Megger

AVTM250302

Megger, Inc.
P.O. Box 9007
Valley Forge, PA 19485-1007
1-800-723-2861

ORDER HOTLINE: 1-800-366-5543
Cable: BIDDLE
Telex:6851045 JGBCO

Instruction Manual
AVTM 250302

Digital Earth Testers *MEGGER DET3/2 & DET5/2*

Catalog Nos. 250302 & 250502

Operating Instructions
Mode d'Emploi
Instrucciones de Uso

Megger

SAFETY WARNING

★ ***The earth spikes, test leads and their terminations must not be touched if an installation earth-fault can arise, unless adequate precautions are taken.***

★ ***When working near high tension systems rubber gloves and shoes should be worn.***

★ ***Special precautions are necessary when "live" earths may be encountered, and isolation switches and fuses are needed in this situation.***

★ ***The terminals of the DET5/2 must be disconnected from any external circuit while its battery cells are being charged. The DET5/2D must be similarly disconnected while its battery cells are changed.***

★ ***Before charging the DET5/2 battery ensure that the correct supply fuse is fitted and the voltage selector is set correctly.***

Refer also to page 14 for further explanations and other precautions.

The warnings and precautions must be read and understood before the instrument is used. They must be observed during use.

NOTE

The instrument is only to be used by a suitably trained and competent person.

CONTENTS

Illustrations

SAFETY WARNING

The earth spikes, test leads and their terminations must not be touched if an installation earth-fault can arise, unless adequate precautions are taken.

When working near high tension systems rubber gloves and shoes should be worn.

Special precautions are necessary when "live" earths may be encountered, and isolation switches and fuses are needed in this situation.

The terminals of the DET5/2 must be disconnected from any external circuit while its battery cells are being charged. The DET5/2D must be similarly disconnected while its battery cells are changed.

Before charging the DET5/2 battery ensure that the correct supply fuse is fitted and the voltage selector is set correctly.

See also to page 14 for further explanations and other precautions.

The warnings and precautions must be read and understood before the instrument is used. They must be observed during use.

NOTE

This instrument is only to be used by a suitably trained and competent person.

CONTENTS

Illustrations

CONTENTS

GENERAL DESCRIPTION

The DET3/2, DET5/2 and DET5/2D MEGGER® Digital Earth Testers are compact instruments designed to measure earth electrode resistance, earth continuity etc. They may also make earth resistance tests which lead to the measurement of soil resistivity. The DET3/2 is powered by a hand cranked generator whereas the DET5/2 has an internal rechargeable battery, with an integral charger unit. The DET5/2D is powered from six internal, replaceable alkaline cells.

TEST METHOD

Each instrument uses 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 DET3/2, DET5/2 and DET5/2D 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.

A simple, latchable, push-button switch provides a three-terminal measurement by internally connecting the 'C1' and 'P1' terminal sockets together.

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 sensiti detection, the resistance is given directly or display.

The test frequency is 135 Hz and in the inte safety the maximum test voltage at the terr limited to 50 V (peak) with respect to earth. circuit current is either 10 mA, 1 mA or 100 depending on the range in use.

INSTRUMENT DESIGN

The instruments are very robust and have to moulded in ABS plastic. Each case is fitted v down carrying handle and four right-angled a are supplied to connect the test leads to the instrument terminals. Test leads are not sup an instrument but form part of an earth testi accessory kit which is available as an additio

All instruments have simple controls. Mount front panel is a rotary range selector and two button switches, one for checking the poten resistance prior to a measurement being ma the other for connecting the 'C1' and 'P1' ter internally for a three-terminal measurement. instrument's 3½ digit liquid crystal display sh test result and also indicates a high current c

TS

GENERAL DESCRIPTION

The DET3/2, DET5/2 and DET5/2D MEGGER® Digital Earth Testers are compact instruments designed to measure earth electrode resistance, earth continuity etc. They may also make earth resistance tests which lead to the measurement of soil resistivity. The DET3/2 is powered by a hand cranked generator whereas the DET5/2 has an internal rechargeable battery, with an integral charger unit. The DET5/2D is powered from six internal, replaceable alkaline cells.

TEST METHOD

Each instrument uses 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 DET3/2, DET5/2 and DET5/2D 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.

A simple, latchable, push-button switch provides a three-terminal measurement by internally connecting the 'C1' and 'P1' terminal sockets together.

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.

The test frequency is 135 Hz and in the interests of safety the maximum test voltage at the terminals is limited to 50 V (peak) with respect to earth. Short circuit current is either 10 mA, 1 mA or 100 μA depending on the range in use.

INSTRUMENT DESIGN

The instruments are very robust and have tough cases moulded in ABS plastic. Each case is fitted with a fold-down carrying handle and four right-angled adaptors are supplied to connect the test leads to the instrument terminals. Test leads are not supplied with an instrument but form part of an earth testing field accessory kit which is available as an additional option.

All instruments have simple controls. Mounted on the front panel is a rotary range selector and two push-button switches, one for checking the potential circuit resistance prior to a measurement being made and the other for connecting the 'C1' and 'P1' terminals internally for a three-terminal measurement. The instrument's 3½ digit liquid crystal display shows the test result and also indicates a high current circuit

GENERAL DESCRIPTION

resistance, a high potential circuit resistance, (both usually caused by a high test spike resistance), a "noisy" environment within the earth making up the test sample, and a low battery voltage in the case of the DET5/2 and DET5/2D, or low generator cranking speed in the case of the DET3/2. As these factors can influence the measurement being made, noise and the current circuit resistance are continuously monitored during a test, while a check of the potential circuit resistance can be made at any time. The display shows all measurements directly in ohms with the decimal point automatically positioned. It also gives an over-range indication to instruct the user to change to a higher range, and a negative sign to show that the current and potential test leads are reversed.

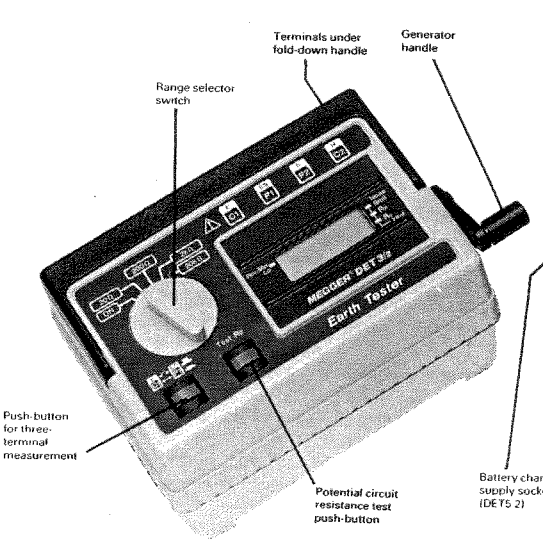
The battery powered testers both have an automatic switch-off after 3 minutes of measurement.

These testers have been designed to comply with the performance specifications of both the BS CP 1013 (1965) specification (from BSI) and the VDE 0413 Part 7 (1982) German specification. For this reason each terminal is marked in a dual way i.e.:—

C1	P1	P2	C2
E	ES	S	H

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.

In terms of safety the instruments meet, in general, the requirements of BS 4743 (1979), IEC 348 (1978) and VDE 0411 (1981).



DET3 2

DET5 2
(DET5 2D is similar)

)ESCRIPTION

potential circuit resistance, (both
a high test spike resistance), a
ent within the earth making up the
low battery voltage in the case of
T5/2D, or low generator cranking
of the DET3/2. As these factors can
urement being made, noise and
esistance are continuously
test, while a check of the potential
an be made at any time. The display
nents directly in ohms with the
natically positioned. It also gives an
n to instruct the user to change to
a negative sign to show that the
f test leads are reversed.

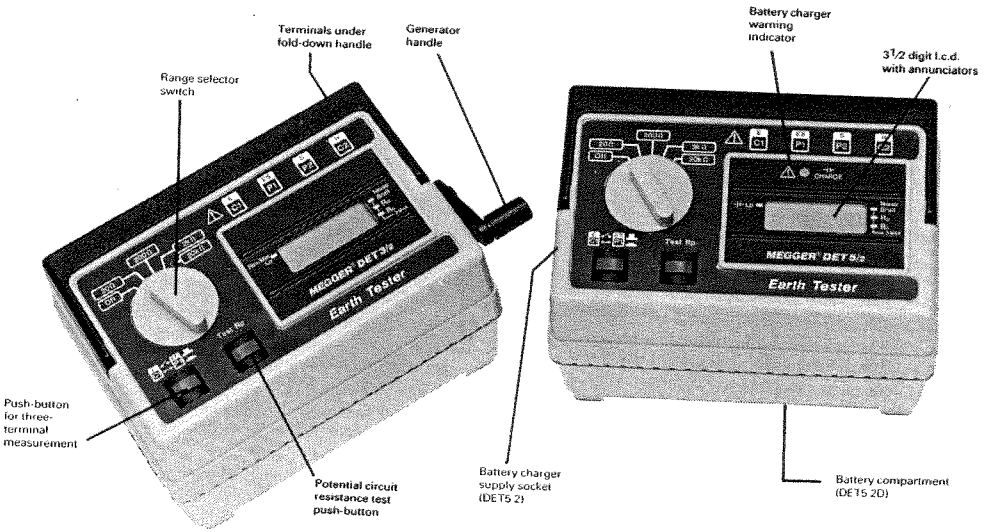
d testers both have an automatic
inutes of measurement.

been designed to comply with the
cations of both the BS CP 1013
(from BSI) and the VDE 0413
n specification. For this reason
ked in a dual way i.e.:—

P1	P2	C2
ES	S	H

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.

In terms of safety the instruments meet, in general, the requirements of BS 4743 (1979), IEC 348 (1978) and VDE 0411 (1981).



DET3 2

DET5 2
(DET5 2D is similar)

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 DET3/2, DET5/2 and DET5/2D 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 or 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 therefore, 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 SYSTEM 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 when there is a need for maintenance of the installation because the required resistance to earth has been exceeded by changing conditions or the ageing of the system.

OTHER APPLICATIONS

For archaeological 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, e.g. 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 10 kΩ for the potential loop can be tolerated on the lowest range, and on the higher ranges greater values can exist.

SPECIFICATION

Earth Resistance Ranges	0,01 Ω to 19,99 Ω 0,1 Ω to 199,9 Ω 1,0 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.
Comply With Standards	BS CP1013 (1965) VDE 0413 Part 7 (1982)
Test Frequency	135 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 consta throughout the range.
Interference	Interference voltages of 20 V ±1,0 V pk to pk potential circuit will have a max. effect of ±1% reading obtained for the 20 Ω to 2 kΩ ranges. For the 20 kΩ range this interference voltage i to 16 V ±1,0 V pk to pk at f.s.d.
Max. Current Spike Resistance	The spike resistance that will introduce an add error is:— 20 Ω range 4 kΩ ±0,5 kΩ 200 Ω range 25 kΩ ±3 kΩ 2 kΩ and 20 kΩ ranges 50 kΩ ±5 kΩ (These are loop resistances, therefore the res under test must be subtracted from these figu

ATIONS

on of satisfactory earthing systems is an
t of electricity supply, wiring safety and
conomics. It is also of great importance in
unications systems.

application of the DET3/2, DET5/2 and
n the testing of earth electrodes, whether
ie form of a single electrode, multiple
nesh systems, earth plates or earth
thing arrangements should be tested
after installation and at periodic intervals

ELECTRODE SITE

electrode or system to perform
it must always have a low total
earth. This value will be influenced by
esistance of the surrounding soil. This in
on the nature of the soil and its moisture
re sinking an electrode or electrode
fore, it is often helpful to survey the
rea before choosing the final position for
It is possible with these instruments to
istivity of the soil over an area and at
s beneath the surface of the ground.
ity surveys may show whether any
o be gained by driving electrodes to a
rather than increasing the cost by
further electrodes and associated
r to obtain a specified total earth system

EARTHING SYSTEM 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 when there is a need for maintenance of the installation because the required resistance to earth has been exceeded by changing conditions or the ageing of the system.

OTHER APPLICATIONS

For archaeological 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, e.g. 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 10 kΩ for the potential loop can be tolerated on the lowest range, and on the higher ranges greater values can exist.

SPECIFICATION

Earth Resistance Ranges

0,01 Ω to 19,99 Ω
0,1 Ω to 199,9 Ω
1,0 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.

Comply With Standards

BS CP1013 (1965)
VDE 0413 Part 7 (1982)

Test Frequency

135 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 the range.

Interference

Interference voltages of 20 V ±1,0 V pk to pk 50 Hz in the potential circuit will have a max. effect of ±1% on the reading obtained for the 20 Ω to 2 kΩ ranges.
For the 20 kΩ range this interference voltage is reduced to 16 V ±1,0 V pk to pk at f.s.d.

Max. Current Spike Resistance

The spike resistance that will introduce an additional 1% error is:—

20 Ω range	4 kΩ ±0,5 kΩ
200 Ω range	25 kΩ ±3 kΩ
2 kΩ and 20 kΩ ranges	50 kΩ ±5 kΩ

(These are loop resistances, therefore the resistance under test must be subtracted from these figures).

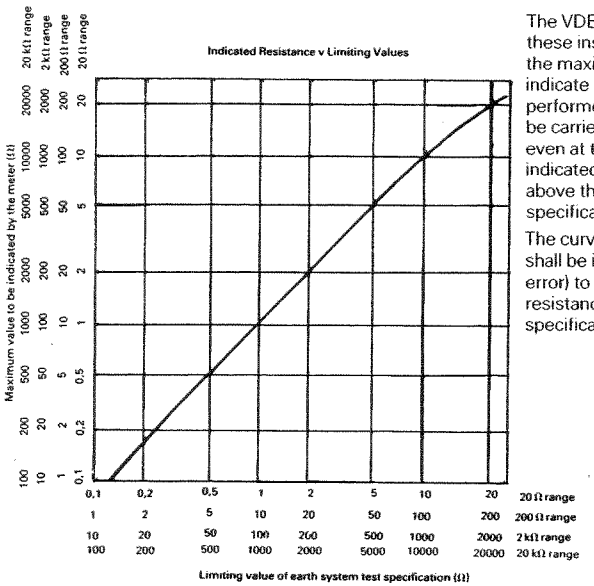
SPECIFICATION

Max. Potential Spike Resistance		The spike resistance that will introduce an additional 1% error is:— 20 Ω range 10 kΩ ±1 kΩ 200 Ω range 25 kΩ ±3 kΩ 2 kΩ and 20 kΩ ranges 100 kΩ ±10 kΩ (These are loop resistances, therefore the resistance under test must be subtracted from these figures).
Max. Output Voltage		50 V
Display		3½ digit l.c.d. maximum reading 1999
Temperature Effect		< ±0,02%/°C over the temperature range −15 °C to +55 °C
Temperature Range	operating	−15 °C to +55 °C (0 °C to +55 °C for the DET5/2D)
	storage	−40 °C to +70 °C (for the DET5/2D, without batteries)
Humidity	operating	95% RH max. at 40 °C
	storage	93% RH max. at 55 °C
Flash Test Voltage Withstand		3 kV a.c. In the event of a system fault the instrument will withstand 240 V a.c. applied between any two terminals.
Fuses	DET3/2, DET5/2 and DET5/2D	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) Internal 100 mA ceramic HBC 20 mm x 5 mm IEC127/1 (for 3/4 terminal switch circuit protection)
	DET5/2 only	50 mA ceramic HBC 20 mm x 5 mm IEC 127/1 240 V a.c. supply, 100 mA ceramic HBC 20 mm IEC 127/1 for 120 V a.c. supply (for circuit prote during battery charging). Internal 1 A ceramic HBC 20 mm x 5 mm IEC 1 (for battery protection)
Power Supply	DET3/2	Internal hand-cranked a.c. generator (Minimur speed 120 r.p.m.)
	DET5/2	Internal rechargeable sealed lead acid cells 12 capacity. Battery voltage range over which bas is maintained, 10,0 V to 13,5 V. Battery life, 80 x (4 hours' continuous use). Battery charging time, 10 hours max. (from co exhausted). Charging supply required, 200 V t or 100 V to 130 V a.c. 50 Hz/60 Hz.
	DET5/2D	6 x 1,5 V alkaline battery cells IEC LR6 type. Ba voltage range over which basic accuracy is ma 6 V to 10 V. Battery life 50 x 3 min tests (2½ ho continuous use); at 0 °C, 15 x 3 min tests (45 m continuous use).
Safety		The instruments will, in general, meet the requ of BS 4743, IEC 348 and VDE 0411 specificatio
	DET3/2 and DET5/2D	Safety Class III
	DET5/2	Safety Class III while operating, Safety Class II battery charging.
Dimensions	DET3/2	210 mm x 128 mm x 125 mm (8¼ in x 5 in x 5 ir
	DET5/2 and DET5/2D	180 mm x 128 mm x 125 mm (7 in x 5 in x 5 in a
Weight	DET3/2	1 kg (2¼ lb approx.)
	DET5/2	1,4 kg (3 lb approx.)
	DET5/2D	0,82 kg (1¾ lb approx.)

ITION

l Spike Resistance		The spike resistance that will introduce an additional 1% error is:— 20 Ω range 10 kΩ ±1 kΩ 200 Ω range 25 kΩ ±3 kΩ 2 kΩ and 20 kΩ ranges 100 kΩ ±10 kΩ (These are loop resistances, therefore the resistance under test must be subtracted from these figures).
'oltage		50 V
		3½ digit l.c.d. maximum reading 1999
:ffect		
Range		< ±0,02%/°C over the temperature range −15 °C to +55 °C
	operating	−15 °C to +55 °C (0 °C to +55 °C for the DET5/2D)
	storage	−40 °C to +70 °C (for the DET5/2D, without batteries)
	operating	95% RH max. at 40 °C
	storage	93% RH max. at 55 °C
		3 kV a.c.
tand		In the event of a system fault the instrument will withstand 240 V a.c. applied between any two terminals.
	DET3/2, DET5/2 and DET5/2D	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) Internal 100 mA ceramic HBC 20 mm x 5 mm IEC127/1 (for 3/4 terminal switch circuit protection)
	DET5/2 only	50 mA ceramic HBC 20 mm x 5 mm IEC 127/1 for 240 V a.c. supply, 100 mA ceramic HBC 20 mm x 5 mm IEC 127/1 for 120 V a.c. supply (for circuit protection during battery charging). Internal 1 A ceramic HBC 20 mm x 5 mm IEC 127/1 (for battery protection)
Power Supply	DET3/2	Internal hand-cranked a.c. generator (Minimum cranking speed 120 r.p.m.)
	DET5/2	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, 80 x 3 min tests (4 hours' continuous use). Battery charging time, 10 hours max. (from completely exhausted). Charging supply required, 200 V to 255 V a.c. or 100 V to 130 V a.c. 50 Hz/60 Hz.
	DET5/2D	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 50 x 3 min tests (2½ hours continuous use); at 0 °C, 15 x 3 min tests (45 minutes continuous use).
Safety		The instruments will, in general, meet the requirements of BS 4743, IEC 348 and VDE 0411 specifications.
	DET3/2 and DET5/2D	Safety Class III
	DET5/2	Safety Class III while operating, Safety Class II while battery charging.
Dimensions	DET3/2	210 mm x 128 mm x 125 mm (8¼ in x 5 in x 5 in approx.)
	DET5/2 and DET5/2D	180 mm x 128 mm x 125 mm (7 in x 5 in x 5 in approx.)
Weight	DET3/2	1 kg (2¼ lb approx.)
	DET5/2	1,4 kg (3 lb approx.)
	DET5/2D	0,82 kg (1¾ lb approx.)

SPECIFICATION



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 indicated should be such that the actual value 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 WITH THE INSTRUMENT

Four right-angled terminal adaptors
  Two Black (P/N EV 6320-206)
  Two Red (P/N EV 6320-207)

Line Cord (DET5/2 only P/N 17032)

Operating Manual AVTM 250302

"Getting Down to Earth" Manual (AVTM25-TA)

OPTIONS

Lead Kit (Catalog No. 250583)

Includes set of three color-coded test leads, pair of 20 inch ground rods and padded case to hol instrument, leads and rods.

OPERATION

WARNINGS

1. As a precaution when working near high tension systems where accidental high potentials on the structure and in the ground are possible, it is recommended that the operator wears rubber gloves (to BS 697: 1986) and stands on a rubber mat or wears rubber shoes. (See para. 3 below).
2. It is preferable that the earth system to be tested is first isolated from the circuit it is protecting. This is not always possible and so the precaution below is most important.
3. **Safety precautions for all live earths**
   Safety precautions are necessary when any live earths may be encountered e.g. when testing the earth of a "live" substation. If a fault occurs at the substation while a test is being conducted, dangerous voltages may exist between the site earth and remote earths established for test purposes. Therefore:—
   a) The instrument must be used within the perimeter fence of the substation where the test is being conducted, and/or in an area where the voltage difference from the earth under test does not exceed 50 V in any circumstances. If this is not possible then rubber gloves and mats must be used.
   b) The P1 and C1 (or ES and E) terminals must be connected to the earth electrode being tested.
   c) The P2 and C2 (or S and H) terminals must be connected to an isolation switch, whose rating will cope with the maximum fault voltages (refer to Fig. 3).
   d) With the isolation switch open, connections to the remote test spikes (electrodes) may be established. Make the connections to the isolation switch first and then connect the remote test spikes (electrodes).
   e) When the remote test spikes have been established the isolation switch may be closed and a test made.
   f) Whilst the test is in progress care must be taken that no one comes into contact with the remote electrodes or the leads running to the P2 and C2 (or S and H) terminals via the isolation switch.
   g) 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 positions.
   h) If a fault occurs while a test is being made the instrument may be damaged. Incorporating fuses at the isolation switch, of rating 100 mA and able to cope with the maximum fault voltage, will provide some protection for the instrument (see Fig. 3).

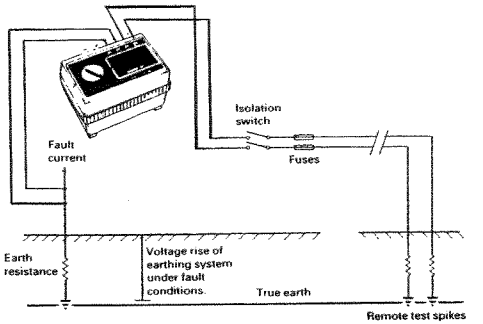


Fig. 3 A method of connection where fault conditions may occur

4. **When charging the DET5/2 battery:—**
   a) Ensure that the instrument is disconn completely from any external circuit
   b) Make sure before switching the supp the correct setting of the voltage sele been made and also that the correctly fuse for that supply has been fitted (s Specification page 9).
   c) The socket to which the instrument is connected for battery charging shoul on/off switch.
5. Repairs to these instruments must only b out by suitably trained and qualified perso
6. If an instrument's protection has been im should not be used and must be sent for r protection is likely to be impaired if, for ex it shows visible damage, it fails to perfor intended measurements, it has been sub prolonged storage under unfavourable co or it has been subjected to severe transpo

PRECAUTIONS

1. The instrument circuit contains static sen devices. If the instrument casing is open reason, care must be exercised in handlin printed circuit board. This should be done accordance with DEF STAN 59-98 and BS specifications for handling electrostatic s devices.

TION

caution when working near high tension where accidental high potentials on the and in the ground are possible, it is ended that the operator wears rubber) BS 697: 1986) and stands on a rubber mat rubber shoes. (See para. 3 below).
rable that the earth system to be tested lated from the circuit it is protecting. This ays possible and so the precaution below portant.

ecautions for all live earths

ecautions are necessary when any live y be encountered e.g. when testing the "live" substation. If a fault occurs at the while a test is being conducted, s voltages may exist between the site emote earths established for test Therefore:—

strument must be used within the eter fence of the substation where the being conducted, and/or in an area where tage difference from the earth under test ot exceed 50 V in any circumstances. If not possible then rubber gloves and mats e used.

and C1 (or ES and E) terminals must be cted to the earth electrode being tested.

c) The P2 and C2 (or S and H) terminals must be connected to an isolation switch, whose rating will cope with the maximum fault voltages (refer to Fig. 3).

d) With the isolation switch open, connections to the remote test spikes (electrodes) may be established. Make the connections to the isolation switch first and then connect the remote test spikes (electrodes).

e) When the remote test spikes have been established the isolation switch may be closed and a test made.

f) Whilst the test is in progress care must be taken that no one comes into contact with the remote electrodes or the leads running to the P2 and C2 (or S and H) terminals via the isolation switch.

g) 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 positions.

h) If a fault occurs while a test is being made the instrument may be damaged. Incorporating fuses at the isolation switch, of rating 100 mA and able to cope with the maximum fault voltage, will provide some protection for the instrument (see Fig. 3).

OPERATION

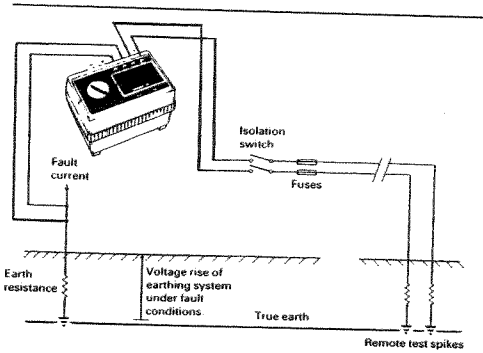


Fig. 3 A method of connection where fault conditions may occur

4. **When charging the DET5/2 battery:—**
   a) Ensure that the instrument is disconnected completely from any external circuit.
   b) Make sure before switching the supply on, that the correct setting of the voltage selector has been made and also that the correctly rated fuse for that supply has been fitted (see the Specification page 9).
   c) The socket to which the instrument is connected for battery charging should have an on/off switch.
5. Repairs to these instruments must only be carried out by suitably trained and qualified personnel.
6. If an instrument's protection has been impaired it should not be used and must be sent for repair. The protection is likely to be impaired if, for example, it shows visible damage, it fails to perform the intended measurements, it has been subjected to prolonged storage under unfavourable conditions, or it has been subjected to severe transport stresses.

PRECAUTIONS

1. The instrument circuit contains static sensitive devices. If the instrument casing is opened for any reason, care must be exercised in handling the printed circuit board. This should be done in accordance with DEF STAN 59-98 and BS 5783, specifications for handling electrostatic sensitive devices.

Note:— Opening the casing will automatically invalidate any warranty covering the instrument unless carried out by an approved repair organisation (see page 55).

2. It is advisable that, when working with the DET5/2 instrument, the battery is fully charged before embarking upon a test sequence. It can be extremely inconvenient if the battery voltage becomes too low while a field test is in progress. Similarly, with the DET5/2D new batteries should always be available.

DISPLAY SYMBOLS

The 3½ digit l.c.d. shows the reading directly and the operator can simply refer to the range switch position for the units of measurement. The instrument's display symbols can also help the operator make certain that the reading is valid. The meaning of each display symbol is given in the following paragraphs.

Low Generator Cranking Speed (DET3/2)

If the generator handle on the DET3/2 is turned too slowly such that there is insufficient output for a test to be performed properly, an arrow '←' appears on the left of the display pointing at the 'Rev/Min Lo' mark on the graphics panel. Any reading on the display should be ignored and the generator turned faster until the arrow disappears before a measured value is accepted.

Low Battery Voltage (DET5/2 and DET5/2D)

Similary on the DET5/2 and DET5/2D, if the battery voltage is too low the arrow on the left of the display will appear pointing at the ' ⊣⊢ Lo' mark on the graphics panel. In this case the batteries hold only enough power for possibly one or two more measurements and must be recharged (DET5/2) or replaced (DET5/2D) before further tests are undertaken.

DET3/2

DET5/2 & DET5/2D

Fig. 4 Low cranking speed and low battery voltage indications.

Reverse Polarity

When the potential test leads are reversed with respect to the current test leads, the reading on the display is preceded by a negative sign. The reading is still valid, but the potential connections should be reversed to remove the negative sign. For a positive measurement the 'C1' and 'P1' (or 'E' and 'ES') connections should go to the electrode being tested, i.e. to one end of the resistance, and the 'C2' and 'P2' (or 'S' and 'H') connections should go to the test spikes, i.e. the other end of the resistance.

Fig. 5 Reverse polarity symbol

High Current Spike Resistance

To indicate that the resistance of the current circuit is too high, a display segment illuminates opposite the 'Rc' mark on the graphics panel. This happens automatically while the tester is switched on, even during a test. Its appearance may be caused by an open circuit or a poor connection in the test lead to the current spike, or, more likely, high resistance in the ground in the vicinity of the current spike and poor contact with that spike. Whatever the cause of the symbol's appearance it must be removed before a test can be regarded as valid. Moistening the ground around the current spike, re-siting the spike position or using more than one spike may problem.

Fig. 6 High current spike resistance sy

High Potential Spike Resistance

To indicate that the resistance of the potent too high a display segment illuminates oppo 'Rp' mark on the graphics panel. This does automatically but should be a preliminary te out by the operator pressing the push-butto 'Test Rp'. The reasons for its appearance m same as for the high current spike resistanc and, as in that case, the problem must be re before a test can be regarded as valid. Agair solution may be moistening the ground or re potential test spike.

Note:— Operating the 'Test Rp' button will display to go blank except for the d point and high potential spike resis symbol (when relevant).

ON

pening the casing will automatically validate any warranty covering the strument unless carried out by an proved repair organisation (see page 55). ole that, when working with the DET5/2 , the battery is fully charged before upon a test sequence. It can be inconvenient if the battery voltage oo low while a field test is in progress. vith the DET5/2D new batteries should ivailable.

IBOLS

c.d. shows the reading directly and the mply refer to the range switch position measurement. The instrument's s can also help the operator make reading is valid. The meaning of each is given in the following paragraphs.

r Cranking Speed (DET3/2)

handle on the DET3/2 is turned too it there is insufficient output for a test d properly, an arrow '←' appears on the ay pointing at the 'Rev/Min Lo' mark on nel. Any reading on the display should the generator turned faster until the rs before a measured value is

Low Battery Voltage (DET5/2 and DET5/2D)

Similary on the DET5/2 and DET5/2D, if the battery voltage is too low the arrow on the left of the display will appear pointing at the ' ⊣⊢ Lo' mark on the graphics panel. In this case the batteries hold only enough power for possibly one or two more measurements and must be recharged (DET5/2) or replaced (DET5/2D) before further tests are undertaken.

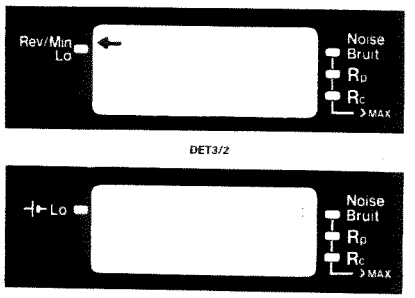


Fig. 4 Low cranking speed and low battery voltage indications.

Reverse Polarity

When the potential test leads are reversed with respect to the current test leads, the reading on the display is preceded by a negative sign. The reading is still valid, but the potential connections should be reversed to remove the negative sign. For a positive measurement the 'C1' and 'P1' (or 'E' and 'ES') connections should go to the electrode being tested, i.e. to one end of the resistance, and the 'C2' and 'P2' (or 'S' and 'H') connections should go to the test spikes, i.e. the other end of the resistance.

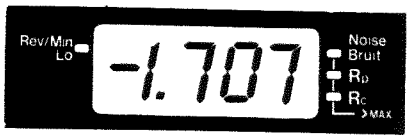


Fig. 5 Reverse polarity symbol

High Current Spike Resistance

To indicate that the resistance of the current circuit is too high, a display segment illuminates opposite the 'Rc' mark on the graphics panel. This happens automatically while the tester is switched on, even during a test. Its appearance may be caused by an open circuit or a poor connection in the test lead to the current spike, or, more likely, high resistance in the ground in the vicinity of the current spike and poor contact with that spike. Whatever the cause of the symbol's appearance it must be removed before a test can be regarded as valid. Moistening the ground around the current spike, re-siting the spike in a new position or using more than one spike may solve the problem.

Fig. 6 High current spike resistance symbol.

High Potential Spike Resistance

To indicate that the resistance of the potential circuit is too high a display segment illuminates opposite the 'Rp' mark on the graphics panel. This does not happen automatically but should be a preliminary test carried out by the operator pressing the push-button marked 'Test Rp'. The reasons for its appearance may be the same as for the high current spike resistance symbol, and, as in that case, the problem must be removed before a test can be regarded as valid. Again the solution may be moistening the ground or re-siting the potential test spike.

Note:— Operating the 'Test Rp' button will cause the display to go blank except for the decimal point and high potential spike resistance symbol (when relevant).

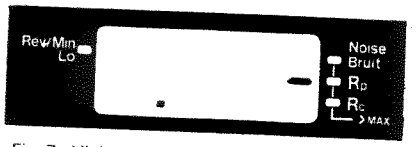


Fig. 7 High potential spike resistance symbol.

Excessive Noise Interference

A display segment will automatically appear opposite the 'Noise' mark on the graphics panel when the interference voltage in the earth being measured is beyond the level which can be rejected by the tester. A valid measurement cannot be made in this condition. The solution may be to wait until the interference has subsided if it is transient in nature or, to choose a different position for the test spikes.

Fig. 8 Excessive noise interference symbol.

Note:— This symbol may also appear with the over-range indication if the resistance being measured is very much greater than the range selected.

Over-range

To indicate that the resistance being measured is above the range selected, the over-range symbol appears. This is a '1' as the left hand digit with the remainder of the display blank except for the decimal point. When this symbol appears switch to a higher range. If it appears on the '20 kΩ' range there is something seriously wrong with the earth electrode under test, (make sure in this case that the high current spike indicator is not showing — see page 17).

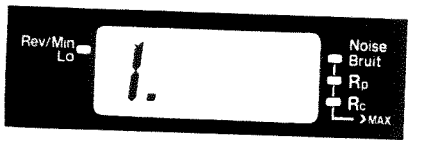


Fig. 9 Over-range symbol.

SETTING-UP THE TEST SPIKES ETC.

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

Test spikes and long test leads are necessary for all types of earth testing and the Earth Testing Field Accessory Kit, ET/KIT, (available as an option) contains the basic equipment.

Recommended test spikes are 13 mm square, or diameter 460 mm long and made of mild steel. These can be driven to a depth of 300 mm with rapid blows from a 1 kg hammer. The size of the cable suitable for use as test leads is not critical but, it should be reasonably flexible and MUST be insulated. At least 100 m length will be needed and a cable size of about 104/0,1 mm is suitable.

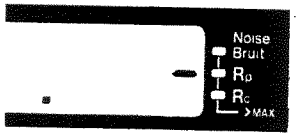
When connections are made to the instrument the right angled adaptors should be used. These are supplied with the instrument and they have screw terminals to take hook or spade connectors, bare wires, or 4 mm plugs.

BASIC TEST PROCEDURE

Four Terminal Measurement

After the test spikes have been set-up an to the instrument for the type of test to b (refer to 'Measuring Techniques'), proce follows:—

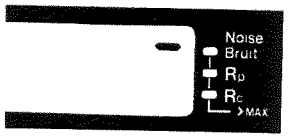
1. Select the measuring range required. C lowest range if it is uncertain which is c may produce the over-range symbol w instrument is operated, if so switch to t range.
2. Turn the generator handle at 120 r.p.m. for the DET3/2.
   Note:— The DET5/2 and DET5/2D ener test circuit as soon as the range
3. Check that the display shows no advers conditions, i.e. that the high current circu and excessive noise symbols are not sh check that the low battery voltage symb and DET5/2D) or low cranking speed sy (DET3/2) is not illuminated.
4. Press the 'Test Rp' push-button to chec potential spike resistance. The high pot circuit resistance symbol should not ap Release the push-button.
5. If all the conditions for a test are satisfac reading given on the display may be acc earth resistance. If any of the display sy (except reverse polarity), illuminate, the



ɔotential spike resistance symbol.

Interference

t will automatically appear opposite
ɔn the graphics panel when the
ge in the earth being measured is
vhich can be rejected by the tester.
ient cannot be made in this
ution may be to wait until the
ubsided if it is transient in nature or,
ent position for the test spikes.



ɔoise interference symbol.

ɔol may also appear with the over-
cation if the resistance being measured is very much greater than the range selected.

Over-range

To indicate that the resistance being measured is above the range selected, the over-range symbol appears. This is a '1' as the left hand digit with the remainder of the display blank except for the decimal point. When this symbol appears switch to a higher range. If it appears on the '20 kΩ' range there is something seriously wrong with the earth electrode under test, (make sure in this case that the high current spike indicator is not showing — see page 17).

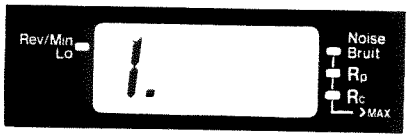


Fig. 9 Over-range symbol.

SETTING-UP THE TEST SPIKES ETC.

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

Test spikes and long test leads are necessary for all types of earth testing and the Earth Testing Field Accessory Kit, ET/KIT, (available as an option) contains the basic equipment.

Recommended test spikes are 13 mm square, or diameter 460 mm long and made of mild steel. These can be driven to a depth of 300 mm with rapid blows from a 1 kg hammer. The size of the cable suitable for use as test leads is not critical but, it should be reasonably flexible and MUST be insulated. At least 100 m length will be needed and a cable size of about 104/0,1 mm is suitable.

When connections are made to the instrument the right angled adaptors should be used. These are supplied with the instrument and they have screw terminals to take hook or spade connectors, bare wires, or 4 mm plugs.

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. Select the measuring range required. Choose the lowest range if it is uncertain which is correct; this may produce the over-range symbol when the instrument is operated, if so switch to the next range.
2. Turn the generator handle at 120 r.p.m. (minimum) for the DET3/2.
   Note:— The DET5/2 and DET5/2D energize the test circuit as soon as the range is selected.
3. Check that the display shows no adverse test conditions, i.e. that the high current circuit resistance and excessive noise symbols are not showing. Also check that the low battery voltage symbol (DET5/2 and DET5/2D) or low cranking speed symbol (DET3/2) is not illuminated.
4. Press the 'Test Rp' push-button to check the potential spike resistance. The high potential circuit resistance symbol should not appear. Release the push-button.
5. If all the conditions for a test are satisfactory the reading given on the display may be accepted as the earth resistance. If any of the display symbols, (except reverse polarity), illuminate, the cause of

the adverse condition must be removed before the reading can be accepted.

Three Terminal Measurement

The basic test procedure is the same as for the Four Terminal Measurement except that the latchable push-button marked 'C1 - P1' ('E - ES') should be pressed and left in its down position. Only one connection is then required from the 'C1' ('E') terminal to the electrode under test. For greatest accuracy this connection should be made with a short lead.

BATTERY CHARGING (DET5/2)

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 switched on, it may be that the battery has become completely exhausted. In this case charge the battery fully before performing any tests.

Note:— It is unwise to allow the battery to become completely exhausted for fear of causing it damage.

Before connecting to the mains supply ensure that the correctly rated fuse is fitted and that the voltage adjuster is set to the right value for the supply to be used. For a 240 V a.c. supply the fuse should be 50 mA and for a 120 V a.c. supply the fuse should be 100 mA. (Type and size of the fuses are given in the Specification). The mains supply fuse is located in the holder which is part of the recessed input plug on the side of the case. Simply slide the holder out to reveal two fuses, the inner one is the working fuse, the outer one is a spare fuse. The voltage adjuster is located on the bottom of the casing. Use a screwdriver to turn the appropriate voltage mark to the indicating arrow.

When the fuse and voltage selector are correctly set, plug the mains supply lead into a suitable socket outlet and switch on. An l.e.d. light on the front panel marked '⊣■— CHARGE' will illuminate to show that the instrument is connected to a mains supply. Leave the battery to charge for 10 hours approximately.

Caution:— Do not leave the test leads connected to the terminals while the instrument is being supplied with mains power.

FITTING OR REPLACING BATTERY CELLS (DET5/2D)

Caution:— Use only battery cells of the correct type (see the Specification). Whenever the battery cells are being fitted or replaced there should be no connections to the instrument terminals.

Unscrew the cover from the battery compartment in the bottom of the case. Remove the old cells and fit each new cell the correct way round, as indicated in the battery compartment moulding. Replace the cover and tighten the securing screws fully.

Do not leave battery cells fitted in the compartment if the instrument will remain unused for a long time, to avoid damage by leaking electrolyte.

AUTOMATIC SWITCH-OFF (DET5/2 and DET5/2D)

To conserve battery power there is an automatic switch-off for these instruments which takes effect after 3 minutes of a test. To switch the instruments on again turn the range switch to the off position and then back to the range required.

This function is not intended as a replacement for the range switch 'Off' position (since it selects a low power mode). Whenever practicable the instrument should be switched off by setting the range switch to the 'Off' position; this will maximise battery life.

REPLACING THE CURRENT SOURCE F FUSE

In addition to the DET5/2 mains supply fu DET3/2, DET5/2 and DET5/2D are fitted v protect the output current source from in overloads, i.e. voltages applied to the C1 terminals.

This fuse is rated at 100 mA and is locate in the base of the instrument case. To cha fuse use a screwdriver to unscrew the ca fuseholder; the fuse is clipped into this ca fuse and replace the cap.

Caution:— Any replacement fuse must be correct type and rating, (see th Specification).

ON

e condition must be removed before the
ı be accepted.

al Measurement

procedure is the same as for the Four
urement except that the latchable
arked 'C1 - P1' ('E - ES') should be
ft in its down position. Only one
ıen required from the 'C1' ('E') terminal
e under test. For greatest accuracy this
uld be made with a short lead.

ıRGING (DET5/2)

uld be charged as soon as the low
r appears on the display. If the display
vhen the instrument is switched on, it
battery has become completely
ıis case charge the battery fully before
tests.

vise to allow the battery to become
tely exhausted for fear of causing it
ɜ.

ng to the mains supply ensure that the
ɹse is fitted and that the voltage
the right value for the supply to be
√ a.c. supply the fuse should be
120 V a.c. supply the fuse should be
100 mA. (Type and size of the fuses are given in the Specification). The mains supply fuse is located in the holder which is part of the recessed input plug on the side of the case. Simply slide the holder out to reveal two fuses, the inner one is the working fuse; the outer one is a spare fuse. The voltage adjuster is located on the bottom of the casing. Use a screwdriver to turn the appropriate voltage mark to the indicating arrow.

When the fuse and voltage selector are correctly set, plug the mains supply lead into a suitable socket outlet and switch on. An l.e.d. light on the front panel marked '⊣■— CHARGE' will illuminate to show that the instrument is connected to a mains supply. Leave the battery to charge for 10 hours approximately.

Caution:— Do not leave the test leads connected to the terminals while the instrument is being supplied with mains power.

FITTING OR REPLACING BATTERY CELLS (DET5/2D)

Caution:— Use only battery cells of the correct type (see the Specification). Whenever the battery cells are being fitted or replaced there should be no connections to the instrument terminals.

Unscrew the cover from the battery compartment in the bottom of the case. Remove the old cells and fit each new cell the correct way round, as indicated in the battery compartment moulding. Replace the cover and tighten the securing screws fully.

Do not leave battery cells fitted in the compartment if the instrument will remain unused for a long time, to avoid damage by leaking electrolyte.

AUTOMATIC SWITCH-OFF (DET5/2 and DET5/2D)

To conserve battery power there is an automatic switch-off for these instruments which takes effect after 3 minutes of a test. To switch the instruments on again turn the range switch to the off position and then back to the range required.

This function is not intended as a replacement for the range switch 'Off' position (since it selects a low power mode). Whenever practicable the instrument should be switched off by setting the range switch to the 'Off' position; this will maximise battery life.

REPLACING THE CURRENT SOURCE PROTECTING FUSE

In addition to the DET5/2 mains supply fuse, both the DET3/2, DET5/2 and DET5/2D are fitted with a fuse to protect the output current source from input overloads, i.e. voltages applied to the C1 and C2 terminals.

This fuse is rated at 100 mA and is located in a holder in the base of the instrument case. To change this fuse use a screwdriver to unscrew the cap of the fuseholder; the fuse is clipped into this cap. Fit a new fuse and replace the cap.

Caution:— Any replacement fuse must be of the correct type and rating, (see the Specification).

MODE D'EMPLOI

AVERTISSEMENTS

1. Lors de travaux à proximité de structures haute tension où il est possible de rencontrer des potentiels dangereux sur les appareillages ou dans le sol, il est conseillé que l'opérateur travaille avec des gants en caoutchouc et se tienne sur un tapis en caoutchouc (voir paragraphe 3 ci-dessous).
2. Il est préférable que la terre à mesurer soit isolée du circuit qu'elle protège. Ceci n'étant pas toujours possible, prendre les précautions indiquées ci-après.
3. **Précautions vis-à-vis des terres en service.** Il est nécessaire de prendre certaines précautions lors de mesures de terres en service, par exemple pour la terre d'une sous-station en fonctionnement. Si un défaut se produit dans la sous-station pendant un essai, des tensions dangereuses peuvent apparaitre entre la terre du site et les terres auxiliaires établies pour les essais. Aussi:
   a) L'appareil doit être utilisé dans le périmètre de protection de la sous-station où l'essai est réalisé et/ou dans une zone où la différence de potentiel de la terre à mesurer n'excède pas 50 V. Si ce n'est pas possible utiliser des gants et des tapis en caoutchouc.
   b) Les bornes P1 et C1 sont reliées à la terre à mesurer.
   c) Les bornes P2 et C2 sont reliées à un sectionneur d'un calibre suffisant pour supporter les tensions maximales de défaut (voir fig. 3).
   d) Le sectionneur étant ouvert, on peut établir les liaisons aux piquets auxiliaires. Faire en premier la liaison au sectionneur et ensuite aux piquets.
   e) On peut alors fermer le sectionneur et effectuer un essai.
   f) Pendant l'essai, s'assurer que personne ne touche aux piquets ou aux fils de liaison.
   g) Le sectionneur doit être ouvert avant de toucher aux piquets auxiliaires, par exemple pour les déplacer.
   h) Si un défaut se produit pendant un essai, l'appareil peut être endommagé. Aussi, il est conseillé de placer des fusibles 100 mA sur le sectionneur (d'un calibre en tension compatible avec les tensions maximales de défaut pour garantir une certaine protection de l'instrument.
4. **Lors de la charge des batteries du DET5/2:—**
   a) S'assurer que l'appareil est totalement débranché de tout circuit externe.
   b) Avant de procéder à la mise sous tension, s'assurer que le sélecteur de tension est sur la bonne gamme et que l'on a placé un fusible de calibre correct (voir les spécifications page 9).
   c) La prise à laquelle est raccordé l'appareil doit être équipée d'un interrupteur marche/arrêt.
5. Les réparations sur ces appareils ne doivent être entreprises que par des services habilités par le fournisseur.
6. Si un appareil est endommagé, il faut l'envoyer en réparation. On considère qu'un appareil est endommagé si un défaut visible est constaté, s'il n'effectue pas correctement les mesures, s'il a été stocké de façon prolongée dans des conditions défavorables ou s'il a subi des chocs importants pendant un transport.

PRECAUTIONS

1. Le circuit de l'appareil contient des éléments sensibles à l'électricité statique. Si l'instrument doit être ouvert, il faut prendre les précautions nécessaires pour la manipulation du circuit conformément aux normes DEF STAN 59-98 et BS 5783.

   Nota:— L'ouverture du boitier, si elle n'est pas réalisée par un service habilité, annule automatiquement la garantie couvrant l'appareil.
2. Il est recommandé, pour le DET5/2, de bien charger les batteries avant de partir pour une série d'essais. De même, pour le DET5/2D un jeu de piles neuves doit toujours être disponible.

SYMBOLES DE L'AFFICHAGE

L'affichage à cristaux liquides fournit directer
lecture, et l'opérateur se rapporte simplemer
position du commutateur de gamme pour les
de mesure. Les symbôles de l'affichage perm
l'opérateur de s'assurer que la lecture est cor
signification des différents symbôles est expl
après:

Vitesse de rotation de la génératrice trop f (DET3/2)

Si la manivelle de la génératrice de DET3/2 es
trop lentement, la tensiòn de sortie étant alor
faible pour réaliser une mesure correcte, un s
apparait sur l'affichage en face de la marque '
Lo'. Il faut alors augmenter la vitesse de rotat
jusqu'à ce que ce segment disparaisse.

Indication tension batterie faible (DET5/2 DET5/2D)

Sur le DET5/2 et DET5/2D, si la tension de ba
trop faible, un segment apparait sur l'affichag
du symbôle '⊣⊢ mini'. Dans ce cas, les ba
ne permettra plus qu'une ou deux mesures e
être rechargée (DET5/2) ou remettent (DET5/
d'effectuer d'autres essais.

'EMPLOI

MENTS

avaux à proximité de structures haute
il est possible de rencontrer des
dangereux sur les appareillages ou dans
t conseillé que l'opérateur travaille avec
en caoutchouc et se tienne sur un tapis
houc (voir paragraphe 3 ci-dessous).
érable que la terre à mesurer soit isolée
qu'elle protège. Ceci n'étant pas toujours
prendre les précautions indiquées

ns vis-à-vis des terres en service.
ssaire de prendre certaines précautions
sures de terres en service, par exemple
re d'une sous-station en fonctionnement.
ut se produit dans la sous-station pendant
les tensions dangereuses peuvent
entre la terre du site et les terres
établies pour les essais. Aussi:
areil doit être utilisé dans le périmètre
tection de la sous-station où l'essai est
et/ou dans une zone où la différence de
tiel de la terre à mesurer n'excède pas
si ce n'est pas possible utiliser des gants
tapis en caoutchouc.
rnes P1 et C1 sont reliées à la terre à
er.

c) Les bornes P2 et C2 sont reliées à un sectionneur d'un calibre suffisant pour supporter les tensions maximales de défaut (voir fig. 3).
d) Le sectionneur étant ouvert, on peut établir les liaisons aux piquets auxiliaires. Faire en premier la liaison au sectionneur et ensuite aux piquets.
e) On peut alors fermer le sectionneur et effectuer un essai.
f) Pendant l'essai, s'assurer que personne ne touche aux piquets ou aux fils de liaison.
g) Le sectionneur doit être ouvert avant de toucher aux piquets auxiliaires, par exemple pour les déplacer.
h) Si un défaut se produit pendant un essai, l'appareil peut être endommagé. Aussi, il est conseillé de placer des fusibles 100 mA sur le sectionneur (d'un calibre en tension compatible avec les tensions maximales de défaut pour garantir une certaine protection de l'instrument.

4. **Lors de la charge des batteries du DET5/2:—**
a) S'assurer que l'appareil est totalement débranché de tout circuit externe.
b) Avant de procéder à la mise sous tension, s'assurer que le sélecteur de tension est sur la bonne gamme et que l'on a placé un fusible de calibre correct (voir les spécifications page 9).
c) La prise à laquelle est raccordé l'appareil doit être équipée d'un interrupteur marche/arrêt.
5. Les réparations sur ces appareils ne doivent être entreprises que par des services habilités par le fournisseur.
6. Si un appareil est endommagé, il faut l'envoyer en réparation. On considère qu'un appareil est endommagé si un défaut visible est constaté, s'il n'effectue pas correctement les mesures, s'il a été stocké de façon prolongée dans des conditions défavorables ou s'il a subi des chocs importants pendant un transport.

PRECAUTIONS

1. Le circuit de l'appareil contient des éléments sensibles à l'électricité statique. Si l'instrument doit être ouvert, il faut prendre les précautions nécessaires pour la manipulation du circuit conformément aux normes DEF STAN 59-98 et BS 5783.

   Nota:— L'ouverture du boitier, si elle n'est pas réalisée par un service habilité, annule automatiquement la garantie couvrant l'appareil.
2. Il est recommandé, pour le DET5/2, de bien charger les batteries avant de partir pour une série d'essais. De même, pour le DET5/2D un jeu de piles neuves doit toujours être disponible.

SYMBOLES DE L'AFFICHAGE

L'affichage à cristaux liquides fournit directement la lecture, et l'opérateur se rapporte simplement à la position du commutateur de gamme pour les unités de mesure. Les symbôles de l'affichage permettent à l'opérateur de s'assurer que la lecture est correcte. La signification des différents symbôles est expliquée ci-après:

Vitesse de rotation de la génératrice trop faible (DET3/2)

Si la manivelle de la génératrice de DET3/2 est tournée trop lentement, la tension de sortie étant alors trop faible pour réaliser une mesure correcte, un segment apparait sur l'affichage en face de la marque 'Rev/Min Lo'. Il faut alors augmenter la vitesse de rotation jusqu'à ce que ce segment disparaisse.

Indication tension batterie faible (DET5/2 et DET5/2D)

Sur le DET5/2 et DET5/2D, si la tension de batterie est trop faible, un segment apparait sur l'affichage en face du symbôle '—|⊢— mini'. Dans ce cas, les batteries ne permettra plus qu'une ou deux mesures et devra être rechargée (DET5/2) ou remettent (DET5/2D) avant d'effectuer d'autres essais.

MODE D'EMPLOI

Inversion de polarité

Quand les piquets potentiels sont inversés par rapport aux piquets courants, la lecture sur l'affichage est précédée parun signe moins. La lecture est valable, mais il faut inverser les piquets potentiel pour obtenir la suppression du signe moins. Pour une mesure positive, les bornes 'C1' et 'P1' doivent être reliées à la terre à mesurer et les bornes 'P2' et 'C2' aux piquets auxiliaires.

Résistance du piquet courant élevée

Pour indiquer que la résistance du circuit courant est trop élevée, un segment apparait en face de la marque Rc. Ceci peut être causé par un circuit ouvert, une mauvaise connexion dans le cordon de liaison au piquet, une résistance élevée dans le sol au voisinage de ce piquet, ou un mauvais contact avec ce piquet. Quelle que soit la cause, il faut y remédier avant de pouvoir réaliser une mesure correcte. On peut par exemple mouiller le sol au voisinage du piquet, déplacer le piquet ou utiliser plusieurs piquets.

Résistance du piquet potentiel élevée

Pour indiquer que la résistance du circuit potentiel est trop importante, un segment apparait en face de la marque Rp. Pour faire ce contrôle, appuyer sur le bouton marqué 'Test Rp'. Les causes et les remèdes sont les mêmes que pour le piquet courant.

Nota:— Quand on appuie sur le bouton 'Test Rp', l'affichage, à l'exception du point décimal, s'éteint.

Bruit parasite excessif

Un segment apparait automatiquement en face de la marque 'Bruit' (Noise) quand la tension parasite dans la terre mesurée est supérieure au niveau qui peut être rejeté par l'appareil. Dans ces conditions, il n'est pas possible de faire une mesure correcte. La solution consiste à attendre la disparition de l'interférence s'il s'agit d'un transitoire, ou de choisir une position différente pour les piquets auxiliaires.

Nota:— Ce symbôle peut aussi apparaitre avec l'indication de dépassement de gamme si la résistance mesurée est très supérieure à la gamme choisie.

Dépassement de gamme

Pour indiquer que la résistance mesurée est supérieure à la gamme choisie, le symbôle de dépassement de gamme apparait. Il s'agit d'un '1' sur le digit de gauche, le reste de l'affichage restant éteint à l'exception du point décimal. Quand ce symbôle apparait, passer sur une gamme supérieure. S'il apparait sur la gamme 2 kΩ, l'électrode mesurée présente un problème sérieux (vérifier toutefois que le symbôle indiquant une résistance de piquet auxiliaire courant n'apparait pas aussi).

MISE EN PLACE DES PIQUETS ETC.

Pour la mesure d'une prise de terre ou d'une résistivité de terrain, les cordons de l'appareil sont reliés à des piquets enfoncés dans le sol. Le type de liaison dépend du type d'essai réalisé, des détails sont fournis au paragraphe suivant 'Techniques de mesure'.

Des piquets et des cordons de grande longueur sont nécessaires pour ces essais. La valise accessoire livrée en option contient les différents éléments nécessaires. Pour la liaison à l'appareil, il faut des adaptateurs à angle droit, qui sont fournis avec l'appareil.

PROCEDURE D'ESSAI DE BASE

Mesure Quatre Bornes

Une fois les piquets mis en place et raccordés à l'appareil en fonction du type d'essai à réaliser, procéder comme suit:

1. Choisir la gamme de mesure. En général, commencer par la gamme la plus faible.
2. Pour le DET3/2, tourner la manivelle au moins à 120 tours par minute.
   Nota:— Le DET5/2 et DET5/2D alimente le circuit dès que la gamme a été sélectionnée.
3. Vérifier que l'affichage n'indique pas de mauvaises conditions d'essai (interférences, résistance piquets trop élevée ....) et qu'il n'y a pas d problème d'alimentation (Vitesse de rot manivelle trop faible sur le DET3/2, charg accumulateurs insuffisante sur le DET5/ DET5/2D).
4. Presser le bouton 'Essai Rp' (Test Rp) po la résistance du piquet potentiel. Le sym résistance élevée ne doit pas apparaitre le bouton.
5. Si toutes les conditions pour un essai co réunies, la lecture fournie par l'affichage donne la résistance de la terre mesurée. symbôles apparait sur l'affichage, il faut supprimer la cause avant de réaliser une

Mesure a Trois Bornes

La procédure de mesure de base est la mê pour la Mesure Quatre Bornes sauf que le poussoir fugitif repéré 'C1 - P1' ('E - ES') do maintenu pressé. Une seule liaison entre la ('E') et la terre en essai est alors nécessaire augmenter la précision, le cordon de liaison plus court possible.

CHARGE DE LA BATTERIE (DET5/2)

La batterie doit être rechargée dès que l'in batterie faible — apparait sur l'affichage. S reste éteint quand l'appareil est mis en ser

: D'EMPLOI

de polarité

; piquets potentiels sont inversés par rapport
ts courants, la lecture sur l'affichage est
parun signe moins. La lecture est valable,
t inverser les piquets potentiel pour obtenir
ision du signe moins. Pour une mesure
es bornes 'C1' et 'P1' doivent être reliées à
nesurer et les bornes 'P2' et 'C2' aux
xiliaires.

e du piquet courant élevée

uer que la résistance du circuit courant est
e, un segment apparait en face de la marque
eut être causé par un circuit ouvert, une
connexion dans le cordon de liaison au
e résistance élevée dans le sol au voisinage
et, ou un mauvais contact avec ce piquet.
soit la cause, il faut y remédier avant de
liser une mesure correcte. On peut par
iouiller le sol au voisinage du piquet,
piquet ou utiliser plusieurs piquets.

du piquet potentiel élevée

er que la résistance du circuit potentiel est
ante, un segment apparait en face de la
. Pour faire ce contrôle, appuyer sur le
qué 'Test Rp'. Les causes et les remèdes
mes que pour le piquet courant.

Nota:— Quand on appuie sur le bouton 'Test Rp', l'affichage, à l'exception du point décimal, s'éteint.

Bruit parasite excessif

Un segment apparait automatiquement en face de la marque 'Bruit' (Noise) quand la tension parasite dans la terre mesurée est supérieure au niveau qui peut être rejeté par l'appareil. Dans ces conditions, il n'est pas possible de faire une mesure correcte. La solution consiste à attendre la disparition de l'interférence s'il s'agit d'un transitoire, ou de choisir une position différente pour les piquets auxiliaires.

Nota:— Ce symbôle peut aussi apparaitre avec l'indication de dépassement de gamme si la résistance mesurée est très supérieure à la gamme choisie.

Dépassement de gamme

Pour indiquer que la résistance mesurée est supérieure à la gamme choisie, le symbôle de dépassement de gamme apparait. Il s'agit d'un '1' sur le digit de gauche, le reste de l'affichage restant éteint à l'exception du point décimal. Quand ce symbôle apparait, passer sur une gamme supérieure. S'il apparait sur la gamme 2 kΩ, l'électrode mesurée présente un problème sérieux (vérifier toutefois que le symbôle indiquant une résistance de piquet auxiliaire courant n'apparait pas aussi).

MISE EN PLACE DES PIQUETS ETC.

Pour la mesure d'une prise de terre ou d'une résistivité de terrain, les cordons de l'appareil sont reliés à des piquets enfoncés dans le sol. Le type de liaison dépend du type d'essai réalisé, des détails sont fournis au paragraphe suivant 'Techniques de mesure'.

Des piquets et des cordons de grande longueur sont nécessaires pour ces essais. La valise accessoire livrée en option contient les différents éléments nécessaires. Pour la liaison à l'appareil, il faut des adaptateurs à angle droit, qui sont fournis avec l'appareil.

PROCEDURE D'ESSAI DE BASE

Mesure Quatre Bornes

Une fois les piquets mis en place et raccordés à l'appareil en fonction du type d'essai à réaliser, procéder comme suit:

1. Choisir la gamme de mesure. En général, commencer par la gamme la plus faible.
2. Pour le DET3/2, tourner la manivelle au moins à 120 tours par minute.
   Nota:— Le DET5/2 et DET5/2D alimente le circuit dès que la gamme a été sélectionnée.
3. Vérifier que l'affichage n'indique pas de mauvaises conditions d'essai (interférences, résistance piquets trop élevée ...) et qu'il n'y a pas de problème d'alimentation (Vitesse de rotation de la manivelle trop faible sur le DET3/2, charge des accumulateurs insuffisante sur le DET5/2 et DET5/2D).
4. Presser le bouton 'Essai Rp' (Test Rp) pour vérifier la résistance du piquet potentiel. Le symbôle de résistance élevée ne doit pas apparaitre. Relâcher le bouton.
5. Si toutes les conditions pour un essai correct sont réunies, la lecture fournie par l'affichage digital donne la résistance de la terre mesurée. Si l'un des symbôles apparait sur l'affichage, il faut en supprimer la cause avant de réaliser une mesure.

Mesure a Trois Bornes

La procédure de mesure de base est la même que pour la Mesure Quatre Bornes sauf que le bouton poussoir fugitif repéré 'C1 - P1' ('E - ES') doit être maintenu pressé. Une seule liaison entre la borne 'C1' ('E') et la terre en essai est alors nécessaire. Pour augmenter la précision, le cordon de liaison doit être le plus court possible.

CHARGE DE LA BATTERIE (DET5/2)

La batterie doit être rechargée dès que l'indication — batterie faible — apparait sur l'affichage. Si l'affichage reste éteint quand l'appareil est mis en service, il est

possible que les batteries soient complètement vides. Dans ce cas, les recharger avant d'effectuer des essais.

Nota:— Il est déconseillé de laisser la batterie se décharger complètement sous peine de risquer de l'endommager.

Avant de relier l'alimentation secteur, s'assurer que l'appareil est équipé d'un fusible de calibre correct, et que le sélecteur de tension est placé sur la bonne gamme. Pour une alimentation 240 V il faut un fusible 50 mA, et pour une alimentation 120 V un fusible 100 mA (le type et la dimension des fusibles sont indiqués dans les spécifications). Le fusible est logé dans la prise d'alimentation encastrée dans le boitier. Faire simplement glisser le port fusible pour accéder aux deux fusibles (le fusible extérieur est une pièce de rechange). Le sélecteur de tension est situé sur la partie inférieure du boitie Utiliser un tournevis pour régler la tension de service.

Relier l'appareil à une prise d'alimentation secteur, et mettre en service. Une lampe LED, repérée 'Secteur' ('Mains on') s'allume pour indiquer que l'appareil est sous tension. Laisser la batterie en charge pendant environ 10 heures.

Attention:— Ne pas laisser les cordons d'essai reliés aux bornes de sortie quand l'appareil est sous tension.

MISE EN PLACE OU REMPLACEMENT DES PILES (DET5/2D)

Attention: N'utiliser que des piles du type spécifié (voir caractéristiques). Lors de la mise en place ou du remplacement des batteries, il ne doit rien avoir de branché sur les bornes de sortie de l'appareil.

Dévisser le couvercle du compartiment piles sur la face inférieure de l'appareil. Retirer les piles usagées et les remplacer par des piles neuves, en respectant les polarités gravées dans le fond du boitier. Replacer le couvercle et revisser la vis de fermeture. Ne pas laisser de piles dans l'appareil si celui-ci doit rester inutilisé pendant une longue période, afin d'éviter des fuites d'électrolyte.

ARRET AUTOMATIQUE (DET5/2 et DET5/2D)

Pour économiser les batteries, ces appareils sont équipés d'un système de coupure automatique qui déclenche au bout de 3 minutes. Pour remettre l'appareil en service, placer le commutateur de gamme sur la position arrêt, puis sur la gamme désirée.

Cette fonction ne remplace pas la position 'ARRET' du commutateur de gamme. Dans la mesure du possible, arrêter l'appareil en plaçant le sélecteur de gamme sur la position 'ARRET', on maximise ainsi l'autonomie des batteries.

REMPLACEMENT DU FUSIBLE DE PROTECTION DE LA SOURCE DE COURANT

En plus du fusible d'alimentation du DET5/2, les modèles DET3/2 - DET5/2 - DET5/2D ont un fusible de protection pour la source de courant contre les surcharges en entrée, par exemple des tensions appliquées aux bornes C1 et C2.

Le fusible a un calibre de 100 mA et est logé dans un porte-fusible à la base du boitier de l'appareil. Pour changer le fusible, retirer le capot du porte-fusible à l'aide d'un tournevis, ôter le fusible défectueux, placer un fusible neuf et revisser le capot.

Nota:— Le fusible de remplacement doit être de même calibre et type que le fusible d'origine (voir les caractéristiques).

INSTRUCCIONES DE USO

ADVERTENCIAS

1. Como precaución cuando se trabaja cerca de sistemas con alta tensión, donde existen altas posibilidades de que se produzcan accidentes en la estructura y en el piso, se recomienda que el operador lleve guantes de goma (de acuerdo con la BS 697 — 1986), que trabaje sobre una esterilla de goma, o bien que lleve zapatos de goma (véase el párrafo 3 más adelante).
2. Es preferible que el sistema de conexión a tierra que ha de ser probado sea primeramente aislado del circuito que está protegiendo. Esto no es siempre posible, por lo que la precaución siguiente es sumamente importante.
3. **Precauciones de seguridad para todas las conexiones a tierra activas**
   Es necesario adoptar precauciones de seguridad cuando existen conexiones a tierra activas, como por ejemplo cuando se está probando la conexión a tierra de una subestación "activa". Si se produce una avería en la subestación cuando se está efectuando una prueba, pueden existir voltajes peligrosos entre la conexión a tierra del emplazamiento y las conexiones a tierra remotas establecidas con fines de prueba. Así pues:
   a) El instrumento debe ser usado dentro del cercado perimétrico de la subestación donde se está llevando a cabo la prueba, y/o en cualquier área donde la diferencia de voltaje proveniente de la conexión a tierra que se está probando no exceda de 50 V en ningunas circunstancias. Si esto no es posible, deben usarse guantes y esterillas de goma.
   b) Los bornes P1 y C1 deben ser conectados al electrodo de conexión a tierra que se está probando.
   c) Los bornes P2 y C2 deben ser conectados a un interruptor de aislamiento cuya capacidad abarque los voltajes máximos de avería (referirse a la figura 3).
   d) Con el interruptor de aislamiento abierto, se pueden establecer las conexiones a las puntas de prueba (electrodos) remotas. Hacer las conexiones al interruptor de aislamiento primero y luego conectar las puntas de prueba (electrodos) remotas.
   e) Cuando se han establecido las puntas de prueba remotas, podrá cerrarse el interruptor de aislamiento y hacerse la prueba.
   f) Mientras se hace la prueba, debe tenerse cuidado de que nadie entre en contacto con los electrodos o con los cables remotos tendidos hasta los bornes P2 y C2 a través del interruptor de aislamiento.
   g) El interruptor de aislamiento debe estar abierto mientras se hace cualquier contacto personal con las puntas de prueba remotas o con los conductores de conexión, por ejemplo cuando se cambian de posición.
   h) Si se produce un fallo mientras se hace una prueba, el instrumento puede estar averiado. La instalación de fusibles en el interruptor de aislamiento, con un régimen de 100 mA y capaces de resistir el máximo voltaje de avería, brindará cierta medida de protección al instrumento (véase la figura 3).
4. **Cuando se carga la batería del DET5/2:**
   a) Asegurar que el instrumento esté completamente desconectado de cualquier circuito exterior.
   b) Antes de conectar la tensión asegurar que se ha puesto correctamente el selector de voltajes, y que se ha instalado el fusible con la capacidad correcta para aquel suministro (véase la página con las especificaciones 9).
   c) La base en la cual se enchufa el instrumento para cargar la batería debe tener un interruptor de conexión/desconexión.
5. Las reparaciones de estos instrumentos deben ser llevadas a cabo por personal profesional debidamente capacitado.
6. Si se ha perjudicado la protección de un instrumento, éste no debe ser usado sino que debe ser devuelto para su reparación. Es probable que la pr haya sido perjudicada si, por ejemplo, m desperfectos visibles, si no realiza las m previstas, si ha estado almacenado dura tiempo en condiciones adversas, o si ha sometido a grandes esfuerzos durante su

PRECAUCIONES

1. El circuito del instrumento contiene disp sensibles a estáticas. Si se abre la tapa p motivo, debe manejarse con cuidado la t circuito impreso. Esto debe hacerse de a las especificaciones DEF STAN 59-98 y E aplicables al manejo de dispositivos sens electrostáticas.
   Nota:— Si se abre por cualquier motivo l invalidará automáticamente las que pudiera tener el instrument que sea llevado a cabo por una fi reparaciones aprobada (véase la p
2. Cuando se trabaja con el instrumento DE aconseja cargar por completo la batería, llevar a cabo una secuencia de pruebas. F resultar extremadamente inconveniente voltaje de la batería desciende demasiad se realiza una prueba de campo.
   De forma similar, para el DET5/2D, siemp tendremos disponibles pilas neuvas.

CCIONES DE USO

CIAS

ecaución cuando se trabaja cerca de
con alta tensión, donde existen altas
ades de que se produzcan accidentes en la
a y en el piso, se recomienda que el
lleve guantes de goma (de acuerdo con la
- 1986), que trabaje sobre una esterilla de
ien que lleve zapatos de goma (véase el
más adelante).
ible que el sistema de conexión a tierra
ser probado sea primeramente aislado
o que está protegiendo. Esto no es
osible, por lo que la precaución siguiente
nente importante.

ones de seguridad para todas las
es a tierra activas

ario adoptar precauciones de seguridad
isten conexiones a tierra activas, como
lo cuando se está probando la conexión a
na subestación "activa". Si se produce
a en la subestación cuando se está
lo una prueba, pueden existir voltajes
s entre la conexión a tierra del
iento y las conexiones a tierra remotas
las con fines de prueba. Así pues:
rumento debe ser usado dentro del
lo perimétrico de la subestación donde
á llevando a cabo la prueba, y/o en cualquier área donde la diferencia de voltaje proveniente de la conexión a tierra que se está probando no exceda de 50 V en ningunas circunstancias. Si esto no es posible, deben usarse guantes y esterillas de goma.

b) Los bornes P1 y C1 deben ser conectados al electrodo de conexión a tierra que se está probando.
c) Los bornes P2 y C2 deben ser conectados a un interruptor de aislamiento cuya capacidad abarque los voltajes máximos de avería (referirse a la figura 3).
d) Con el interruptor de aislamiento abierto, se pueden establecer las conexiones a las puntas de prueba (electrodos) remotas. Hacer las conexiones al interruptor de aislamiento primero y luego conectar las puntas de prueba (electrodos) remotas.
e) Cuando se han establecido las puntas de prueba remotas, podrá cerrarse el interruptor de aislamiento y hacerse la prueba.
f) Mientras se hace la prueba, debe tenerse cuidado de que nadie entre en contacto con los electrodos o con los cables remotos tendidos hasta los bornes P2 y C2 a través del interruptor de aislamiento.
g) El interruptor de aislamiento debe estar abierto mientras se hace cualquier contacto personal con las puntas de prueba remotas o con los conductores de conexión, por ejemplo cuando se cambian de posición.
h) Si se produce un fallo mientras se hace una prueba, el instrumento puede estar averiado. La instalación de fusibles en el interruptor de aislamiento, con un régimen de 100 mA y capaces de resistir el máximo voltaje de avería, brindará cierta medida de protección al instrumento (véase la figura 3).

4. **Cuando se carga la batería del DET5/2:**
   a) Asegurar que el instrumento esté completamente desconectado de cualquier circuito exterior.
   b) Antes de conectar la tensión asegurar que se ha puesto correctamente el selector de voltajes, y que se ha instalado el fusible con la capacidad correcta para aquel suministro (véase la página con las especificaciones 9).
   c) La base en la cual se enchufa el instrumento para cargar la batería debe tener un interruptor de conexión/desconexión.
5. Las reparaciones de estos instrumentos deben ser llevadas a cabo por personal profesional debidamente capacitado.
6. Si se ha perjudicado la protección de un instrumento, éste no debe ser usado sino que debe ser devuelto para su reparación. Es probable que la protección haya sido perjudicada si, por ejemplo, muestra desperfectos visibles, si no realiza las mediciones previstas, si ha estado almacenado durante un largo tiempo en condiciones adversas, o si ha sido sometido a grandes esfuerzos durante su transporte.

PRECAUCIONES

1. El circuito del instrumento contiene dispositivos sensibles a estáticas. Si se abre la tapa por cualquier motivo, debe manejarse con cuidado la tarjeta de circuito impreso. Esto debe hacerse de acuerdo con las especificaciones DEF STAN 59-98 y BS 5783, aplicables al manejo de dispositivos sensibles a las electrostáticas.

   Nota: — Si se abre por cualquier motivo la tapa esto invalidará automáticamente las garantías que pudiera tener el instrumento, a menos que sea llevado a cabo por una firma de reparaciones aprobada (véase la página 55).
2. Cuando se trabaja con el instrumento DET5/2, se aconseja cargar por completo la batería, antes de llevar a cabo una secuencia de pruebas. Puede resultar extremadamente inconveniente si el voltaje de la batería desciende demasiado mientras se realiza una prueba de campo.
   De forma similar, para el DET5/2D, siempre tendremos disponibles pilas neuvas.

INSTRUCCIONES DE USO

SIMBOLOS DE LA VISUALIZACION

La visualización a cristal líquido de 3½ dígitos, muestra la lectura directamente y el operador puede simplemente referirse a la posición del interruptor de alcance para las unidades de medición. Los símbolos de la visualización del instrumento pueden también ayudar al operador a asegurar que sea válida la lectura. En los párrafos siguientes se incluyen los significados de cada símbolo de visualización.

Baja velocidad de giro del generador (DET3/2)

Si la manivela del generador DET3/2 es girada demasiado lentamente, de modo que no hay suficiente salida para llevar a cabo una prueba correcta, aparecerá una flecha ' ← ' a la izquierda de la visualización apuntando hacia la marca 'Rev/Min Lo' (giro lento) incluida en el panel gráfico. Cualquier lectura en la visualización debe ser ignorada y el generador debe ser girado con mayor rapidez hasta que la flecha desaparezca antes de que pueda ser aceptado el valor medido.

Bajo voltaje de la batería (DET5/2 y DET5/2D)

De manera parecida en el DET5/2 y DET5/2D, si el voltaje de la batería es demasiado bajo, la flecha de la izquierda aparecerá indicando hacia la marca '⊣⊢ Lo' del panel gráfico. En este caso, las baterías retiene solamente energía suficiente para efectuar posiblemente una o dos mediciones más, y deberá ser recargada (DET5/2) o reponer (DET5/2D) antes de llevarse a cabo pruebas posteriores.

Polaridad invertida

Cuando los conductores de prueba de potencial son invertidos con respecto a los conductores de prueba de corriente, la lectura de la visualización irá precedida de un signo negativo. La lectura es todavía válida, pero las conexiones de potencial deben ser invertidas para retirar el signo negativo. Para realizar una medición positiva, las conexiones 'C1' y 'P1' (o 'E' y 'ES') deben hacerse al electrodo que se está probando, i.e. hasta un extremo de la resistencia, y las conexiones 'C2' y 'P2' (o 'S' y 'H') deberán hacerse a las puntas de prueba, i.e. al otro extremo de la resistencia.

Alta resistencia de la pica de corriente

Para indicar que es demasiado alta la resistencia del circuito de corriente, se ilumina un segmento de la visualización situado enfrente de la marca 'Rc' del panel gráfico. Esto ocurre automáticamente mientras está conectado el probador, o incluso durante una prueba. Su aparición puede ser causada por un circuito abierto o una conexión defectuosa entre el conductor de pruebas y la pica de corriente o, más probablemente, a causa de una alta resistencia existente en el terreno cercano a la pica de corriente, y a un contacto incorrecto con dicha pica. Cualesquiera que sea la causa de la aparición del símbolo, éste debe ser retirado antes de considerarse válida la prueba. El problema puede ser solucionado humedeciendo el terreno situado alrededor de la pica de corriente, o bien reposicionando la pica en un nuevo lugar, o usando más de una pica.

Alta resistencia de la pica de potencial

Para indicar que es demasiado alta la resistencia del circuito de potencial, se ilumina un segmento de la visualización situado enfrente de la marca 'Rp' del panel gráfico. Esto no ocurre automáticamente, sino que debe ser llevado a cabo por el operador como prueba preliminar al pulsar el botón marcado 'Test Rp'. Su aparición puede ser causada por el mismo símbolo empleado en la resistencia de pica de alta corriente y, como en este caso, el problema debe ser solucionado antes de considerarse válida la prueba. De nuevo la solución puede consistir en humedecer el terreno o en reposicionar en un nuevo lugar la pica de prueba de potencial.

Nota:— El accionamiento del botón 'Test Rp' pondrá en blanco la visualización, exceptuando el punto decimal y el símbolo de alta resistencia de pica de potencial (en los casos aplicables).

Interferencia por ruidos excesivos

Se encenderá automáticamente un segmento enfrente de la marca 'Noise' (ruido) en el panel cuando el voltaje de interferencia existente en conexión a tierra que se está midiendo está n del nivel que puede ser rechazado por el prob Una medición válida no podrá hacerse en est condición. La solución puede consistir en esp que desaparezca la interferencia, si es de nat transitoria, o en seleccionar una posición dife para las puntas de prueba.

Nota:— Este símbolo puede aparecer tambie indicación de fuera de alcance, si la re que se está midiendo es mucho may alcance seleccionado.

Fuera de alcance

El símbolo fuera de alcance aparece cuando medir con el instrumento un valor de resister se halla por encima de su capacidad máxima.

La indicación fuera de alcance es un '1' como izquierdo, con el resto de la visualización en b exceptuando el punto decimal. Cuando apare símbolo, poner un alcance mayor. Si aparece alcance de '2 kΩ', existe algo sumamente gr electrodo de conexión a tierra que se está pr (en este caso, asegurar que no esté encendi

CIONES DE USO

DE LA VISUALIZACION

ón a cristal líquido de 3½ dígitos,
ctura directamente y el operador puede
referirse a la posición del interruptor de
as unidades de medición. Los símbolos
ición del instrumento pueden también
rador a asegurar que sea válida la lectura.
s siguientes se incluyen los significados
olo de visualización.

id de giro del generador (DET3/2)

del generador DET3/2 es girada
ntamente, de modo que no hay
da para llevar a cabo una prueba
ecerá una flecha ' ← ' a la izquierda
ción apuntando hacia la marca 'Rev/Min
) incluida en el panel gráfico. Cualquier
isualización debe ser ignorada y el
e ser girado con mayor rapidez hasta
lesaparezca antes de que pueda ser
lor medido.

le la batería (DET5/2 y DET5/2D)

recida en el DET5/2 y DET5/2D, si el
atería es demasiado bajo, la flecha de la
ecerá indicando hacia la marca '⊣⊢'
gráfico. En este caso, las baterías retiene
ergía suficiente para efectuar posiblemente una o dos mediciones más, y deberá ser recargada (DET5/2) o reponer (DET5/2D) antes de llevarse a cabo pruebas posteriores.

Polaridad invertida

Cuando los conductores de prueba de potencial son invertidos con respecto a los conductores de prueba de corriente, la lectura de la visualización irá precedida de un signo negativo. La lectura es todavía válida, pero las conexiones de potencial deben ser invertidas para retirar el signo negativo. Para realizar una medición positiva, las conexiones 'C1' y 'P1' (o 'E' y 'ES') deben hacerse al electrodo que se está probando, i.e. hasta un extremo de la resistencia, y las conexiones 'C2' y 'P2' (o 'S' y 'H') deberán hacerse a las puntas de prueba, i.e. al otro extremo de la resistencia.

Alta resistencia de la pica de corriente

Para indicar que es demasiado alta la resistencia del circuito de corriente, se ilumina un segmento de la visualización situado enfrente de la marca 'Rc' del panel gráfico. Esto ocurre automáticamente mientras está conectado el probador, o incluso durante una prueba. Su aparición puede ser causada por un circuito abierto o una conexión defectuosa entre el conductor de pruebas y la pica de corriente o, más probablemente, a causa de una alta resistencia existente en el terreno cercano a la pica de corriente, y a un contacto incorrecto con dicha pica. Cualesquiera que sea la causa de la aparición del símbolo, éste debe ser retirado antes de considerarse válida la prueba. El problema puede ser solucionado humedeciendo el terreno situado alrededor de la pica de corriente, o bien reposicionando la pica en un nuevo lugar, o usando más de una pica.

Alta resistencia de la pica de potencial

Para indicar que es demasiado alta la resistencia del circuito de potencial, se ilumina un segmento de la visualización situado enfrente de la marca 'Rp' del panel gráfico. Esto no ocurre automáticamente, sino que debe ser llevado a cabo por el operador como prueba preliminar al pulsar el botón marcado 'Test Rp'. Su aparición puede ser causada por el mismo símbolo empleado en la resistencia de pica de alta corriente y, como en este caso, el problema debe ser solucionado antes de considerarse válida la prueba. De nuevo la solución puede consistir en humedecer el terreno o en reposicionar en un nuevo lugar la pica de prueba de potencial.

Nota:— El accionamiento del botón 'Test Rp' pondrá en blanco la visualización, exceptuando el punto decimal y el símbolo de alta resistencia de pica de potencial (en los casos aplicables).

Interferencia por ruidos excesivos

Se encenderá automáticamente un segmento enfrente de la marca 'Noise' (ruido) en el panel gráfico cuando el voltaje de interferencia existente en la conexión a tierra que se está midiendo está más allá del nivel que puede ser rechazado por el probador. Una medición válida no podrá hacerse en esta condición. La solución puede consistir en esperar a que desaparezca la interferencia, si es de naturaleza transitoria, o en seleccionar una posición diferente para las puntas de prueba.

Nota:— Este símbolo puede aparecer también con la indicación de fuera de alcance, si la resistencia que se está midiendo es mucho mayor que el alcance seleccionado.

Fuera de alcance

El símbolo fuera de alcance aparece cuando se intenta medir con el instrumento un valor de resistencia que se halla por encima de su capacidad máxima.

La indicación fuera de alcance es un '1' como dígito izquierdo, con el resto de la visualización en blanco exceptuando el punto decimal. Cuando aparece este símbolo, poner un alcance mayor. Si aparece en el alcance de '2 kΩ', existe algo sumamente grave en el electrodo de conexión a tierra que se está probando (en este caso, asegurar que no esté encendido el

indicador de alta pica de corriente — véase la indicación previa).

PREPARACION DE PUNTAS DE PRUEBA, ETC.

Para llevar a cabo la prueba de electrodos de conexión a tierra y para el estudio de sensibilidad de resistividad a tierra, los conductores de prueba del instrumento son conectados en picas enterradas en la tierra. El modo en que se hacen las conexiones depende del tipo de prueba que se está llevando a cabo, y los detalles de las mismas se incluyen en la sección siguiente 'Técnicas de medición'.

Las puntas de prueba y los conductores de prueba largos son necesarios para todos los tipos de pruebas de conexión a tierra, y el juego de accesorios de campaña para la prueba de conexiones a tierra (ET/KIT — ofrecido como opción) contiene el equipo básico.

Las puntas de prueba recomendadas son de acero suave y miden 13 mm cuadrados por 460 mm de largo. Estas puntas pueden ser insertadas hasta una profundidad de 300 mm con golpes rápidos de un martillo de 1 kg de peso. El tamaño del cable usado como conductor de prueba no es crítico, pero ha de tener una flexibilidad razonable y DEBE estar aislado. Será necesario un largo de 100 m como mínimo, siendo apropiado un tamaño de cable de unos 19/0,3 mm.

Cuando se hacen las conexiones al instrumento, deben usarse adaptadores en ángulo recto. Estos adaptadores son enviados con el instrumento y tienen bornes roscados para recibir conectores en forma de gancho o pala, hilos desnudos, o enchufes de 4 mm.

PROCEDIMIENTO DE PRUEBA BASICO

Medidas a cuatro terminales

Después de que han sido preparadas las puntas de prueba y conectadas al instrumento para el tipo de prueba que ha de ser llevada a cabo (referirse a 'Técnicas de medición'), proceder como sigue:

1. Seleccionar el alcance de medición requerido. Escoger el alcance más corto si se tienen dudas en cuanto al alcance correcto. Esto puede hacer aparecer el símbolo de fuera de alcance, cuando se pone en marcha el instrumento. Si esto es así, poner el alcance siguiente.
2. Para el DET3/2, girar la manivela del generador a 120 r.p.m. (como mínimo).
   Nota:— El DET5/2 y DET5/2D energiza el circuito de prueba, tan pronto como es seleccionado el circuito de prueba.
3. Comprobar que la visualización no muestre condiciones de prueba adversas, i.e. que no aparezcan los símbolos de alta resistencia de circuito de corriente y ruido excesivo. Además, comprobar que no brillen los símbolos de bajo voltaje de batería (DET5/2 y DET5/2D) y baja velocidad de giro (DET3/2).
4. Pulsar el botón 'Test Rp' para comprobar la resistencia de la pica de potencial. El símbolo de alta resistencia del circuito de potencial no debe aparecer. Soltar el botón.
5. Si son satisfactorias todas las condiciones para llevar a cabo una prueba, la lectura que aparece en la visualización puede ser aceptada como la resistencia de la conexión a tierra. Si se enciende uno cualquiera de los símbolos de la visualización (exceptuando el de polaridad invertida), debe hacerse desaparecer la cuasa de la condición adversa antes de que la lectura pueda ser aceptada.

Medida a tres terminales

El procedimiento es básicamente el mismo que para medidas a 4 terminales, excepto que el botón marcado "C1 - P1" (E - ES) deberá estar presionado y colocado en su posición más baja. Sólo se requiere una conexión desde el terminal "C1" (E1) al electrodo bajo prueba. Para mayor precisión esta conexión deberá hacerse con un cable de prueba corto.

CARGA DE BATERIA (DET5/2)

La batería debe ser cargada tan pronto como aparece en la visualización el indicador de bajo nivel de batería.

Si la visualización permanece en blanco cuar conmuta el instrumento, puede ser que la b haya descargado por completo. En este cas batería por completo antes de llevar a cabo algunas.

Nota:— No es aconsejable permitir que la b descargue por completo, porque pu recibir desperfectos.

Antes de conectarlo al suministro de la red, que se instala el fusible correcto y que el aju voltaje tenga la capacidad apropiada para el que ha de ser usado. Para un suministro de el fusible debe ser de 50 mA y para uno de debe ser de 100 mA (el tipo y el tamaño de l se incluye en las Especificaciones). El fusibl suministro de la red está situado en el portal cual forma parte del enchufe de entrada reba incluido en el lateral de la caja. Simplemente portafusibles para sacarlo y dejar al descubie fusibles. El interior es el que funciona y el ex el de repuesto. El selector de voltaje está sit fondo de la caja. Usar un destornillador para marca del voltaje apropiado hasta la flecha in

Una vez puestos correctamente el fusible y e de voltajes, enchufar el conductor del suminr red en un enchufe apropiado y llevar a cabo l conexión. Se encenderá una luz LED incluida

JCCIONES DE USO

e alta pica de corriente — véase la previa).

CION DE PUNTAS DE PRUEBA, ETC.

a cabo la prueba de electrodos de conexión ara el estudio de sensibilidad de resistividad conductores de prueba del instrumento ados en picas enterradas en la tierra. El ue se hacen las conexiones depende del eba que se está llevando a cabo, y los las mismas se incluyen en la sección 'écnicas de medición'.

de prueba y los conductores de prueba necesarios para todos los tipos de pruebas n a tierra, y el juego de accesorios de ara la prueba de conexiones a tierra (ET/KIT como opción) contiene el equipo básico.

de prueba recomendadas son de acero den 13 mm cuadrados por 460 mm de puntas pueden ser insertadas hasta una d de 300 mm con golpes rápidos de un 1 kg de peso. El tamaño del cable usado uctor de prueba no es crítico, pero ha de exibilidad razonable y DEBE estar aislado. ario un largo de 100 m como mínimo, opiado un tamaño de cable de unos

Cuando se hacen las conexiones al instrumento, deben usarse adaptadores en ángulo recto. Estos adaptadores son enviados con el instrumento y tienen bornes roscados para recibir conectores en forma de gancho o pala, hilos desnudos, o enchufes de 4 mm.

PROCEDIMIENTO DE PRUEBA BASICO

Medidas a cuatro terminales

Después de que han sido preparadas las puntas de prueba y conectadas al instrumento para el tipo de prueba que ha de ser llevada a cabo (referirse a 'Técnicas de medición'), proceder como sigue:

1. Seleccionar el alcance de medición requerido. Escoger el alcance más corto si se tienen dudas en cuanto al alcance correcto. Esto puede hacer aparecer el símbolo de fuera de alcance, cuando se pone en marcha el instrumento. Si esto es así, poner el alcance siguiente.
2. Para el DET3/2, girar la manivela del generador a 120 r.p.m. (como mínimo).
   Nota:— El DET5/2 y DET5/2D energiza el circuito de prueba, tan pronto como es seleccionado el circuito de prueba.
3. Comprobar que la visualización no muestre condiciones de prueba adversas, i.e. que no aparezcan los símbolos de alta resistencia de circuito de corriente y ruido excesivo. Además, comprobar que no brillen los símbolos de bajo voltaje de batería (DET5/2 y DET5/2D) y baja velocidad de giro (DET3/2).
4. Pulsar el botón 'Test Rp' para comprobar la resistencia de la pica de potencial. El símbolo de alta resistencia del circuito de potencial no debe aparecer. Soltar el botón.
5. Si son satisfactorias todas las condiciones para llevar a cabo una prueba, la lectura que aparece en la visualización puede ser aceptada como la resistencia de la conexión a tierra. Si se enciende uno cualquiera de los símbolos de la visualización (exceptuando el de polaridad invertida), debe hacerse desaparecer la cuasa de la condición adversa antes de que la lectura pueda ser aceptada.

Medida a tres terminales

El procedimiento es básicamente el mismo que para medidas a 4 terminales, excepto que el botón marcado "C1 - P1" (E - ES) deberá estar presionado y colocado en su posición más baja. Sólo se requiere una conexión desde el terminal "C1" (E1) al electrodo bajo prueba. Para mayor precisión esta conexión deberá hacerse con un cable de prueba corto.

CARGA DE BATERIA (DET5/2)

La batería debe ser cargada tan pronto como aparece en la visualización el indicador de bajo nivel de batería. Si la visualización permanece en blanco cuando se conmuta el instrumento, puede ser que la batería se haya descargado por completo. En este caso, cargar la batería por completo antes de llevar a cabo pruebas algunas.

Nota:— No es aconsejable permitir que la batería se descargue por completo, porque puede recibir desperfectos.

Antes de conectarlo al suministro de la red, asegurar que se instala el fusible correcto y que el ajustador de voltaje tenga la capacidad apropiada para el suministro que ha de ser usado. Para un suministro de 240 V c.a. el fusible debe ser de 50 mA y para uno de 120 V c.a. debe ser de 100 mA (el tipo y el tamaño de los fusibles se incluye en las Especificaciones). El fusible del suministro de la red está situado en el portafusibles, el cual forma parte del enchufe de entrada rebajado incluido en el lateral de la caja. Simplemente deslizar el portafusibles para sacarlo y dejar al descubierto dos fusibles. El interior es el que funciona y el exterior es el de repuesto. El selector de voltaje está situado en el fondo de la caja. Usar un destornillador para girar la marca del voltaje apropiado hasta la flecha indicadora.

Una vez puestos correctamente el fusible y el selector de voltajes, enchufar el conductor del suministro de la red en un enchufe apropiado y llevar a cabo la conexión. Se encenderá una luz LED incluida en el

panel frontal marcada 'Mains On' para mostrar que el instrumento está conectado a un suministro de la red. Dejar que se cargue la batería durante 10 horas aproximadamente.

Precaución:— No dejar los conductores de prueba conectados a los bornes mientras el instrumento recibe energía de la red.

COLOCAR O REEMPLAZAR LAS PILAS (DET5/2D)

Precaución:— Utilizar únicamente pilas del tipo correcto (ver la especificación). Las pilas de repuesto no deberán tener ningún tipo de conexión a los terminales del instrumento.

Separar la tapa del compartimento de las pilas del fondo de la caja. Sacar las pilas viejas y colocar las nuevas en el lugar correcto, como se indica en el compartimento. Volver a poner la tapa y apretar el tornillo de seguridad.

Si el equipo no va a ser usado durante mucho tiempo no deje las pilas puestas, evitará la avería producida por pérdida de electrolitos.

DESCONEXION AUTOMATICA (DET5/2 y DET5/2D)

Para conservar la carga de las pilas estos instrumentos se desconectan automáticamente a los 3 minutos de haber realizado una prueba. Para conectar nuevamente el instrumento girar el conmutador de rango a la posición "OFF" (desconexión) y seleccionar de nuevo el rango requerido.

Esta función no intenta sustituir a la posición "OFF" (desconexión) del instrumento, sino que selecciona un modo de bajo consumo. Por tanto el instrumento deberá desconectarse colocando el interruptor de rango en la posición "OFF" (desconexión). Esto optimizará la vida de las pilas.

RECAMBIO DEL FUSIBLE PROTECTOR DE LA FUENTE DE CORRIENTE

Además del fusible de alimentación del DET5/2, el DET3/2, DET5/2 y DET5/2D tienen un fusible para proteger la salida de la fuento de corriente contra sobre-cargas. Por ejemplo tensiones aplicadas a los terminales C1 y C2.

Este fusible tiene una capacidad de 100 mA y va alojado en un portafusibles situado en la base del instrumento. Cuando se recambia este fusible, usar un destornillador para desenroscar la tapa del portafusibles. El fusible va sujeto a esta tapa. Colocar un nuevo fusible y volver a instalar la tapa.

Precaución:— Todos los fusibles de repuesto deben ser correctos en cuanto a tipo y capacidad (véase la sección Especificaciones).

FALL-OF-POTENTIAL METHOD

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

Hammer the current test spike into the ground some 30 metres to 50 metres away from the earth electrode ('E') to be tested. Connect this spike to the instrument terminal 'C2' (or 'H').

Hammer the potential test spike into the ground mid-way between the current test spike and the earth electrode. Connect this spike to the instrument terminal 'P2' (or 'S').

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 these spikes (remote electrodes), it is preferable not to lay the wires close to each other in order to minimise the effect of mutual inductance.

Connect the 'C1' (or 'E') and the 'P1' (or 'ES') instrument terminals to the earth electrode 'E'. The diagram of Fig. 10 shows the connections.

Operate the instrument as explained in the 'Basic Test Procedure' on page 19, and note the resistance measurement obtained.

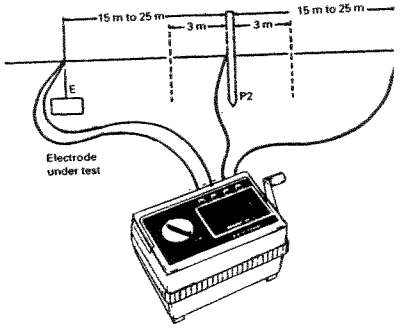


Fig. 10 Fall-of-Potential method for measuring resistance of an earth electrode.

Move the potential spike 3 metres farther awa the earth electrode and make a second resista measurement. Then move the potential spike 3 metres nearer the earth electrode (than the position) and make a third resistance measure

CCIONES DE USO

marcada 'Mains On' para mostrar que el está conectado a un suministro de la red. cargue la batería durante 10 horas nente.

— No dejar los conductores de prueba conectados a los bornes mientras el instrumento recibe energía de la red.

) REEMPLAZAR LAS PILAS (DET5/2D)

— Utilizar únicamente pilas del tipo correcto (ver la especificación). Las pilas de repuesto no deberán tener ningún tipo de conexión a los terminales del instrumento.

ɔa del compartimento de las pilas del ɜja. Sacar las pilas viejas y colocar las lugar correcto, como se indica en el ɪto. Volver a poner la tapa y apretar el ɡuridad.

o va a ser usado durante mucho tiempo as puestas, evitará la avería producida ɜ electrolitos.

ON AUTOMATICA (DET5/2 y

ɪr la carga de las pilas estos instrumentos an automáticamente a los 3 minutos de haber realizado una prueba. Para conectar nuevamente el instrumento girar el conmutador de rango a la posición "OFF" (desconexión) y seleccionar de nuevo el rango requerido.

Esta función no intenta sustituir a la posición "OFF" (desconexión) del instrumento, sino que selecciona un modo de bajo consumo. Por tanto el instrumento deberá desconectarse colocando el interruptor de rango en la posición "OFF" (desconexión). Esto optimizará la vida de las pilas.

RECAMBIO DEL FUSIBLE PROTECTOR DE LA FUENTE DE CORRIENTE

Además del fusible de alimentación del DET5/2, el DET3/2, DET5/2 y DET5/2D tienen un fusible para proteger la salida de la fuento de corriente contra sobre-cargas. Por ejemplo tensiones aplicadas a los terminales C1 y C2.

Este fusible tiene una capacidad de 100 mA y va alojado en un portafusibles situado en la base del instrumento. Cuando se recambia este fusible, usar un destornillador para desenroscar la tapa del portafusibles. El fusible va sujeto a esta tapa. Colocar un nuevo fusible y volver a instalar la tapa.

Precaución:— Todos los fusibles de repuesto deben ser correctos en cuanto a tipo y capacidad (véase la sección Especificaciones).

MEASURING TECHNIQUES Testing Earth Electrodes

FALL-OF-POTENTIAL METHOD

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

Hammer the current test spike into the ground some 30 metres to 50 metres away from the earth electrode ('E') to be tested. Connect this spike to the instrument terminal 'C2' (or 'H').

Hammer the potential test spike into the ground mid-way between the current test spike and the earth electrode. Connect this spike to the instrument terminal 'P2' (or 'S').

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 these spikes (remote electrodes), it is preferable not to lay the wires close to each other in order to minimise the effect of mutual inductance.

Connect the 'C1' (or 'E') and the 'P1' (or 'ES') instrument terminals to the earth electrode 'E'. The diagram of Fig. 10 shows the connections.

Operate the instrument as explained in the 'Basic Test Procedure' on page 19, and note the resistance measurement obtained.

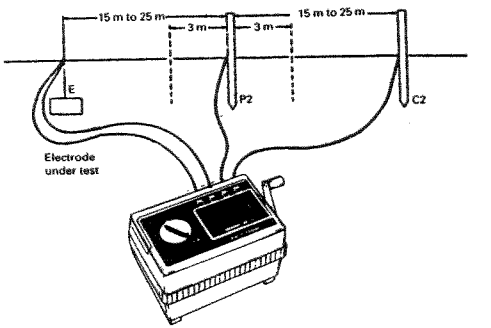


Fig. 10 Fall-of-Potential method for measuring resistance of an earth electrode.

Move the potential spike 3 metres farther away from the earth electrode and make a second resistance measurement. Then move the potential spike 3 metres nearer the earth 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 'E' is to join the 'P1' and 'C1' (or 'E' and 'ES') instrument terminals together and then connect both to the earth electrode 'E' using only one test lead, (as shown in Fig. 11). Press the button labelled 'C1-P1' ('E-ES') to automatically connect these two terminals internally. 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 electrode 'E' and connect it to the 'C2' and 'P2' (or 'H' and 'S') terminals joined together, then measure its resistance in the normal way. This lead resistance can then be deducted from the earth resistance measurements. This procedure is not, of course, necessary if the 'C1' and 'P1' (or 'E' and 'S') terminals are connected by separate test leads.

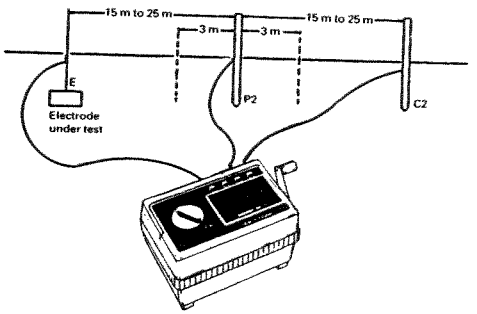


Fig. 11 Fall-of-Potential method using single lead to the earth electrode.

THE 61,8% RULE

To obtain a sensible 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 two areas, see the diagram of Fig. 12. If these requirements are not met, the Fall-of-Potential method may give unsatisfactory results.

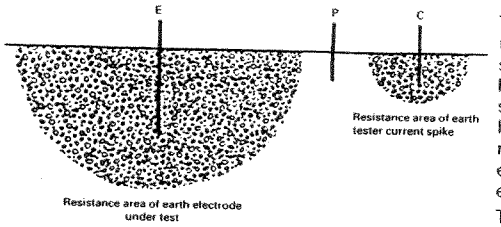


Fig. 12 Resistance areas associated with electrode and current spike.

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 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 only a the earth electrode and both current and spikes are in a straight line, when the so homogeneous and when the earth electi small resistance area that can be approxi hemisphere. Bearing these limitations in method can be used, with care, on small electrode systems consisting of a single etc. and on medium systems with sever

The diagram of Fig. 13 shows the layout Rule.

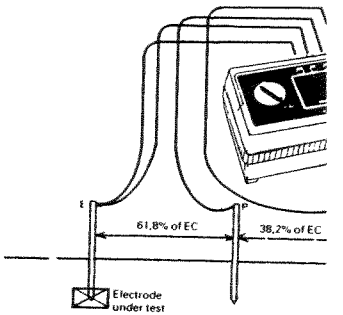


Fig. 13 The 61,8% Rule method

ee resistance readings agree with each other, ıe required accuracy, then their average may as the resistance to earth of the electrode. If ıngs disagree beyond the required accuracy ılternative method should be used e.g. the ule or the Slope method etc.

'otential Method With Short 'E' Lead

way of making connections to the earth ə 'E' is to join the 'P1' and 'C1' (or 'E' and 'ES') ınt terminals together and then connect both rth electrode 'E' using only one test lead, (as ı Fig. 11). Press the button labelled 'C1-P1' o automatically connect these two terminals '. This should ONLY be done if the test lead ept short because its resistance will be in the measurement.

Earth electrode test lead resistance can be determined separately. First remove it from the electrode 'E' and connect it to the 'C2' and 'P2' (or 'H' and 'S') terminals joined together, then measure its resistance in the normal way. This lead resistance can then be deducted from the earth resistance measurements. This procedure is not, of course, necessary if the 'C1' and 'P1' (or 'E' and 'S') terminals are connected by separate test leads.

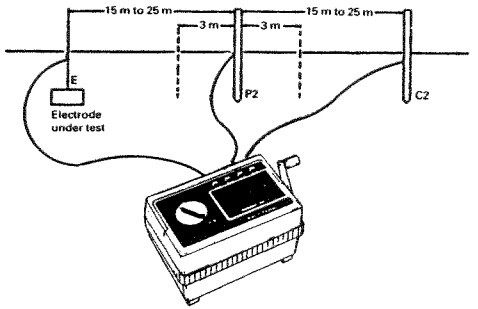


Fig. 11 Fall-of-Potential method using single lead to the earth electrode.

THE 61,8% RULE

To obtain a sensible 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 two areas, see the diagram of Fig. 12. If these requirements are not met, the Fall-of-Potential method may give unsatisfactory results.

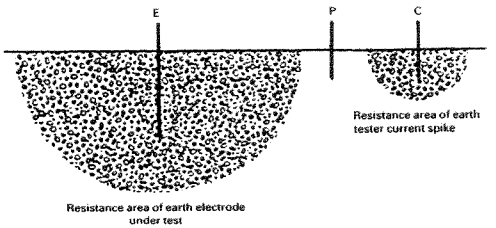


Fig. 12 Resistance areas associated with electrode and current spike.

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 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 only applies when the earth electrode and both current and potential spikes are 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. 13 shows the layout for the 61,8% Rule.

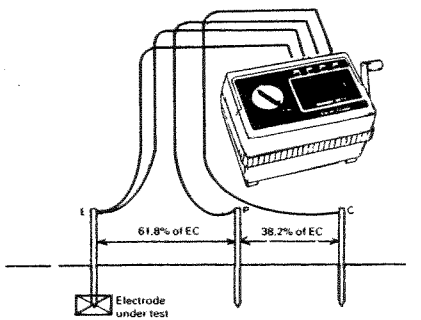


Fig. 13 The 61,8% Rule method.

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 which 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 electrode in metres from centre of earth system	Distance to current electrode 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 either unknown 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 test spikes 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. 14. The remote current spike is placed 50 metres or more away from the earth electrode system to be measured and connected to the instrument's 'C2' (or 'H') 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' (or 'S') terminal. The test spikes and the earth system should all be in a straight line.

The instrument's 'C1' and 'P1' (or 'E' and 'ES') terminals are connected separately to some point on the earth electrode system.

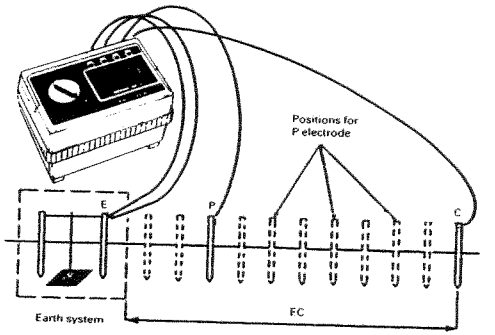


Fig. 14 Connections for the Slope method.

The earth resistance is measured at each separate position of the potential spike and the resistance curve plotted from the results. At least six readings are needed. The diagram of Fig. 15 shows an example. Drawing the curve will show up any incorrect points which may be either re-checked or ignored.

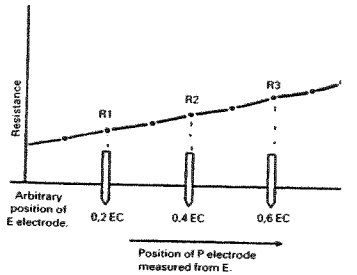


Fig. 15 Resistance curve from Slope met

Suppose the distance from the earth elect system to the current spike is EC. From th equivalent resistance readings to potential positions 0,2 EC, 0,4 EC and 0,6 EC can be These are called R1, R2 and R3 respective

Calculate the slope coefficient μ

where $$\mu = \frac{R3 - R2}{R2 - R1}$$

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

purposes the current spike should be
s to 50 metres from the centre of the earth
under test. The potential spike should be
n the ground 61,8% of this distance,
and in a straight line with, the current spike
arth electrode. The distance is measured
earth electrode.

th electrode system is of medium size
g several rods, then these distances must be
l. The following table gives a range of
which agree with the rule. In the first
Maximum dimension" is the maximum
across the earth electrode system to be
l.

n n s	Distance to potential electrode in metres from centre of earth system	Distance to current electrode in metres from centre of earth system
	62	100
	93	150
	124	200

r accuracy an average reading can be
by moving the current spike, say 10 metres,
nd then away from its first position and
rther 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 either unknown 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 test spikes 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. 14. The remote current spike is placed 50 metres or more away from the earth electrode system to be measured and connected to the instrument's 'C2' (or 'H') 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' (or 'S') terminal. The test spikes and the earth system should all be in a straight line.

The instrument's 'C1' and 'P1' (or 'E' and 'ES') terminals are connected separately to some point on the earth electrode system.

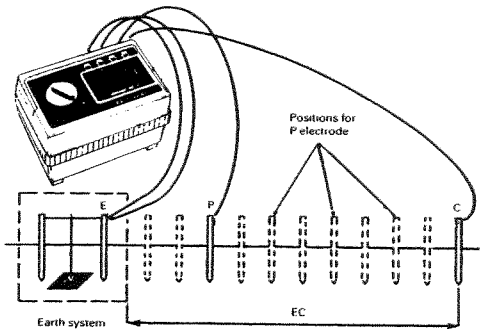


Fig. 14 Connections for the Slope method.

The earth resistance is measured at each separate position of the potential spike and the resistance curve plotted from the results. At least six readings are needed. The diagram of Fig. 15 shows an example. Drawing the curve will show up any incorrect points which may be either re-checked or ignored.

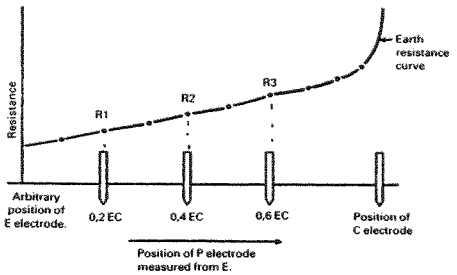


Fig. 15 Resistance curve from Slope method tests.

Suppose the distance from the earth electrode system to the current spike is EC. From the curve equivalent resistance readings to potential spike 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 41 obtain the value of

$$\frac{P_T}{EC}$$

for this value of μ.

P_T is the distance to the potential electrode at the position where the true resistance would be measured.

Multiply the value of $\frac{P_T}{EC}$ by EC to obtain the distance P_T.

From the curve read off the value of resistance that corresponds to this value of P_T. The value obtained is the earth electrode system's resistance.

Notes:— (i) If the value of μ obtained is not covered in the table on page 41 then the current spike will have to be moved farther 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. 16 for example.

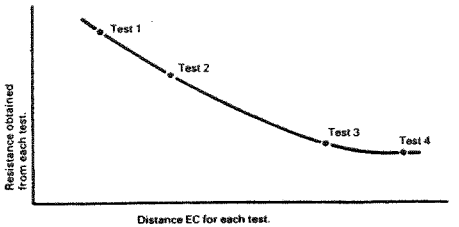


Fig. 16 Possible results from several Slope method tests.

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.

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
0.40	0.6432	6431	6429	6428	6426	6425	6423	6422	6420
0.41	0.6418	6416	6415	6413	6412	6410	6409	6408	6406
0.42	0.6403	6402	6400	6399	6397	6396	6395	6393	6392
0.43	0.6389	6387	6386	6384	6383	6382	6380	6379	6377
0.44	0.6374	6373	6372	6370	6369	6367	6366	6364	6363
0.45	0.6360	6359	6357	6356	6354	6353	6351	6350	6348
0.46	0.6346	6344	6343	6341	6340	6338	6337	6336	6334
0.47	0.6331	6330	6328	6327	6325	6324	6323	6321	6320
0.48	0.6317	6315	6314	6312	6311	6310	6308	6307	6305
0.49	0.6302	6301	6300	6298	6297	6295	6294	6292	6291
0.50	0.6288	6286	6285	6283	6282	6280	6279	6277	6276
0.51	0.6273	6271	6270	6268	6267	6265	6264	6262	6261
0.52	0.6258	6256	6255	6253	6252	6252	6248	6247	6245
0.53	0.6242	6241	6239	6238	6236	6235	6233	6232	6230
0.54	0.6227	6226	6224	6223	6221	6220	6218	6217	6215
0.55	0.6212	6210	6209	6207	6206	6204	6203	6201	6200
0.56	0.6197	6195	6194	6192	6191	6189	6188	6186	6185
0.57	0.6182	6180	6179	6177	6176	6174	6172	6171	6169
0.58	0.6166	6165	6163	6162	6160	6159	6157	6156	6154
0.59	0.6151	6150	6148	6147	6145	6144	6142	6141	6139
0.60	0.6136	6134	6133	6131	6130	6128	6126	6125	6123
0.61	0.6120	6118	6117	6115	6113	6112	6110	6108	6107
0.62	0.6104	6102	6100	6099	6097	6096	6094	6092	6091
0.63	0.6087	6086	6084	6083	6081	6079	6076	6076	6074
0.64	0.6071	6070	6068	6066	6065	6063	6061	6060	6058

e on page 41 obtain the value of

$$\frac{P_T}{EC}$$

of μ.

nce to the potential electrode at the
e the true resistance would be

alue of $\frac{P_T}{EC}$ by EC to obtain the distance P_T.

ve read off the value of resistance that
to this value of P_T. The value obtained is
trode system's resistance.

If the value of μ obtained is not covered in the table on page 41 then the current spike will have to be moved farther away from the earthing system.
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. 16 for example.

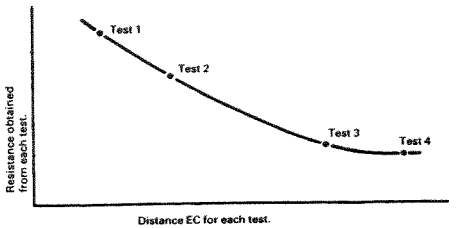


Fig. 16 Possible results from several Slope method tests.

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.

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	6431	6429	6428	6426	6425	6423	6422	6420	6419
0.41	0.6418	6416	6415	6413	6412	6410	6409	6408	6406	6405
0.42	0.6403	6402	6400	6399	6397	6396	6395	6393	6392	6390
0.43	0.6389	6387	6386	6384	6383	6382	6380	6379	6377	6376
0.44	0.6374	6373	6372	6370	6369	6367	6366	6364	6363	6361
0.45	0.6360	6359	6357	6356	6354	6353	6351	6350	6348	6347
0.46	0.6346	6344	6343	6341	6340	6338	6337	6336	6334	6333
0.47	0.6331	6330	6328	6327	6325	6324	6323	6321	6320	6318
0.48	0.6317	6315	6314	6312	6311	6310	6308	6307	6305	6304
0.49	0.6302	6301	6300	6298	6297	6295	6294	6292	6291	6289
0.50	0.6288	6286	6285	6283	6282	6280	6279	6277	6276	6274
0.51	0.6273	6271	6270	6268	6267	6265	6264	6262	6261	6259
0.52	0.6258	6256	6255	6253	6252	6252	6248	6247	6245	6244
0.53	0.6242	6241	6239	6238	6236	6235	6233	6232	6230	6229
0.54	0.6227	6226	6224	6223	6221	6220	6218	6217	6215	6214
0.55	0.6212	6210	6209	6207	6206	6204	6203	6201	6200	6198
0.56	0.6197	6195	6194	6192	6191	6189	6188	6186	6185	6183
0.57	0.6182	6180	6179	6177	6176	6174	6172	6171	6169	6168
0.58	0.6166	6165	6163	6162	6160	6159	6157	6156	6154	6153
0.59	0.6151	6150	6148	6147	6145	6144	6142	6141	6139	6138
0.60	0.6136	6134	6133	6131	6130	6128	6126	6125	6123	6121
0.61	0.6120	6118	6117	6115	6113	6112	6110	6108	6107	6105
0.62	0.6104	6102	6100	6099	6097	6096	6094	6092	6091	6089
0.63	0.6087	6086	6084	6083	6081	6079	6076	6076	6074	6073
0.64	0.6071	6070	6068	6066	6065	6063	6061	6060	6058	6057

Chart for use with the Slope method (contd.)

μ	0	1	2	3	4	5	6	7	8	9
0.65	0.6055	6053	6052	6050	6049	6047	6045	6044	6042	6040
0.66	0.6039	6037	6036	6034	6032	6031	6029	6027	6026	6024
0.67	0.6023	6021	6019	6018	6016	6015	6013	6011	6010	6008
0.68	0.6006	6005	6003	6002	6000	5998	5997	5995	5993	5992
0.69	0.5990	5989	5987	5985	5984	5982	5980	5979	5977	5976
0.70	0.5974	5973	5971	5969	5967	5965	5964	5962	5960	5959
0.71	0.5957	5955	5953	5952	5950	5948	5947	5945	5943	5942
0.72	0.5940	5938	5936	5935	5933	5931	5930	5928	5926	5924
0.73	0.5923	5921	5920	5918	5916	5914	5912	5911	5909	5907
0.74	0.5906	5904	5902	5900	5899	5897	5895	5894	5892	5890
0.75	0.5889	5887	5885	5883	5882	5880	5878	5877	5875	5873
0.76	0.5871	5870	5868	5866	5865	5863	5861	5859	5858	5856
0.77	0.5854	5853	5851	5849	5847	5846	5844	5842	5841	5839
0.78	0.5837	5835	5834	5832	5830	5829	5827	5825	5824	5822
0.79	0.5820	5818	5817	5815	5813	5812	5810	5808	5806	5805
0.80	0.5803	5801	5799	5797	5796	5794	5792	5790	5788	5786
0.81	0.5785	5783	5781	5779	5777	5775	5773	5772	5770	5768
0.82	0.5766	5764	5762	5760	5759	5757	5755	5753	5751	5749
0.83	0.5748	5746	5744	5742	5740	5738	5736	5735	5733	5731
0.84	0.5729	5727	5725	5723	5722	5720	5718	5716	5714	5712
0.85	0.5711	5709	5707	5705	5703	5701	5699	5698	5696	5694
0.86	0.5692	5690	5688	5686	5685	5683	5681	5679	5677	5675
0.87	0.5674	5672	5670	5668	5666	5664	5662	5661	5659	5657
0.88	0.5655	5653	5651	5650	5648	5646	5644	5642	5640	5638
0.89	0.5637	5635	5633	5631	5629	5627	5625	5624	5622	5620

μ	0	1	2	3	4	5	6	7	8
0.90	0.5618	5616	5614	5612	5610	5608	5606	5604	5602
0.91	0.5598	5596	5594	5592	5590	5588	5586	5584	5582
0.92	0.5578	5576	5574	5572	5570	5568	5565	5563	5561
0.93	0.5557	5555	5553	5551	5549	5547	5545	5543	5541
0.94	0.5537	5535	5533	5531	5529	5527	5525	5523	5521
0.95	0.5517	5515	5513	5511	5509	5507	5505	5503	5501
0.96	0.5497	5495	5493	5491	5489	5487	5485	5483	5481
0.97	0.5477	5475	5473	5471	5469	5467	5464	5462	5460
0.98	0.5456	5454	5452	5450	5448	5446	5444	5442	5440
0.99	0.5436	5434	5432	5430	5428	5426	5424	5422	5420
1.00	0.5416	5414	5412	5409	5407	5405	5403	5400	5398
1.01	0.5394	5391	5389	5387	5385	5383	5380	5378	5376
1.02	0.5371	5369	5367	5365	5362	5360	5358	5356	5354
1.03	0.5349	5347	5345	5344	5340	5338	5336	5333	5331
1.04	0.5327	5325	5322	5320	5318	5316	5313	5311	5309
1.05	0.5305	5302	5300	5298	5296	5293	5291	5289	5287
1.06	0.5252	5280	5278	5276	5273	5271	5269	5267	5264
1.07	0.5260	5258	5255	5253	5251	5249	5247	5244	5242
1.08	0.5238	5235	5233	5231	5229	5229	5224	5222	5219
1.09	0.5215	5213	5211	5209	5206	5204	5202	5200	5197
1.10	0.5193	5190	5188	5185	5183	5180	5178	5175	5173
1.11	0.5168	5165	5163	5160	5158	5155	5153	5150	5148
1.12	0.5143	5140	5137	5135	5132	5130	5127	5125	5122
1.13	0.5118	5115	5113	5110	5108	5105	5103	5100	5098
1.14	0.5093	5090	5088	5085	5083	5080	5078	5075	5073

for use with the Slope method (contd.)

0	1	2	3	4	5	6	7	8	9
0.6055	6053	6052	6050	6049	6047	6045	6044	6042	6040
0.6039	6037	6036	6034	6032	6031	6029	6027	6026	6024
0.6023	6021	6019	6018	6016	6015	6013	6011	6010	6008
0.6006	6005	6003	6002	6000	5998	5997	5995	5993	5992
0.5990	5989	5987	5985	5984	5982	5980	5979	5977	5976
0.5974	5973	5971	5969	5967	5965	5964	5962	5960	5959
0.5957	5955	5953	5952	5950	5948	5947	5945	5943	5942
0.5940	5938	5936	5935	5933	5931	5930	5928	5926	5924
0.5923	5921	5920	5918	5916	5914	5912	5911	5909	5907
0.5906	5904	5902	5900	5899	5897	5895	5894	5892	5890
0.5889	5887	5885	5883	5882	5880	5878	5877	5875	5873
0.5871	5870	5868	5866	5865	5863	5861	5859	5858	5856
0.5854	5853	5851	5849	5847	5846	5844	5842	5841	5839
0.5837	5835	5834	5832	5830	5829	5827	5825	5824	5822
0.5820	5818	5817	5815	5813	5812	5810	5808	5806	5805
0.5803	5801	5799	5797	5796	5794	5792	5790	5788	5786
0.5785	5783	5781	5779	5777	5775	5773	5772	5770	5768
0.5766	5764	5762	5760	5759	5757	5755	5753	5751	5749
0.5748	5746	5744	5742	5740	5738	5736	5735	5733	5731
0.5729	5727	5725	5723	5722	5720	5718	5716	5714	5712
0.5711	5709	5707	5705	5703	5701	5699	5698	5696	5694
0.5692	5690	5688	5686	5685	5683	5681	5679	5677	5675
0.5674	5672	5670	5668	5666	5664	5662	5661	5659	5657
0.5655	5653	5651	5650	5648	5646	5644	5642	5640	5638
0.5637	5635	5633	5631	5629	5627	5625	5624	5622	5620

μ	0	1	2	3	4	5	6	7	8	9
0.90	0.5618	5616	5614	5612	5610	5608	5606	5604	5602	5600
0.91	0.5598	5596	5594	5592	5590	5588	5586	5584	5582	5580
0.92	0.5578	5576	5574	5572	5570	5568	5565	5563	5561	5559
0.93	0.5557	5555	5553	5551	5549	5547	5545	5543	5541	5539
0.94	0.5537	5535	5533	5531	5529	5527	5525	5523	5521	5519
0.95	0.5517	5515	5513	5511	5509	5507	5505	5503	5501	5499
0.96	0.5497	5495	5493	5491	5489	5487	5485	5483	5481	5479
0.97	0.5477	5475	5473	5471	5469	5467	5464	5462	5460	5458
0.98	0.5456	5454	5452	5450	5448	5446	5444	5442	5440	5438
0.99	0.5436	5434	5432	5430	5428	5426	5424	5422	5420	5418
1.00	0.5416	5414	5412	5409	5407	5405	5403	5400	5398	5396
1.01	0.5394	5391	5389	5387	5385	5383	5380	5378	5376	5374
1.02	0.5371	5369	5367	5365	5362	5360	5358	5356	5354	5351
1.03	0.5349	5347	5345	5344	5340	5338	5336	5333	5331	5329
1.04	0.5327	5325	5322	5320	5318	5316	5313	5311	5309	5307
1.05	0.5305	5302	5300	5298	5296	5293	5291	5289	5287	5284
1.06	0.5252	5280	5278	5276	5273	5271	5269	5267	5264	5262
1.07	0.5260	5258	5255	5253	5251	5249	5247	5244	5242	5240
1.08	0.5238	5235	5233	5231	5229	5229	5224	5222	5219	5217
1.09	0.5215	5213	5211	5209	5206	5204	5202	5200	5197	5195
1.10	0.5193	5190	5188	5185	5183	5180	5178	5175	5173	5170
1.11	0.5168	5165	5163	5160	5158	5155	5153	5150	5148	5145
1.12	0.5143	5140	5137	5135	5132	5130	5127	5125	5122	5120
1.13	0.5118	5115	5113	5110	5108	5105	5103	5100	5098	5095
1.14	0.5093	5090	5088	5085	5083	5080	5078	5075	5073	5070

Chart for use with the Slope method (contd.)

μ	0	1	2	3	4	5	6	7	8	9
1.15	0.5068	5065	5062	5060	5057	5055	5052	5050	5047	5045
1.16	0.5042	5040	5037	5035	5032	5030	5027	5025	5022	5020
1.17	0.5017	5015	5012	5010	5007	5005	5002	5000	4997	4995
1.18	0.4992	4990	4987	4985	4982	4980	4977	4975	4972	4970
1.19	0.4967	4965	4962	4960	4957	4955	4952	4950	4947	4945
1.20	0.4942	4939	4936	4933	4930	4928	4925	4922	4919	4916
1.21	0.4913	4910	4907	4904	4901	4899	4896	4893	4890	4887
1.22	0.4884	4881	4878	4875	4872	4870	4867	4864	4861	4858
1.23	0.4855	4852	4849	4846	4843	4841	4838	4835	4832	4829
1.24	0.4826	4823	4820	4817	4814	4812	4809	4806	4803	4800
1.25	0.4797	4794	4791	4788	4785	4783	4780	4777	4774	4771
1.26	0.4768	4765	4762	4759	4756	4754	4751	4748	4745	4742
1.27	0.4739	4736	4733	4730	4727	4725	4722	4719	4716	4713
1.28	0.4710	4707	4704	4701	4698	4696	4693	4690	4687	4684
1.29	0.4681	4678	4675	4672	4669	4667	4664	4661	4658	4655
1.30	0.4652	4649	4645	4642	4638	4635	4631	4628	4625	4621
1.31	0.4618	4614	4611	4607	4604	4601	4597	4594	4590	4586
1.32	0.4583	4580	4577	4573	4570	4566	4563	4559	4556	4553
1.33	0.4549	4546	4542	4539	4535	4532	4529	4525	4522	4518
1.34	0.4515	4511	4508	4505	4501	4498	4494	4491	4487	4484
1.35	0.4481	4477	4474	4470	4467	4463	4460	4457	4453	4450
1.36	0.4446	4443	4439	4436	4432	4429	4426	4422	4419	4415
1.37	0.4412	4408	4405	4402	4398	4395	4391	4388	4384	4381
1.38	0.4378	4374	4371	4367	4364	4360	4357	4354	4350	4347
1.39	0.4343	4340	4336	4333	4330	4326	4323	4319	4316	4312

μ	0	1	2	3	4	5	6	7	8
1.40	0.4309	4305	4301	4296	4292	4288	4284	4280	4275
1.41	0.4267	4263	4258	4254	4250	4246	4242	4237	4233
1.42	0.4225	4221	4216	4212	4208	4204	4200	4195	4191
1.43	0.4183	4178	4174	4170	4166	4162	4157	4153	4149
1.44	0.4141	4136	4132	4128	4124	4120	4115	4111	4107
1.45	0.4099	4094	4090	4086	4082	4077	4073	4069	4065
1.46	0.4056	4052	4048	4044	4040	4035	4031	4027	4023
1.47	0.4014	4010	4005	4001	3997	3993	3989	3985	3980
1.48	0.3972	3968	3964	3959	3955	3951	3947	3943	3938
1.49	0.3930	3926	3921	3917	3913	3909	3905	3900	3896
1.50	0.3888	3883	3878	3874	3869	3864	3859	3854	3850
1.51	0.3840	3835	3830	3825	3820	3816	3811	3806	3801
1.52	0.3791	3786	3781	3776	3771	3766	3760	3755	3750
1.53	0.3740	3735	3730	3724	3719	3714	3709	3704	3698
1.54	0.3688	3683	3677	3672	3667	3662	3656	3651	3646
1.55	0.3635	3630	3624	3619	3613	3608	3602	3597	3591
1.56	0.3580	3574	3569	3563	3557	3552	3546	3540	3534
1.57	0.3523	3517	3511	3506	3500	3494	3488	3482	3477
1.58	0.3465	3459	3453	3447	3441	3435	3429	3423	3417
1.59	0.3405	3399	3393	3386	3380	3374	3368	3362	3355

for use with the Slope method (contd.)

0	1	2	3	4	5	6	7	8	9
0.5068	5065	5062	5060	5057	5055	5052	5050	5047	5045
0.5042	5040	5037	5035	5032	5030	5027	5025	5022	5020
0.5017	5015	5012	5010	5007	5005	5002	5000	4997	4995
0.4992	4990	4987	4985	4982	4980	4977	4975	4972	4970
0.4967	4965	4962	4960	4957	4955	4952	4950	4947	4945
0.4942	4939	4936	4933	4930	4928	4925	4922	4919	4916
0.4913	4910	4907	4904	4901	4899	4896	4893	4890	4887
0.4884	4881	4878	4875	4872	4870	4867	4864	4861	4858
0.4855	4852	4849	4846	4843	4841	4838	4835	4832	4829
0.4826	4823	4820	4817	4814	4812	4809	4806	4803	4800
0.4797	4794	4791	4788	4785	4783	4780	4777	4774	4771
0.4768	4765	4762	4759	4756	4754	4751	4748	4745	4742
0.4739	4736	4733	4730	4727	4725	4722	4719	4716	4713
0.4710	4707	4704	4701	4698	4696	4693	4690	4687	4684
0.4681	4678	4675	4672	4669	4667	4664	4661	4658	4655
0.4652	4649	4645	4642	4638	4635	4631	4628	4625	4621
0.4618	4614	4611	4607	4604	4601	4597	4594	4590	4586
0.4583	4580	4577	4573	4570	4566	4563	4559	4556	4553
0.4549	4546	4542	4539	4535	4532	4529	4525	4522	4518
0.4515	4511	4508	4505	4501	4498	4494	4491	4487	4484
0.4481	4477	4474	4470	4467	4463	4460	4457	4453	4450
0.4446	4443	4439	4436	4432	4429	4426	4422	4419	4415
0.4412	4408	4405	4402	4398	4395	4391	4388	4384	4381
0.4378	4374	4371	4367	4364	4360	4357	4354	4350	4347
0.4343	4340	4336	4333	4330	4326	4323	4319	4316	4312

μ	0	1	2	3	4	5	6	7	8	9
1.40	0.4309	4305	4301	4296	4292	4288	4284	4280	4275	4271
1.41	0.4267	4263	4258	4254	4250	4246	4242	4237	4233	4229
1.42	0.4225	4221	4216	4212	4208	4204	4200	4195	4191	4187
1.43	0.4183	4178	4174	4170	4166	4162	4157	4153	4149	4145
1.44	0.4141	4136	4132	4128	4124	4120	4115	4111	4107	4103
1.45	0.4099	4094	4090	4086	4082	4077	4073	4069	4065	4061
1.46	0.4056	4052	4048	4044	4040	4035	4031	4027	4023	4018
1.47	0.4014	4010	4005	4001	3997	3993	3989	3985	3980	3976
1.48	0.3972	3968	3964	3959	3955	3951	3947	3943	3938	3934
1.49	0.3930	3926	3921	3917	3913	3909	3905	3900	3896	3892
1.50	0.3888	3883	3878	3874	3869	3864	3859	3854	3850	3845
1.51	0.3840	3835	3830	3825	3820	3816	3811	3806	3801	3796
1.52	0.3791	3786	3781	3776	3771	3766	3760	3755	3750	3745
1.53	0.3740	3735	3730	3724	3719	3714	3709	3704	3698	3693
1.54	0.3688	3683	3677	3672	3667	3662	3656	3651	3646	3640
1.55	0.3635	3630	3624	3619	3613	3608	3602	3597	3591	3586
1.56	0.3580	3574	3569	3563	3557	3552	3546	3540	3534	3528
1.57	0.3523	3517	3511	3506	3500	3494	3488	3482	3477	3471
1.58	0.3465	3459	3453	3447	3441	3435	3429	3423	3417	3411
1.59	0.3405	3399	3393	3386	3380	3374	3368	3362	3355	3349

METHOD WHEN "DEAD" EARTH IS AVAILABLE

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 these cases an alternative low resistance earth such as a water main may be available. This is referred to as a "dead" earth.

This must be of very low resistance to earth and connections are as shown in Fig. 17 with the 'C1-P1' ('E-ES') button in the depressed position. This test will give the combined resistance 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.

However, great care must be taken before deciding to adopt this method and its use is not to be encouraged. This is because non-metallic piping and jointing materials are commonly found in water main and other installations nowadays and such materials are totally unsuitable as a substitute earth spike. 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.

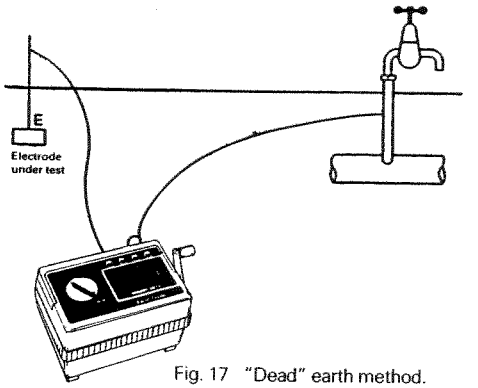


Fig. 17 "Dead" earth method.

If only two test leads are used as shown in the diagram, the resistance of both leads will be included in the measurement. The resistance of the leads can be found by joining their ends together, operating the instrument and taking the reading in the usual way. This value should be subtracted from the total to obtain the combined resistance of the earth electrode and the "dead" earth.

15th EDITION IEE WIRING REGULATIONS REQUIREMENT

Regulation 613-4 of the 15th Edition IEE Wiring Regulations specifies that the resistance of earth electrodes must be measured and the method to be used is described in Appendix 15 Item 4. This is basically the Fall-of-Potential method, but specifies that the potential spike must be moved 6 metres either side of the central position for the second and third resistance measurements (see Fig. 18). If the three results are in substantial agreement, the average of them is taken as the resistance of the earth electrode. If there is no agreement then the current spike must be moved farther away from the electrode and the tests repeated.

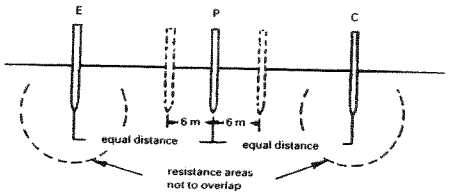


Fig. 18 Test spike positions for the 15th Edition IEE Wiring Regulations.

OTHER METHODS

There are other earth electrode resistance tes methods among which are the Four Potential the Intersecting Curves method and the Star-[method which is suitable for congested urban

D WHEN "DEAD" EARTH IS AVAILABLE

niques using test spikes explained earlier are erred methods of earth testing. In congested nay not be possible to find suitable sites for spikes, nor sufficient space to run the test these cases an alternative low resistance ch as a water main may be available. This is to as a "dead" earth.

it be of very low resistance to earth and ons are as shown in Fig. 17 with the 'C1-P1' utton in the depressed position. This test will combined resistance of the two earths in that of the "dead" earth is negligible then the nay be taken as that of the electrode under

, great care must be taken before deciding to s method and its use is not to be encouraged. ecause non-metallic piping and jointing are commonly found in water main and tallations nowadays and such materials are suitable as a substitute earth spike. Before ig this method, the user must be quite sure art of the "dead" earth installation contains other non-metallic materials.

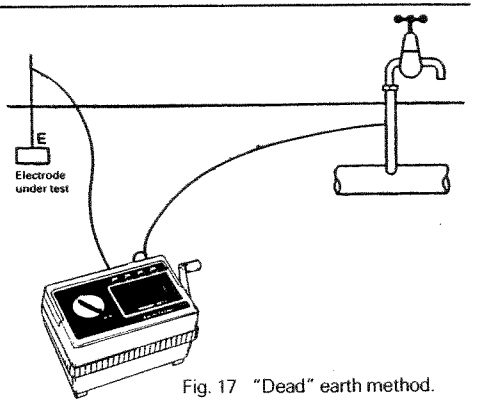


Fig. 17 "Dead" earth method.

If only two test leads are used as shown in the diagram, the resistance of both leads will be included in the measurement. The resistance of the leads can be found by joining their ends together, operating the instrument and taking the reading in the usual way. This value should be subtracted from the total to obtain the combined resistance of the earth electrode and the "dead" earth.

15th EDITION IEE WIRING REGULATIONS REQUIREMENT

Regulation 613-4 of the 15th Edition IEE Wiring Regulations specifies that the resistance of earth electrodes must be measured and the method to be used is described in Appendix 15 Item 4. This is basically the Fall-of-Potential method, but specifies that the potential spike must be moved 6 metres either side of the central position for the second and third resistance measurements (see Fig. 18). If the three results are in substantial agreement, the average of them is taken as the resistance of the earth electrode. If there is no agreement then the current spike must be moved farther away from the electrode and the tests repeated.

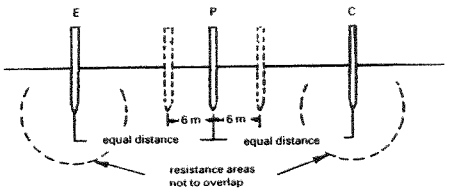


Fig. 18 Test spike positions for the 15th Edition IEE Wiring Regulations.

OTHER METHODS

There are other earth electrode resistance testing methods among which are the Four Potential method, the Intersecting Curves method and the Star-Delta method which is suitable for congested urban areas.

MEASURING TECHNIQUES Determining 'Touch' and 'Step' Potential

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 to earth occurred.

Connect the instrument in the following way:—
Terminal 'C1' (or 'E') to the substation earth.
Terminal 'C2' (or 'H') to the current spike inserted in the ground some distance away.
Terminal 'P1' (or 'ES') to the structure being tested e.g. the perimeter fence.
Terminal 'P2' (or 'S') to a potential spike inserted in the ground 1 metre away from the perimeter fence adjacent to the point where a person might stand.

Operate the instrument and record the resistance indicated. 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.

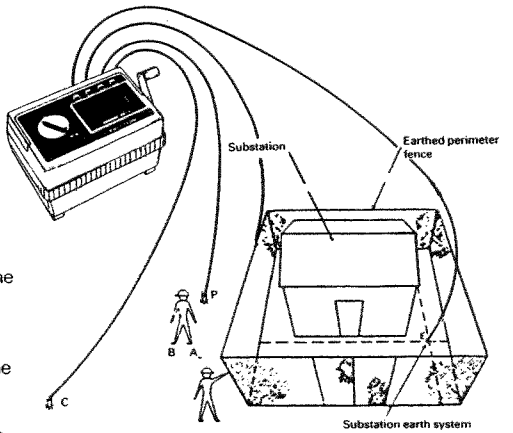


Fig. 19 Determining 'Touch' and 'Step' potential.

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.

Connect the 'C1' and 'C2' (or 'E' and 'H') terminals as described for touch potential measurement above. Connect the 'P1' and 'P2' terminals to test spikes inserted in the ground at positions A and B respectively, (see Fig. 19); A is nearest to the substation earth. Positions A and B are 1 metre apart, or the length of a step.

Operate the instrument and 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 be known (as is the case with Touch potential). From Ohm's Law (V = I x R), the Step potential can be calculated.

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 ohm-cms	Source of information
Ashes	350	Higgs
Coke	20-800	—
Peat	4,500-20,000	—
Garden earth – 50% moisture	1,400	Ruppel
" " – 20% moisture	4,800	"
Clay soil – 40% moisture	770	"
" " – 20% moisture	3,300	—
London clay	400-2,000	—
Very dry clay	5,000-15,000	—
Sand – 90% moisture	13,000	Ruppel
" – normal moisture	300,000-800,000	—
Chalk	5,000-15,000	—
Consolidated sedimentary rocks	1,000-50,000	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 is to 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 driven into the ground in a stright 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. 20.

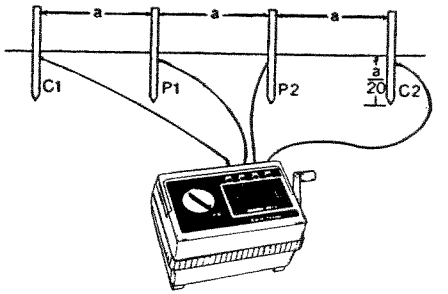


Fig. 20 Connections for resistivity testing.

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. 21 on page 50. 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 '1/20 a' 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 '1/20 b', '1/20 c', '1/20 d', 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.

CALCULATION OF RESISTIVITY

Assuming that the soil in which the tests w is homogeneous the resistivity is given by t formula:—

$$\rho = 2\pi aR$$

where R is the resistance measured in ohm test spike spacing in metres and ρ is the res ohm-metres.

For non-homogeneous soils the formula wil apparent resistivity which is very approxima average value to a depth equal to the test sp spacing 'a'.

ARIATIONS IN SOIL RESISTIVITY

ıce to earth of an earth electrode is
ɔy the resistivity of the surrounding soil.
ity depends upon the nature of the soil and
content and can vary enormously as seen
below:—

	Specific resistance in ohm-cms	Source of information
	350	Higgs
	20-800	—
	4,500-20,000	—
-50% moisture	1,400	Ruppel
-20% moisture	4,800	"
moisture	770	"
moisture	3,300	—
	400-2,000	—
	5,000-15,000	—
oisture	13,000	Ruppel
l moisture	300,000-800,000	—
	5,000-15,000	—
sedimentary	1,000-50,000	Broughton Edge & Laby

s impossible to forecast the resistivity of
ı any degree of accuracy it is important to
ɜ resistance of an earth electrode when it
own and thereafter at periodic intervals.
ng an electrode into the ground for a new
t is often advantageous to make a
survey of the soil resistivity of the
site. This will enable decisions to be made on the best position for the electrode(s) and to decide whether any advantage is to 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 driven into the ground in a stright 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. 20.

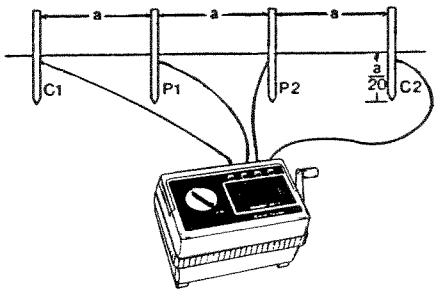


Fig. 20 Connections for resistivity testing.

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. 21 on page 50. 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 '1/20 a' 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 '1/20 b', '1/20 c', '1/20 d', 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.

CALCULATION OF RESISTIVITY

Assuming that the soil in which the tests were made is homogeneous the resistivity is given by the formula:—

$$\rho = 2\pi aR$$

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'.

MEASURING TECHNIQUES Measuring Resistivity of the Soil

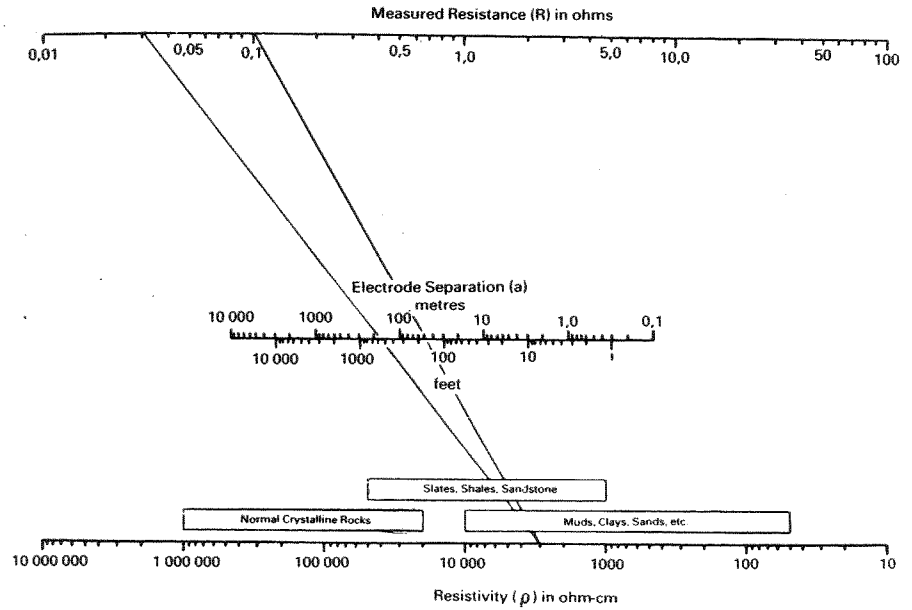


Fig. 21 Nomogram for resistivity calculations.

MEASURING TECHNIQUES Continuity Testing

To test the continuity of conduit or other earth conductors the instrument is connected as shown in Fig. 22. It will measure metallic resistances of low inductance or capacitance. Make sure that the circuit is 'dead' i.e. de-energized, before connecting the instrument for measurement.

Due to the inherent high accuracy of the instrument and the low continuity resistance to be measured, the 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.

The resistance of the test leads may be found by connecting them to the 'P1' and 'P2' (or 'ES' and 'S') terminals and joining their free ends together. 'C1' and 'P1', and 'C2' and 'P2' (or 'E' and 'ES', and 'S' and 'H'), must be joined together before the measurement is made in the normal way. The test lead resistance is subtracted from the original reading to give the value of the continuity resistance. Alternatively use of the four terminal technique will eliminate the test lead resistance.

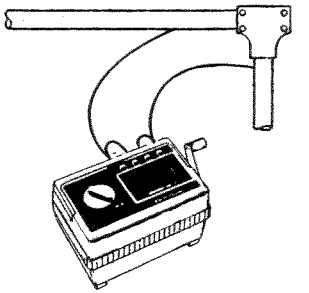


Fig. 22 Continuity testing.

SURING TECHNIQUES Measuring Resistivity of the Soil

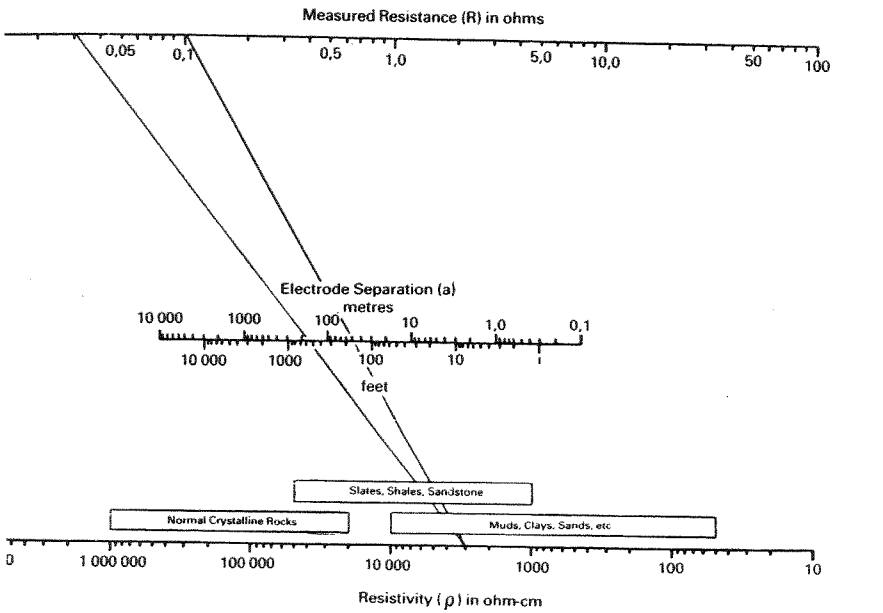


Fig. 21 Nomogram for resistivity calculations.

MEASURING TECHNIQUES Continuity Testing

To test the continuity of conduit or other earth conductors the instrument is connected as shown in Fig. 22. It will measure metallic resistances of low inductance or capacitance. Make sure that the circuit is 'dead' i.e. de-energized, before connecting the instrument for measurement.

Due to the inherent high accuracy of the instrument and the low continuity resistance to be measured, the 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.

The resistance of the test leads may be found by connecting them to the 'P1' and 'P2' (or 'ES' and 'S') terminals and joining their free ends together. 'C1' and 'P1', and 'C2' and 'P2' (or 'E' and 'ES', and 'S' and 'H'), must be joined together before the measurement is made in the normal way. The test lead resistance is subtracted from the original reading to give the value of the continuity resistance. Alternatively use of the four terminal technique will eliminate the test lead resistance.

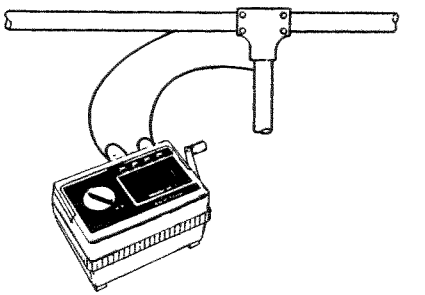


Fig. 22 Continuity testing.

CIRCUIT DESCRIPTION

The instrument employs the four terminal measurement principle, and so the potential drop across the earth resistance under test is fed to the measuring circuit via terminals 'P1' and 'P2' (or 'ES' and 'S'). An input buffer stage prevents the measuring circuit from loading the earth resistance being tested.

The test signal controls a constant current a.c. source powered from a 'floating' supply and switched to provide the three ranges. The test current is passed via the 'C1' and 'C2' (or 'E' and 'H') terminals through the earth under test.

A crystal controlled oscillator is at the heart of the waveform generator circuit. The fundamental frequency so derived is then sub-divided to provide a test signal of 135 Hz. Waveforms are also generated to operate the phase sensitive filter and detector circuits.

To remove noise imposed on the test signal as it passes through the earth under test, a phase sensitive filter is employed. The measurement signal is shown on the display directly in the units of ohms.

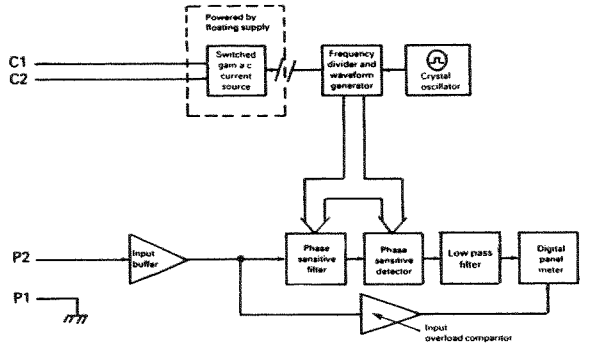


Fig. 23 Block diagram of instrument circuit.

WARRANTY

Products supplied by Biddle Instruments are warranted against defects in
and workmanship for a period of one year following shipment. Our lia
specifically limited to replacing or repairing, at our option, defective equ
Equipment returned to the factory for repair *must* be shipped prepaid and i
This warranty does not include batteries, lamps, or other expendable items
the original manufacturer's warranty shall apply. We make no other warrar
warranty is void in the event of abuse (failure to follow recommended op
procedures) or failure by the customer to perform specified maintena
indicated in this manual.

REPAIRS

Biddle Instruments maintains a complete instrument repair service, and
mends that its customers take advantage of this service in the event of equ
malfunction. Please indicate all pertinent information including problem
toms and attempted repairs. When returning equipment for repair, either i
of warranty, it *must* be shipped prepaid and insured, and marked for the a
of the Repair Department.

)ESCRIPTION

t employs the four terminal
principle, and so the potential drop
h resistance under test is fed to the
uit via terminals 'P1' and 'P2' (or 'ES'
ut buffer stage prevents the measuring
ding the earth resistance being tested.

controls a constant current a.c. source
a 'floating' supply and switched to
ee ranges. The test current is passed
l 'C2' (or 'E' and 'H') terminals through
test.

A crystal controlled oscillator is at the heart of the waveform generator circuit. The fundamental frequency so derived is then sub-divided to provide a test signal of 135 Hz. Waveforms are also generated to operate the phase sensitive filter and detector circuits.

To remove noise imposed on the test signal as it passes through the earth under test, a phase sensitive filter is employed. The measurement signal is shown on the display directly in the units of ohms.

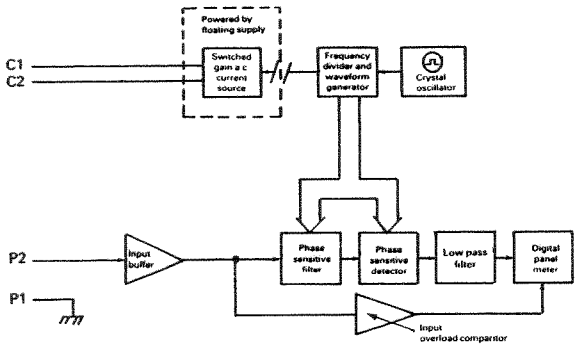


Fig. 23 Block diagram of instrument circuit.

WARRANTY

Products supplied by Biddle Instruments are warranted against defects in material and workmanship for a period of one year following shipment. Our liability is specifically limited to replacing or repairing, at our option, defective equipment. Equipment returned to the factory for repair *must* be shipped prepaid and insured. This warranty does not include batteries, lamps, or other expendable items, where the original manufacturer's warranty shall apply. We make no other warranty. The warranty is void in the event of abuse (failure to follow recommended operating procedures) or failure by the customer to perform specified maintenance as indicated in this manual.

REPAIRS

Biddle Instruments maintains a complete instrument repair service, and recommends that its customers take advantage of this service in the event of equipment malfunction. Please indicate all pertinent information including problem symptoms and attempted repairs. When returning equipment for repair, either in or out of warranty, it *must* be shipped prepaid and insured, and marked for the attention of the Repair Department.