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A-1

TECHNICAL MANUAL

OPERATING

AND

MAINTENANCE INSTRUCTIONS

CONDUCTOR FAULT LOCATOR

MODEL 710A

Federal Stock No.

6625-148-8121

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SECTION 1

INTRODUCTION – GENERAL DESCRIPTION

1-1. GENERAL DESCRIPTION

1-2. The Dynatel Model 710A Fault Meter/Locator is a cable test set that can be used by non-technical personnel for locating high and low resistance faults in telephone cables up to 200,000 feet long. Shorts, crosses, grounds and battery crosses can be located accurately, with distance measurements displayed in feet. The Model 710A is a compact, battery-powered portable unit designed for telephone system test-desk or field operation by non-technical personnel.

1-3. The Model 710A uses two basic hook-ups for testing telephone conductors: single-pair, and separate good-pair. Both hook-ups require a strap (short circuit) at the far end of the cable under test. The basic set-up and equivalent test circuit are explained in more detail in Section 2. When the Model 710A is properly connected, it can be used to perform the following conductor analysis and distance tests:

1. Good-pair and bad-pair fault analysis
2. Strap continuity
3. Distance to strap (from the 710A)
4. Distance to strap and back (loop length)
5. Distance to fault (from the 710A)
6. Distance from the strap to the fault.

Overall distance measurement accuracy is ±0.5% of reading ±1 digit for common copper conductors from 19 to 26 gauge. The unit may also be used on 17 and 19 gauge aluminum conductors. A special conductor temperature compensation circuit maintains measurement accuracy over a conductor temperature range of 0°F (–18°C) to 140°F (60°C). A self-test circuit is built into the cable for convenient field performance tests or adjustments, which can be made without additional test equipment.

1-4. The meter and the test circuitry is protected from cable voltages up to ±350V dc or 250V ac. A ground clip ensures operator safety. The cabinet is made of yellow fiberglass for light weight, durability, and visibility. The Model 710A is water-resistant for operation in inclement weather. All internal circuits are sealed for protection against fungus and humidity.

1-5. SPECIFICATIONS

1-6. Specifications are listed in Table 1-1.

1-7. Environmental Conditions

1-8. The Model 710A has no cooling or other environmental requirements. Ambient operating temperature range is specified in Table 1-1. The Model 710A is designed for portable operation in any weather.

NOTE

Battery life is maximum when the Model 710A is operated at temperatures near 70°F. Battery life gets shorter whenever the operating temperatures go significantly above or below 70°F.

1-9. Storage Conditions

1-10. The Model 710A has no short-term storage requirements. However, for best battery life, storage temperatures should be below 70°F.

1-11. For longer storage periods (e.g., longer than 60 to 180 days) the batteries should be removed.

1-12. When not in use, place cables in the storage compartment in the lid, and secure the lid.

1-13. EQUIPMENT SUPPLIED

1-14. The Dynatel 710A is shipped with all equipment required for normal field operation, including batteries and conductor strap. See Table 1-2.

1-15. OPTIONAL ACCESSORIES

1-16. The following items are available for use with the Model 710A:

1-17. Extension Cable (Part No. 9002). A 33-ft extension cable extends the length of the test cable or thermo-calibrator cable. All tests may be performed using the extension cable without correction or allowance, since all distance measurements are made from the test clips on the test cable. Several extension cables may be used in series.

Table 1-1. Specifications

Fault Location Range	100,000 ft nominal, in 3 ranges; 200,000 ft max.
Cable Temp Range	0° to 140°F nominal
Conductor Gauge Calibration	19, 22, 24 and 26 AWG copper; useable with B service and D underground wire, and aluminum wire
Fault Location Accuracy	±0.5% of reading ±1 digit
Battery Requirement	2 ea 4.5V NEDA 3* 2 ea 9V NEDA 1602* 1 ea 45V NEDA 213*
Battery Life	500 hours nominal; 6 to 12 mo. depending on usage
Environment	
Operating Temperature Range	-20°C to +55°C
Storage Temperature Range	-40°C to +55°C
Size	11" wide X 7' deep X 9" high
Weight	14 pounds

*or equivalent, see Table 4-1.

Table 1-2. Equipment Supplied

1. Model 710A Conductor Fault Locator (includes lid, batteries and carrying strap)
2. Conductor strap* (Dynatel Part No. 9006)
3. Operator's Handbook*
4. Test Cable*

*Item contained in lid storage compartment.

1-18. Thermo-Calibrator (Part No. 9004). The thermo-calibrator is a remote temperature sensor with a 15-ft cable. It is used to measure cable temperature for maximum fault location accuracy. The probe may be used as a portable temperature sensor or it may be permanently buried at cable depth for local buried cable temperature indications.

1-19. Extended Test Cable (Part No. 9005). The extended Test Cable is similar to the standard 9003 Test Cable in function. Length is 40 ft; the self-test feature is not included.

1-20. Test Desk Line Selectors. The Test Desk Line Selectors convert the Model 710A for convenient service bureau testing. It is compatible with Western Electric Type 12, 14, modified 14, and 16 test boards; and also with the Automatic Electric No. 1 test board.

1-21. There are two test desk line selectors: Model 2001 for desk or table top operation and Model 2005 for in-drawer operation. All other characteristics of both models are the same. Both line selectors are connected to the Dynatel 710A Fault Locator with a single plug-in cable; fault location readings and test selections are made with the 710A.

1-22. The line selectors are provided with two TIP/RING/SLEEVE plugs for direct access to the wroking cable pair to be tested. A standard Wheatstone Bridge shoe is used for testing non-working pairs. Access to working pairs is through jacks on the Type 12, 14, modified 14 and 16 test boards. Test controls are activated by four test control knobs corresponding to the four wires of a bridge circuit to select any combination of Tip, Ring or Sleeve.

1-23. TEST TOOLS AND EQUIPMENT

1-24. The only item required for maintenance is a multimeter such as the HP 412A, or equivalent. Specifications are not critical; however the input impedance should be 1 megohm or greater.

SECTION 2

OPERATION

2-1. RECEIVING INSPECTION

2-2. This instrument was carefully inspected and tested before shipment. It should be free of scratches or defects, and it should operate properly upon receipt. Inspect the instrument for physical damage received in transit and test the electrical performance of the instrument (see para. 4-15). If the instrument is damaged in any way, or fails to operate properly, file a claim with the carrier immediately.

2-3. INSTALLATION

2-4. The Dynatel 710A is a portable, battery-powered unit. When shipped from the factory, all batteries are installed and the unit is ready to operate. There are no other power or installation requirements. Normal battery life is about 500 hours or 6 to 12 months, depending on usage. For battery data, see Section 4.

2-5. NORMAL OPERATION

2-6. The Model 710A can be used by non-technical personnel to locate conductors that are shorted or grounded, including high and low resistance faults and battery crosses. Note that in the operating instructions, the following terminology is used:

- Short: a conduction path between two conductors
- Cross: a conduction path from a conductor to ground or battery.
- Tip and Ring Conductors: conductors connected to the tip and ring (respectively) of a standard phone plug.
- Strap: a short-circuit connected for the test at some point beyond the fault location.

2-7. The Model 710A locates fault in two ways: The distance in feet from the unit to the fault (DISTANCE TO FAULT), and the distance from the strap to the fault (STRAP TO FAULT). The entire fault location procedure is summarized on the cover of the storage compartment. The following procedures explain each step in detail, including information for proper sequential operation of all controls. For best results always use the entire test procedure.

2-8. Set-Up and Turn-On

1. Remove the lid from the Model 710A and take the Conductor Strap and Test Cable out of the storage compartment in the lid.
2. Connect the Test Cable to the TEST CABLE Receptacle on the Model 710A Panel.
3. The unit is now ready for operation; follow the step-by step instructions in the following paragraphs. Note that the unit is ON whenever the MEASUREMENT selector is set to any position other than OFF, and the Test Cable is plugged in. If desired, check the Model 710A operation according to the performance test procedure starting at paragraph 4-15. This is a self-test that includes the battery test procedure. The panel features are shown in Figure 2-1 and defined in Table 2-1.

2-9. FAULT LOCATION PROCEDURE

2-10. All tests with the 710A require at least one good conductor (preferably a good pair) in the test circuit, along with a bad or fault conductor. The FAULTMETER test is used to locate both faulted and good conductors. Be sure to check as many conductors as are available in order to obtain a clear understanding of the trouble in the cable, and to select good and fault conductors. NEVER dig a hole on the basis of a single trouble reading if additional pairs are available for test. For best results, make written notation of the conductors tested; list the pair number and the condition of the tip and the ring conductors.

NOTES

- The current from the FAULTMETER is limtied to about 50 microamperes to minimize the "drying effect" on conductor faults.
- Voltage on the conductors under test will not affect the measurement accuracy of the Model 710A. See paragraph 1-4 for maximum permissible voltages

2-11. Faultmeter Operation

1. Set the 710A MEASUREMENT selector to FAULTMETER. This turns the 710A ON.

Table 2-1. Model 710A Panel Feature Descriptions

NOTE

Be sure to operate all controls in the sequence specified in Paragraphs 2-9 through 2-35.

NAME	DESCRIPTION
1. TEST CABLE Receptacle	Provides means of connecting faulted and nonfaulted conductors to bridge circuits
2. Meter	Provides direct readout of null detector, Faultmeter, Loopmeter and battery tests in the fault-locating sequence.
3. DISTANCE MULTIPLY BY	Selects multiplier for NULL/FEET distance dial reading in one of three ranges: 1, 10, or 100.
4. NULL 1	Adjusts the first null during the test procedure.
5. NULL 2	Adjusts the second null during the test procedure.
6. PRESS FOR NULL 2	Enable pushbutton switch for NULL 2 adjustment.
7. NULL/FEET distance dial & Adjustment	Adjust for null during test procedure; digital dial reads out test distances directly in feet
8. MEASUREMENT	Selects operating mode. For information and operating sequence, see Paragraphs 2-9 through 2-35. Also see Paragraph 4-17, steps 4 & 5 for battery test instructions.
9. Conductor TEMPERATURE	Adjustment compensates for the effects of temperature on conductor resistance.
10. LOOPMETER	Provides a means for checking the continuity of the good conductor and faulted conductor and whether they are correctly strapped together at the far end.
11. Conductor GAUGE	Selects appropriate calibration to compensate for different resistances of various conductor gauges.
12. OVERRANGE Indicator	Indicates when total length of conductor exceeds the limits of circuitry within test set, or when the internal protection fuse may be open, or when the far end strap becomes disconnected.

2. Connect the black test clip to ground.

3. Connect the red test clip to the *tip* conductor of a pair. Note the indication on the FAULTMETER side of the panel meter. A fault from 0 ohms to 1.5 megohms is indicated as a FAULT. A light fault from 1.5 to 15 megohms is indicated as HIGH RESISTANCE while a resistance from 15 to 200 megohms is indicated as GOOD. Since the meter is labeled GOOD, HIGH RESISTANCE and FAULT, no other interpretation is necessary. A FAULT reading indicates a tip ground or battery cross. See paragraph 2-37 for the resistance values on the FAULTMETER scale.

4. Connect the red test clip to the *ring* conductor, and note the FAULTMETER indication. A FAULT reading indicates a ring ground or battery cross.

5. Leave the red test clip connected to the ring conductor, and touch the tip conductor to ground. Note the FAULTMETER indication; a FAULT reading indicates a cross, or a tip-ring short due to conduction through the fault to ground. Due to the high sensitivity of the FAULTMETER, tinsel transfer clips or any material with less than 1 megohm resistance may be used to ground the conductor. The black test clip may also be connected directly to the conductor under test, but the grounding method is usually more convenient and safer.

6. Select a good conductor, or if possible, a good pair. When selecting a single good conductor, the FAULTMETER reading should be between the null line and the first 0 in GOOD. When selecting a good pair, the FAULTMETER reading for each conductor can be farther to the right, as long as the indicator stays in the green (GOOD) area.

2-12. Instrument Hook-Up.

2-13. When the FAULTMETER check is complete, connect the 710A for the fault location test as shown in Figure 2-2. There are two basic hook-ups: a one-pair hook-up and a two-pair (separate good pair) hook-up. The one-pair hook-up is used when one of the pair of faulted conductors is good and the other conductor is grounded or crossed to the battery. The two-pair hook-up *must* be used if the two conductors are shorted, or when the second conductor of a pair shows a fault or a high resistance. For measuring strap-to-fault distances on long cables, the two-pair hook-up is more accurate when the fault is near the strap; therefore, the two-pair hook-up is generally preferred. Note that the good-pair conductors do not have to be the same length and gauge as the "bad pair" conductors (pair under test). Thus, when the entire cable has failed, it is often possible to use a good pair in a second cable. Always be sure to connect the red clip to the faulty conductor. For a one-pair hook-up, connect the black clip to ground; for a two-pair hook-up, connect the black clip to the other conductor in the faulty pair.

NOTES

- If only one good conductor is available, and a one-pair test is used, the yellow test clip may be left disconnected. The green test clip is the instrument protective ground and should *always* be connected to earth ground.

- Once the instrument hook-up is complete, returning the MEASUREMENT switch to FAULTMETER will cause the panel meter to register in the FAULT (red) area, if there is faulted conductor. If there is no fault indication, the hookup is incorrect or the fault is intermittent. Locate another faulted conductor.

2-14. Strap Connection. A strap, or shorting jumper must be connected between the fault conductor and the good conductor(s) at the far end of the pair under test (See Figure 2-2). If possible, use the conductor strap (Part No. 9006). For a two-pair hook-up, connect the two extreme end clips to the two good conductors and the center clip to the Fault conductor. See Figure 2-2B.

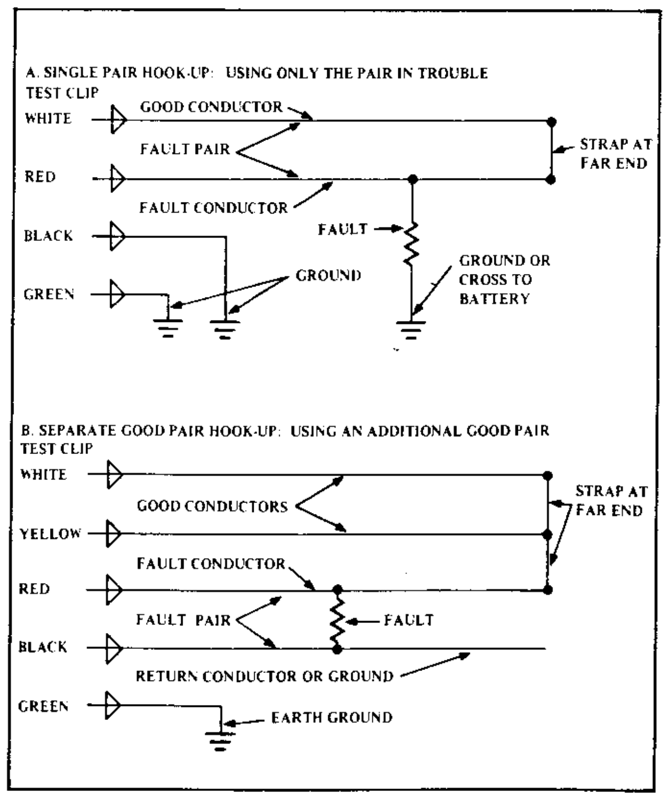


Figure 2-2. Basic Test Hook-ups

If it is not possible to use the conductor strap, make a direct, twisted connection or use "B" connectors. If wire is used, use 19 gauge copper; make it as short as possible, and make a good connection.

NOTES

- A good strap connection is IMPORTANT. The length of wire used to strap the fault conductor to the good pair is included in all distance measurements. Do not use tinsel transfer clip leads when making the strap connection. Some tinsel transfer clip leads are electrically equivalent to 600 feet of 19 gauge copper.
- If a long time is required to make the strap connection, conserve battery power and prevent fault "drying" by turning the 710A OFF. When the strap is connected, continue to paragraph 2-15.

2-15. Loopmeter Test

2-16. After the Fault and good conductors have been connected as shown in Figure 2-2, the continuity of the conductor loop and strap is then tested with the Loopmeter:

1. Set the MEASUREMENT selector to LOOPMETER.
2. Set the LOOPMETER selector to GOOD PAIR.
3. Note the indication on the LOOPMETER on the left side of the panel meter.

NOTE

When using a one-pair hook-up, the LOOP-METER will indicate OPEN. Go to step 4.

A GOOD indication means the good pair has continuity and is correctly strapped at the far end. The series loop and strap resistance is less than 500 ohms. A HIGH RESISTANCE indication means the resistance is between 1500 ohms and 50,000 ohms, which is higher than allowable for a normal telephone circuit. An OPEN indication means the resistance is greater than 50,000 ohms.

4. Set the LOOPMETER selector to GOOD TO FAULT. A GOOD indication means the good conductor and the fault conductor have continuity and are correctly strapped at the far end.

5. If the LOOPMETER indicates OPEN for either check, check the strap connection. If necessary, select another combination of good and fault conductors.

2-17. Conductor Gauge Selector.

2-18. Set the GAUGE switch to the gauge of the fault conductor under test.

2-19. Conductor Temperature Control.

2-20. Set the TEMPERATURE control to the approximate temperature of the fault conductor under test. The temperature for underground and buried cable may vary from 30° to 80°F. A typical temperature is 55°F, depending upon the depth, the geographic location and the season of the year. A more accurate temperature can be obtained by measuring the temperature of water running from an underground pipe. The temperature of aerial cable will be close to the temperature of the air, depending upon the time of day and exposure to the sun; it may be as high as 120°F in direct sunlight in the summer.

2-21. DISTANCE-TO-STRAP Measurement.

2-22. This measurement serves as a check on conductor gauge and cabling routing. With a two-pair hook-up, the DISTANCE-TO-STRAP measures the length of the conductor connected to the red clip. The red, yellow and white clips may be interchanged if it is desired to measure the length of the other conductors individually. When using a one-pair hook-up, the DISTANCE-TO-STRAP measures the length of the conductor connected to the red clip plus the length of the conductor connected to the white clip divided by 2.

2-23. Distance-to-Strap Measurement Procedure:

1. Set the MEASUREMENT selector to DISTANCE-TO-STRAP.
2. Set the MULTIPLY BY selector and turn the NULL/FEET dial until the panel meter needle is exactly centered at the NULL point. For additional information on setting the null and using the NULL/FEET dial, see paragraph 2-24.
3. Read the distance to strap at the center of the NULL/FEET dial.

2-24. Reading the NULL/FEET Dial. The NULL/FEET dial indicates the distance measurement in feet for distance to strap, distance to fault, and distance from strap to fault measurements. The MULTIPLY BY selector is the range switch for the NULL/FEET dial. There are three distance ranges:

0 to 1000 feet
0 to 10,000 feet
0 to 100,000 feet

To read distance, multiply the NULL/FEET distance reading by the setting of the MULTIPLY BY selector. When the MULTIPLY BY selector is set to 1, the NULL/FEET dial reads directly in feet. For example, a reading of 123 indicates 123 feet, and 023 indicates 23 feet. When the MULTIPLY BY selector is set to 10, multiply the NULL/FEET distance reading by 10. For example, a reading of 123 feet indicates 1230 feet. Similarly, when the MULTIPLY BY selector is set to 100, multiply the distance reading by 100. Thus a reading of 123 would indicate 12,300 feet.

2-25. If the first number on the NULL/FEET dial is 0 and the MULTIPLY BY selector is set to 10 or 100, the MULTIPLY BY selector may be set to lower range for increased accuracy. If the total conductor length is longer than the limit of the circuitry within the instrument, the OVER-RANGE light flashes, indicating that a reading cannot be obtained with the MULTIPLY BY selector in that position. Set the MULTIPLY BY selector to a higher (longer) range.

2-26. OVER-RANGE. The OVER-RANGE light flashes whenever the total length of the conductor between the red and white test clips exceeds the range of the Model 710A circuitry, and a valid null cannot be obtained. Usually the solution is to set the MULTIPLY BY selector to a higher range.

2-27. If the instrument or far-end strap becomes disconnected, the light will also flash.

NOTE

If the OVER-RANGE light continues to flash, even when the red and white test clips are connected together, then the internal protection fuse may be open. See Section 4-12.

2-28. Series Fault Test.

2-29. A test for a series resistance fault (partial open) in the fault conductor can be performed when using the two-pair hook-up, and the good pair is the same length and gauge as the fault conductor. Use the following procedure:

1. Measure the DISTANCE-TO-STRAP and record the distance.

2. Disconnect the yellow test clip and measure the DISTANCE-TO-STRAP again.

If the fault conductor has a series fault, the first distance measurement will be more than 5% longer than the second distance measurement. In this case, do not use the fault conductor for testing; select another faulty conductor with the Faultmeter, and repeat the test procedure starting at paragraph 2-9. If the first measurement is shorter than the second measurement, the unbalance is due to the good conductor, and it will not affect the measurements.

2-30. NULL Procedures.

2-31. The Model 710A NULL controls must must be adjusted for each individual hookup *before* measuring fault distances. Adjust the NULL controls as follows:

1. Set the MEASUREMENT switch to NULL

2. Adjust the NULL 1 control for a null reading at the center of the panel meter.

3. Press and hold the PRESS FOR NULL 2 pushbutton, and simultaneously adjust the NULL 2 control. First, turn the NULL 2 control so the meter needle moves away from the NULL; then adjust the NULL 2 control so the meter needle is exactly nulled, or centered. If the meter needle cannot be set away from null before final adjustment, the fault may have dried out. Recheck the fault conductor with the FAULTMETER (See paragraph 2-11).

NOTES

- The NULL 2 control affects the accuracy of the DISTANCE-TO-STRAP and STRAP-TO-FAULT measurements. Once it is set, do not change it. If it is disturbed, re-set it as described in step 3 above.

- If meter pointer seems to oscillate during the NULL procedure, it may indicate more than one fault on the conductor under test. To dampen the meter action, set the MULTIPLY BY selector to X100.

2-32. DISTANCE-TO-FAULT Measurement.

1. Set the MEASUREMENT selector to DISTANCE TO FAULT.

2. Adjust the NULL/FEET dial so that the panel meter indicates a null.

3. Note and record the reading on the NULL/FEET dial. This reading, multiplied by the setting of the MULTIPLY BY selector is the distance from the Model 710A to the fault in feet. If the first digit on the NULL/FEET dial is zero, the MULTIPLY BY selector may be set to a lower range for better accuracy.

NOTES

- Be sure to determine if there are any load coils, bridge taps or conductor guage changes between the test-set and the far-end-strap. If so, see paragraph 2-56.
- The length and gauge of the good pair does not affect the distance measurement accuracy. If necessary, it is possible to use a good pair from another cable.

2-33. STRAP-TO-FAULT Distance Measurement

1. Set the MEASUREMENT selector to STRAP TO FAULT.

2. Adjust the NULL/FEET dial so that the panel meter indicates a null.

3. Note and record the reading on the NULL/FEET dial. This reading, multiplied by the setting of the MULTIPLY BY selector is the distance from the strap to the fault in feet. If the first digit on the NULL/FEET dial is zero, the MULTIPLY BY selector may be set to a lower range for better accuracy. See also the notes in paragraph 2-32.

2-34. LOOP LENGTH Measurement.

2-35. When the MEASUREMENT switch is set to LOOP LENGTH, the total length of conductors between the white and red test clips is measured. The electrical length of load coils can be measured for the actual conductor gauge and temperature. See the applications information following paragraph 2-42.

NOTE

The LOOP LENGTH includes the electrical length of one conductor of the good pair.

2-36. Using the 710A as an Ohmmeter.

2-37. Both the FAULTMETER and the LOOPMETER can be used as an ohmmeter. The LOOPMETER is useful for resistance measurements from 100 ohms to 1 megohm, while the FAULTMETER is useful from less than 1 megohm to over 200 megohms. For high resistance measurements, set the measurement switch to FAULTMETER and use the red and black clips for test. The calibration is shown in Figure 2-3. For low resistance measurements, set the measurement switch to LOOPMETER, set the LOOPMETER switch to GOOD PAIR and use the white and yellow clips for test.

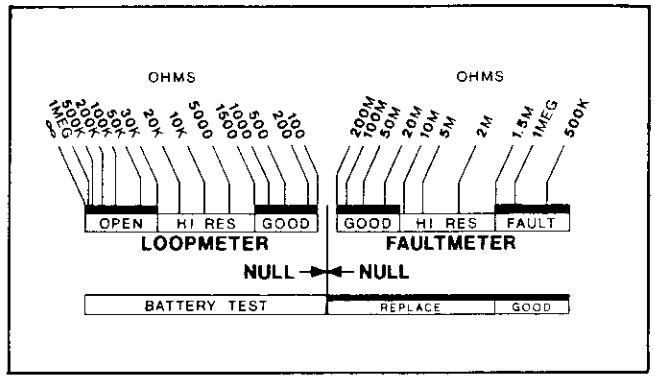


Figure 2-3. Using the 710A as an Ohmmeter

2-38. TURN-OFF

2-39. To turn the 710A off, turn the MEASUREMENT selector fully counterclockwise to OFF. For maximum battery life, turn the 710A OFF when not in use. The Test Cable is interlocked so that all power is off whenever the Test Cable is removed from the TEST CABLE receptacle. The cable must be removed to secure the cover.

2-40. WET WEATHER OPERATION.

2-41. The 710A is designed for all-weather operaton. The batteries are supported in a waterproof tray in the bottom of the enclosure. The tray assembly is designed so that up to ½-inch of water can collect in the enclosure without contacting the batteries. However, when the Model 710A is used in rain or wet snow, the enclosure should be drained frequently. To drain the enclosure, tip the Model 710A on its side, and allow accumulated water to run out. Minimize water accumulation by covering the panel with the lid whenever possible.

2-42. SPECIAL APPLICATIONS

2-43. B Service and D Underground Wire

2-44. B service wire contains iron and has electrical characteristics similar to 24 gauge copper. When testing "B" service wire, set GAUGE switch to 24 and the TEMPERATURE control to a temperature 26°F lower than the actual conductor temperature. For D underground wire, set GAUGE SWITCH to 19 and temperature control 15°F lower than actual conductor temperature.

2-45. Bridge Taps

2-46. When a bridge tap is located between the test-set and the strap, it is necessary to determine whether the fault is in

the main section or in the bridge tap section. A fault that is located anywhere in the bridge tap section will measure to the point where the bridge tap is spliced into the main section.

2-47. To determine whether the fault is in the splice or the bridge tap section, disconnect the strap from the main section and connect a strap at an access point in the bridge tap section. The fault is now measured in the main section to the splice and then in the bridge tap section to the strap. If the fault still measures to the splice, then the fault is in the splice.

2-48. Good Pair in Separate Cable

2-49. The good pair does not have to be in the same cable as the fault pair, and does not have to be of the same gauge or the same length as the fault pair.

2-50. When testing short cable sections or buried drop, it is often faster to use a separate good pair such as "B" service wire of JKT wire. "B" service wire is very convenient because its foot markers can be used to measure the actual distance on the surface. When a reel of several hundred feet of wire has both ends available for connection, this wire need not be cut. Just roll off required amount of wire to complete the test, then roll back for reuse. Since only one pair is required for test, the other pair may be used as a talk pair.

2-51. The single pair hook-up cannot be used when the good conductor is a different length or gauge. The LOOP LENGTH measurement will include the length and gauge of one of the good pair and should not be used when a separate drop is connected.

2-52. Electrical Mapping

2-53. Since a fault anywhere in a bridge tap section will measure to the point where the bridge tap is spliced into the main cable, this allows a convenient way to electrically map the cable at the time of installation.

2-54. Using the standard single pair hook-up, measure the DISTANCE TO STRAP and record for future use. Without changing the strap, ground the fault conductor anywhere along a bridge tap and measure the DISTANCE TO FAULT in the usual manner. This is the distance from the test-set to the splice where the bridge tap starts.

2-55. If this information is included in the records, then a fault that occurs in that cable section later can be located in feet from one of the original splice check points.

2-56. Load Coils

2-57. When a load coil is located in the cable section under test, measure the DISTANCE TO FAULT in the usual manner. If the DISTANCE TO FAULT is less than the distance to the load coil, then this is the correct distance. If the DISTANCE TO FAULT is longer than the distance to the load coil, then the STRAP TO FAULT measurement is correct.

2-58. The DISTANCE TO STRAP will measure longer than the true length by an amount equal to the electrical length of the load coil. The electrical length of load coils can be from 10 feet to over 1000 feet depending upon which coil is used and the conductor gauge.

2-59. To measure the electrical length of an individual load coil, connect it to the red and white clips, set the measurement switch to LOOP LENGTH, set the conductor GAUGE and TEMPERATURE controls and rotate the digital dial for a null. The electrical length may be read directly in feet from the digital dial and MULTIPLY BY switch.

2-60. If a fault is located between two identical sets of load coils, then the electrical length of the load coil may be subtracted from either the DISTANCE TO FAULT or STRAP TO FAULT distances to obtain a correct measurement.

2-61. With two load coils in a section of cable, the DISTANCE TO STRAP will measure longer than the true length by an amount equal to the length of both load coils.

2-62. A chart for recording the electrical length of some common load coils is shown below:

CODE	ELECTRICAL LENGTH OF COIL AND STUB*			
	19 ga.	22 ga.	24 ga.	26 ga.
632	470	235	147	91
652	484	242	150	94
662	480	240	149	94

*Calculated for 5-foot stub at 70°F

2-63. Equivalent Length Calculations

2-64. For some measurement problems it is necessary to change an actual conductor length to an equivalent length of another gauge. Equivalent length calculations are not necessary because the 710A can compute the equivalent length and display the answer directly in feet on the digital dial.

2-65. Connect the 710A to a cable section, or the test fault, set the measurement switch to DISTANCE TO FAULT, and set the digital dial and MULTIPLY BY switch to the actual conductor length. Set the GAUGE switch to the gauge of the conductor and adjust the NULL 2 control for a null. Now set the gauge switch to the equivalent gauge and adjust the digital dial for a null. The equivalent length of the conductor is read directly from the digital dial.

2-66. Extension Length Calculations

2-67. Normally all measurements are made from the test clips on the test cable. When the 9002 extension cable is used, no calculations are necessary since all measurements are still made from the test clips.

2-68. If a length of conductor is connected between the test clips and the cable to be tested, then an allowance must be made for the length and gauge of this short section.

Example: A 40-foot length of 26 gauge conductor is used to connect the test clips to a 22 gauge cable and the DISTANCE TO FAULT measures 500 feet of 22 gauge conductor.

2-69. Connect a strap at the location where the 26 gauge conductor connects to the 22 gauge cable and measure the DISTANCE TO STRAP with the GAUGE switch set to 22 gauge. The electrical length of this short section measures 101.5 feet and must be subtracted from the DISTANCE TO STRAP and DISTANCE TO FAULT measurements to obtain the true length.

2-70. In this case, subtract 101.5 feet from the 500 foot measurement to obtain a distance of 398.5 feet from the fault to the point where the 26 gauge conductor connects to the cable.

2-71. Temperature Considerations

2-72. Bridge type instruments measure the resistance of the conductors to determine their length. The resistance of copper changes when its temperature is changed, so temperature must be taken into account if an accurate length measurement is to be made. The resistance of copper changes by approximately 0.218% for each °F change in temperature. A few degrees may be insignificant, but a 25°F error in temperature will cause the length measurement to be in error by more than 5%. This phenomenon applies to all resistance bridge type instruments.

2-73. The TEMPERATURE control on the 710A should be set to the temperature of the fault conductor in the section being tested. If part of the cable is underground and part of the cable is aerial, then an estimate of each should be made and a temperature selected that represents an average condition for the section being tested. If the fault is found to be in the first portion of cable, then the TEMPERATURE control should be set to the temperature of that portion of cable for the fault distance measurements.

2-74. When the conductor temperature is below 0°F, set the TEMPERATURE control to 0°F for all distance measurements. The last DISTANCE TO FAULT and STRAP TO FAULT readings can be easily corrected for the exact temperature.

Example: Correct a distance measurement for a conductor temperature of –40°F. First, record the distance reading with the TEMPERATURE control set to 0°F, then set the TEMPERATURE control to +40°F and subtract this new distance reading from the 0°F reading. Now add this difference to the 0°F reading to obtain the –40°F distance.

2-75. Two Conductor Gauges

2-76. When two conductor gauges are used in a cable section, set the GAUGE switch to the gauge of the conductor at the test-set end and measure the DISTANCE TO FAULT in the normal manner. If the distance to fault is less than the distance where the gauge changes, then the DISTANCE TO FAULT measurement is correct.

2-77. If the distance to fault is longer than the length of the first gauge, then set the GAUGE switch to the gauge of conductor at the far-end strap and measure the STRAP-TO-FAULT distance. This is the correct distance from the strap to the fault without calculation.

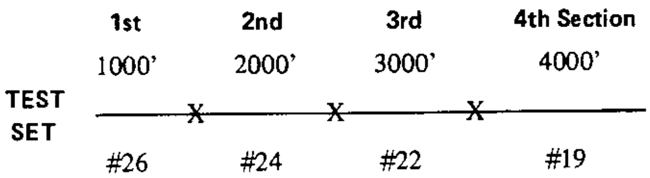
2-78. If the cable has the same gauge at each end and has a section with a different gauge in the middle, refer to MULTI-GAUGE MEASUREMENTS.

2-79. Multi-Gauge Measurements

2-80. When several conductor gauges are involved and the fault is located in the gauge of conductor that is connected to the test-set or the far-end-strap, then this may be measured directly. Refer to the preceding paragraph TWO CONDUCTOR GAUGES.

2-81. If the distance to the fault is longer than the length of the first gauge section, then set the GAUGE switch to the gauge of the second section and measure the DISTANCE TO FAULT again. Now subtract the equivalent length of the first gauge section and add the actual length of the first gauge section to obtain the true distance from the test-set to the fault.

Example: In the diagram shown below, the DISTANCE TO FAULT measures 2200 feet of 24 gauge conductor.



2-82. To obtain the equivalent length of the first section, set to DISTANCE TO FAULT, to 26 gauge, to 100 on the digital dial, to 10 on the MULTIPLY BY switch and adjust NULL 2 control for a null. Now set the GAUGE switch to 24 gauge and adjust the digital dial for a null. This is the 24 gauge equivalent length of 1000 feet of 26 gauge conductor. (ANSWER: 1606 feet.)

2-83. To obtain the actual distance to fault, subtract the 1606 feet from the measured distance of 2200 feet and add the 1000 feet of actual length. (ANSWER: 1594 feet from test-set to fault.)

2-84. If the fault is in the third section, then use the same process except use the STRAP TO FAULT measurement instead of the DISTANCE TO FAULT.

SECTION 3

CIRCUIT DESCRIPTION

3-1. GENERAL

3-2. The Dynatel 710A uses a sequence of precise resistance measurements to detect, evaluate and locate telephone line faults such as a single-conductor series fault, shorts, battery or ground crosses, or a fault on a bridge tap (lateral). To locate a fault, the 710A measures the conductor/fault circuit resistance; internal compensation circuits correct for conductor gauge and temperature variations, so that the calibrated readout indicates each measurement directly in feet without any conversion or correction.

3-3. The 710A uses either a one-conductor hook-up (Figure 2-2A) or a two-pair hook-up (Figure 2-2B). The two-pair hook-up is preferred because it is more versatile, and in some cases is more accurate. It is therefore used for the following discussions. A faulty conductor is first isolated with the FAULTMETER test by checking the resistance of suspected conductors. Similarly, a good conductor (or good pair) is isolated by the FAULTMETER. Then the test circuit is connected as shown in Figure 2-2A or 2-2B. The LOOP-METER test measures the continuity of the entire circuit when shorted by a strap at the far end.

3-4. To make resistance measurements, the 710A uses precision resistors and three sealed (non-field-repairable) active circuit modules. The modules are:

Meter Amplifier (A1)
Current Amplifier (A2)
Regulator (A3)

Since the three modules contain all the active circuits and they are sealed, they will be discussed briefly. The main emphasis will be on the difference between one test circuit and another, which is a function of the setting of the front-panel switches.

3-5. The Meter Amplifier module is basically a high-gain dc voltage amplifier that drives the meter display. It has a non-linear (logarithmic) gain, such that gain is very high at low input voltages (near null); the gain progressively decreases as the input voltage increases. The meter indicates full scale when the input is about 450 mV. The non-linear gain provides high sensitivity for accurate resistance measurements and a large dynamic range for quick evaluation of telephone line resistances. The meter amplifier module contains two logarithmic amplifiers. In the NULL measurement mode they are cascaded to achieve 100X higher sensitivity for precise measurement of distance to fault.

3-6. The current amplifier module provides a precisely controlled output current that is independent of load resistance. The current is routed through the conductor circuits, and the resulting voltages are then measured to derive conductor/fault circuit resistance for the distance measurements.

3-7. The regulator module has two functions: first, it supplies regulated voltages (±5V and -450 mV) for A1 and A2, and second, regulated current for the FAULTMETER and NULL functions. The current is independent of load resistance and voltage (up to -48V). The regulator power sources are the two 9V batteries that supply power for A1, two 4.5V batteries for A2, and a 45 volt battery for the regulated bias current.

3-8. Functional Test Circuits

3-9. The circuit modules are used in nine functional circuits that are connected by the front-panel controls, for the various test functions of the 710A. The nine circuit functions correspond to the positions of the MEASUREMENT switch on the front panel. They are described as follows.

3-10. Faultmeter. The faultmeter circuit isolates and evaluates good and fault conductors. It does so by measuring the resistance between any two conductors connected to the *red* and *black* test clips, as shown in Figure 3-1. The Regulator (A3) supplies a current that goes from pin 3 up through the 7500 ohm resistor, through the fault pair and back through the 45V battery to pin 1. This current is independent of fault resistance and voltages on the conductor up to -48V. The current is set at about 60 μA by the 100 K ohm potentiometer between pins 3 and 2.

3-11. The 60 μA current produces a voltage drop across the 7500 ohm resistor. This voltage drop is amplified by the A1 Meter Amplifier to drive the meter. With a direct short to ground between the *red* and *black* clips, this voltage is set at -450 mV which causes full scale meter deflection. With an open circuit, the meter reads null or zero. As a result of the Meter Amplifier's logarithmic response, the meter displays the entire range of resistance values encountered with telephone line faults. Any resistance less than 1.5 megohm is

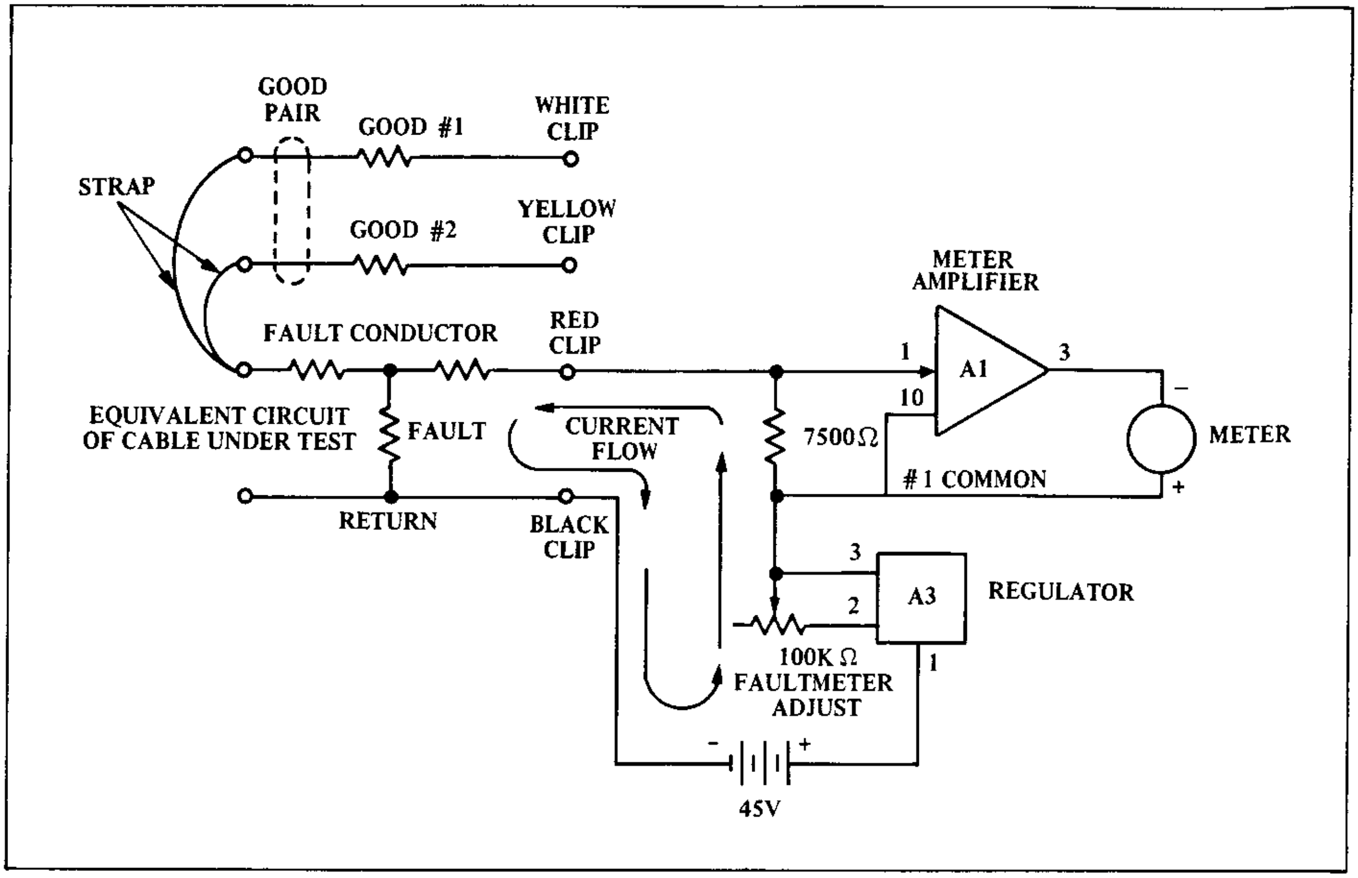


Figure 3-1. Faultmeter Functional Diagram

considered a fault; resistance between 1.5 and 10 megohms is a high resistance fault. 20 megohms and up is considered good.

3-12. Loopmeter. The LOOPMETER circuit (Figure 3-2) measures resistance and continuity of telephone line pairs. It is used with the far-end strap to check strap continuity and resistance through the good pair, and also through the fault conductor and one side of the good pair. The MEASUREMENT selector is set to LOOPMETER, and the LOOPMETER switch is in the GOOD PAIR position for good pair resistance. When the LOOPMETER is set to GOOD-TO-FAULT, it measures the resistance of the fault conductor and one side of the good pair.

3-13. The Meter Amplifier input is biased so that it reads full scale when the *white* and *yellow* leads are connected to an open circuit. This is done by dividing +5V through the resistor network (R1 through R5), so that A1 pin 1 is held at -45° mV. With the *white* and *yellow* leads connected to a good pair with a strap, current is shunted through the good pair, which reduces the voltage applied to pin 1. The meter scale is calibrated to compensate for the resistor network and the non-linear response of the A1 Meter Amplifier, so that it reads the loop resistance directly.

3-14. When good pair continuity is established, the LOOPMETER switch is set to GOOD TO FAULT for testing the good #1 conductor and the fault conductor (connected to the *red* clip). This confirms the proper strap connection and detects possible series faults or other irregular connections.

3-15. Distance to Strap. The distance to strap circuit is shown in Figure 3-3. This circuit measures the distance to the strap in feet, and compensates for the conductor gauge and temperature. The circuit is connected so that the current amplifier A2 generates a regulated current based on the -450 mV reference voltage input at pin 8. This current is independent of load resistance. It goes from pin 5 through the gauge resistor selected by the GAUGE and RANGE switches, then up through the good #1 conductor, the strap, and back through the fault conductor to A2 pin 6.

3-16. The TEMPERATURE control and the NULL/FEET dial are connected between -5VR and ground so that the voltage at the center arm of the NULL/FEET potentiometer can be adjusted between ground (common #1) and about

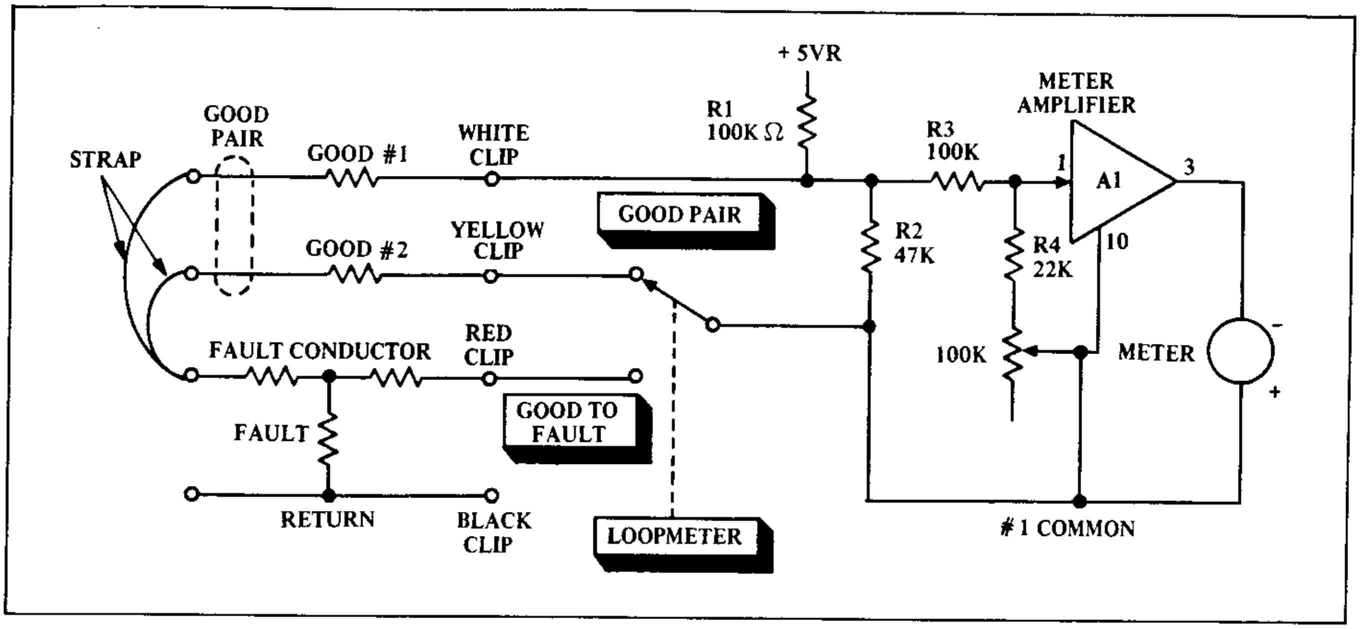


Figure 3-2. Loopmeter Circuit Functional Diagram

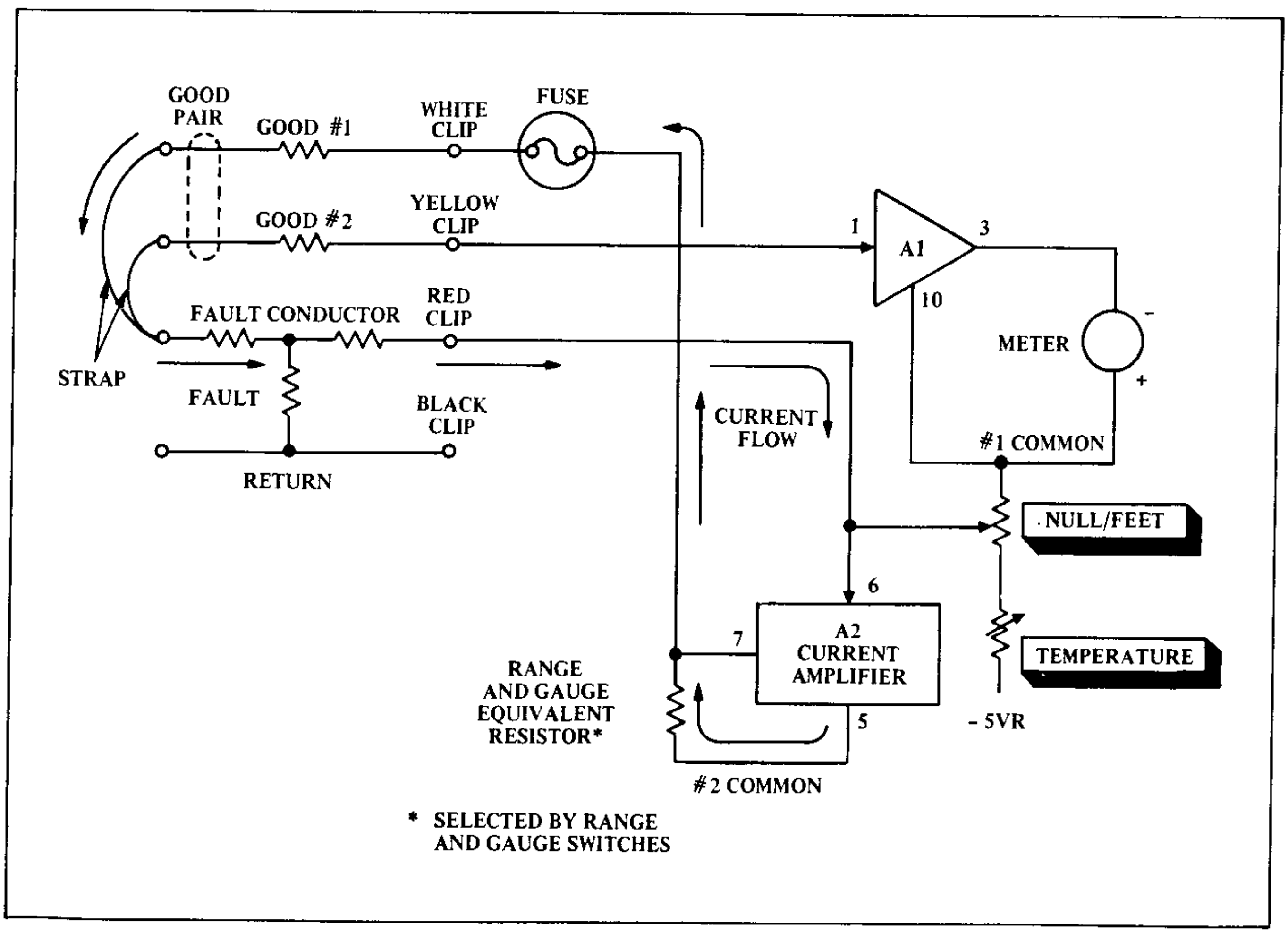


Figure 3-3. Distance to Strap Functional Diagram

-460 mV. The TEMPERATURE control varies the voltage slightly to compensate for conductor temperature.

3-17. When the NULL/FEET dial is set so that the meter indicates NULL (zero), the voltage at A1 pin 1 is zero. In this condition the voltage drop across the fault conductor is balanced by the voltage drop across the RANGE/GAUGE resistor and the good #1 (white) conductor. As a result, the voltage at the strap is zero, and the NULL/FEET dial reads the distance to strap in feet.

3-18. **NULL.** The purpose of the null circuit (Figure 3-4) is to set the arm of the NULL #2 potentiometer in preparation for the distance-to-fault measurements. The NULL #2 potentiometer is connected across the good #2 and fault conductors, and its arm is adjusted to correspond to the location of the fault on the fault conductor. This is accomplished in two steps:

a. **Null 1.** First, the meter circuit is nulled with the NULL 1 Adjust to compensate for galvanic or other stray voltages. The meter circuit has 100X higher sensitivity in this configuration because the two log amplifiers in A1 are cascaded. In the cascade circuit, the input is to A1-9 (the first amplifier), out at A1-7 to the input of the second amplifier at A1-1. The second amplifier output is from A1-3 to the meter.

b. **Null 2.** In the NULL 2 configuration, A3 pins 2 and 3 shorted. The regulator generates a 200 μA current, using the 45V battery as a source. When the NULL 2 switch is closed, this current flows into the arm of the NULL 2 potentiometer (100 K ohm). It splits through the two potentiometer legs, flows through the fault end Good #2 conductors, and returns through the fault to the minus side of the 45V battery. Meter Amplifier A1 senses the voltage between *red* and *white* test clips (Fault and Good #1). When NULL 2 is adjusted so that the meter reads zero, the resistances of its two legs are proportional to the fault conductor resistances on either side of the fault.

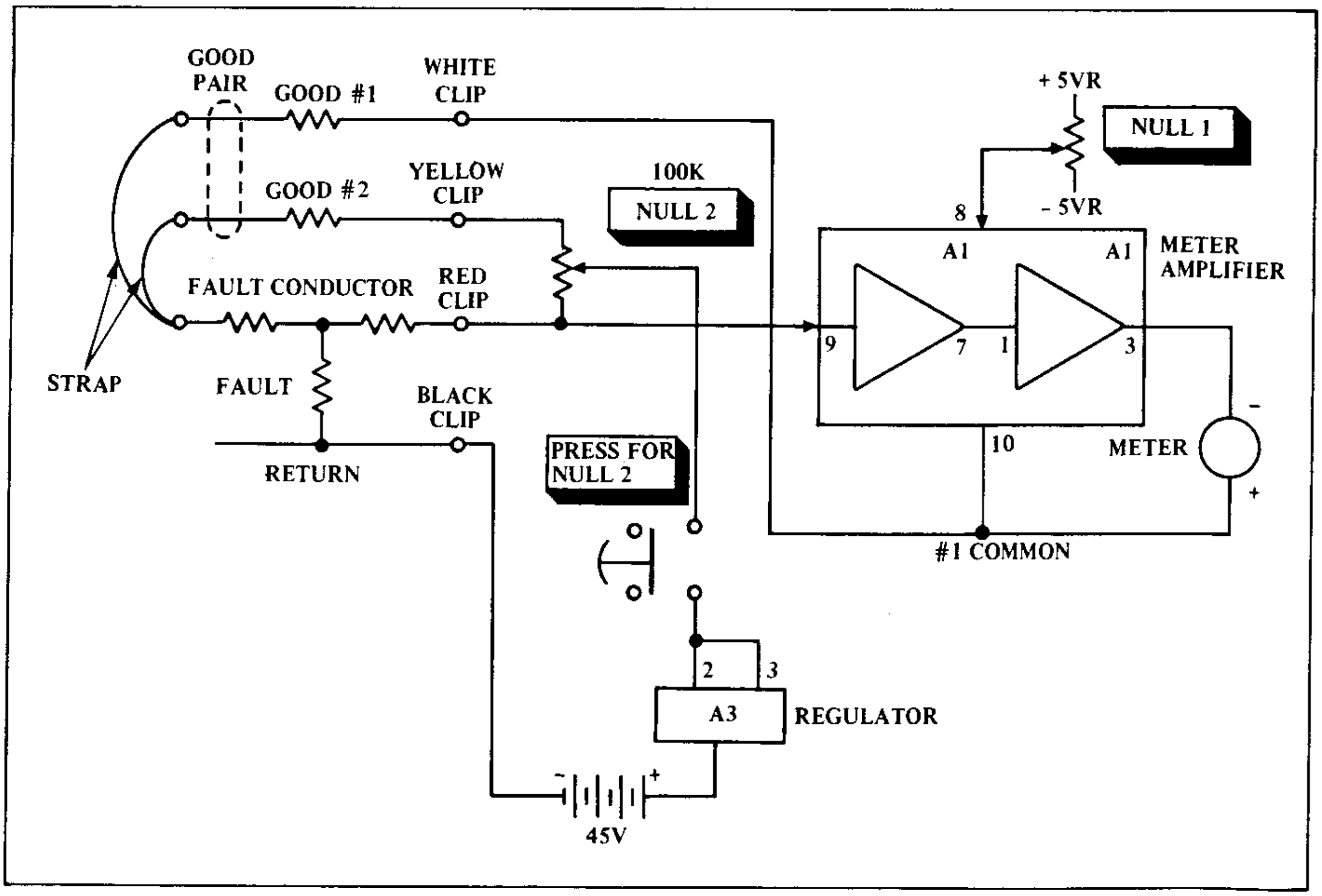


Figure 3-4. Null Circuit Functional Diagram

3-19. Distance to Fault. Figure 3-5 shows the distance to fault measurement circuit. Its operation is the same as the DISTANCE TO STRAP circuit except for one point: The A1 Meter Amplifier is connected to the arm of the NULL 2 adjust. As a result of the NULL 2 adjustment, the center arm position is proportional to the position of the fault on the fault conductor. When the FEET dial is nulled out, it reads the distance to the fault in feet.

3-20. Strap to Fault. Figure 3-6 shows the circuit for measuring the distance from the strap back to the fault. The operation is similar to the DISTANCE TO FAULT circuit. The polarity of the current source is reversed, and the connections to A1 and the NULL/FEET dial pot are reversed. Thus, when the NULL/FEET dial is adjusted to null the intput to A1, it reads the distance from the strap back to the fault.

3-21. Battery Test. Figure 3-7 shows the equivalent circuit for the battery test positions on the MEASUREMENT selector (BATTERY TEST 1, 2 and 3). For BATTERY TEST 1, the two 4.5V batteries, a 38.3 K ohm series resistor and a 150 ohm parallel resistor, are switched into the meter circuit. BATTERY TEST 2 tests the two 9V batteries with a 76.8 K ohm series resistor and a 4700 ohm parallel resistor. The 45V battery is tested in BATTERY TEST 3 with only a 196 K ohm series resistor. A good battery is indicated by full scale deflection. In all test positions, the load on the battery is the same as the actual operating load.

3-22. Power Supplies. The A3 Regulator provides regulated power for the A1 and A2 modules. These are shown respectively in Figures 3-8 and 3-9.

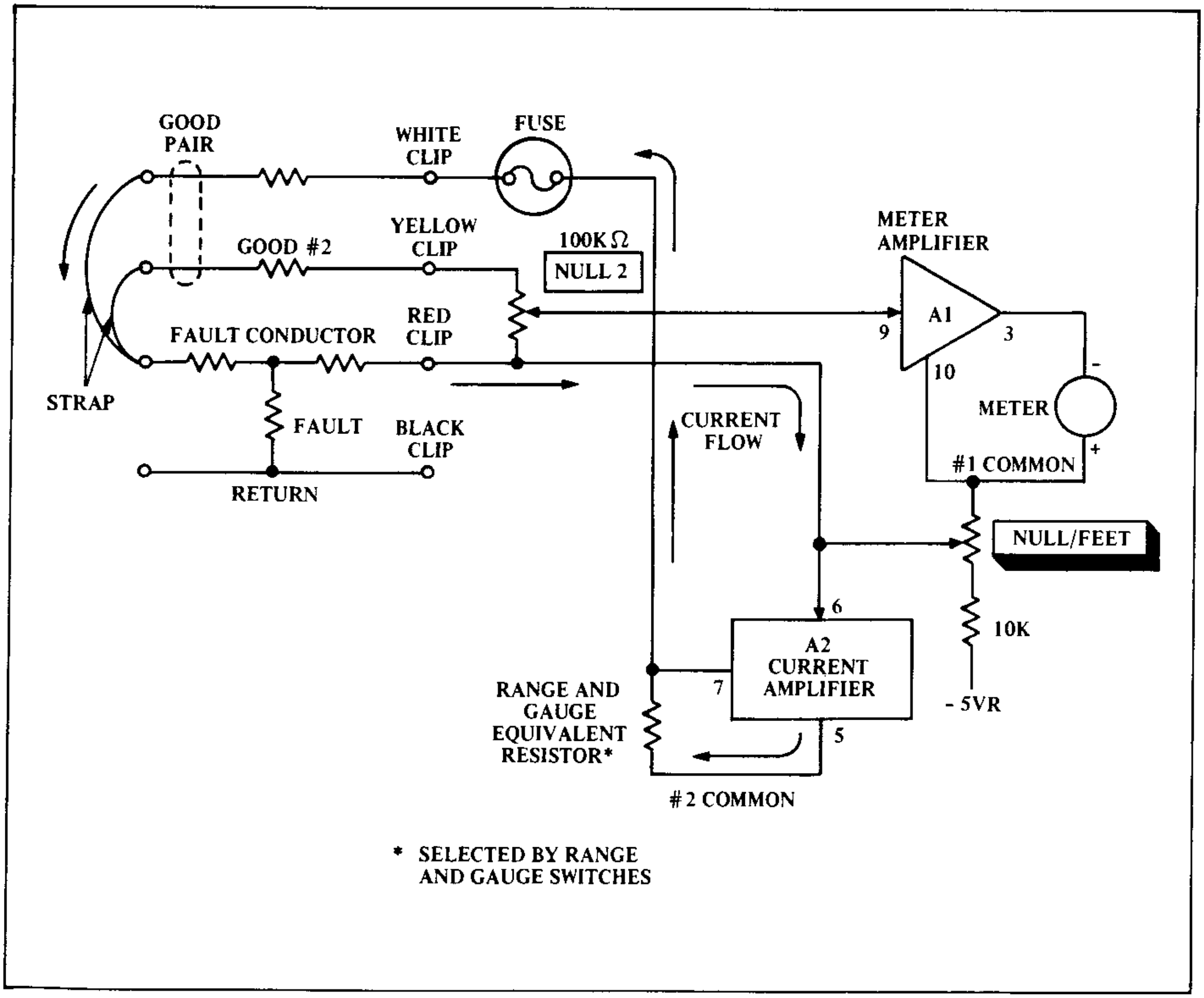


Figure 3-5. Distance to Fault Functional Diagram

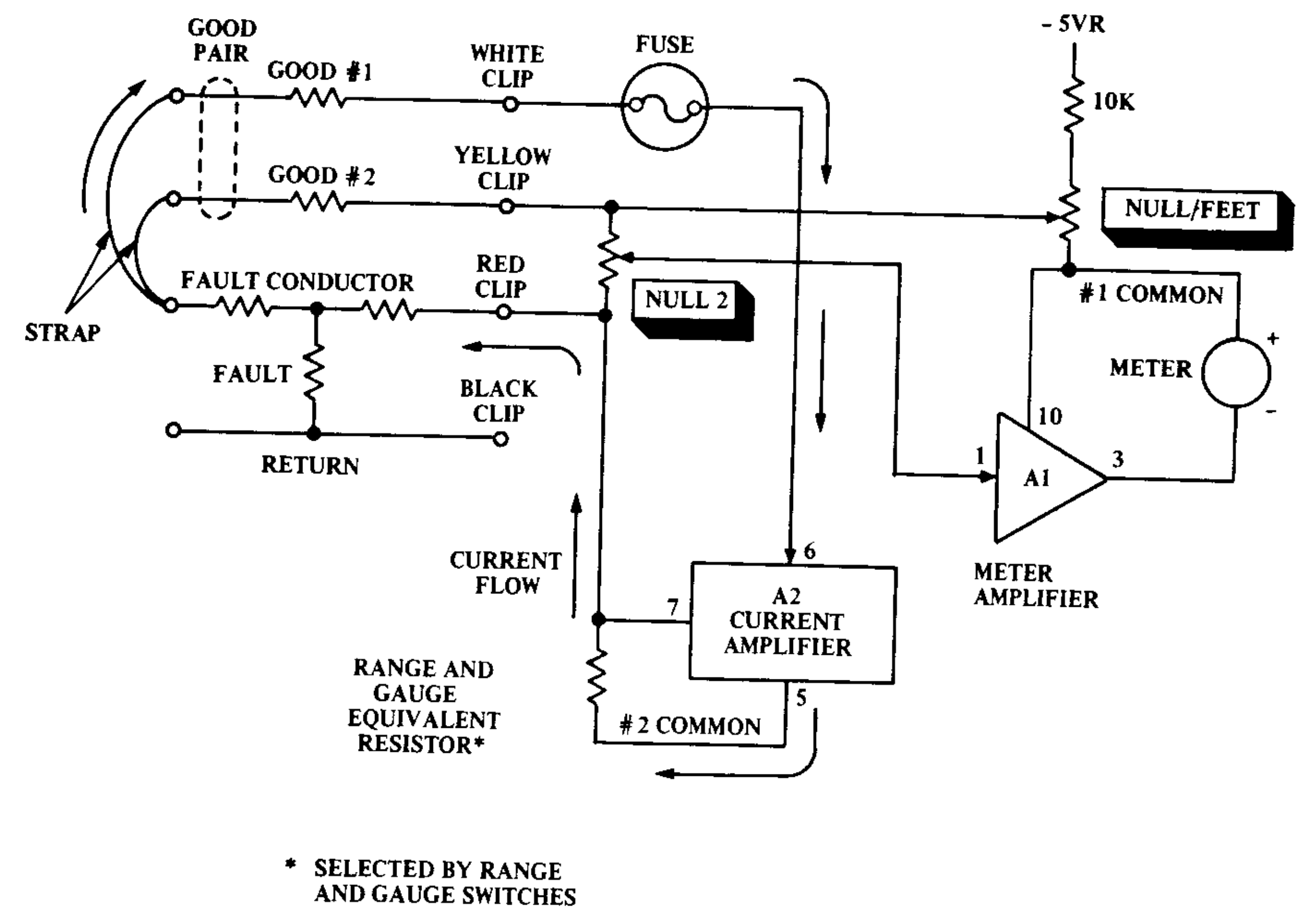


Figure 3-6. Strap to Fault Functional Diagram

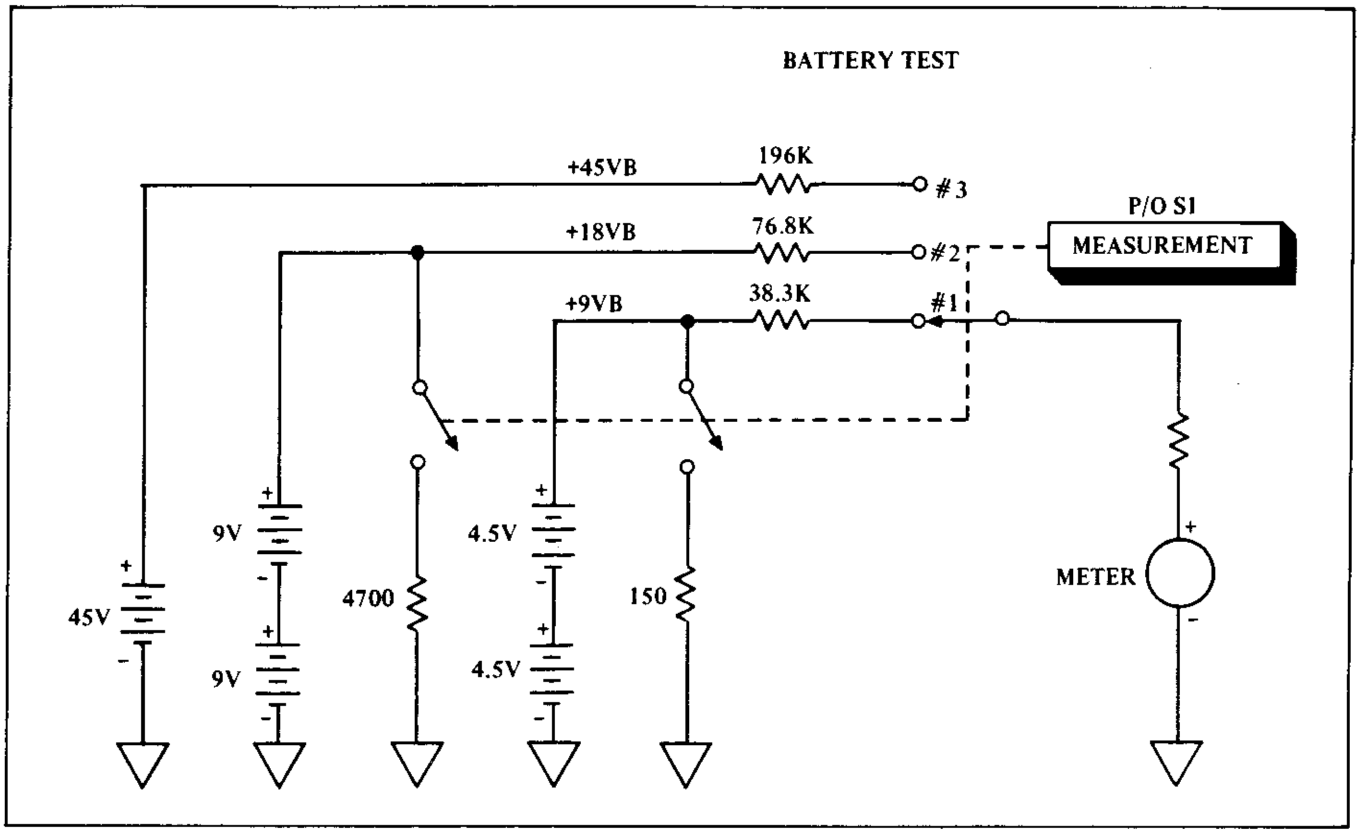


Figure 3-7. Battery Test Functional Diagram

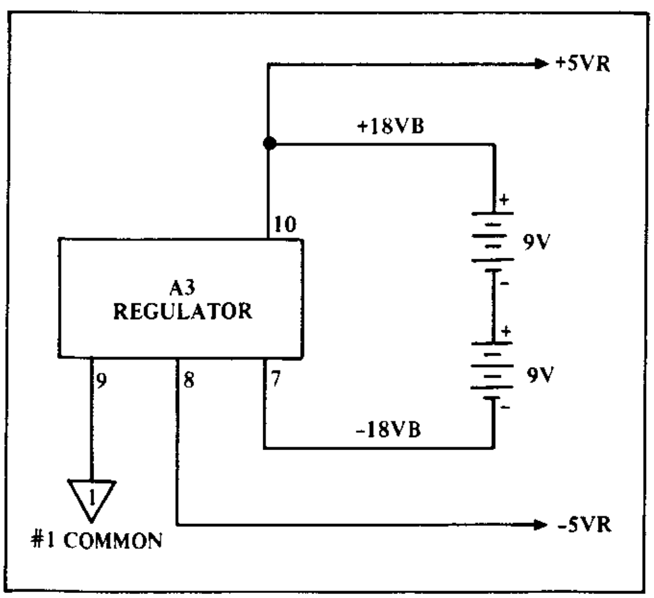


Figure 3-8. Meter Amplifier Power Supply Functional Diagram

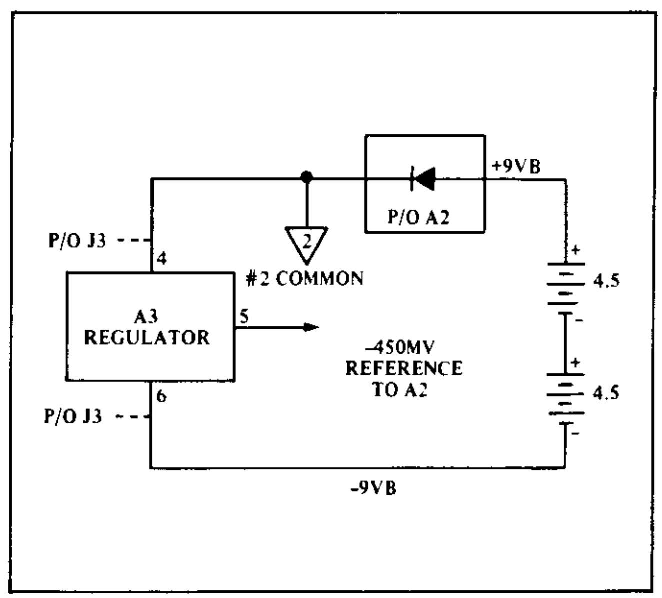


Figure 3-9. Current Amplifier Power Supply Functional Diagram

SECTION 4

MAINTENANCE

4-1. PERIODIC MAINTENANCE

4-2. The Dynatel Model 710A is designed for dependable all-weather operation. All active circuit components are sealed in three non-field-repairable plug-in modules. All other circuits are sealed for protection against fungus and humidity. Adjustment and calibration is normally required only if a component is replaced. The 710A has a built-in self-test feature, so that adjustments and performance tests can be made with a minimum of additional test equipment.

4-3. To ensure maximum performance, the following procedures should be performed every 30 days:

1. Check the performance of the Model 710A by the procedure given in Section 4-15.

2. Make a visual inspection of the instrument and check for dust or moisture. Blow accumulated dust or light moisture away using a compressed air hose with a maximum pressure of 50 PSIG.

WARNING

When using an air hose, safety glasses must be worn to protect eyes from dust particles and grit.

4-4. Excessive Moisture

4-5. The Model 710A is sealed against moisture. If it becomes waterlogged, remove the battery tray cover, remove any excessive water and dry the instrument (including batteries) in a 130°F oven.

4-6. Lubrication

4-7. All switch assembly wafers in the Model 710A have a protective coating. The switch detent should be lubricated *only* if it squeals or sticks.

CAUTION

Use only non-migratory silicon grease that will not penetrate. Avoid over-lubrication; use sparingly. Otherwise, leakage resistance may be decreased and the instrument performance impaired.

4-8. Battery Replacement

4-9. Nominal battery life is 500 hours, or 6 to 12 months, depending on usage. All batteries usually reach replacement time simultaneously, so that normal practice is to replace all batteries simultaneously. Test interval is not critical; since battery current drain is low, battery checks can be made at monthly or semi-monthly intervals, depending on usage.

4-10. When the batteries are checked, if one battery indicates REPLACE on the meter, and all others indicate GOOD, then the one battery is probably defective, and should be replaced.

4-11. Battery Replacement Procedure. The Model 710A uses five carbon-zinc dry-cell batteries, as indicated in Table 4-1. The batteries are located in the bottom section

Table 4-1. Battery Cross Reference Chart

QUANTITY	VOLTAGE	NEDA	EVEREADY	BURGESS	RAY-O-VAC
2 each	4.5V	3	736	F3	A3
2 each	9V	1602	246	2N6	1602
1 each	45V	213	415	U30	213

of the fiberglass enclosure. To replace the batteries, use the following procedure:

1. Open the fasteners that hold the bottom section of the enclosure to the center section, and separate the two sections. Lift off the cover to the battery tray.

2. Disconnect and replace each battery with a comparable battery as indicated in Table 4-1. Make sure that all batteries are seated properly in the support tray, and that they are connected properly (The red lead always goes to the positive terminals on each battery).

NOTE

The battery cable is connected to the 4.5V batteries with machine screws. When using terminal-type batteries, remove the machine screws and connect the #8 lugs directly.

3. Replace and secure the panel assembly.

4-12. Fuse

4-13. A standard 1 Amp., 3AG fuse protects the instrument from damage as a result of accidental connection to a power line. The instrument will not be damaged when connected to voltages up to 350 volts dc and up to 250 volts ac. The fuse is located inside the battery compartment near the battery cable socket.

4-14. Fuse Test Procedure:

1. Set the MEASUREMENT switch to DISTANCE TO STRAP and note the OVER-RANGE light flashing. Make sure that all test clips are disconnected and separated.

2. Connect the red and white test clips together. The light should stop flashing. If the light continues to flash, replace the fuse.

4-15. Performance Test

4-16. The following procedure accurately checks the Model 710A, the test cable and the extension cable. The test cable furnished with the 710A has an artificial line with four self-test terminals built into the top of the plug. The four terminals are colored white, yellow, red and black. The artificial line represents a cable that is 1000 ft. ±1 ft long with 26 gauge copper conductors at a conductor temperature of 70°F. In addition, it has a test fault located at a distance of 100 ±0.1 feet from the test set. See Figure 4-1.

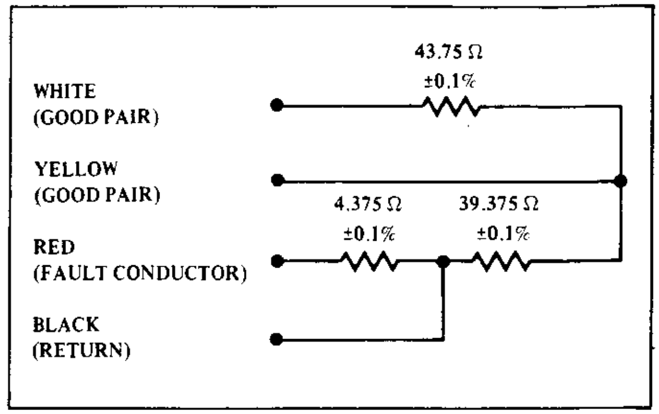


Figure 4-1. Test Fault Circuit Used in Dynatel 9003 Self-Test Cable

4-17. The accuracy of the test fault is ±0.1% for all measurements which are used for all calibration. The accuracy of the 710A test set is 0.5% of reading ±1 digit for all distance measurements.

1. Connect the Test Cable (Part No. 9003) to the front panel TEST CABLE receptacle.

2. Note that the colored test terminals on the top of the TEST CABLE plug match the colors on the TEST CABLE clips. Connect each clip to the test terminal with the matching color.

3. Turn the MEASUREMENT selector OFF. The meter pointer should be exactly on the NULL line. If not, adjust with the small screwdriver; the adjustment screw is located at the left edge of the meter face.

4. Turn the MEASUREMENT selector to BATTERY TEST 1. This position tests the 9V supply (two 4.5V batteries). The panel meter should indicate GOOD on the bottom scale. If the meter indicates REPLACE, replace with two 4.5V batteries.

5. Repeat Step 4 for BATTERY TEST 2 (18V supply; two 9V batteries), and 3 (45V battery) on the MEASUREMENT selector.

6. Set the MEASUREMENT selector to FAULTMETER. The meter pointer should indicate FAULT on the FAULTMETER side of the panel meter. This means that a fault exists between the red and black clip leads, which are normally connected to the fault-conductor and the return, respectively. See Figure 4-1.

7. Set the MEASUREMENT selector to LOOPMETER.

8. Set the LOOPMETER selector to GOOD PAIR. The panel meter pointer should point to the left of the NULL line, between the NULL and the GOOD zone on the LOOPMETER scale. This checks the continuity of the good pair and the strap.

9. Set the LOOPMETER selector to GOOD TO FAULT. The meter pointer should be at about the same position as it was in Step 8. This checks the continuity of the good conductor, the fault conductor and the strap.

10. Set the Model 710A controls as follows:

GAUGE	26
NULL/FEET	000 (fully clockwise)
MULTIPLY BY......	1
MEASUREMENT.....	DISTANCE TO STRAP

11. Set the TEMPERATURE control so that the meter pointer points exactly to the NULL line. The temperature control should indicate approximately 70° ±3°F. Steps 10 and 11 check the calibration of the Model 710A by measuring the distance to the strap in the 1000 foot artificial line.

NOTE

If the OVER-RANGE light flashes refer to paragraph 4-12.

12. Set the MEASUREMENT selector to NULL.

13. Adjust the NULL 1 control so that the meter pointer is exactly on the NULL line.

14. Hold the PRESS FOR NULL 2 pushbutton down and simultaneously adjust the NULL 2 control. Be sure to adjust the NULL 2 control so the meter pointer is to either side of NULL line (to be sure that it operates). Then adjust the NULL 2 control so the meter pointer is exactly on the NULL line. In this test, the NULL 2 control position should be one turn clockwise from the counter-clockwise stop when the meter is exactly nulled.

NOTE

After the NULL 2 control is adjusted, it should not be moved until the test procedure is complete.

NULL 1 control balances the bridge circuit, and the NULL 2 control locates the fault position between the test-set and the strap. For a fault located at the test-set, the NULL 2 control would be at the counter-clockwise stop when the meter is nulled; for a fault located at the far end, or strap end, the NULL 2 control would be 10 turns clockwise (at the clockwise stop) when the meter is nulled.

15. Set the MEASUREMENT selector to DISTANCE TO FAULT.

16. Adjust the NULL/FEET control so that the meter pointer is exactly at the NULL. The digital dial on the NULL/FEET control should indicate 100 ±2 feet. This test measures the distance from the Model 710A to the fault in the electrical line at 100 feet.

17. Set the MEASUREMENT selector to STRAP TO FAULT.

18. Adjust the NULL/FEET control so that the meter pointer is exactly at the NULL. The digital dial should indicate 900 ±2 feet. This test measures the distance from the strap back to the fault in the artificial line, which is 900 feet.

19. Set the MEASUREMENT selector to LOOP LENGTH.

20. Set the MULTIPLY BY selector to 10.

21. Set the NULL/FEET control so that the meter pointer is exactly at the null. The NULL/FEET dial should indicate 200 ±2, which is read as 2000 ±20 feet. This test measures the length of the complete loop from the 710A to the strap and back to the test set in the artificial line, which is 2000 feet.

22. If the accessory extension cable (Part No. 9002) is to be checked, connect it between the panel TEST CABLE receptacle and the standard test cable (Part No. 9003). After the cable is connected, repeat Steps 10 through 21.

23. To check the 19, 22 and 24 gauge calibration using the 9003 Test Cable and test fault on the top of the plug, set the Model 710A controls as follows:

GAUGE	26
TEMPERATURE	70°F
NULL/FEET	000 (fully clockwise)
MULTIPLY BY	1
MEASUREMENT	DISTANCE TO STRAP

24. The meter pointer should point to null. If not, adjust the TEMPERATURE control for a precise null. TEMPERATURE control should be 70 ±3°F.

25. Set the MULTIPLY BY switch to 10 and adjust the NULL/FEET control for null. NULL/FEET dial should read 100 ±2.

26. Set the GAUGE switch to 24 and adjust the NULL/FEET control for null. The NULL/FEET dial should read 161 ±2.

27. Set the GAUGE switch to 22 and adjust the NULL/FEET control for null. The NULL/FEET dial should read 257 ±2

28. Set the GAUGE switch to 19 and adjust the NULL/FEET control for null. The NULL/FEET dial should read

29. Set the MEASUREMENT switch to NULL and adjust the NULL 1 control for a precise meter null.

30. While holding down the NULL 2 pushbutton, adjust the NULL 2 control for a precise null. (Do not move this control during the next 4 steps.)

31. Set the MEASUREMENT switch to DISTANCE TO FAULT, the GAUGE switch to 26, and the MULTIPLY BY switch to 1, and adjust the NULL/FEET control for null. The NULL/FEET dial should read 100 ±2.

32. Set the GAUGE switch to 24 and adjust the NULL/FEET control for null. The NULL/FEET dial should read ~~518~~ ±2. 161 ±2

33. Set the GAUGE switch to 22 and adjust the NULL/FEET control for null. The NULL/FEET dial should read 257 ±2.

34. Set the GAUGE switch to 19 and adjust the NULL/FEET control for null. The NULL/FEET dial should read 518 ±2.

35. The preceding tests do not check the highest (X100) distance range of the Model 710A. Normally this is not required; however, the X100 range can be tested by connecting a ~~437.5~~-ohm, ±0.1%, ¼ watt resistor between the RED and WHITE test clips of the 9003 test cable and setting the Model 710A controls as follows:

GAUGE	26
TEMPERATURE	70°F
NULL/FEET	1000 (fully clockwise)
MULTIPLY BY	10
MEASUREMENT	DISTANCE ~~TO STRAP~~

36. The meter pointer should point to null. If not, adjust the temperature dial for a precise null. The TEMPERATURE control should be 70 ±3°F.

37. Set the MULTIPLY BY selector to 100.

38. Set the NULL/FEET control for a precise null on the meter. The NULL/FEET dial should read 100 ±2.

39. Set the GAUGE selector to 24 and adjust the NULL/FEET control for null. The NULL/FEET dial should read 161 ±2.

40. Set the GAUGE selector to 22 and adjust the NULL/FEET control for null. The NULL/FEET dial should read 257 ±2.

41. Set the GAUGE selector to 19 and adjust the NULL/FEET control for null. The NULL/FEET dial should read 518 ±2.

4-18. ADJUSTMENT AND CALIBRATION

4-19. Routine adjustment and calibration is unnecessary unless a component has been replaced. If any of the components listed in Table 4-2 have been replaced, make the adjustment(s) listed prior to returning the unit to service. If the performance test procedure indicates the unit is out of calibration, it is probably due to a faulty component. Be sure to isolate that cause prior to making any adjustment. See Paragraph 4-30 for troubleshooting information. All adjustments are independent and can be made in any order, with the exception of the balance adjustment, which must be preceded by the calibration potentiometer adjustment (A4R27; see paragraph 4-30).

4-20. Required Test Equipment. No electronic test equipment is required for adjustment and calibration.

Table 4-2. Adjustments Required Following Component Replacement

NOTE

For all adjustments be sure the panel is facing up; otherwise meter balance will adversely affect adjustment accuracy.

COMPONENT REPLACED	ADJUST ON A5	SEE PARAGRAPH
Meter Amplifier (A1)	R12, R19, R24, and R6	4-22, 4-24, 4-25, 4-26
Current Amplifier (A2)	R27	4-27
Voltage Regulator (A3)	R24, R6, R27	4-25 thru 4-27
Control Module (A5)	All adjustments	4-22 thru 4-28
Panel Meter (M1)	R24, R6	4-25 and 4-26
NULL/FEET Control (R1)	R31, R27	4-23 and 4-27
Temperature Control (R2)	R27	4-27
Null 2 Control (R4)	R27 and R2	4-27 and 4-28
All Trimmer Resistors:		
Loopmeter (R6)	Adjust Trimmer(s) indicated	4-26
Dial Zero (R31)		4-23
Null Zero (R19)		4-24
Amplifier Zero (R12)		4-22
Calibrate (R27)		4-27
Balance (R2)		4-27 and 4-28
Faultmeter (R24)		4-25

4-21. Set-Up Procedure

1. Remove the four Phillips-head screws from the panel of the Model 710A.

2. Lift the panel/chassis assembly from the enclosure by the GAUGE and MULTIPLY BY selector knobs.

WARNING

Do not lift by the NULL/FEET dial.

3. Disconnect the battery cable.

4. Place the Model 710A panel/chassis assembly on a work surface for convenient access to assembly A5. Open the bottom of the enclosure for access to the battery cable connector. Pull the battery cable through the

bottom panel of the center section of the enclosure and reconnect it to J6.

NOTE

A5 is the only printed circuit assembly in the Model 710A. For circuit component locations, see Figure 4-2.

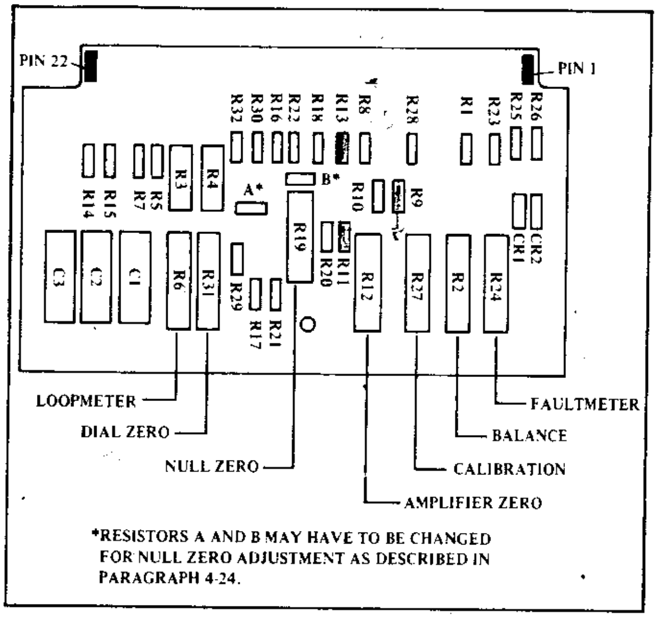


Figure 4-2. Control Module (A5) Component Identification (Dynatel Part No. 9010-0014)

5. Connect the Test Cable (Part No. 9003) to the TEST CABLE receptacle.

6. Set the Model 710A controls as follows:

GAUGE 26
TEMPERATURE .... 70°F STD.
MULTIPLY BY...... 1
LOOPMETER ...... GOOD PAIR
MEASUREMENT .... OFF

7. Adjust the Meter Zero Set so that the meter is nulled – that is, the meter pointer is centered on the meter scale at the NULL line. The zero set adjustment is at the left edge of the meter face.

NOTE

For all adjustments, be sure panel is facing up; otherwise meter balance will affect adjustments.

8. Clip the white, yellow, red, and black test clips together.

4-22. Amplifier Zero Adjustment

1. Follow the set-up procedure in paragraph 4-21.
2. Set the MEASUREMENT selector to LOOPMETER.
3. Adjust A5R12 so that the meter is exactly nulled.

4-23. Dial Zero Adjustment

1. Follow the set-up procedure in paragraph 4-21.
2. Set the MEASUREMENT selector to DISTANCE TO STRAP.
3. Set the NULL/FEET dial fully counterclockwise to 000.
4. Set A5R31 so that the meter is exactly nulled.

4-24. Null Zero Adjustment

1. Follow the set-up procedure in paragraph 4-21.
2. Set the measurement selector to NULL.
3. Set the NULL 1 control five turns from the fully counterclockwise position.

NOTE

The NULL 1 control drives a 10-turn potentiometer with a planetary drive that allows the knob to slip at the end of the potentiometer travel.

4. Adjust A5R19 so the meter is nulled. This adjustment centers the NULL 1 control range and is not critical.

NOTES

NULL ZERO OFFSET INFORMATION
(not applicable unless A1 has been replaced):

- If the null zero adjust is set fully clockwise and the meter indicator is still on the LOOPMETER side of null, then install a 150 K ohm ±2%, ¼ watt metal oxide film resistor in position "A" (shown on Figure 4-2), and readjust the null zero for approximately null on the meter.
- If the null zero adjust is set fully counterclockwise direction and the meter is still on the FAULTMETER side of null, then install a 150 K ohm ±2%, ¼ watt metal oxide film resistor in position "B" (shown on Figure 4-2), and readjust the null zero for approximately null on the meter.

4-25. Faultmeter Adjustment

1. Follow the set-up procedure in paragraph 4-21.

2. Connect the black clip to the red, white and yellow clips.

3. Set the MEASUREMENT selector to FAULTMETER.

4. Adjust A5R24 so the meter needle points to about 2/23-inch *less* than full-scale on the FAULTMETER scale (right side of the panel meter).

4-26. Loopmeter Adjustment

If Adj can't be made check -0011- module.

1. Follow the set-up procedure in paragraph 4-21, with the exception of Step 8. Disconnect all test clips; make sure that the white and yellow clips do not touch.

2. Set the MEASUREMENT selector to LOOPMETER.

3. Adjust A5R6 so the meter needle points to about 1/32-inch *less* than full-scale on the LOOPMETER scale (left side of the panel meter).

4-27. Calibration Potentiometer Adjustment

1. Follow the set-up procedure in paragraph 4-21, with the exception of Step 8. Connect the white, yellow and red test clips to the test fault terminals of the same color on the Test Cable plug.

2. Set the Model 710A controls as follows:

MEASUREMENT . . . . DISTANCE TO STRAP
NULL/FEET . . . . 000 (fully clockwise)
TEMPERATURE. . . . . 70°F STD

3. Adjust A4R27 so that the meter is exactly nulled. This adjustment calibrates the 710A for all conductor gauges and distance ranges.

4-28. Balance Adjustment

1. Follow both the set-up procedure in paragraph 4-21 and the calibration potentiometer adjustment procedure in paragraph 4-27.

2. Remove the yellow clip from the yellow terminal on the Test Cable plug.

3. Adjust A5R2 so that the meter is exactly nulled.

4-29. When the adjustment procedure is completed, return the unit to service by reversing Steps 1 through 4 of the set-up procedure (paragraph 4-21). Be sure to turn the MEASUREMENT selector OFF.

4-30. TROUBLESHOOTING

4-31. For troubleshooting purposes, the Model 710A consists of a switching network and three non-repairable plug-in modules. To troubleshoot, follow the preliminary set-up procedure in paragraph 4-21, Steps 1 through 7. Always be sure the batteries are good and the meter zero-set is properly adjusted. Then follow the steps in Table 4-3 in the order given.

4-32. Since the Model 710A is a sophisticated test instrument, sometimes a malfunction may not be located by the procedures in Table 4-3. If that occurs, check the test point voltages and currents as listed in Tables 4-4 and 4-5. As a last resort, check modules A1, A2, and A3 by substituting all three of the modules, and if possible, a Test Cable. If substitution corrects the fault, (even though the unit may be somewhat out of calibration), then it is definitely located in the Test Cable or one of the three modules. To isolate the malfunction, replace the three modules and the cable one at a time with the original units until the trouble recurs. If substitution locates a faulty module, replace it with a spare and make the adjustments indicated in paragraph 4-18 and subsequent paragraphs. If the trouble is not corrected by substitution, it is probably in the switches, chassis components, or chassis wiring. Check all components carefully. Note that Table 4-5 lists battery current drains for various switch positions, and should be used if battery life becomes abnormally short.

4-33. Required Test Equipment. The only electronic test equipment necessary for troubleshooting the Model 710A is a multimeter such as the HP 412A, or equivalent, which is used for voltage and resistance checks. Specifications are not critical; however, the input impedance should be 1 megohm or greater.

4-34. DISASSEMBLY AND REPAIR

4-35. Meter Replacement Procedure

1. Remove the panel assembly; use the procedure in paragraph 4-21, Steps 1 through 3.

2. Remove the Control Assembly A5.

3. Disconnect the meter wiring.

4. Remove the 6-32 jam nuts and the 6-32 mounting nuts. If the 6-32 machine screws rotate, apply pressure to the front panel over the head of the screw.

5. Remove the meter and install the new meter.

6. To secure the meter follow Steps 1 through 4 in reverse order.

NOTE

Be sure to use the jam nuts to prevent vibration from loosening the meter.

4-36. NULL/FEET Dial Replacement Procedure

1. Remove the panel assembly; use the procedure in paragraph 4-21, Steps 1 through 3.

2. Unsolder and disconnect the electrical connections on the dial assembly.

3. Set the dial anywhere between 100 and 900.

CAUTION

This step is important for preventing damage to the dial end stops in Step 4.

4. Remove the 3/8" – 32 nut holding the assembly to the panel.

5. Remove the potentiometer, dial assembly and bezel from the front of the panel. Replace the potentiometer and dial assembly, as required.

6. To secure the NULL/FEET dial, follow Steps 1 through 5 in the reverse order. Be sure to observe the caution in Step 3 before tightening.

4-37. Switch Repair and Replacement.

4-38. The GAUGE, MULTIPLY BY and MEASUREMENT switches in the Model 710A are constructed of special high-resistance insulators and precision resistors; they are sealed for protection against moisture and fungus, and they are tested with a megohmmeter. The high insulation resistance is critical to the operation of the Model 710A. Therefore, for best results, if a switch or component resistor malfunctions, the entire Model 710A should be returned to the factory for repair. Contact the Dynatel customer service department for additional information

4-39. REPACKAGING FOR SHIPMENT

4-40. The Model 710A is designed for rugged use so that careful packaging for shipment is not critical. The unit should be enclosed in a sturdy shipping container, with packing material placed around all sides of the unit. Finally, wrap the shipping container with strong tape, and mark the container to indicate that it contains FRAGILE ELECTRONIC EQUIPMENT.

Table 4-3. Troubleshooting Procedures

STEP	TEST PROCEDURE	NORMAL INDICATION	IF INDICATION IS NOT NORMAL
1.	a. Set MEASUREMENT selector to OFF b. Set the NULL/FEET dial fully clockwise to 000. c. Connect the test cable clips to the terminals of the same color on the test cable plug.	NONE	–
2.	Test all batteries.	Batteries GOOD	Replace batteries as necessary.
3.	a. Set MEASUREMENT selector to FAULTMETER	FAULTMETER indicates FAULT (near full scale).	Check test cable, A1 module or A3 module*; adjust A5R24; check A5R23.
	b. Remove RED test clip	Meter indicates NULL (within white null zone).	Check test cable,** A1 module* or A3 module*; adjust A5R12; check A5R8 thru A5R13; check common #1 wiring.
4.	a. Set MEASUREMENT selector to LOOPMETER and replace RED test clip.	Meter in null zone to left of null line.	Check test cable**.
	b. Set LOOPMETER to GOOD TO FAULT	Same as previous test.	Check test cable**.
	c. Remove WHITE test clip.	Meter indicates OPEN (near full scale).	Check test cable**; adjust A5R26; Check A5R3, A5R4 and A5R5.
	d. Replace WHITE test clip.		

*Check modules A1 through A3 according to Tables 4-4 and 4-5.
**See Figure 4-6.

Table 4-3. Troubleshooting Procedures (Continued)

STEP	TEST PROCEDURE	NORMAL INDICATION	IF INDICATION IS NOT NORMAL
5.	a. Set the MEASUREMENT selector to DISTANCE TO STRAP. b. Adjust the TEMPERATURE control so meter is nulled.	Precise meter null. TEMPERATURE control setting between 68° to 70°F is acceptable.	Check test cable**; adjust A5R27. If meter indicates FAULT, check A2 module*. If OVER-RANGE light flashes, check fuse.
6.	Set the MULTIPLY BY selector to 10; set the GAUGE selector to 24; adjust the NULL/FEET dial so the meter is nulled.	NULL/FEET dial indicates 1606 ±16.	Check resistors on GAUGE switch, or replace switch assembly.
7.	Set the GAUGE selector to 22 and repeat Step 6.	NULL/FEET dial indicates 2574 ±26.	Same as Step 6.
8.	Set the GAUGE selector to 19 and repeat Step 6.	NULL/FEET dial indicates 5177 ±52.	Same as Step 6.
9.	a. Set the MULTIPLY BY selector to 1 b. Set the GAUGE selector to 26 c. Adjust TEMPERATURE control for precise meter NULL.	—	—
10.	Remove YELLOW test clip.	Precise meter null.	Check NULL 2 control; adjust A5R2; check A5R1.
11.	Set MEASUREMENT selector to NULL and adjust NULL 1 control for precise null.	Precisely null.	Check test cable** and A1 module*; check MEASUREMENT switch contact; adjust A5R19; check A5R16, A5R17, A5R18, A5R20, A5R21, and A5R22.
12.	Set the NULL 2 control fully counter-clockwise (CCW) and press the NULL 2 button.	Meter indication slightly to the left of the left green (GOOD) zone.	Check test cable** and A3 module*.
13.	Depress and hold the NULL 2 button and set the NULL 2 control for precise null.	Precise null. NULL 2 should be one turn from CCE stop. Do not change NULL 2 setting until check-out is completed.	Check test cable** and A3 module*.
14.	Set the MEASUREMENT selector to STRAP TO FAULT and adjust the NULL/FEET dial for meter null.	Null on meter; NULL/FEET dial indicates 900 ±2.	Check and/or replace the NULL/FEET dial potentiometer assembly.
15.	Set the MEASUREMENT selector to DISTANCE TO FAULT and adjust the NULL/FEET dial for meter null.	Null on meter; NULL/FEET dial indicates 100 ±2.	Same as Step 14; adjust A5R31; Check A5R29 and A5R30.
16.	Set the MEASUREMENT selector to LOOP LENGTH; set the MULTIPLY BY selector to 10 and adjust the NULL/FEET dial for meter null.	Null on meter; NULL/FEET dial indicates 2000 ±10.	

*Check modules A1 through A3 according to Tables 4-4 and 4-5.
**See Figure 4-6.

Table 4-3. Troubleshooting Procedures (Continued)

STEP	TEST PROCEDURE	NORMAL INDICATION	IF INDICATION IS NOT NORMAL
17.	Disconnect the RED and WHITE test clips and short them together; adjust NULL/FEET dial for meter null.	Null on meter; NULL/ FEET dial indicates 000.	Adjust A5R31; check A5R29 and A5R30.
18.	Disconnect the RED and WHITE test clips.	OVER-RANGE light should flash.	Check the test cable**, A2 module*, and OVER-RANGE light-emitting diode.
19.	Re-connect the RED and WHITE test clips, to each other. Connect OHM-METER or FAULTMETER of another 710A between the RED and GREEN test clips. Then set the MEASURE-MENT selector to the OFF, FAULT-METER, LOOPMETER and DISTANCE TO STRAP positions.	Resistance more than 500 MΩ in each measurement selector position.	NOTE: The GREEN clip is chassis ground Unplug the test cable to determine if leak-age is in test cable or instrument. If leakage is in cable, replace; if leakage is in instru-ment, return to the Dynatel factory for repair.
20.	Set the MEASUREMENT selector OFF; disconnect OHMMETER from RED test clip and touch to the knob set-screws of the TEMPERATURE, NULL 1 and NULL 2 controls.	Resistance more than 500 MΩ for each setscrew.	Replace chassis insulating washers for appropriate control. NOTE: Use only DELRIN washers.
21.	Re-assemble the Model 710A; be sure to set the NULL/FEET dial between 100 and 900 before returning unit to service.	—	—

*Check modules A1 through A3 according to Tables 4-4 and 4-5.
**See Figure 4-6.

Table 4-4. Test Point Voltages

TEST SET-UP:

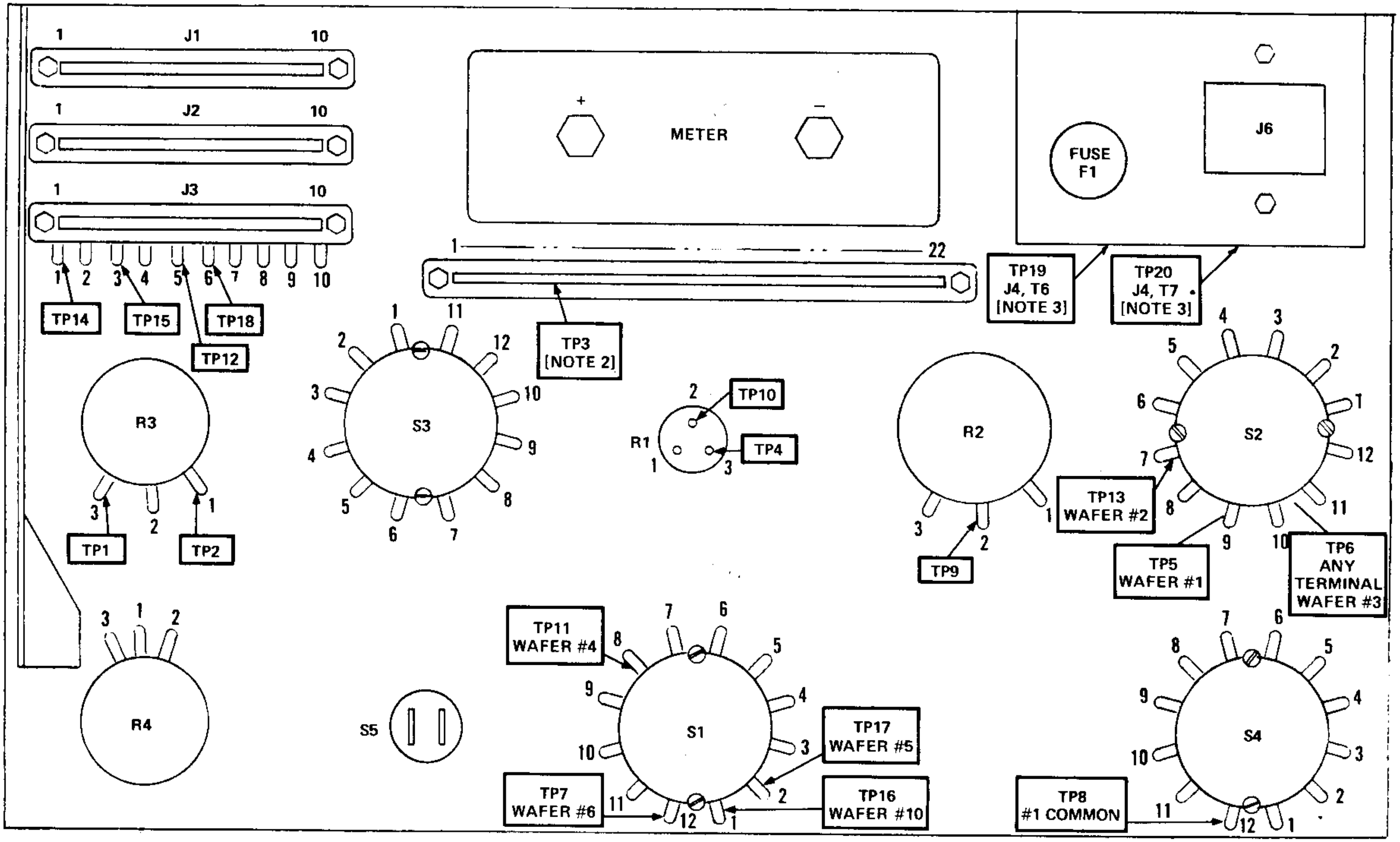
1. Connect self-test cable as indicated in paragraph 4-21.
2. Set the Model 710A controls as follows:

   GAUGE 26
   TEMPERATURE . . . . . . 70°F
   MULTIPLY BY 1
   MEASUREMENT . . . . . DISTANCE TO STRAP
   NULL/FEET . . . . Fully Clockwise (000)

3. Measure with digital multimeter; for test points, see Figure 4-3.

TEST POINTS	NOMINAL VOLTAGES	VOLTAGE RANGE	POSSIBLE MALFUNCTIONS
BATTERY AND REGULATOR VOLTAGES			
1-20	18.8V	13 to 19	B2, two 9 volt batteries
1-2	9.99V	9.6 to 10.6	10 volt regulator
8-1	+5.00V	4.8 to 5.3	+5 volt regulator
8-2	–4.98V	4.8 to 5.3	–5 volt regulator
18-13	8.45V	7.6 to 9.5	B1, two 4.5 volt batteries
19-14	46.3V	42 to 48	B3, 45 volt battery
ASSEMBLY A1 – VOLTAGES (70°F and meter at NULL)			
8-9	4.21V	4.1 to 4.3	Temperature control circuit
8-4	482 mV	460 to 490	NULL/FEET control circuit
8-10	482 mV	460 to 490	NULL/FEET control circuit
8-11	479 mV	455 to 488	NULL/FEET control circuit
8-7	0.2 mV	±5 mV	A1 Amp. (input pin #1)
8-3	1.9 mV	±5 mV	A1 Amp. zero offset circuit
ASSEMBLY A2 – VOLTAGES (All gauges and all ranges)			
6-5	461 mV	435 to 465	A2 output voltage
6-12	457 mV	440 to 460	A2 reference voltage
ASSEMBLY A3 – VOLTAGES (Set measurement switch to FAULTMETER)			
16-17	385 mV	375 to 450	A3 Regulator output voltage
14-15	43V	40 to 46	A3 Regulator supply voltage

NOTE: Test point 8 is #1 Common
Test point 6 is #2 Common



NOTES:
1. WAFER #1 IS LOCATED CLOSEST TO PANEL.
2. TP3 AT JUNCTION OF R8, R9 and R10.
3. J4 (15 PIN SOCKET) IS ON CHASSIS.

Figure 4-3. Interior Component Locations and Test Points (Viewed from Behind the Front Panel).

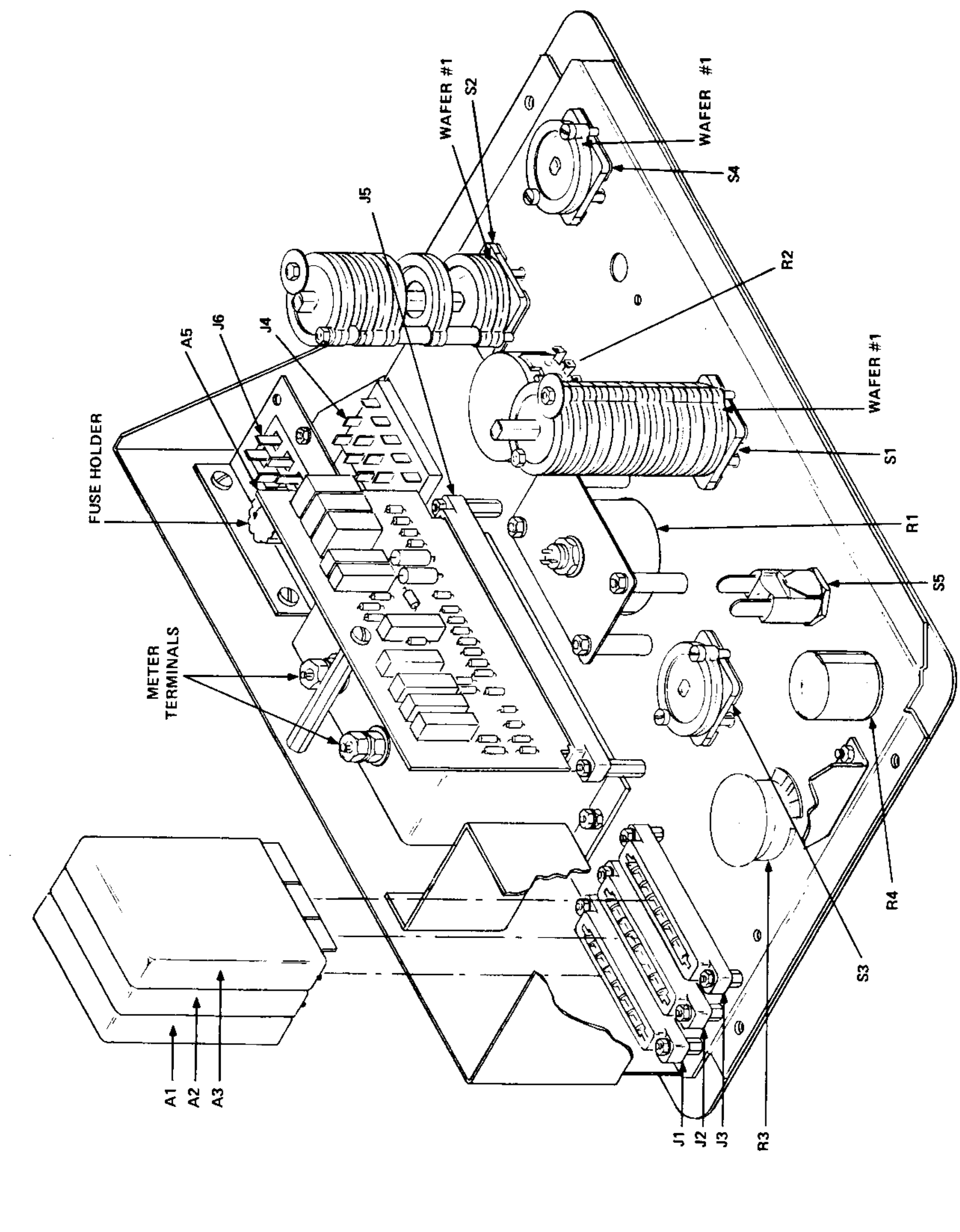


Figure 4-4. Exploded View of Dynatel Model 710A Interior

Table 4-5. Battery Current Drain

TEST SET-UP

1. Connect self-test cable as indicated in paragraph 4-21.
2. Measure current at battery terminals.

BATTERY	MEASUREMENT SWITCH	GAUGE SWITCH	MULTIPLY BY SWITCH	ACTION	BATTERY CURRENT**
4.5V	C thru G	19	1	None	58 mA
	C thru G	22	1	None	30 mA
	C thru G	24	1	None	20 mA
	C thru G	26	1	None	13.5 mA
	C thru G	19	10	None	8.0 mA
	C thru G	26	10	None	3.5 mA
	C thru G	19	100	None	3.0 mA
	C thru G	26	100	None	2.5 mA
	C, E, F, & G	–	–	Remove RED clip. Replace RED clip after test.	0 to 30 mA FLASHING LIGHT 24 mA average
9V	A thru G	–	–	None	2.2 mA typical; 1.8 to 2.8 mA acceptable
45V	A	–	–	None	55 μA typical
	A	–	–	Remove RED clip.	0 μA
	D	–	–	Push NULL 2 button.	190 μA typical; 140 to 250 μA

*Letters shown refer to MEASUREMENT switch positions.
**Currents are nominal and can vary by ±10%