Digital Earth Testers
MEGGER® DET5/4R & DET5/4D

User Guide

MEGGER

MeterCenter (800) 230-6008

SAFETY WARNINGS

- Special precautions are necessary when 'live' earths may be encountered, and isolation switches and fuses are needed in this situation. See page 9.
- The earth spikes, test leads and their terminations **must not** be touched while the instrument is switched 'On'.
- When working near high tension systems rubber gloves and shoes should be worn.
- The ***DET5/4D*** must be disconnected from any external circuit while its battery cells are changed.
- Replacement fuses **must** be of the correct type and rating
- Before charging the ***DET5/4R*** battery ensure that the correct supply fuse is fitted and the voltage selector is set correctly.
- Warnings and precautions **must** be read and understood before the instrument is used. They must be observed during use.

NOTE

THIS INSTRUMENT MUST ONLY BE USED BY SUITABLY TRAINED AND COMPETENT PERSONS.

CONTENTS

<u>Symbols used on the instrument</u>

⚠ Caution: Refer to accompanying notes.

CE Equipment complies with EU Directives

Illustrations

⚠ ***DET 5/4R*** **Battery Charger Power cord**

If the power cord plug is not suitable for your type of socket outlets, do not use an adaptor. You should use a suitable alternative power cord, or if necessary change the plug by cutting the cord and fitting a suitable plug.

The colour code of the cord is:

Earth (Ground)	Yellow / Green
Neutral	Blue
Phase (Line)	Brown

If using a fused plug, a 3 Amp fuse to BS 1362 should be fitted.

Note: A plug severed from the power cord should be destroyed, as a plug with bare conductors is hazardous in a live socket outlet.

GENERAL DESCRIPTION

The ***DET5/4R*** and ***DET5/4D MEGGER®*** Digital Earth Testers are compact portable instruments designed to measure earth electrode resistance and perform four terminal continuity tests. They may also make earth resistance tests which lead to the measurement of soil resistivity. The ***DET5/4R*** has an internal rechargeable battery, with an integral charger unit. The ***DET5/4D*** is powered from six internal, replacement alkaline cells.

TEST METHOD

The instruments use the well known four-terminal method of measurement in which the resistance of the current circuit test leads does not affect the result.
In the ***DET5/4R*** and ***DET5/4D*** the resistance of the Potential circuit test leads can also be ignored because a buffer stage is incorporated to prevent the measuring circuit from loading the earth resistance under test.
Operation of the instrument is extremely simple. Two modes of operation are selected by means of two push buttons; one for a three terminal test and one for a four terminal test. All other functions of the instrument are automatic.
A reversing d.c. test current, generated electronically from a "floating" constant current source within the instrument, is passed via the '**C1**' and '**C2**' terminals through the earth being tested. The potential developed across the earth is compared with the current and, after filtering and phase sensitive detection the resistance is given directly on the digital display.
Test frequency is 128 Hz and in the interests of safety the maximum test voltage is limited to 50 V (peak) between **C1** and **C2** terminals. Short circuit current is a maximum of 10 mA.

INSTRUMENT DESIGN

The instruments are very robust and have tough cases moulded in ABS plastic. Test leads are not supplied with an instrument but form part of an earth testing field accessory kit which is available as an option. This kit also includes test spikes (electrodes) for making temporary earth spikes.
Mounted on the front panel are two push-button switches for testing using either 3 or 4 terminal measurement. The instrument's 3½ digit liquid crystal display shows the test result, warns of problems with the test conditions and also indicates low battery voltage. LEDs show high current circuit resistance, a high Potential circuit resistance, (both usually caused by a high test spike resistance) and a 'Noisy' earth environment. As these factors can influence the measurement being made, noise and current circuit resistance are continuously monitored during a test, while a check of the Potential circuit resistance is made at the start of each test. The display shows all

measurements directly in ohms or kilohms with the decimal point automatically positioned. It also gives an over-range indication if the resistance under test exceeds 20 kΩ.

This instruments has been designed to comply with the performance specifications of BS7430 (formerly CP 1013 from BSI), BS7671 (IEE Wiring Regulations) IEC 364, NFC 15-100 French Specification and VDE 0413 Part 7 (1982) German specification.

The terminal '**C1'** ('**E**') is for the Current connection to the earth electrode to be tested.
The terminal '**P1**' ('**ES**') is for the Potential connection to the earth electrode to be tested.
The terminal '**P2**' ('**S**') is for the connection to the remote Potential test spike.
The terminal '**C2**' ('**H**') is for the connection to the remote Current test spike.

APPLICATIONS

The installation of satisfactory earthing systems is an essential part of electricity supply, wiring safety and installation economics. It is also of great importance in many communications systems.
The primary application of the ***DET5/4R*** and ***DET5/4D*** is in the testing of earth electrodes, whether these take the form of a single electrode, multiple electrodes, mesh systems, earth plates or earth strips. All earthing arrangements should be tested immediately after installation and at periodic intervals thereafter.

CHOICE OF ELECTRODE SITE

For an earth electrode system to perform satisfactorily it must always have a low total resistance to earth. This value will be influenced by the specific resistance of the surrounding soil. This in turn depends on the nature of the soil and its moisture content. Before sinking an electrode or electrode system it is often helpful to survey the surrounding area before choosing the final position for the electrode. It is possible with these instruments to obtain the resistivity of the soil over an area and at different levels beneath the surface of the ground. These resistivity surveys may show whether any advantage is to be gained by driving electrodes to a greater depth, rather than increasing the cost by having to add further electrodes and associated cables, in order to obtain a specified total earth system resistance.

EARTHING SYSTEMS MAINTENANCE

After installation, checks may be made on an earthing system to see if there is any significant change in the resistance over a period of time or under different soil moisture conditions, (e.g. brought about by changing weather conditions or different seasons of the year). Such checks will indicate if the earth electrode resistance to earth has been exceeded by changing soil conditions or ageing of the system.

OTHER APPLICATIONS

For archeological and geological purposes, an investigation of soil structure and building remains can be carried out at varying measured depths, by the resistivity survey technique.
In all cases the accuracy of the instrument readings may be taken to be higher than the changes caused by natural variables in soil characteristics.
A further application is in continuity testing, for example checking the resistance of conductors used in an earthing circuit.
Resistances between 0,01 Ω and 19,99 kΩ can be measured with a basic accuracy of ±2% of reading ±3 digits. Individual test spike resistances of up to 4 kΩ for the Current loop or 75 kΩ for the Potential circuit can be tolerated on the lowest range, and on the higher ranges greater Current loop values can exist.

FEATURES AND CONTROLS

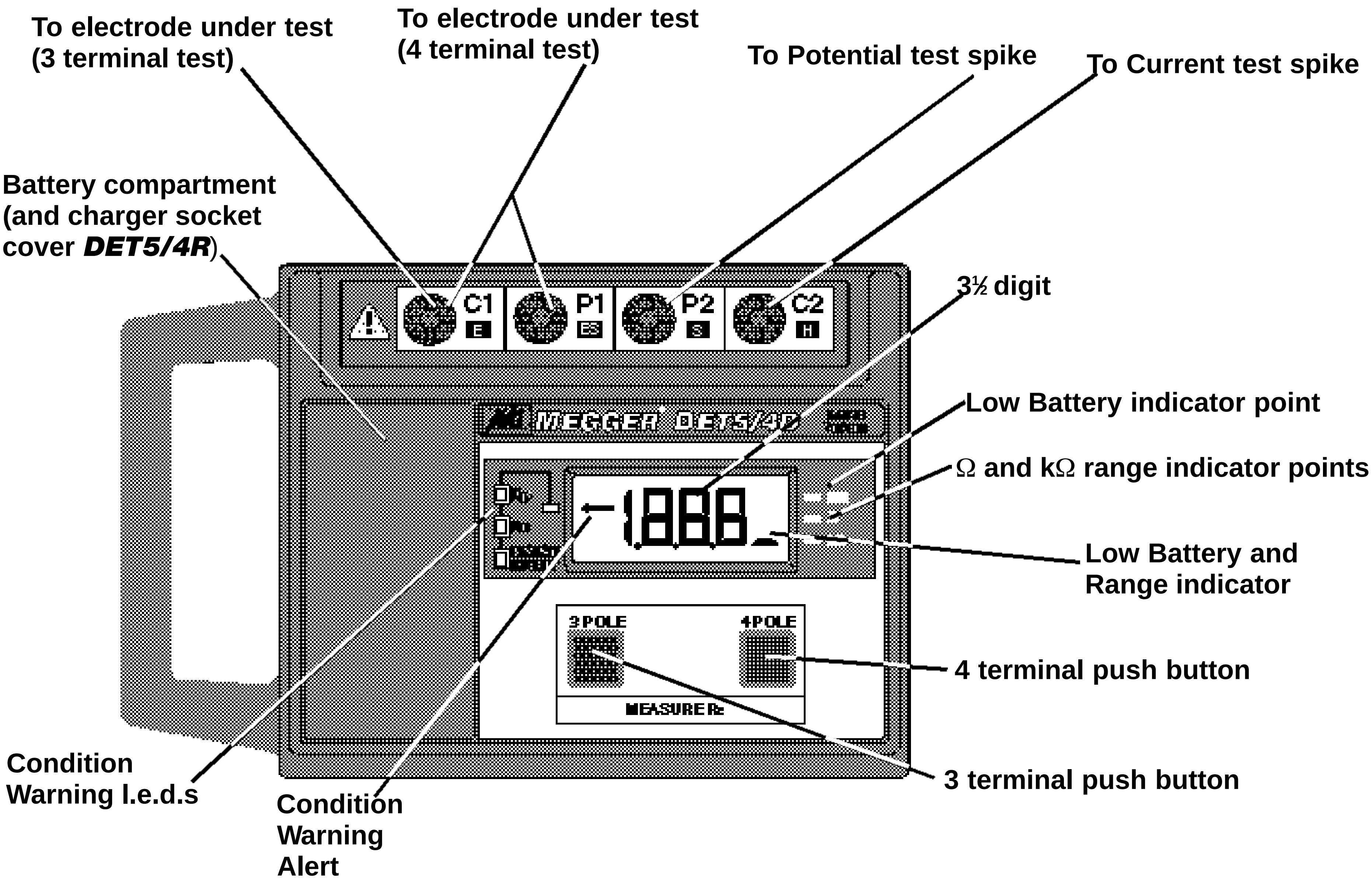


Figure 1. DET5/4 Features

⚠ Live Earth Safety Precautions

It is preferable that the earth electrode to be tested is first isolated from the circuit it is protecting, so that only the earth is measured and not the complete system. When this is done, the circuits and equipment must be de-energised. If however this is not possible, the earth electrode should be duplicated so that when it is disconnected for test purposes, the other one provides the necessary circuit protection. The following safety precautions are essential when working near high tension systems where any unintentional ‘Live' earths may be encountered between the site earth and remote earths established for test purposes. A 'Live' earth is one that carries current from the mains supply, *or could do so under fault conditions*.

1. All persons involved **must** be trained and competent in isolation and safety procedures for the system to be worked on. They must be clearly instructed not to touch the earth electrode; test spikes; test leads, or their terminations if any 'Live' earths may be encountered. It is recommended that they wear appropriate rubber gloves, rubber soled shoes, and stand on a rubber mat.

2. The '**P**' and '**C**' terminals should be connected through a double pole isolation switch, the rating of which will cope with the maximum fault voltage and current. The isolation switch must be open whilst any personal contact is made with the remote test spikes, or the connecting leads, e.g. when changing their position.

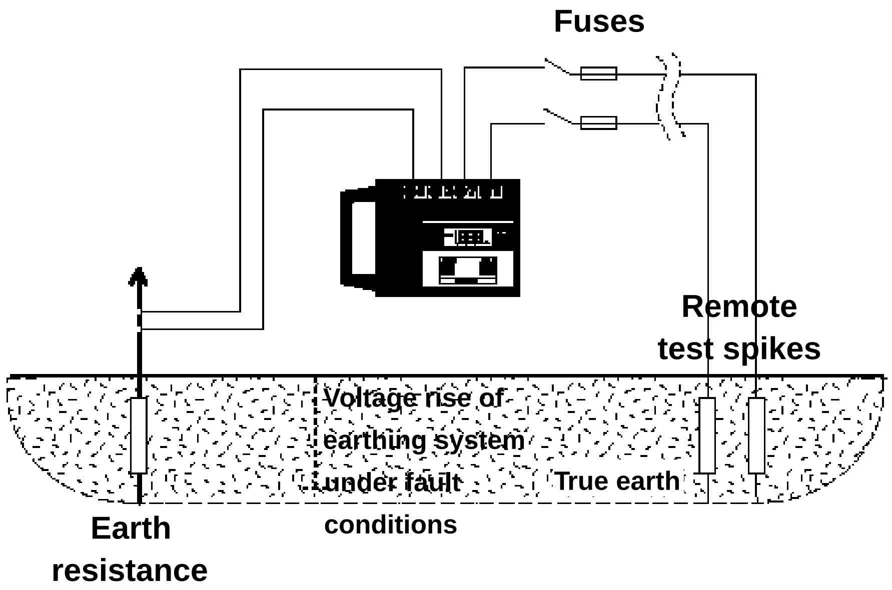


Fig.2 A method of disconnection where fault conditions may occur.

Note: If a fault occurs while a test is being made the instrument may be damaged. Incorporating fuses at the isolation switch, rated at 100 mA, and able to cope with the maximum fault voltage will provide some protection for the instrument.

GENERAL TESTING PROCEDURE

Firmly connect the instrument terminals to the respective earth electrode and test spikes. See '**Basic Test Procedure**'.

1. Press and hold the appropriate push button for approximately 2 seconds. This starts the test sequence including display test; circuit condition and 'Noise' monitoring. ***DET5/4*** remains on for 30 seconds, or until a push button is pressed to turn Off.

2. Check the circuit condition warning LEDs. If any adverse conditions are indicated, the cause should be rectified (to prevent a false reading), before the test continues. **Note:-** If the Current spike resistance is too high for the required measurement range, the ***DET5/4*** will autorange to a range which can tolerate a higher Current spike resistance. This results in a loss of resolution.

3. If conditions for the test are satisfactory, the display will stabilise, and the reading given may be accepted.

4. It is advisable that the battery of the ***DET5/4R*** is fully charged before embarking on a test sequence. It can be extremely inconvenient if the battery becomes too low while a field test is in progress. Similarly, with the ***DET5/4D*** new batteries should always be available.

DISPLAY SYMBOLS

The 3½ digit display shows the reading directly in Ω or **k**Ω adjacent to the range indicator, with the decimal point automatically positioned. If the resistance under test exceeds 19,99kΩ, an over-range symbol appears ('**1**' as left hand digit).

Low battery voltage

If the battery voltage is too low the segment of the display alongside the battery symbol will flash. In this case the batteries hold only enough charge for one or two more measurements and must be recharged (***DET5/4R***) or replaced (***DET5/4D***) before further testing.

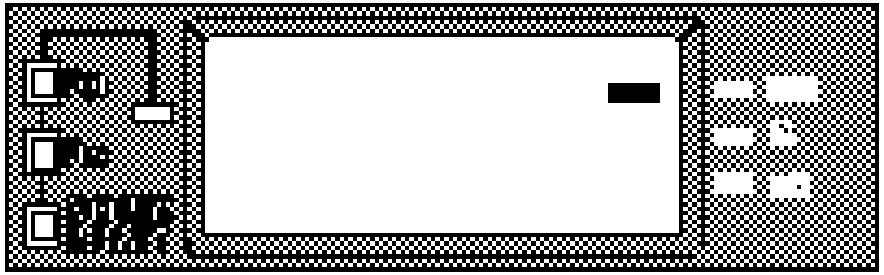


Fig. 3 Low battery voltage indication

CIRCUIT CONDITION WARNING INDICATORS

Warning LED's to the left of the display will indicate any excessive resistance in the Current circuit or Potential circuit, and any excessive electrical 'Noise' in the circuit. The illumination of any of these LED's will always be accompanied by a warning alert indicator at the top left of the display screen.

High Current Spike Resistance (Rc)

During a test, if the resistance of the Current circuit is too high for accurate measurement, the **Rc** LED automatically illuminates, accompanied by the warning alert indicator on the display. This may be caused by an open circuit, poor test lead connections, or excessive resistance of the soil near the electrode under test and/or the remote Current spike. Whatever causes the condition warning to appear should be cleared before a test can be regarded as valid. Moistening the soil around the Current spike; re-siting the spike in a new position or using more than one spike may solve the problem.

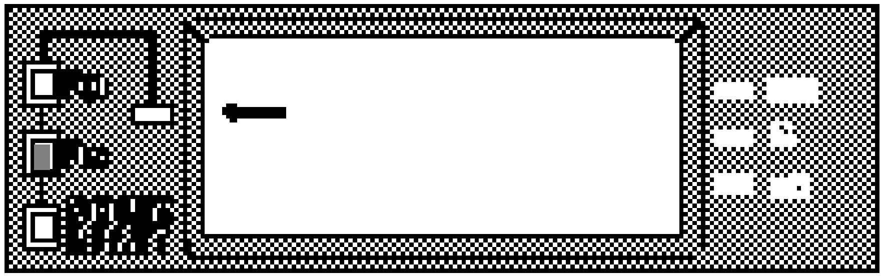


Fig. 4 High Current spike resistance warning

High Potential Spike Resistance (Rp)

If the resistance of the Potential circuit is too high for an accurate measurement, the **Rp** LED automatically illuminates, accompanied by the warning alert indicator on the display. This may be caused by an open circuit, poor test lead connections, or excessive resistance of the soil near the electrode under test and / or the remote Potential spike. Whatever causes the condition warning to appear should be cleared before a test can be regarded as valid. Moistening the soil around the Potential spike; re-siting the spike in a new position or using more than one spike may solve the problem. Note that Potential spike resistance is only checked on commencement of a test, and is not a continuous process. To re-check Potential spike resistance, press the appropriate push button to re-set the instrument and commence a new test.

Excessive Noise Interference (NOISE /BRUIT)

During a test, if the interference voltage in the earth being measured is beyond the level that can be rejected by the Instrument, the '**NOISE**' LED will illuminate, accompanied by the warning alert indicator on the display.

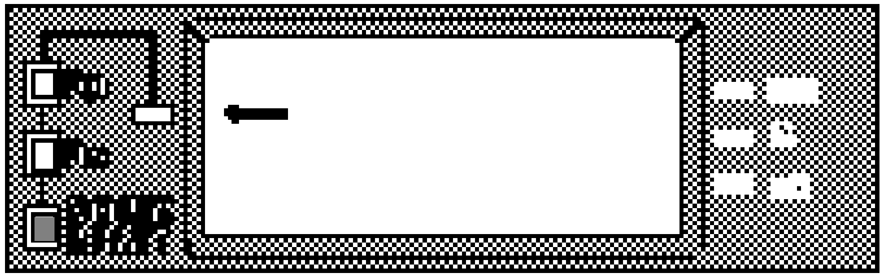


Fig. 5 Excessive ‘Noise‘ Warning

Valid measurements cannot be made in this condition, and the solution may be to wait until the interference has subsided. Alternatively, choose a new position for the two remote test spikes, by re-siting them at right angles to their first position; still in a straight line, and try again.

REVERSE POLARITY

When the Potential leads are reversed with respect to the Current leads, the display flashes between the test bars and a reading. To take a valid reading, ensure that the '**P1**' electrode is closer to '**C1**' than the '**P2**' electrode.

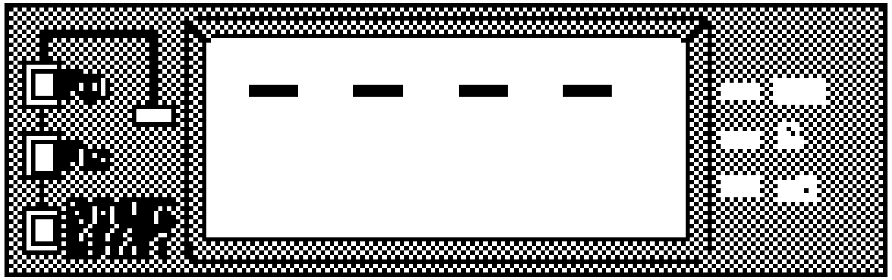


Fig. 6 Reverse Polarity Indication

SETTING UP THE TEST SPIKES ETC.

For earth electrode testing and for earth resistivity surveying, the instrument's test leads are connected to spikes inserted in the ground. The way the connections are made depends on the type of test being undertaken and the details are given in the next section, '**Measuring Techniques**'.

Test spikes and long test leads are necessary for all types of earth testing and the optional earth testing field accessory kits contain the basic equipment.

BASIC TEST PROCEDURE

Four Terminal Measurement

After the test spikes have been set up and connected to the instrument for the type of test to be carried out (refer to '**Measuring Techniques'**) proceed as follows:-

1) Press and hold the **4 pole** push button. After a short pause, this will begin the test sequence and include spike resistance and 'Noise' verification.
2) Check that the display shows no adverse test conditions, i.e. the '**Rp'**; '**Rc'** and '**Noise'** LED's with their alert warning indicator are not showing. Also check that the low battery voltage warning is not flashing.
3) After a few seconds the display will stabilise. If the conditions for a test are satisfactory the reading given on the display may be accepted as the earth resistance. If any of the condition warning indicators illuminate, the cause of the adverse condition must be removed before the reading can be accepted. The instrument autoranges on both the earth resistance and Current loop resistance. If the Current spike resistance is too high for the required measurement range, the instrument will autorange up to a lower current range which can tolerate a higher Current spike resistance. This results in a loss of resolution.
4) The push-button may be released at any time after the instrument has commenced its test sequence. Once the button has been released, the test will continue for approximately 30 seconds.
   To switch the instrument 'Off' before the test period has elapsed, press and **immediately release** either of the two push buttons. If the button is held, the instrument will reset itself, and begin another test sequence starting at point 1.

Three Terminal Measurement

The basic test procedure is the same as for the four terminal measurement except that the **3 pole** push button is used to operate the instrument. Only one connection is then required from the '**C1**' terminal to the electrode under test. For greatest accuracy this connection should be made with a short, low resistance lead since this lead resistance is included in the measured value.

BATTERY CHARGING (***DET5/4R***)

It is advisable that the battery of the ***DET5/4R*** is fully charged before embarking on a test sequence. It is beneficial to the battery to keep it fully charged.

The battery should be charged as soon as the low battery indicator appears on the display. If the display remains blank when the instrument is operated, it is likely that the battery is completely exhausted. Do not allow the battery to become completely exhausted as this could damage it.

Caution:- Before commencing battery charging ensure that:

A correctly rated fuse is fitted and that the voltage selector is set to the correct value for the supply to be used. For a 240 V a.c. supply the fuse should be 100 mA and for a 120 V a.c. supply the fuse should be 200 mA. (Type and sizes of the fuses are given in the Specification). The mains supply fuse is located in the holder which is part of the mains socket. This is reached by undoing the two screws located on the underside of the instrument which hold in place the protective panel covering the mains socket. The supply voltage selection is by reversing the position of the fuse holder in the mains socket.

When the fuse and voltage selector are correctly set, plug the mains supply lead into a suitable socket outlet and switch on. An LED will illuminate alongside the mains supply inlet marked '**CHARGE**' to show that the instrument is connected to a mains supply. Leave the battery to charge for approximately 10 hours. When completed, replace the protective cover for the mains supply to ensure instrument protection.

FITTING OR REPLACING BATTERY CELLS (***DET5/4D***)

Caution:- Use only battery cells of the correct type (Alkaline IEC LR6).

Caution:- Before fitting or replacing battery cells ensure that all test terminal connections are disconnected.

Unscrew the cover for the battery compartment by removing the screws in the base of the instrument. Remove the old cells and fit the new cells as indicated on the battery compartment moulding. Replace the cover and tighten the securing screws.
To avoid damage by leaking electrolyte, do not leave batteries fitted in an instrument which will remain unused for extended periods of time.

FALL-OF-POTENTIAL METHOD

This is the basic method for measuring the resistance of earth electrode systems. However, it may only be practical on small, single earth electrodes because of limitation on the size of area available to perform the tests.

Insert the Current test spike into the ground some 30 to 50 metres away from the earth electrode to be tested. Firmly connect this spike to the instrument terminal '**C2**'.

Insert the Potential test spike into the ground midway between the Current test spike and the earth electrode. Firmly connect this spike to the instrument terminal '**P2**'.

Note:- It is important that the Current spike, the Potential spike and the earth electrode are all in a straight line. Also when running the test leads out to each remote spike, it is preferable not to lay the wires close to each other in order to minimise the effect of mutual inductance.

Firmly connect the '**C1**' and the '**P1**' instrument terminals to the earth electrode. The diagram of Fig. 7 shows the connections.
Operate the instrument as explained in the '**Basic Test Procedure**', and note the resistance obtained.

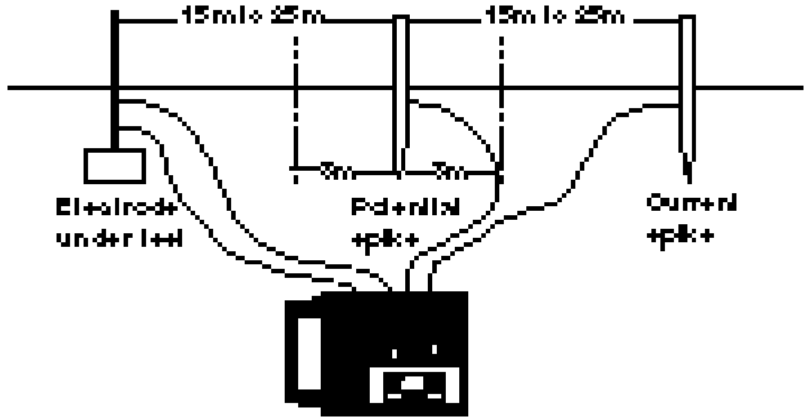


Fig.7 Fall-of-Potential method.

Move the potential spike 3 metres further away from the earth electrode and make a second resistance measurement. Then move the potential spike 3 metres nearer the electrode (than the original position) and make a third resistance measurement. If the three resistance readings agree with each other, within the required accuracy, then their average may be taken as the resistance to earth of the electrode. If the readings disagree beyond the required accuracy then an alternative method should be used e.g. the 61,8% Rule or the Slope Method etc.

Fall-of-Potential Method with Short 'E' Lead

Another way of making connections to the earth electrode is to connect to the earth electrode using only one test lead (as shown in Fig. 8). The 3 pole push button should be used to operate the instrument and the single connection made to the ‘**C1**’ terminal. This should **ONLY** be done if the test lead can be kept short because its resistance will be included in the measurement.

Note:- Earth electrode test lead resistance can be determined separately. First remove it from the the electrode and connect to the '**C2**' and '**P2**' terminals. Press the 3 pole push button. The lead resistance can then be deducted from the earth resistance measurements. This procedure is not, of course, necessary if the '**C1**' and '**P1**' terminals are connected by separate test leads.

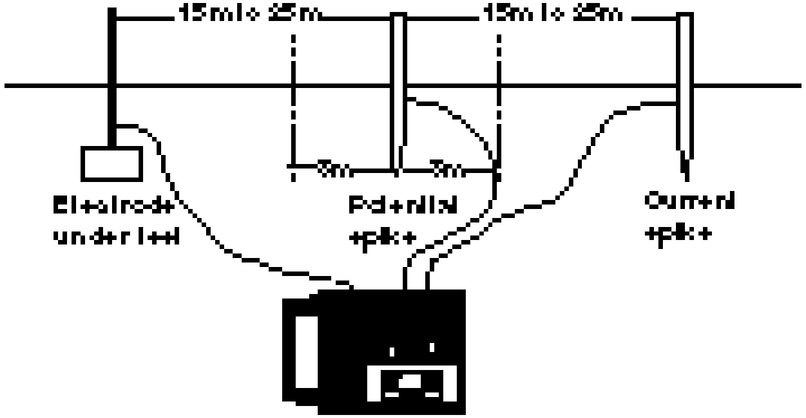


Fig. 8 Fall-of-Potential method using a single lead to the earth electrode.

THE 61,8% RULE

To obtain an accurate reading using the Fall-of-Potential method the current spike must be correctly sited in relation to the earth electrode. Since both possess ‘resistance areas’, the Current spike must be sufficiently remote to prevent these areas overlapping. Furthermore, the Potential spike must be between these areas, see the diagram of Fig.9. If these requirements are not met, the Fall-of-Potential method may give unsatisfactory results.

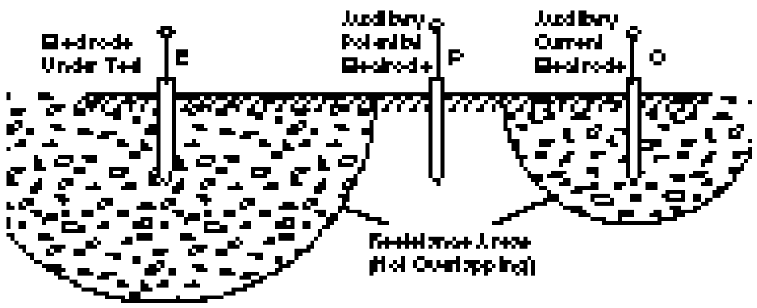


Fig 9. Resistance areas associated with an earth electrode and current spike.

Theoretically, both the Current and Potential spikes should be at an infinite distance from the earth electrode. However, by graphical considerations and by actual test it can be demonstrated that:-

The '**true**' resistance of the earth electrode is equal to the measured value of resistance when the Potential spike is positioned 61,8% of the distance between the earth electrode and the Current spike, away from the earth electrode.

This is the 61,8% Rule and strictly applies only when the earth electrode and Current and Potential spikes lie in a straight line, when the soil is homogeneous and when the earth electrode has a small resistance area that can be approximated by a hemisphere. Bearing these limitations in mind this method can be used, with care, on small earth electrode systems consisting of a single rod or plate etc. and on medium systems with several rods. The diagram of Fig. 10 shows the connections for the 61,8% Rule.

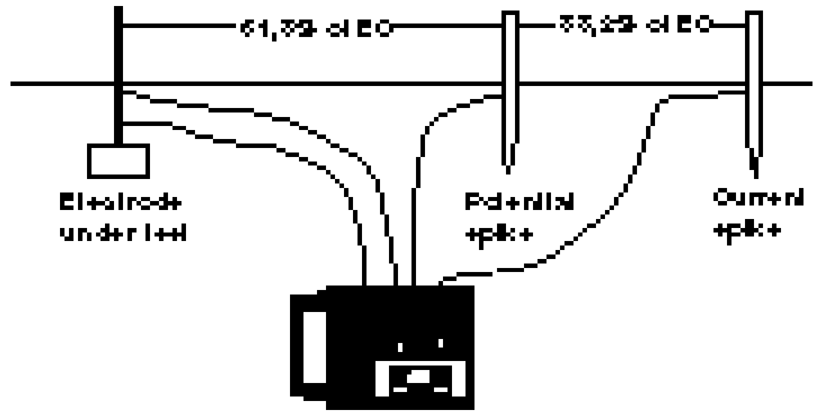


Fig.10 The 61,8% Rule method.

For most purposes the Current spike should be 30 metres to 50 metres from the centre of the earth electrode under test. The Potential spike should be inserted in the ground 61,8% of this distance, between and in a straight line with, the Current spike and the earth electrode. The distance is measured from the earth electrode. If the earth electrode system is of medium size containing several rods, then these distances must be increased. The following table gives a range of distances that agree with the rule. In the first column '**Maximum dimension**' is the maximum distance across the earth electrode system to be measured.

Maximum dimension in metres	Distance to Potential spike in metres from centre of earth system	Distance to Current spike in metres from centre of earth system
5	62	100
10	93	150
20	124	200

For greater accuracy an average reading can be calculated by moving the current spike, say 10 metres, towards and then away from its first position and making further resistance measurements. (Remember that the Potential spike must also be moved in accordance with the 61,8% Rule). The average of the three readings can then be calculated.

THE SLOPE METHOD

This method is more applicable to larger earth electrode systems or where the position of the centre of the earthing system is not known or inaccessible (e.g. if the system is beneath the floor of a building). The Slope method can also be used if the area available for siting the earth electrodes is restricted. It can be tried if the previous methods prove unsatisfactory and generally yields results of greater accuracy than those methods.

The equipment is set up as shown in Fig. 11. The remote Current spike is placed 50 metres or more from the earth electrode system to be measured and connected to the instrument's '**C2**' terminal. The Potential spike is inserted at a number of positions consecutively, between the earth system and the Current spike, and connected to the '**P2**' terminal. The test spikes and the earth system should all be in a straight line.

The instrument's '**C1**' and '**P1**' terminals are connected separately to some point on the earth electrode system.

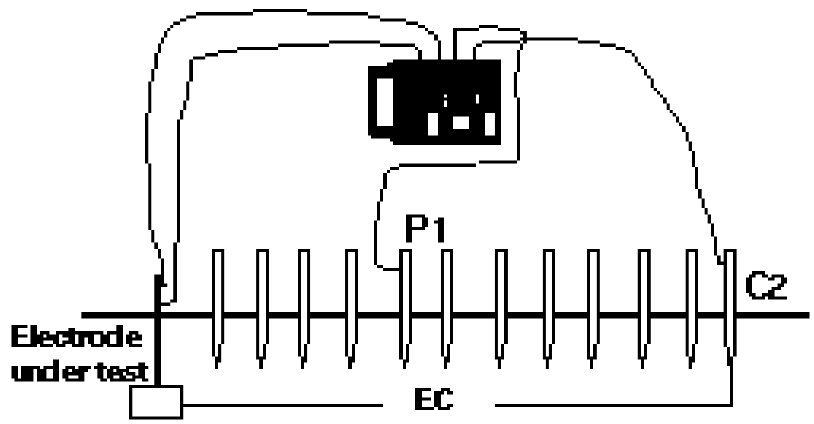


Fig. 11 Connections for the Slope method

The earth resistance is measured at each separate position of the Potential spike and the resistance curve is plotted from the results. At least six readings are needed. The diagram of Fig. 12 shows an example. Drawing the curve will show up any incorrect points which may be either rechecked or ignored.

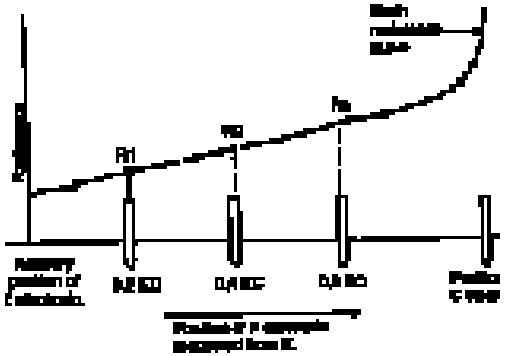


Fig. 12 Resistance curve from Slope method tests.

Suppose the distance from the earth electrode system to the current spike is **EC**. From the curve equivalent resistance readings to Potential positions 0,2**EC**, 0,4**EC** and 0,6 **EC** can be found. These are called R1, R2 and R3 respectively.

Calculate the slope coefficient μ, where

$$\mu = \frac{(R3-R2)}{(R2-R1)}$$

which is a measure of the change of slope of the earth resistance curve.

From the table on page 35 obtain the value of $\mathbf{P_t}$ **/ Ec** for this value of **μ**.
$\mathbf{P_t}$ is the distance to the Potential electrode at the position where the '**true'** resistance would be measured.
Multiply the value of $\mathbf{P_t}$ **/ Ec** by **Ec** to obtain the distance $\mathbf{P_t}$.

From the curve read off the value of resistance that corresponds to this value of $\mathbf{P_t}$. The value obtained is the earth electrode system's resistance.

Note:- (i) If the value of **μ** obtained is not covered in the table then the current spike will have to be moved further away from the earthing system.

(ii) If it is necessary, further sets of test results can be obtained with different values of **EC**, or different directions of the line of **EC**. From the results obtained of the resistance for various values of the distance **EC** another curve can be plotted, as shown in Fig. 13 for example.

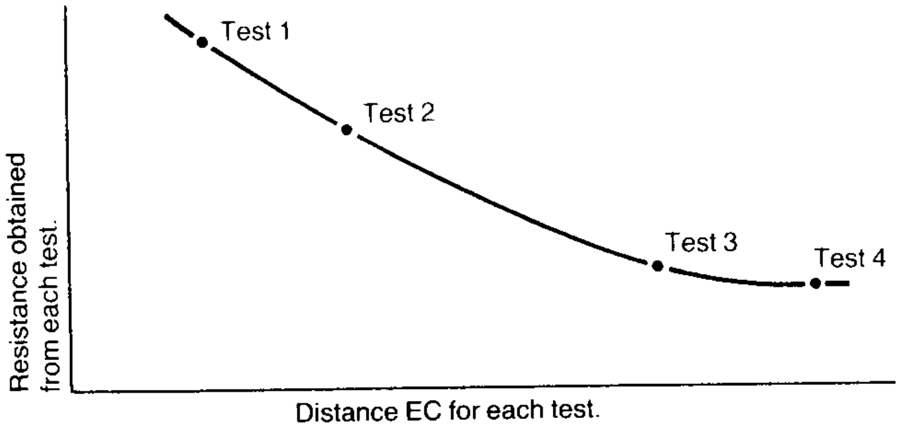


Fig.13 Possible results from several Slope method tests.

This shows how the resistance is decreasing as the distance chosen for **EC** is increased.
The curve indicates that the distances chosen for **EC** in tests (1) and (2) were not large enough, and that those chosen in tests (3) and (4) were preferable because they would give the more correct value of the earth resistance.

(iii) It is unreasonable to expect a total accuracy of more than 5%. This will usually be adequate, bearing in mind that this sort of variation occurs with varying soil moisture conditions or non-homogeneous soils.

METHOD USING A ‘DEAD’ EARTH

The techniques using test spikes explained earlier are the preferred methods of earth testing. In congested areas it may not be possible to find suitable sites for the test spikes, nor sufficient space to run the test leads. In such cases a low resistance conductive water main may be available. This is referred to as a ‘dead’ earth.
Great care must be taken before deciding to adopt this method and its use is not to be encouraged. Before employing this method, the user must be quite sure that no part of the ‘dead‘ earth installation contains plastic or other non-metallic materials.

1) Using a shorting bar supplied, short together terminals ‘**P2**’ and ‘**C2**’.
2) <u>Firmly</u> connect a test lead to ‘**C1**’and the other test lead to ‘**P2**’ and ‘**C2**’.
3) <u>Firmly</u> connect the free ends of the test leads together as shown in Fig. 14.
4) Press the <u>**3 pole**</u> test push, and take a reading in the normal way.

This test will give give the combined resistance to earth of the two earths in series. If that of the ‘dead‘ earth is negligible then the reading may be taken as that of the electrode under test .
The resistance of the two test leads can be found by firmly joining their free ends together, pressing the <u>**3 pole**</u> test push and taking the reading in the usual way. Test lead resistance can then be subtracted from the original reading, to obtain the combined resistance of the earth electrode and the ‘dead’ earth.

Fig. 14 ‘Dead’ earth testing

BS7671 (16TH EDITION WIRING REGULATIONS) REQUIREMENTS

Regulation 713-11 of BS7671 specifies that the resistance of earth electrodes must be measured. The accompanying Guidance Notes describe a method of test that is very similar to the Fall-of-Potential method. If the maximum deviation from the average of the three readings is better than 5% then the average can be taken as the earth electrode resistance. If the deviation exceeds 5% then the current spike should be moved further away from the electrodes and the tests repeated.

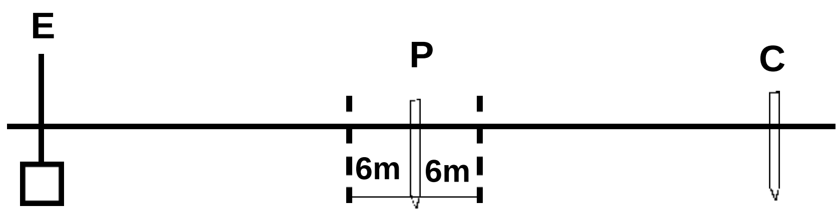


Fig.15 Test spike positions for BS7671 testing

Other Methods

There are other methods of earth electrode testing among which are the Four Potential, Intersecting Curves and Star Delta methods. **AVO INTERNATIONAL** have produced a book entitled ‘A Simple Guide to Earth Testing’ (Part Number 6171-230) which explains all these test methods and gives other helpful information about earth testing. It is available from the instrument manufacturer or one of their approved distributors.

DETERMINING ‘TOUCH’ POTENTIAL

‘Touch’ potential is the potential difference a person would experience across his body if he were, for example, standing on the ground outside the earthed perimeter fence of a substation and touching the fence at the time a fault occurred.

Firmly connect the instrument as follows:-

1) Terminal '**C1**' to the substation earth.
2) Terminal '**C2**' to the Current spike inserted in the ground some distance away.
3) Terminal '**P1**' to the structure being tested e.g. the perimeter fence.
4) Terminal '**P2**' to the Potential spike inserted in the ground 1 metre away from the perimeter fence adjacent to the point where a person might stand.
5) Press the **4 pole** test push, and take a reading in the normal way. This is the effective resistance between the point of test on the fence and the Potential spike as seen by the test current.

The maximum value of the current that would flow in the earth when a fault to earth occurred at the substation must be known. The maximum fault current has to be calculated from the parameters associated with the substation ratings involved. From Ohm's Law (V = I x R), the Touch potential can be calculated.

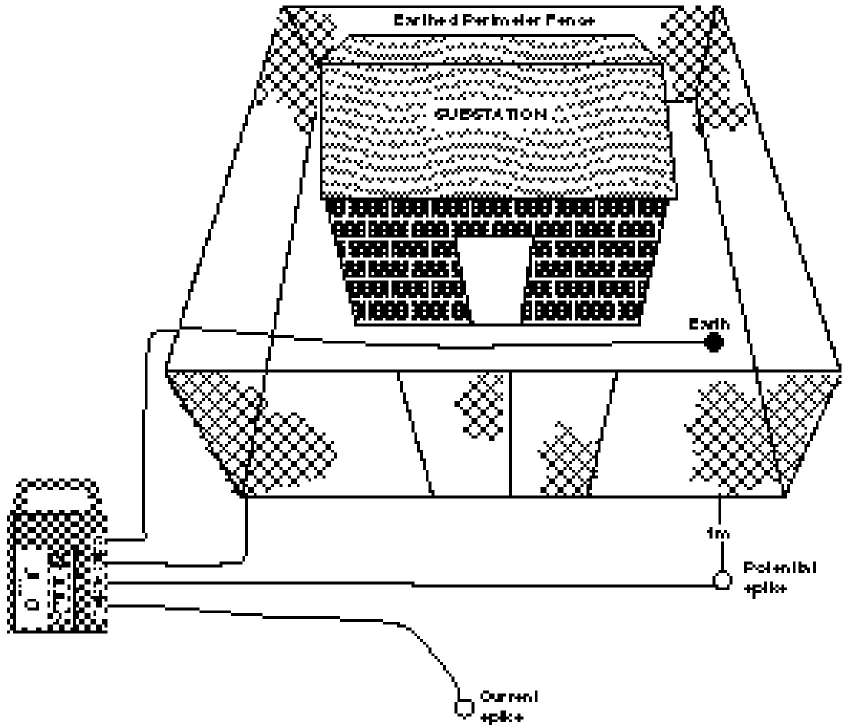


Fig. 16 Determining 'Touch' potential.

DETERMINING ‘STEP’ POTENTIAL

‘Step’ potential is the potential difference a person would experience between his feet as he walked across the ground in which a fault current was flowing.

Firmly connect the instrument as follows :-

1) Terminal '**C1**' to the substation earth.

2) Terminal '**C2**' to the Current spike inserted in the ground some distance away.

3) Firmly connect the '**P1**' and '**P2**' terminals to test spikes inserted in the ground 1 metre apart, (or the length of a step) at positions **A** and **B** respectively. **A** is nearest to the substation earth.

4) Press the **<u>4 pole</u>** test push, and take a reading in the normal way.

Record the resistance indicated. This is the effective resistance across the positions **A** and **B**, as seen by the test current.
The maximum value of the current that would flow in the earth when a fault to earth occurred at the substation must again be known. From Ohm's Law the ‘Step potential’ can be calculated.

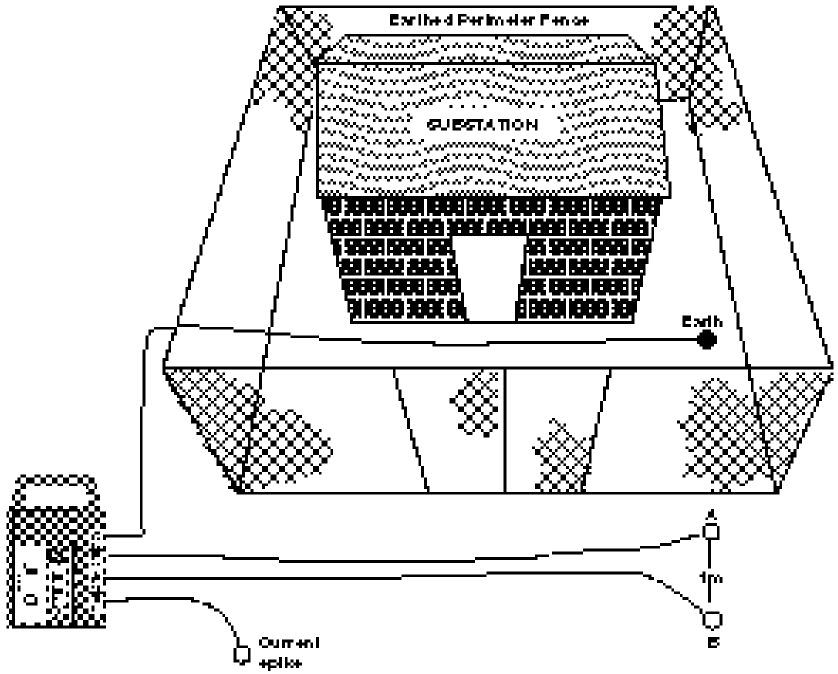


Fig.17 Determining ‘Step’ potential

TYPICAL VARIATIONS IN SOIL RESISTIVITY

The resistance to earth of an earth electrode is influenced by the resistivity of the surrounding soil. The resistivity depends upon the nature of the soil and its moisture content and can vary enormously as seen in the table below:-

Material	Specific resistance in Ω-cms	Information source
Ashes	350	Higgs
Coke	20 - 800	
Peat	4500 - 20000	
Garden earth - 50% moisture	1400	Ruppel
Garden earth - 20% moisture	4800	Ruppel
Clay soil - 40% moisture	770	Ruppel
Clay soil - 20% moisture	3300	
London clay	400 - 2000	
Very dry clay	5000 - 15000	
Sand - 90% moisture	13000	Ruppel
Sand - normal moisture	300000 - 800000	
Chalk	5000 - 15000	
Consolidated Sedimentary rocks	1000 - 50000	Broughton Edge & Laby

Because it is impossible to forecast the resistivity of the soil with any degree of accuracy it is important to measure the resistance of an earth electrode when it is first laid down and thereafter at periodic intervals. Before sinking an electrode into the ground for a new installation it is often advantageous to make a preliminary survey of the soil resistivity of the surrounding site. This will enable decisions to be made on the best position for the electrode(s) and to decide whether any advantage can be gained by driving rods to a greater depth. Such a survey may produce considerable savings in electrode and installation costs incurred trying to achieve a required resistance.

LINE TRAVERSE

The most common method of measuring soil resistivity is often referred to as the line traverse. Four test spikes are inserted into the ground in a straight line at equal distances '**a**' and to a depth of not more than 1/20 of '**a**'. The instrument is connected to the test spikes as shown in Fig.18.

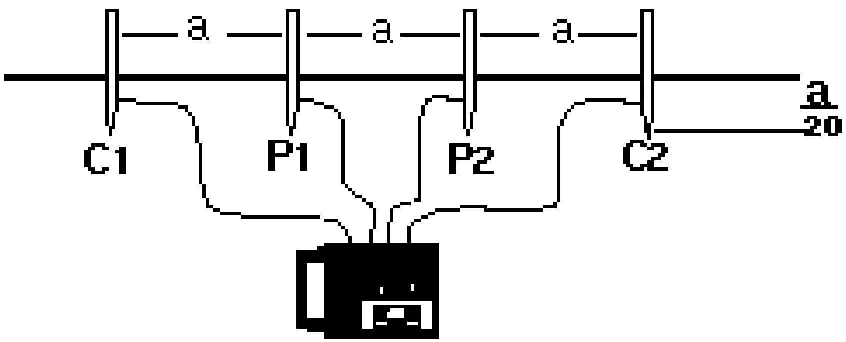


Fig. 18 Soil resistivity measurement.

The instrument is operated and the measurement made in the normal way. The resistivity may be calculated from the formula given opposite or from the nomogram shown in Fig.19. This is the average soil resistivity to a depth '**a**'.

The four test spikes are then re-positioned for further tests along a different line. If both the spacing '**a**' and the depth **a/20** are maintained, a directly comparable reading will be obtained each time, and thus regions of lowest resistivity can be located over a given area (at the constant depth '**a**').

Re-spacing the test spikes at separations '**b**', '**c**', '**d**', etc will yield results from which a profile of the resistivity at new depths **b/20, c/20, d/20**,etc.can be obtained.

If the same line for the test spikes is maintained, but the separation of them is progressively widened, resistivity values at various depths can be obtained. By this means depth surveys may be made.

More details can be found in the **AVO INTERNATIONAL** publication ‘A Simple Guide to Earth Testing’ (Part Number 6171-230).

CALCULATION OF RESISTIVITY

Assuming that the tests were carried out in homogeneous soil the resistivity is given by the formula:-

$$\rho = \mathbf{2\pi aR}$$

where **'R'** is the resistance measured in ohms, **'a'** is the test spike spacing in metres and 'ρ' is the resistivity in ohm-metres.

For non-homogeneous soils the formula will give an apparent resistivity which is very approximately the average value to a depth equal to the test spike spacing '**a**'.

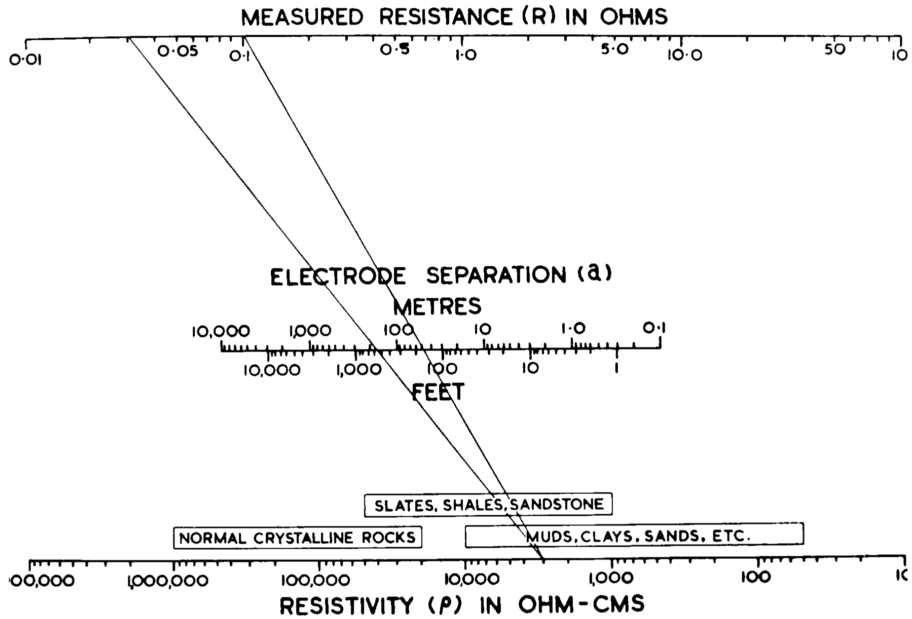


Fig. 19 Resistivity calculation Nomogram

MEASURING TECHNIQUES Continuity Testing

The ***DET 5/4*** will measure metallic resistances of low inductance or capacitance. To test the continuity of conduit or other earth conductors the instrument can be connected as a 4 pole tester, or connected as shown in Fig. 20. Ensure that the circuit is de-energised, before connecting the instrument for measurement.

Note:- Due to the inherent high accuracy of the instrument and the low continuity resistance to be measured, contact resistance between the test lead clips and the conduit becomes a factor in the measured value. Contact resistance should therefore be kept as low as possible.

1) Using a shorting bar supplied, short together terminals '**P2'** and **'C2'**.
2) Firmly connect a test lead to '**C1**',and the other test lead to '**P2**' and '**C2**'.
3) Firmly connect the free ends of the test leads across the isolated circuit under test.
4) Press the **3 pole** test push, and take a reading in the normal way.

The resistance of the two test leads can be found by firmly joining their free ends together, pressing the **3 pole** test push and taking the reading in the usual way. Test lead resistance can then be subtracted from the original reading, to give a 'true' value of continuity resistance.

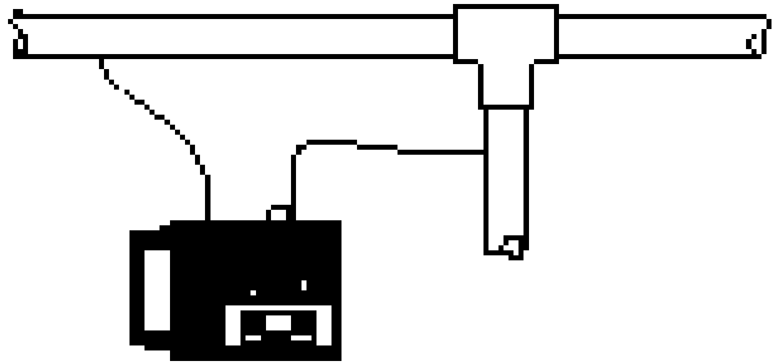


Fig. 20 Continuity testing.

CIRCUIT DESCRIPTION

The instrument uses the four terminal method of measurement. A reversing d.c. test current is injected into the earth through terminals '**C1**' and '**C2**'. The potential developed across the earth is monitored with '**P1**' and '**P2**'. A three pole test is achieved by shorting terminals '**C1**' and '**P1'** together through an internal relay.
At the beginning of a test, the control logic initiates a Potential spike resistance check, monitoring the input over-range detector for the result. The instrument autoranges by the control logic monitoring the output of the over-range detector and switching the current source to a lower current output. The instrument also autoranges if the if the high current loop resistance detector senses too much current loop resistance for the preset range.
The instrument measuring circuitry is connected to terminals '**P1**' and '**P2**'. The voltage limiter and input buffer prevent damage to the instrument and loading of the resistance under test. Synchronous filtering and detection are used to recover the test signal from noisy environments followed by filtering and conversion to a reading by the digital panel meter.
The test signal frequency is produced by dividing the frequency of a crystal oscillator. This is then passed through logic circuitry to produce the waveforms for synchronous filtering and detection.

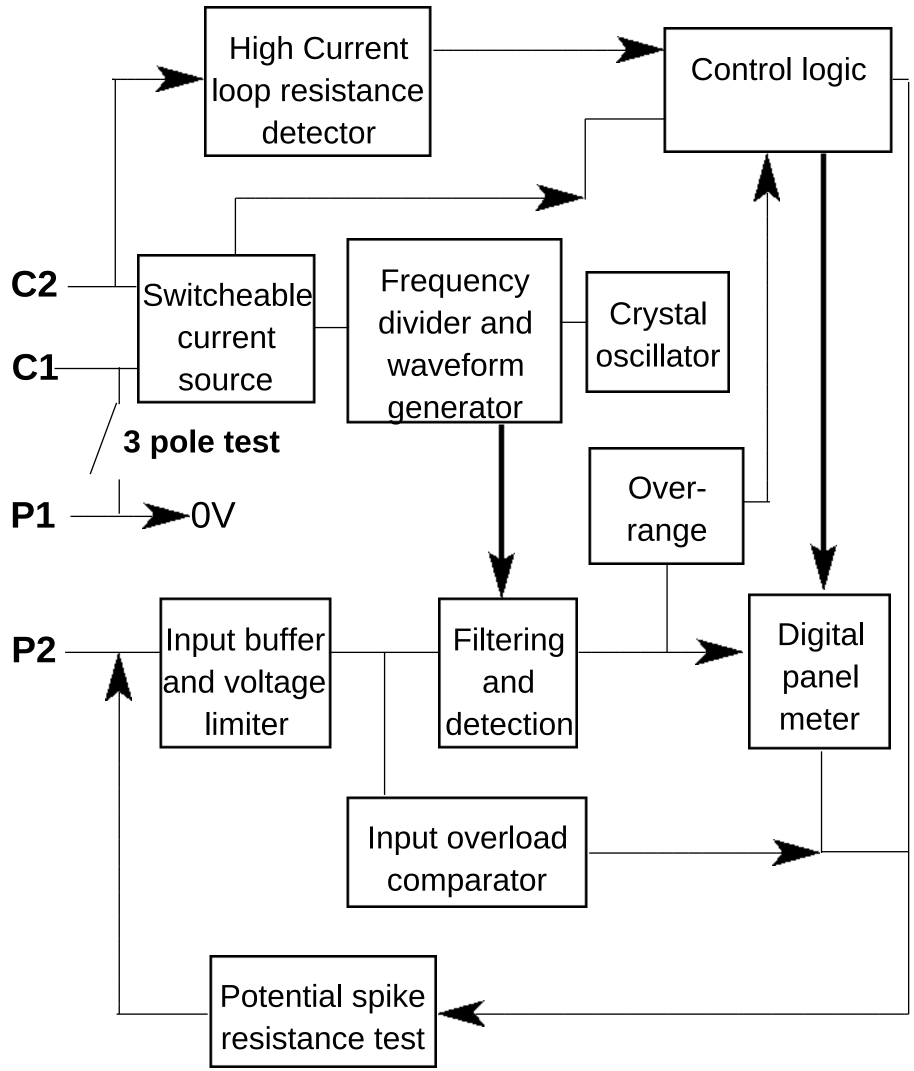


Fig. 21 Block diagram of instrument circuit

SPECIFICATION

Earth Resistance Ranges:	0,01 Ω to 19,99 Ω 0,1 Ω to 199,9 Ω 1 Ω to 1,999 kΩ 10 Ω to 19,99 kΩ		
Accuracy (23°C ±2°C):	±2% of reading ±3 digits. Total service error ±5% of reading ±3 digits		
Compliance with Standards:	BS 7430 (1992)	BS7671 (1992)	NFC 15-100
	VDE 0413 Part 7 (1982)	IEC364	
Test Frequency:	128 Hz ±0,5 Hz		
Test Current:	20 Ω range	10 mA a.c. r.m.s.	
	200 Ω range	1 mA a.c. r.m.s.	
	2 kΩ and 20 kΩ ranges	100 µA a.c. r.m.s	
	Test current (= short circuit current) is constant throughout a range.		
Interference:	Interference voltages of 40 V pk to pk at 50 Hz, 60 Hz, 200 Hz or 16⅔ Hz in the Potential circuit will have a max. effect of typically ±1% on the reading obtained for the 20 Ω to 2 kΩ ranges. If the '**Noise**' indicator is not showing, the maximum error due to 'noise' voltage on these ranges will not exceed 2%. In the 20 kΩ range this is reduced to 32 V pk to pk.		
Max. Current Loop Resistance:	The loop resistance that will introduce an additional 1% error is:		
	20 Ω range	4 kΩ	
	200 Ω range	40 kΩ	
	2 kΩ and 20 kΩ ranges	400 kΩ	
	These are loop resistances, therefore the resistance under test must be subtracted from these figures. If the '**Rc**' indicator is not showing, the maximum error will not exceed 2%.		

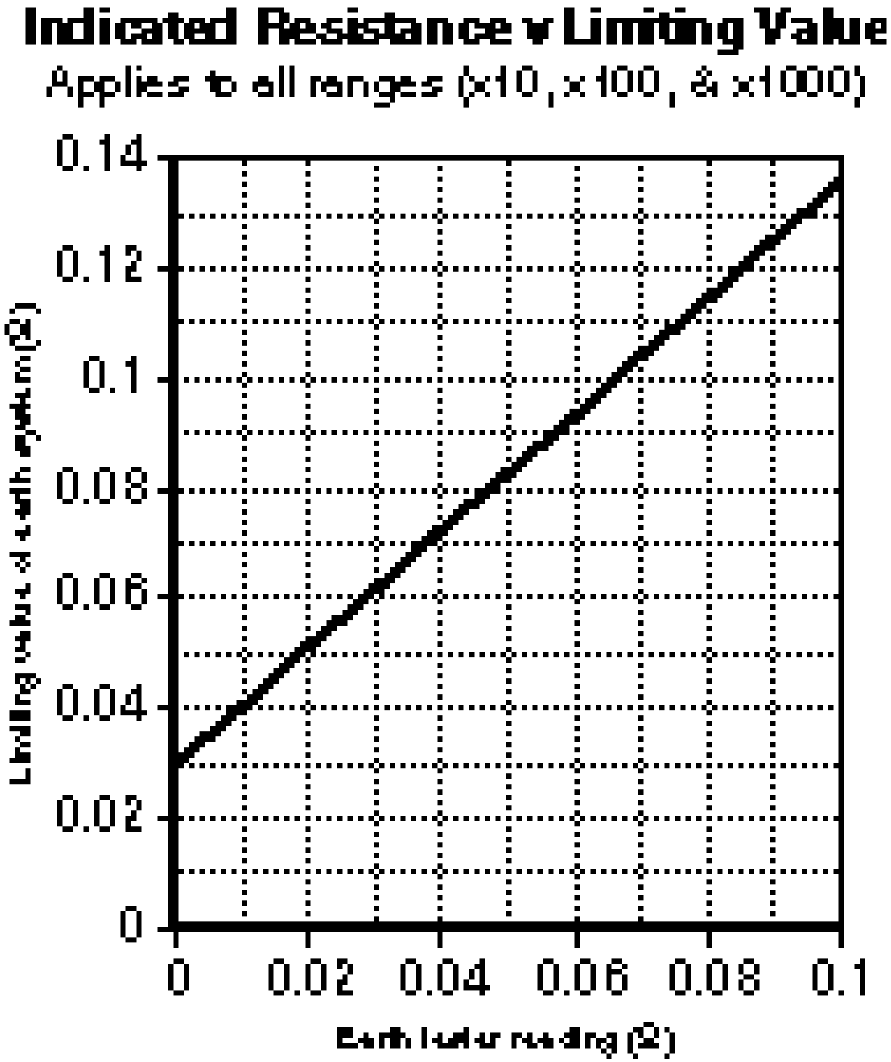
Max. Potential Spike Resistance:		An additional error (typically 1%) will be introduced by a Potential spike resistance of 75 kΩ. If the '**Rp**' indicator is not showing, the maximum error will not exceed 2%.
Max. Output Voltage:		50 V
Display:		3½ digit l.c.d. maximum reading 1999
Instrument Protection:		IP54
Temperature Effect:		<±0,1%/°C over the temperature range - 15°C to +55°C
Temperature Range:	operating:	-20°C to +45°C (0°C to +55°C for the ***DET5/4D***)
	storage:	-40°C to +70°C (for the DET5/4D, without batteries)
Humidity:	operating:	90% RH max. at 45°C
	storage:	70% RH max. at 55°C
Flash Test:		2,3 kV a.c.
Voltage Withstand:		In the event of a system fault the instrument will withstand 240 V a.c. applied between any two terminals.
Power Supply:	***DET5/4R***:	Internal rechargeable sealed lead acid cells 12 V, 0,8 Ah capacity. Battery voltage range over which basic accuracy is maintained, 10,0 V to 13,5 V. Battery life; 600 x 15 s tests Battery charging time, 10 hours max. (from completely exhausted). Charging supply required, (user selectable) 200 V to 255 V a.c. or 100 V to 130 V a.c. 50 Hz/60 Hz.

SPECIFICATION

	DET5/4D:	6 x 1,5 V alkaline battery cells IEC LR6 type. Battery voltage range over which basic accuracy is maintained, 6 V to 10 V. Battery life; 600 x 15 s tests.
Fuses:	***DET5/4D***:	Internal 100 mA ceramic HBC 20 mm x 5 mm IEC 127/1 (for current source protection) Internal 100 mA ceramic HBC 20 mm x 5 mm IEC 127/1 (for Potential circuit protection)
	DET5/4R:	Internal 100 mA ceramic HBC 20 mm x 5 mm IEC 127/1 (for current source protection) Internal 100 mA ceramic HBC 20 mm x 5 mm IEC 127/1 (for Potential circuit protection) 100 mA ceramic HBC 20 mm x 5 mm IEC 127/1 for 240 V a.c.supply, or 200 mA ceramic HBC 20 mm x 5 mm IEC127/1 for 120 V a.c supply (for circuit protection during battery charging). Mains power cord fused plug: 3 Amp fuse to BS 1362
Safety:		The instrument meets the requirements for safety to IEC 1010-1 1995), EN61010-1 (1995).
E.M.C:		In accordance with IEC61326 including Amendment No.1
Dimensions:		240 mm x 160 mm x 70 mm (9,4 in x 6,3 in x 2,75 in approx.)
Weight:	***DET5/4R***:	1,27 kg (2,8 lb approx.)
	DET5/4D:	0,82 kg (1.5 lb approx.)
Cleaning:		Wipe the disconnected instrument with a clean cloth dampened with soapy water or Isopropyl Alcohol (IPA) .

The VDE 0413 part 7 specification stipulates that these instructions should contain a diagram showing the maximum value which the instrument must indicate in certain conditions. An earth test being performed on any electrode system would normally be carried out to a particular specification. Therefore, even at the instrument's worst accuracy, the reading is never above the limiting value required by the particular specification in question.

The curve opposite shows the maximum value which shall be indicated by the instrument (at its maximum error) to ensure that the limiting value of the earth resistance given in the relevant earth electrode test specification is met.



ACCESSORIES

SUPPLIED	Part Number
User Guide	6172-132
Shorting bars (x2)	5131-365
Power cord (for battery charging ***DET5/4R***)	

OPTIONAL

Instrument carrying harness	6220 - 537
Carrying Case	6431 - 585

Publications

'Getting Down to Earth'	AVTM25-TA

Four Terminal Earth Testing kit 6310 - 755
Carrying bag containing:-
Club hammer, 4 x spikes,
3m (x2) cable and 30m,
50m of cable on winders.

Four Terminal Compact Earth Testing kit 6210 - 161
Compact carrying bag containing:-
4 x push in spikes, 3m, 15m, 30,
and 50m of cable on cable tidy.

Three Terminal Compact Earth Testing Kit 6210 - 160
Compact carrying bag containing:-
3 x push spikes, 3m, 15m and 30m
of cable on a cable tidy.

U.S. OPTIONS	Cat. Number
Standard Accessory kit	250579

Canvas case containing:-
2 x 20 in rods, leads
(25,50 &100 ft)

Deluxe Accessory kit 250581
Padded case to hold instrument,
2 x 20 in rods, leads
(25,50 &100 ft)

Soil Resistivity kit 250586
Padded case to hold instrument,
4 x 20 in rods and test leads
(4 x 50ft)

Chart for use with the Slope Method

Values of $P_{t / EC}$ for Values of μ

μ	0	1	2	3	4	5	6	7	8	9
0.40	0.6432	0.6431	0.6429	0.6428	0.6427	0.6425	0.6424	0.6422	0.6421	0.642
0.41	0.6418	0.6417	0.6415	0.6414	0.6412	0.6411	0.641	0.6408	0.6407	0.6405
0.42	0.6404	0.6403	0.6401	0.64	0.6398	0.6397	0.6395	0.6394	0.6393	0.6391
0.43	0.639	0.6388	0.6387	0.6385	0.6384	0.6383	0.6381	0.638	0.6378	0.6377
0.44	0.6375	0.6374	0.6372	0.6371	0.637	0.6368	0.6367	0.6365	0.6364	0.6362
0.45	0.6361	0.6359	0.6358	0.6357	0.6355	0.6354	0.6352	0.6351	0.6349	0.6348
0.46	0.6346	0.6345	0.6344	0.6342	0.6341	0.6339	0.6338	0.6336	0.6335	0.6333
0.47	0.6332	0.633	0.6329	0.6328	0.6326	0.6325	0.6323	0.6322	0.632	0.6319
0.48	0.6317	0.6316	0.6314	0.6313	0.6311	0.631	0.6308	0.6307	0.6306	0.6304
0.49	0.6303	0.6301	0.63	0.6298	0.6297	0.6295	0.6294	0.6292	0.6291	0.6289
0.50	0.6288	0.6286	0.6285	0.6283	0.6282	0.628	0.6279	0.6277	0.6276	0.6274
0.51	0.6273	0.6271	0.627	0.6268	0.6267	0.6266	0.6264	0.6263	0.6261	0.626
0.52	0.6258	0.6257	0.6255	0.6254	0.6252	0.6251	0.6249	0.6248	0.6246	0.6245
0.53	0.6243	0.6242	0.624	0.6239	0.6237	0.6235	0.6234	0.6232	0.6231	0.6229
0.54	0.6228	0.6226	0.6225	0.6223	0.6222	0.622	0.6219	0.6217	0.6216	0.6214
0.55	0.6213	0.6211	0.621	0.6208	0.6207	0.6205	0.6204	0.6202	0.6201	0.6199
0.56	0.6198	0.6196	0.6194	0.6193	0.6191	0.619	0.6188	0.6187	0.6185	0.6184
0.57	0.6182	0.6181	0.6179	0.6178	0.6176	0.6174	0.6173	0.6171	0.617	0.6168
0.58	0.6167	0.6165	0.6164	0.6162	0.6161	0.6159	0.6157	0.6156	0.6154	0.6153
0.59	0.6151	0.615	0.6148	0.6147	0.6145	0.6143	0.6142	0.614	0.6139	0.6137
0.60	0.6136	0.6134	0.6133	0.6131	0.6129	0.6128	0.6126	0.6125	0.6123	0.6122
0.61	0.612	0.6118	0.6117	0.6115	0.6114	0.6112	0.6111	0.6109	0.6107	0.6106
0.62	0.6104	0.6103	0.6101	0.6099	0.6098	0.6096	0.6095	0.6093	0.6092	0.609
0.63	0.6088	0.6087	0.6085	0.6084	0.6082	0.608	0.6079	0.6077	0.6076	0.6074

Chart for use with the Slope Method (continued)

μ	0	1	2	3	4	5	6	7	8	9
0.64	0.6072	0.6071	0.6069	0.6068	0.6066	0.6064	0.6063	0.6061	0.606	0.6058
0.65	0.6056	0.6055	0.6053	0.6052	0.605	0.6048	0.6047	0.6045	0.6043	0.6042
0.66	0.604	0.6039	0.6037	0.6035	0.6034	0.6032	0.6031	0.6029	0.6027	0.6026
0.67	0.6024	0.6022	0.6021	0.6019	0.6017	0.6016	0.6014	0.6013	0.6011	0.6009
0.68	0.6008	0.6006	0.6004	0.6003	0.6001	0.5999	0.5998	0.5996	0.5994	0.5993
0.69	0.5991	0.599	0.5988	0.5986	0.5985	0.5983	0.5981	0.598	0.5978	0.5976
0.70	0.5975	0.5973	0.5971	0.597	0.5968	0.5966	0.5965	0.5963	0.5961	0.596
0.71	0.5958	0.5956	0.5955	0.5953	0.5951	0.595	0.5948	0.5946	0.5945	0.5943
0.72	0.5941	0.594	0.5938	0.5936	0.5934	0.5933	0.5931	0.5929	0.5928	0.5926
0.73	0.5924	0.5923	0.5921	0.5919	0.5918	0.5916	0.5914	0.5912	0.5911	0.5909
0.74	0.5907	0.5906	0.5904	0.5902	0.5901	0.5899	0.5897	0.5895	0.5894	0.5892
0.75	0.589	0.5889	0.5887	0.5885	0.5883	0.5882	0.588	0.5878	0.5876	0.5875
0.76	0.5873	0.5871	0.587	0.5868	0.5866	0.5864	0.5863	0.5861	0.5859	0.5857
0.77	0.5856	0.5854	0.5852	0.585	0.5849	0.5847	0.5845	0.5843	0.5842	0.584
0.78	0.5838	0.5836	0.5835	0.5833	0.5831	0.5829	0.5828	0.5826	0.5824	0.5822
0.79	0.5821	0.5819	0.5817	0.5815	0.5813	0.5812	0.581	0.5808	0.5806	0.5805
0.80	0.5803	0.5801	0.5799	0.5797	0.5796	0.5794	0.5792	0.579	0.5789	0.5787
0.81	0.5785	0.5783	0.5781	0.578	0.5778	0.5776	0.5774	0.5772	0.5771	0.5769
0.82	0.5767	0.5765	0.5763	0.5762	0.576	0.5758	0.5756	0.5754	0.5752	0.5751
0.83	0.5749	0.5747	0.5745	0.5743	0.5742	0.574	0.5738	0.5736	0.5734	0.5732
0.84	0.5731	0.5729	0.5727	0.5725	0.5723	0.5721	0.572	0.5718	0.5716	0.5714
0.85	0.5712	0.571	0.5708	0.5707	0.5705	0.5703	0.5701	0.5699	0.5697	0.5695
0.86	0.5694	0.5692	0.569	0.5688	0.5686	0.5684	0.5682	0.568	0.5679	0.5677
0.87	0.5675	0.5673	0.5671	0.5669	0.5667	0.5665	0.5664	0.5662	0.566	0.5658
0.88	0.5656	0.5654	0.5652	0.565	0.5648	0.5646	0.5645	0.5643	0.5641	0.5639
0.89	0.5637	0.5635	0.5633	0.5631	0.5629	0.5627	0.5625	0.5624	0.5622	0.562

μ	0	1	2	3	4	5	6	7	8	9
0.90	0.5618	0.5616	0.5614	0.5612	0.561	0.5608	0.5606	0.5604	0.5602	0.56
0.91	0.5598	0.5596	0.5595	0.5593	0.5591	0.5589	0.5587	0.5585	0.5583	0.5581
0.92	0.5579	0.5577	0.5575	0.5573	0.5571	0.5569	0.5567	0.5565	0.5563	0.5561
0.93	0.5559	0.5557	0.5555	0.5553	0.5551	0.5549	0.5547	0.5545	0.5543	0.5541
0.94	0.5539	0.5537	0.5535	0.5533	0.5531	0.5529	0.5527	0.5525	0.5523	0.5521
0.95	0.5519	0.5517	0.5515	0.5513	0.5511	0.5509	0.5507	0.5505	0.5503	0.5501
0.96	0.5499	0.5497	0.5495	0.5493	0.5491	0.5489	0.5487	0.5485	0.5483	0.5481
0.97	0.5479	0.5476	0.5474	0.5472	0.547	0.5468	0.5466	0.5464	0.5462	0.546
0.98	0.5458	0.5456	0.5454	0.5452	0.545	0.5447	0.5445	0.5443	0.5441	0.5439
0.99	0.5437	0.5435	0.5433	0.5431	0.5429	0.5427	0.5424	0.5422	0.542	0.5418
1.00	0.5416	0.5414	0.5412	0.541	0.5408	0.5405	0.5403	0.5401	0.5399	0.5397
1.01	0.5395	0.5393	0.539	0.5388	0.5386	0.5384	0.5382	0.538	0.5378	0.5375
1.02	0.5373	0.5371	0.5369	0.5367	0.5365	0.5362	0.536	0.5358	0.5356	0.5354
1.03	0.5352	0.5349	0.5347	0.5345	0.5343	0.5341	0.5338	0.5336	0.5334	0.5332
1.04	0.533	0.5327	0.5325	0.5323	0.5321	0.5319	0.5316	0.5314	0.5312	0.531
1.05	0.5307	0.5305	0.5303	0.5301	0.5298	0.5296	0.5294	0.5292	0.529	0.5287
1.06	0.5285	0.5283	0.5281	0.5278	0.5276	0.5274	0.5271	0.5269	0.5267	0.5265
1.07	0.5262	0.526	0.5258	0.5256	0.5253	0.5251	0.5249	0.5246	0.5244	0.5242
1.08	0.5239	0.5237	0.5235	0.5233	0.523	0.5228	0.5226	0.5223	0.5221	0.5219
1.09	0.5216	0.5214	0.5212	0.5209	0.5207	0.5205	0.5202	0.52	0.5197	0.5195
1.10	0.5193	0.519	0.5188	0.5186	0.5183	0.5181	0.5179	0.5176	0.5174	0.5171
1.11	0.5169	0.5167	0.5164	0.5162	0.5159	0.5157	0.5155	0.5152	0.515	0.5147
1.12	0.5145	0.5143	0.514	0.5138	0.5135	0.5133	0.513	0.5128	0.5126	0.5123
1.13	0.5121	0.5118	0.5116	0.5113	0.5111	0.5108	0.5106	0.5103	0.5101	0.5099
1.14	0.5096	0.5094	0.5091	0.5089	0.5086	0.5084	0.5081	0.5079	0.5076	0.5074
1.15	0.5071	0.5069	0.5066	0.5064	0.5061	0.5059	0.5056	0.5053	0.5051	0.5048

Chart for use with the Slope Method (continued)

μ	0	1	2	3	4	5	6	7	8	9
1.16	0.5046	0.5043	0.5041	0.5038	0.5036	0.5033	0.5031	0.5028	0.5025	0.5023
1.17	0.502	0.5018	0.5015	0.5013	0.501	0.5007	0.5005	0.5002	0.5	0.4997
1.18	0.4994	0.4992	0.4989	0.4987	0.4984	0.4981	0.4979	0.4976	0.4973	0.4971
1.19	0.4968	0.4965	0.4963	0.496	0.4957	0.4955	0.4952	0.4949	0.4947	0.4944
1.20	0.4941	0.4939	0.4936	0.4933	0.4931	0.4928	0.4925	0.4923	0.492	0.4917
1.21	0.4914	0.4912	0.4909	0.4906	0.4903	0.4901	0.4898	0.4895	0.4892	0.489
1.22	0.4887	0.4884	0.4881	0.4879	0.4876	0.4873	0.487	0.4868	0.4865	0.4862
1.23	0.4859	0.4856	0.4854	0.4851	0.4848	0.4845	0.4842	0.4839	0.4837	0.4834
1.24	0.4831	0.4828	0.4825	0.4822	0.4819	0.4817	0.4814	0.4811	0.4808	0.4805
1.25	0.4802	0.4799	0.4796	0.4794	0.4791	0.4788	0.4785	0.4782	0.4779	0.4776
1.26	0.4773	0.477	0.4767	0.4764	0.4761	0.4758	0.4755	0.4752	0.475	0.4747
1.27	0.4744	0.4741	0.4738	0.4735	0.4732	0.4729	0.4726	0.4723	0.472	0.4717
1.28	0.4714	0.4711	0.4707	0.4704	0.4701	0.4698	0.4695	0.4692	0.4689	0.4686
1.29	0.4683	0.468	0.4677	0.4674	0.4671	0.4668	0.4664	0.4661	0.4658	0.4655
1.30	0.4652	0.4649	0.4646	0.4643	0.4639	0.4636	0.4633	0.463	0.4627	0.4624
1.31	0.462	0.4617	0.4614	0.4611	0.4608	0.4604	0.4601	0.4598	0.4595	0.4592
1.32	0.4588	0.4585	0.4582	0.4579	0.4575	0.4572	0.4569	0.4566	0.4562	0.4559
1.33	0.4556	0.4552	0.4549	0.4546	0.4542	0.4539	0.4536	0.4532	0.4529	0.4526
1.34	0.4522	0.4519	0.4516	0.4512	0.4509	0.4506	0.4502	0.4499	0.4495	0.4492
1.35	0.4489	0.4485	0.4482	0.4478	0.4475	0.4471	0.4468	0.4464	0.4461	0.4458
1.36	0.4454	0.4451	0.4447	0.4444	0.444	0.4437	0.4433	0.443	0.4426	0.4422
1.37	0.4419	0.4415	0.4412	0.4408	0.4405	0.4401	0.4398	0.4394	0.439	0.4387
1.38	0.4383	0.4379	0.4376	0.4372	0.4369	0.4365	0.4361	0.4358	0.4354	0.435
1.39	0.4347	0.4343	0.4339	0.4335	0.4332	0.4328	0.4324	0.4321	0.4317	0.4313
1.40	0.4309	0.4306	0.4302	0.4298	0.4294	0.429	0.4287	0.4283	0.4279	0.4275
1.41	0.4271	0.4267	0.4264	0.426	0.4256	0.4252	0.4248	0.4244	0.424	0.4236

μ	0	1	2	3	4	5	6	7	8	9
1.42	0.4232	0.4228	0.4225	0.4221	0.4217	0.4213	0.4209	0.4205	0.4201	0.4197
1.43	0.4193	0.4189	0.4185	0.4181	0.4177	0.4173	0.4168	0.4164	0.416	0.4156
1.44	0.4152	0.4148	0.4144	0.414	0.4136	0.4131	0.4127	0.4123	0.4119	0.4115
1.45	0.4111	0.4106	0.4102	0.4098	0.4094	0.409	0.4085	0.4081	0.4077	0.4072
1.46	0.4068	0.4064	0.406	0.4055	0.4051	0.4047	0.4042	0.4038	0.4034	0.4029
1.47	0.4025	0.402	0.4016	0.4012	0.4007	0.4003	0.3998	0.3994	0.3989	0.3985
1.48	0.398	0.3976	0.3971	0.3967	0.3962	0.3958	0.3953	0.3949	0.3944	0.3939
1.49	0.3935	0.393	0.3925	0.3921	0.3916	0.3912	0.3907	0.3902	0.3897	0.3893
1.50	0.3888	0.3883	0.3878	0.3874	0.3869	0.3864	0.3859	0.3855	0.385	0.3845
1.51	0.384	0.3835	0.383	0.3825	0.3821	0.3816	0.3811	0.3806	0.3801	0.3796
1.52	0.3791	0.3786	0.3781	0.3776	0.3771	0.3766	0.3761	0.3756	0.3751	0.3745
1.53	0.374	0.3735	0.373	0.3725	0.372	0.3715	0.3709	0.3704	0.3699	0.3694
1.54	0.3688	0.3683	0.3678	0.3673	0.3667	0.3662	0.3657	0.3651	0.3646	0.364
1.55	0.3635	0.363	0.3624	0.3619	0.3613	0.3608	0.3602	0.3597	0.3591	0.3586
1.56	0.358	0.3574	0.3569	0.3563	0.3558	0.3552	0.3546	0.354	0.3535	0.3529
1.57	0.3523	0.3518	0.3512	0.3506	0.35	0.3494	0.3488	0.3483	0.3477	0.3471
1.58	0.3465	0.3459	0.3453	0.3447	0.3441	0.3435	0.3429	0.3423	0.3417	0.3411
1.59	0.3405	0.3399	0.3392	0.3386	0.338	0.3374	0.3368	0.3361	0.3355	0.3349

REPAIR AND WARRANTY

The instrument circuit contains static sensitive devices, and care must be taken in handling the printed circuit board. If the protection of an instrument has been impaired it should not be used, and be sent for repair by suitably trained and qualified personnel. The protection is likely to be impaired if, for example, the instrument shows visible damage, fails to perform the intended measurements, has been subjected to prolonged storage under unfavourable conditions, or has been exposed to severe transport stresses.

New Instruments are Guaranteed for 3 Years from the Date of Purchase by the User.

Note: Any unauthorized prior repair or adjustment will automatically invalidate the Warranty.

Instrument Repair and Spare Parts

For service requirements for ***MEGGER***® Instruments contact

AVO INTERNATIONAL
Archcliffe Road
Dover
Kent CT17 9EN Tel: +44 (0)1304 502243
England Fax: +44 (0)1304
207342

or

AVO INTERNATIONAL
Valley Forge Corporate Center
2621 Van Buren Avenue
Norristown, PA 19403 Tel: +1 (610) 676-8500
U.S.A. Fax: +1 (215) 676-8610

or an approved repair company.

Approved Repair Companies

A number of independent instrument repair companies have been approved for repair work on most ***MEGGER***® instruments, using genuine ***MEGGER***® spare parts. Consult the Appointed Distributor/Agent regarding spare parts, repair facilities and advice on the best course of action to take.

Returning an Instrument for Repair

If returning an instrument to the manufacturer for repair, it should be sent, freight pre-paid, to the appropriate address. A copy of the Invoice and of the packing note should be sent simultaneously by airmail to expedite clearance through Customs. A repair estimate showing freight return and other charges will be submitted to the sender, if required, before work on the instrument commences.

AVO INTERNATIONAL

MeterCenter
825 W. Queen Creek Rd., Suite 2118 - Chandler, AZ 85248 USA
Tel +1 480-659-8351 Toll Free (800) 230-6008
Fax +1 480-659-8361
Email Sales@MeterCenter.com Website http://www.MeterCenter.com

This instrument is manufactured in the United Kingdom.
The company reserves the right to change the specification or design without prior notice.

Part No 6172-132 - Edition 9 - Printed in England - 12HH