

FAULT LOCATING OUTSIDE PLANT

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NOTICE

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1. GENERAL

1.01 This section describes the procedures in flowchart format used to locate conductor, wire, and cable troubles in outside plant. The procedures outlined are intended to permit fault locating in the least time-consuming manner and should be considered as guidelines rather than hard and fast rules. These procedures are established to:

- Reduce the number of double dispatches
- Eliminate unnecessary dispatches
- Provide for better coordination of tests performed by wire repair with those performed by cable repair.

In addition to the above, these fault locating procedures can provide a basis for training the repair forces.

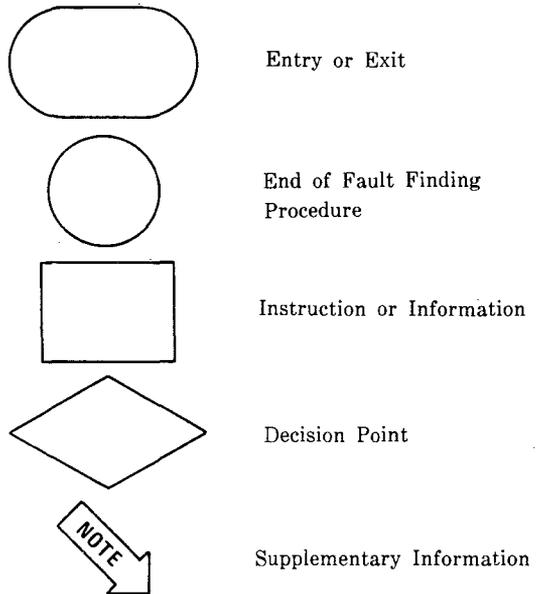
1.02 When this section is reissued, the reason for reissue will be listed in this paragraph.

1.03 The flowcharts cover two major areas; one for the wire repair group, and one for the cable repair group. Under cable repair, there is distribution plant and feeder plant. Each is divided into aerial, buried with pedestal access, buried out of sight, and under the feeder; an additional section

covering underground. To use the flowcharts, go to the first chart in the section for the type of plant that is to be worked on. Follow the chart until you locate the trouble, or you come to a block that directs you to another section or directs you to take other action.

1.04 The flowcharts were developed for use with the test sets listed in Part 3, or their equivalents, and should be available to repair personnel.

1.05 The blocks in the flowcharts have four shapes whose meanings are explained below. In addition to the four blocks, an open arrow is used on the flowcharts to indicate a note on a given step in the fault-finding procedure.



1.06 Fault locating procedures are outlined as follows:

- Fig. 1-8—Wire Repair (Aerial and Buried)
- Fig. 9-19—Cable Repair (Aerial and Buried)
- Fig. 20-27—Cable Repair (Aerial and Buried and Underground Feeder)
- Fig. 28-38—Typical Faults

2. PRECAUTIONS		139A	(Section 105-242-100) A tone generator used by station forces in troubleshooting individual conductors and pairs in cables, inside wiring and service drops.
2.01	Although not listed in the flowcharts, safety procedures shall be observed. At all times observe the safety procedures and precautions outlined in the following sections:		
SECTION	TITLE	145A	(Section 634-200-225) A general purpose test set that can be used to measure resistance, AC and DC voltages, line current, open faults to 20 KFT, circuit loss, noise, and provide tone for identification purposes.
620-060-510	Below Ground Protection		
620-060-520	Joint Use Below Ground Protection		
620-102-010	Outside Plant Precautions Underground and Buried Work	146A	(Section 634-200-504) Used for wire identification, construction testing, and fault locating; replaces the 76C test set.
620-135-010	Guarding Work Areas		
620-140-501	Testing and Ventilating Manholes		
629-100-010	Buried Plant Precautions	170A	(Section 634-315-502) Used to trace buried service wire and to pinpoint shield or conductor grounds in service wire (requires AT-8681 B ground probe).
2.02	Observation of safety procedures shall not be limited to the above mentioned sections. Precautions in applicable test set sections shall also be observed.	173A	(Section 634-315-501) Used to pinpoint sheath damage in buried PIC cables. Requires an AT-8681 B ground probe when test set is in the fault locating mode.
2.03	Always call the below ground plant protection center in your area to obtain permission to dig up underground plant.		
3. TEST SETS		188A	(Section 081-705-102) A voltage tester used to indicate the presence of hazardous voltages in the range from 50 to 20,000 volts, 60 Hz AC. Up to 2000 volts DC may be tested when using the B temporary bond.
3.01	Test sets required by the outside plant repair forces for fault locating are listed below:		
91A	(Section 106-300-100) An audio amplifier kit consisting of a 147C amplifier, 513A probe and a headset.	1013B	(Section 106-020-113) This handset has dial capability for communication in outside plant.
101B	(Sections 106-340-115 and 634-305-505) A hand held exploring coil intended for use with 147-type amplifier.	1097A	(Sections 634-020-505 and 644-104-100) Narrowband filter designed for use with the 147C amplifier. Permits toning where noise or power influence is a problem.
105D	(Sections 106-340-115 and 634-305-505) Exploring coil mounted on a pole used in fault locating in aerial plant.		

AT-8629 (Section 105-241-100) Test probe used with 1013-type handset to detect an identification signal on a telephone line without damaging the insulation.

AT-8681 (Section 634-220-505) B ground probe used with 170A and 173A test sets for locating faults in the sheath of buried service wire and buried cable.

KS-14103L6 (Section 634-305-502) Used to break down high resistance faults in paper or pulp insulated copper conductors so they can be run down with an exploring coil.

Dynatel* 710 or equivalent (Section 634-305-514) Used to locate faults in buried, underground or aerial PIC and pulp cables.

Delcon 4910F or equivalent (Sections 106-340-110 and 634-305-510) Used for locating opens in conductors.

Metrotech 440 or equivalent (Sections 106-350-113 and 634-220-501) Used to locate, trace, and determine the depth of underground conductors, pipes, and cable in conduit.

Time Domain (TDR) Reflectometer A test set such as the TDR cable fault locator sends pulses of energy down a cable pair under test. When these pulses encounter the end of the cable pair or any impedance discontinuity (Fault), a portion of the energy is reflected. The elapsed time for the pulse return is a measure of distance to the fault and the shape of the returned pulse identifies the type of cable fault.

*Trademark of Dynatel Corporation

3.02 The test center (test desk) should have fault locating test sets such as the Delcon 4913A, Dynatel 720, or their equivalent. The test desk should have up-to-date copies of cable records and

location maps. These maps will show location of terminals where a cable pair makes multiple appearances or other points of access along the cable route. This will permit the repair forces to make measurements closer to the actual fault location.

3.03 In case wire repair forces have a trouble that is beyond their ability to locate and/or repair, they should arrange for temporary service by making pair transfers before returning the trouble ticket to the dispatch center for subsequent repair. Pair transfers must be made in accordance with local practices. As a rule of thumb, however, the transfer is made after wire repair has made three climbs and/or investigated three terminals without locating the trouble. In the case of resistive type faults, wire repair should assist the test desk in making bridge measurements and should record the results on the trouble ticket. This information will help cable repair in their subsequent work.

3.04 In some instances, the cable repair following these flowcharts will need to replace service wire or drop wire. For this reason, it is important that supplies of this wire and accessories be available on their repair vehicle.

3.05 In the case of buried out-of-sight plant, the procedures were developed with the assumption that the following conditions exist:

- (1) Service wires are waterproof.
- (2) Cable is waterproof.
- (3) Splices and enclosures are encapsulated.
- (4) Two pairs are dedicated from a Feeder Distribution Interface (FDI) to the customer and are cut dead ahead.
- (5) Any nonworking second pairs are grounded at the protectors.
- (6) No access points exist between the FDI and the protector, or between the FDI and the central office.

Although the above assumptions were made in developing the procedures for buried out-of-sight plant, the methods described are applicable even if some of the conditions do not exist.

4. WIRE REPAIR

4.01 Fault locating procedures for wire repair are shown in Fig. 1 through 8. These procedures cover aerial plant, buried plant with pedestal closures, and buried out-of-sight plant.

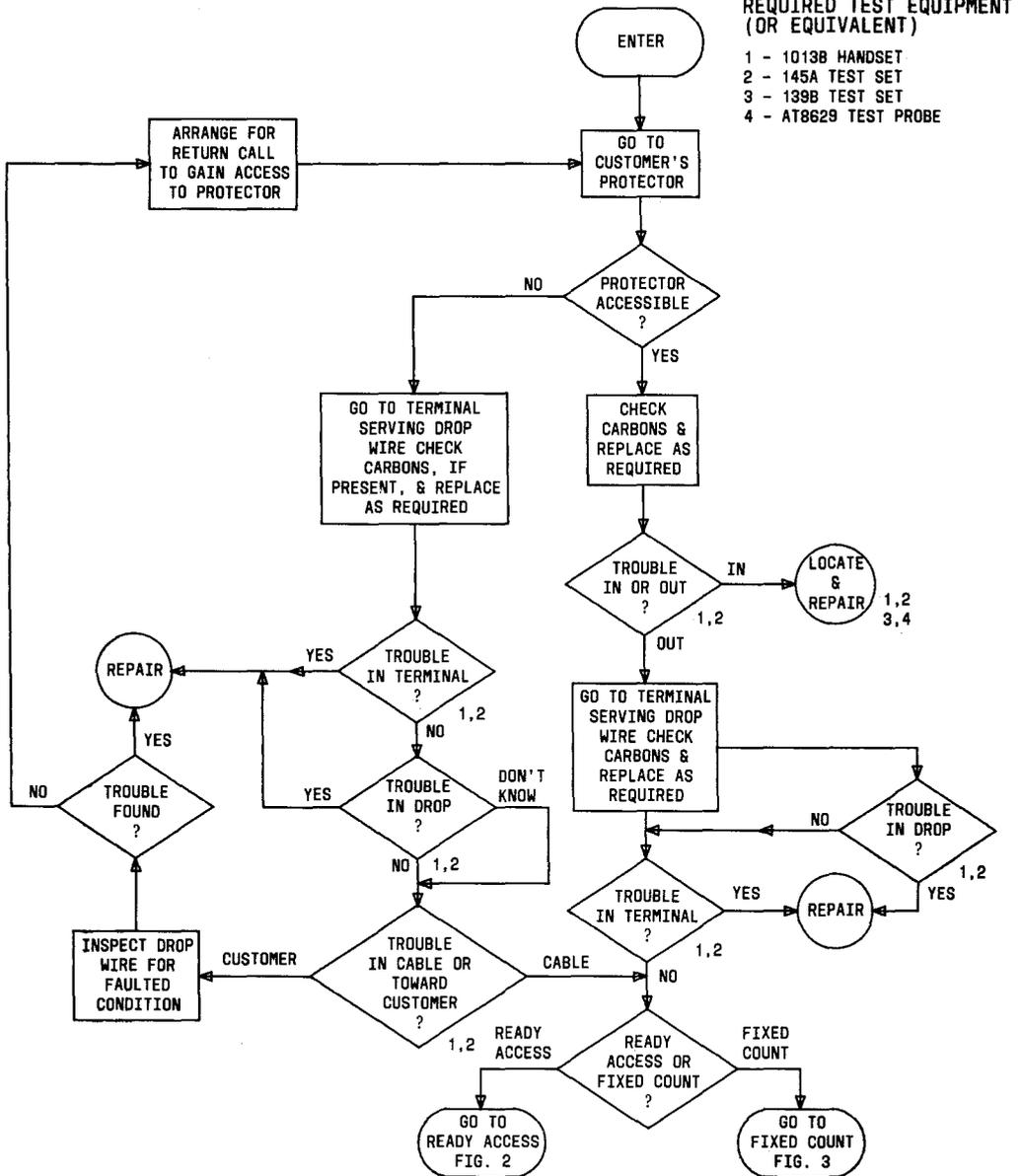
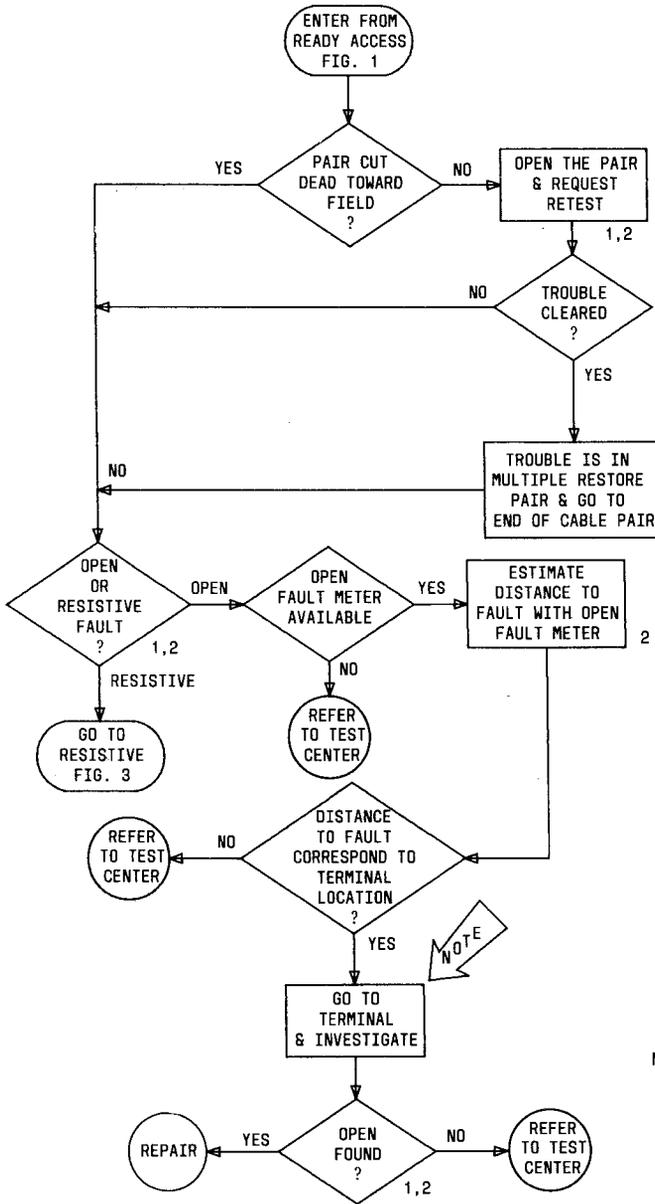


Fig. 1—Wire Repair—Aerial Plant

REQUIRED TEST EQUIPMENT
(OR EQUIVALENT)

- 1 - 1013B HANDSET
- 2 - 145A TEST SET



NOTE:
BE ALERT TO THE POSSIBILITY
OF A SPLIT WITH ANOTHER PAIR.

Fig. 2—Wire Repair—Aerial Plant (Ready Access)

REQUIRED TEST EQUIPMENT
(OR EQUIVALENT)

- 1 - 1013B HANDSET
- 2 - 145A TEST SET

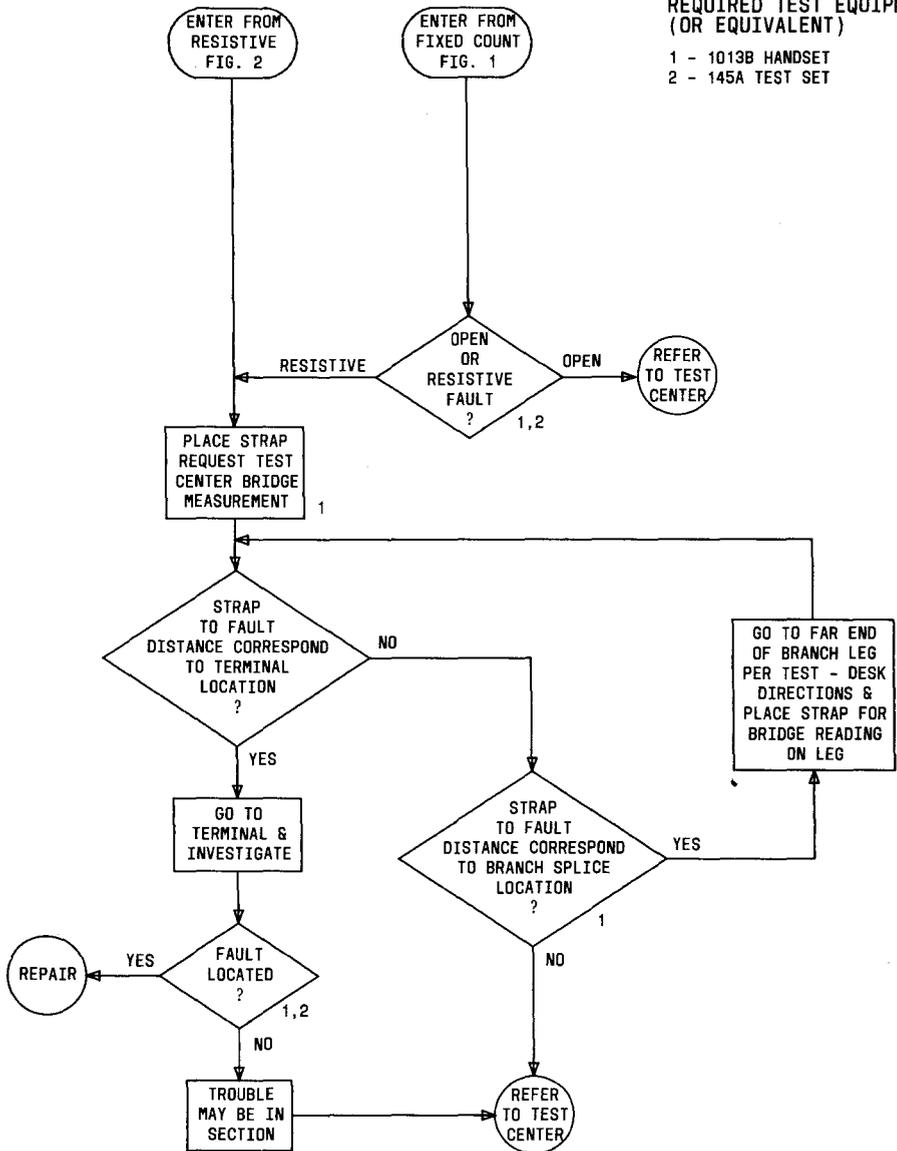


Fig. 3—Wire Repair—Aerial Plant (Fixed Count)

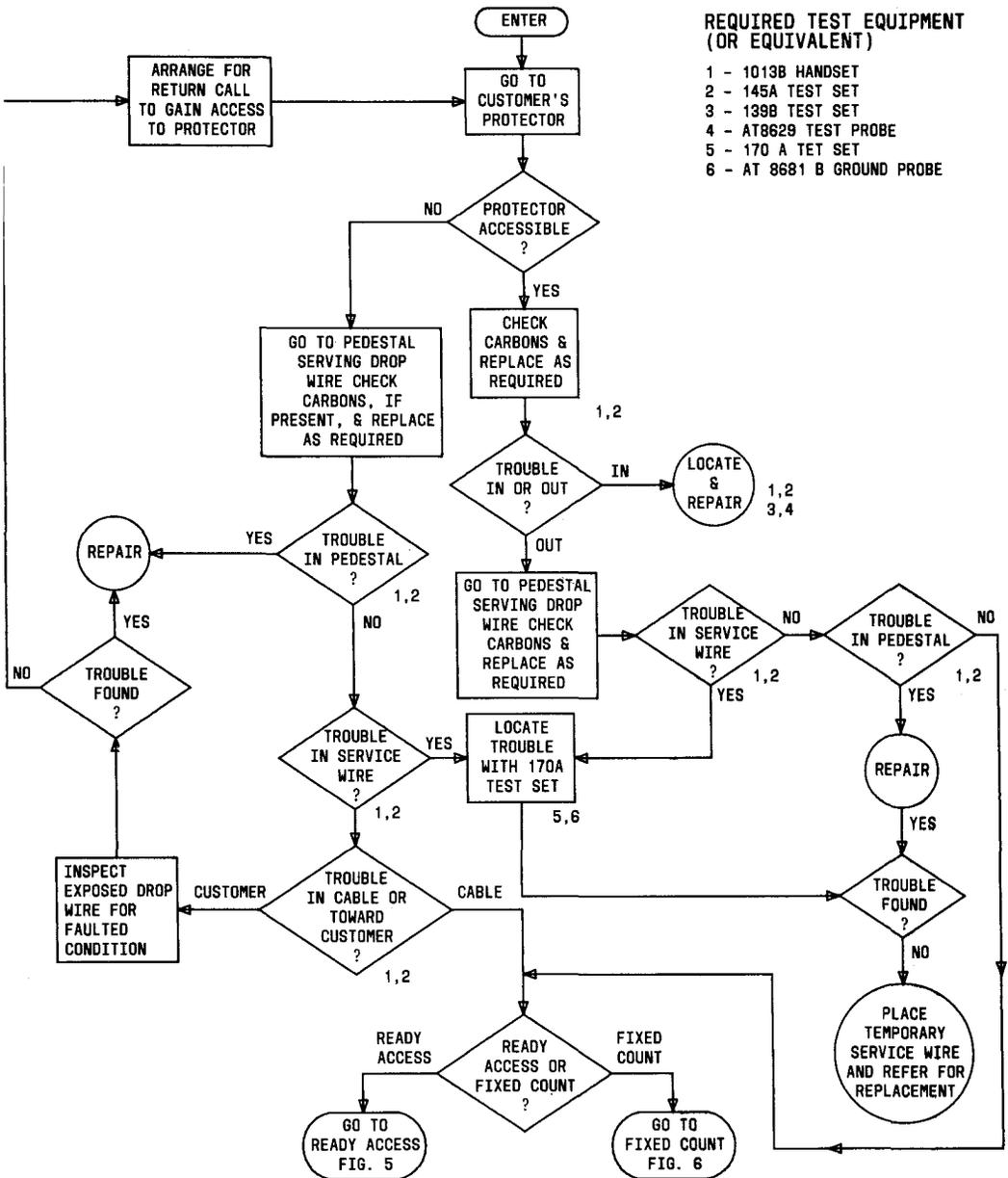
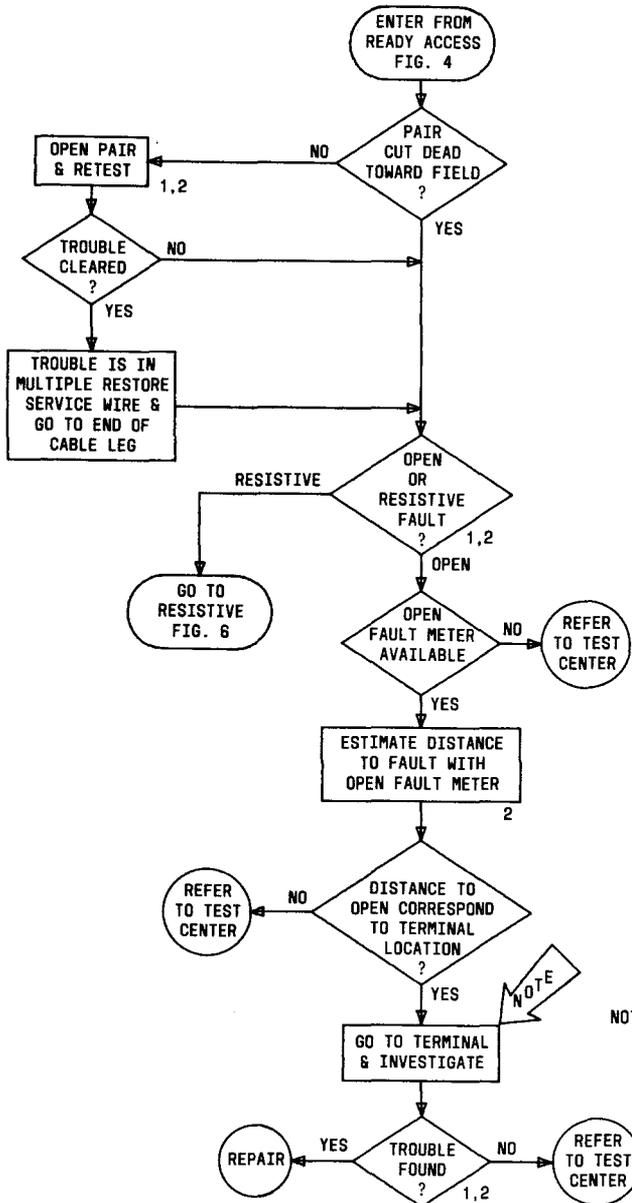


Fig. 4—Wire Repair—Buried Plant With Pedestal Closures

REQUIRED TEST EQUIVALENT
(OR EQUIVALENT)

- 1 - 1013B HANDSET
- 2 - 145A TEST SET



NOTE: BE ALERT TO THE POSSIBILITY OF A SPLIT WITH ANOTHER PAIR.

Fig. 5—Wire Repair—Buried Plant With Pedestal Closures (Ready Access)

REQUIRED TEST EQUIVALENT
(OR EQUIVALENT)

- 1 - 1013B HANDSET
- 2 - 145A TEST SET

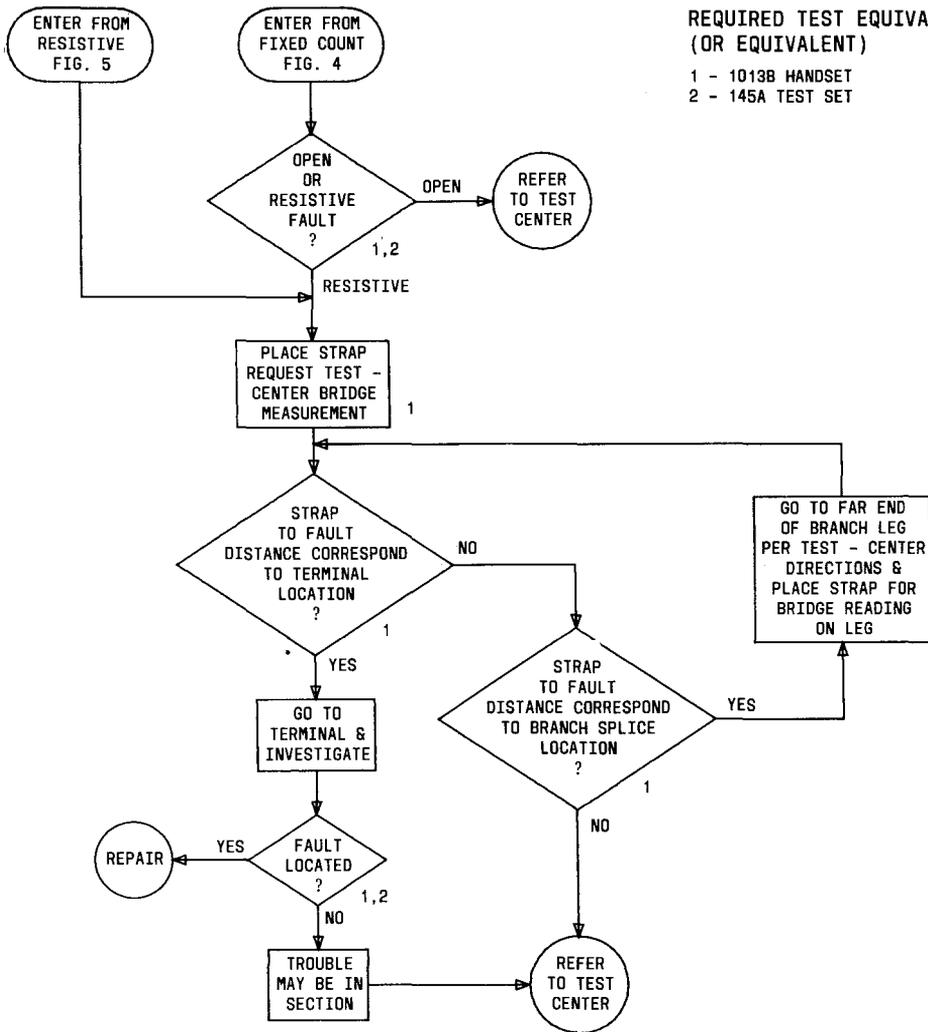
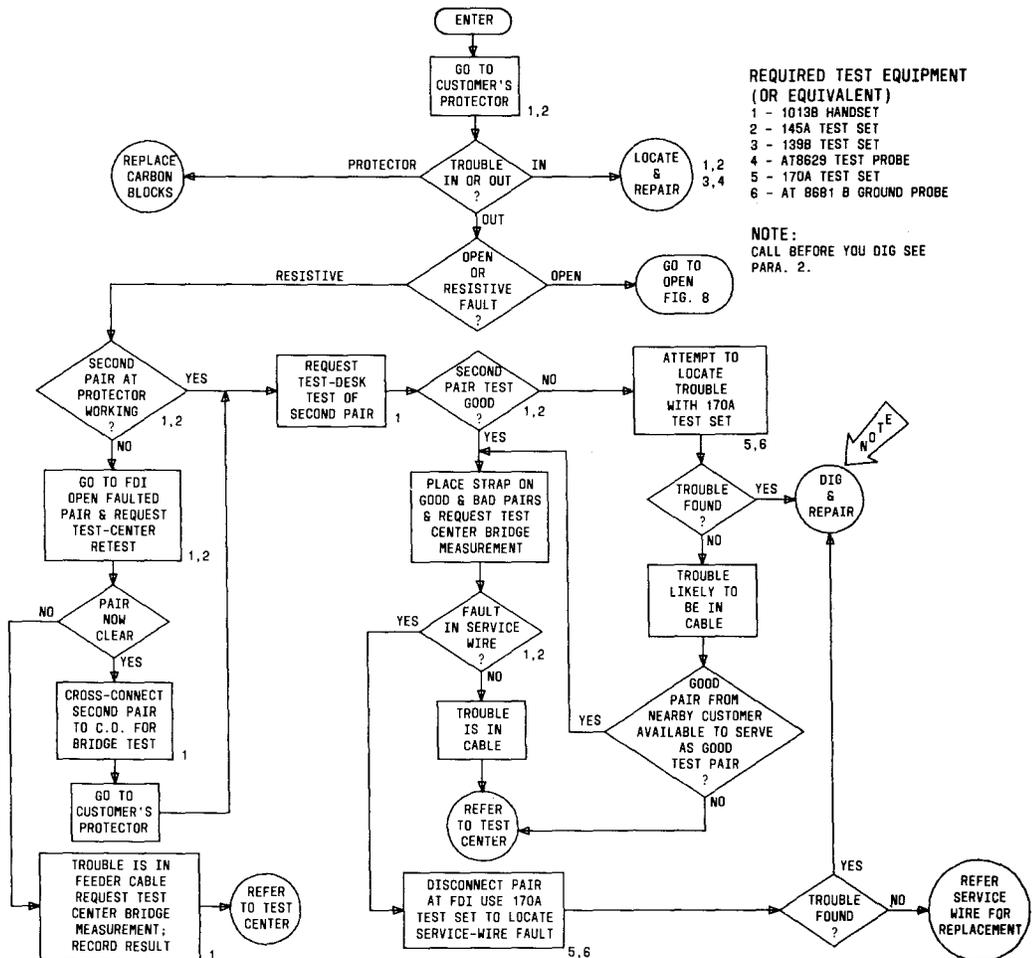


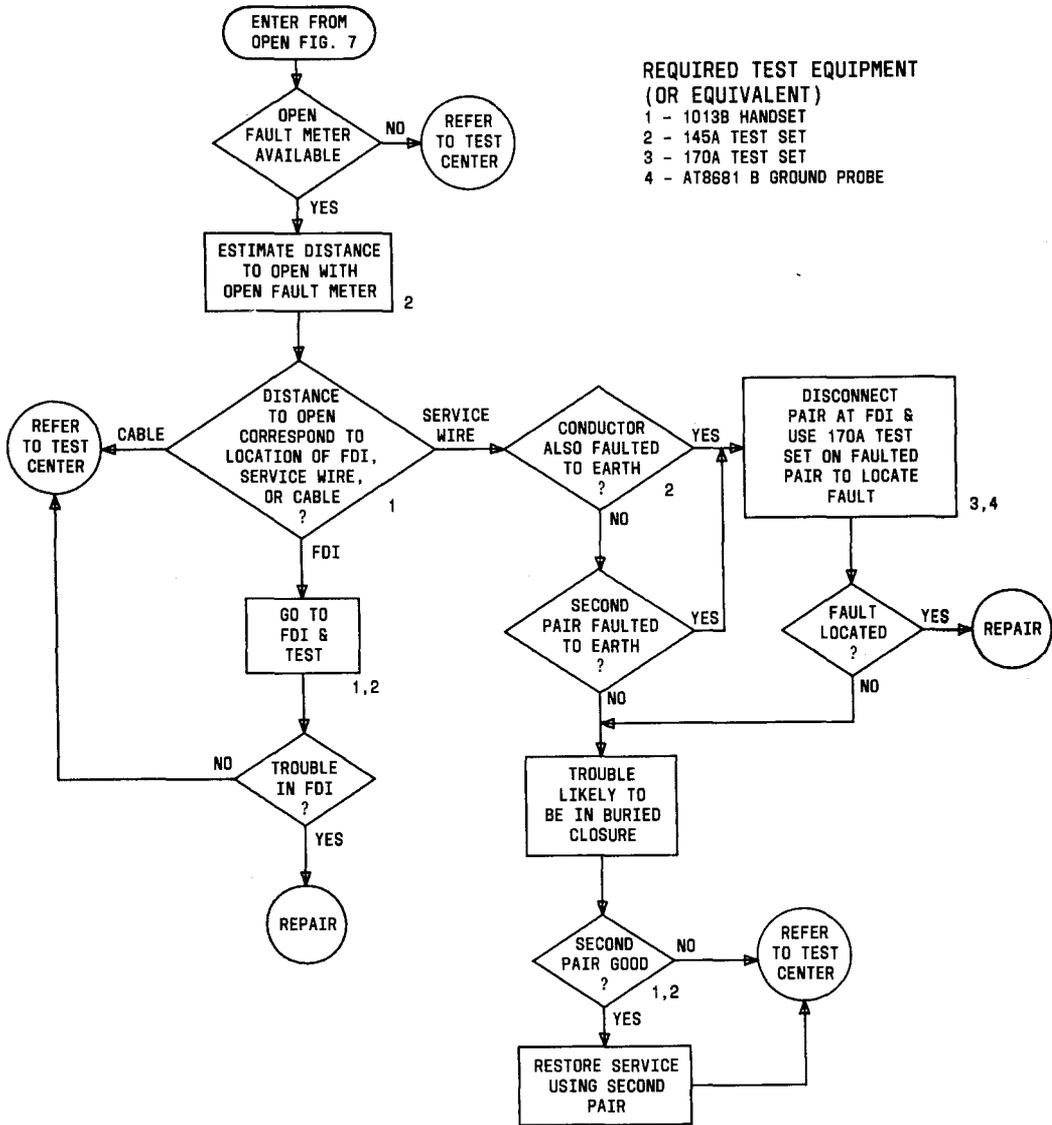
Fig. 6—Wire Repair—Buried Plant With Pedestal Closures (Fixed Count)



- REQUIRED TEST EQUIPMENT (OR EQUIVALENT)**
- 1 - 1013B HANDSET
 - 2 - 145A TEST SET
 - 3 - 139B TEST SET
 - 4 - AT8629 TEST PROBE
 - 5 - 170A TEST SET
 - 6 - AT 8681 B GROUND PROBE

NOTE:
CALL BEFORE YOU DIG SEE PARA. 2.

Fig. 7—Wire Repair—Buried Out of Sight



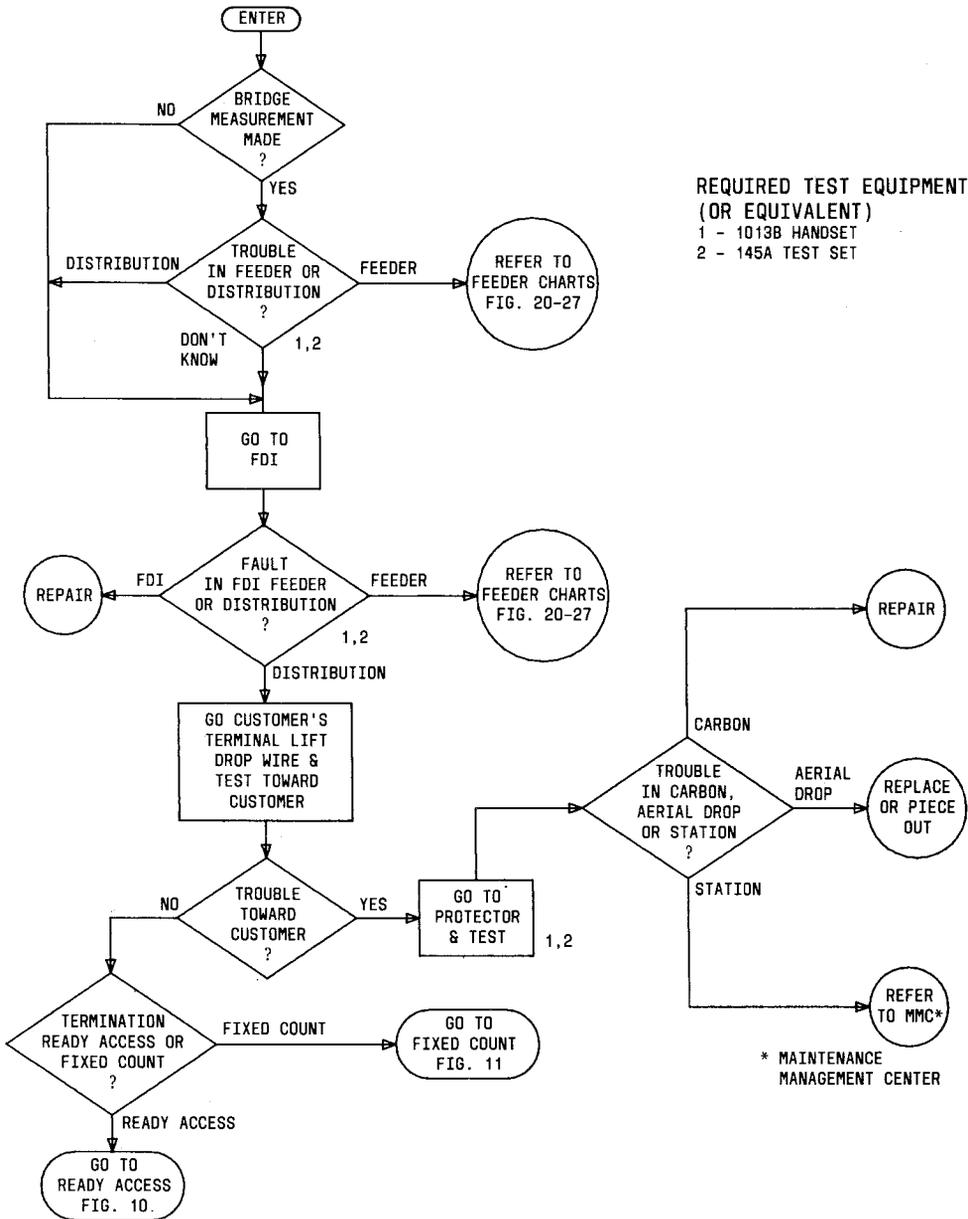
REQUIRED TEST EQUIPMENT
(OR EQUIVALENT)
1 - 1013B HANDSET
2 - 145A TEST SET
3 - 170A TEST SET
4 - AT8681 B GROUND PROBE

Fig. 8—Wire Repair—Buried Out of Sight (Open Fault)

5. CABLE REPAIR

5.01 Fault locating procedures for cable repair are shown in Fig. 9 through 27. These procedures cover:

- Aerial distribution
- Buried distribution with pedestal closures
- Buried out-of-sight distribution
- Aerial feeder
- Buried feeder with pedestal closures
- Buried out-of-sight feeder
- Underground feeder.



REQUIRED TEST EQUIPMENT
(OR EQUIVALENT)
1 - 1013B HANDSET
2 - 145A TEST SET

Fig. 9—Cable Repair—Aerial Distribution

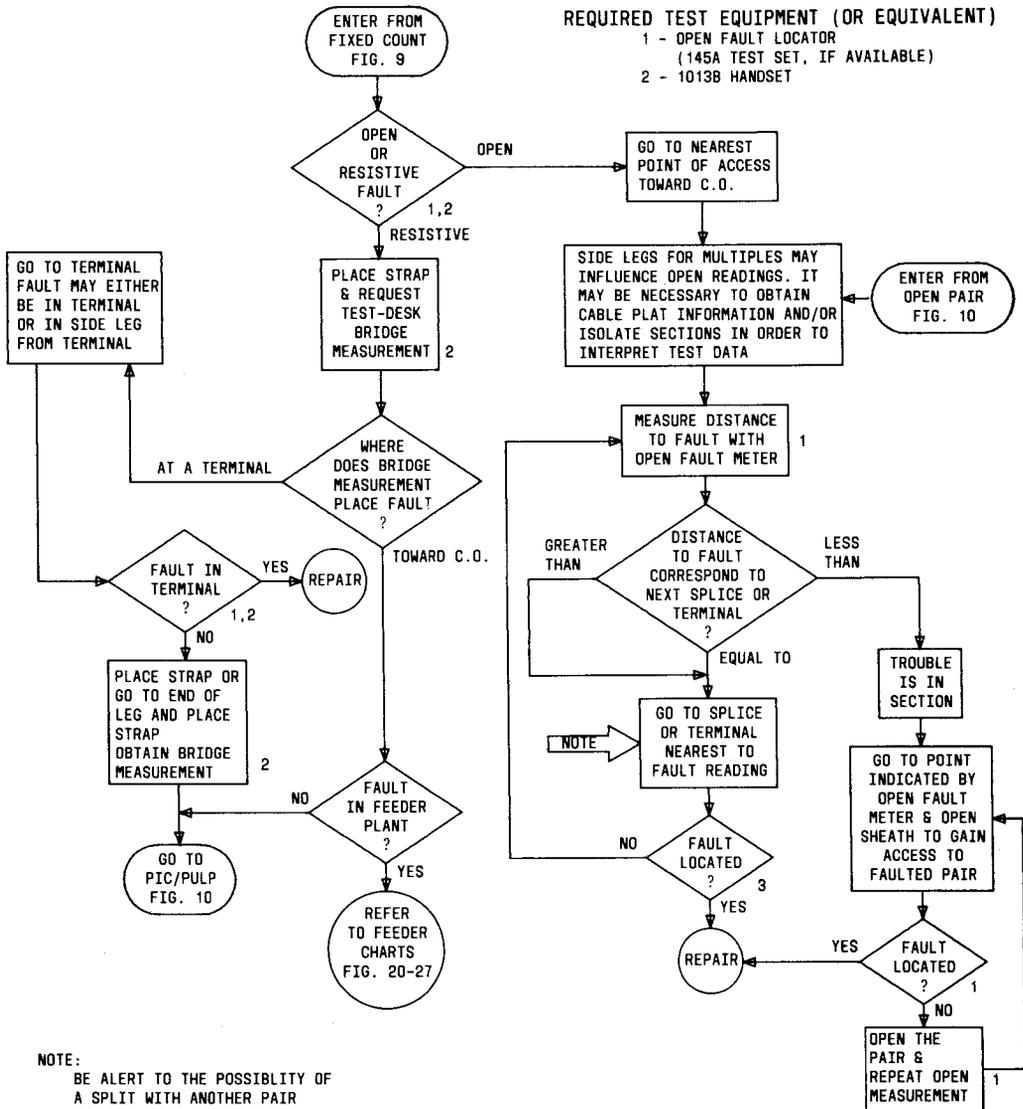
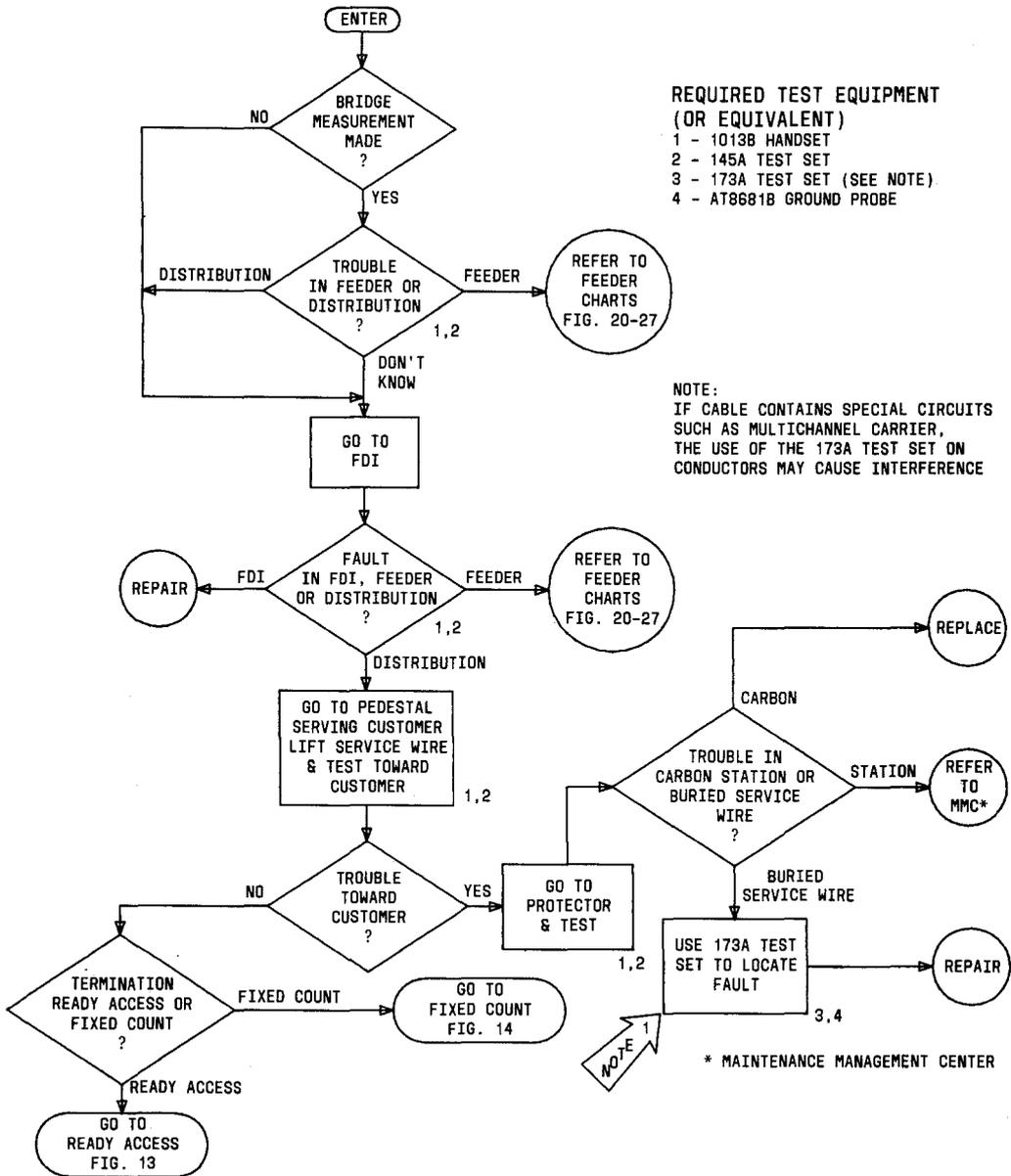


Fig. 11—Cable Repair—Aerial Distribution (Fixed Count, Open Fault)



**REQUIRED TEST EQUIPMENT
(OR EQUIVALENT)**

- 1 - 1013B HANDSET
- 2 - 145A TEST SET
- 3 - 173A TEST SET (SEE NOTE)
- 4 - AT8681B GROUND PROBE

NOTE:
IF CABLE CONTAINS SPECIAL CIRCUITS SUCH AS MULTICHANNEL CARRIER, THE USE OF THE 173A TEST SET ON CONDUCTORS MAY CAUSE INTERFERENCE

* MAINTENANCE MANAGEMENT CENTER

Fig. 12—Cable Repair—Buried Distribution With Pedestal Closures

REQUIRED TEST EQUIPMENT
(OR EQUIVALENT)

- 1 - OPEN FAULT LOCATOR (145A TEST SET, IF AVAILABLE)
- 2 - 1013B HANDSET
- 3 - 145A TEST SET

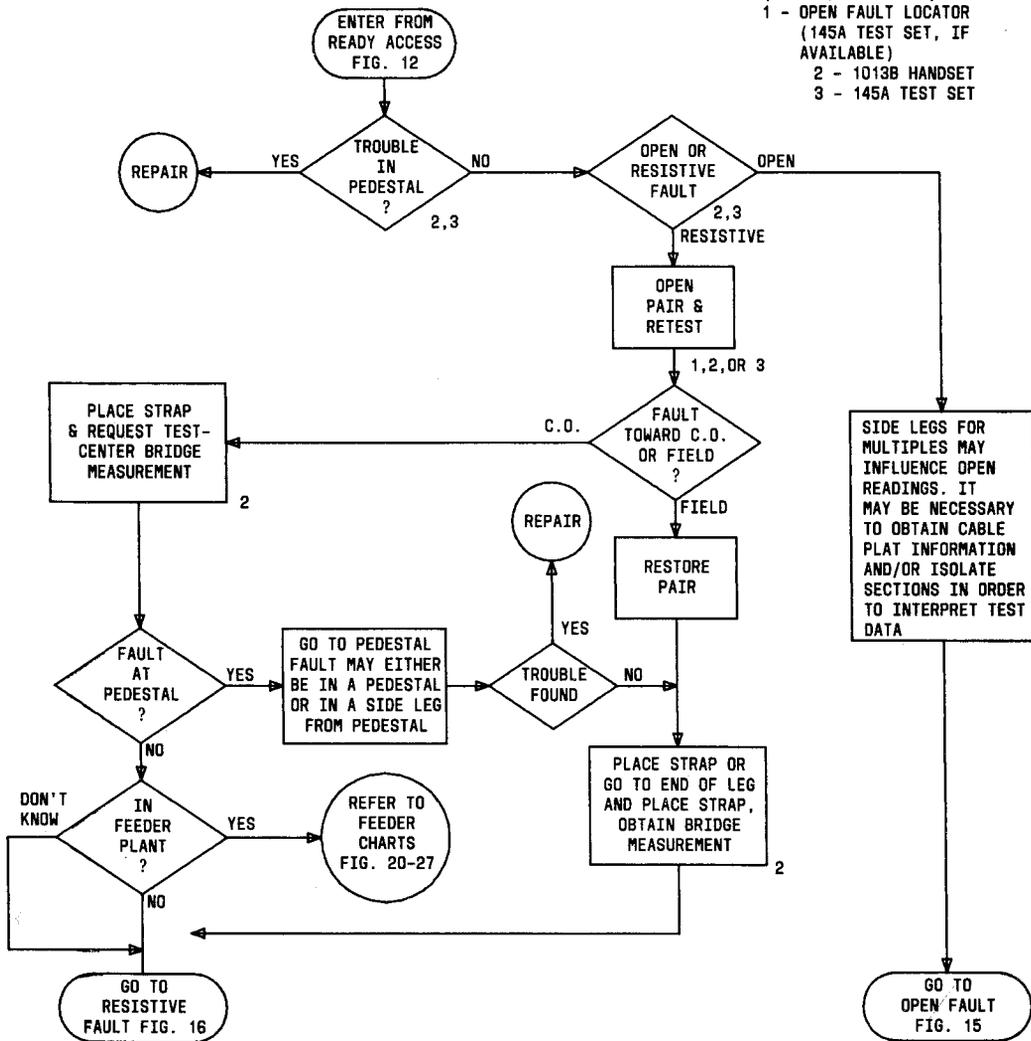
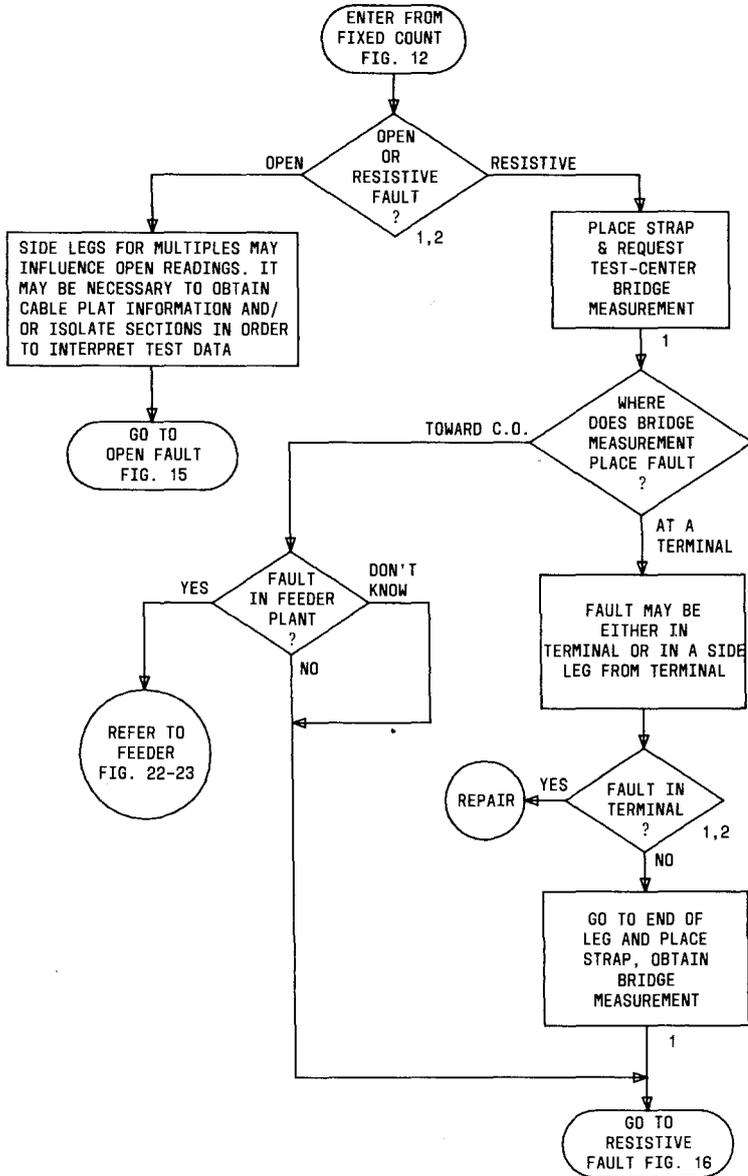


Fig. 13—Cable Repair—Buried Distribution With Pedestal Closures (Ready Access)



REQUIRED TEST EQUIPMENT
(OR EQUIVALENT)
1 - 10138 HANDSET
2 - 145A TEST SET

Fig. 14—Cable Repair—Buried Distribution With Pedestal Closures (Fixed Count)

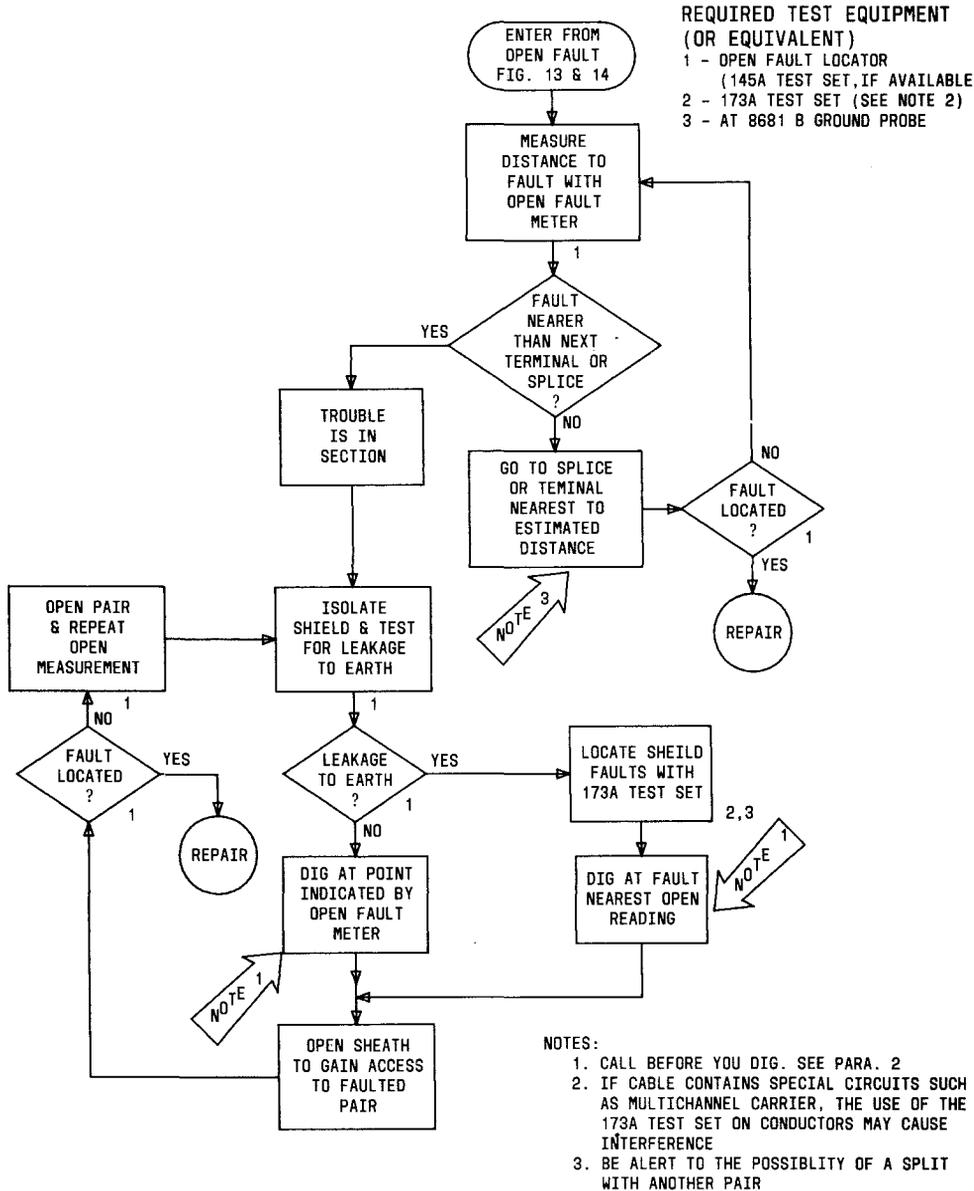


Fig. 15—Cable Repair—Buried Distribution With Pedestal Closures (Open Fault)

REQUIRED TEST EQUIPMENT (OR EQUIVALENT)

- | | |
|-------------------------------|--------------------------------|
| 1 - 91A TEST SET | 7 - 1013B HANDSET |
| 2 - 101A TEST SET | 8 - 145A TEST SET |
| 3 - 105A TEST SET | 9 - 173A TEST SET (SEE NOTE 3) |
| 4 - 1097A FILTER | 10 - DYNATEL 710A TEST SET |
| 5 - CABLE LOCATING TEST SET | 11 - AT - 8681 B GROUND PROBE |
| 6 - KS-14103 L6 BREAKDOWN SET | |

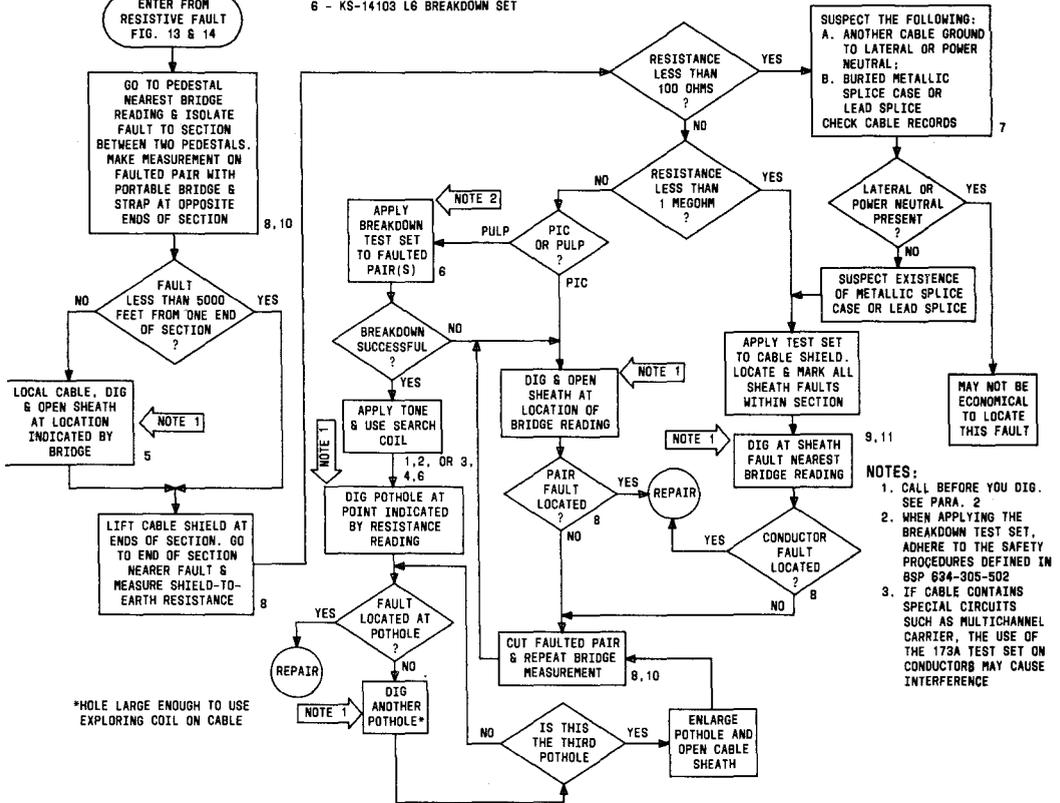


Fig. 16—Cable Repair—Buried Distribution With Pedestal Closures (Resistive Fault)

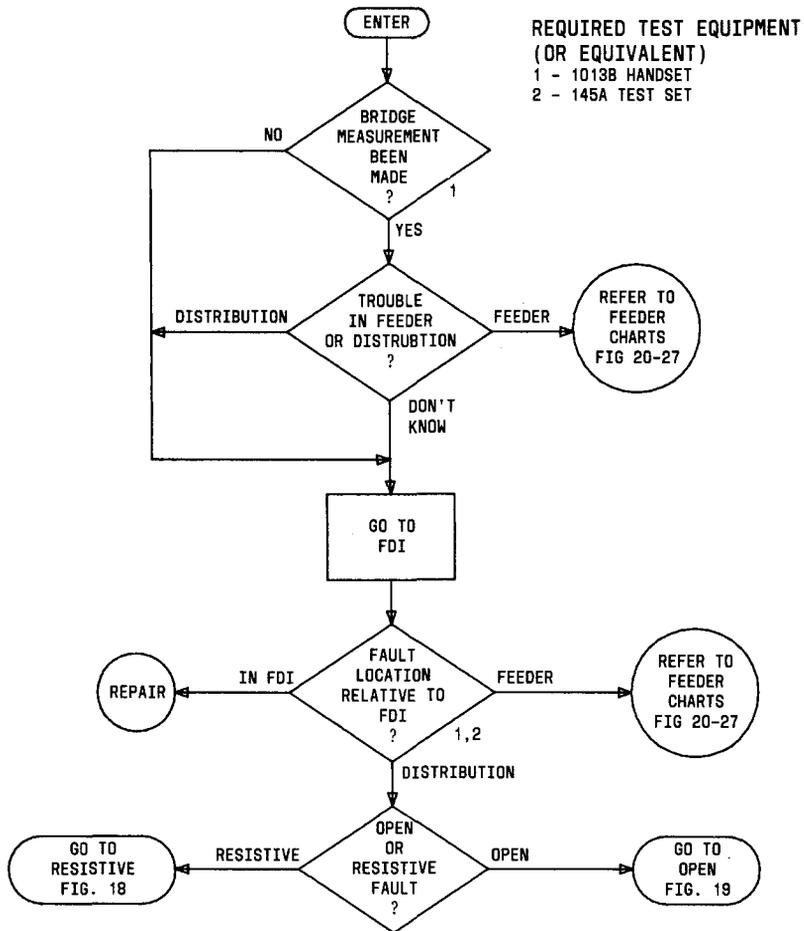


Fig. 17—Cable Repair—Buried Out-of-Sight Distribution

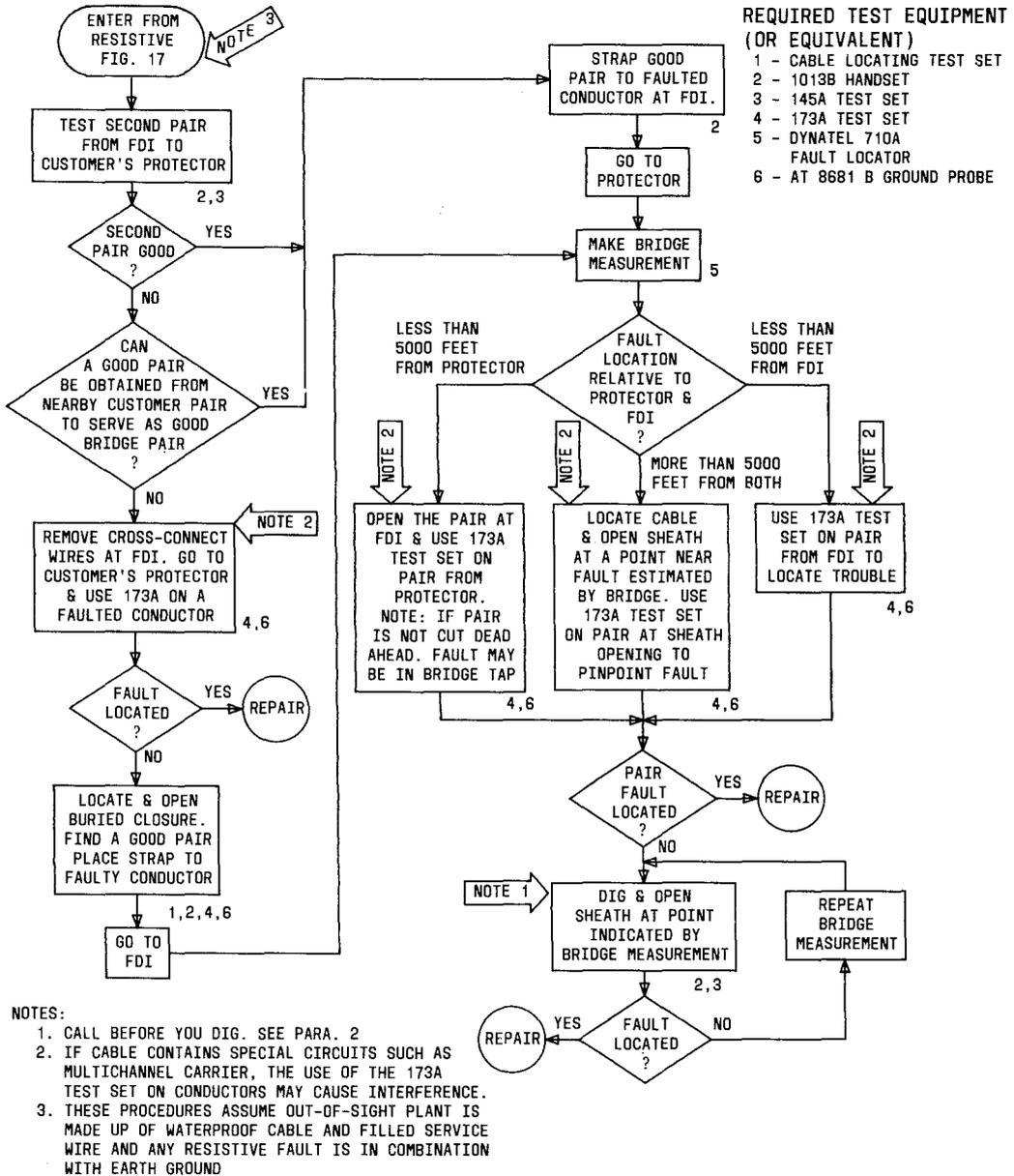


Fig. 18—Cable Repair—Buried Out-of-Sight Distribution (Resistive Fault)

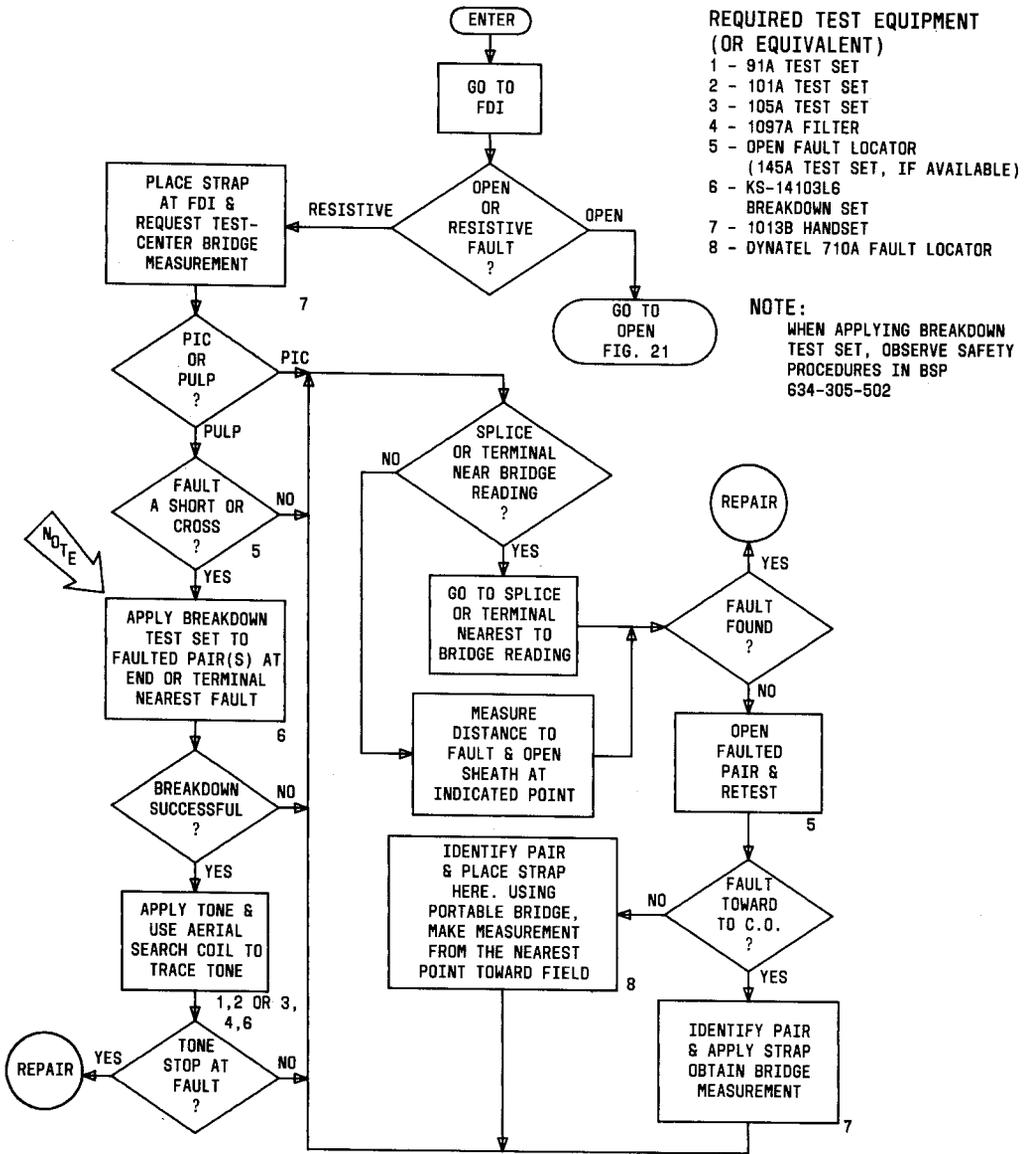


Fig. 20—Cable Repair—Aerial Feeder

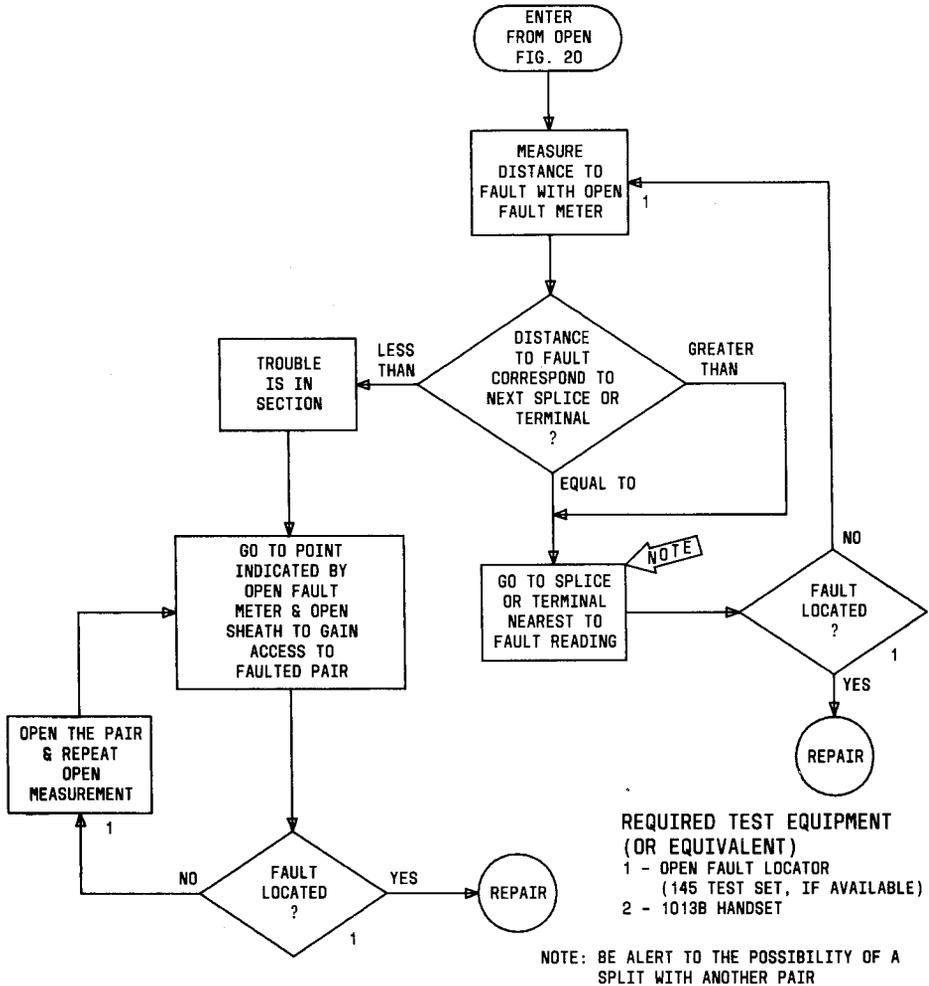
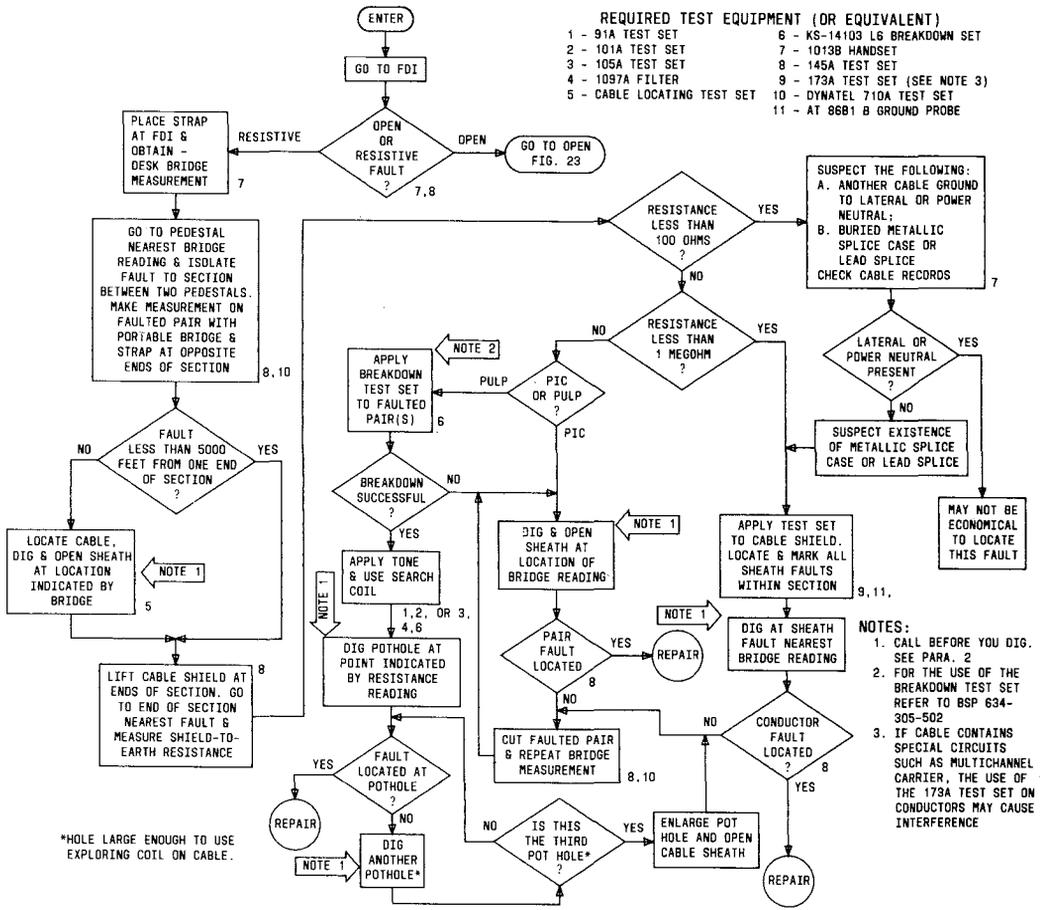


Fig. 21—Cable Repair—Aerial Feeder (Open Fault)



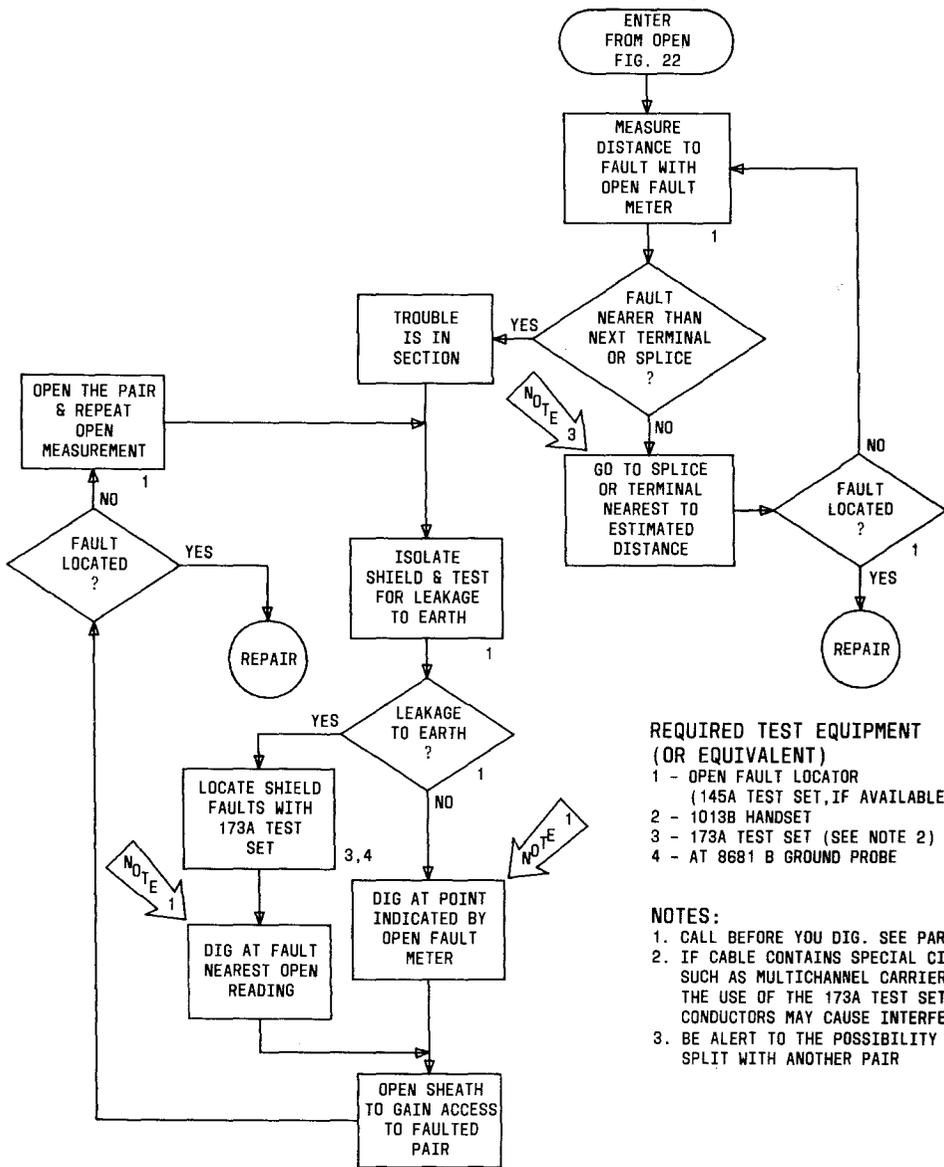


Fig. 23—Cable Repair—Buried Feeder With Pedestal Closures (Open Fault)

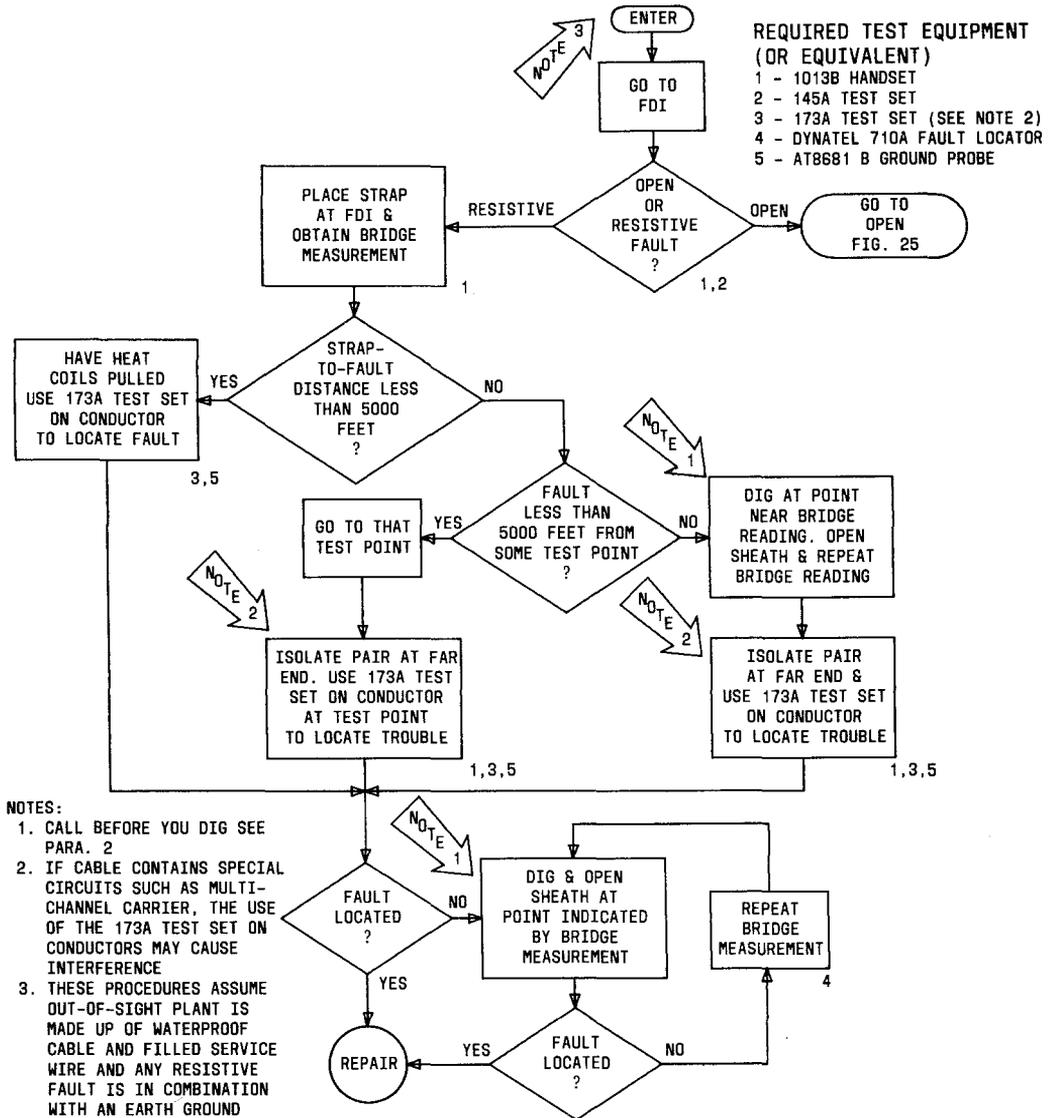


Fig. 24—Cable Repair—Buried Out-of-Sight Feeder

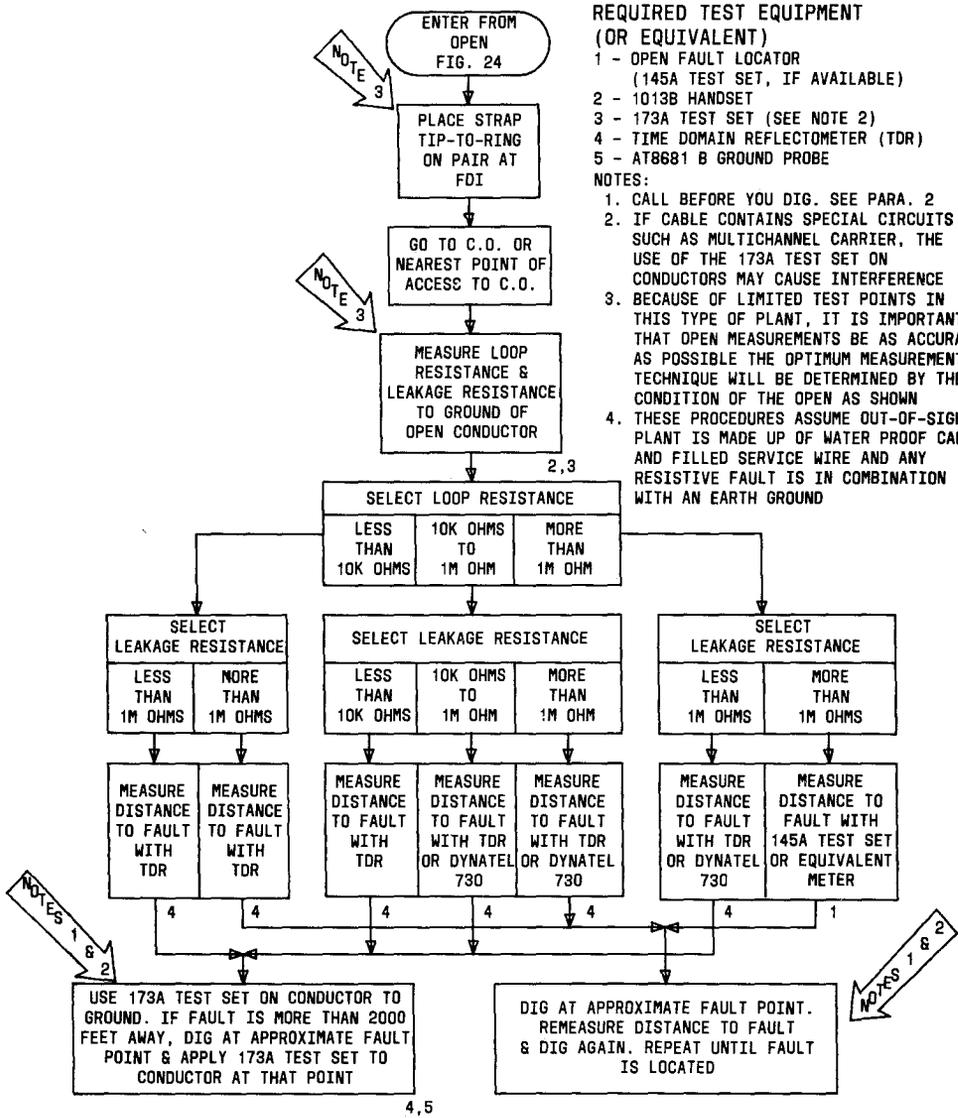


Fig. 25—Cable Repair—Buried Out-of-Sight Feeder (Open Fault)

REQUIRED TEST EQUIPMENT (OR EQUIVALENT)

- | | |
|-------------------------------|-------------------|
| 1 - 91A TEST SET | 5- 1013B HANDSET |
| 2 - 101A TEST SET | 6 - 145A TEST SET |
| 3 - 1097A FILTER | 7 - DYNATEL 710A |
| 4 - KS-14103 L6 BREAKDOWN SET | FAULT LOCATOR |

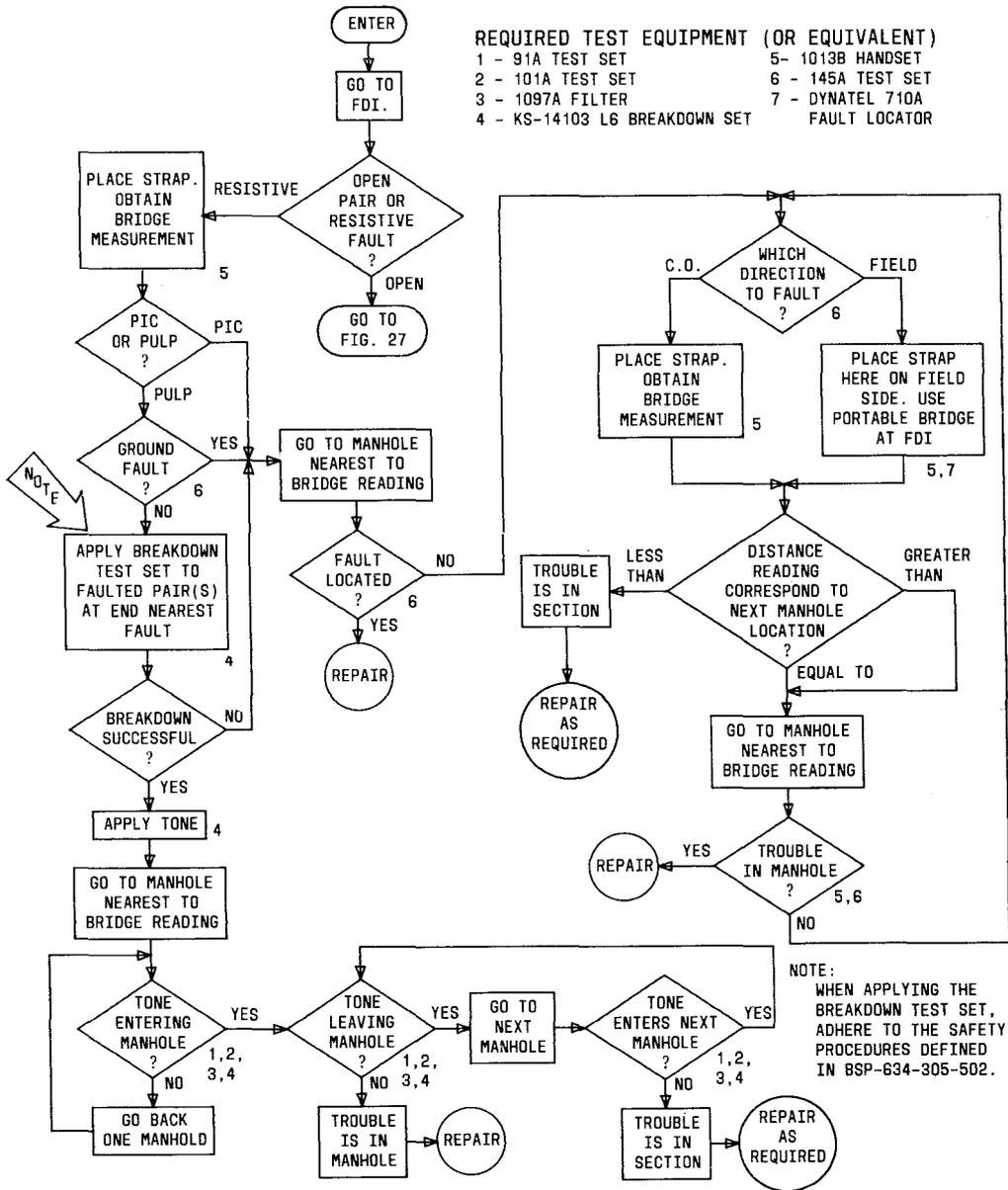


Fig. 26—Cable Repair—Underground Feeder

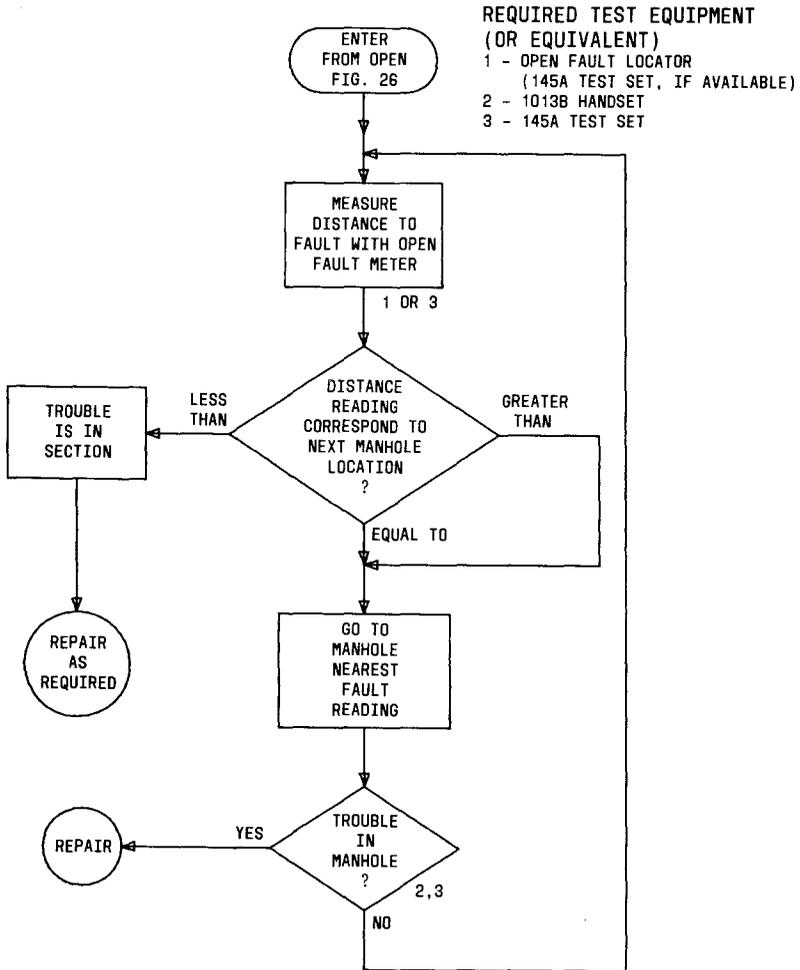


Fig. 27—Cable Repair—Underground Feeder (Open Fault)

5.02 The detection of conductor faults in cable plant is usually associated with customer trouble reports, ALIT, noisy carrier circuits and the like. These faults are usually caused by water entering the cable, lightning surges, physical damage to the sheath or other similar mishaps. The various techniques for locating conductor faults consist of

a series of flowcharts that are designed to provide a systematic approach to fault location. Figures 28 and 29 are flowcharts relating to PIC cable repair in the underground plant. In addition, Fig. 30 and 31 cover the procedure to be followed when the cable trouble is known or suspected to be water related.

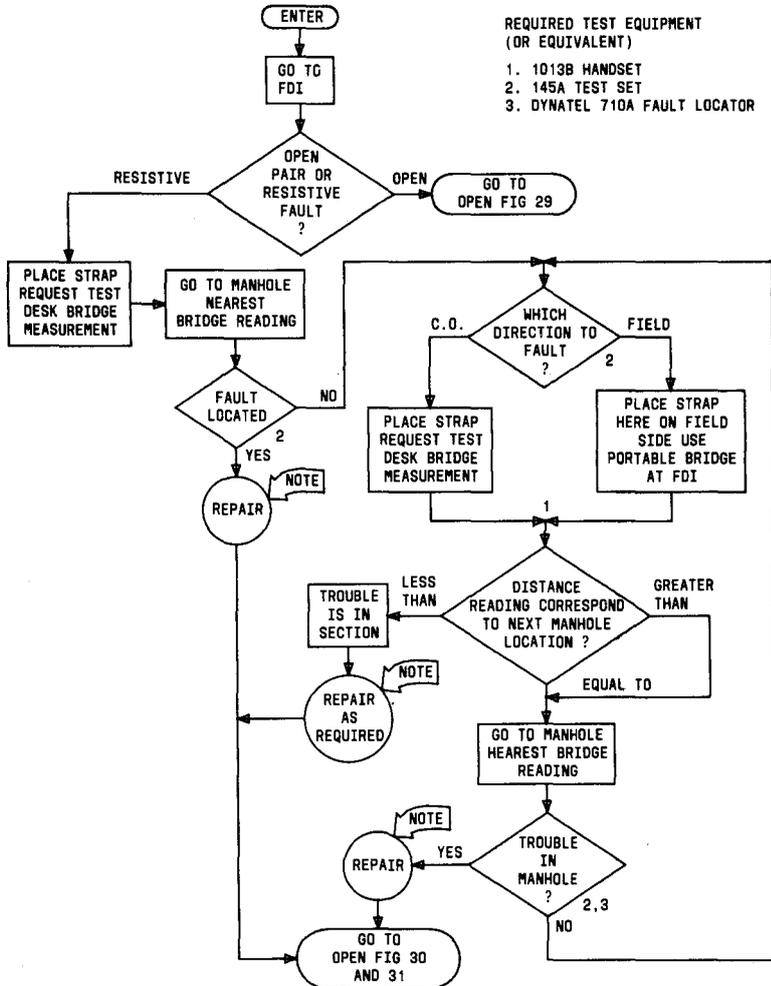
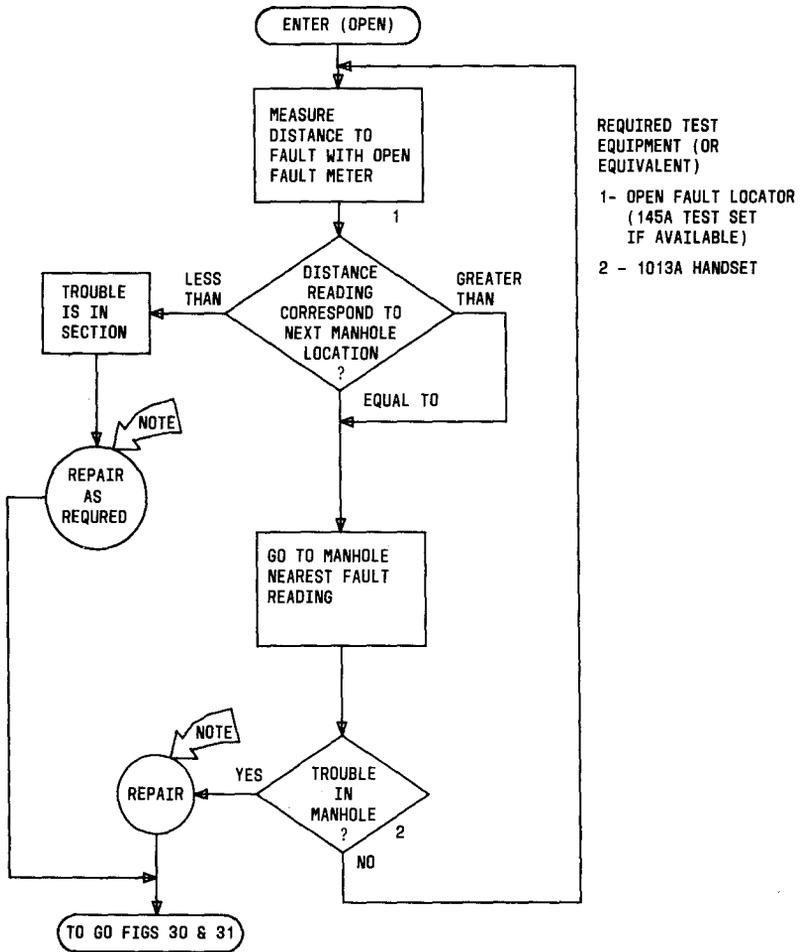


Fig. 28—Resistive Fault—Underground PIC



NOTE:
 AFTER REPAIR OF OPEN FAULT IS COMPLETED, AND IT IS SUSPECTED THAT THE TROUBLE WAS WATER RELATED, TESTS USING THE 176A SICK PIC OR TDR SHOULD BE MADE IN BOTH DIRECTION FROM THE OPEN SPLICE TO ENSURE THAT NO WATER IS PRESENT IN ADJACENT CABLE SECTIONS - SEE FIGURES 30 AND 31.

Fig. 29—Open Fault—Underground PIC

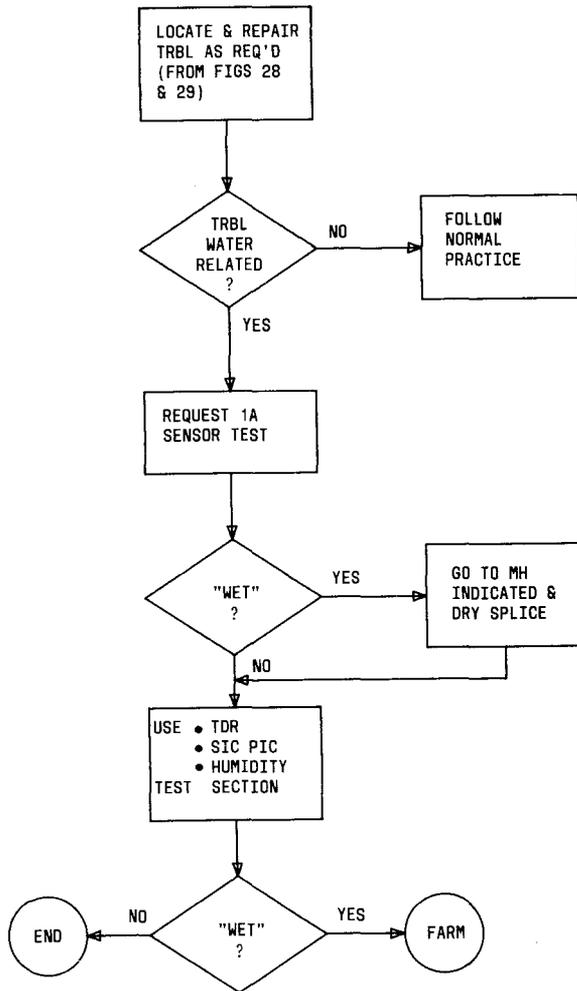


Fig. 30—Craft Procedure

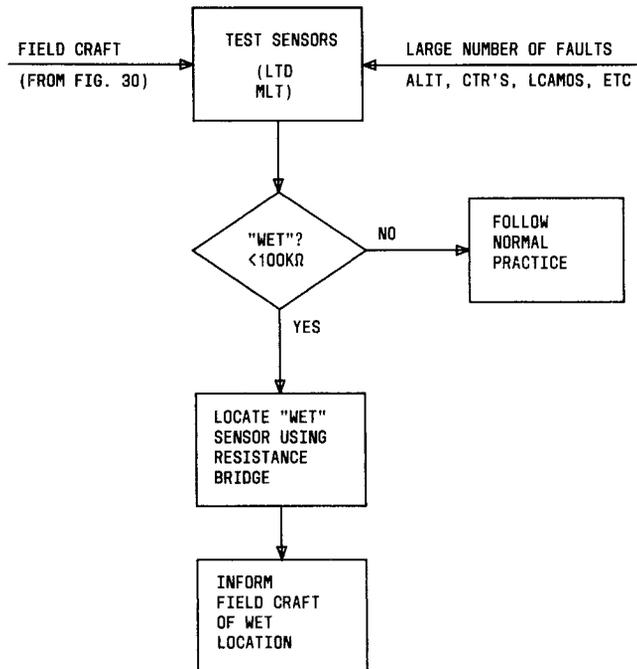
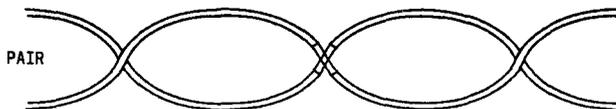


Fig. 31—Test Center Procedure

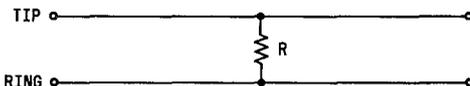
6. TYPE OF FAULTS

6.01 Typical faults to be found along with a description of the fault, symptoms and probable causes are shown in Fig. 32 through 38.

6.02 Splicing errors can include opens and crosses. However, the most common would include splits, transpositions, splice backs, and reversals. Since splicing errors should be corrected during acceptance testing, these kinds of faults have **not** been included in this section.



SCHEMATIC



DESCRIPTION - THE TWO WIRES OF A PAIR ARE IN CONTACT WITH EACH OTHER OR IN CONTACT WITH EACH OTHER THROUGH A RESISTIVE PATH

SYMPTOMS -

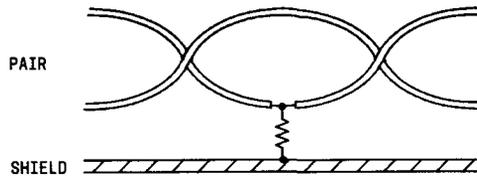
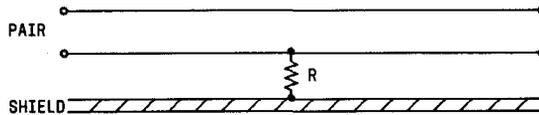
- RESISTANCE FROM TIP TO RING IN RANGE OF 0 TO 2 MEGOHM
- MAY BE A REDUCTION IN SIGNAL LEVEL
- MAY HAVE PERMANENT DIAL TONE
- CUSTOMER'S LINE MAY BE NOISY

PROBABLE

CAUSES -

- BREAKDOWN TEST APPLICATION
- CABLE DAMAGE
- MOISTURE
- METALLIC CONTACT OF WIRES
- LIGHTNING DAMAGE
- ABRASION OF SERVICE WIRE
- TERMINAL DETERIORATION
- CORROSION
- INSECT OR RODENT ACTIVITY

Fig. 32—Short

**SCHEMATIC**

DESCRIPTION - EITHER TIP OR RING OR TIP AND RING ARE IN CONTACT WITH SHIELD OF THE CABLE OR OTHER GROUNDED OBJECT

SYMPTOMS -

- RESISTANCE FROM TIP OR RING TO SHIELD OF CABLE OR OTHER GROUNDED OBJECT
- MAY HAVE REDUCTION IN SIGNAL LEVEL
- MAY HAVE PERMANENT DIAL TONE
- CUSTOMERS LINE MAY BE NOISY

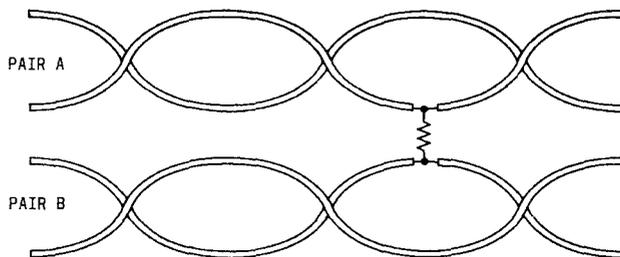
PROBABLE

CAUSE -

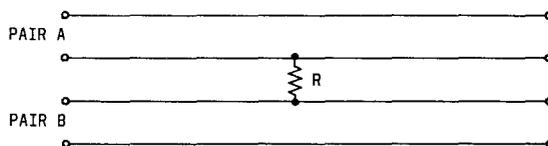
- BAD CARBON IN PROTECTOR
- MOISTURE
- CABLE OR WIRE DAMAGE
- LIGHTNING DAMAGE
- TERMINAL DETERIORATION
- INSECT OR RODENT ACTIVITY
- CORROSION
- WATER IN CABLE
- POOR INSULATION

CAUTION - A CROSS TO TIP OF ANOTHER PAIR MAY APPEAR AS A GROUND

Fig. 33—Ground



SCHEMATIC

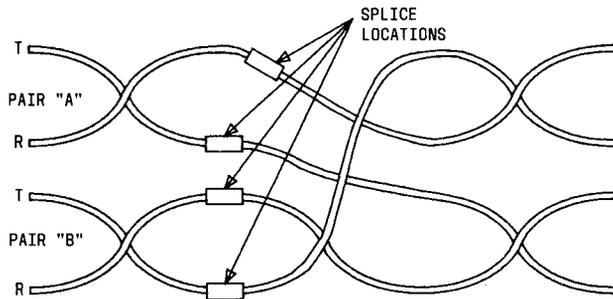


DESCRIPTION - ONE WIRE OF ONE PAIR IN CONTACT WITH ONE WIRE OF ANOTHER PAIR OR IN CONTACT WITH EACH OTHER THROUGH A RESISTIVE PATH.

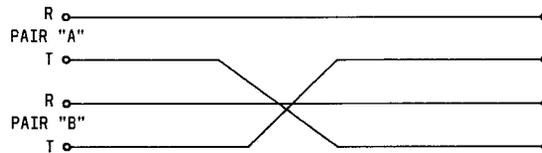
- SYMPTOMS -
- MAY HAVE CROSS
 - MAY HAVE FOREIGN BATTERY
 - CAPACITANCE UNBALANCE BETWEEN CONDUCTORS AND GROUND
 - MAY HAVE REDUCTION IN SIGNAL LEVEL
 - MAY HAVE PERMANENT DIAL TONE
 - CUSTOMER'S LINE MAY BE NOISY
 - MAY APPEAR AS A GROUND IF CROSSED TO TIP OF ANOTHER PAIR

- PROBABLE CAUSE -
- MOISTURE
 - CABLE DAMAGE
 - LIGHTNING
 - TERMINAL DETERIORATION
 - INSECT OR RODENT ACTIVITY
 - CORROSION
 - WATER IN CABLE
 - POOR INSULATION

Fig. 34—Cross



SCHEMATIC



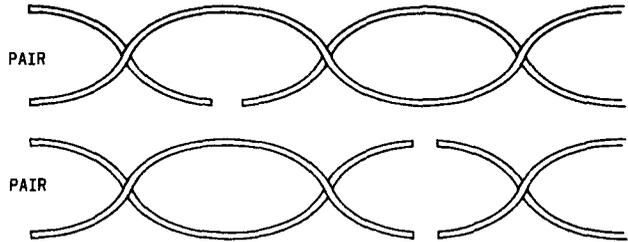
DESCRIPTION - TIP OF ONE PAIR IS CONNECTED TO TIP OF ANOTHER OR RING OF ONE PAIR IS CONNECTED TO RING OF ANOTHER

SYMPTOMS -

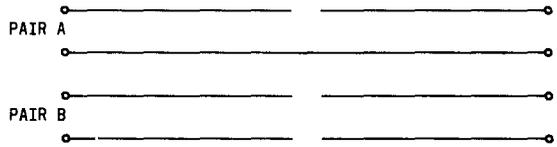
- NO CONTINUITY BEYOND SPLIT
- IF SPLIT IS MIDWAY ON PAIR THE TIP TO RING LENGTH MEASUREMENT WILL BE SHORT
- IF SPLIT BEYOND POINT OF SERVICE CONNECTION, PAIR WILL BE NOISY
- IF SPLIT IS NEAR THE END THE PAIR WILL LOOK LIKE A BALANCED OPEN FAULT

PROBABLE CAUSE - SPLICING ERROR (WILL ALWAYS BE LOCATED AT POINT OF PAIR CONNECTION WORK).

Fig. 35—Splits



SCHEMATIC

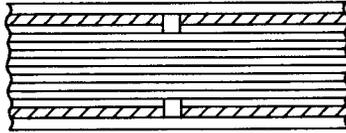


DESCRIPTION - EITHER TIP, RING OR BOTH TIP AND RING ARE OPEN

- SYMPTOMS -
- NO DIAL TONE
 - NO C.O. BATTERY
 - MAY HAVE UNBALANCE BETWEEN CONDUCTORS
 - MAY BE NOISE ON PAIR

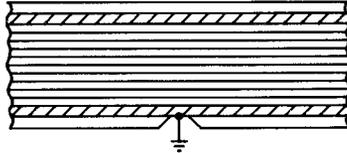
- PROBABLE CAUSE -
- CORROSION
 - BAD SPLICE CONNECTION
 - LIGHTNING DAMAGE
 - CABLE OR WIRE DAMAGE
 - RODENT DAMAGE
 - ABRASION
 - TERMINAL DETERIORATION

Fig. 36—Opens



- DESCRIPTION - LACK OF SHIELD CONTINUITY
- SYMPTOMS -
- NOISE ON LINES
 - NO SHIELD CONTINUITY
 - MAY BE NUMBER OF PAIRS IN TROUBLE AT SAME LOCATION
- PROBABLE CAUSE -
- CORROSION DUE TO MOISTURE
 - POOR CONNECTION AT BOND CLIP
 - BOND OMITTED
 - LIGHTNING
 - POWER LINE CONTACT

Fig. 37—Open Shield



- DESCRIPTION - INTEGRITY OF SHEATH VIOLATED
- SYMPTOMS -
- WATER IN CABLE
 - NUMBER OF PAIRS IN TROUBLE AT SAME LOCATION
 - DC RESISTANCE BETWEEN SHIELD AND EARTH
- PROBABLE CAUSE -
- SHEATH DAMAGED DURING INSTALLATION
 - CABLE OR SERVICE WIRE DAMAGED AFTER INSTALLATION
 - LIGHTNING
 - RODENT DAMAGE

Fig. 38—Sheath Break