Digital Earth Testers
MEGGER® DET5/3R & DET5/3D

User Guide
Guide Utilisateur
Gebrauchsanleitung
Guía del Usuario

MEGGER®

SAFETY WARNINGS

- 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 ***DET5/3D*** must be disconnected from any external circuit while its battery cells are changed.
- Replacement fuses **must** be of the correct type and rating
- Before charging the ***DET5/3R*** 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

This instrument must only be used by suitably trained and competent persons.

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Illustrations

DET 5/3R Battery Charger Power cord:
If the power cord plug is not suitable for your type of socket outlets, do not use an adaptor. You should use a suitable alternative power cord, or if necessary change the plug by cutting the cord and fitting a suitable plug.

The colour code of the cord is:

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

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

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

GENERAL DESCRIPTION

The ***DET5/3R*** and ***DET5/3D MEGGER®*** Digital Earth Testers are compact instruments designed to measure earth electrode resistance and perform four terminal continuity tests. They may also make earth resistance tests which lead to the measurement of soil resistivity. The ***DET5/3R*** has an internal rechargeable battery, with an integral charger unit. The ***DET5/3D*** is powered from six internal, replacement 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 ***DET5/3R*** and ***DET5/3D*** the resistance of the potential circuit test leads can also be ignored because a buffer stage is incorporated to prevent the measuring circuit from loading the earth resistance under test.

Operation of the instrument is extremely simple. Two modes of operation are selected by means of two push buttons; one for a three terminal test and one for a four terminal test. All other functions of the instrument are automatic.

A reversing d.c. test current, generated electronically from a “floating” constant current source within the instrument, is passed via the ‘C1‘ and ‘C2’ terminals through the earth being tested. The potential developed across the earth is compared with the current and, after filtering and phase sensitive detection the resistance is given directly on the digital display.

The test frequency is 128 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 a maximum of 10 mA.

INSTRUMENT DESIGN

The instruments are very robust and have tough cases moulded in ABS plastic. Test leads are not supplied with an instrument but form part of an earth testing field accessory kit which is available as an option. This kit also includes test spikes (electrodes) for making temporary earth spikes.

Mounted on the front panel are two push-button switches for testing using either 3 or 4 terminal measurement. The instrument’s 3½digit liquid crystal display shows the test result and also indicates a low battery voltage. LEDs show high current circuit resistance, a high potential circuit resistance, (both usually caused by a high test spike resistance) and a “noisy” earth environment, As these factors can influence the measurement being made, noise and current circuit resistance are continuously monitored during a test, while a check of the potential circuit resistance is made at the start of each test. The display shows all measurements directly in ohms or kilohms

with the decimal point automatically positioned. It also gives an over-range indication if the resistance under test exceeds 20 kΩ.

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

The terminal C1 (E) is for the current connection to the earth electrode to be tested.
The terminal P1 (ES) is for the potential connection to the earth electrode to be tested.
The terminal P2 (S) is for the connection to the remote potential test spike.
The terminal C2 (H) is for the connection to the remote current test spike.
In terms of safety the instruments meet, in general, the requirements of IEC 1010-1(1990).

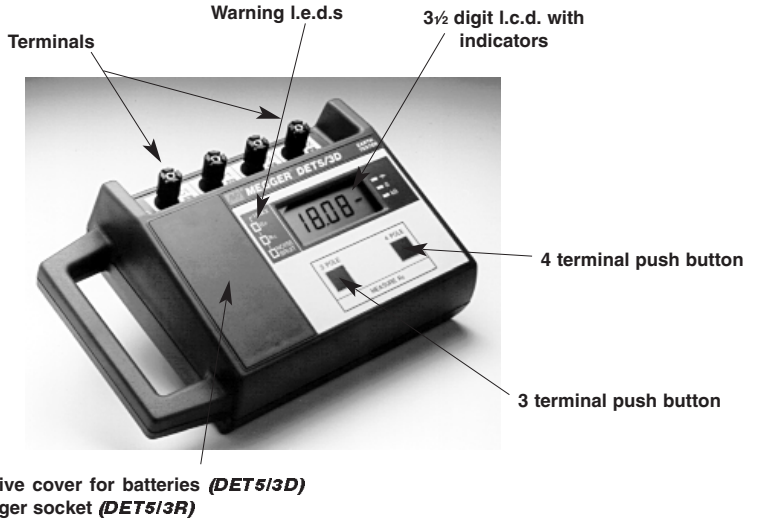


Figure 1. DET5/3D Earth Tester

APPLICATIONS

The installation of satisfactory earthing systems is an essential part of electricity supply, wiring safety and installation economics. It is also of great importance in many communications systems.

The primary application of the ***DET5/3R*** and ***DET5/3D*** is in the testing of earth electrodes, whether these take the form of a single electrode, multiple electrodes, mesh systems, earth plates or earth strips. All earthing arrangements should be tested immediately after installation and at periodic intervals thereafter.

CHOICE OF ELECTRODE SITE

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

EARTHING SYSTEMS MAINTENANCE

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

OTHER APPLICATIONS

For 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, for example checking the resistance of conductors used in an earthing circuit.

Resistances between 0,01 Ω and 19,99 kΩ can be measured with a basic accuracy of ±2% of reading ±3 digits. Individual test spike resistances of up to 4 kΩ for the current loop or 100 kΩ for the potential circuit 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 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 7430 (1992) BS7671 (1992) VDE 0413 Part 7 (1982) IEC364 NFC 15-100
Test Frequency	128 Hz ±0,5 Hz
Test Current	20 Ω range 10 mA a.c. r.m.s. 200 Ω range 1 mA a.c. r.m.s. 2 kΩ and 20 kΩ ranges 100 µA a.c. r.m.s Test current (= short circuit current) is constant throughout a range.
Interference	Interference voltages of 20 V ±1,0 V pk to pk at 50 Hz, 60 Hz, 200 Hz or 16⅔ Hz in the potential circuit will have a max. effect of ±1% on the reading obtained for the 20 Ω to 2 kΩ ranges. In the 20 kΩ range this is reduced to 16 V pk to pk.
Max. Current Loop Resistance	The loop resistance that will introduce an additional1% error is: 20 Ω range 4 kΩ 200 Ω range 40 kΩ 2 kΩ and 20 kΩ ranges 400 kΩ (These are loop resistances, therefore the resistance under test must be subtracted from these figures).

SPECIFICATION

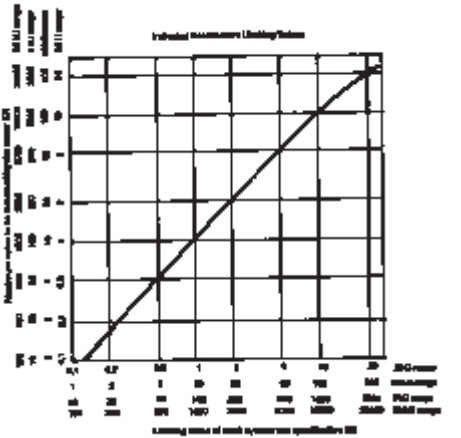
Max. Potential Spike Resistance		75 kΩ
Max. Output Voltage		50 V
Display		3½ digit l.c.d. maximum reading 1999
Instrument Protection		IP54
Temperature Effect		<±0,1%/°C over the temperature range - 15°C to +55°C
Temperature Range	operating	-20°C to +45°C (0°C to +55°C for the ***DET5/3D***)
	storage	-40°C to +70°C (for the DET5/3D, without batteries)
Humidity	operating	90% RH max. at 45°C
	storage	70% RH max. at 55°C
Flash Test		3 kV a.c.
Voltage Withstand		In the event of a system fault the instrument will withstand 240 V a.c. applied between any two terminals.
Power Supply	***DET5/3R***	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; 800 x 15 s tests Battery charging time, 10 hours max. (from completely exhausted). Charging supply required, (user selectable) 200 V to 255 V a.c. or 100 V to 130 V a.c. 50 Hz/60 Hz.
	DET5/3D	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; 5oo x 15 s tests.

Fuses	***DET5/3D***	Internal 100 mA ceramic HBC 20 mm x 5 mm IEC 127/1 (for current source protection) Internal 100 mA ceramic HBC 20 mm x 5 mm IEC 127/1 (for potential circuit protection)
	DET5/3R	Internal 100 mA ceramic HBC 20 mm x 5 mm IEC 127/1 (for current source protection) Internal 100 mA ceramic HBC 20 mm x 5 mm IEC 127/1 (for potential circuit protection) 50 mA ceramic HBC 20 mm x 5 mm IEC 127/1 for 240 V a.c.supply, or 100 mA ceramic HBC 20 mm x 5 mm IEC127/1 for 120 V a.c supply (for circuit protection during battery charging). Mains power cord fused plug : 3 Amp fuse to BS 1362
Safety		The instrument meets the requirements for safety to IEC 1010-1 1992), EN61010-1 (1993).
E.M.C.		The instrument meets EN 50081-1 and EN 50082-1 (1992).
Dimensions		238 mm x 153 mm x 70 mm (9,4 in x 6 in x 2,75 in approx.)
Weight	***DET5/3R***	1,27 kg (2,8 lb approx.)
	DET5/3D	0,82 kg (1.5 lb approx.)

SPECIFICATION

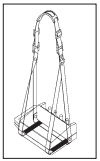
The VDE 0413 part 7 specification stipulates that these instructions should contain a diagram showing the maximum value which the instrument must indicate in certain conditions. An earth test being performed on any electrode system would normally be carried out to a particular specification. Therefore, even at the instrument's worst accuracy, the reading 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

	PART NUMBER
SUPPLIED	
User Guide	
Power cord (for battery charging ***DET5/3R***)	
OPTIONAL	
Instrument carrying harness	6220 - 537
Carrying Case	6420 - 103
Four Terminal Earth Testing kit	6310 - 755
comprising carrying bag containing:- Club hammer, 4 x galvanized steel spikes 12 mm square x 450 mm long; two spike extractors, 3m (x2), 30, and 50m lengths of terminated cable on cable winders.	
Four Terminal Compact Earth Testing kit	6210 - 161
comprising carrying bag containing:- 4 x push in galvanized steel spikes 10 mm diam. x 450 mm long; 3m, 15m, 30, and 50m lengths of terminated cable on a shaped cable tidy.	
Three Terminal Compact Earth Testing Kit	6210 - 160
comprising carrying bag containing:- 2 x push in galvanized steel spikes 10 mm diam. x 450 mm long; 3m, 15m and 30m lengths of terminated cable on a shaped cable tidy.	
Publications	
'A Simple Guide To Earth Testing'	6171 - 230
'Getting Down to Earth'	AVTB25-TA



Carrying Harness 6220-537

Four Terminal Earth Testing Kit 6310 - 755

Four Terminal Compact Earth Testing Kit 6210-161

Fig.2 Instrument Accessories

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 of 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
   When measuring live earths, safety hazards 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 (for 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, establish connections .Make the connections to the isolation switch first and then connect the remote test spikes (electrodes).

e) When the remote test spikes have been connected the isolation switch may be closed and a measurement 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 position.

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).

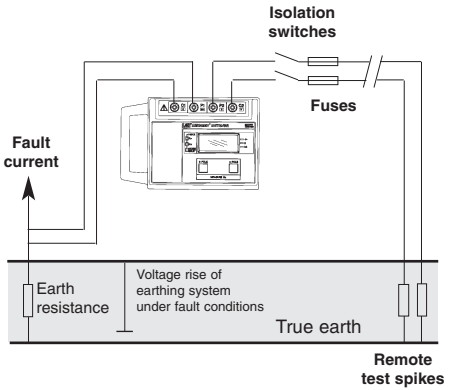


Fig. 3 A method of disconnection where fault conditions may occur

4. When charging the ***DET5/3R*** battery:-

a) Before switching the supply on, make sure that the voltage selector has been correctly set and that the correctly rated fuse for that supply has been fitted (see the Specification page 9).

b) 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 subject 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 taken in handling the printed circuit board. This should be done in accordance with DEF STAN 59-98 and BS 5783, specifications for handling electrostatic devices.

Note:- Opening the casing may invalidate any warranty covering the instrument unless carried out by an approved repair organisation. (See page 58).

2. It is advisable that, when working with the ***DET5/3R*** the battery is fully charged before embarking on a test sequence. It can be extremely inconvenient if the battery becomes too low while a field test is in progress. Similarly, with the ***DET5/3D*** new batteries should always be available.

DISPLAY SYMBOLS

The 3½ digit l.c.d. shows the reading directly and the Ω or **k**Ω symbol on the display for the units of measurement. The 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 battery voltage

If the battery voltage is too low the segment of the display alongside the battery symbol will flash. In this case the batteries hold only enough charge for one or two more measurements and must be recharged (***DET5/3R***) or replaced (***DET5/3D***) before further testing.

Figure 4 Low battery symbol

High Current Spike Resistance

To indicate that the resistance of the current circuit is too high for an accurate measurement, an LED 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 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. 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.

High Potential Spike Resistance

To indicate that the resistance of the potential probe is too high an LED illuminates alongside the Rp mark on the graphics panel. This test is carried out at the

beginning of a test before a reading is taken. The reasons for its appearance are the same as for the high current spike resistance symbol and similar remedies may be used.

Figure 5 High current spike LED

Excessive Noise Interference
The '**Noise**' LED lights 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 or to choose a different position for the test spikes.

Over-range
To indicate that the resistance being measured is beyond the maximum range an 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 there is something wrong with the earth electrode under test or the connections to the instrument or electrodes.

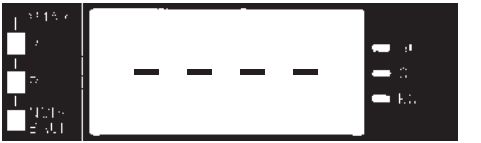


Figure 6 Test bars

Reverse polarity
When the potential test leads are reversed with respect to the current leads, the display flashes between the test bars and a reading. To take a valid reading, make sure that the 'P1' electrode is closer to 'C1' than the 'P2' electrode.

OPERATION

SETTING UP THE TEST SPIKES ETC.

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

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

BASIC TEST PROCEDURE

Four Terminal Measurement

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

1) Press the push button marked 4 pole. This will begin the test sequence and include spike resistance and noise verification.
2) Check that the display shows no adverse test conditions, i.e. the high current and voltage circuit resistance and excessive noise symbols are not showing. Also check that the low battery voltage warning is not flashing.
3) After a few seconds the display will stabilise. If the conditions for a test are satisfactory the reading given on the display may be accepted as the earth resistance. If any of the display symbols illuminate the cause of the adverse condition must be removed before the reading can be accepted. The instrument autoranges on both the earth resistance and current loop resistance. If the current spike resistance is too high for the required measurement range, the instrument will autorange up to a lower current range which can tolerate a higher current spike resistance. This results in a loss of resolution.

Three Terminal Measurement

The basic test procedure is the same as for the four terminal measurement except that the button marked 3 pole should be used to operate the instrument. 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, low resistance lead since this lead resistance is included in the measured value.

BATTERY CHARGING (*DET5/3R*)

The battery should be charged as soon as the low battery indicator appears on the display. If the display remains blank when the instrument is operated it 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 a correctly rated fuse is fitted and that the voltage selector is set to the correct value for the supply to be used. For a 240 V a.c. supply the fuse should be 50 mA and for a 120 V a.c. supply the fuse should be 100 mA. (Type and sizes of the fuses are given in the Specification). The mains supply fuse is located in the holder which is part of the mains socket. This is reached by undoing the two screws located on the underside of the instrument which hold in place the protective panel covering the mains socket. The supply voltage selection is by reversing the position of the fuse holder in the mains socket.

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

FITTING OR REPLACING BATTERY CELLS (*DET5/3D*)

Caution:- Use only battery cells of the correct type (see the Specification). Whenever battery cells arebeing fitted or replaced there should be no connections to the instrument terminals.
Unscrew the cover for the battery compartment by removing the screws in the base of the instrument. Remove the old cells and fit the new cell as indicated on the battery compartment moulding. Replace the cover and tighten the securing screws.
To avoid damage by leaking electrolyte, do not leave batteries fitted in an instrument which will remain unused for extended periods of time.

FONCTIONNEMENT

AVERTISSEMENTS

1. A titre de précautions, lors d'une intervention àproximité de circuits à haute tension qui peuven présenter des potentiels accidentels élevés au niveau de l'ouvrage et dans le sol, il est recommandé que l'opérateur porte des gants en caoutchouc (respectant la norme BS 697: 1986) et qu'il se tienne sur un tapis en caoutchouc ou qu'il porte des chaussures en caoutchouc (voir paragraphe 3 ci-dessous).
2. Avant de tester un système de mise à la terre, il est préférable au préalable de l'isoler du circuit qu'il est sensé protéger. Cela n'est pas toujours possible et, par conséquent, la précaution suivante est absolument vitale.
3. Consignes de sécurité concernant toutes les mises à la terre sous tension.
   La mesure de mises à la terre sous tension peut présenter des dangers comme; par exemple: mesure de la mise à la terre d'une sous-station "sous tension". Si une anomalie se produit au niveau de cette sous-station, pendant le déroulement d'un essai, des tensions dangereuses peuvent apparaître entre les mises à la terre du site et les mises à la terre éloignées mises en place pour réaliser ce tests. Dans ces cas-là, il convient de procéder comme suit.

a) Utiliser l'instrument à l'intérieur de la clôture périphérique de la sous-station où a lieu l'essai et/ou dans une zone où le différentiel de tension en provenance de la mise à la terre à l'essai ne dépasse jamais 50 V. Si cela n'est pas possible, il faut porter des gants en caoutchouc et se tenir sur des tapis en caoutchouc.
b) Les bornes P1 et C1 (ou ES et E) doivent être reliées à l'électrode de mise à la terre qui est testée.
c) Les bornes P2 et C2 (ou S et H) doivent être reliées à un rupteur qui a les capacités nominales suffisantes pour résister aux tensions anormales maximales (voir Fig. 3).
d) Ouvrir le rupteur puis faire les connexions. Commencer par les connexions au niveau du rupteur puis brancher les pointes d'essai à distance (électrodes).
e) Après avoir branché les pointes d'essai à distance, il est possible de fermer le rupteur pour effectuer une mesure.
f) Pendant le déroulement de l'essai, il faut faire très attention et s'assurer qu'aucune personne n'entre en contact avec les électrodes à distance ou avec les conducteurs qui relient les bornes P2 et C2 (ou S et H) par le biais du rupteur.
g) Il faut ouvrir le rupteur chaque fois qu'un opérateur doit toucher les pointes d'essai à distance ou les conducteurs de branchement comme, par exemple, pour en changer la position.
h) Si une anomalie se produit pendant le déroulement

d'un essai, l'instrument risque d'être endommagé. L'intégration, au niveau du rupteur, de fusibles de 100 mA en mesure de résister à la tension anormale maximale permettra à cet instrument de bénéficier d'une certaine protection (voir Fig. 3)

4. Pendant la recharge de la batterie du ***DET5/3R*** :

a) Avant de mettre le circuit sous tension, vérifier que le selecteur de tension occupe la position correcte et s'assurer également que le fusible qui a été mis en place a une puissance qui correspond à cette tension d'alimentation (voir page 9 des Spécifications).

b) La prise femelle sur laquelle vient se brancher cet instrument pour charger la batterie doit comporter un interrupteur marche/arrêt.

5. Ces instruments doivent uniquement être réparés par un personnel dûment formé et qualifié.

6. Si la protection d'un instrument s'est affaiblie, il ne faut pas se servir de cet instrument mais l'envoyer à un atelier de réparation. Cette protection est très probablement affectée lorsque, par exemple l'instrument présente des signes visibles d'endommagement, il n'est pas en mesure d'effectuer les mesures prévues, il a été stocké pendant une période prolongée dans des conditions défavorables ou il a été soumis à des contraintes importantes pendant un transport.

PRECAUTIONS

1. Le circuit de cet instrument contient des dispositifs qui sont sensibles à l'électricité statique. Si le boîtier de cet instrument a été ouvert, qu'elle qu'en soit la raison, il faut procéder avec le plus grand soin pour manipuler la carte à circuits imprimés. Cette manutention doit se faire en respectant les critères de manutention des dispositifs électrostatiques qui sont spécifiés dans les normes DEF STAN 59-98 et BS 5783.

Nota : l'ouverture du boîtier rend nulle et non avenue la garantie éventuelle qui couvre cet instrument, sauf si cette activité est effectuée par un organisme agréé de réparation (voir page 58)

2. Lors d'une intervention à l'aide du ***DET 5/3R***, il est recommandé de toujours charger au maximum la batterie avant de commencer une séquence d'essai. Il est très désagréable de devoir interrompre des essais en campagne parce quecette batterie tombe à plat. De même, en cas d'utilisation du ***DET5/3D***, il faut toujours avoir à sa disposition des batteries neuves.

FONCTIONNEMENT

SYMBOLES AFFICHES

L'écran à cristaux liquides de 3,5 caractères peut afficher directement le résultat et le symbole Ω ou **k**Ω d'unité de mesure. Plusieurs symboles à l'écran peuvent en outre aider l'opérateur à s'assurer que les résultats obtenus sont valides. Les paragraphes suivants donnent l'explication de chaque symbole ainsi affiché.

Tension insuffisante de la batterie

Si la tension de la batterie est insuffisante, le segment d'affichage qui se trouve au niveau du symbole de la batterie se met à clignoter. Dans ce cas-là, la batterie a une charge suffisante pour effectuer une ou deux mesures supplémentaires et il faut la recharger (***DET5/3R***) ou la remplacer (***DET5/3D***) avant d'effectuer d'autres essais.

Résistance de pointe de courant élevé

Ce symbole indique que la résistance du circuit de courant est trop élevée pour effectuer une mesure précise. Dans ce cas-là, une DEL s'allume au niveau du repère **Rc** du panneau graphique. Cela se produit automatiquement dès la mise sous tension de l'appareil de mesure, même pendant le déroulement d'un test. Son apparition peut être provoquée par un court-circuit ou un faux contact au niveau du conducteur d'essai qui aboutit à la pointe de courant ou, ce qui est plus probable, à la présence d'une résistance élevée dans le sol à proximité de la pointe de courant. Quelle que soit la cause entraînant l'apparition de ce symbole, il faut le faire disparaître avant de pouvoir considérer qu'un test est valable. Pour résoudre ce problème, il suffit parfois d'humidifier le sol à proximité de la pointe de courant, de modifier l'emplacement de la pointe de courant ou d'utiliser plusieurs pointes de courant.

Résistance de pointe à potentiel élevé

Ce symbole indique que la résistance de la sonde de potentiel est trop élevée. Dans ce cas-là, une DEL s'allume au niveau du repère **Rp** du panneau graphique. Cet essai s'effectue au début d'un test avant même d'effectuer une mesure. Son apparition est due aux mêmes raisons que l'allumage du symbole de résistance de pointe de courant élevé et il convient d'employer les mêmes remèdes.

Bruits parasites excessifs

La DEL '**BRUIT**' s'allume dès que la tension parasite dans la mise à la terre faisant l'objet de mesures dépasse le seuil que peut rejeter l'appareil de mesure. Aucune mesure valable ne peut s'effectuer lorsque cette condition est présente. Pour résoudre ce problème, il faut attendre que le parasite ait diminué ou modifier l'emplacement des pointes d'essai.

Dépassement de gamme
Ce symbole indique que la résistance faisant l'objet de mesures dépasse la limite maximale. Dans ce cas-là, le symbole de dépassement de gamme s'allume. Le premier chiffre à gauche est un "1" et le reste de l'écran reste vide, à l'exception du point décimal. Lorsque ce symbole apparaît, cela indique que l'électrode de mise à la terre faisant l'objet des essais présente une anomalie ou que les connexions à destination de l'instrument ou des électrodes sont défectueuses.

Inversion de polarité
Lorsque les conducteurs d'essai de potentiel sont inversés par rapport aux conducteurs de courant, l'écran clignote entre les barres d'essai et l'apparition d'un résultat. Pour obtenir un résultat valable, il faut s'assurer que l'électrode "P1" est plus près de "C1" que l'électrode "P2".

MISE EN PLACE DES POINTES D'ESSAI ET AUTRES ACTIVITES
Pour tester des électrodes de mise à la terre et déterminer la résistivité de mises à la terre, il faut brancher les conducteurs d'essai de cet instrument sur des pointes enfoncées dans le sol. Les branchements à effectuer dépendent en fait du type d'essai à réaliser. La section suivante intitulée "**Techniques de mesure**" en fournit des détails complets.
Pour tous les types d'essais de mises à la terre, il faut se procurer des pointes d'essai et de longs conducteurs d'essai. La trousse des accessoires d'essai en campagne de mises à la terre qui est proposée en option contient l'équipement de base.

PROCEDURE D'ESSAI DE BASE
Mesure avec quatre bornes
Après avoir installé les pointes d'essai et les avoir branchées sur l'instrument en fonction du type d'essai à réaliser (voir section "**Techniques de mesure**"), procéder de la manière suivante:
1) Appuyer sur le bouton-poussoir portant la référence 4 pôles. Cela lance la séquence d'essai avec vérification de la résistance des pointes et du bruit.
2) Vérifier qu'aucune condition risquant d'affecter les essais n'est indiquée à l'écran c'est-à-dire qu'il faut s'assurer que les symboles de résistance des pointes de courant élevé, de résistance des pointes de potentiel élevé et de bruits parasites excessifs

restent éteints. Vérifier également que les témoins lumineux indiquant une tension insuffisante de la batterie ne clignotent pas.

3) Au bout de quelques secondes, l'affichage se stabilise. Si les conditions de réalisation d'un essai sont satisfaisantes, la valeur inscrite à l'écran peut être acceptée comme représentant la résistance de mise à la terre. Si l'un des symboles de l'écran s'allume, il faut éliminer la cause de cette condition négative avant d'accepter la valeur affichée. Cet instrument sélectionne automatiquement les plages de résistance des mises à la terre et des boucles de courant. Si la résistance des pointes de courant est trop élevée pour la plage de mesure requise, l'instrument passe automatiquement à une gamme à courant moins élevé qui peut tolérer une résistance plus élevée de pointe de courant. Cela entraîne une diminution de la résolution.

Mesures avec trois bornes

La procédure d'essai est essentiellement identique à celle des mesures à quatre bornes si ce n'est qu'il convient d'appuyer sur le bouton portant la référence trois pôles lors du fonctionnement de cet instrument. Une seule connexion est alors requise entre la borne "C1" ("E") et l'électrode testée. Pour renforcer la précision, cette connexion doit utiliser un conducteur de faible longueur et à faible résistance étant donné que la résistance de ce conducteur est intégrée à la valeur mesurée.

RECHARGE DE BATTERIE (*DET5/3R*)

Il faut recharger la batterie dès que le symbole de batterie à plat apparaît à l'écran. Si l'écran d'affichage reste vierge pendant le fonctionnement de l'instrument, il est probable que la batterie est tombée complètement à plat. Dans ce cas-là, il faut recharger au maximum la batterie avant d'effectuer des essais.

Nota: il n'est pas recommandé d'attendre que la batterie soit complètement à plat car cela risque de provoquer des dégâts. Avant tout branchement sur l'alimentation secteur, s'assurer qu'un fusible de puissance correcte a été mise en place et que le sélecteur de tension occupe la position qui correspond à la tension qui va être employée. Aux alimentations secteur de 240 V, il faut employer un fusible de 50 mA ; pour une alimentation secteur de 100 V, il faut employer un fusible de 100 mA. Les spécifications indiquent le type et la taille de ces fusibles. Le fusible d'alimentation secteur se trouve dans un porte-fusible qui fait partie de la prise femelle secteur. Pour y accéder, il faut desserrer les deux vis qui sont implantées sous cet instrument et qui maintiennent en position le panneau de protection qui recouvre la prise femelle secteur. Pour sélectionner la tension d'alimentation, il suffit d'inverser la position du porte-fusible dans la prise femelle secteur.

Après avoir correctement réglé le fusible du sélecteur de tension, brancher le conducteur de l'alimentation

secteur dans une prise appropriée puis mettre l'ensemble sous tension. Une DEL s'allume au niveau du symbole d'alimentation secteur avec apparition du message '**CHARGE**' qui indique que l'instrument est relié à une alimentation secteur. Charger la batterie pendant environ 10 heures. Une fois la recharge terminée, remettre en place le couvercle de protection de l'alimentation secteur pour bien protéger cet instrument.

MISE EN PLACE OU REMPLACEMENT DES ELEMENTS DE BATTERIE (***DET5I3D***)

Attention: Utiliser uniquement des éléments de batterie du type correct (voir spécifications). Chaque fois qu'il faut monter ou remplacer des éléments de batterie, il ne doit pas y avoir de branchements au niveau des bornes de l'instrument.

Dévisser le couvercle du compartiment de la batterie en retirant les vis au pied de l'instrument. Retirer les éléments usagés puis mettre en place des éléments neufs, comme indiqué, sur le moulage du compartiment de la batterie. Remettre en place le couvercle puis en serrer les vis de fixation.

Pour éviter tout endommagement provoqué par une fuite d'électrolyte, ne pas laisser la batterie à l'intérieur d'un instrument qui doit rester inutilisé pendant une période prolongée.

HINWEISE

1. Da bei Arbeiten in der Nähe von Hochspannungsanlagen an Aufbauten und im Boden starke Spannungen vorliegen können, empfiehlt es sich, Gummihandschuhe (nach BS 697:1986) zu tragen und auf einer Gummimatte zu stehen oder Gummischuhe zu tragen (vgl. Absatz 3 unten).
2. Das zu prüfende Erdungssystem sollte zunächst von dem Stromkreis, den es absichert, getrennt werden. Dies ist nicht immer möglich, weshalb die untenstehenden Vorsichtsmaßnahmen unbedingt beachtet werden müssen.
3. Sicherheitsvorkehrungen bei allen spannungsführenden Erdungsleitungen
   Beim Prüfen von spannungsführenden Erdungsleitungen können Sicherheitsrisiken auftreten, z.B. wenn die Erdungsleitung einer unter Spannung stehenden Nebenstation geprüft wird. Wenn an der Nebenstation während der Prüfung eine Störung auftritt, können gefährliche Spannungen zwischen der Erdungsleitung der Anlage und weiter entfernten, für Prüfzwecke eingerichteten Erdungsleitungen bestehen. Deshalb sind folgende Hinweise zu beachten:

a) As Instrument muß innerhalb des Eingrenzungszauns der Nebenstation, an welcher die Prüfung vorgenommen wird, und/oder in einem Bereich, in dem die Spannungsdifferenz zu der geprüften Erdungsleitung unter keinen Umständen 50 V übersteigt, vorgenommen werden. Sollte dies nicht möglich sein, müssen Gummihandschuhe und Gummimatten verwendet werden.

b) Die Anschlüsse P1 und C1 (bzw. ES und E) müssen mit der zu prüfenden Erdelektrode verbunden werden.

c) Die Anschlüsse P2 und C2 (bzw. S und H) müssen mit einem Trennschutzschalter verbunden werden, dessen Nennleistung auf die höchsten Fehlerspannungen ausgelegt ist (vgl. Abb. 3).

d) Die Verbindungen müssen bei offenem Trennschutzschalter hergestellt werden. Stellen Sie die Verbindungen zum Trennschutzschalter zuerst und anschließend die Verbindungen zu den entfernt angebrachten Prüfstäben (Elektroden) her.

e) Wenn die entfernt angebrachten Prüfstäbe angeschlossen sind, darf der Trennschutzschalter geschlossen und eine Messung vorgenommen werden.

f) Während der Prüfung muß darauf geachtet werden, daß niemand in Kontakt mit den entfernt angebrachten Elektroden oder den über den Trennschutzschalter zu den Anschlüssen P2 und C2 (bzw. S und H) geführten Leitungen kommt.

g) Der Trennschutzschalter muß grundsätzlich geöffnet sein, wenn jegliche Personen, z.B. zwecks Umsetzung, in Berührung mit den entfernt angebrachten Prüfstäben oder Verbindungsleitungen kommen.

h) Falls während der Prüfung eine Störung auftritt, kann das Instrument dadurch beschädigt werden. Durch Verwendung von Sicherungen mit einer Nennleistung von 100 mA, die in der Lage sind, die höchste Fehlerspannung zu bewältigen, kann das Instrument in gewissem Umfang geschützt werden (vgl. Abb. 3).

4. Aufladen der ***DET5/3R***-Batterie:

a) Achten Sie vor dem Einschalten der Stromversorgung darauf, daß der Spannungswähler auf die richtige Spannung eingestellt und eine Sicherung mit der für diese Stromversorgung geeigneten Nennleistung eingesetzt ist (vgl. Technische Daten, S. 9).

b) Die Steckdose, an welche das Instrument zum Aufladen der Batterie angeschlossen wird, muß einen Ein/Ausschalter haben.

5. Reparaturen an diesem Instrument dürfen nur von entsprechend ausgebildeten und erfahrenen Mitarbeitern ausgeführt werden.

6. Sollte die Schutzeinrichtung eines Instruments beeinträchtigt worden sein, darf es nicht benutzt und muß zur Reparatur an das Werk geschickt werden. Die Schutzeinrichtung ist z.B. wahrscheinlich beeinträchtigt, wenn sie sichtbare Schäden aufweist, nicht die angestrebten Messungen leistet, längere Zeit unter ungünstigen Bedingungen gelagert oder hohen Transportbelastungen ausgesetzt worden ist.

VORSICHTSMASSNAHMEN

1. Der Schaltkreis des Instruments enthält Geräte, die empfindlich gegenüber statischer Elektrizität sind. Falls das Gehäuse des Instruments aus irgendeinem Grund geöffnet wird, muß die gedruckte Schaltung sorgfältig behandelt werden, und zwar entsprechend den Vorschriften von DEF STAN 59-98 und BS 5783 über die Handhabung elektrostatischer Geräte.

Hinweis: Jedes Öffnen des Gehäuses, das nicht von einer autorisierten Reparaturwerkstätte vorgenommen wird, führt automatisch zum Erlöschen der Garantie des Instruments.

2. Es empfiehlt sich, beim Arbeiten mit dem ***DET5/3R*** vor Beginn einer Prüfsequenz darauf zu achten, daß die Batterie voll aufgeladen ist. Es kann außerordentlich lästig sein, wenn die Batterie im Verlauf einer Feldprüfung zu schwach wird. Für den ***DET5/3D*** gilt entsprechend, daß stets frische Batterien verfügbar sein sollten.

ANZEIGE SYMBOLE

Die 3,5 Stellen große Flüssigkristallanzeige liefert direkte Ergebnisse und die Ohm- und kOhm-Werte auf der Anzeige für die Meßeinheiten. Die Anzeigesymbole helfen auch bei der Überprüfung der Gültigkeit der angezeigten Werte. Die Bedeutung der einzelnen Anzeigesymbole wird in den nachstehenden Absätzen erläutert.

Batteriespannungsanzeige

Wenn die Batterie zu schwach wird, blinkt im Abschnitt der Anzeige neben der Batterie das Batteriesymbol auf. In diesem Fall reicht die Kapazität der Batterie nur noch für eine oder zwei Messungen aus, weshalb die Batterie vor weiteren Messungen entweder aufgeladen (***DET5/3R***) oder ausgewechselt (***DET5/3D***) werden muß.

Prüfstab für Starkstromwiderstand

Um anzuzeigen, daß der Widerstand des Stromkreises zu hoch für eine genaue Messung ist, leuchtet gegenüber der Rc-Markierung der grafischen Darstellung eine Leuchtanzeige auf. Dies geschieht bei eingeschaltetem Prüfgerät automatisch und auch während einer Prüfung. Diese Anzeige kann durch einen offenen Schaltkreis oder eine schlechte Verbindung des Prüfkabels zum betreffenden Prüfstab bzw. eher durch hohen Widerstand im Boden um den betreffenden Prüfstab ausgelöst werden. Unabhängig von der Ursache der Symbolauslösung muß es jedoch abgeschaltet werden, bevor eine Prüfung als gültig gewertet werden kann. Das Problem kann durch Befeuchten des Bodens um den Stab, durch Umsetzen des Stabs an eine andere Stelle oder durch die Verwendung von mehr als einem Stab gelöst werden.

Prüfstab für Hochspannungswiderstand

Um anzuzeigen, daß der Widerstand der Spannungssonde zu hoch ist, leuchtet neben der Rp-Markierung auf der grafischen Darstellung eine Leuchtanzeige auf. Dieser Test wird vor Beginn jeder Prüfmaßnahme und vor dem Ablesen des Meßergebnisses durchgeführt. Dieses Symbol leuchtet aus denselben Gründen wie das Symbol für den Starkstromwiderstand auf und kann durch ähnliche Abhilfemaßnahmen abgeschaltet werden.

Übermäßige Rauschstörung

Die '**Noise**'-Leuchtanzeige leuchtet auf, wenn die in der jeweils gemessenen Erdung vorliegende Funkstörspannung über dem vom Prüfgerät zurückweisbaren Niveau liegt. Unter solchen Bedingungen kann keine Messung vorgenommen werden. Vielmehr muß abgewartet werden, bis die Störung sich abschwächt, oder eine andere Position fürdie Prüfstäbe gesucht werden.

Überbereich
Um anzuzeigen, daß der gemessene Widerstand über dem Höchstwert liegt, erscheint ein Überbereichssymbol. Dabei handelt es sich um die Ziffer "1'auf der linken Seite, wobei der Rest der Anzeige mit Ausnahme des Dezimalpunkts leer bleibt. Wenn dieses Symbol erscheint, liegt eine Störung an der zu prüfenden Erdelektrode oder den Verbindungen zum Instrument oder zu den Elektroden vor.

Polaritätsumkehrung
Wenn die Spannungsprüfkabel bezüglich der Stromkabel umgepolt werden, stellt die Anzeige abwechselnd die Prüfbalken und ein Meßergebniß dar. Um ein gültiges Ergebnis erzielen zu können, muß darauf geachtet werden, daß sich die "P1"-Elektrode näher bei der "C1"- als bei der "P2"-Elektrode befindet.

EINRICHTUNG DER PRÜFSTÄBE usw.
Für die Prüfung von Erdelektroden und die Überwachung des Erdwiderstands werden die Prüfkabel des Instruments an in den Boden gesteckte Prüfstäbe angeschlossen. Das Anschlußverfahren richtet sich nach der jeweiligen Art der Prüfung, deren Einzelheiten im untenstehenden Abschnitt "**Meßverfahren**'beschrieben sind.
Für alle Arten von Erdungsprüfverfahren sind Prüfstäbe und lange Prüfkabel erforderlich; die notwendigen Geräte sind in der als Zubehör lieferbaren Ausstattung für die Feldprüfung enthalten.

GRUNDLEGENDES PRÜFVERFAHREN
Messung mit vier Anschlüssen
Wenn die Prüfstäbe installiert und für den zu prüfenden Gerätetyp an das Instrument angeschlossen sind (vgl. "**Meßverfahren**"), verfahren Sie wie folgt:

1. Drücken Sie die mit "4 pole'markierte Taste. Damit wird die Prüfsequenz eingeleitet, und der Prüfstabwiderstand und die Rauschüberprüfung werden verarbeitet.
2. Überprüfen Sie, ob die Anzeige keine gegenteiligen Prüfbedingungen meldet, d.h. die Symbole für Starkstrom- und Spannungswiderstand sowie übermäßiges Rauschen nicht angezeigt werden. Überprüfen Sie außerdem, ob die Anzeige für schwache Batterie aufleuchtet.

3. Nach einigen Sekunden stabilisiert sich die Anzeige. Wenn die Prüfbedingungen befriedigend sind, kann der von der Anzeige gemeldete Wert als Erdungswiderstand gewertet werden. Falls jegliche Anzeigensymbole aufleuchten, muß die Ursache für den jeweiligen widrigen Umstand beseitigt werden, bevor der angezeigte Wert akzeptiert werden kann. Das Instrument reagiert automatisch sowohl auf den Erdungs- als auch auf den Stromschleifenwiderstand. Falls der Stromstabwiderstand zu hoch für den angestrebten Meßbereich ist, stellt sich das Instrument automatisch auf einen geringeren Strombereich ein, der einen höheren Stromstabwiderstand verarbeiten kann. Dies führt zu einem Auflösungsverlust.

Messung mit drei Anschlüssen

Bei diesem Prüfverfahren handelt es sich im wesentlichen um dasselbe Verfahren wie bei der Messung mit vier Anschlüssen, jedoch mit der Ausnahme, daß die mit "3 pole'markierte Taste für den Betrieb des Instruments verwendet werden sollte. In diesem Fall ist nur eine Verbindung vom Anschluß "C1'("E") an die zu prüfende Elektrode erforderlich. Für genaueste Meßergebnisse kann für die Verbindung ein kurzes Kabel mit geringem Widerstand verwendet werden, da dieser Kabelwiderstand in den Meßwert einbezogen wird.

BATTERIELADUNG (*DET5/3R*)

Die Batterie sollte aufgeladen werden, sobald die Anzeige für die Batteriekapazität auf der Anzeige erscheint. Falls die Anzeige beim Betrieb des Instruments leer bleibt, könnte dies daran liegen, daß die Batterie vollkommen erschöpft ist. In diesem Fall muß die Batterie vor jeglichen weiteren Prüfungen aufgeladen werden.

Hinweis: Die Batterie sollte niemals vollständig entladen werden, da sie dadurch Schaden leiden könnte. Achten Sie vor dem Anschluß an den Netzstrom darauf, daß eine Sicherung der richtigen Nennleistung installiert und der Spannungswähler auf die korrekte Spannung eingestellt ist. Die Nennleistung der Sicherung sollte bei einer Wechselspannung von 240 V 50 mA und bei einer Wechselspannung von 120 V 100 mA betragen (Art und Größe der Sicherungen sind in den Technischen Daten vermerkt). Die Netzstromsicherung befindet sich in der in den Netzstecker ingetrierten Halterung, die nach Lösen der beiden Schrauben an der Unterseite des Instruments zugänglich ist und die auch die Schutzverkleidung der Netzsteckdose enthält. Die Wahl der Stromversorgung erfolgt durch Umkehrung der Position der Sicherungshalterung in der Netzstromsteckdose.
Stecken Sie nach korrekter Einstellung von Sicherung und Spannungswähler den Netzstecker in eine

geeignete Netzsteckdose und schalten Sie das Gerät ein. Daraufhin erscheint neben der Stromversorgung eine Leuchtanzeige die Markierung '**CHARGE**', wodurch angezeigt wird, daß das Instrument an den Neztstrom angeschlossen ist. Lassen Sie die Batterie ungefähr 10 Stunden lang aufladen. Setzen Sie anschließend zum Schutz des Geräts die Abdeckung für die Stromversorgung wieder ein.

EINSETZEN ODER AUSWECHSELN DER BATTERIEN (***DET5/3D***)

Achtung: Verwenden Sie nur Batterien des richtigen Typs (vgl. Technische Daten). Während des Einsetzens oder Auswechselns von Batterien sollten keine Kabel an das Instrument angeschlossen sein.

Schrauben Sie die Abdeckung des Batteriefachs an der Unterseite des Instrumentengehäuses ab. Entfernen Sie die alten Batterien, und setzen Sie die neuen Batterien entsprechend den Angaben des Batteriefachs ein. Schrauben Sie die Abdeckung wieder auf.

Wenn ein Instrument für längere Zeiträume nicht benutzt wird, sollten die Batterien entfernt werden, um dem Austreten von Batterieflüssigkeit vorzubeugen.

FUNCIONAMIENTO

NORMAS DE SEGURIDAD

1. Como precaución cuando se trabaje en sistemas de alta tensión donde haya un peligro potencial en la estructura misma del sistema o al nivel del suelo, se recomienda utilizar guantes de caucho que cumplan la norma BS 697 de 1986, pararse sobre un tapete de caucho y utilizar zapatos con suela del mismo material. (véase el párrafo 3 a continuación).
2. En lo posible, cuando se vaya a verificar un sistema de tierra, primero debe aislarse del circuito que está protegiendo; y si no puede hacer, se recomienda seguir cuidadosamente las medidas que se describen a continuación:-
3. Normas de seguridad en sistemas de tierra bajo tensión. Cuando se miden sistemas de tierra que están bajo tensión pueden darse situaciones de riesgo, por ejemplo al presentarse un fallo en una subestación, pueden haber voltajes peligrosos entre la tierra de la subestación y las tierras remotas establecidas para la prueba.

Por esta razón:-

a) El instrumento debe utilizarse dentro del perímetro del cercado de la subestación donde se está realizando la prueba, o en un área donde la diferencia de voltaje de la tierra bajo prueba no exceda por ningún motivo a los 50 V. Cuando no puedan seguirse estas normas, deben utilizarse guantes y tapetes de caucho.
b) Los terminales P1 y C1 (o ES y E) deben conectarse al electrodo de tierra que se está probando.
c) Los terminales P2 y C2 (o S y H), deben conectarse a un interruptor de aislamiento, cuyo grado nominal debe coincidir con los voltajes máximos bajo condiciones de fallo (véase la figura 3).
d) Hacer las conexiones con el interruptor de aislamiento abierto. Conectar primero los terminales al interruptor de aislamiento y después a las picas de prueba remotas (electrodos).
e) Cuando se hayan conectado los terminales a las picas de prueba remotas, cerrar el interruptor de aislamiento y hacer la medición respectiva.
f) Mientras se esté realizando la prueba, nadie debe tocar los electrodos remotos o los cables que van a los terminales P2 y C2 (o S y H) a través del interruptor de aislamiento.
g) Mientras el interruptor de aislamiento esté abierto, no debe haber ningún contacto personal con las picas de prueba remotas o los cables de conexión, por ejemplo al cambiarlos de posición.
h) El instrumento puede dañarse durante la realización de la prueba. Para protegerlo se recomienda instalar fusibles de 100 mA en el interruptor de aislamiento y capaces de resistir el voltaje máximo bajo una condición de fallo (véase la figura 3).

4. Cuando cargue la pila del ***DET5/3R:***-

a) Antes de conectar la fuente de alimentación, verifique que el voltaje corresponde con el fijado en el selector de la unidad y que el fusible es idóneo para el tipo de corriente de la fuente (véase la sección de Especificaciones técnicas en la página 9).

b) El enchufe al cual va a conectarse la unidad para recargar la pila debe tener un interruptor de encendido y apagado.

5 El proceso de reparación del instrumento sólo debe realizarlo un técnico debidamente cualificado y capacitado.

6. El instrumento no debe utilizarse si cualquiera de sus medios de protección presenta una condición de daño, y en este caso debe enviarse para reparación. Por ejemplo, cuando se presenten signos visibles de deterioro, fallos de funcionamiento, haya estado almacenado en condiciones no favorables o transportado inadecuadamente.

PRECAUCIONES

1. Los circuitos del instrumento están compuestos por dispositivos sensibles a la electricidad estática. Si por alguna razón se llegase a abrir la caja del probador; se debe tener extremo cuidado en el manejo de la tarjeta de circuitos impresos. Este debe hacerse siguiendo las normas DEF STAN 59-98 y BS 5783 sobre manejo de dispositivos electrostáticos.

Nota:la apertura de la caja deja sin validez la garantía, excepto que sea realizada por un centro técnico autorizado. (véase la página 58).

2. Para evitar inconvenientes, se recomienda recargar completamente la pila del ***DET5/3R*** antes de ejecutar cualquier prueba, y en el caso de las unidades ***DET5/3D*** se recomienda tener a mano pilas nuevas.

SÍMBOLOS DE LA PANTALLA

La pantalla de cristal líquido de 3 dígitos, presenta en forma directa las lecturas, y los símbolos Ω y **k**Ω representan a las unidades de medida. Los símbolos de la pantalla también sirven para garantizar la validez de las lecturas y su significado se describe a continuación.

Voltaje bajo de la pila

Cuando el voltaje de la pila está en un nivel bajo, parpadea el símbolo de la pila a lo largo de la pantalla. En este caso, la pila tiene una carga suficiente para hacer una o dos mediciones más y debe recargarse (***DET5/3R***), o reemplazarse (***DET5/3D***).

Resistencia alta en la barra de corriente

Cuando la resistencia del circuito de corriente es demasiado alta para obtener una medición exacta, se ilumina el LED del símbolo Rc en el panel de gráficos. Esta condición se presenta automáticamente cuando se enciende el probador, inclusive durante las pruebas, y la causa puede ser un circuito abierto o una conexión mal hecha entre el cable de prueba y la barra de corriente, y con más probabilidad, por una resistencia alta en el área cercana a la barra de corriente. En cualquier caso, la condición debe corregirse antes de realizar la prueba. El problema puede solucionarse humedeciendo el área alrededor de la barra de corriente, cambiando el sitio de la barra o utilizando más de una barra.

Resistencia alta en la barra de potencial

Cuando la resistencia de la sonda de potencial es demasiado alta, se ilumina el LED del símbolo Rp en el panel de gráficos. Esta verificación se realiza al inicio antes de tomar la lectura de la prueba. Las causas de esta condición son las mismas de la resistencia alta en la barra de corriente mencionadas en el punto anterior, y deben tomarse las mismas medidas para corregirla.

Ruido excesivo

El LED "**NOISE**'se ilumina cuando se detecta un voltaje de interferencia que está por encima del límite máximo del probador, en el sistema de tierra que se está midiendo. Bajo esta condición las mediciones no son válidas. El problema puede corregirse esperando hasta que pase la interferencia o hacer la prueba en un lugar diferente de las picas.

Límite excedido
Para indicar que la resistencia está por encima del límite aceptable, aparece un "1'a la izquierda y el resto de la pantalla en blanco excepto por el punto decimal. Esta condición se presenta por un fallo en el electrodo de tierra donde se está realizando la prueba, o por un problema de conexión en el instrumento o los electrodos.

Polaridad invertida
Cuando la polaridad de los cables de prueba de potencial es diferente a la que tienen los cables de corriente, la pantalla parpadea entre las picas de prueba y el valor de la lectura. Para corregir esta condición, compruebe si el electrodo "P1'está más cerca de "C1'que lo que está el electrodo "P2".

INSTALACIÓN DE LAS PICAS DE PRUEBA etc.
Para realizar las pruebas del electrodo y analizar la resistencia del sistema de tierra, los cables de prueba del instrumento deben conectarse a las picas clavadas. La forma como deben realizarse las conexiones depende del tipo de prueba a realizar cuyos detalles se dan en la sección de "**Técnicas de medición**".
Las picas y los cables largos de prueba se necesitan para realizar todos los tipos de prueba de tierra. El kit opcional de pruebas de campo contiene todo el equipo básico necesario.

PROCEDIMIENTO BÁSICO PARA LA REALIZACIÓN DE PRUEBAS
Medición de cuatro terminales
Después de clavar las picas y conectar el instrumento de acuerdo al tipo de prueba a ejecutarse (véase la sección "**Técnicas de medición**"), siga los pasos que se describen a continuación:-

1. Pulse el botón marcado con "4 pole'(4 polos). Se inicia la secuencia de verificación que incluye la resistencia de la pica y el ruido.
2 Compruebe que no aparezcan en la pantalla símbolos que indiquen una condición adversa para a realización de la prueba, por ejemplo, resistencia alta en la pica de corriente y de potencial, y ruido exesivo. También verifique que no haya una condiciónde bajo voltaje de la pila.

3. La pantalla se estabiliza después de unos segundos. Si las condiciones para la realización de la prueba son satisfactorias, la lectura que aparezca en la pantalla puede aceptarse como la resistencia del sistema de tierra. Mientras que si se indica una condición adversa, ésta debe corregirse para que la lectura sea válida. El instrumento determina automáticamente los rangos de la resistencia de tierra y la del ciclo de corriente. Si la resistencia de la pica de corriente está por encima del rango de medición necesario, el instrumento cambia automáticamente de rango por uno más bajo que pueda tolerar la resistencia de la pica de corriente, dando como resultado una pérdida de resolución.

Medición de tres terminales

El procedimiento básico para la realización de la prueba es el mismo que se utiliza para la medición de cuatro terminales excepto que hay que pulsar el botón marcado con "3 pole'(3 polos). Sólo debe hacerse una conexión desde el terminal "C1'("E") al electrodo que está bajo prueba. Para una mayor exactitud, esta conexión debe hacerse con un cable corto de resistencia baja ya que el valor de la resistencia del cable se añade al valor medido.

CARGA DE LAS PILAS (*DET5/3R*)

La pila debe cargarse tan pronto aparezca el símbolo que denota una condición de carga baja. Si la pantalla del instrumento queda en blanco mientras se está realizando una prueba, es porque se ha agotado completamente la pila, y en este caso debe cargarse para poder seguir realizando la prueba.

Nota:- la pila no debe dejarse descargar completamente ya que puede dañarse.

Antes de conectar el instrumento a la fuente de alimentación compruebe que el fusible instalado es el adecuado y que el selector de voltaje está en la posición que corresponde a la de la fuente. Para una fuente de 240 V c.a. debe utilizarse un fusible de 50 mA y para una de 120 V c.a., uno de 100 mA (el tipo y el tamaño de los fusibles aparecen en las Especificaciones técnicas). El fusible de la fuente de alimentación principal está localizado en el compartimiento respectivo en la toma de la fuente; y se accede soltando los dos tornillos que están en la cara inferior del instrumento los cuales sostienen el panel de protección de la toma. El voltaje de la fuente se selecciona invirtiendo la posición del portafusible en la toma.

Cuando el tipo fusible y la posición del selector de voltaje sean adecuados, enchufe el cable de

alimentación y encienda el instrumento. Se enciende un LED marcado con "**CHARGE**'y localizado en la entrada de la fuente de alimentación indicando que el instrumento está conectado. El proceso de carga de la pila dura 10 horas aproximadamente. Cuando finalice la carga, vuelva a colocar el panel de protección de la fuente de alimentación del instrumento.

INSTALACIÓN O REEMPLAZO DE LAS PILAS
(DET5I3D)

Precaución:- Únicamente utilice pilas del tipo adecuado (véase la sección de Especificaciones técnicas). Los terminales del instrumento no deben estar conectados cuando se vayan a instalar o reemplazar las pilas.

Suelte los dos tornillos localizados en la base del instrumento y retire la cubierta del compartimiento de las pilas. Extraiga las pilas viejas y coloque las nuevas tal como está indicado en el compartimiento. Vuelva a colocar la cubierta y ajuste los tornillos.

Para evitar la pérdida del electrolito, extraiga las pilas del instrumento cuando vaya a dejar de utilizarlo por un período prolongado.

FALL-OF-POTENTIAL METHOD

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

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

Hammer the potential test spike into the ground midway 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 each spike (remote electrode), 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. The diagram of Fig. 7 shows the connections.
Operate the instrument as explained in the '**Basic Test Procedure**' on page 18, and note the resistance obtained.

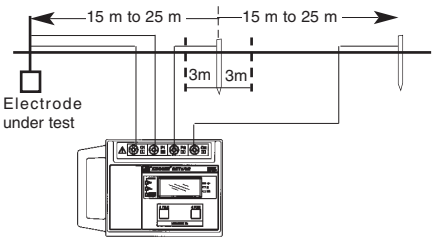


Fig.7 Fall-of-Potential method for measuring resistance of an earth electrode.

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

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

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

Note:- Earth electrode test lead resistance can be determined separately. First remove it from the the electrode and connect to the 'C2' and 'P2' (or 'H' and 'S') terminals in the normal way. This lead resistance can 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.

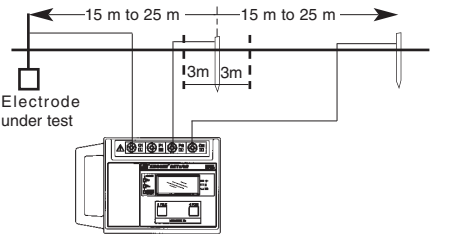


Fig. 8 Fall-of-Potential method using a single lead to the earth electrode (three terminal test).

THE 61,8% RULE

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

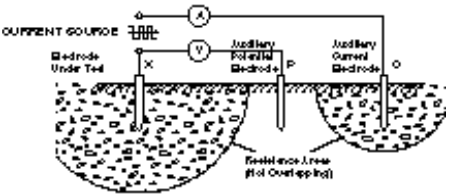


Figure 9. Resistance areas associated with an earth electrode and current spike.

Theoretically, both the current and potential spikes should be at an infinite distance form the earth electrode! However, by graphical considerations and by actual test it can be demonstrated that:-
The "**true**'resistance of the earth electrode is equal to the measured value of resistance when the potential spike is positioned 61,8% of the distance between the earth electrode and the current spike, away from the earth electrode.

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

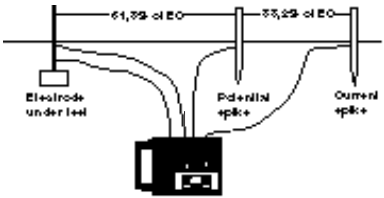


Fig.10 The 61,8% Rule method.

For most purposes the current spike should be 30 metres to 50 metres from the centre of the earth electrode under test. The potential spike should be inserted in the ground 61,8% of this distance, between and in a straight line with, the current spike and the earth electrode. The distance is measured from the earth electrode.

If the earth electrode system is of medium size containing several rods, then these distances must be

increased. The following table gives a range of distances that agree with the rule. In the first column "Maximum dimension'is the maximum distance across the earth electrode system to be measured.

Maximum dimension in metres	Distance to potential 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 not known or inaccessible (e.g. if the system is beneath the floor of a building). The Slope method can also be used if the area available for siting the earth electrodes is restricted. It can be tried if the previous methods prove unsatisfactory and generally yields results of greater accuracy than those methods.

The equipment is set up as shown in Fig. 11. The remote current spike is placed 50 metres or more from the earth electrode system to be measured and connected to the instrument's 'C2' (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.

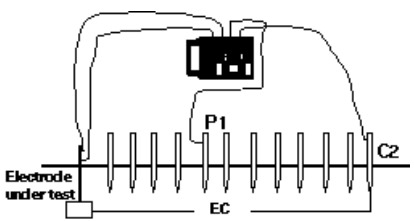


Fig. 11 Connections for the Slope method

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

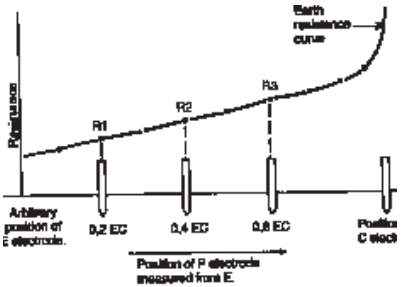


Fig. 12 Resistance curve from Slope method tests.

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

Calculate the slope coefficient μ
where μ = (R3-R2)/(R2-R1)
which is a measure of the change of slope of the earth resistance curve.

From the table on page 44 obtain the value of 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 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.

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

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

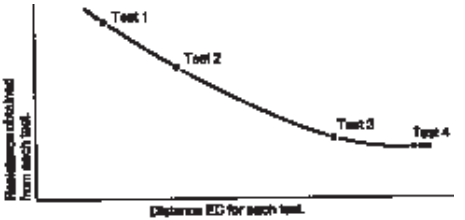


Fig.13 Possible results from several Slope method tests.

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

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

Chart for use with the Slope Method

Values of $P_{t/EC}$ for Values of μ

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

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

Chart for use with the Slope Method (continued)

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

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

Chart for use with the Slope Method (continued)

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

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 such cases a water main may be available. This is referred to as a "dead'earth.

This must be of low resistance to earth and connections as shown in Fig. 14 using the three terminal test. This test will give give the combined resistance to earth of the two earths in series. If that of the "dead'earth is negligible then the reading may be taken as that of the electrode under test.

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 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.

The Star-Delta method is therefore preferable for use in congested urban areas and it is explained (along with other methods referred to here) in the book 'A Simple Guide to Earth Testing' published by **AVO INTERNATIONAL.**

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 can then be subtracted from the total to obtain the combined resistance of the earth electrode and the 'dead'earth.

BS7671 (16TH EDITION WIRING REGULATIONS) REQUIREMENT

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

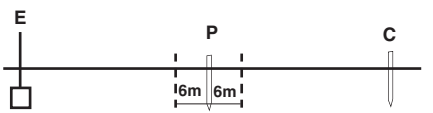


Fig.14 Test spike positions for BS7671 testing

Other Methods

There are other methods of earth electrode testing among which are the Four Potential, Intersecting Curves and Star Delta methods. **AVO INTERNATIONAL** have produced a book entitled 'A Simple Guide to Earth Testing' which explains all these test methods and gives other helpful information about earth testing. It is available from the instrument manufacturer or one of their approved distributors and has the part no. 6171-230.

TOUCH POTENTIAL

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

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.

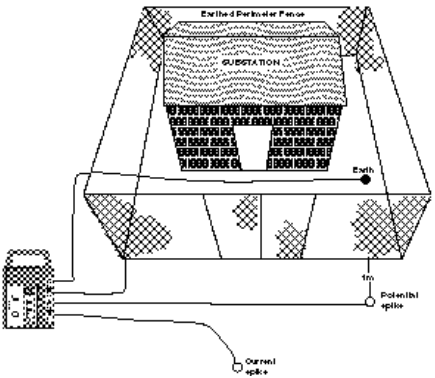


Fig. 15 Determining 'Touch' potential.

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 the 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.16); 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 again be known. From Ohm's Law the Step potential can be calculated.

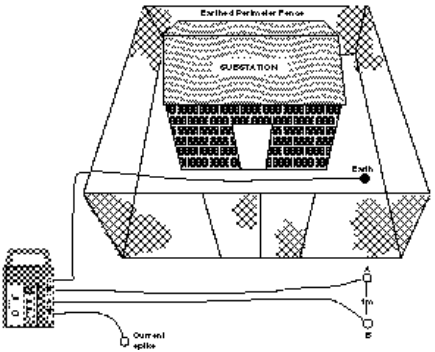


Fig. 16 Determining 'Step' potential.

TYPICAL VARIATIONS IN SOIL RESISTIVITY

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

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

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

LINE TRAVERSE

The most common method of measuring soil resistivity is often referred to as the line traverse. Four test spikes are driven into the ground in a straight line at equal distances 'a' and to a depth of not more than 1/20 of 'a'. The instrument is connected to the test spikes as shown in Fig.17.

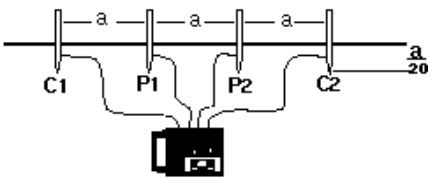


Fig. 17 Connections for resistivity testing.

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.18. 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 '1/20a' 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 form which a profile of the resistivity at new depths '1/20b', '1/20c', '1/20d', etc. can be obtained.

If the same line for the test spikes is maintained, but the separation of them is progressively widened, resistivity values at various depths can be obtained. By this means depth surveys may be made. More details can be found in the publication ‘A Simple Guide to Earth Testing’.

CALCULATION OF RESISTIVITY

Assuming that the tests were carried out in homogeneous soil 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'.

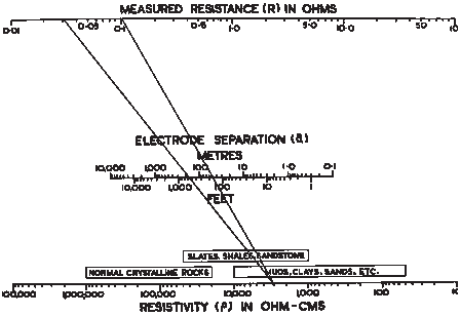


Fig. 18 Nomogram for resistivity calculations.

MEASURING TECHNIQUES Continuity Testing

To test the continuity of conduit or other earth conductors the instrument is connected as shown in Fig.19. It will measure metallic resistances of low inductance or capacitance. Make sure that the circuit is 'dead' i.e. de-energised, 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 eliminated by using four terminal measurement. Alternatively the resistance can be found by joining them together and taking a measurement and subtracting this value from the measurement.

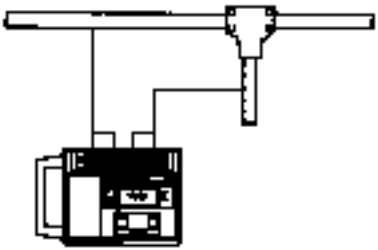


Fig.19 Continuity testing.

CIRCUIT DESCRIPTION

The instrument uses the four terminal method of measurement. A reversing d.c. test current is injected into the earth through terminals C1 and C2. The potential developed across the earth is monitored with P1 and P2. A three pole test is achieved by shorting terminals C1 and P1 together through an internal relay. At the beginning of a test , the control logic initiates a potential spike resistance check, monitoring the input overload comparator for the result. The instrument autoranges by the control logic monitoring the output of the overrange detector and switching the current source to a lower current output. The instrument also autoranges if the if the high current loop resistance detector senses too much current loop resistance for the preset range.

The instrument measuring circuitry is connected to terminals P1 and P2. The voltage limiter and input buffer prevent damage to the instrument and loading of the resistance under test. Synchronous filtering and detection are used to recover the test signal from noisy enviroments followed by filtering and conversion to a reading by the digital panel meter.

The test signal frequency is produced by dividing the frequency of a crystal oscillator. This is then passed through logic circuitry to produce the waveforms for synchronous filtering and detection.

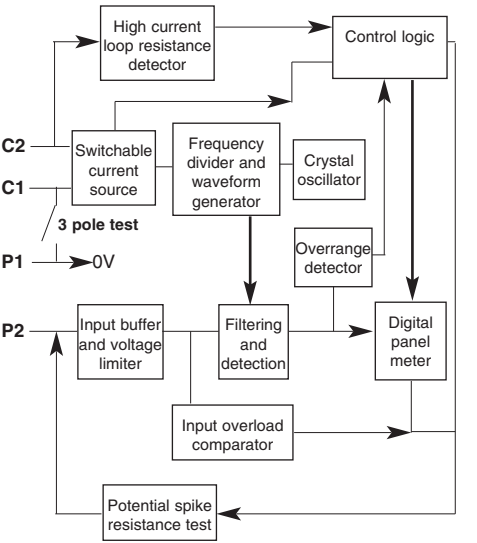


Fig.20 Block diagram of instrument circuit.

REPAIR AND WARRANTY

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

New Instruments are Guaranteed for 1 Year from the Date of Purchase by the User.

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

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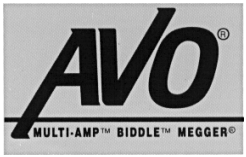
If returning an instrument to the manufacturer for repair, it should be sent, freight pre-paid, to the appropriate address. A copy of the Invoice and of the packing note should be sent simultaneously by airmail to expedite clearance through Customs. A repair estimate showing freight return and other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



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