BURIED WIRE TESTING

Contents

1. GENERAL

1.01 This section describes methods of locating faults in buried wire.

1.02 The general procedure for locating a fault involves one or more of the following steps, depending upon circumstances.

(a) Determining the nature and magnitude of the fault.
(b) Localizing the fault to a particular branch or section of the buried wire system.
(c) Making Wheatstone bridge measurements when this is possible.
(d) Tracing the path of the wire to the vicinity of the fault by the exploring coil method.
(e) Running down the fault by the exploring coil method by further Wheatstone bridge measurements or by a "cut and try" method.

2. APPARATUS

2.01 The following apparatus may be required.

Amplifier: **4-B AMPLIFIER.** (For amplifying tone pick-up in the receivers).

Bridge: **PORTABLE WHEATSTONE BRIDGE.** (For fault locating measurements).

Coil: **BICYCLE WHEEL EXPLORING COIL.** (For use in tracing the path of a wire and running down faults.

Condenser: **1 MF CONDENSER.** (For use with the Wheatstone bridge when locating opens).

Megger: **400 VOLT MEGGER.** (For insulation resistance tests and for use as a source of potential when measuring high resistance faults).

Rods: **GROUND RODS.** (For use in making electrical tests).

Receivers: **PAIR OF 528 RECEIVERS.** (For use with the bicycle wheel exploring coil and 19-C test set).

Test Sets: **17-TYPE TEST SET.** (For talking purposes and continuity tests).
20-C TEST SET. (For supplying current in tracing the path of a wire and in running down faults).
19-C TEST SET. (For running down faults).
43-A OR 45-A TEST SET. (For supplying tone when locating opens with the Wheatstone bridge).

Voltmeter: **HIGH RESISTANCE VOLTMETER.** (For use in testing for grounded circuits).

3. PRECAUTION

3.01 Test clips shall not be used to penetrate the insulation in making tests on U-distribution wire as the resulting puncture will cause permanent injury to the insulation.

4. TESTS DURING INSTALLATION

4.01 In laying wire, the conductors at the outer end of each section or reel of wire should be short-circuited and wrapped with rubber tape to facilitate testing the wire at the reel during installation. The inner end of the wire may be exposed by removing the metal plate on the side of one of the flanges of the reel in case it is desired to have access to it for testing purposes. When anything occurs in the plowing operation which would indicate that the wire may have been broken or the insulation injured, the plow should be stopped and the conductors tested for an open circuit or a ground. Immediately after a length of wire has been placed and before it is spliced, a continuity test should be made and the insulation resistance of both conductors to ground should be measured simultaneously. The insulation resistance should be not less than 100 megohm miles.

5. COMPLETION TESTS

5.01 After the splices in a section of wire or branch have been made the wire should be tested for an open circuit and the insulation resistance between conductors and between conductors and ground should be measured to determine whether the conductors are in good electrical condition. The insulation resistance should be not less than 100 megohm miles.

6. LOCATING FAULTS—PRELIMINARY TESTS

6.01 Preliminary tests should be made by the test deskman or by the repairman with the 17-type test set, megger, or with a receiver and battery to determine the nature and magnitude of the fault, if possible.

7. SECTIONALIZING THE FAULT

7.01 In general, the methods for testing and localizing faults in drop and block wiring described in Division 625 are applicable to buried wire.

7.02 At the first buried wire terminal out from the central office, the repairman should test the line both ways and also any branch connected to the main line. The battery and receiver method (using 17-type test set) should be used to determine whether a wire contains a short-circuit or open. A megger or voltmeter should be used to determine whether the wire is grounded. If the fault is not found in the line toward the central office or in the branch line, the conductors should be reconnected to the terminal. These tests should be repeated at the next and succeeding terminals until the particular section containing the fault is found. If, preparatory to starting the sectionalizing tests, the fault is suspected to exist in a certain part of the wire, a test should be made first at the terminal nearest to and on the central office side of he section suspected of being in trouble.

7.03 After the fault has been sectionalized, an inspection should be made between the two terminals to see if there is any evidence of the cause of the trouble, such as road work, soil erosion, pole setting, etc.

7.04 If the trouble cannot be located by inspection, the faulty pair should be opened at the terminals on both sides of the fault so that Wheatstone bridge measurements or other tests can be made.

8. WHEATSTONE BRIDGE MEASUREMENTS

8.01 Methods of locating faults with a Wheatstone bridge are described in the field trial instructions on cable fault locating.

8.02 **Grounds and Shorts:** A single conductor ground can be located by the Varley method. If both conductors are grounded or if the fault is a short-circuit, it will be necessary to run an auxiliary wire on the ground between the two terminals in order to provide a "good" conductor for the Varley measurement. If it is necessary to lay an auxiliary wire on the ground and the section in trouble is long, say more than one-half mile in length, it may be advisable to sectionalize the trouble by the "cut and try" method to a shorter section. In the event that there is available a second buried wire, having terminals conveniently located with respect to the faulty pair, a conductor of the second pair can be used as the "good" wire.

8.03 The resistance of buried wire is 53.5 ohms per loop mile at 68° F. The resistance applying at the time fault locating measurements are made should be determined by a loop resistance measurement made in connection with the Varley measurements.

8.04 The battery in the Wheatstone bridge can be used in making bridge measurements to locate grounds and short-circuits having resistances of not more than a few thousand ohms. For faults of higher resistance, the 54-volt battery of a 45-A test set or the "earth" and "guard" terminals of a megger should be used as the source of potential for the bridge. With these external sources of potential, faults up to 50,000 ohms can be located in favorable conditions. In measuring high resistance faults, measurements should be made at both ends of the section.

8.05 **Opens** can be located by the Murray method, using a 1 MF condenser, and tone from a 43-A or 45-A test set. If both conductors are open, the equivalent capacitance of a "good" conductor can be calculated by taking the sum of the bridge balancing resistances obtained by measurements on the faulty conductor taken from the two ends of the faulty section.

8.06 After the readings have been made, the resistance or capacitance should be translated into feet. Account must be taken of any loops left at terminals, in subscriber premises or anywhere in the line and of any loading coils that may be located in the section. The resistance of each coil winding is 2.1 ohms or 4.2 ohms for the loop resistance. Locations determined from each end should check closely and if they do not agree errors in measurements, calculations or double faults are indicated. The length of the section and the distance to the fault can be determined by measuring with a tape, by pacing or by other means.

8.07 **Combined Faults:** It may be necessary to locate complicated faults such as a combined ground and open by a "cut and try" method.

8.08 If it is necessary to trace the path of the wire, this can best be done by the bicycle wheel exploring coil method.

9. TRACING THE PATH OF A WIRE

9.01 The methods of tracing the path of a buried conductor described in Division 634 are applicable to buried wire. The 20-C test set should be connected between the wires and ground at one end of the section. The other end should be clear.

10. RUNNING DOWN FAULTS

10.01 After Wheatstone bridge readings have been made and the wire has been traced to the calculated location, the wire should be exposed by excavation. If there are two pairs of wire in the same trench, the faulty pair can be identified as outlined in Part 11. The faulty wire should be cut and then tested in both directions from the point to determine which section contains the fault. If the fault is not at the indicated point, further bridge readings should be made.

10.02 **Grounds** having resistances up to 10,000 ohms can generally be localized by the bicycle wheel exploring coil method, provided the length of wire beyond the fault is very short, say not over 50 feet. At the terminal or far end of the section containing the fault, a 20-C test set should be connected between the faulty wire and ground, using terminals 3 and 5. The cut end should be clear. Intermittent tone should be used.

Beginning at a point between the 20-C test set and the excavation where the tone can be heard, walk along the path of the wire toward the excavation with the bicycle wheel held in a vertical position and its plane in line with the direction of the wire. This position of the coil will give maximum tone pickup. The tone will be heard in the receivers at its full intensity between the 20-C test set and the fault. Beyond the fault the volume of tone will diminish. If the fault resistance is high, the decrease in tone will be slight. If the tone picked up by the exploring coil and receiver is not sufficiently loud, a 4-B amplifier should be connected between the coil and the receivers.

10.03 At the point where a decided decrease in tone occurs, the wire should be exposed but not disturbed. Listening to the tone by running the 19-C exploring coil along the exposed wire may be helpful in determining whether the fault is on either side of this excavation. If no change in tone intensity is evident, it may be assumed that the fault has either cleared or that it is not at this point and further tests should be made before cutting the wire. It should be borne in mind that in the case of high resistance faults there may be some carry-over of the tone, in which case accurate locations may not be practicable. Also, there is some possibility of clearing the fault by exposing the wire. When it seems probable that the point of fault has been found or where some positive indication of damage is visible, the supposedly damaged piece of wire should be removed. Tests should then be made in both directions with the Wheatstone bridge or megger to determine if the trouble has been cleared.

10.04 **Open:** If both conductors are open at the same point, the fault may be located with the bicycle wheel exploring coil and 20-C test set. The test set should be connected between both wires and ground using terminals 3 and 4. Intermittent tone should be used. The coil should be held as described in paragraph 10.02. The tone will diminish in volume from the test set to the open and very little, if any, tone should be heard beyond the open.

11. IDENTIFYING FAULTY WIRE

11.01 Where there are two buried wires in the same trench, they can be identified after exposure by the use of the 19-C and 20-C test sets. Terminals 3 and 5 and intermittent tone should be used. If the fault is an open on one conductor, the test set should be connected between the good conductor and ground. If both conductors are open, the set should be connected between either or both of the conductors and ground. If one of the conductors is grounded, the set should be connected between the faulty conductor and ground. If both conductors are grounded, or in the case of a short-circuit, the 20-C test set should be connected between one or both conductors and ground.

11.02 At the excavation the two pairs should be separated about one foot and the 19-C test set held against each pair in turn. The greater volume of tone will be heard in the receivers when the test set is held against the pair to which tone is connected.

12. "CUT AND TRY" METHOD

12.01 A fault which cannot be located by the above methods must be located by the "cut and try" method. The wire should be exposed and cut at the approximate center of the section in which the fault has been isolated. After the wire has been cut, tests should be made in each direction from the cut to determine which section contains the fault. The section containing the fault should be exposed at the approximate center, the wire cut and tested in both directions. These operations should be repeated until the section containing the fault has been shortened sufficiently to allow it to be readily replaced.