LOCATING OPEN FAULTS USING THE DELCON 4910-TYPE OPEN FAULT LOCATORS

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1. GENERAL

1.01 This section covers the use of the Hewlett-Packard/Delcon 4910-Type Open Fault Locators. Refer to Section 106-340-110 for description and maintenance of these test sets.

1.02 This section is reissued to add the DELCON 4910F Open Fault Locator (Fig. 1).

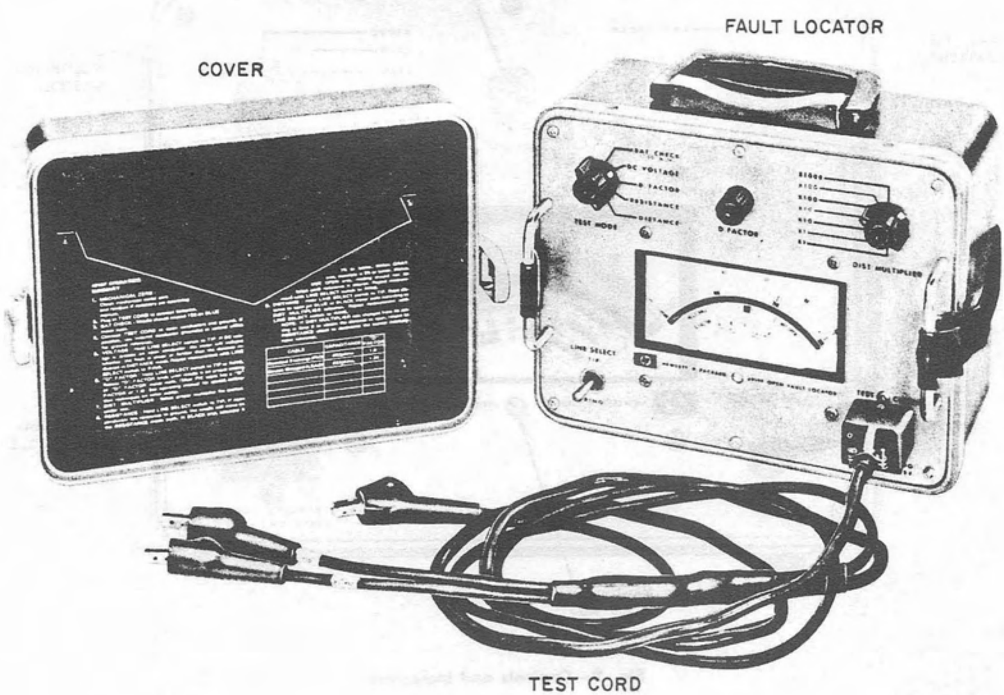


Fig. 1—Model 4910F Open Fault Locator with Cover and Test Cord

1.03 The DELCON 4910B Open Fault Locator is superseded but will be retained in this section due to the large number of test sets in use.

2. PRELIMINARY CHECKS AND ADJUSTMENTS

2.01 Before using the Delcon 4910F Open Fault Locator, the following instrument zero checks should be made to ensure accurate results:

(a) ***Mechanical Zero:*** The mechanical meter zero (Fig. 2) is used to position the meter pointer on zero under ***no power*** conditions. The meter was mechanically zeroed at the factory. ***This adjustment is very stable and should not be touched unless absolutely necessary.*** It can occasionally go out of adjustment, especially when subjected to extreme temperature changes and mechanical shock. To readjust:

(1) With test cord disconnected.

(2) Place test set on level surface with panel facing up.

(3) With a small screwdriver, adjust the mechanical zero adjustment until the pointer is aligned exactly over the "0" calibration mark.

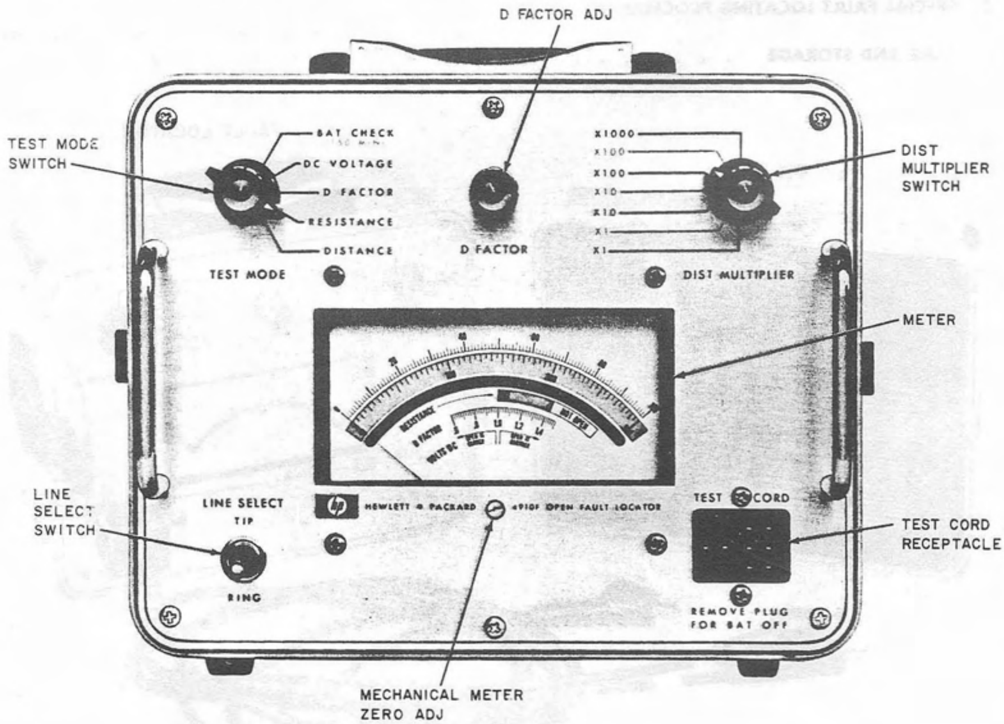


Fig. 2—Controls and Indicators

(b) ***Electrical Zero:*** The electrical circuits in the test set are very stable and do not require routine readjustment. However, it is good practice to periodically check electrical zero, especially if there is any doubt about measurement results. Electrical zero should also be checked after repairing or replacing the test cord. To check:

(1) Check mechanical zero and readjust if necessary per 2.01 (a).

(2) Test batteries per 2.02 and replace if necessary. ***Batteries must be good to perform these tests.***

(3) Connect TEST CORD to test set and leave clips free.

(4) Set TEST MODE switch to RESISTANCE. Hold LINE SELECT switch to RING. Meter should read at left edge of black area on the RESISTANCE scale. If it does not, it will be necessary to perform the readjustments per Section 106-340-110.

(5) Set TEST MODE switch to DISTANCE. Set DIST. MULTIPLIER switch to X100 black. Hold LINE SELECT switch to RING. Meter should read exactly "0". If it does not, it will be necessary to perform the readjustments per Section 106-340-110.

(6) Repeat step (5) with DIST. MULTIPLIER switch set to X1 black.

2.02 ***Battery Checks:*** Two tests are required to determine the quality of all the batteries. The BAT CHECK function tests the ***instrument operating supplies.*** (See Fig. 3 for locations of battery supplies.) The D FACTOR control tests the ***line charging supply.***

(a) ***To test instrument operating supplies:***

(1) Connect TEST CORD.

(2) Hold TEST MODE switch in BAT TEST position. The meter must read ***at least*** 150 on the blue scale.

(b) ***To test line charging supply:***

(1) Connect TEST CORD.

(2) Set TEST MODE switch to D FACTOR.

(3) Hold LINE SELECT switch in RING position. Rotate D FACTOR control through its complete range.

(4) The D FACTOR control must have sufficient range to adjust the meter over the complete D FACTOR scale. If not, replace all batteries.

3. PREPARATION FOR FAULT LOCATING

3.01 ***Test Cord Connections.*** The test set is always connected to the fault in the same way (See Fig. 4):

(a) The pair under test must be open at both ends of the section in which the fault has been isolated (ie, at adjacent access points).

3.02 ***Isolation:*** The first step in locating a fault is to isolate it to the shortest section possible; preferably between two adjacent access points. This can be done by taking successive readings with the test set until the fault is bracketed between two adjacent access points.

Note: In aerial cable, it is acceptable to connect the ground clip to a grounded messenger if the shield is not accessible.

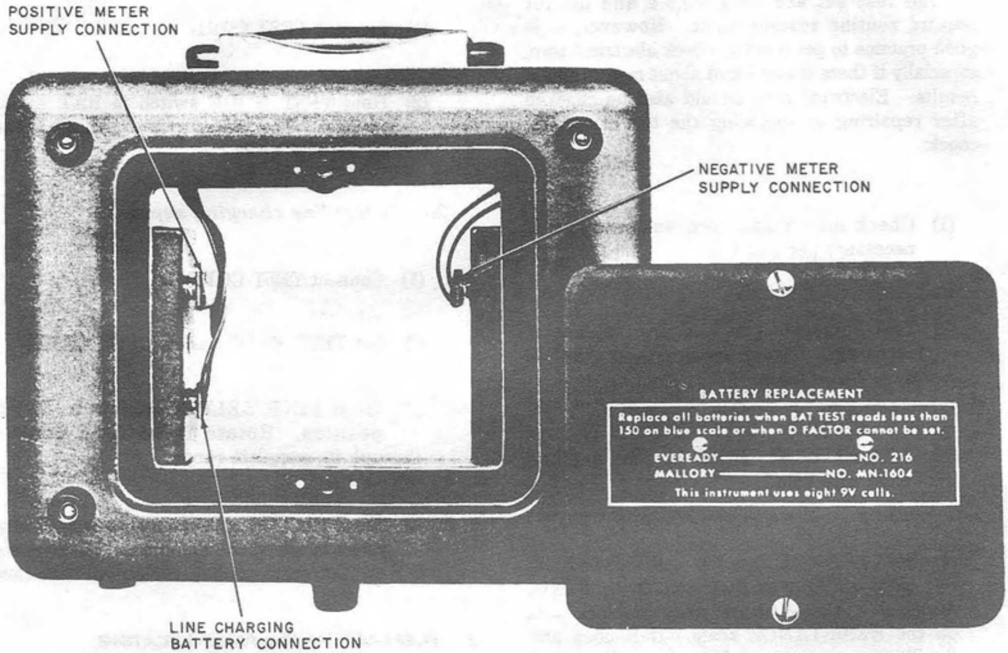
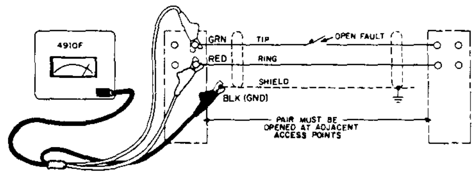
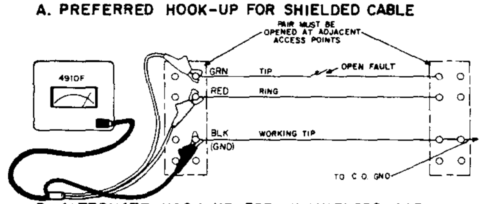


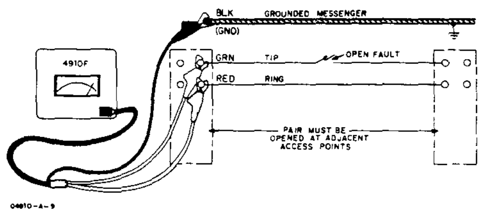
Fig. 3—Battery Location



A. PREFERRED HOOK-UP FOR SHIELDED CABLE



B. ALTERNATE HOOK-UP FOR UNSHIELDED CABLE OR WHERE SHIELD IS INACCESSIBLE



C. ALTERNATE HOOK-UP FOR AERIAL CABLE WHERE SHIELD IS INACCESSIBLE

Fig. 4—Test Cord Connections and Isolation

4. BASIC FAULT LOCATING PROCEDURE

(a) Perform ***Preliminary Checks and Adjustments*** as given in Part 2.

(b) ***Perform Preparation for Fault Locating*** described in Part 3.

(c) Set TEST MODE switch to DC VOLTAGE. Hold LINE SELECT switch in RING position.

(d) Observe VOLTS DC scale on meter. The needle must be within the bracketed area. If the meter reads in the OPEN IS CLOSER or the OPEN IS FARTHER areas there is excessive dc voltage on the circuit and a valid distance reading cannot be made.

Note: If the voltage test indicates that a valid measurement cannot be made, there is a good chance that the measurement can be made from the other end of the cable. The probability of foreign battery existing on both sides of an open fault is small.

(e) Hold LINE SELECT switch in TIP position to test for dc voltage on the tip side of the pair. The needle must be within the bracketed area.

Note: If there is an open fault on only one side of the pair, it is necessary to test only that side of the pair for dc voltage. In this case a valid distance measurement can be made even if there is excessive dc voltage on the opposite side of the pair.

(f) Set TEST MODE switch to D FACTOR. Refer to Fig. 5 to determine D FACTOR for cable under test. Adjust D FACTOR control to set this figure on the D FACTOR meter scale.

Note: If the capacitance of the cable under test is unknown, or in doubt, refer to 5.01 or 5.02 for special calibration technique.

(g) Set DIST MULTIPLIER switch as closely to range of total section length as possible.

Example: Open fault has been isolated between two terminals. Plant records show these terminals to be 2150 feet apart. The closest ***full scale*** range to this distance is 3000 feet (300 X 10 blue), therefore, the DIST MULTIPLIER is set to X10 blue.

(h) Set TEST MODE switch to RESISTANCE.

Hold LINE SELECT switch in RING position.

(i) Observe RESISTANCE scale on meter:

(1) If the needle reads at the left end of the black area, the ring side of the pair is free of shunt resistance and a distance reading can be made with specified accuracy.

(2) If the needle reads anywhere within the black area, there will be up to −1% ***additional*** error in the distance-to-fault reading.

(3) If the needle reads anywhere within the gray area, there will be up to −5% ***additional*** error in the distance-to-fault reading.

(4) If the needle reads in the NOT OPEN area, shunt resistance across the circuit is too low for a valid distance-to-fault reading and must be cleared.

(j) Hold LINE SELECT switch to TIP position to test for resistance on the tip side of the pair. The rules in step (i) also apply to the tip test.

Note: If there is an open fault on only one side of the pair, it is necessary to test only that side of the pair for resistance. In this case a valid distance reading can be made even if there is prohibitive resistance on the opposite side of the pair.

(k) Set TEST MODE switch to DISTANCE. Hold LINE SELECT switch to TIP or RING, depending on which side of pair is faulted.

(l) With LINE SELECT switch depressed, set DIST MULTIPLIER switch to position that provides HIGHEST on-scale meter reading.

♦***Caution: It is important that the RESISTANCE tests be made on the same DIST MULTIPLIER ranges as the final distance readings. If it is necessary to change the DIST MULTIPLIER setting***

from Step (g) when making the final distance to fault reading, it will be necessary to repeat these tests on that distance range.◀

(m) Read distance-to-fault from meter and DIST MULTIPLIER setting. Check for high induced line voltage per 5.08(a).

Example: Meter reads 215 on blue scale with DIST MULTIPLIER switch set to X10 blue.

Therefore, distance-to-fault is 215 × 10 = 2150 feet.

(n) If there are open faults on both sides of the pair, repeat steps (k) through (m) with LINE SELECT switch in opposite position.

(o) Measure off fault location, keeping in mind variations in path and depth, slack loops, length of cable on risers, etc.

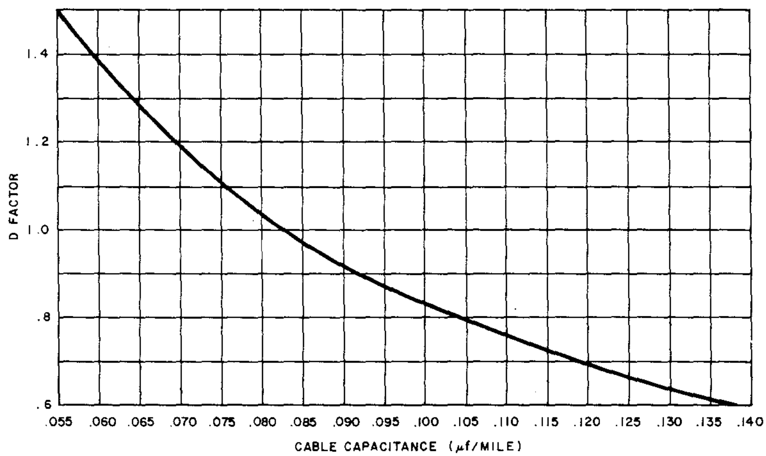


Fig. 5—D Factor Calibration Chart

5. SPECIAL FAULT LOCATING PROCEDURES

5.01 ***D FACTOR Calibrator for Unknown Cable Capacitance:*** When a cable with unknown capacitance is encountered, D FACTOR must be calibrated against a known length of the same type of cable. Ideally, this calibration should be made on a good pair in the cable under test if the section length is precisely known. This is especially desirable if the capacitance change is due to temperature, aging, etc. Calibration can also be made against a known length of nonworking cable as outlined in the Alternative Procedure (5.02).

(a) Determine ***exact*** length of cable section under test.

(b) Connect test set to good pair in same cable as faulty pair. Make sure good pair is isolated (open) at both ends.

(c) Make DC VOLTAGE and RESISTANCE tests to assure condition of good pair.

> ♦***Caution: It is important that the RESISTANCE tests be made on the same DIST MULTIPLIER ranges as the final distance reading. If it is necessary to change the DIST MULTIPLIER setting from Step (d) when making the final distance to fault readings, it will be necessary to repeat these tests on that distance range.***♦

(d) Set TEST MODE switch to DISTANCE. Set DIST MULTIPLIER switch to proper range for length of good pair (ie, the range that will give the highest on-scale reading).

(e) Hold LINE SELECT switch to RING. Adjust D FACTOR control until meter reads exact length of good pair.

(f) Hold LINE SELECT switch to TIP. Check to see if meter still reads length of good pair. If not, the "good" pair is faulty and another good pair must be found.

(g) Set TEST MODE switch to D FACTOR. Hold LINE SELECT switch to RING. Read D FACTOR on meter and record.

(h) Reconnect test set to faulty pair and locate open using Basic Fault Locating Procedure and D FACTOR from step (g).

5.02 ***D FACTOR Calibration for Unknown Cable Capacitance (Alternative Technique).***

(a) Select a length of cable of the same type as the one being tested. This cable can be any length between 50 and 100 feet, but its length must be known precisely.

(b) Determine pair to be measured. Identify 30 percent of the pairs in the same binder group and short these conductors to the shield at the ***far end.***

(c) Connect Test Set TIP and RING clips to pair to be measured. Connect GND clip to nonshorted pair shield.

(d) Set TEST MODE switch to DISTANCE. Set DIST MULTIPLIER switch to X1 black.

(e) Hold LINE SELECT switch to RING. Adjust D FACTOR control until meter reads exact length of cable.

(f) Set TEST MODE switch to D FACTOR. Hold LINE SELECT switch to RING. Read D FACTOR on meter and record.

(g) Reconnect test set to open pair in faulty cable and locate open using Basic Fault Locating Procedure. Use D FACTOR from step (f).

5.03 ***Measuring Length of Nonworking Cable.*** This technique can be used to inventory cable on the reel or to measure new installations for precise plant records. Since D FACTOR is based on at least 30 percent working pairs in the cable, this condition must be simulated on nonworking cable. This involves shorting 30 percent of the pairs, in the same binder group as the measured pair, to the shield.

(a) Determine pair to be measured. Identify 30 percent of the pairs in the same binder group and short these conductors to the shield at the ***far end.*** (Fig. 6).

(b) Connect Test Set TIP and RING clips to pair to be measured. Connect GND clip to shield.

(c) Use Basic Fault Locating Procedure to measure length of cable. Determine D

FACTOR from Fig. 5. Since the pair is open at the end of the cable, the test set will measure the entire length of the cable.

Note: Unshielded cable cannot be measured on the reel because of capacitive coupling between coils.

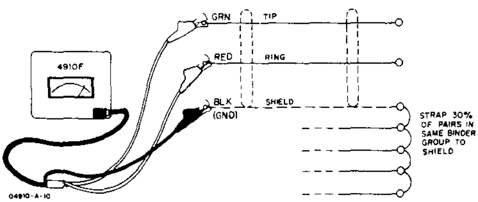


Fig. 6—Measuring Length

5.04 ***Measuring Percent of Distance to Fault:*** This technique can be used to determine the "ball park" location of an open when neither the capacitance nor the exact length of the cable is known. For example, it can be used if there is a good probability that the fault is located in a splice and the locations of the splices are known.

(a) Connect test set to a good pair in the same cable as the faulty pair. Make sure good pair is isolated (open) at both ends.

(b) Make DC VOLTAGE and RESISTANCE tests to assure condition of good pair.

(c) Set TEST MODE switch to DISTANCE. Set DIST MULTIPLIER switch to any black multiplier position that will produce a full scale meter reading when the D FACTOR control is adjusted.

(d) Hold LINE SELECT switch to RING. Adjust D FACTOR control until meter reads exactly 100 on the upper (black) scale.

(e) Reconnect TIP and RING clips to faulty pair. Perform DC VOLTAGE and RESISTANCE tests. ***Do not disturb D FACTOR control.***

(f) Set TEST MODE switch to DISTANCE. Hold LINE SELECT switch to TIP or RING (depending on which side of the pair the fault is located).

(g) Read percentage distance to fault on upper (black) meter scale.

Example: Test Set is connected to good pair per step (a) TEST MODE switch is set to DISTANCE and LINE SELECT switch held to RING. The D FACTOR control is adjusted to full scale with the DIST MULTIPLIER switch set to X100 (black). Next, the test set is reconnected to the faulty pair, which has an open fault on the tip side. There are three known closures in the cable at 185 feet, 2150 feet, and 6550 feet and the cable is estimated to be 12,000 feet long. Setting the TEST MODE switch to DISTANCE and depressing the LINE SELECT switch to TIP, the meter reads 50. Therefore, the fault is located at 50 percent of the total length of the cable. Since the third closure is nearest the halfway point, it is the likely trouble spot.

5.05 ***Compensating for Build-Out Networks:*** Build-out capacitors and networks add to the distance reading in relation to their capacitance. When a capacitor appears across the pair under test, the distance reading obtained will be greater than the actual distance and must be calculated out by a formula. **(Loading coils do not add any appreciable capacitance to the circuit and need not be considered).**

(a) Perform Basic Fault Locating Procedure to measure distance-to-fault. Use specified cable capacitance to determine D FACTOR.

(b) Calculate equivalent length of build-out capacitor using the following formula:

Note: Do not use equivalent length data on build-out capacitor for compensation.

Equivalent Length (Ft.) = Build-out Cap. (μf) X D FACTOR divided by .0000234

(c) Subtract equivalent length from distance-to-fault reading. The result is the correct distant-to-fault.

Example: A reading of 11,500 feet is obtained on a loaded section of 0.067 μf/mile cable. Plant record shows a 0.0115 μf build-out capacitor in the section. (D FACTOR is 1.24).

SOLUTION:

Equivalent length = (0.0115) (1.24)/0.0000234 = 609 feet

Distance-to-fault = 11,5000 − 609 = 10,891 feet

5.06 ***Locating Fault in Cable with Bridge Tap:*** Bridge taps add capacitance to the circuit and, therefore, add distance to the test set reading. Since bridge legs often use different capacitance cable than that of the main cable, the test set must be connected to different points, depending on the relative position of the fault (Fig. 7).

(a) Connect test set to near end and measure distance-to-fault. (Set D FACTOR for capacitance of ***main cable.)*** If the distance reads ***ahead*** of, or at, the bridge tap, the reading is valid. If the reading indicates the fault is ***beyond*** the bridge tap, the reading is invalid and you must proceed to step (b).

(b) Connect test set to far end and measure distance-to-fault. (Set D FACTOR for capacitance of ***main cable.)*** If the distance reads between the bridge tap and far end, the reading is valid. If the reading indicates the fault is ***beyond*** the bridge tap, the fault is located in the bridge leg and the reading is invalid. Proceed to step (c).

(c) Connect test set to far end of ***bridge leg*** and measure distance-to-fault. (Set D FACTOR for capacitance of ***bridge leg.)*** If the fault is located anywhere in the bridge leg, the reading will be valid.

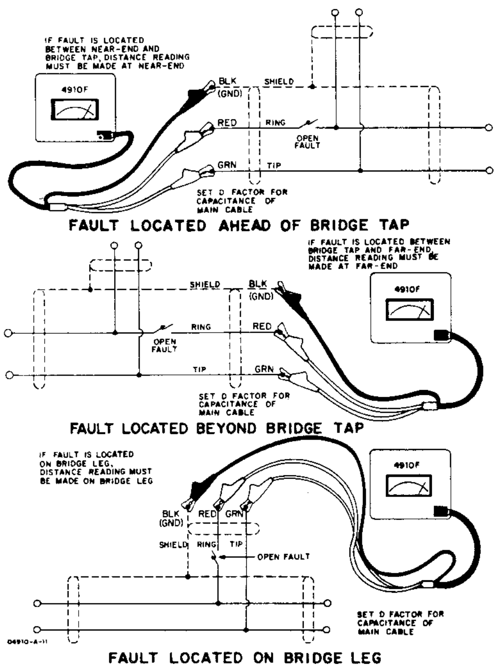


Fig. 7—Locating Fault in Cable with Bridge Tap

5.07 *Locating Fault in Multi-Capacitance Cable:* Cables with a change in capacitance between access points present a problem in that the D FACTOR setting is applicable only to its respective cable section. For example, a 0.083 µf/mile PIC cable may be spliced to a 0.067 µf/mile paper insulated cable. This would require D FACTOR settings of 1.0 and 1.24, respectively, if each section were being tested independently. In cases where there is no access at the capacitance change point, open faults can be located by a two-test method (Fig. 8).

(a) Connect test set to ***near end*** and measure distance-to-fault. (Set D FACTOR for capacitance of ***near end*** section). If distance reads ahead of, or at, capacitance change point the reading is valid. If reading indicates the fault is ***beyond*** the capacitance change point, the reading is invalid and you must proceed to step (b).

(b) Connect test set to ***far end*** and measure distance-to-fault. (Set D FACTOR for capacitance of ***far end*** section.) If distance reads between the capacitance change point and far end the reading is valid.

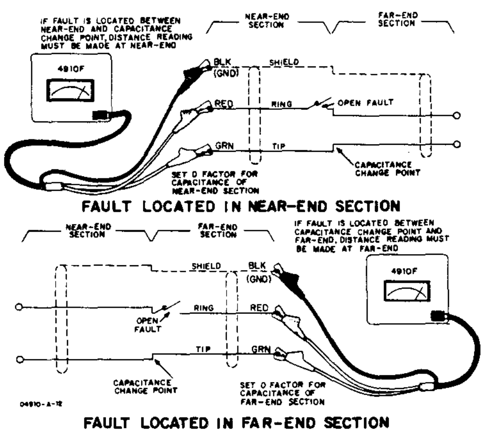


Fig. 8—Locating Fault in Multicapacitance Cable

5.08 *Coping with High Induced Line Voltage:* The test set is designed to reject induced line voltage by a factor of 50 (34dB). This is sufficient to cope with all but the most severe cases of induced voltage on the pair. In extreme cases, the following procedure can be used to achieve a valid distance-to-fault measurement.

(a) Test to determine if problem is due to voltage on pair. This can be done by depressing the LINE SELECT switch to TIP or RING several times in rapid succession. If readings vary each time switch is depressed, this is probably due to ac varying the line capacitance charge.

(b) To determine correct distance-to-fault, take at least 20 readings on the open conductor by depressing the LINE SELECT switch to TIP or RING (depending on which side of the pair is faulted) in rapid succession. Note the highest and lowest reading. Add these two readings together and divide by two. The answer is the distance-to-fault.

Readings

2250	2450
2650	2600
2025	2100
2350	2050
2800	3000 Highest
2700	2750
2400	2500
2975	2900
Lowest 2000	2950
2300	2220

Distance to Fault = (2000 + 3000)/2 = 2500 Feet

5.09 ***Locating Open Shield Bond:*** The test set can be used to locate an open in a buried cable if the shield is ***completely*** open, ***ungrounded*** and if there is only one open in the section under test. This technique is especially helpful in locating missing shield bonds. (Fig. 9).

(a) Completely isolate shield at both ends of cable. Connect red (RING) clip to shield and the green and black clips to ground at near end.

(b) Perform DC VOLTAGE and RESISTANCE tests with TEST MODE switch in RING position. There must be ***no*** indication of voltage or resistance for this application.

(c) Set TEST MODE switch to DISTANCE. Hold LINE SELECT switch to RING position. Adjust DIST MULTIPLIER switch and D FACTOR control for a reading of 100 on the upper (black) meter scale. Record distance setting.

(d) Reconnect test set to far-end. ***Do not disturb D FACTOR setting from step (c).***

(e) Perform DC VOLTAGE and RESISTANCE tests with TEST MODE switch in RING position. There must be ***no*** indication of voltage or resistance.

(f) Set TEST MODE switch to DISTANCE. Hold LINE SELECT switch to RING. Set DIST MULTIPLIER switch for highest on-scale meter reading. ***Do not disturb D FACTOR setting from step (c).*** Record distance reading.

(g) Add readings from steps (c) and (f).

(h) Divide sum from step (g) into step (c).

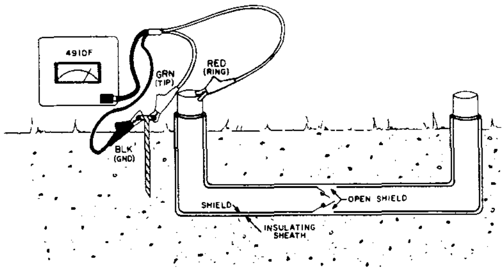
(i) Multiply total length of cable section by answer from step (h). This is the distance from the near end to the fault.

Example: A 12,000 foot section of cable contains three splices at 2300 feet, 6670 feet, and 9290 feet from the near end. Continuity tests show an open in the shield somewhere in this section. The test set is connected to the near end and the D FACTOR control is adjusted for a reading of 100 on the X100 black DIST MULTIPLIER range (10,000 feet). The 4910F is reconnected to the far end and the distance reads 8000 feet. Therefore:

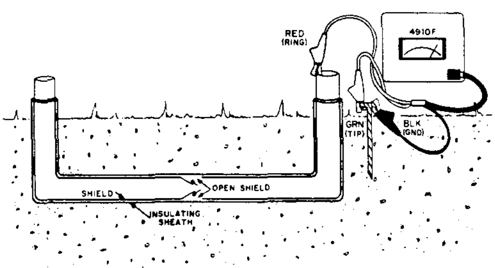
Distance-to-fault =

$10{,}000/(10{,}000 + 8{,}000) \times 12{,}000 = 6666$ feet.

Since the second splice (6670 feet) is closest to this calculated distance, the shield bond must be open at this splice.



LOCATING OPEN SHIELD–FIRST READING



04910-A-13 LOCATING OPEN SHIELD-SECOND READING

Fig. 9—Locating Open Shield Bond

6. CARE AND STORAGE

6.01 Disconnect the test cord and store in the cover when not in use.

6.02 If maintenance or battery replacement is required, refer to Section 106-340-110.

6.03 When not in use, store the test set in a place away from direct heat, such as furnaces or radiators, and where the test set will not be exposed to excessive humidity or moisture.

6.04 Do not permit discharged batteries to remain in the test set. When long periods of storage are anticipated (several months), remove batteries before storage.

7. SUPERSEDED 4910B OPEN FAULT LOCATOR

INSTRUMENT ZERO TESTS AND ADJUSTMENTS

7.01 Before using the Delcon 4910B Open Fault Locator, the following instrument zero checks should be made to ensure accurate results:

(a) ***Meter Zero:*** With the TEST MODE switch in OFF position (Fig. 10) the meter pointer should indicate exactly zero. If not, set the pointer to zero by turning the small black disc to obtain zero meter reading (Fig. 11).

(b) ***Amplifier Zero:*** With the TEST MODE switch set to VOLTAGE and the test cord connected to the test set, actuate the LINE SELECT switch. The meter should indicate exactly zero. If not, adjust the AMPLIFIER ZERO set control in the battery compartment (Fig. 12) to obtain zero meter reading.

(c) ***Test Cord Zero:*** With the TEST MODE switch set to DISTANCE position and the range selector switch set to 100, actuate the LINE SELECT switch. The meter should indicate exactly zero. If not, adjust the TEST CORD ZERO set control in the battery compartment (Fig. 12) to obtain zero meter reading.

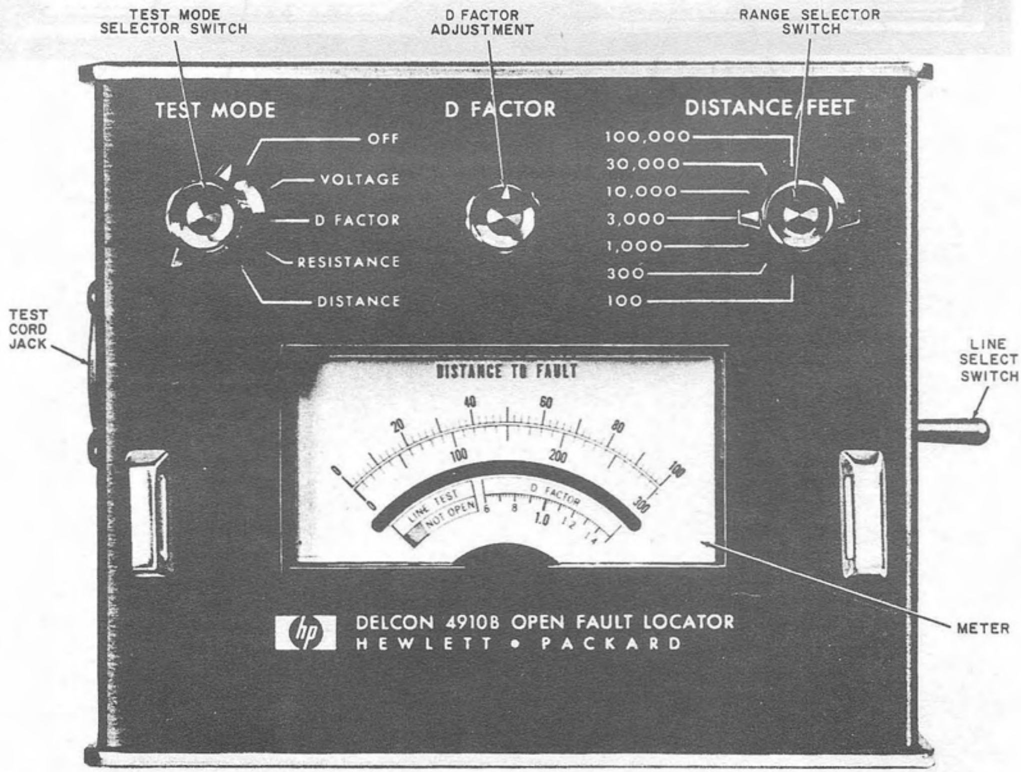


Fig. 10—Meter and Controls on Delcon 4910B

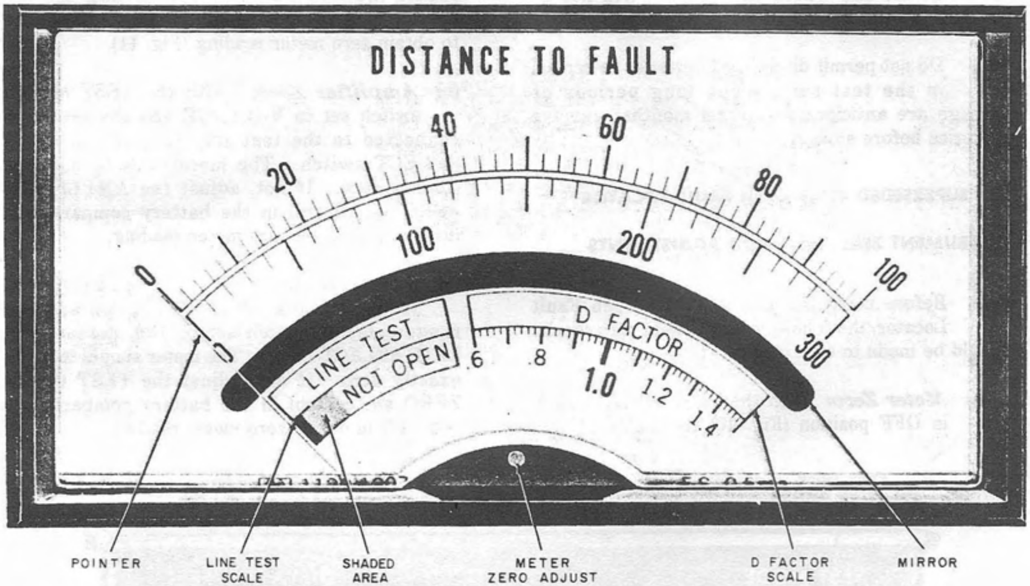


Fig. 11—Delcon Meter Scale

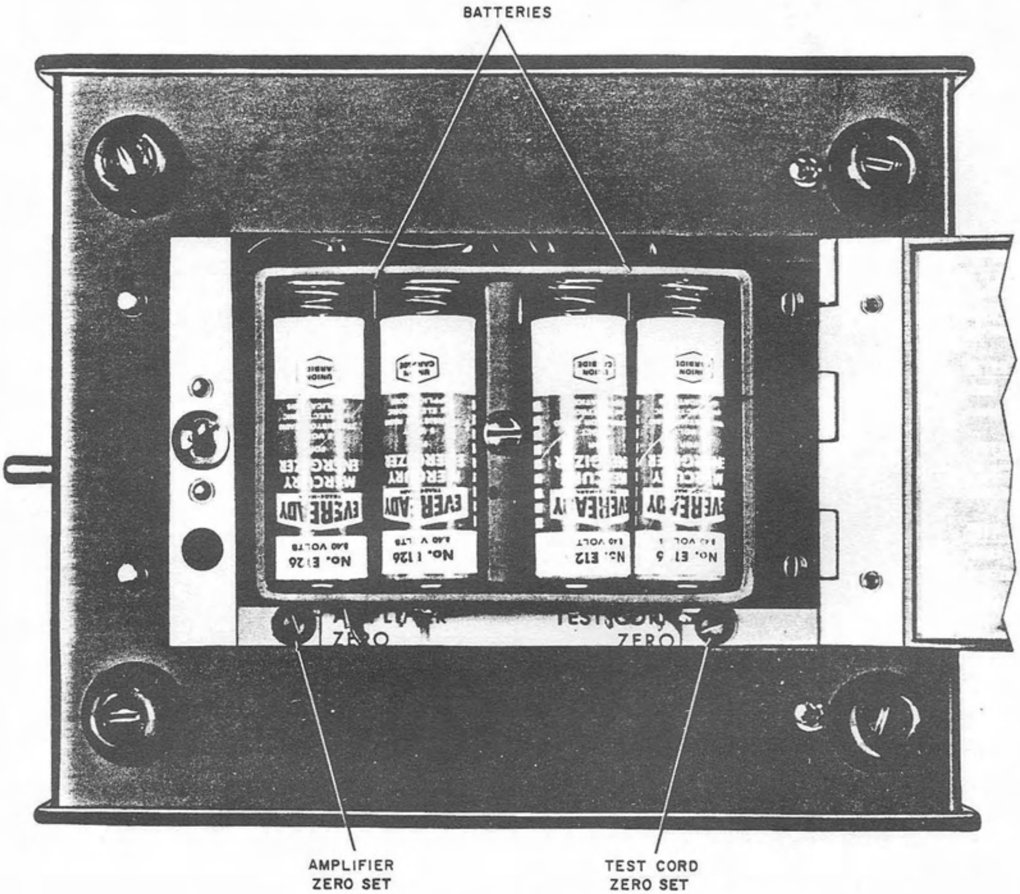


Fig. 12—Access to Zero Adjustments and Batteries

7.02 After the above checks and any necessary adjustments have been made, the test set is ready to be used for locating faults in conductors.

7.03 The procedures used to locate faults with the 4910B are essentially the same as those for the 4910F.