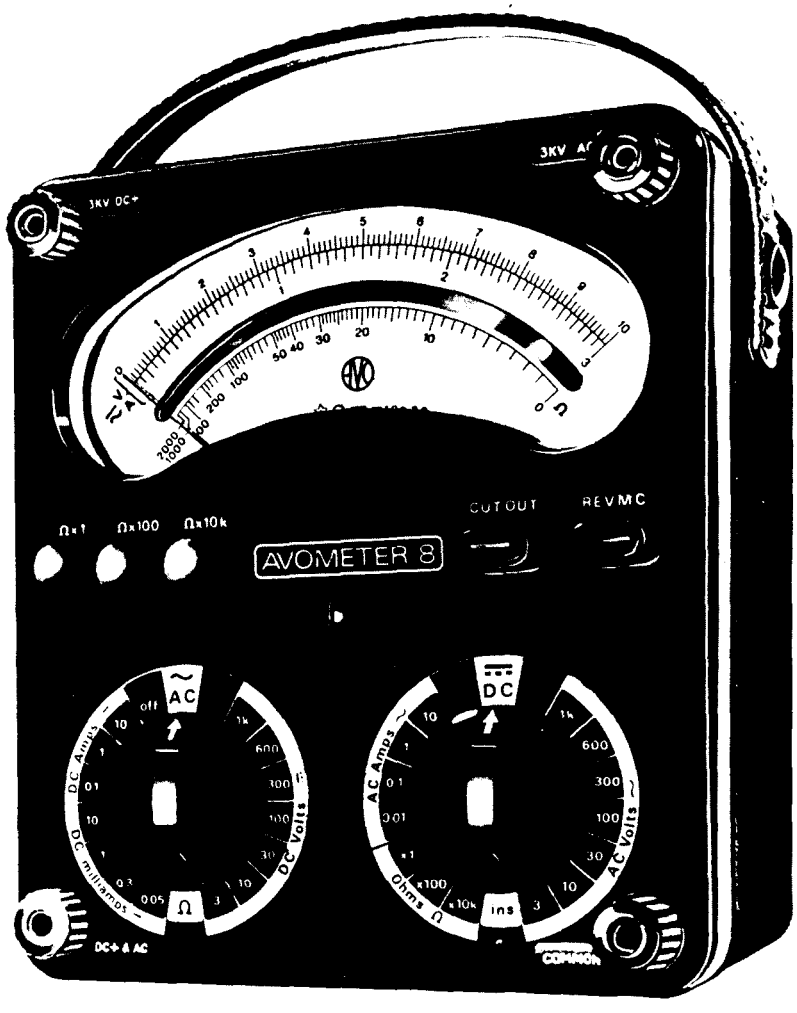
Model 8 mk 5
AVOMETER®



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INTRODUCTION

It is inevitable that instruments will fail from time to time, mainly due to accidental misuse, and when they do, it is essential they are repaired to the highest possible standard. This booklet has been prepared therefore, to aid instrument servicing organisations and it is hoped that it will form a useful guide to the trained engineer who has the task of servicing our products.

The instrument has not been dealt with in absolute detail for 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 components and spare parts and fit them into the instrument, which will then only require a minimum degree of calibration and test.

Particular note should be taken of the advice which is given throughout this booklet regarding the use of the complete sub-assemblies, it is advisable to keep a number of key items in stock, in order that they can be immediately available when required.

No attempt should be made to service the meter unless the full range of recommended test equipment is available.

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 these 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 assemblies is adopted. If it is essential to undertake the more complicated tasks then very much more equipment will be required and for certain fine operations, good eyesight and a steady hand are essential.

Experience has shown that the following conditions are important:

(a) The air in the repair room should be filtered and controlled to 20°C at which temperature most instruments are calibrated.

(b) In order to see clearly small components and foreign matter, a well-lit, plain, light-coloured bench is essential. Small fibres or hairs around the moving coils can very often only be seen under the light from tungsten lamps.

(c) Many cleaning fluids and adhesives are highly inflammable so do not smoke when repairing instruments.

INSTRUMENTS AND TEST GEAR

Suitable precision voltage and current meter ac and dc (Digital *AVOMETER* DA 116 or equivalent)
An Ohmmeter or *AVOMETER* Model 8 (for fault-finding)
A substitute movement encased and with flying leads (37.5 μA f.s.d. 2667 Ω)
A Resistance Box
A Wheatstone Bridge complete with galvanometer
Controlled voltage and current supplies
Thermometer (all measurements to be carried out at 20°C)
Draught-proof box with mountings for movement and having a glass cover and connections for test purposes
A potential divider for checking scale shape linearity (See Section 16)
Flash Testing Equipment (7kV ac r.m.s. 50Hz)
(This equipment does not include that necessary for major movement repairs. Please refer to Section 8(b).)

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 type transformers at settings when the output voltage differs appreciably from that of the input.

TOOLS AND OTHER AIDS

De-soldering equipment with solder removal facilities
A temperature controlled 60W soldering iron (essential for film wiring) *e.g.* Weller No. 5.
Screwdrivers for 2BA, 4BA and 6BA screws
Torque screwdriver 8BA 3 to 4 in. lb
A set of watchmaker's screwdrivers
Posidrive No. 1 and No. 2 point
A set of BA box spanners
A set of open-ended BA spanners
Tweezers suitable for light work
Pliers (various sizes)
A pair of sidecutters
A hand drill
One each of the following taps 2BA, 6BA, 8BA and a tap wrench
Special ring nut spanner for terminals
Pencil brushes
$\frac{1}{2}$ in. brush
An eye glass
Bellows or air blast

SPARE PARTS

A stock of spare parts
A stock of recently manufactured appropriate batteries (1.5V and 15V)
A stock of film wiring

MISCELLANEOUS ITEMS

Some small receptacles to hold piece parts
Small glass jars with lids for fluids (i.e. alcohol) for switch cleaning and liquid soap (washing-up liquid) for cleaning the case and glass
A reel of good quality cored solder (60% tin, 40% lead) in 20s.w.g. (1mm) such as (Ersin multicore)
A number of steel needles (for removing magnetic particles from movements)
White cellulose paint
Cellulose thinners
Tubes of adhesive such as Bostik type 1768 white (17523-163)
Tubes of bostik (black) or similar glazing compound
Thin mineral oil (use only to polish outside of meter)
MS4 silicone grease (Midland Silicone)
Wash leather
Cleaning cloth (lint-free)

2. Suggested repair procedure

When the instrument arrives for repair, examine it carefully and note any signs of transit damage. 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 and the tough ABS case would probably show no signs of external damage. Always give the customer full details of any suspected transit damage, particularly when damage to the instrument is more serious than that reported by him. The customer may wish to claim financial damages from the carrier who shipped the instrument and because of this, the packing material in which the instrument arrives should be retained. It is also 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 charges, we strongly advise that the instrument should be examined and an estimate submitted before any work is carried out. Do not overlook the conditions of the leads, prods and clips and also the batteries when quoting. This procedure and the acceptance of the estimate will provide a safeguard against disputes arising over the charges 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 batteries (1.5V and 15V) which are readily accessible from the back of the instrument (See Section 6) for testmeters requiring no more than the replacement of batteries are often returned for repair. On some types of 1.5V batteries which have zinc cases (either customer or factory fitted) a white deposit can appear on the base of the battery. This can give rise to a high resistance connection in the ohms x 1 circuit and this in turn, gives rise to inaccurate readings. To eliminate this problem, the base of the battery should be carefully cleaned with a suitable abrasive (i.e. fine emery cloth) and silicone grease (MS4) smeared on the base of the battery to prevent a recurrence.

Although the 15V battery may have an e.m.f. of 15V, its internal resistance can increase so much with time that 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 worthwhile removing the battery and momentarily checking its short circuit current on the 100mA dc 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.

If the battery replacement is all that is found necessary the instrument should still 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 7) and the full extent of the fault reported to the customer before proceeding with the repair.

Should the reported fault not be apparent, it may be intermittent and if it cannot be located, the fullest information should be obtained from the customer, in order to highlight the likely portions of the circuit. Intermittent faults can often be traced by changing the instrument operating temperature by $\pm$ 10°C from ambient temperature.

The customer may occasionally insist that a fault is due to defective manufacture, but investigation will frequently show that damage has been caused by misuse, *e.g.* overloads, such as the application of high voltage to resistance or current ranges. Some users imagine that the cut-out should protect the instrument fully in all circumstances, in spite of warnings given by the Company to the contrary. The customer should be informed if this is the cause before any work on the instrument is commenced. Even if the instrument appears to be free from fault, it should nevertheless be carefully examined for pivot damage or stick and correct balance.

4. Fault diagnosis

Note: Read Section 7 before opening the instrument.

A visual examination of the interior will probably show where a fault lies, but do not dismantle any parts before examination or test. A drawing of the film wiring layout is given in Fig. 1 to assist in tracing circuit connections.

Provided the movement appears to be in order a few well-chosen tests will certainly determine the extent of the fault (See Section 9). If the movement is suspect, it should be disconnected and a substitute connected to the appropriate points to facilitate diagnosis.

For electrical tests a source of variable ac/dc voltage and current, 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.

If it is required to check the accuracy of the instrument, this may be done by comparison with a higher accuracy instrument such as a Digital *AVOMETER* DA 116.

5. Specification

After repair the instrument should meet the following accuracies under reference conditions outlined in BS 89 1977 and IEC 51:

D.C. Voltage and Current Ranges: ± 1% of f.s.d.
A.C. Voltage and Current Ranges: ± 2% of f.s.d. (50Hz) } Unless otherwise agreed by the customer.

Frequency Response: Variation from reading at 50Hz on ac current ranges or ac voltage ranges up to 300V not greater than ± 3% between 15Hz and 15kHz.

Temperature Effect: Variation due to temperature change not greater than 0.15%/°C.

In addition ensure that the instrument meets the following requirements:

Balance: ± 1% max. at 45°.

Zero: Ensure that the meter can be set to the zero position (mechanical) and that the adjustment is approx. equal either side of the zero position. Check for sticks over the whole scale with the meter in the horizontal position.

Ohms Zero: Ensure that this can be set satisfactorily on all three ranges, x1, x100 and x10k.

6. To replace fuse or batteries

It will not be necessary to open the instrument to test or replace the batteries or fuse. Simply turn the $\frac{1}{4}$ turn fastener on the back of the instrument until the slot is vertical. Lift off the battery cover when the 15V and 1.5V batteries, 1A fuse and spare fuse will be readily accessible. When replacing the batteries ensure that they are replaced in the correct polarity as indicated on the case moulding.

7. Removal of the case from the panel

With the instrument face downwards remove the battery cover as in Section 6. Remove the two screws which can now be seen. Remove the two *AVO* seals at the bottom of the case and also the two screws which will be found below the seals. Lift the case clear of the panel taking care not to break the connections to the battery compartment. Still holding the case turn it over and remove the four push-on battery clips. When replacing the case ensure that the battery clips are re-connected correctly as indicated on the moulding. It is important to ensure that the red positive battery lead is pushed right home and is lying flat.

Ensure that the sealing gasket is kept in a safe place as it will be required when re-assembling the instrument.

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 9), to check the suspected part of the circuit by means of an ohmmeter or multimeter until the fault is located.

It is not advisable to dismantle the instrument further until the need to do so has been established.

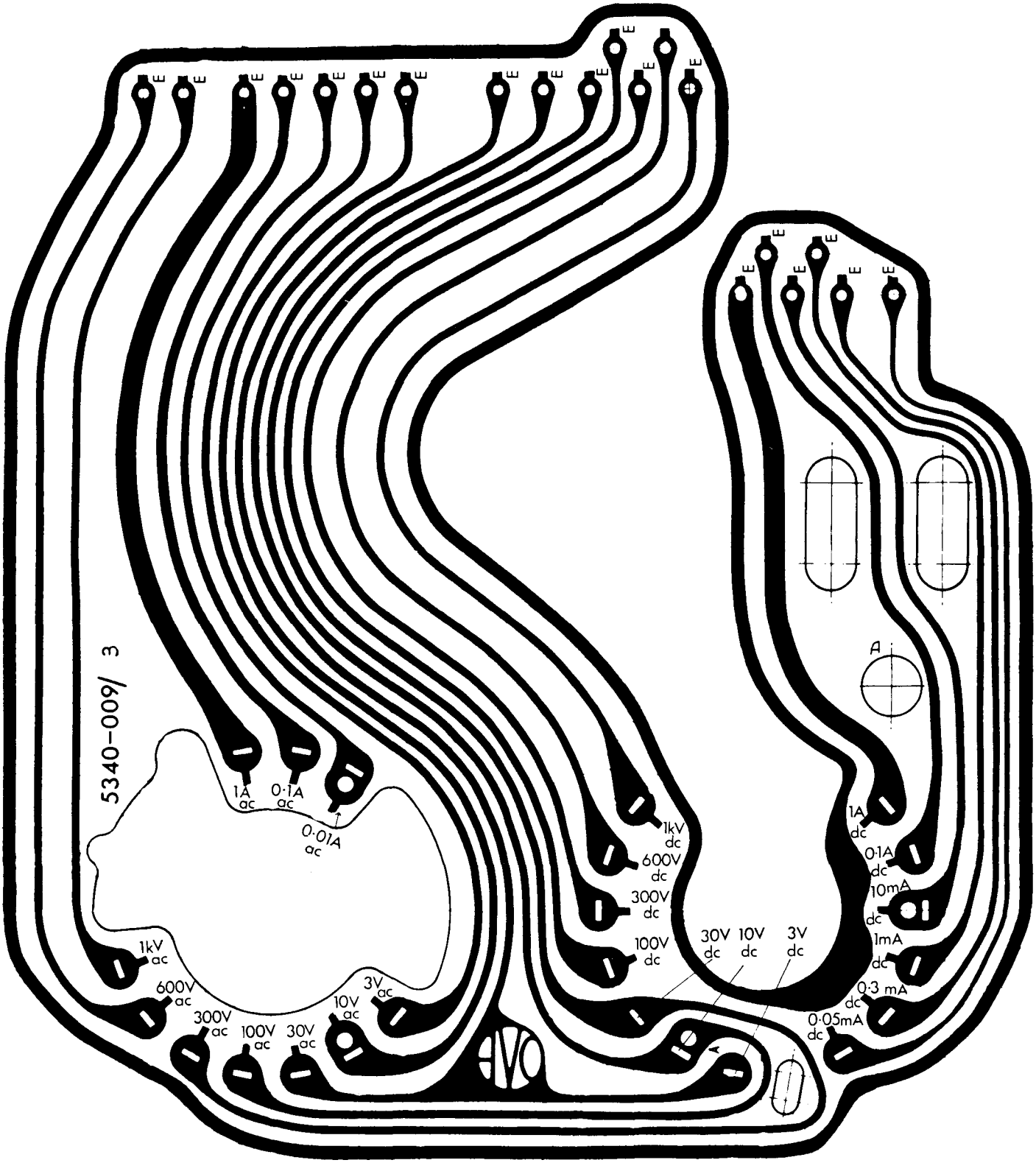


Fig. 1 Film Wiring Layout

THE SUPPLY OF INTERCHANGEABLE PARTS AND SUB-ASSEMBLIES

8. Sub-assemblies

Reference to the Parts Lists will show that the instrument has been 'laid out' 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) Switch and Component Printed Circuit Board Assemblies
(b) The Movement
(c) The Cut-out and Rev. M.C. mechanisms
(d) Film Wiring

The following notes may assist in deciding the best course of action when faults arise on these assemblies.

(a) PRINTED CIRCUIT BOARDS

Individual components on these boards can be readily replaced after identification from the circuit diagram. If, however, it is necessary to remove the transformer or the film wiring some form of solder removing iron will be required. When servicing the printed circuit board, great care is necessary to ensure that the minimum of solder is used, as excessive solder may cause short circuits. 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. Except under guarantee it is considered that repair by bridging on the printed circuit boards is permissible, provided all traces of burning are removed and the board thoroughly cleaned. However, if the damage is extensive it may be preferable to replace the whole board. If the printed circuit shunt or resistor is damaged, replacement items are obtainable from *AVO*. After any repair work on these boards all residue flux and dirt must be cleaned off.

(b) THE MOVEMENT

The movement is such a specialised item that in the event of a defect, complete replacement is recommended. Such a replacement is provided with facilities for adjustment to its correct resistance. If a movement is replaced, the swamp which accompanies the new movement must replace the swamp which will be found on the Rev. M.C. assembly. (See Section 14). Before commencing any work on the movement see Instructions for removal of the movement — Section 14.

IMPORTANT: Swamps and movement are not interchangeable with each other and if a movement is replaced the swamp must also be replaced as indicated above. In the unlikely event of a swamp failure, a suitable replacement (*i.e.* wirewound resistor) could be fitted by measuring the resistance of the moving coil assembly at 20°C, subtract this value from 2667Ω and place an equivalent suitable resistor in the position occupied by the swamp on the Rev. M.C. assembly.

Each movement is individually calibrated and is matched to a scaleplate of a particular characteristic.

(c) THE CUT-OUT AND REV. M.C. MECHANISM

Re-building these mechanisms is not as easy as it would first appear. They are supplied as complete assemblies for replacement purposes and it will be found more economical to purchase a new assembly than to attempt to repair the old.

Cut-out contacts are available as a spare part and the replacement of burnt-out contacts is reasonably simple, but we would not advise more complicated servicing to be undertaken on these assemblies.

If the Rev. M.C. mechanism is replaced and not the movement, the swamp on the faulty mechanism must be transferred to the new mechanism. It is unlikely that the swamp will be faulty.

(d) FILM WIRING

The film wiring is quite robust and can be creased or folded without damaging the tracks. It is possible, however, for the epoxy coating to crack if too sharp a bend is placed on the material. Under normal assembly and servicing operations, the bond strength of this material is extremely good, although under overload conditions the tracks can be damaged.

Great care must be taken when soldering the film wiring, and it is recommended that a temperature controlled iron be used. (Weller No. 5 60W).

FAULT-FINDING AND SERVICING INFORMATION

9. Fault-finding guide

The guide below is given to assist in the rapid location of a fault. To enable the most suitable method of repair to be selected the information obtained from this Section should be carefully considered with the details given in Section 8 regarding the supply of sub-assemblies.

Comprehensive servicing information and details regarding the removal and replacement of main assemblies are given in Sections 11 to 21.

Test No. (Sect. 10)	SYMPTOMS	PROBABLE FAULT
—	No reading on any range or intermittent reading only.	Leads open circuit or intermittent, switch, cut-out or circuit fault. 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.
All	No reading on an isolated current, voltage or resistance range.	Suspect a faulty connection and/or component between the switch contact and the shunt, multiplier or transformer concerned.
3—9	One or more dc current ranges inoperative and lower ranges incorrect.	One or more shunt sections open circuit.
10—17	No dc voltage readings (or erratic readings) beyond a particular range.	An open circuit in a resistor beyond the last working range.
3—9	Reads approx. 33% high on d.c. volts.	Shunt chain open circuit.
18—29	Low, or fails to read on ac, but is correct on dc.	Suspect a faulty diode or current transformer. (See Section 13).
30—32	Ohms range inoperative, intermittent or incorrect.	Batteries not making satisfactory contact. (See Section 3). Zero ohm potentiometer or fuse faulty.
30—32	Inability to attain ohms zero setting or ohms zero drifts shortly after being set. Low readings on Ω x 100 range.	Battery deterioration. (See Section 3).
3—32	Instability of reading in general.	Broken leads or dirty switches, cut-out and reverse moving coil contacts.
—	Cut-out fails to re-set.	Damage or obstruction in cut-out or cut-out knob wrongly positioned.
—	Cut-out fails to operate on overloads.	Cut-out contacts badly burnt or cut-out damaged. (See Section 14).
—	Low readings on all current and voltage ranges and/or over-damped movement. Sometimes offset zero.	Hairspring turns stuck together or caught up. Partial short circuit in moving coil.
—	Pointer sticks at one particular point.	Dust, hair or other foreign body fouling the movement. It may be in the gap, on the scaleplate or on the window glass.
—	Slight uniform pointer stick. over the whole scale.	Tight in jewels, blunted pivots, dirt in jewels or possible damaged jewels.
—	Pointer stuck firmly.	Pivot out of jewel.
—	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. (See Section 15).

NOTE: The last four symptoms could all be caused by transit damage.

10. **Fault Analysis chart**

TESTS		Inst. switch setting	CAUSES OF			Other remarks
No.	Input		High inst. indication	Low inst. indication	No indication	
1	100mV	0.05mA dc	Wrong movement sensitivity or inaccurate swamp resistor		Movement or swamp open circuit	Movement + swamp = 2667Ω
2	Scale shape test	0.05mA dc	Distorted movement		—	Full scale current 37.5μA
DC Current						
3	.05mA	.05mA dc	R15, 6k667Ω high	R15, 6k667Ω low	Shunt chain o.c. switch contacts not making on pcb	
4	.3mA	.3mA dc	R14, 933R3Ω high	R14, 933R3Ω low		
5	1mA	1mA dc	R13, 360R high	R13, 360R low		
6	10mA	10mA dc	R12, 36R high	R12, 36R low		
7	0.1A	0.1A dc	R11, 3R6Ω high	R11, 3R6Ω low		
8	1A	1A dc	R10, .36R high	R10, .36R low		
9	10A	10A dc	R9, .04R high	R9, .04R low		
D.C. Volts						
10	3V	3V dc	R16, 58kΩ low	R16, 58kΩ high	Preceding resistor o.c. Dry joint. Switch contacts not making on pcb	
11	10V	10V dc	R17, 140kΩ low	R17, 140kΩ high		
12	30V	30V dc	R18, 400kΩ low	R18, 400kΩ high		
13	100V	100V dc	R20, 800kΩ low	R20, 800kΩ high		
14	300V	300V dc	R21, 4MΩ low	R21, 4MΩ high		
15	600V	600V dc	R22, 6MΩ low	R22, 6MΩ high		
16	1000V	1000V dc	R23, 8MΩ low	R23, 8MΩ high		
17	3000V	3000V dc	R24, 40MΩ low	R24, 40MΩ high		
A.C. Volts						
18	3V	3V ac	R8, 3200R low	R8, 3200R high	On 3V and 10V ranges, C1, C2 short circuit. Preceding resistor o.c. Dry joint. Switch contacts not making on pcb	R6, R8 adjusted on calibration
19	10V	10V ac	*R6, 7k low	*R6,7k high		
20	30V	30V ac	R16, 58kΩ low	R16, 58kΩ high		
21	100V	100V ac	R17, 140kΩ low	R17, 140kΩ high		
22	300V	300V ac	R18, 400kΩ low	R18, 400kΩ high		
23	600V	600V ac	R19, 600kΩ low	R19, 600kΩ high		
24	1000V	1000V ac	R20, 800kΩ low	R20, 800kΩ high		
25	3000V	3000V ac	R25, 4MΩ low	R25, 4MΩ high		
A.C. Current						
26	0.01A	0.01A ac	C3 short circuit		Transformer, D1, D2 o.c. Switch contacts not making on pcb	
27	0.1A	0.1A ac				
28	1A	1A ac				
29	10A	10A ac				
Resistance						
30	R	x1	R29, R30 889Ω or R1 18R4Ω low	R29, R30 889Ω or R1 18R4Ω high	Resistors o.c. Switch contacts not making on pcb	R1 adjusted on calibration. Check batteries
31	100R	x100	R2, 2k16Ω low	R2, 2k16Ω high		
32	10000R	x10k	†R3, 62kΩ low	†R3, 62kΩ high		

* R6 is now 800Ω and is in series with R32 (8,2kΩ)

† R3 is now 51kΩ

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 the assemblies are removed without further damage and also to ensure that any re-setting operations necessary for the correct functioning of the instrument are carried out satisfactorily.

11. Removal and replacement of switch printed circuit board

The components on the board can be replaced without removing the board or disturbing the film wiring, but the following instructions are given should it be necessary to replace the board.

Having removed the case from the panel (See Section 7), remove the knobs from the Ω x 1 and Ω x 10k potentiometers. These can be gently levered off with a small screwdriver. Ensure that the felt washers under the knobs do not fall out, or if they do, keep them in a safe place as they will be required when re-assembling.

Place the panel face downwards on the bench, unsolder the movement wires marked '1' and '2' on the pcb from underneath the switch printed circuit board and the wire marked 'Ins' on the top of the board near the Common terminal.

Also unsolder the two wires connected to the Ω x 100 potentiometer and the wires marked 'O' and 'R' on the top of the printed circuit board which connect to the battery.

Remove the two terminal screws, lift off the tags and remove the plastic caps from the terminal spindles. A further screw which is located on the top of the switch printed circuit board just below the Ω x 1 potentiometer should also be removed. Finally unsolder the six connections on the small film wiring, using suitable de-soldering equipment.

The board can now be lifted and if pressure is exerted on the switch contact arms with the thumbs, it will help to release the board.

The new board and new small printed film wiring can be replaced by reversing the procedure outlined above. Great care should be taken when soldering the new film wiring. Use as little heat and as small an amount of solder as possible. When replacing the potentiometer knobs ensure that the felt washers, if not already in position, are replaced.

12. Removal of printed circuit component board

Some of the components on the board can be replaced without disturbing the board at all, but if it is necessary to reach the underside of the board or the movement, Rev. M.C. or cut-out, the following instructions should be followed.

Remove the four screws, one at each corner of the board. Pull back the tags on the high voltage terminals and take off the plastic caps from the terminals and put them in a safe place. If both parts of the plastic caps are removed, note their position in order that they can be replaced correctly.

The board can now be raised and tilted back so that the underside is visible and the movement, Rev. M.C. and cut-out are accessible. For most operations it is unnecessary to remove the board and it is recommended that unless it is necessary to replace the component board it should not be completely removed or the film wiring unsoldered.

If however, the board has to be replaced, the two heavy gauge wires from the underside of the board and a further heavy gauge wire which goes through a hole in the board to the transformer copper strip, should be disconnected and the film wiring unsoldered. The board can now be removed.

Reversing the above order will enable a new board to be replaced. Care must be taken when replacing the film wiring. Also ensure that the two parts of the terminal plastic insulation caps are in the correct position.

13. Transformer or diode replacement

Disconnect the two heavy gauge wires, one at each side of the transformer, which are connected to the copper strip around the laminations. Remove the four screws, one at each corner of the printed circuit component board, pull back the two tags from the high voltage terminals and take off the plastic caps. The board can now be tilted back to give access to the underside.

Unsolder the eight transformer pins on the underside of the component board. Suitable solder removing equipment will be required and care must be taken not to overheat the printed circuit track.

Remove the two screws supporting the transformer on the underside of the component board. It will now be possible for the transformer to be eased away from the board. The transformer component board will also be accessible enabling the diodes to be replaced if required. These should be replaced as a pair.

Reverse the above procedure to mount a new transformer.

14. Removing the movement, rev. m.c. and cut-out

The printed circuit board should be tilted back as in Section 13. Then remove the two long hexagon pillars located close to the high voltage terminals. Remove the two posidrive screws and their wavy washers located on the movement mounting plate, one close to the movement cover in the centre of the instrument, the other, close to the cover of the Rev. M.C. mechanism. Care must be taken not to drop the screws or washers into the instrument.

NOTE: The cut-out must be in the re-set position and the Rev. M.C. switch in the forward position.

Disconnect the two movement wires connected to the underside of the switch printed circuit board and marked '1' and '2' on the pcb. Disconnect the heavy gauge wires connected, one to the Common terminal, the other to the transformer copper strip. Disconnect the earthing wire from the Common terminal (connected between Common terminal and the underside of the switch film wiring).

The movement mounting plate can now be raised from the panel and gently drawn out. Great care must be taken not to damage the pointer. The transparent cover can then be removed by removing the two 6BA screws.

To replace the movement reverse the above procedure ensuring that the zero pip locates correctly with the movement. (See next para. regarding the movement swamp).

The same instructions apply if the Rev. M.C. is to be replaced. The Rev. M.C. mechanism is released from the mounting plate by removing the two self-tapping screws. However, if the Rev. M.C. mechanism is replaced and not the movement, the swamp on the faulty mechanism must be transferred to the new mechanism. Similarly if the movement is replaced and not the Rev. M.C. the new swamp supplied with the movement must replace the swamp on the Rev. M.C.

Movement and swamp are matched and cannot be interchanged.

The instructions detailed for removing the movement should also be followed if it is desired to remove the cut-out.

After removal from the panel the replacement of burnt cut-out contacts is simple. The cut-out should be in the open position and if a small screwdriver is slipped under the contact at the end opposite to the soldered joint, the contact can be lifted and withdrawn. Replace with a new contact and slide back into the cut-out. To remove the cut-out for replacement remove the two retaining screws.

As the replacement of burnt contacts or the removal of the movement for servicing may have disturbed the tripping value, the cut-out setting should be checked. The cut-out should operate with an approximate forward overload of 12:1. The cut-out can be tested using the circuit given below.

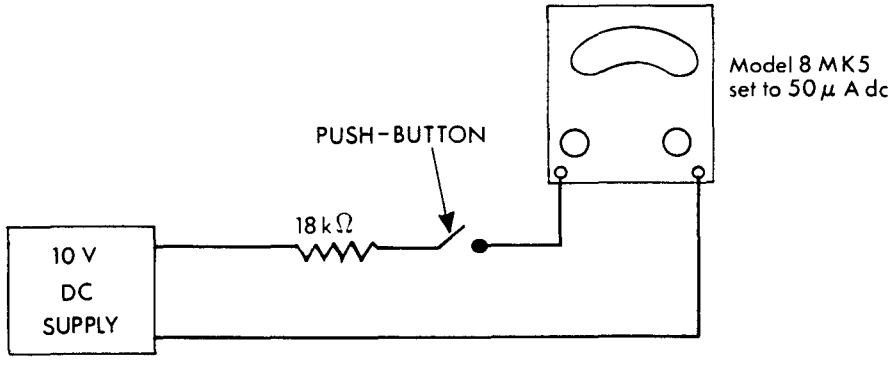


Fig. 2 for checking cut-out setting.

The only recommended adjustment necessary would be to ensure that the movement pointer deflects approx. equally above full scale and below the zero mark. This can be balanced by slackening off the cut-out fixing screws and rotating the whole cut-out assembly (ensure that the cut-out is not tripped) to achieve equal deflection, then carefully tighten screws.

15. Re-balancing the movement

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 allows a pointer change of ±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 balancing effect. If a satisfactory balance cannot be achieved, the pivots will almost certainly be defective. 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.

16. Checking scale shape linearity

The Circuit Diagram of a suitable Scale Shape Test Set is given in Fig. 3. The Model 8 Mark 5 movement scale shape may be checked as follows:

(a) Connect the movement under test to the terminals marked + and −.

(b) Set the Test Set Range switch to Position 10.

(c) Set the ON/OFF switch to ON.

(d) Set the full scale deflection of the movement by rotating the coarse and fine controls 100kΩ and 20kΩ.

(e) The cardinal points of the scale can then be checked by rotating the range switch to positions 9, 8, 7 etc. down to 1.

(f) Return the Range switch to Position 10 to ascertain that the full scale deflection has not altered.

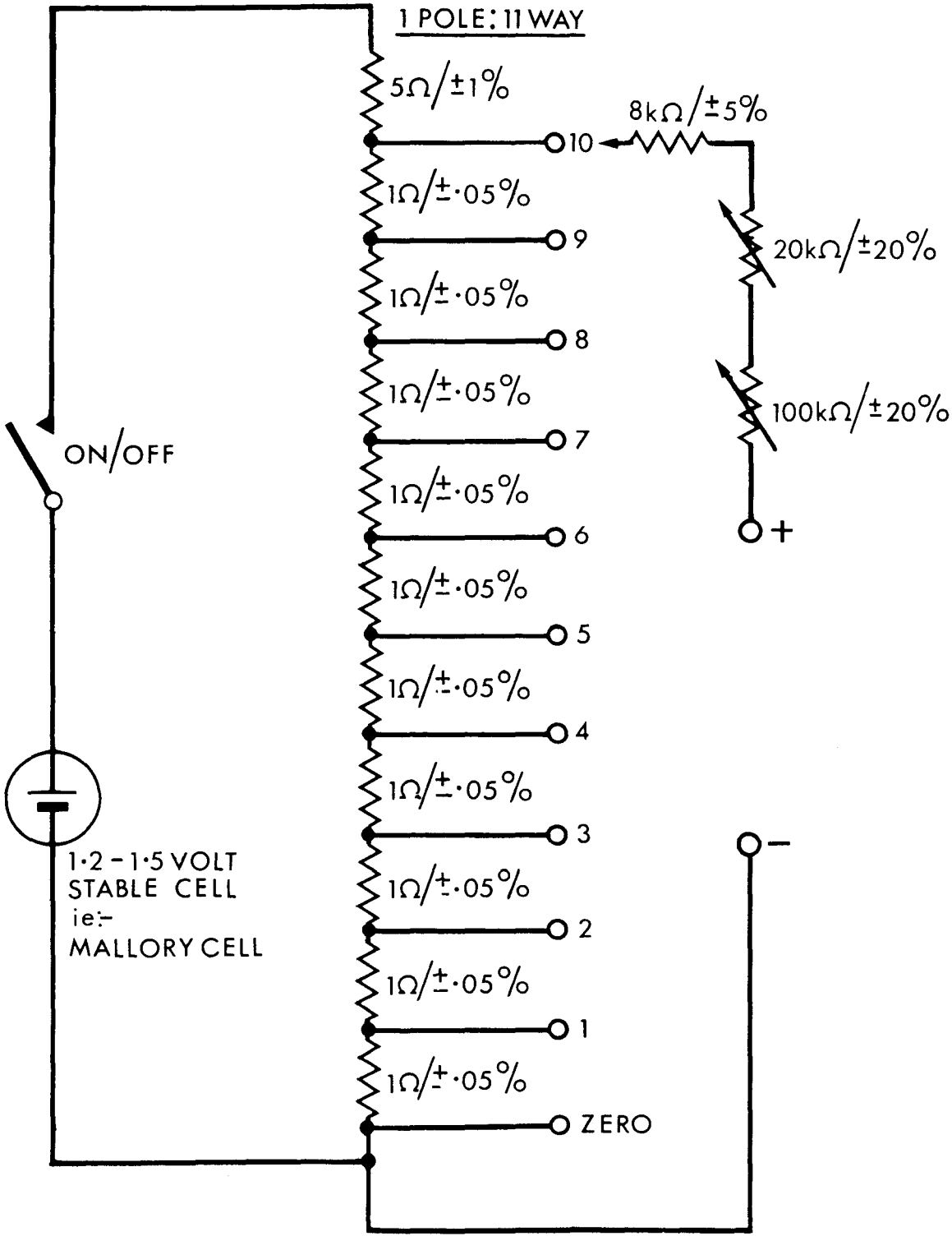


Fig. 3 Movement Scale shape test set

17. Replacing range switch rings and film wiring

Remove the switch printed circuit board as in Section 11. Remove the circlip on the spindle and the large circlip and washer on the moulded hub. Remove the three screws on the switch ring. Withdraw the switch rings complete with the film wiring and contacts. Remove the wire connection to the switch rings and disconnect the film wiring from the component board.

The switch rings can now be replaced by reversing the above procedure. Care must be taken when soldering the film wiring.

18. Replacing potentiometers

Two potentiometers, the Ω x 1 and the Ω x 10k are located on the switch printed circuit board. The knobs should be removed from these as in Section 11 using a small screwdriver if necessary. Take particular care not to lose the felt washers.

Disconnect the wire connections to the potentiometer tags, noting their position. Remove the nut and the potentiometer will then slide out. Replace by reversing procedure.

To replace the Ω x 100 potentiometer remove the switch printed circuit board as in Section 11 and fold back the component printed circuit board as in Section 13. Remove the potentiometer knob as for the Ω x 1 and the Ω x 10k potentiometers. Disconnect the wire connections to the potentiometer tags noting their positions. Remove the screws holding the potentiometer plate to the front panel. Finally remove the nut which will release the potentiometer from the plate.

Reverse the above order to replace this potentiometer.

19. Replacing the printed circuit shunt (mounted on the printed circuit component board)

Disconnect the one soldered connection to the film wiring on the printed circuit shunt. Take particular care not to damage the film wiring. Release the printed circuit component board as in Section 13. Unsolder four connections to the printed circuit shunt on the underside of the printed circuit component board. The shunt can then be eased out.

Replace the shunt, re-solder connections, ensuring that the printed circuit board does not become overheated. Re-solder the film wiring connection, again ensuring that the minimum of solder is used and great care taken not to overheat the film.

20. Replacing printed circuit resistor (mounted on switch printed circuit board)

Tilt the instrument on its side and remove in the usual manner for a resistor, taking care to use the minimum of solder when replacing and not to overheat the board.

21. Front panel replacement

As outlined in previous sections, remove printed circuit board, component printed circuit board, movement, Rev. M.C., cut-out, switch rings, potentiometers and terminals.

To remove the Rev. M.C. and cut-out knobs, remove the spring from the knobs and the knobs will then fall down to the panel. Turn the knob 90° and it will then fall out. When replacing, reverse the procedure and ensure that when replacing the spring, the widest part should be against the front panel. In later versions with rubber shrouds, ensure that the shroud fits outside the head of the knob.

If the labels are damaged, the range labels can be replaced without removing the knobs. The *AVOMETER* 8 label can be replaced by removing only the potentiometer knobs.

Note: Should the white bezel become loose it can be made firm using the white Bostik type 1768.

FINAL PROCEDURE

It is most important to ensure cleanliness during repair. It is almost certain, however, that dirt 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 if it is removed, until it is ready to be fixed to the panel and take all possible steps to keep it dirt 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 :

22. The appearance of the repaired instrument

Having ensured that the instrument is correct 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. Ensure that the gasket is in position and fit the case to the panel using the original screws. Fit new AVO seals. (Part No. 5210-026).

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 painstaking attention.

23. Flash Test

Before leaving the factory every instrument is subjected to a flash test of 7000V ac r.m.s. 50Hz between the terminals and the case fixing screws. It is advisable that a corresponding test should be given to the instrument after repair which can be applied as follows :

All the terminals shall be connected together and connected to one side of the specified voltage supply and a probe, (complying with the requirements for a rigid test finger as specified in IEC 414 1973) connected to the other side of the supply and applied to all exposed metal parts on the outside of the instrument.

ORDERING SPARE PARTS

Please follow the procedure set out below, in order that your requirement may be dealt with as speedily as possible.

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.

2. Detail Required

When ordering state the number and description of the item required, its location in the instrument, the quantity and the complete *AVOMETER* serial number.

FRONT PANEL ASSEMBLY (Plate 1)

Item No.	Description	AVO Part No.
1	Pillars (4) and screws (4)	6120–264
2	Capacitor 470pF (C3)	6120–296
3	Capacitor 220pF (C1)	6120–294
4	Resistor 889R (R29, R30)	6120–292
θ 5	Capacitor 0.015 μF (C2)	6120–295
6	Diode OA95 (D1, D2 supplied as a pair)	6120–109
7	Resistor 270R (R31)	6120–291
8	Transformer Complete	6120–248
9	Component Printed Circuit Board Complete (*see breakdown*)	6120–246
10	Push-on terminal caps (2 red, 2 black)	6120–265
11	4 Battery wires and crimp-on connectors complete	6120–253
‡ 12	Resistor 180k (R4)	6120–288
13	Resistor 1M8 (R5)	6120–289
14	Terminals complete with red/black caps, nuts, screws and insulators (4)	6120–245
15	Switch printed circuit with eyelets and prestincerts only	6120–266
16	Printed circuit board switch complete	6120–250
§ 17	Resistor 20k (R26)	6120–290
*18	Resistor 62k (R3)	6120–287
19	Resistor 2k16 (R2)	6120–286
20	Printed Resistor 18R4 (R1)	6120–284
ϕ † 21	Potentiometer 15k with knob and felt washer complete	6120–251
ϕ ° 22	Potentiometer 18k with knob and felt washer complete	6120–252
23	Switch printed circuit board complete	6120–247
24	Printed circuit shunt (R9, R10, R11)	6120–285
–	3 Front panel labels (not illustrated)	6120–270
25	Sealing ring	5150–108

* 77k on early instruments. On later instruments value changed to 62k and this may be 77k in parallel with 400k. Then changed to 51kΩ Part No. 26834–496.

‡ Later instruments 177k Part No. 26835–773.

§ Later instruments 18k Part No. 26834–485.

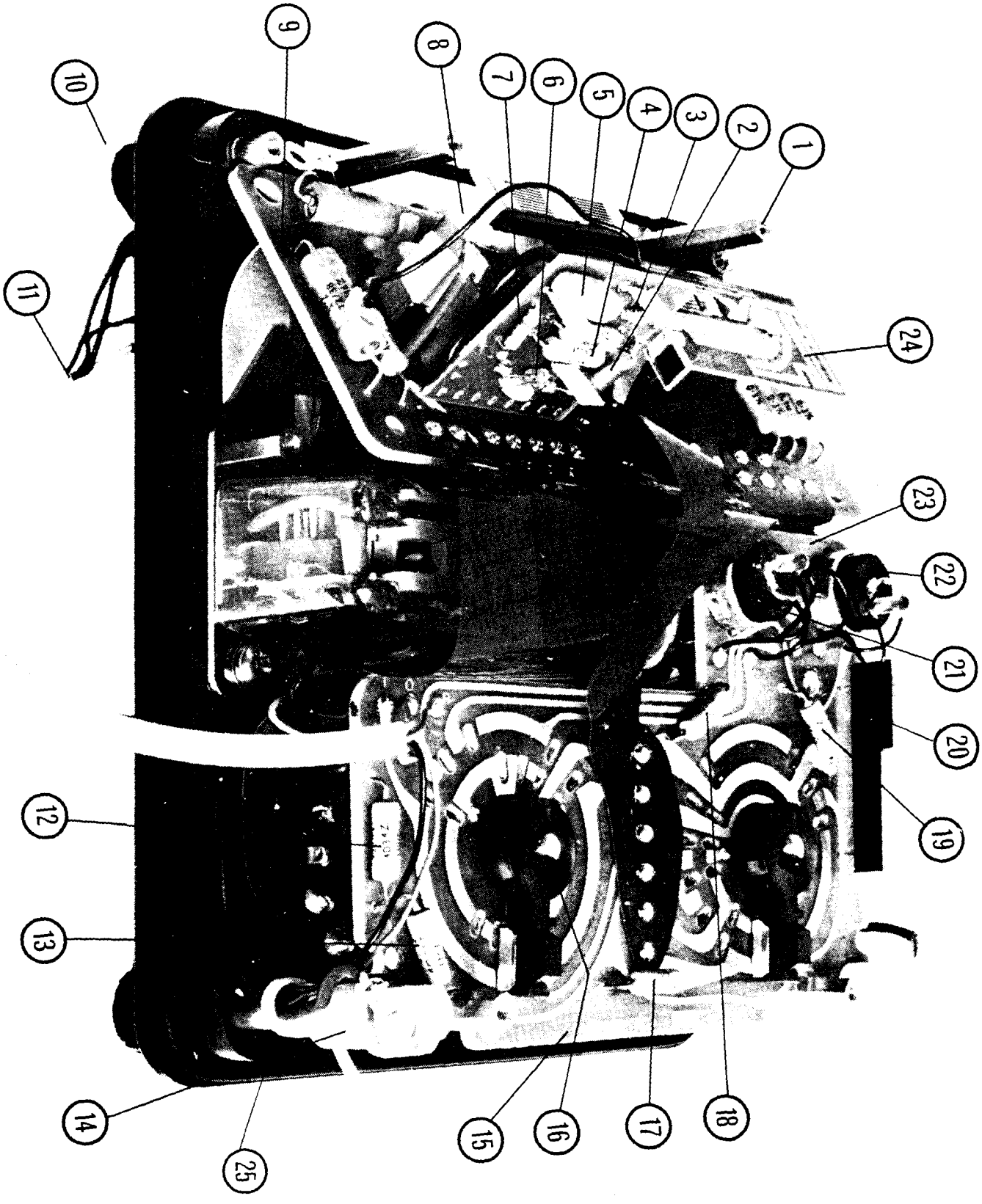
† Later instruments 18k Part No. 6120–252.

θ On later instruments C2 changed to 10nF Part No. 27889–611 and also C4 added in parallel with C2. C4 value is 2,2nF Part No. 27889–707.

° An alternative potentiometer to fit older boards is available on Part No. 6121–041.

ϕ The value of both these potentiometers is now 22kΩ (changed in Nov. 1981), and complete with knob and felt washer, etc. has Part No. 6121–041.

FRONT PANEL ASSEMBLY (Plate 1)

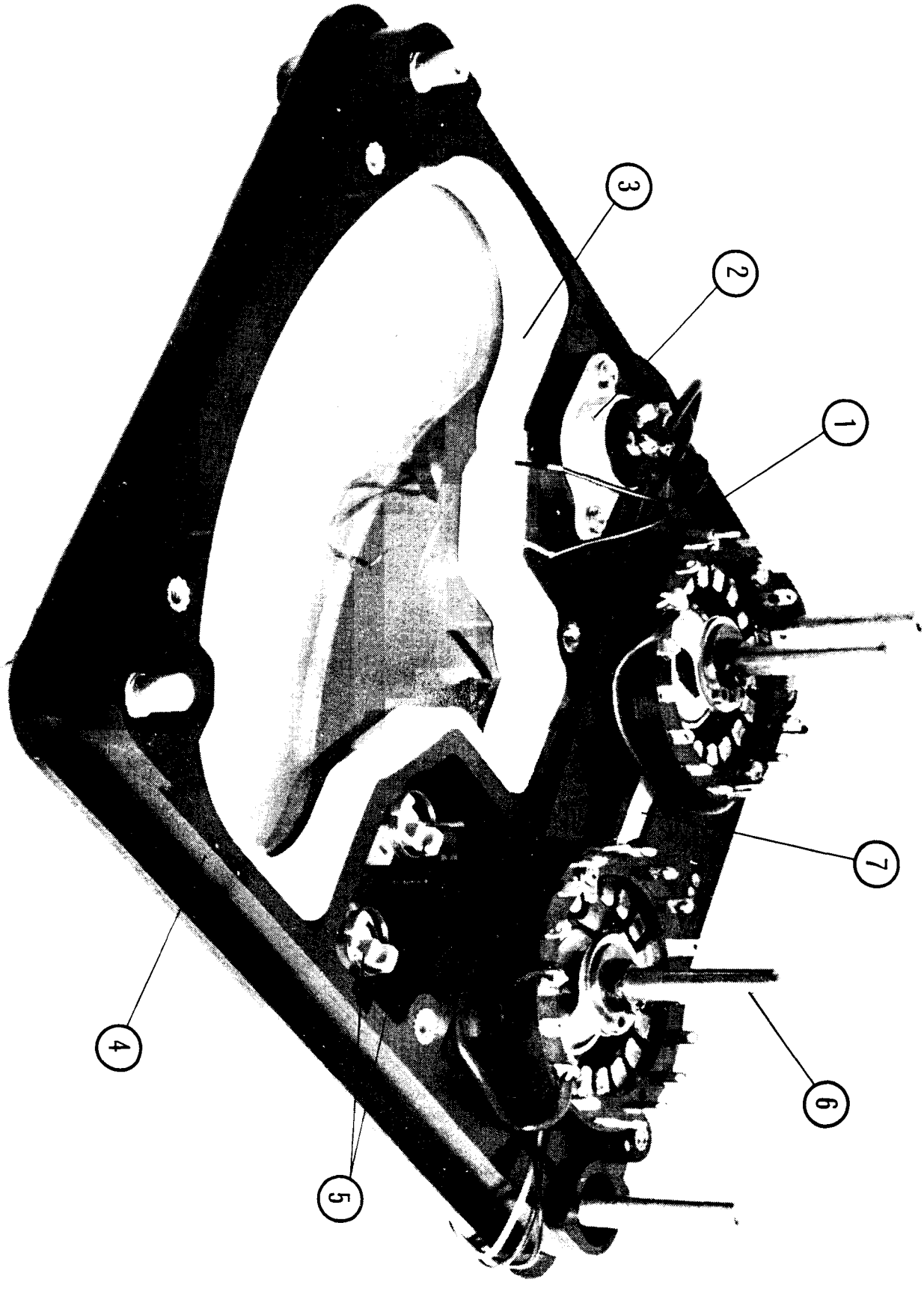


FRONT PANEL SUB-ASSEMBLY (Plate 2)

Item No.	Description	
1	Front panel filled plus inserts, zero adjuster, glass sealing ring, gasket and all labels complete	6120-244
* 2	Potentiometer 18k with knob and felt washer complete	6120-303
3	Gasket	6120-256
4	Front panel glazed, including Rev. M.C. and Cut-out knobs, springs and rubber shrouds	6120-269
5	Rev. M.C. and Cut-out knobs and 2 springs complete (to fit early version without rubber shroud)	6120-258
5a	Rev. M.C. and Cut-out knobs, rubber shrouds and 2 springs complete (to fit later version with rubber shrouds)	6120-595
6	Range switch knobs with contact, hub, washers, circlips, spring and ball	6120-255
7	Contact plate	6120-257

* 15k on early instruments. The value of this potentiometer is now 22kΩ (changed in Nov. 1981), and complete with knob and felt washer, etc. has Part No. 6121-048.

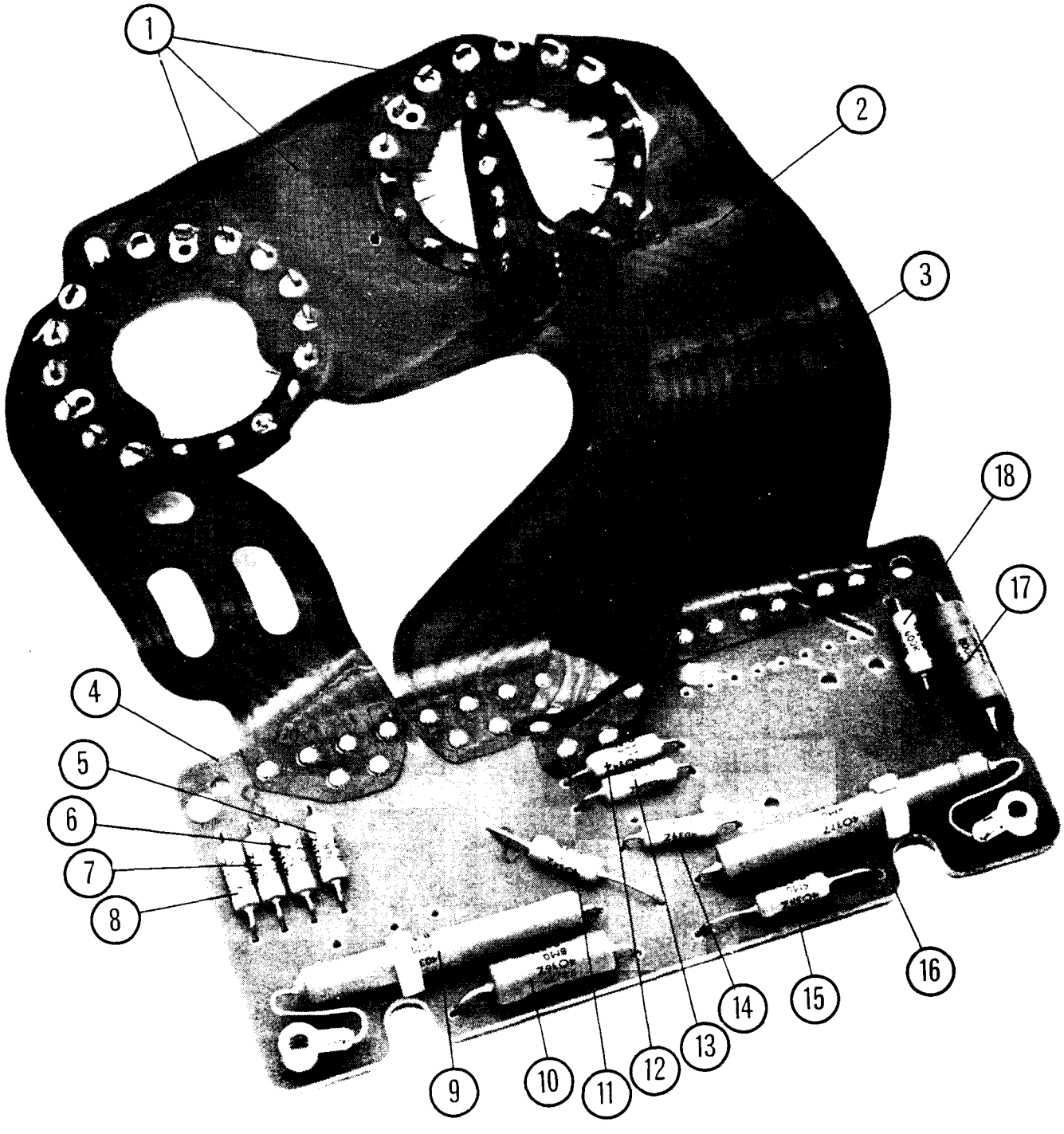
FRONT PANEL SUB-ASSEMBLY (Plate 2)



COMPONENT PRINTED CIRCUIT BOARD & FILM WIRING (Plate 3)

Item No.	Description	AVO Part No.
1	Both film wiring with switch rings complete	6120–249
2	Large film wiring	5340–009
3	Small film wiring	5340–010
4	Component Printed Circuit Board with eyelets and prestincerts only	6120–267
5	Resistor 36R (R12)	6120–268
6	Resistor 360R (R13)	6120–271
7	Resistor 933R3 (R14)	6120–272
8	Resistor 6k667 (R15)	6120–273
9	Resistor 40M (R24)	6120–282
10	Resistor 8M (R23)	6120–281
11	Resistor 6M (R22)	6120–280
12	Resistor 58k (R16)	6120–274
13	Resistor 140k (R17)	6120–275
14	Resistor 400k (R18)	6120–276
15	Resistor 4M (R21)	6120–279
16	Resistor 4M (R25)	6120–283
17	Resistor 800k (R20)	6120–278
18	Resistor 600k (R19)	6120–277

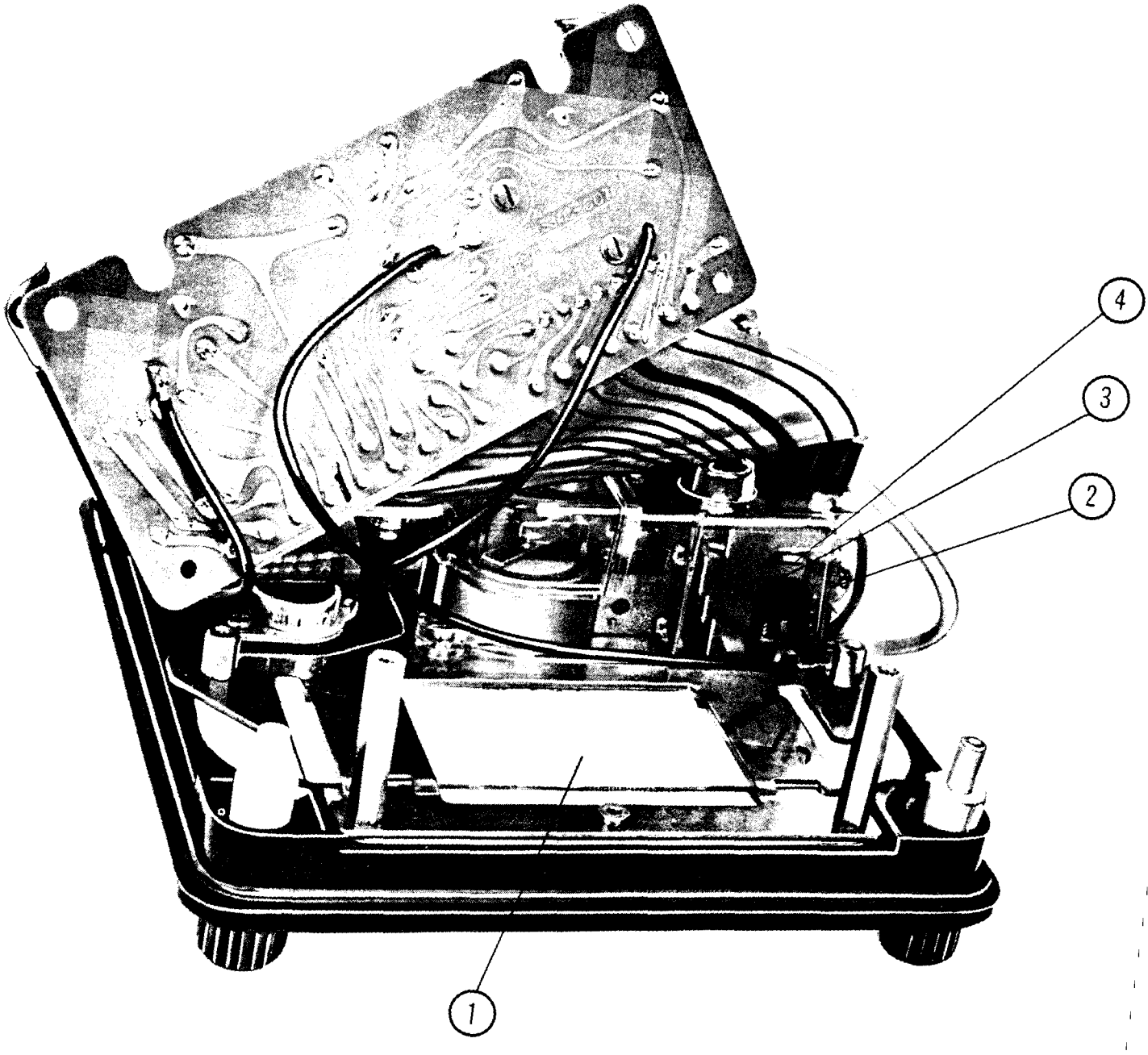
COMPONENT PRINTED CIRCUIT BOARD & FILM WIRING (Plate 3)



MOVEMENT ASSEMBLY (Plate 4)

Item No.	Description	AVO Part No.
1	Movement and Cut-out with cover, Rev. M.C. switch and 2 fixing screws complete	6120–254
2	Rev. M.C. switch, printed circuit board and 2 self-tapping screws	6120–302
3	Cut-out assembly complete	6120–300
4	Cut-out contacts (3) and push-on fix	6120–301

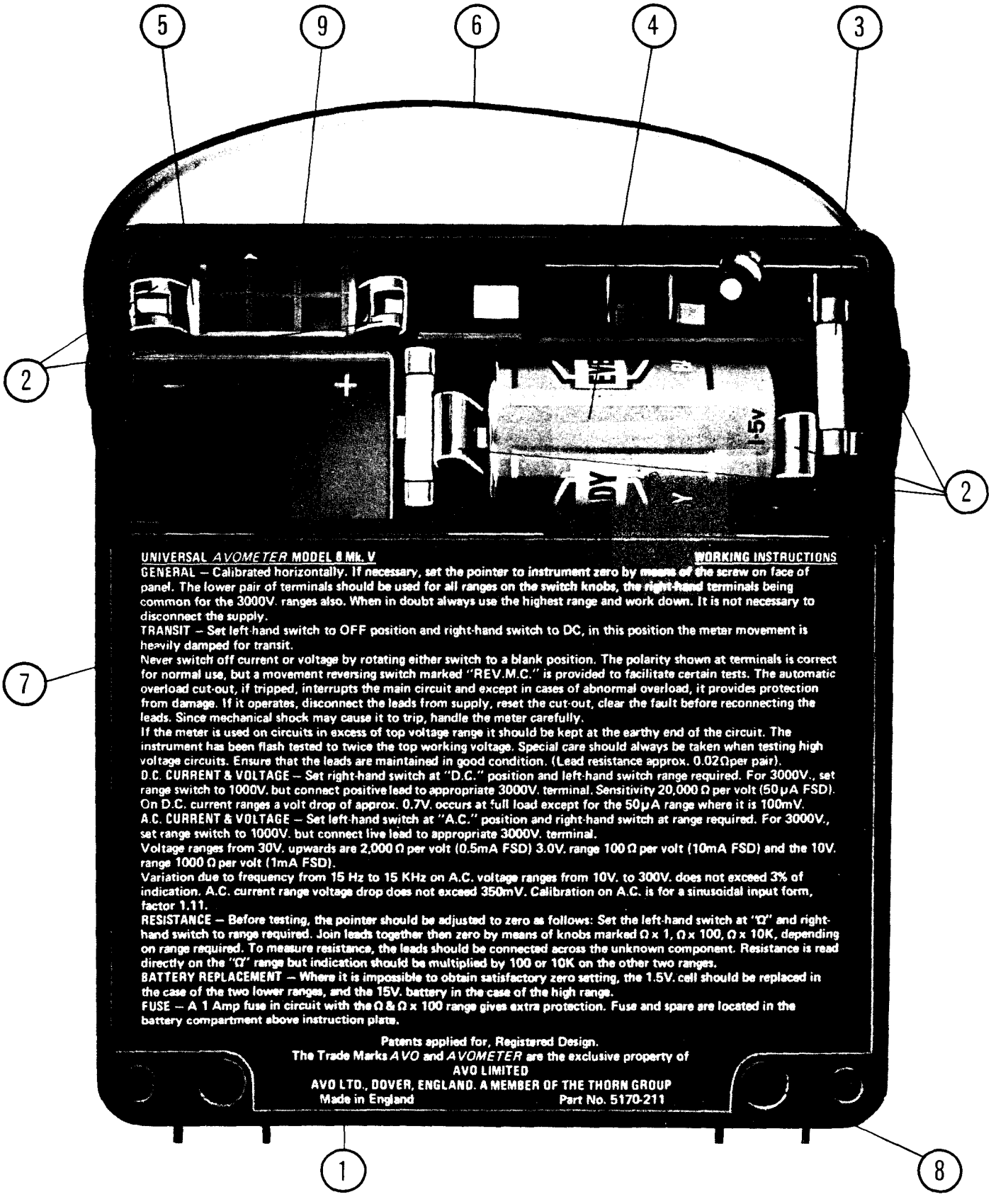
MOVEMENT ASSEMBLY (Plate 4)



CASE ASSEMBLY (Plate 5)

Item No.	Description	AVO Part No.
1	Case and four fixing screws complete	6120–259
2	Battery & fuse clips (5 off complete)	6120–260
3	Fuses 1A ceramic cartridge (Pack of 5)	6120–299
4	Battery 1.5V	25511–013
5	Battery adaptor (allows use of B154 battery)	5210–064
	Battery 15V (B154)	25511–182
6	Handle	6120–263
7	Instruction Plate	6120–262
8	AVO seals	5210–026
-	Battery cover + ¼ turn fastener (not illustrated)	6120–261

CASE ASSEMBLY (Plate 5)



UNIVERSAL *AVOMETER* MODEL 8 Mk. V **WORKING INSTRUCTIONS**

GENERAL – Calibrated horizontally. If necessary, set the pointer to instrument zero by means of the screw on face of panel. The lower pair of terminals should be used for all ranges on the switch knobs, the right-hand terminals being common for the 3000V. ranges also. When in doubt always use the highest range and work down. It is not necessary to disconnect the supply.

TRANSIT – Set left-hand switch to OFF position and right-hand switch to DC, in this position the meter movement is heavily damped for transit.

Never switch off current or voltage by rotating either switch to a blank position. The polarity shown at terminals is correct for normal use, but a movement reversing switch marked "REV.M.C." is provided to facilitate certain tests. The automatic overload cut-out, if tripped, interrupts the main circuit and except in cases of abnormal overload, it provides protection from damage. If it operates, disconnect the leads from supply, reset the cut-out, clear the fault before reconnecting the leads. Since mechanical shock may cause it to trip, handle the meter carefully.

If the meter is used on circuits in excess of top voltage range it should be kept at the earthy end of the circuit. The instrument has been flash tested to twice the top working voltage. Special care should always be taken when testing high voltage circuits. Ensure that the leads are maintained in good condition. (Lead resistance approx. 0.02Ωper pair).

D.C. CURRENT & VOLTAGE – Set right-hand switch at "D.C." position and left-hand switch range required. For 3000V., set range switch to 1000V. but connect positive lead to appropriate 3000V. terminal. Sensitivity 20,000 Ω per volt (50 μA FSD). On D.C. current ranges a volt drop of approx. 0.7V. occurs at full load except for the 50 μA range where it is 100mV.

A.C. CURRENT & VOLTAGE – Set left-hand switch at "A.C." position and right-hand switch at range required. For 3000V., set range switch to 1000V. but connect live lead to appropriate 3000V. terminal.

Voltage ranges from 30V. upwards are 2,000 Ω per volt (0.5mA FSD) 3.0V. range 100 Ω per volt (10mA FSD) and the 10V. range 1000 Ω per volt (1mA FSD).

Variation due to frequency from 15 Hz to 15 KHz on A.C. voltage ranges from 10V. to 300V. does not exceed 3% of indication. A.C. current range voltage drop does not exceed 350mV. Calibration on A.C. is for a sinusoidal input form, factor 1.11.

RESISTANCE – Before testing, the pointer should be adjusted to zero as follows: Set the left-hand switch at "Ω" and right-hand switch to range required. Join leads together then zero by means of knobs marked Ω x 1, Ω x 100, Ω x 10K, depending on range required. To measure resistance, the leads should be connected across the unknown component. Resistance is read directly on the "Ω" range but indication should be multiplied by 100 or 10K on the other two ranges.

BATTERY REPLACEMENT – Where it is impossible to obtain satisfactory zero setting, the 1.5V. cell should be replaced in the case of the two lower ranges, and the 15V. battery in the case of the high range.

FUSE – A 1 Amp fuse in circuit with the Ω & Ω x 100 range gives extra protection. Fuse and spare are located in the battery compartment above instruction plate.

Patents applied for, Registered Design.
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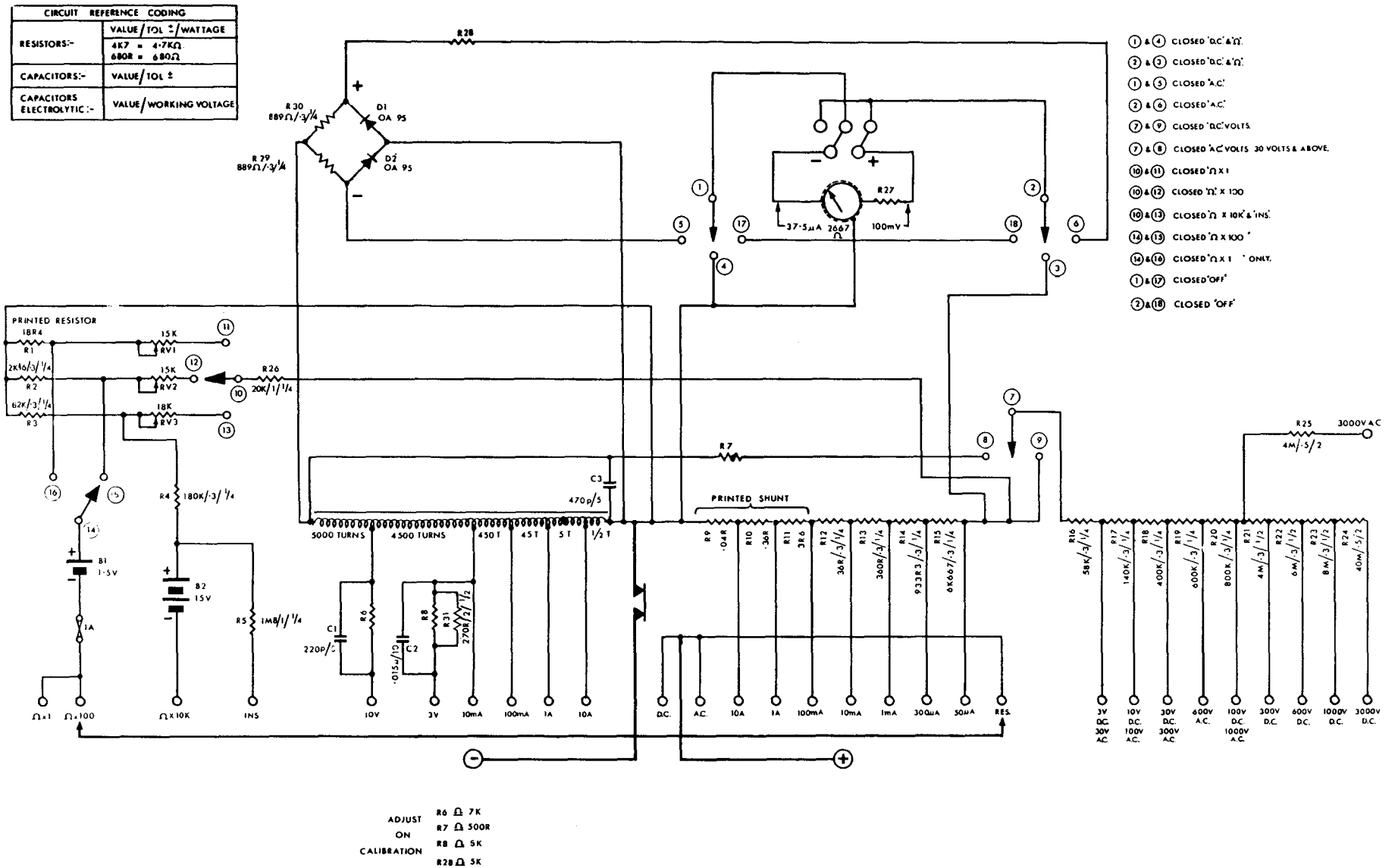
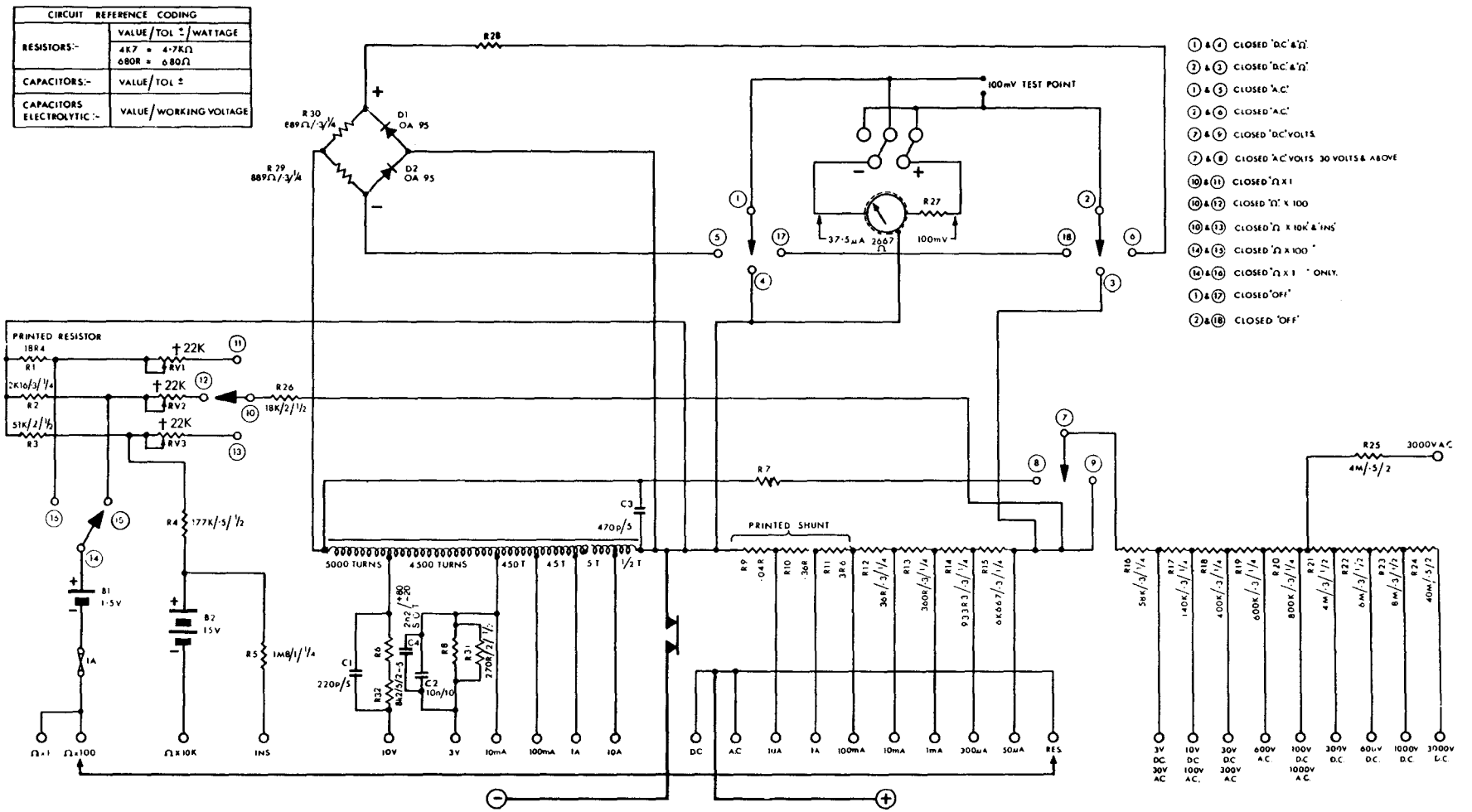
CIRCUIT DIAGRAM (early version)



CIRCUIT DIAGRAM (later version)



*On earlier versions there was no C4 and C2 value was 0,015µF ±10%.

†On earlier versions RV1, RV2 and RV3 were 18kΩ.