

Marconi Moisture Meter

Model 933D



- Moisture content measured to within 0.5% in a few seconds.
- Calibrations available for more than 200 different substances.
- Supplied with optional ISO or standard wheat and barley scales.
- Quick-loading compression cell eliminates packing errors.
- Compact, portable and battery operation.
- Calibration check facility.

MOISTURE METER

933D

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Chapter 1

GENERAL INFORMATION

1.1 FEATURES

The moisture meter measures the percentage moisture content of a wide range of hygroscopic materials, particularly those of organic origin, in the field or laboratory.

The test cell which is of the compression type and is stowed in the instrument when not in use, is suitable for granular, powdery or fibrous substances and for specimens in the form of sheets or boards up to one inch in thickness. An important function of the test cell is the application of considerable pressure to the specimen under test in order to bring the sample to a uniform state and minimize packing errors.

Direct reading temperature-correcting calculator scales can be slipped onto the instrument for the commoner materials, such as cereal grains, cigarette tobacco and rice, while a large number of calibration charts are available for substances ranging from apple rings to wool socks.

The standard model is powered by two 9 V internal dry batteries.

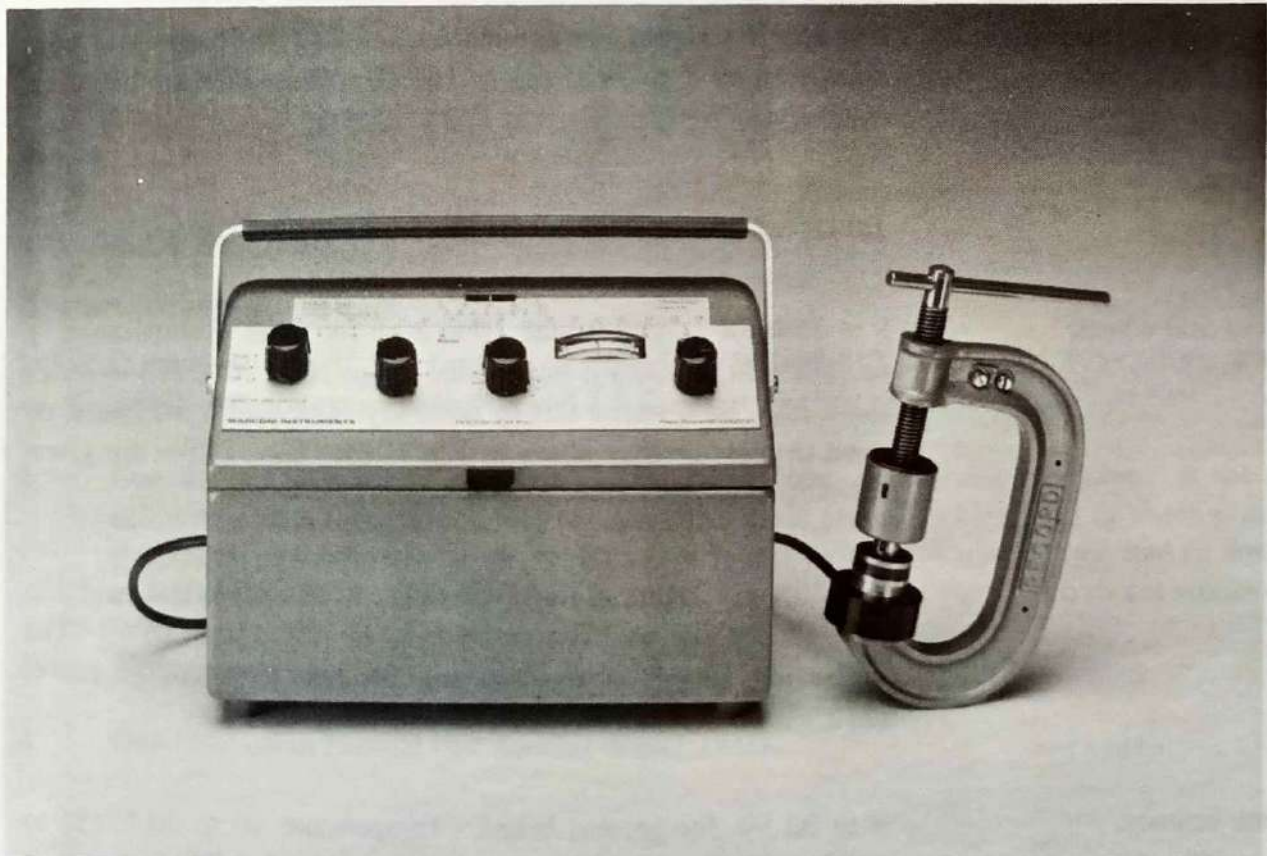


Fig. 1.1 The moisture meter with compression cell electrode and calculator scale fitted

1.2 DATA SUMMARY

RANGE:	Moisture contents from below air-dry to near saturation.
ACCURACY:	The basic accuracy of the instrument is $\pm 0.5\%$ m.c., but variations due to the nature of the samples may reduce this to $\pm 1\%$ m.c. The accuracy tends to fall at high moisture contents.
SELF-CHECK FACILITY:	The instrument may be checked against the internal standard resistance of $1\text{ M}\Omega$ at a meter reading of 40.
CALIBRATION:	The calibrations, which are made by comparison with standard analytical procedures, are based on ground samples wherever possible.
SCALES:	The standard apparatus includes the Calibration Data for the cereal grains and agricultural seeds.
Cereal grains and agricultural seeds:	9 to 25% for wheat, rye and maize; 8 to 24% for barley and oats. Temperature -1 to 38°C (30 to 100°F). The scales are based on oven drying for four hours at 120°C (248°F). Tables are provided covering agricultural seeds.
Flour and wheat:	9 to 25% for ground wheat; 10 to 20% for flour. Temperature -1 to 38°C (30 to 100°F); outside the range 10 to 30°C (50 to 86°F) there may be a slight fall in accuracy. The scales are based on oven drying for four hours at 120°C (248°F). Tables are given for other mill stocks and products.
Cigarette tobacco:	8 to 20% for 'cigarette rag' (equivalent to cut whole leaf) and 9 to 21% for cut lamina. Temperature 10 to 30°C (50 to 86°F). The scales are based on oven drying for sixteen hours at 100°C (212°F).
Tick beans:	9 to 22.5% for ground beans. Temperature 10 to 30°C (50 to 86°F). The scale is based on oven drying for fifteen hours at 105°C (221°F).

Rice: 10 to 22% for polished rice. Temperature 10 to 30°C (50 to 86°F). The scale is based on oven drying for fifteen hours at 105°C (221°F).

Paper: 4 to 13% for paper; 6 to 22% for chemical wood pulp and boards. Temperature 10 to 32°C (50 to 90°F). Supplementary information is provided covering many types of wood pulp, paper and boards. The scales are based on oven drying to constant weight at 102 to 105°C (215.5 to 221°F).

POWER SUPPLY: Internal batteries: two PP3 9 V or equivalent.

DIMENSIONS:	Height	Width	Depth
	7 $\frac{3}{4}$ in	11 $\frac{3}{8}$ in	5 $\frac{1}{4}$ in
	(197 mm)	(28 mm)	(135 mm)

WEIGHT: 7 lb (3.1 kg) approximately.

1.3 ACCESSORIES

Accessories supplied

- 1 Compression Cell Electrode Assembly type 43147-013 (Electrode 37582-106, Ring 37438-306, Plunger 33646-701 and 3 ft Connecting Cable 43125-038).
- 2 One set of Calibration Data, 46883-036 - see under Accessories available. A set of calibration data comprises a slip-on calculator scale and a booklet, card or sheet giving supplementary information on substances covered by the calculator scale and in some cases, allied substances.
- 3 Thermometer.
- 4 One Instruction Manual Part number 46882-171D.



Fig. 1.2 The moisture meter showing accessories

Accessories available

1 Standard Calibration Data:

Cereal grains and agricultural seeds	TM 4473A/1
Flour and wheat	TM 4473A/2
Cigarette tobacco	TM 4473A/3
Tick beans	TM 4473A/8
Polished rice and paddy	TM 4473A/9
Paper	TM 4473A/10

2 Special Calibration Data; can be supplied to order for a wide range of materials.

3 Small grinder; for grinding whole grain etc.

4 Spare Standard Electrode TM 4178A; for compression cell electrode assembly.

5 Two 9 V batteries: Exide type DT3. Ever Ready type PP3, Ray-o-Vac type R3 or Vidor type VT3 or equivalent.

Chapter 2 OPERATION

2.1 Installation

NOTE: The performance of this instrument may be impaired by lengthy exposure to a damp atmosphere. Drying for a short period in a warm dry atmosphere will restore it to give normal performance.

Ensure that the instrument is switched OFF before connecting any leads and only switched on when actually taking measurements, hence prolonging the life of the batteries.

2.2 Controls and connections

Balance controls

The electrical principle employed in the instrument is the variation of conductivity of the specimen with moisture content. Conductivity is measured by adjusting the coarse and fine BALANCE controls to give a standard meter indication; the reading on the controls is then easily converted into moisture content by reference to the scale on the instrument or to a chart supplied with it.

In addition to the two BALANCE controls there is a rotary switch marked OFF-ZERO-READ and a ZERO knob for standardising the instrument taking a measurement.

NOTE: If either of the BALANCE controls becomes loose it must not be secured without first carrying out the standardisation test detailed in Sect. 4.2.

Electrode connections

The compression cell electrode is normally stowed in the lower front compartment of the moisture meter. Also inside this compartment are three sockets RED, GREEN and BLACK. Connect one end of the electrode 2-core cable to the RED and BLACK sockets and connect the other end to the two sockets on the compression cell electrode containing the specimen; wire colours are not important. (The GREEN socket is not connected to the compression cell electrode on this instrument.)

Two other sockets labelled CALIBRATION CHECK are provided for connection to the RED and BLACK sockets for test purposes.

Calculator scales

If a scale is available for the substance to be tested slide the scale into position see Fig. 1.1. If there is no scale available then select the appropriate calibration data sheet.

The following sections give the general method of operating the instrument. Detailed procedures that apply to particular materials are given in the calibration data supplied for each group of substances.

2.3 PREPARATION OF SAMPLE

Granular or powdery substances

The instrument may be used in two ways:

- (a) On whole grain
- (b) On the flour or meal produced by coarse grinding.

Tests on unground granular substances are strongly influenced by the surface moisture. Tests on whole grains of wheat indicate substantially the bran moisture. For this reason it is advisable to test the sample both whole and ground, to give an indication of the moisture distribution as well as its average value.

The fineness of grinding is not important but the loss of moisture which may occur, especially with damp samples, must be minimised. Therefore avoid very fine grinding. After grinding, flush out the grinder with the sample to be tested and discard the first ground sample.

Fibrous material

In general the procedure is the same as for granular materials.

The cavity for the test cell should be approximately half filled with the specimen until packed uniformly, pressing the specimen down in much the same manner as filling a pipe. After the test the compressed plug should be about 1/16 inch thick.

2.4 LOADING THE COMPRESSION CELL

The following description may appear complicated because each detail is mentioned but the procedure will be found quite simple and convenient.

- (1) Unscrew the clamp. Withdraw the test cell. Take out the plunger.
- (2) See that the insulating ring is well seated on the electrode with its open end upwards. In handling the electrode, hold by the edges. Do not handle the upper surface as this may deposit moisture on the insulating surface between the two electrode rings.
- (3)
 - (a) For whole grains put enough into the test cell to form a single layer.
 - (b) For ground samples half fill the test cell with meal. After the test the compressed plug should be about 1/16 inch. Ensure that the sample is lying uniformly in the bottom of the test cell; a gentle shake will ensure this in most cases.
- (4) Insert the plunger and hold it down (to prevent the sample slipping to one side) then slide the complete test cell into the clamp.
- (5) Screw the clamp down until the two parts of the cylindrical spring housing, mounted on the end of the screw, become flush.

CAUTION The spring is compressed solid by about a half turn of the screw beyond standard thrust at which tests are made. The solid point can easily be felt on the tommy-bar. **DO NOT ATTEMPT** to tighten beyond this point as it is possible for a strong operator to strain the clamp.

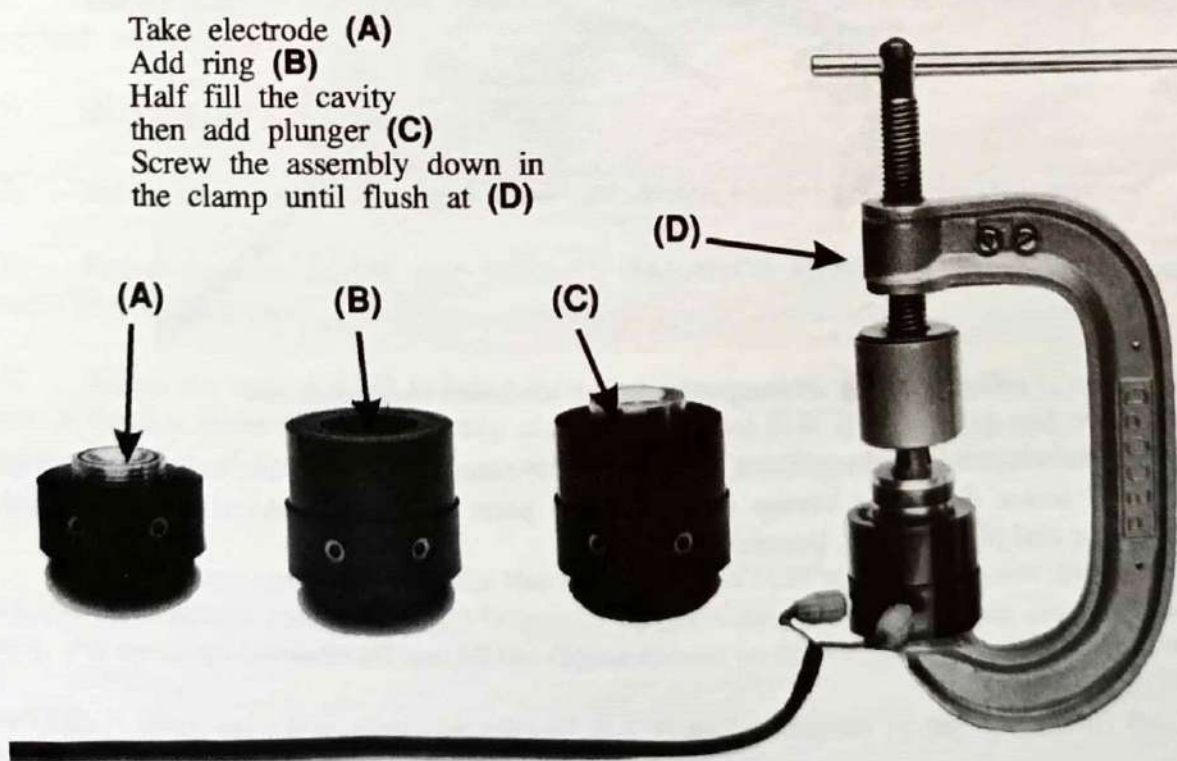


Fig. 2.1 Compression cell electrode assembly

Sheets and boards (e.g. cardboard)

The ring and plunger of the test cell are not required for these materials. Thin sheets should be folded to give a thickness of about 0.01 inch.



Fig. 2.2 Use of compression cell with thin sheet material

Place the electrode in position on the base of the clamp. Put the sheet to be tested on the electrode and screw down the clamp until the two parts of the cylindrical spring housing, mounted on the end of the screw, become flush.

2.5 READING THE INSTRUMENT

Set Scale

Slide the calculator between the central retaining clip and the BALANCE scale graduations as shown in Fig. 1.1. Move the scale along until the vertical index line on the central retaining clip is in alignment with the ambient temperature on the temperature scale. (See Sect. 2.6 if the material under test is not at ambient temperature.) Fig 2.3 illustrates the sequence of operations.

Set ZERO

Switch to ZERO. The meter pointer will deflect.

Turn the ZERO knob until the pointer rests at the centre mark.

NOTE: The 'tens' knob (left-hand BALANCE knob) should not be on the 0 or 1 positions when setting zero. As these are the most sensitive ranges, traces of leakage due to atmospheric humidity and effect of electrostatic induction may cause the reading to be a little unsteady. Switch to any range other than 0 or 1 to set zero.

Switch position ZERO is the 'stand-by' position during a series of measurements.

Read

The accuracy of the instrument may be checked against the internal standard resistance if required - see Sect. 4.2.

- (1) Having filled the cell, switch to READ.
- (2) Set the units KNOB (the right-hand BALANCE knob) to approximately 0.
- (3) Rotate the tens KNOB (the left-hand BALANCE knob) until the pointer crosses the centre line on the meter.
- (4) Adjust the units KNOB to bring the pointer to the line. If the reading is on the negative part of the dial move the tens one step clockwise (unless it is already at 0) and rebalance. The negative section of the dial should never be used if a reading can be obtained on the positive section.

The figures appearing against the KNOB POINTER marks constitute the dial reading. Except for readings above 50, little is gained by recording the figure more closely than half a unit. For readings between 50 and 60 the figure should be determined to one tenth of a unit.

NOTE: With very low moisture content (i.e. 0 or 1 positions of the 'tens' dial) the reading may be a little unsteady due to electrostatic effects.

Convert to moisture content

Sliding scales

Transpose the readings obtained on the knob dials to the fixed black scale.

Read the actual moisture content on the sliding red scale opposite the point obtained on the fixed black scale.

Paper charts

If no scale is available for the substance under test, convert the dial reading to moisture content by means of the calibration data sheet.

NOTE: Switch OFF when measurements are completed in order to conserve power.

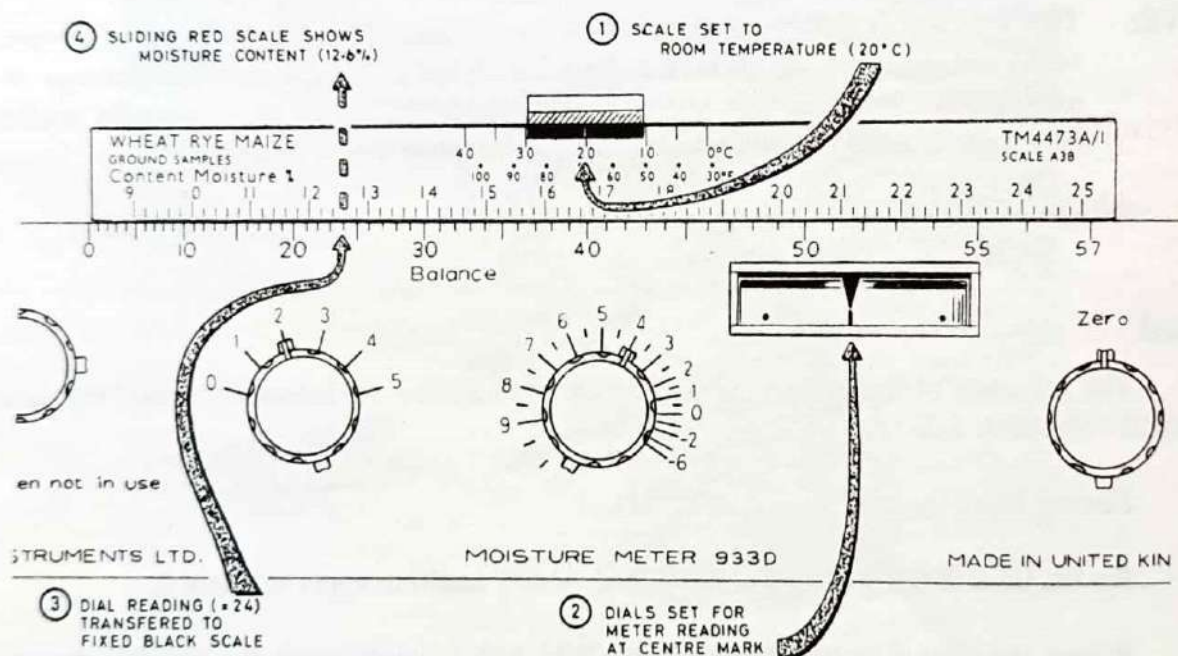


Fig. 2.3 Sequence of reading moisture content

2.6 AVOIDING ERRORS

Sampling errors

If several samples are tested from a stock of material the readings generally will vary a little. These variations are due to local differences in the moisture content of the bulk and not to inaccuracies in the instrument. To get a representative reading it is therefore necessary to test enough samples to make sure a good average is obtained.

At least two readings should be taken. If these differ, one or two more should be taken. For work of ordinary accuracy, two readings are usually sufficient if they differ by not more than two units for readings up to 40, one unit for readings between 40 and 50 and half a unit from 50 to 55. Between 55 and 60 the equivalent moisture content scale contracts rapidly and readings should agree within about 0.1 unit.

Correcting for sample temperature

The temperature corrections included in the calibration data scales or sheets are only valid if the sample and cell are at the same temperature. Although this will normally be so, temperature differences can occur in situations such as testing grain that is still hot after passing through a drying process. Unless the time can be spared to let the grain cool down the reading will not be correct. If the normal scale temperature correction is made for the temperature of the sample, the possible measurement inaccuracy is as shown below; this includes the basic inaccuracy of $\pm 0.5\%$.

If this degree of error is not acceptable it may be possible to save time by gently heating up the test cell to match the temperature of the grain.

<i>Temperature difference between cell and sample,</i>	<i>Total inaccuracy moisture content</i>
5°C	1.0%
10°C	1.6%
15°C	2.1%
20°C	2.7%

This shows that if the total error must be within say, 2%, the maximum permissible temperature difference is 14°C (25°F).

Chapter 3

TECHNICAL DESCRIPTION

3.1 CIRCUIT DESCRIPTION

The electrical measuring circuit, as shown in Fig. 7.1, consists of a Wheatstone bridge in which the specimen forms one arm and the two calibrated moisture controls form the ratio arms. The out-of-balance voltage is applied to the inputs of a FET differential amplifier and displayed on a centre zero meter.

When the function switch is in ZERO position the sample is disconnected and the 'UNITS' arm of the bridge is shorted out. The ZERO control, R19, is then used to balance the amplifier for zero output.

Preset resistor, R16, is adjusted during test to ensure that the instrument reads correctly when standard resistors are used in place of the electrode.

Chapter 4

MAINTENANCE

4.1 INTRODUCTION

This chapter contains information for keeping the equipment in good working order and checking the overall performance. In case of trouble or for advice on servicing this instrument, please write or telephone your nearest representative, whose name and address can be found on the label affixed to the inside front cover of the instrument.

Screw fasteners

Screw threads used are all metric, sizes M2, M3 and M4.

4.2 TESTING

To check that the instrument is working correctly the following simple tests may be carried out.

Calibration

Join the RED and BLACK sockets in the front compartment to the CAL CHECK sockets, using the electrode lead. Set zero and check that the dial reading is 40 ± 0.25 . If this is in error because of a loose BALANCE knob, set zero by rotating the spindle and then secure the knob at the position where the dial reading is 40. USE BOX SPANNER TO LOOSEN/TIGHTEN NUT (9 mm) UNDER KNOB CAP.

Continuity of leads, etc.

Connect the electrode and set zero. Put the electrode in position in the clamp, without the ring. Short circuit the electrode rings with a piece of wire or close the clamp down on a piece of metal foil. The dial reading should be 60.

Leakage

Having checked continuity as above, unscrew the clamp and secure the electrode down on the base by means of the empty electrode ring.

Take the dial reading which should, ideally, be off scale below -6.

A high reading on the dial shows leakage which may be in the electrode or the leads. It can be located by removing these parts individually

In connection with leakage across the electrode face it is important to remember the following rule:

The instrument reading on the empty test cell (without plunger) should be at least 10 divisions below, or preferably 15 to 20 below, the reading obtained with the sample in position. For testing very dry samples the 'empty' reading should be below 0 but for normal use a reading as high as 25 is tolerable. Application of this rule will save wasting time on unnecessary cleaning.

4.3 CLEANING

The test cell electrode must be kept clean. The surface area in the vicinity of the socket holes and especially the thin insulating ring between the annular metal electrodes should receive particular attention. A brisk rub with a dry cloth is usually all that is needed but the part may be washed with water and may also be dried by gentle heat (max. 50 °C) if necessary.

It is inadvisable to use wax polishes to clean the insulating parts of the test cell, as the materials from which these parts are constructed are superior to wax as a water repellent.

If sticky or oily substances are tested as a matter of routine, it is advisable to have one or two spread electrodes which can be used while the others are cleaned.

4.4 LUBRICATION

Keep the moving parts of the clamp lubricated and free from grit. The ball-and-claw joint of the swivel nose should be washed from time to time to remove the old grease and dirt and re-lubricated with grease or heavy oil. The screw should be cleaned and greased occasionally. Inadequate lubrication may cause rapid wear and will make the clamp stiff: it should be possible to turn the tommy-bar with one finger at the 'flush' setting.

4.5 ACCESS AND LAYOUT

The diagram Fig. 4.1 illustrates the accessibility of the components of the Moisture Meter 933D.

Access to the replaceable dry batteries is explained in section 4.6.

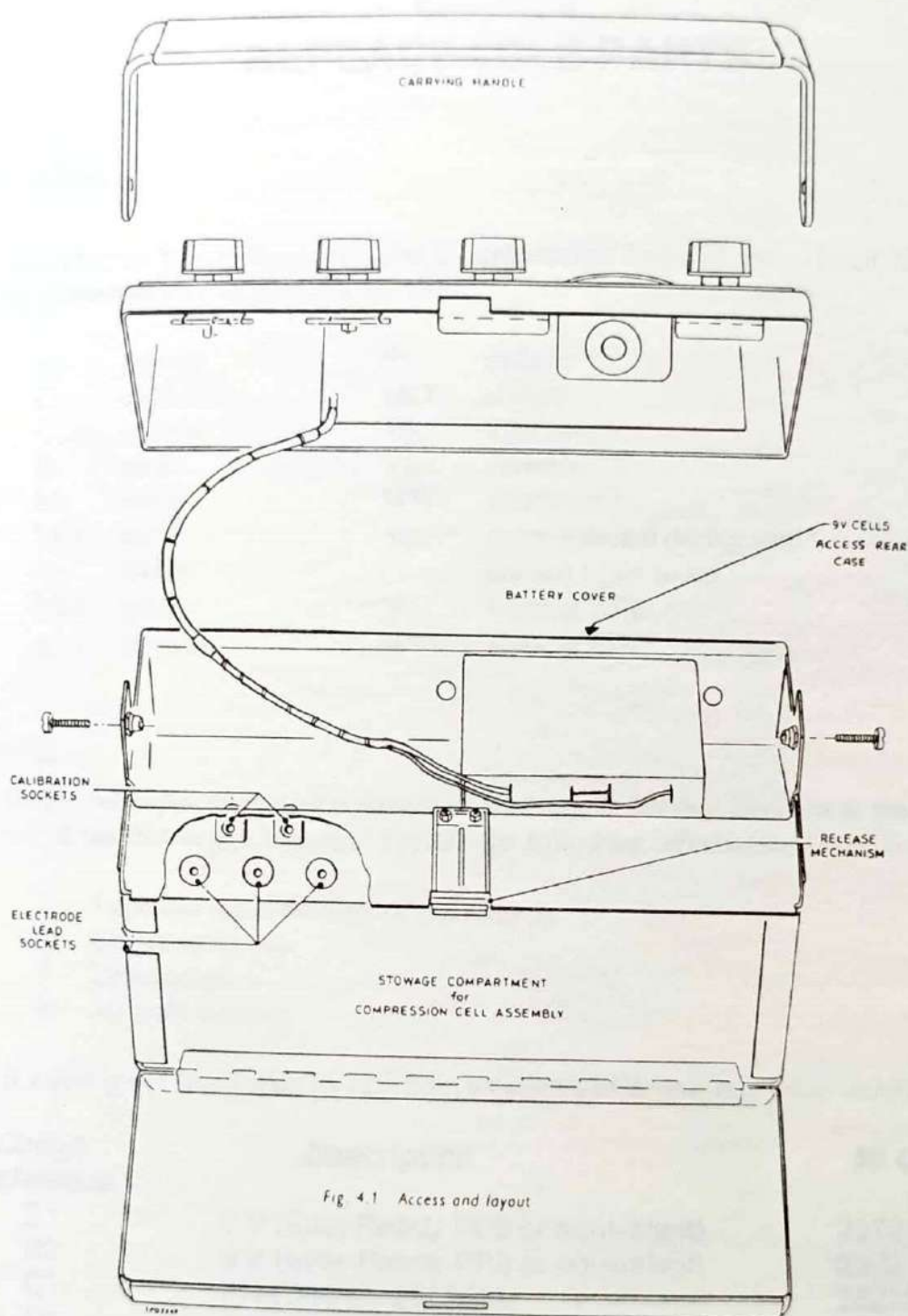


Fig. 4.1 Access and layout

4.6 CHANGING THE BATTERIES

A battery compartment accessible from outside the instrument has been fitted. Lift the two drawers and pull out to replace batteries.

Chapter 6

REPLACEABLE PARTS

Introduction

This chapter lists replaceable parts in alphabetical order of their circuit references. The following abbreviations and symbols are used:

B:	battery	S:	switch
C:	capacitor	SKT:	socket
Carb:	carbon	TR:	transistor
D:	diode	Var:	variable
M:	meter	WW:	wirewound
Met:	metal	+	value selected during test; normal value listed
Ox:	oxide	W:	watts at 70°C
Plas:	plastic	W**:	watts at 40°C
R:	resistor		

Ordering

Orders for replacement parts should be sent to our Service Division at the address on the back cover of the Instruction Manual. Specify the following information for each part required:

1. Type and serial number of instrument.
2. Circuit reference.
3. Description.
4. MI code number.

If a part is not listed state its function, location and description when ordering.

<i>Circuit reference</i>	<i>Description</i>	<i>MI Code</i>
B1	9 V (Ever Ready PP3 or equivalent)	23721-243
B2	9 V (Ever Ready PP3 or equivalent)	23721-243
C1	Plas 330 pF 2% 350V	26272-083
D1	1N4148	28336-676
D2	1N4148	28336-676
M1	f.s.d. 150-0-150 μ A	44558-411
R1	Carb 100 M Ω 2% 1W	24681-999
R2	Met film 10 M Ω 1% 1W	24767-999
R3	Met ox 1 M Ω 2% $\frac{1}{2}$ W	24573-145
R4	Met film 100 k Ω 2% $\frac{1}{4}$ W	24773-321
R5	Met film 10 k Ω 2% $\frac{1}{4}$ W	24773-297

<i>Circuit reference</i>	<i>Description</i>	<i>MI Code</i>
R6	Met film 1.1 k Ω 2% $\frac{1}{4}$ W	24773-274
R7	Met film 10 k Ω 2% $\frac{1}{4}$ W	24773-297
R8	Carb 10 M Ω 10% $\frac{1}{8}$ W	24321-885
R9	Met film 15 k Ω 2% $\frac{1}{4}$ W	24773-301
R10	Met film 10 k Ω 2% $\frac{1}{4}$ W	24773-297
R11	Met film 1.5 k Ω 2% $\frac{1}{4}$ W	24773-277
R12	Met film 4.7 k Ω 2% $\frac{1}{4}$ W	24773-289
R13	Met film 10 k Ω 2% $\frac{1}{4}$ W	24773-297
R14	Met film 15 k Ω 2% $\frac{1}{4}$ W	24773-301
R15	Met film 300 k Ω 2% $\frac{1}{4}$ W	24773-332
R16	Var Carb 10 k Ω 20% $\frac{1}{4}$ W	25611-078
R17	Met film 12 k Ω 2% $\frac{1}{4}$ W	24773-299
R18	Met ox 1 M Ω 2% $\frac{1}{2}$ W	24573-145
R19	Var WW 10 k Ω 10% 1W	25815-134
R20	Var WW 2 k Ω 10% 1W	25853-220
SA	3-position	44340-010
SB	6-position	44340-009
SKTD	Single pole panel mounting	23421-132
SKTE	Single pole panel mounting	23421-132
TR1	BF244B	28459-011
TR2	BC308	28433-455
TR3	BC238B	28452-781
TR4	BC308	28433-455
TR5	BF244B	28459-011

Chapter 7

CIRCUIT DIAGRAMS

Circuit notes

1. COMPONENT VALUES

Resistors: no suffix = ohms, k = kilohms, M = megohms.

Capacitors: no suffix = microfarads, p = picofarads.

+ = value selected during test, nominal value shown.

2. SYMBOLS

 arrow indicates clockwise rotation of knob.

 etc., external front or rear panel marking.

 tag on printed board.

 other tag.

 preset control.

 printed board designation.

3. VOLTAGES

Shown in *italics* adjacent to point to which the measurement refers. DC relative to chassis unless otherwise stated.

4. SWITCHES

Rotary switches are drawn schematically.

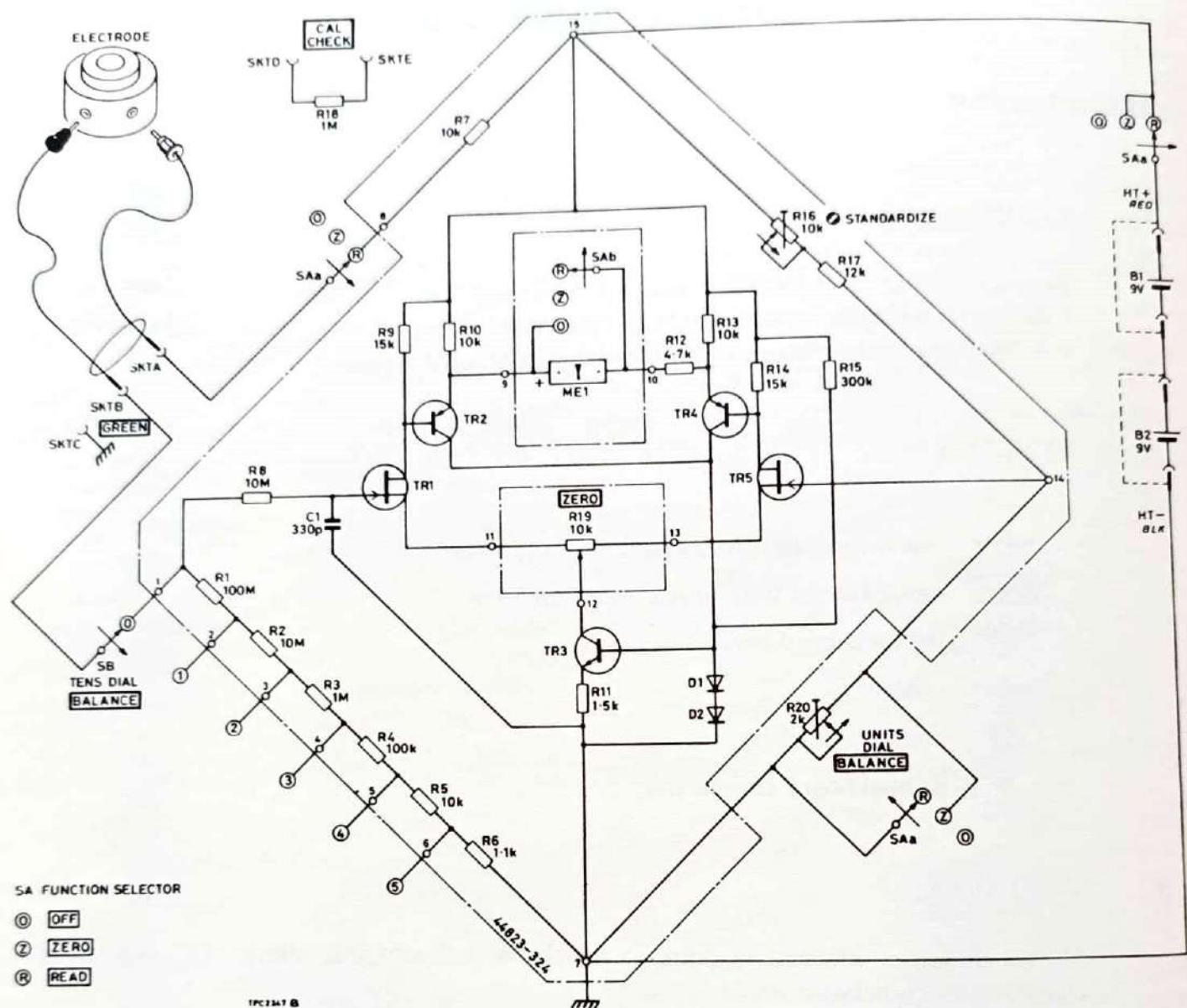


Fig. 7.1 Circuit diagram of moisture meter

**Service Division
Marconi Instruments Limited
The Airport
Luton
Bedfordshire
LU2 9NS
Tel: (0582) 33866
Telex: 825248
Fax: (0582) 417573**

