LOCATING CONDUCTOR FAULTS USING THE DELCON 4912F CONDUCTOR FAULT LOCATOR

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1. GENERAL

1.01 This section covers the use of the Delcon 4912F Conductor Fault Locator. Refer to Section **106-360-092NB** for description and maintenance of this test set.

1.02 Whenever ths section is reissued, the reason(s) for reissue will be provided in this paragraph.

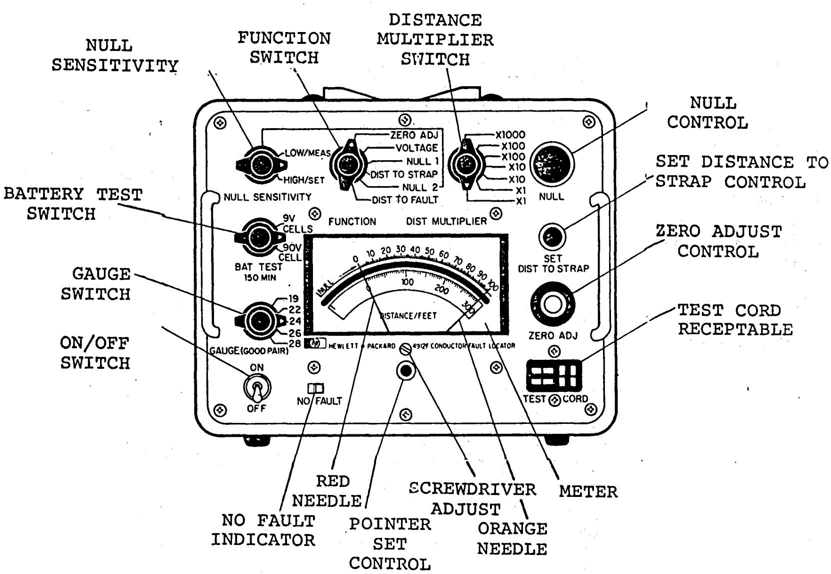

Figure 1. 4912 CONDUCTOR FAULT LOCATOR - CONTROLS & INDICATORS

2. PROCEDURES FOR SELF-CHECK OF INSTRUMENT (Fig. 2)

2.01 Connect output cable to TEST CORD receptacle.

2.02 Connect a **green** lead of output cable to each GOOD WIRE of test circuit; connect **red** lead to BAD WIRE and **black** lead to OTHER SIDE OF FAULT.

2.03 With the ON/OFF switch set to OFF, check that **red** needle aligns with "0" marking of scale. If it does not, mechanically zero needle with **screwdriver adjustment**. located immediately below meter. Set ON/OFF switch on ON, hold BAT TEST switch first to 9V CELLS and then to 90V CELL. If batteries are suitable for operation, **red** needle reads a minimum of 150 on lower scale of meter.

2.04 Set FUNCTION switch to ZERO ADJ; turn ZERO ADJ control until **red** needle is set to "0" marking of scale.

2.05 Set FUNCTION switch to VOLTAGE; observe that **red** needle does not move from "0" marking.

2.06 Set FUNCTION switch to NULL 1. Hold NULL SENSITIVITY switch to LOW/MEAS and turn NULL control until **red** needle is set on "0" marking of scale. Repeat nulling process with switch held to HIGH/SET.

2.07 Set FUNCTION switch to DISTance TO STRAP and GUAGE switch to 26. Hold NULL SENSITIVITY switch to LOW/MEAS and record distance-to-strap readout, that is, use **pointer set control** and set **orange** needle to whatever the distance, as indicated by **red** needle, happens to be. The SELF CHECK circuit is equivalent to 3,000 -feet of #26 guage wire; therefore, with NULL SENSITIVITY switch held to LOW/MEAS, the **red** needle should deflect to "300" marking of lower scale. Set DISTance MULTIPLIER switch to proper range — in this case (**blue**-x10); hold NULL SENSITIVITY to HIGH/SET and, with SET DISTance TO STRAP control, align **red** needle with **orange** needle.

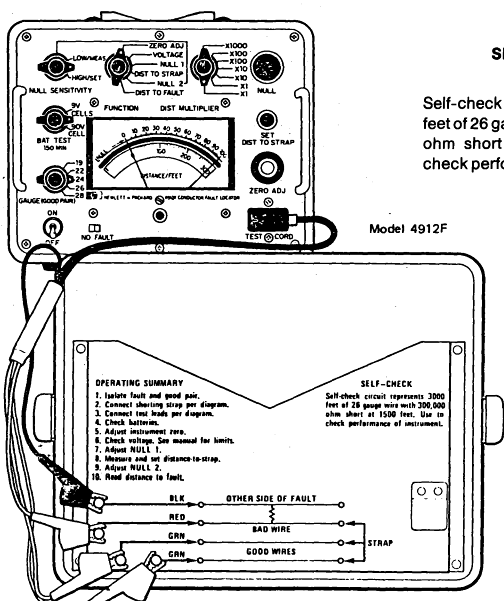

FIGURE 2. INSTRUMENT TURNON & SELF-CHECK PROCEDURES

2.08 Set FUNCTION switch to NULL 2. Hold NULL SENSITIVITY switch to LOW/MEAS and turn NULL control until **red** needle is set to "0" marking of scale. Repeat nulling process with switch held to HIGH/SET. (Momentarily, remove **black** lead from OTHER SIDE OF FAULT; observe **red** flag appears in NO FAULT window.)

2.09 Set FUNCTION switch to DIST TO FAULT; observe that **red** needle reads "1500" (150 x 10 = 1,500 feet) on lower scale.

3. PRELIMINARY PROCEDURES

3.01 Isolate both the good-and-bad conductors at each access point.

3.02 With an ohmmeter, measure tht total resistance between the two bad conductors and between each bad conductor and shield. Carefully observe each reading and determine which one is lowest in resistance.

3.03 To locate a fault with the 4912, a conductor pair that is "known-to-be-good" is required. The **good** pair need not be in the same cable bundle as the **bad** pair; it need not even be the same guage —but the pair **must** be "without" fault.

3.04 With an ohmmeter, measure the total resistance between the two good conductors and between each good conductor and shield. As a minimum in either case, the resistance must not be less than 1,000,000 ohms. If fault resistance exceeds 20,000 ohms, the resistance between conductors of good pair and between each good conductor and shield should be at least 50-times greater, that is, for a fault resistance of 350,000 ohms, the isolation resistance should be about 17,500,000 ohms.

3.05 If the conductor-to-conductor resistance is less than the conductor-to-shield resistance, the good-and-bad conductors should be strapped (shorted together) and the conductor-to-conductor configuration used in locating the fault. Conversely, if the conductor-to-shield resistance is less, the conductors should be strapped and the fault located in a conductor-to-shield configuration. Before attempting to locate the fault in either case, use an ohmmeter and check for continuity between the three strapped conductors.

4. MEASUREMENTS PROCEDURES

4.01 The 4912 is always connected to the fault in exactly the same way. Connect a **green** lead of output cable to each of the good conductors. If fault is conductor-to-conductor, connect **red** lead of output cable to the conductor that measures highest resistance to shield. If both conductors of the bad pair measures about the same resistance or an "open-to-shield", connect **red** lead to either conductor. In either case, connect **black** lead to other conductor of bad pair. If fault is conductor-to-shield, **always** connect **red** lead to conductor and **black** lead to shield.

4.02 With the ON/OFF switch set to OFF, check that **red** needle is centered on "0" marking of scale. If it is not, insert screwdriver or similar tool in **screwdriver adjustment** slot, located immediately below meter, and slowly turn to the left until **red** needle deflects to the left of zero — this left-of-zero adjustment removes tension on the meter suspension system. Now, slowly, turn adjustment screw to the right until **red** needle is centered on "0" marking of scale.

4.03 Set ON/OFF switch to ON; hold BAT TEST switch first to 9V CELLS and then to 90V CELL. If batteries in the 4912 are suitable for operation, **red** needle reads a minimum of 150 on lower scale of meter.

4.04 Set FUNCTION switch to ZERO ADJ; turn ZERO ADJ control until **red** needle is set to "0" marking of scale.

4.05 Set FUNCTION switch to VOLTAGE. If the reading is greater than ten minor divisions on upper scale, hold NULL SENSITIVITY switch to LOW and repeat measurement. Should the needle now deflect more than one minor division, an accurate distance-to-fault measurement simply cannot be made. If, in **low-gain**, the voltage measurement can be made with a deflection of no more than 1-division and both NULLs 1 and 2 can also be made in **low-gain**, a valid distance-to-fault measurement can possibly be made within the stated accuracy of instrument. On the other hand, if **high-gain** is required to make either null and **low-gain** is required to make a voltage measurement within the 1-division limit, a valid distance-to-fault measurement cannot be made within stated accuracy of instrument.

4.06 Set FUNCTION switch to NULL 1. Hold NULL SENSITIVITY switch to LOW/MEAS and turn NULL control until **red** needle is set to "0" marking of scale. Repeat nulling process with NULL SENSITIVITY switch held to HIGH/SET.

4.07 Set FUNCTION switch to DISTance TO STRAP and GUAGE switch to guage **good** conductors. Hold NULL SENSITIVITY switch to LOW/MEAS and rotate DISTance MULTIPLIER switch until **red** needle reads as far upscale as possible. For example, if distance-to-strap is 540-feet, DISTance MULTIPLIER switch will be set to "**black** etching — x-10". To record distance-to-strap readout, use **pointer set** control and set **orange** needle to whatever the distance, as indicated by **red** needle, happens to be; in this case, "54" on upper scale. Now, hold NULL SENSITIVITY switch to HIGH/SET and turn SET DISTance TO STRAP control until **red** needle is set to same scale marking as **orange** needle.

NOTE If standard "dropwire" or "other" wire is used for the **good** pair, it is difficult to simulate the exact length of the **bad** conductors. When using the 4912 under these conditions, it is recommended that the length of **bad** conductors be physically measured and the measured distance used to determine length of good-conductor **drop**. If guage of "drop" is compatible with any one of those on the GUAGE switch, the procedure in step 4.07 above, is applicable. If guage of "drop" is **not** compatible with one of the selectable guages, proceed as follows: Physically measure length of **bad** conductors and use this distance to determine length of required "drop". Set FUNCTION switch to DISTance TO STRAP, GUAGE switch to any position, and DISTance MULTIPLIER switch to the required range. Hodl NULL SENSITIVITY switch to HIGH/SET and turn SET DISTance TO STRAP control until **red** needle is set to proper scale marking.

4.08 Set FUNCTION switch to NULL 2. Hold NULL SENSITIVITY switch to LOW/MEAS and turn NULL control until **red** needle is set to "0" marking of scale. Repeat nulling process with NULL SENSITIVITY switch held to HIGH/SET.

NOTE In making NULL 2, if the NO FAULT flag appears, it does not necessarily mean that the fault cannot be located. If enough current is flowing through the fault to allow for a stable null, the distance-to-fault may be read. When the **flag** appears, the operator is forewarned that the fault may be drying out. Rather than the slow methodical process of performing NULL 2, it is recommended that the NULL SENSITIVITY switch and NULL control be used in a series of short meaningful steps to minimize the possibility of fault dry-out.

NOTE In making NULL 2, the conductor length between the point-of-meaurement and the point-of-fault can spell the difference between success and failure. For instance, if the fault resistance is high and fault is only a few feet from the point-of-measurement, the conductor resistance is obviously very, very small. Since this resistance is in one balance-arm of the bridge, the unbalance voltages can become extremely small — in fact, so small that they cannot be easily resolved by the amplifier. For this situation, is may be all but impossible to make a stable NULL 2. Suppose the measurement is made from the other end. Because the conductor length is now longer, the equivalent bridge-arm resistances are much higher and, what at first appears to be a non-measurable fault is easily measured. When making NULL 2, the operator should closely observe the needle movement versus the amount of NULL-control movement. Under ideal conditions (low fault resistance and long conductor length between point-of-measurement and point-of-fault), a small movement of the NULL-control produces a sharp deflection of needle. Under worst-case conditions, the needle movement is sluggish and indecisive — even for relatively large movements of the NULL control.

4.09 Set FUNCTION switch to DISTance TO FAULT. From example in step 4.07, the **red** needle can now read anything from 0 to 540 feet. If the reading is 540 (54 x 10 = 540 feet), the fault is located at or very near the strapping point. If the reading is zero, the fault is located at or very near the point-of-measurement and the strapping-point should be interchanged and the operating sequence repeated. In both cases, the results must be consistent, that is, if the distance-to-fault at one end is 30 feet, at the other end, it will measure 540-30, or 510 feet.

5. BRIDGE-TAP CALCULATION

5.01 Connect 4912 at access point #1. To determine distance-to-strap, refer to Section 3 and perform "Preliminary Procedures" and steps 4.01 through 4.07 of "Measurement Procedures". REMEMBER — set GAUGE switch to gauge of GOOD, not bad conductors.

5.02 Complete sequence of measurements — NULL 2 and DISTance-TO-FAULT as described in steps 4.08 and 4.09 of Section 4.

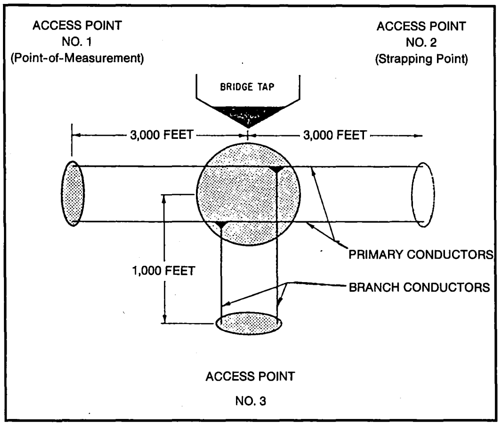

FIGURE 3

EXAMPLES:

1. In Figure 3, the distance-to-strap is 6,000 feet (DISTance MULTIPLIER set to **black** — x100 — fullscale reading of 10,000 feet on upper scale. Suppose the distance-to-fault readout is 1,500 feet. The instrument tolerance is ± 1% of fullscale; thus, the **maximum** variance is ± 100-feet. To allow for environmental variations, open primary conductors 1,700 feet from access point #1 and locate fault on the 3,000-foot range (DISTance MULTIPLIER set to blue—x10). If maximum accuracy is required, downrange instrument to the 100-foot range (DISTance MULTIPLIER set to **black** -x1); open conductors and locate fault to within ± 1-foot of indicated reading.

2. Suppose distance-to-fault readout is 2,950-feet. On this range, the tolerance is still ± 100-feet; therefore, the fault may be in the primary cable run, it may be right at the bridge-tap, or it may be anywhere along the branch conductors. (If the fault is in the branch leg, it will show up at the tap as long as accesses #1 and #2 are used for the measuring-and-strapping points.) To locate the fault easily and quickly, strap (short together) conductors at access point #3 and re-measure fault.

3. Suppose the reading is 3,400 feet. Obviously, the fault is in the branch leg; open bridge-tap splice and pin-point the location. If, with the point-of-measurement at access #1 and the strap at access #3, the reading is the same as in step 2 (2,950 feet), the fault location is still uncertain. Open the splice and isolate both primary and branch conductors at the bridge tap. With an ohmmeter, check and determine which conductors are clear. Connect 4912 to bad conductors and locate the fault.

6. MULTI-GAUGE CALCULATION - TWO SECTIONS

6.01 Gauge and length of wires between point-of-measurement and strapping-point must be known.

6.02 Choose gauge at point-of-measurement as "base" gauge of plant.

6.03 Convert second gauge to an equivalent length of the base gauge.

6.04 Connect 4912 at access point #1. To determine distance-to-strap, refer to Section 3 and perform "Preliminary Procedures" and steps 4.01 through 4.07 of "Measurement Procedures". REMEMBER — set GAUGE switch to gauge of GOOD, not bad conductors.

6.05 If distance-to-fault, as read by the instrument, is less than the length of base gauge, the answer is correct and no further calculation is required. If distance-to-fault is greater than length of base gauge, subtract base-gauge length from readout distance; convert the resultant figure to whatever gauge it happens to be — in Figure 4, the second section is #19 gauge.

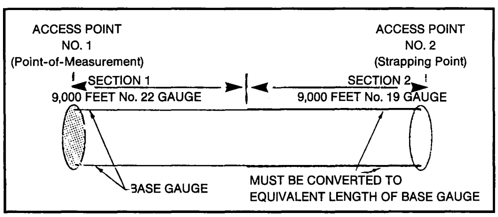

FIGURE 4

CALCULATIONS:

1. Distance-to-Strap*= K + L_e where

   K = length of base gauge

   L_e = length of second gauge converted to base-gauge equivalent

2. Distance-to-Fault = K + C where

   K = length of base gauge

   C = length of base gauge subtracted from readout distance and result converted to distance in terms of the second gauge.

*This figure, 13,464 feet in Figure 4, is readout directly by the 4912 — no calculation is required.

EXAMPLES:

1. In Figure 4, the base gauge is #22; therefore, the 19-gauge section must be converted to the equivalent length of #22 gauge wire. Calculations are as follows:

   given, 9,000 feet of #19 gauge (actual) for conversion to #22 gauge (equivalent) length,

   from Table 3, conversion factor is .496,

   Thus, .496 x 9,000 = 4,464 feet — equivalent length of #22 gauge wire,

   total distance, that is, distance-to-strap = 9,000 + 4,464 = 13,464 feet.

NOTE

With GAUGE switch set to 22 (base-gauge in Figure 4), the readout distance-to-strap is as indicated — 13,464 feet. Instead of 22, suppose GAUGE switch is set to 19. Now, the base-gauge is #19 and the #22 gauge wire must be converted to the equivalent length of #19 gauge. From Table 3, the conversion factor is 2.01; thus, 2.01 x 9,000 = 18,090 feet. Distance-to-strap, as read by 4912, = 9,000 + 18,090 = 27,090 feet. Obviously, if the point-of-measurement and strapping-point are interchanged, the distance-to-strap, as measured by the 4912, also changes. After the first measurement is made (next step), it is desirable, if at all possible, to isolate fault to a section of single-gauge conductor. In this case, calculations and conversions are minimized.

2. Complete sequence of measurements — NULL 2 and DISTance-TO-FAULT as described in steps 4.08 and 4.09 of Section 4.

3. Suppose the distance-to-fault readout is 7,500 feet. Since this distance is less than base-gauge length (9,000 feet), it follows that the fault is in the first section of cable. Thus, 7,500 is a valid number and no further calculation is required.

4. Suppose the distance-to-fault readout is 11,000 feet; now, the fault is somewhere in the second section but exactly how far is yet to be determined. Calculations are as follows:

   subtract length of base gauge to find equivalent distance —

   11,000-9,000=2,000 feet,

   convert 2,000 feet equivalent #22 gauge back to actual #19 gauge; from Table 3, conversion factor is 2.01; hence 2.01 x 2,000 = 4.020 feet of #19 gauge wire,

   therefore, fault is 4,020 feet into second section, or 9,000 + 4,020 = 13,020 feet from point-of-measurement.

7. LOAD COIL CALCULATION WITH SINGLE GAUGE CONDUCTOR

7.01 Type and number of load coils between point-of-measurement and strapping-point must be known. Also physical length of each section and equivalent gauge length of each load coil (Table 1).

7.02 Connect 4912 at access point #1. To determine distance-to-strap, refer to Section 3 and perform "Preliminary Procedures" and steps 4.01 through 4.07 of "Measurement Procedures". REMEMBER — set GAUGE switch to gauge of GOOD, not bad, conductors.

7.03 Calculate equivalent length of one load coil in terms of the single-gauge conductor. Multiply this figure by the number of load coils — see step 2 under EXAMPLES.

7.04 If distance-to-fault, as read by instrument, is less than the physical distance to first load coil, the answer is correct and no further calculation is required. To get correct answer if readout is greater than the physical distance to first load coil, subtract from the readout figure the equivalent gauge-length of all loading coils that appear between the point-of-measurement and the distance-to-fault.

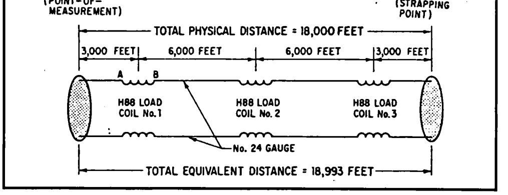

FIGURE 5

CALCULATIONS:

1. Distance-to-Strap* = nR_LM+D where,

   n = number of load coils

   R_L = resistance of one load coil in ohms

   M = feet-per-ohm of single-gauge conductor

   D = physical wire length in feet between point-of-measurement and strapping point

*This figure, 18993 feet in Figure 5 is readout directly by the 4912 — no calculation is required.

2. Distance-to-Fault=$W-nR_LM$ where;

   W = distance-to-fault readout of instrument

   n = number of load coils

   R_L = resistance of one load coil in ohms

   M = feet-per-ohm of single-gauge conductor

EXAMPLES:

1. From Table 1, the resistance of one H88 load coil is 8.5-ohms; from Table 2, #24 gauge wire equals 38.9 feet-per-ohm. Therefore, one load coil is the equivalent of 331 feet (38.9 x 8.5 = 331) and three load coils equals (3 x 331), or 993 feet — equivalent length of #24 gauge wire.

2. In Figure 5, the total physical distance is 3,000 + 6,000 + 6,000 + 3,000 = 18,000 feet. Generally, the physical distances are determined by "plant" records or other statistics. By measurement, the total physical distance = R-L where,

   R = distance-to-strap, as read by 4912-18,993 feet

   L = equivalent length of all load coils - 993 feet; thus, 18,993-993 = 18,000 feet

3. Complete sequence of measurements - NULL 2 and DISTance-TO-FAULT as described in steps 4.08 and 4.09 of Section 4.

4. Suppose the distance-to-fault readout is 2,850 feet. Since the distance to first load coil is 3,000 feet it follows that the fault is between the point-of-measurement and the first load coil. Thus, 2,850 is a valid number and no further calculation is required.

Suppose the distance-to-fault readout is 15,500 feet. Figure 5 shows two loading coils in the first 15,000 feet of cable and the equivalent length of each coil is known to be 331 feet. To obtain the **true** distance-to-fault, the equivalent distance represented by the two load coils must be subtracted - 2 x 331 = 662 and, 15,500 - 662 = 14,838 feet.

TABLE 1. DC RESISTANCE AND EQUIVALENT LENGTHS OF COMMON LOAD COILS

Code	DC Resistance (in Ohms)	Equivalent Wire Length in Feet*				
		#19 gauge	#22 gauge	#24 gauge	#26 gauge	#28 gauge
659	3.25	403	202	126	80	50
632	4.20	521	261	163	103	65
658	4.50	558	280	175	110	69
D66	6.00	744	373	234	147	92
H88	8.50	1,054	529	331	208	131
652	8.50	1,054	529	331	208	131

* All values are calculated for a temperature of 68-degrees Fahrenheit. If the temperature is substantially different than 68°F, compensation for all values is recommended.

TABLE 2. DC CHARACTERISTICS OF COMMON WIRE GAUGE

Gauge	Resistance-Per-1,000 Feet (in Ohms)	Feet-Per-Ohm
19	8.050	124.0
22	16.100	62.2
24	25.670	38.9
26	40.810	24.5
28	64.900	15.4

* Resistance values and linear units are calculated for a temperature of 68-degrees Fahrenheit. If the temperature is substantially different than 68°F, compensation for these values is recommended.

TABLE 3. WIRE CONVERSION

ACTUAL GAUGE		FACTOR TO DETERMINE EQUIVALENT GAUGE							
		10	13	16	19	22	24	26	28
10	M	1.0	.500	.255	.126	.082	.039	.024	.015
13	U L	2.0	1.0	.510	.252	.125	.078	.049	.030
16	T	3.92	1.98	1.0	.494	.248	.153	.095	.060
19	I	7.94	3.97	2.02	1.0	.496	.310	.193	.121
22	P L	16.0	7.99	4.07	2.01	1.00	.624	.389	.244
24	Y	25.6	12.80	8.52	3.22	1.60	1.00	.623	.391
26	B	41.1	20.6	10.5	5.18	2.57	1.61	1.00	.628
28	Y	65.4	32.7	16.7	8.24	4.09	2.58	1.59	1.0