Megger

"REGISTERED TRADE MARK."

hand-book on

CONTINUITY AND POLARITY TESTING

MEGGER

"Registered Trade Mark"

HANDBOOK ON CONTINUITY AND POLARITY TESTING

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FOREWORD

The Electricity Supply Regulations 1937 made by the Electricity Commissioners prescribe in effect (Section 26) that the Electricity Supply Undertakings shall not permanently connect an installation unless they are satisfied that the connection would not cause a leakage exceeding one ten thousandth part of the maximum current to the installation.

Now this regulation pre-supposes that some form of test be carried out, and whilst no specific tests are mentioned it is usual in practice to measure the insulation resistance of an installation prior to connecting it up.

Further, Section 27 of the above regulations stipulates that the Supply Undertakings shall not be compelled to give a supply of energy to any consumer unless they are satisfied that all conductors and apparatus are constructed, installed and protected so as to prevent danger; that all single-pole switches are inserted in live conductors only; and that (Section 29) the consumer's wiring is either completely enclosed in metal which is electrically continuous or alternatively so constructed, installed and protected as to prevent danger.

Sections 27, 28 and 29 also state that:
"Any consumer's installation which complies with the provisions of the Institution of Electrical Engineers Regulations shall be deemed to fulfil the requirements of this regulation."

In the following pages reference is therefore made to the I.E.E. Regulations which give a more precise idea of the requirements.

Figure 1. The Meg Insulation and Continuity Tester described on Page 31. Suitable for measuring insulation resistance at 500 volts and conductor resistance at low pressure.

TESTING OF INSTALLATIONS

The Regulations of the Institution of Electrical Engineers state that in the interests of safety all electrical installations, where steel conduit, lead sheathing or armoured cable is used, should be tested both for insulation resistance and for continuity of the conduit or sheathing. Tests should also be carried out to verify the polarity of switches and 3-pin socket-outlets.

Great importance is attached to continuity on which depends the earthing of the connected appliances and the correct operation of the protective fuses. The dangers of bad continuity are illustrated in Figure 2.

Insulation Tests

In Regulations Nos. 1101 to 1104,* the I.E.E. lay down the requirements as regards insulation resistance.

The method of carrying out insulation tests and the instruments recommended for the purpose are not dealt with in this book, but are described in an illustrated booklet (No. 200) obtainable from Evershed & Vignoles Ltd.

Continuity Tests

The I.E.E. Regulations governing continuity (Nos. 403I, 405K, 1001-1009) prescribe that:

> "The electrical resistance of the metal sheathing and/or armouring, together with the resistance of the earthing lead, measured from the connection with the earth electrode to any other position in the completed installation, shall not exceed 1 ohm."

In this book are described a few simple methods of making tests to ascertain that an installation does comply with the regulations as regards continuity, and on Pages 29 and 31 will be found particulars of the instruments recommended for this purpose.

The term "conduit" used in this book should be taken as implying steel conduit, lead sheathing or armouring.

* I.E.E. Regulations for the Electrical Equipment of Buildings, eleventh edition.

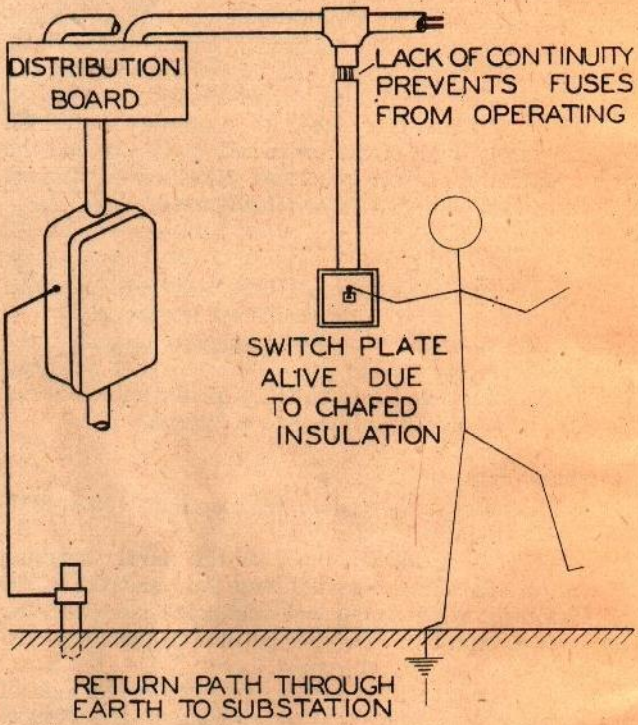


Figure 2. Diagram showing danger of bad continuity and how a man may receive a shock.

Polarity Tests

I.E.E. Regulation No. 1105 lays down that,

> "a test shall be made to verify that all non-linked single pole switches have been fitted in the same conductor throughout and such conductor shall be . . . . the non-earthed conductor of the supply."

Polarity tests should also be carried out at 3-pin socket outlets to see that the terminal marked "L" is connected to the non-earthed conductor as laid down in I.E.E. Regulation No. 608H. The disposition of the contacts should be in accordance with British Standard Specification No. 546 as shown in Figure 3.

Figure 3. Diagram showing disposition of contacts in a 3-pin socket-outlet as viewed from the front.

Simple means of testing polarity are described in this book and the tests are so arranged that they may be carried out at the same time and with the same instruments as the continuity tests, thus effecting a saving in time.

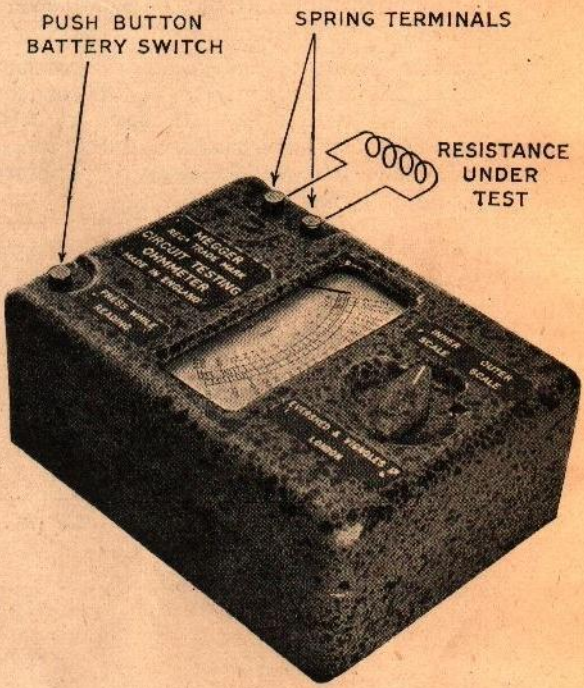


Figure 4. The Megger Circuit Tester described on Page 29 ; pattern with two terminals and press button battery switch.

WHEN TO MAKE CONTINUITY AND POLARITY TESTS

On a new installation it is recommended that the contractor should make preliminary tests of the continuity of the conduit before the latter is covered over by plaster. On completed installations, continuity and polarity tests should be made after the contractor has satisfied himself that the insulation of the wiring is in a sound condition.

Tests should also be carried out on any earthed apparatus connected to the system, such as washing machines, cookers, kettles, irons, etc.

It must be remembered that an installation tested originally and found correct may not continue in such a condition indefinitely. Rusting at tubing joints, the corrosion of earth clips and the breakage of flexible earth leads will impair the continuity. Installations should therefore be tested periodically to ensure that the continuity is not deteriorating.

METHODS OF CARRYING OUT CONTINUITY AND POLARITY TESTS

Tests may either be carried out with the circuit dead or with the circuit alive.

On pages 11 and 15 are described two methods of making continuity and polarity tests on a dead circuit. The former, which is the simpler, is the more suitable for small installations, whereas the latter is often more convenient for large buildings.

The manner of carrying out continuity and polarity tests with the circuit alive is described on Page 19, while the special method of test mentioned on Page 23 applies only to continuity measurement.

It is important that the instrument test leads should make a good, clean contact with the metal work at the points tested.

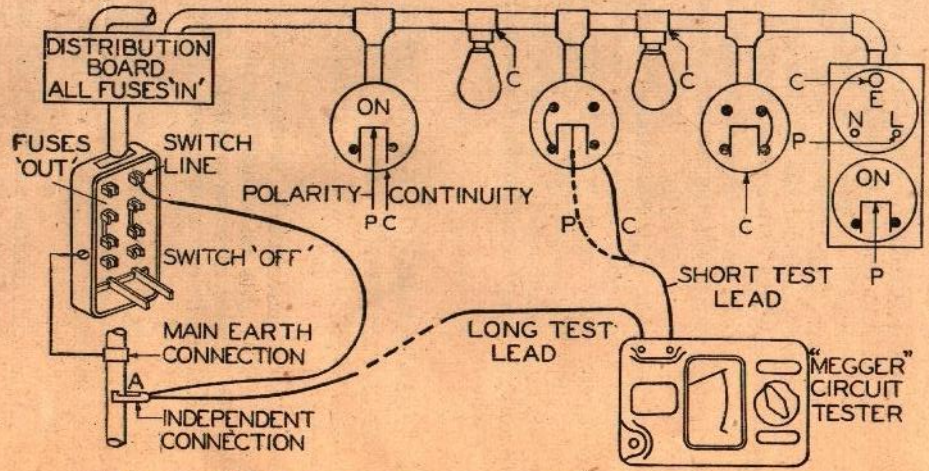


Figure 5. Tests with circuit dead (Method 1). Test at points C for continuity and at points P for polarity.

Tests with circuit dead. Method 1, using a long test lead. Figure 5

The continuity and polarity tests described below should be carried out together at each point in turn.

Before testing

(1) Open the main switch and, as a precaution, remove the main fuses.

(2) See that all fuses are inserted in the distribution boards.

(3) Connect the red (switch) conductor on the installation side of the main fuse to the consumer's main earth as shown in Figure 5.

(4) Connect one terminal of the testing instrument by a long test lead to the consumer's main earth, using an independent test connection as shown at "A" (Figure 5).

By using an independent connection the resistance of the main earth connection is included in the continuity measurements.

To measure continuity

Connect the other terminal of the instrument by a short lead to the points marked "C" in Figure 5, i.e. to switch boxes, ceiling roses, earth sockets of 3-pin socket-outlets, and to the conduit at 2-pin sockets.

If the resistance measured is 1 ohm or less, the continuity is satisfactory.

If the resistance is only slightly above 1 ohm the continuity can generally be passed as satisfactory. The resistance measured actually includes the resistance of the leads which may, if desired, be measured on the instrument and deducted.

If after deducting the resistance of the leads the continuity is still too high (over 1 ohm), the cause of the high resistance must be sought by measurements made along the line of conduit or metal sheathing as shown in Figure 6, until the joint causing the high resistance is located.

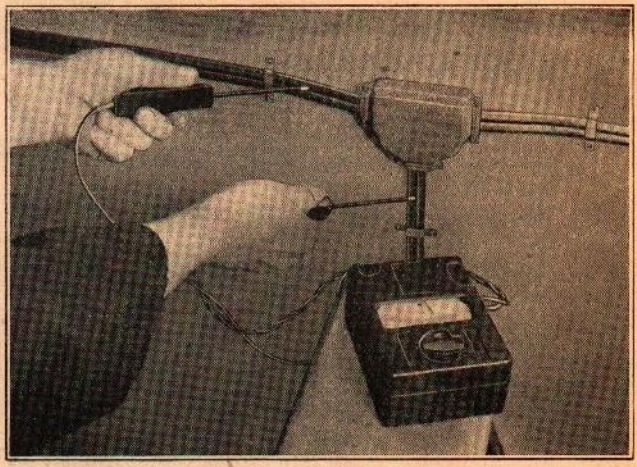


Figure 6. Measuring continuity across a junction box.

To test polarity

Connect the terminal of the instrument having the short lead to points marked "P" in Figure 5, i.e., to the "L" socket of 3-pin socket-outlets any switch controlling the socket being closed, and to the bridge pieces of all local switches, the switch in question being in the "closed" or "on" position.

If a resistance of 1 *ohm or less is obtained in any of the above polarity tests, the polarity of the socket or switch is correct.*

With 2-way corridor switches which have no definite "on" position, test one switch in each pair in both "on" and "off" positions and take the lower reading.

In the case of 3-pin socket-outlets a check test may be made on the "N" socket, when a high resistance should be obtained.

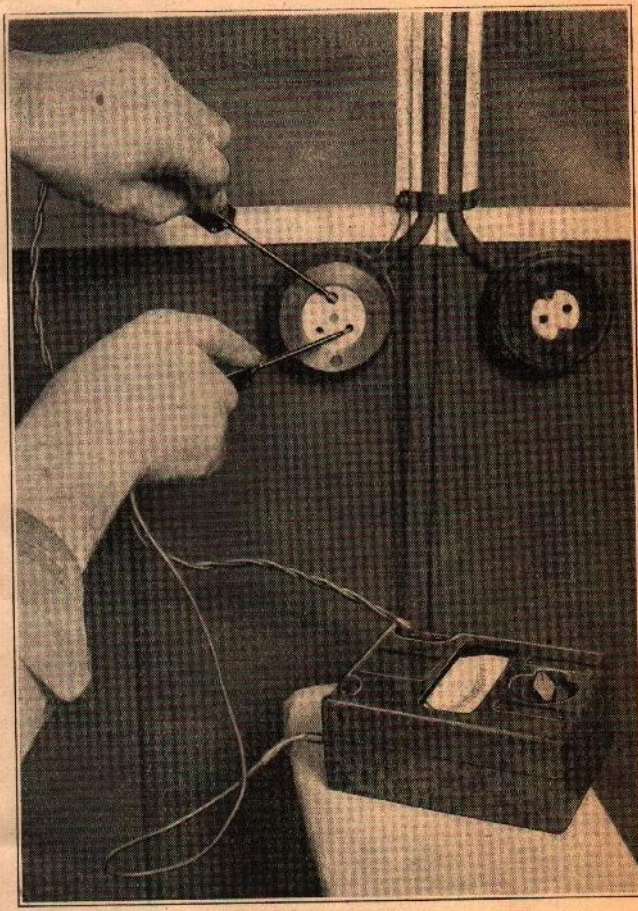
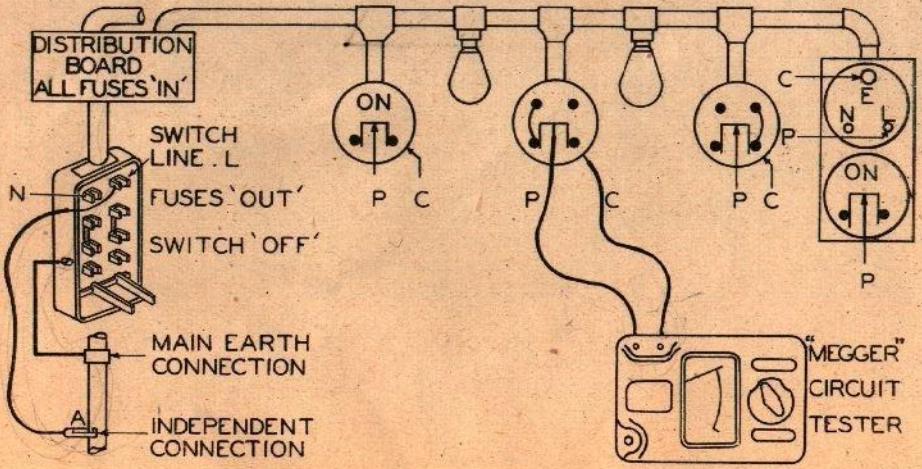


Figure 7. Measuring the continuity resistance of an installation at a 3-pin socket by Method 2, Page 15 (main switch off).



THE RESISTANCE MEASURED SHOULD BE ONE OHM OR LESS

Figure 8. Tests with circuit dead (Method 2). Test between points C and P.

Tests with circuit dead. Method 2, using the circuit wiring instead of a long test lead. Figure 8.

Before testing

(1) Open the main switch and, as a precaution, remove the main fuses.

(2) See that all fuses are inserted in the distribution boards.

(3) Connect the red (switch) conductor on the installation side of the main fuse to the consumer's main earth, using an independent test connection as shown at "A" (Figure 8).

By using an independent connection, the resistance of the main earth connection is included in the measurements.

Continuity and polarity tests

Close the switch under test, and when testing at a 3-pin socket-outlet or at a ceiling rose, close any switch controlling this point. Where 2-way corridor switches are installed, test separately the two switches in both "On" and "Off" positions, and take the lower readings.

Connect one terminal of the testing instrument to points marked "C" (see Figures 7 and 8) and the other terminal to points marked "P," or, in the case of 2-pin sockets or ceiling roses, to each conductor taking the lower of the two readings.

If the resistance measured is 1 ohm or less, the continuity is satisfactory and the polarity correct.

If the resistance measured is above 1 ohm this point should be noted for further investigation, as described on page 17.

The resistance measured above includes the resistance of *one* conductor from the main switch to the point under test. If, therefore, the resistance measured is only slightly above 1 ohm the continuity may generally be passed as satisfactory.

The approximate resistance of one conductor may, however, be obtained as follows :—

Join together the red and black conductors on the consumer's side of the main fuses ("L" and "N" in Figure 8).

Measure the resistance at an adjacent ceiling rose or wall socket across the two contacts which will supply current to the lamp or other apparatus, as shown in Figure 9, and take *half* the value so obtained. The switch controlling the particular outlet must be in the "closed" or "on" position.

Figure 9. Measuring resistance of conductors, lead and return (main switch off)

Further investigation if high readings are obtained

In order to ascertain whether the high readings are due to bad continuity, wrong polarity or to both causes, proceed as follows :—

Connect one lead of the testing instrument to the conduit at some other point where good continuity has been proved (see Figure 10).

Connect the other lead in turn :

(*a*) to the switch box or to the earth socket of the outlet under test, to check the continuity.

(*b*) to the bridge piece of the "closed" switch or to the "L" socket of the 3-pin socket-outlet, to check the polarity.

In each case a reading of 1 *ohm or less should be obtained if the continuity and polarity are correct.*

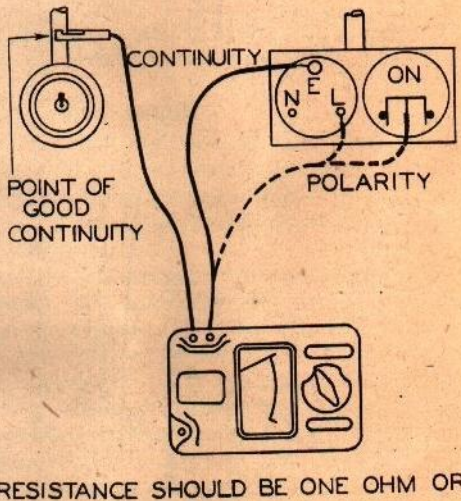


Figure 10. Tests to ascertain if a high reading is due to bad continuity or wrong polarity.

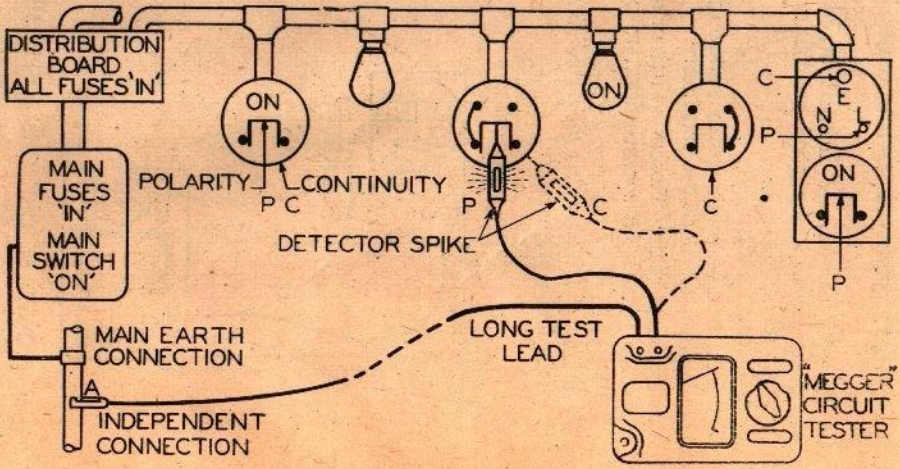


Figure 11. Tests with circuit alive, using an **Evershed** Detector Spike. Test at points C for continuity and at points P for polarity.

Tests with circuit alive, using an Evershed Detector Spike. Figure 11.

Before testing :

(1) See that all fuses are inserted in the distribution boards.

(2) Connect one terminal of the testing instrument by a long test lead to the consumer's main earth, using an independent test connection as shown at "A," (Figure 11).

(3) Connect the other terminal of the instrument to an Evershed Detector Spike described on Page 32. This Spike protects the instrument in the event of any section of the conduit being alive (see Figure 13), while enabling the polarity tests to be carried out concurrently.

IMPORTANT

If during a test the lamp in the Detector Spike lights up, the Spike must on no account be pushed home.

To measure continuity

Test with the Detector Spike at points marked "C," Figure 11. If the lamp in the Detector Spike does not light push the Spike home and take a reading on the instrument.

If the measured resistance is 1 ohm or less, the continuity is satisfactory.

If the resistance is only slightly above 1 ohm the continuity can generally be passed as satisfactory. The resistance measured actually includes the resistance of the leads which may, if desired, be measured on the instrument and deducted.

If the lamp in the Detector Spike lights up this indicates that both the continuity of the conduit and the insulation of the circuit wiring are faulty.

In these circumstances, the faulty circuit should be isolated at the first opportunity and the insulation fault corrected before any further tests on the continuity can be made.

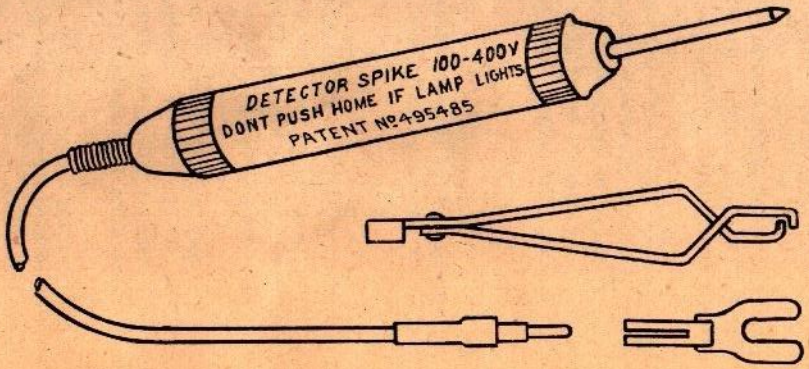


Figure 12. The Evershed Detector Spike described on Page 32.

To test polarity

All switches *must* be in the "closed" or "on" position when tested. With 2-way corridor switches, the "on" position can be seen by observing the lamp they control. When testing 3-pin socket-outlets, any switch controlling the socket must be closed.

Touch the Detector Spike lightly on the points marked "P" (Figure 11); the spike must *not* be pushed home.

If the lamp in the Detector Spike lights up the polarity is correct. NOTE.—This deduction only applies if the switch is in the "ON" position when tested.

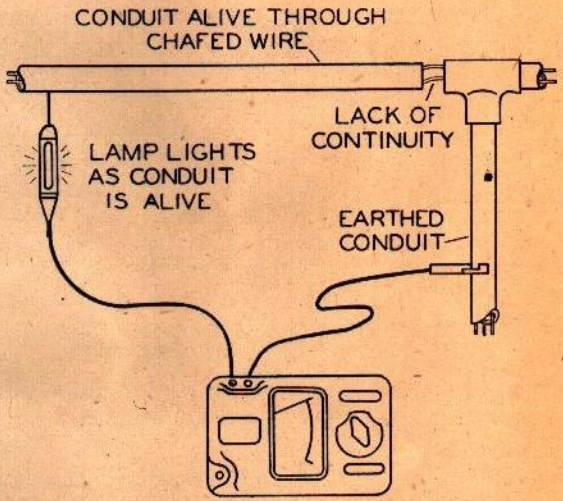
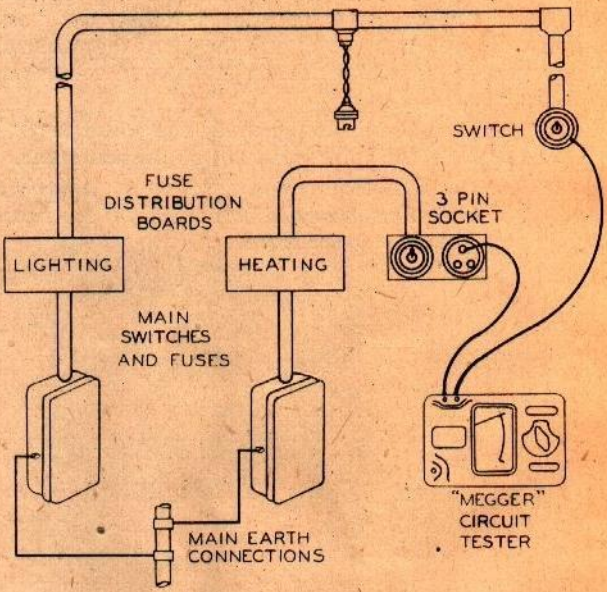


Figure 13. Diagram showing advisability of using an Evershed Detector Spike when testing continuity with the circuit alive.



RESISTANCE MEASURED SHOULD NOT EXCEED TWO OHMS
(ONE OHM ON EACH CONDUIT SYSTEM)

Figure 14. Alternative method of measuring continuity on installations containing two independent wiring systems.

Alternative method of testing the continuity of installations containing two independent wiring systems. Figure 14.

In a building where two independent sets of wiring are installed, simple tests for continuity can be made as shown in Figure 14, between the conduits or boxes of the two installations.

These tests may be carried out with the circuits dead or alive, but under the latter condition it is advisable to use the Detector Spike described on Page 32.

For these tests to be of value, it is essential that the two main switch boxes should have separate connections to the consumer's main earth, and that the two runs of conduit should not make electrical contact with one another at any point except through the two earths.

These tests will measure the continuity resistance of both installations, up to the points tested. The values obtained will include the resistance of the connections to earth of each installation, and should not exceed 2 ohms (1 ohm on each installation).

The resistance of the testing leads to the instrument are included in the measurements obtained in the above test. Where these leads are long, their resistance may be measured and deducted if an exact value of the continuity is desired.

It should be pointed out that if the two runs of conduit happen to touch one another at any point, a low reading will be obtained regardless of whether the conduit systems are connected to earth. With this method of test it is advisable, therefore, to make a further check test between each conduit run and the consumer's main earth.

Polarity tests must be carried out separately as described on Pages 12 and 15 if the circuit is dead, or on Page 21 if the circuit is alive.

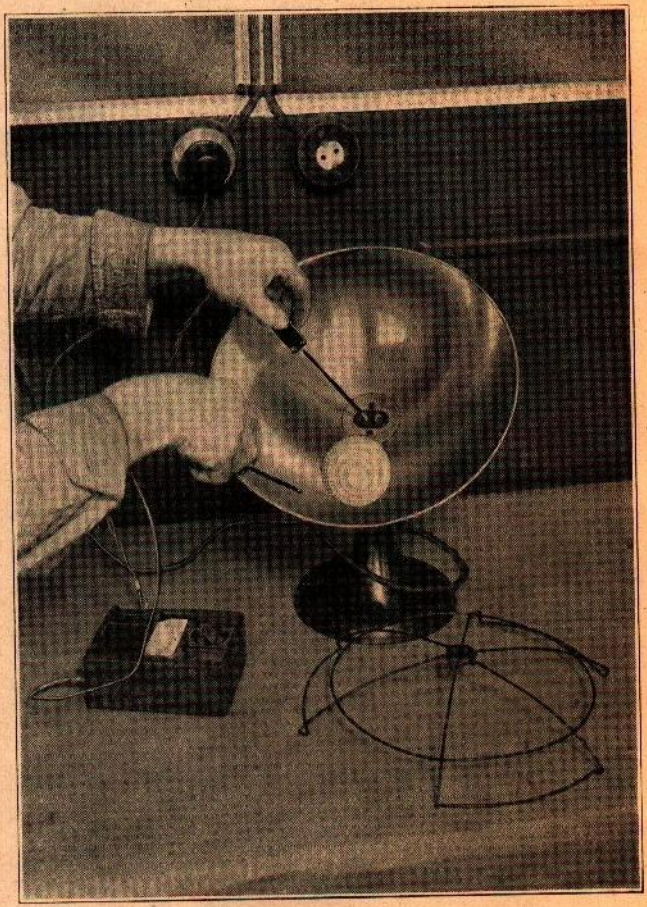


Figure 15. Measurement of continuity from the frame of a bowl fire to earth, as described on Page 27. Element removed for convenient access to terminal.

TEST FOR CONTACT BETWEEN ELECTRICAL CONDUIT OR SHEATHING AND GAS PIPES

I.E.E. Regulations 403A and 405B lay down that metal sheathing or conduit must be :

"prevented by spacing, insulation or other means, from coming into contact . . . with gas pipes . . ."

To see that an installation complies with this regulation, an additional test should be made. This may be carried out in the following manner provided that the conduit has been previously tested as just described and found to be electrically continuous throughout.

Disconnect temporarily the main earth connection and any other earth connections (see Figure 16).

Connect one terminal of the testing instrument to the gas piping and the other terminal to any point on the tested circuit, and take a reading.

A comparatively high reading should be obtained. If the resistance is of a low value, say 1 or 2 ohms, the gas pipe is probably in metallic contact with the conduit, in which case a close inspection is necessary to locate the point or points of contact.

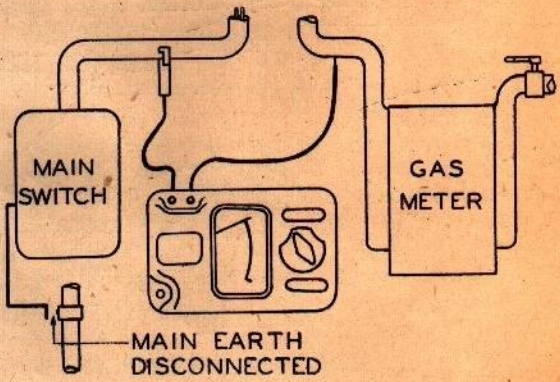


Figure 16. Test for contact between conduit and gas pipes.

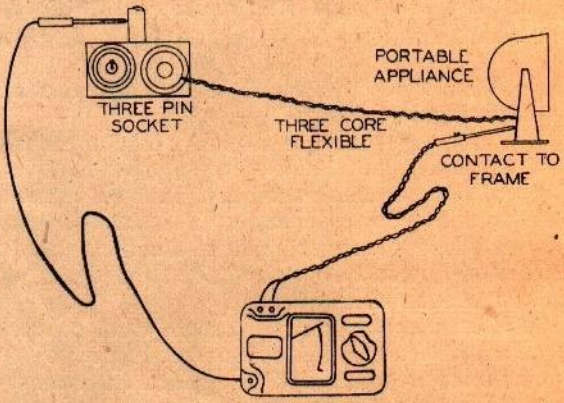


Figure 17 Earthing of portable apparatus. Simple method of test if continuity of installation is sound.

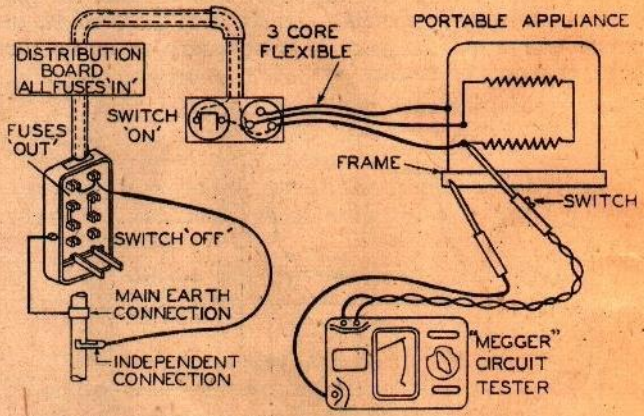


Figure 18. Earthing of portable apparatus. Method of test if continuity of installation is doubtful.

CONTINUITY TESTS ON APPARATUS INSTALLED

The tests so far described have been on the installation itself; if, however, any apparatus is arranged to be earthed by means of three core flexible or otherwise, the continuity resistance from the frame of each piece of apparatus to earth should be measured.

If the installation has recently been tested by the methods just described, it is merely necessary to measure the resistance between the frame of the apparatus and the earth pin or the conduit at the 3-pin socket-outlet (see Figure 17). The reading obtained should be nearly zero. This test may be carried out with the circuit alive if the insulation of the apparatus is good. If in doubt, use the Detector Spike described on Page 32.

If the apparatus being tested is connected at a later date to an installation whose continuity is in doubt, a test may either be made directly between the frame of the apparatus, when connected, and the consumer's main earth, using a long lead as described in Method 1, Page 11, or by using the circuit wiring, when the following procedure should be adopted (see Figure 18):

(1) Open the main switch and withdraw the main fuses.
(2) Join together the red and black conductors on the consumer's side of the main fuses and connect them to the consumer's main earth, using an independent earth connection.
(3) Close the switch controlling the apparatus to be tested.
(4) Measure the resistance between a convenient terminal of the apparatus and the frame as shown in Figure 18 and Photograph Figure 15. In the latter, the element is shown removed for convenience in obtaining access to the terminal on which the ohmmeter spike can be used.

This test gives the continuity resistance of the apparatus under test, of the branch circuit and of the connection to earth, and should not exceed 1 ohm after making allowance for the resistance of one conductor as explained in Figure 9, Page 16.

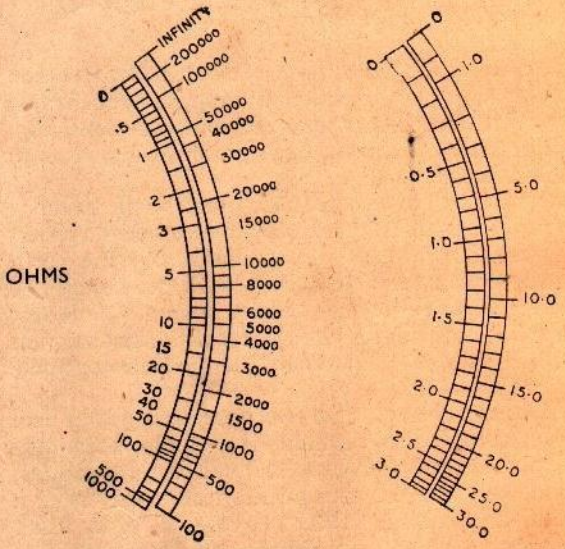


Figure 19. Two alternative scales that can be provided on the Megger Circuit Tester (full size).

NOTE. The Megger Circuit Tester, which is fully described in List No. 514, is not suitable for measuring insulation resistance of circuits. For the latter purpose, the 500-volt wee-Megger Insulation Tester described in List No. 208, or other Megger or Meg Insulation Testers should be used.

INSTRUMENTS USED FOR CONTINUITY AND POLARITY TESTING

The Megger Circuit Tester

The Megger Circuit Tester illustrated in Figure 4 consists of a direct reading ohmmeter and a small dry battery, the whole being contained in a moulded case of such a size ($5\frac{3}{8} \times 4 \times 2\frac{1}{4}$ ins.) that it can be conveniently carried in a jacket pocket. Two typical scales are shown full size in Figure 19.

The instrument is exceedingly simple to use and will give accurate results, the reading of the instrument being independent of the exact voltage of the battery; the only effect of reduced voltage is that the needle becomes sluggish and when this happens, the battery, which is an ordinary $4\frac{1}{2}$-volt flash lamp battery, should be replaced.

A battery switch is incorporated with each instrument. Two patterns of instruments are available, the two terminal instrument in which the switch is incorporated in the instrument case as shown in Figure 4, and the three terminal instrument, which is similar in appearance and is provided with two testing spikes, the switch being fitted in the handle of one of the spikes, as shown in Figures 7 and 20.

Both instruments can be used to make the tests described in this book, the former being possibly the more convenient for this particular purpose. If, however, the instrument is also required to test other apparatus, such as wireless sets, the three terminal instrument is often the more convenient as it leaves the hands free to manipulate both testing spikes.

For continuity and polarity tests, the two terminal instrument should be connected as shown in Figures 5, 8 and 11, and the three terminal instrument as shown in Figure 20. To enable a three terminal instrument to be used with a Detector Spike an adaptor can be provided, as shown in Figure 21.

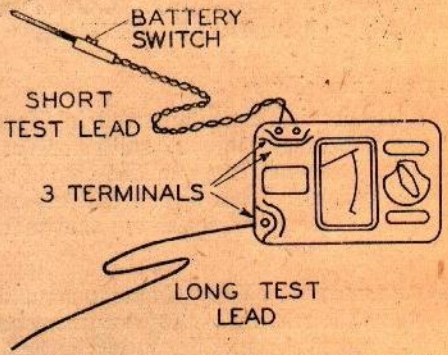


Figure 20. Diagram of connections of three terminal Megger Circuit Tester.

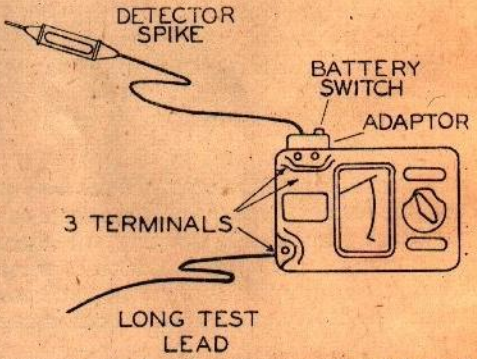


Figure 21. Diagram showing three terminal Megger Circuit Tester fitted with switch adaptor for use with an Evershed Detector Spike.

The Meg Insulation and Continuity Tester

The Meg Insulation and Continuity Tester shown in Figure 1 is equally simple to use. This instrument, which contains a hand-driven generator and a direct reading ohmmeter can be used for making insulation tests (at high pressure) as well as the continuity tests described in this book, which are made at low pressure.

A sample scale is shown in Figure 22 and full particulars can be obtained from List No. 454.

Figure 22. Full size scale of a Meg Insulation and Continuity Tester.

The Evershed Detector Spike

When testing for continuity and polarity on circuits which are alive, an Evershed Detector Spike (Figure 12) must be used to protect the testing instrument from damage. This consists of a spring loaded spike and a neon lamp contained in a cylindrical body of transparent material provided with a flexible lead for connection to the testing instrument.

If during a test the Spike comes into contact with live metal the neon lamp will light up but no damage will be done to the instrument provided that the spring loaded Spike is not pushed home. If the lamp does not light the Spike may then be pushed home and the measurement made. The act of pushing home the spike short circuits the high resistance neon lamp.

The Evershed Detector Spike is fully described in List 192.

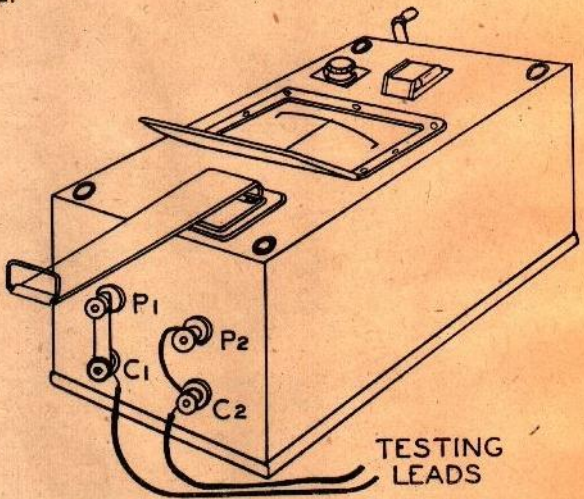


Figure 23. Connections of Megger Earth Tester when used for measuring continuity.

TESTING IN RURAL AREAS

The Megger and Meg Earth Testers

The tests described in this book are primarily intended for use in built-up areas where a good earth is usually available.

In rural areas, however, a water main or other good earth may not be available and the conduit has, in consequence, to be connected to an earth plate.

In addition, therefore, to testing the continuity of the conduit up to the earth plate, it is necessary that the resistance of the earth plate itself to earth should be measured. This resistance also should not exceed 1 ohm (see I.E.E. Regulation 1005B).

The measurement of the earth plate resistance involves the use of a special instrument and for this purpose a Megger Earth Tester or a Meg Earth Tester should be used. These instruments and the method of carrying out such tests are described in Pocket Book 202.

The Megger and Meg Earth Testers may also be used for carrying out the continuity tests just described by connecting them in the manner shown in Figures 23 and 24.

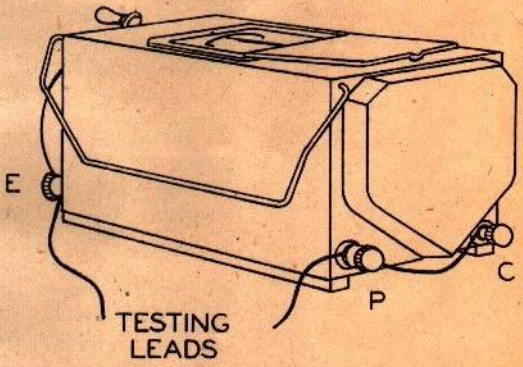


Figure 24. Connections of Meg Earth Tester when used for measuring continuity

STRAY CURRENTS

The movements of the testing instruments described in this book contain no control springs, the pointers therefore will not take up a definite position on the scale until the battery switch is operated or the generator handle is turned.

If, however, after making the test connections and prior to pressing the battery switch or turning the generator handle, the pointer is observed to move across the scale, this will indicate the presence of stray or vagabond D.C. currents in the conduit under test. If these currents are considerable, two test readings should be taken, the test leads on the instrument terminals being interchanged between tests. The mean of the two readings will give the correct value.

This procedure applies to the Megger Circuit Tester and to the Meg Insulation and Continuity Tester. With Megger and Meg Earth Testers, however, only the one reading is necessary, as this is unaffected by stray currents.

NOTES

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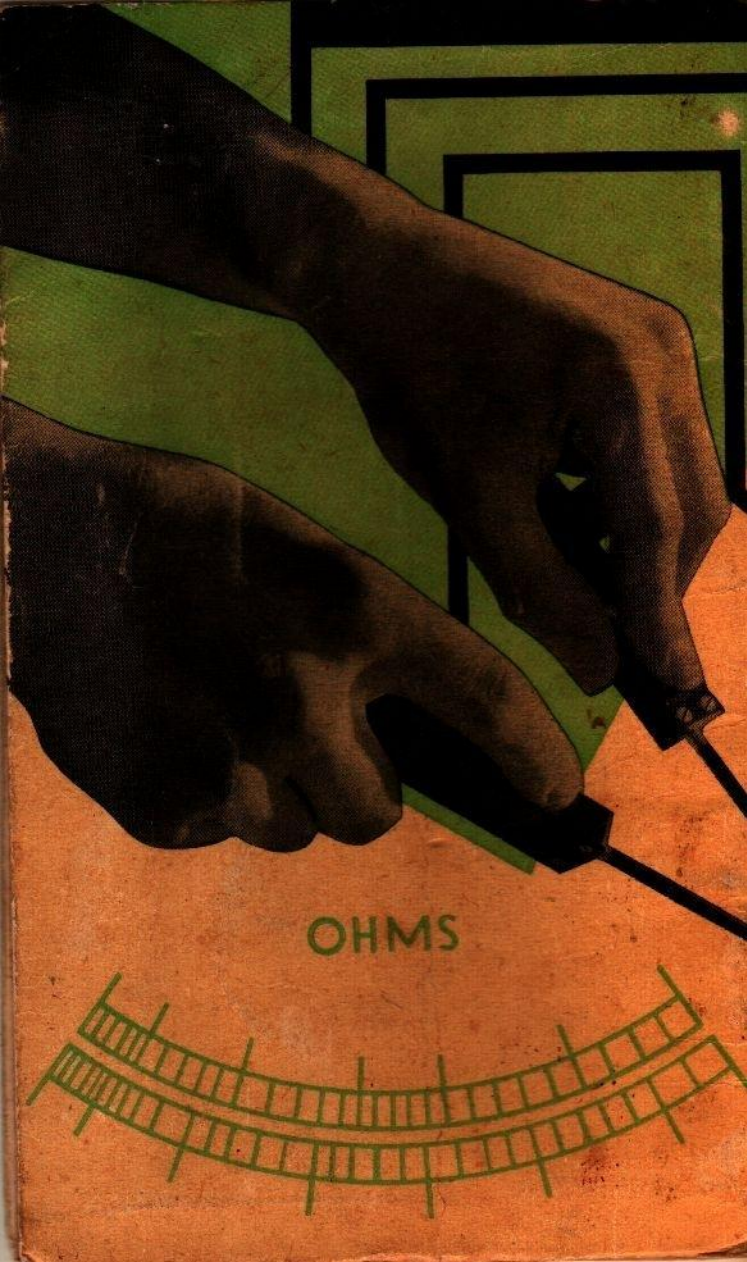
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