change when the click is finally home, the switch should be rotated to all range positions. It may occasionally happen that a slight rotation of the cam will give an increased factor of safety all round. If so, re-set and having found the optimum position re-tighten the screw firmly. Ensure however, that the leaves are truly positioned laterally so that they do not catch on a wrong lift.

Ensure that all leaf springs are in alignment (viewed from the top) to allow the ceramic plungers freedom of movement. All the leaf contacts should have a good side clearance.

(b) 'D.C. Ranges' switch. When set at 'Resistance' the set of contacts nearest the cut-out contacts should be in the lifted position. The cams should be turned until the contacts are in this position and then set the cams at the centre of the rise and fall of the contacts. The screw in the top of the cam should be tightened firmly.

17. CUT-OUT REPAIR AND SETTING

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. The collar should allow the bush to be turned without restraint but there should be no floppiness.

As the tripping value may have been disturbed by the replacement of the fixed or moving contacts, or by having removed the movement for servicing, the cut-out setting should be checked. It is assumed that the leaf spring which returns the bell crank on the movement is correctly adjusted. (See Section 18).

Ensure that all contacts are clean and set correctly. The contacts are arranged in such a manner that when the cut-out is being re-set, the outer contacts make first, and the gold-silver contacts last. When the cut-out trips, the inner contacts should move from their static position by 1/32in. (0.8mm) before breaking, thus transferring the current to the outer contacts which should break after a further movement of 1/32in. (0.8mm). The arcing therefore takes place between the outer contacts and safeguards the inner gold-silver contacts which must always maintain low contact resistance when the cut-out is closed.

If the cut-out is over or under sensitive (see cut-out operation in abbreviated specification), loosen the guide pillar and screw securing the cut-out table and rotate it minutely so that lever just engages the jewel in the bell crank sufficiently to cause correct operation when the fixing screws are re-tightened. Confirm the setting be several tests.

The cut-out mechanism of an instrument will sometimes be found to be so sensitive that it flies out whenever the instrument is touched. This symptom is usually due to the cut-out table having been turned too far clockwise. The trouble may usually be cured by rotating the cut-out table minutely in an anti-clockwise direction.

18. DISMANTLING THE MOVEMENT

If it is essential to dismantle the movement the following instructions should be followed:-

First remove the movement from the panel (See Section 7). Be most careful to ensure that ferrous objects such as screwdrivers are not allowed to come in contact with the 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 itself can subsequently be extracted from the assembly for any necessary attention. To do this, the 10BA screw securing the cut-out leaf spring on the base of the frame assembly should be carefully removed together with the leaf spring. 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 slackened 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(r). If new hairsprings have been fitted, it is most important that they are orientated correctly. The leaf spring must only just be strong enough to return the bell cranks after displacement.

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 de-greased before mounting. For colletted springs, it is only the outer end which required 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 refitting, 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 leaf spring does not foul the thrust rod. Hold a piece of 1/16in. of non-magnetic material between the magnet and 2BA screwdriver while tightening the screws which operation must be done firmly.

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 reset the cut-out mechanism. (See Section 17).

The bottom zero adjuster should be set so that the external screw gives about equal pointer adjustment above and below scale plate 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.

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.

FINAL PROCEDURE

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 reboxing 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, i.e., 3/8 in. long. The use of screws of incorrect length can cause the breakdown of an instrument on flash test.

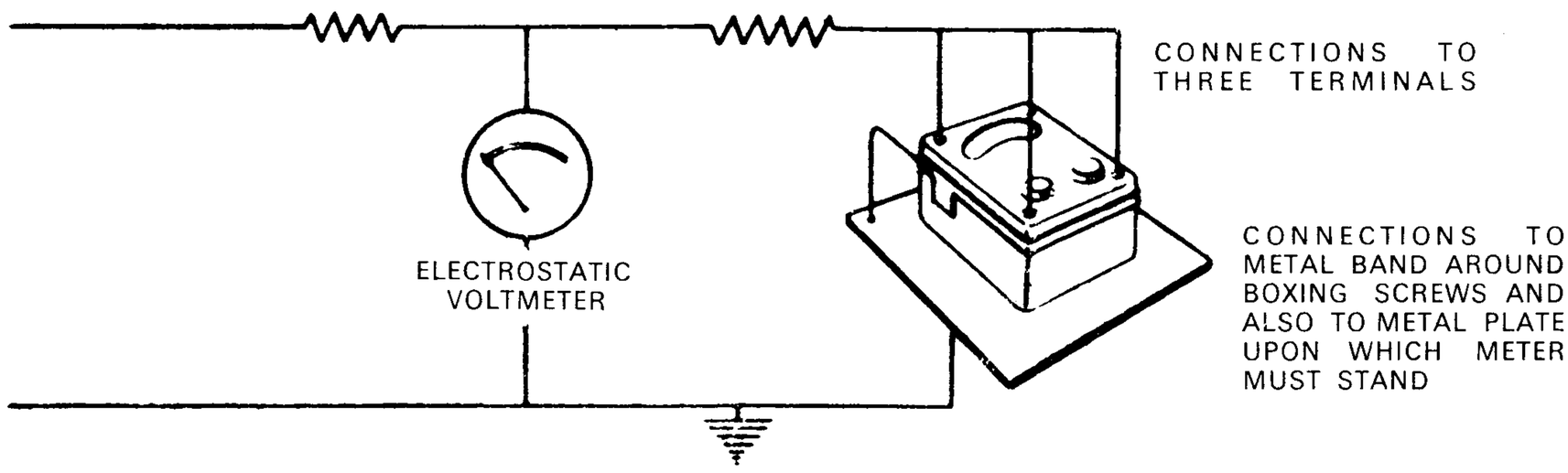
It is so important that ranges are clearly marked that should the white fillings be defaced, the old fillings should be removed and replaced with a white filling wax or alternatively with white cellulose paint using a very fine brush or mapping pen. The paint should be left to dry, and surplus then rubbed off with a rag slightly damped with methylated spirit. The surplus paint will then be removed without destroying the surface of the fillings, but care must be taken to ensure that it is not deposited in the 'crackle' finish of the moulding.

Take a small stiff bristle or hair brush, give it a very slight dressing of thin mineral oil, and brush out the dirt from the stippled surface of the mouldings. Place a little thin mineral oil on a piece of clean rag, and thoroughly wipe over the whole of the mouldings.

The general 'brightening up' of an instrument will usually have a most profound psyschological 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 by applying twice the maximum voltage + 1000V at 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 a safety switch in the primary circuit to the transformer. (See abbreviated specification).



The test voltage should be raised and lowered gradually. Indication of breakdown will be given by the failure of the needle 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 neglibile 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.