BELL SYSTEM PRACTICES
Outside Plant Construction and Maintenance

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AT&T Co Standard

CABLE TESTING—GENERAL
LOCATING FAULTS IN LONG OR LOADED CABLES BY THE EXPLORING COIL METHOD

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1. GENERAL

1.01 This section covers the theory of locating grounds, crosses and split pairs in long or loaded cables by the exploring coil method and indicates the manner in which the tracing current should be connected to the faulty wires. It replaces Issue 1.

1.02 This section is reissued in connection with revising and expanding the information covered in Issue 1.

2. THEORY

2.01 In the exploring coil method of running down faults as applied to short, non-loaded cables, an alternating current of audible frequency is transmitted over the faulty wire or wires through the fault, and the electromagnetic field set up around the cable is detected by means of an exploring coil. No tone or a material decrease in the tone heard in the receiver when the exploring coil is held on the cable at a point beyond the fault, as compared to the tone heard when the coil is held on the cable at a point before the fault, indicates the location of the fault.

2.02 The 99A and 95B as well as the 78A and 95A (or 47B Test Sets) are designed for use in running down grounds, crosses and split pairs in long or loaded cables by the exploring coil method. While satisfactory for short non-loaded cable, the

76-type Test Set (or 20C or similar tone set) and the 75-type Test Set (or other exploring coils) can not be used successfully in long or loaded cables. Because of the frequency of the 76-type, 20C and similar tone sets, the current carries beyond the fault on the faulty wires so that no difference, or only slight difference in tone is distinguishable on the two sides of the fault. The main factors contributing to the spreading of the tone are as follows:

2.03 If, in a long cable the fault is so located that there is considerable cable beyond the fault, the capacitive impedance of the portion of the faulty wire beyond the fault may be relatively small. This impedance acts as a shunt around the fault resistance, causing the tracing current to divide at the fault, part flowing through the fault and part flowing along the faulty wire beyond the fault. Unless the fault is of very low resistance, the carry-over of tracing current may produce an appreciable tone beyond the fault.

2.04 In some cases this condition can be partially corrected by making the connections so that the longer length of cable is between the tone source and the fault. This procedure may not always be effective, however, as the tracing current attenuates rapidly in flowing along the cable. If the length of the cable from the tone source to the fault is very long, there may be insufficient tracing current at the fault to produce the required volume of tone.

2.05 In the case of a loaded cable, spreading of the tone results from transformer action of loading coils associated with the faulty wires. The flow of tracing current in the windings connected to the faulty wires induces voltages in the windings connected to the good wires, and because of the capacitances of the good wires, the induced voltages cause current to flow beyond the fault, where its magnetic field is picked up by the exploring coil. The summation of these and other electric and magnetic induction effects which tend to produce tone beyond the fault is defined as "carry-over."

2.06 In order to apply the exploring coil method of fault locating to long or loaded cables, precautions must be taken to reduce the carry-over to a small value. This can best be done by the use of a very low frequency tracing current, since with such a current the capacitive impedance beyond the fault will increase while the induction effects and current attenuation will decrease. It has been found practicable to run down faults in long or loaded cables by employing a tracing current of 20 cycles. At low frequency the exploring coil pickup is very small and accordingly, it must be amplified. Also, as the low frequency is practically inaudible, a visual means of pickup is employed in the 78A set, and in the 99A set the inaudible signal is converted to a frequency in the audible range.

2.07 To locate a ground on a cable conductor, a source of low frequency tracing current is connected between the faulty wire and ground causing the current to flow over the wire and through the fault to sheath. In the sheath the current divides, part flowing along the sheath directly back to the source and part flowing along the sheath away from the source, finally returning to the source through ground. The relative amounts of current flowing in the two directions depend on the relative impedances to ground of the sheath on the two sides of the fault. The field caused by the portion of the return current which flows along the sheath directly back to the source, opposes the field due to the current in the faulty wire, and the resultant field is a combination of these two. The portion of the return current which flows along the sheath away from the source also produces a field. The low frequency exploring coil is so constructed that it is not affected by the current flowing in the sheath; thus, the coil is made to respond only to the magnetic field produced by the faulty wires, as illustrated below.

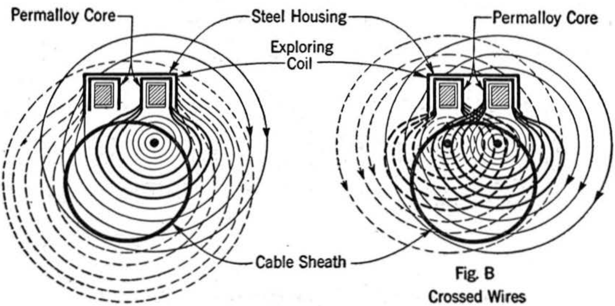


Fig. A
Grounded Wire

Fig. B
Crossed Wires

Fig. A { Dashed Circles: Magnetic Field due to Sheath Currents.
Solid Circles: Magnetic Field due to current in grounded wire.

Fig. B { Dashed Circles: Magnetic Field due to current in one of the crossed wires.
Solid Circles: Magnetic Field due to current in the other of the crossed wires.

Flux useful in causing pickup in exploring coil is shown by heavy circles.

Relative Positions of Exploring Coil and Faulty Wires are such as to cause maximum pickup.

2.08 In the case of a ground, maximum pickup occurs when the faulty conductor is under one of the outside pole pieces in the core of the coil.

2.09 In the case of a cross, the source of tracing current is connected between the two crossed wires. As indicated by the sketch in Paragraph 2.07, at certain points along the cable one of the crossed wires, carrying current in one direction, lies on one side of the center of the core, and the other crossed wire, carrying current in the opposite direction, lies on the other side of the center of the core. The electromagnetic fields caused by these two currents are cumulative with respect to the coil winding and are larger with greater separation of the wires.

2.10 If the crossed wires are close together, the electromagnetic fields produced tend to neutralize each other and very little voltage is induced in the exploring coil. This effect also accounts for the fact that the coil is ordinarily not suitable for running down short circuits or crosses between wires of a quad.

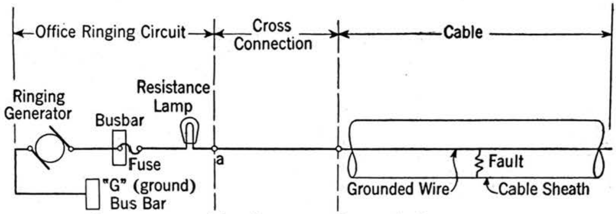
2.11 The electromagnetic fields produced by a split pair is similar to that produced by a cross. On one side of the split the two wires carrying current are relatively far apart and thus a relatively large electromagnetic field is produced while on the other side, the two wires form a pair thus producing a relatively small field.

2.12 The method requires the use of a 20-cycle tracing current. This is obtainable from the ringing generator in the central office and is transmitted over the wires under test.

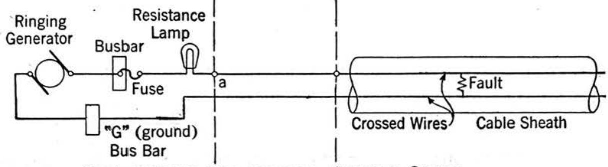
3. CONNECTING TONE TO FAULTY WIRES

3.01 In some offices 20-cycle ringing current is terminated in a jack in the MDF. jack boxes. The connection to the cable wires is made by means of a test cord.

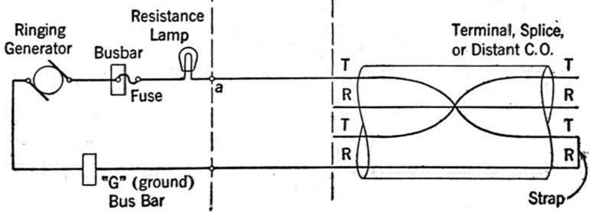
3.02 Where the tracing current is not available at the jack boxes, the office generator can be connected to the wires as shown in the following diagrams. The office ringing circuit (105V±) used should be spare, as the shunt on the circuit caused by the fault resistance may interfere with the operation of a working circuit. The circuit should be equipped with a fuse and resistance lamp. If the fault is a ground or a cross, the wires should be cleared at the far end. If the fault is a split, the wires at the far end should be connected as shown.



CONNECTIONS FOR RUNNING DOWN A GROUND



CONNECTIONS FOR RUNNING DOWN A CROSS



CONNECTIONS FOR RUNNING DOWN SPLIT PAIR

Notes: Point "a" can be either generator terminal on M.D.F. or binding post of resistance lamp.
Lamp and Fuse used should be spare.

3.03 If the fault to be located is a ground, a single wire lead should be run from the "105V±" bus bar at the fuse board and connected to the faulty wire at the protector blocks of the MDF or CDF. In the case of a cross or split pairs, two leads should be provided from the fuse board, the "105V±" lead being connected to one of the faulty wires at the frame, and the "G" lead to the other faulty wire.

3.04 The resistance lamp should be of the C, D, E or L series. For low resistance faults (300 to 500 ohms) near the generator end of the cable, the use of the C lamp is preferable. This lamp has a resistance of approximately 1000 ohms when 100 milliamperes are flowing in the circuit. For faults of higher resistance, or low resistance faults at considerable distance from the generator end of the cable, the D, E or L lamp should be used. These lamps have resistances of approximately 385, 250 and 100 ohms, respectively, when 100 milliamperes are flowing in the circuit.

3.05 The correctness of the connections can usually be checked by observing the resistance lamp. If the fault is of low resistance the same brilliancy as when point "a" in the sketch in Paragraph 3.01 is connected directly to ground. If the fault resistance is over 600 or 800 ohms and at a considerable distance from the generator the lamp will glow dimly or possibly not at all. The tester should arrange to call the office, if necessary, to have the condition of the lamp reported to him. In this way he may be able to determine whether there has been any change in the resistance of the fault.