BELL SYSTEM PRACTICES
Outside Plant Construction and Maintenance

SECTION G74.420
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CABLE SPLICING
REPAIR OF UNDERGROUND CABLE

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1. GENERAL

1.01 This section is issued for the guidance of field forces in the repair of conductor and sheath faults in underground cable.

2. PRECAUTIONS

Exchange Cables

2.01 Exchange cables may contain toll, program or other special circuits and except in the case of total failure, the method of determining the presence of such circuits and

the method of handling them shall be in accordance with local routine.

2.02 Conductors which have been repaired should be tested before the trouble is considered cleared.

2.03 **Dial System Lines:** Care should be exercised in handling dial system lines in order that interference with the operation of mechanical equipment in the central office may be avoided.

(a) Short circuits, crosses and grounds, even though only momentary, will interfere with the operation of the central office equipment and, in the case of trunk lines, are very apt to put the equipment out of order.

(b) A reversal puts certain of the central office apparatus out of order and considerable delay may be caused in restoring service, as such trouble is not readily detected by the central office forces.

Toll Cables

2.04 The local routine with regard to opening and closing toll cables shall be followed.

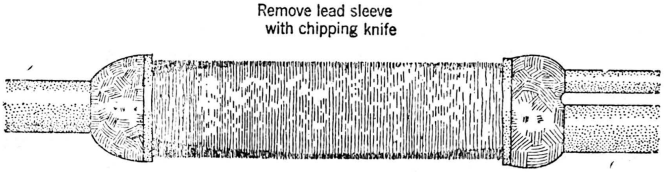
2.05 When working in splices in which balancing units, condensers, building-out stubs or loading coil terminals are connected, care should be exercised to avoid damaging the connections. If in making repairs it is necessary to open connections temporarily, tag the individual conductors so as to ensure reestablishing the original connections. Balancing units in splices should be placed to one side during boiling operations as boiling with hot paraffin may appreciably change their capacitance.

2.06 **Cables Under Pressure:** Advise the test deskman at the office where the alarm is located before releasing the pressure. In wiping or unwiping joints or running seams on sleeves in cables maintained under pressure, a hole should be drilled in the sleeve or sheath with the cable boring tool, or, if there is a valve in the sleeve, the valve core should be removed so that gas may escape through the opening while solder work is in progress.

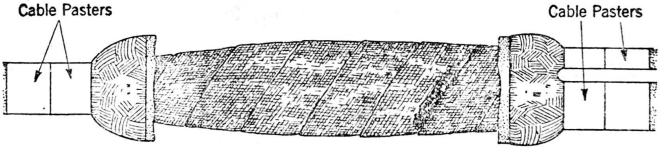
3. OPENING SLEEVES

3.01 **Temporary Cable Bond:** The sheath should be made continuous by placing a temporary cable bond between the cable sheaths on each side of the splice before the splice is opened

3.02 **Removing Sleeve:** In opening a sleeve that is not to be reused, the center portion of the sleeve should be removed as illustrated below before unwiping the joints. This will facilitate unwiping as well as removing the end sections of the sleeve.



3.03 If the sleeve is filled with paraffin, boil out the splice with hot paraffin, or during cold weather with a mixture of paraffin and splicing oil. While the splice is still hot clean the inside of the sleeve ends with muslin so as to avoid dripping of paraffin during the unwiping operations. Then place cable pasters on the sheath as illustrated below to prevent tinning during the unwiping operations.



3.04 Unwipe each joint, loosening the end section from the sheath by twisting it as soon as the solder has been removed. The end sections can then be chipped off. Excess solder should be wiped off the sheath to facilitate placing the new sleeve.

3.05 If the trouble is due to moisture penetration through a crack at or close to a wiped joint or if appreciable water has entered the sleeve, it may not be advisable to remove the joints by unwiping them as under certain conditions the moisture might be driven further under the sheath by the heat of the solder. When it appears inadvisable to unwipe the sleeve, the joints and the associated sheath may be cut into sections with a chipping knife and removed from the cable.

3.06 **Removing Sleeve for Reuse:** When the sleeve is to be reused on completion of the repairs, the splice can be opened as outlined below.

(1) If the cable is maintained under pressure, release the pressure as outlined in paragraph 2.06.

(2) Scrape the joints to remove all dirt.

(3) Place cable pasters on the sleeve and cable sheath to prevent tinning these parts.

(4) Heat the joint by pouring molten solder over it and after the joint has become plastic, wipe off the solder.

(5) Before the joint becomes chilled, insert a screwdriver or other suitable tool between the sleeve and the sheath and pry open the end of the sleeve. Pliers may also be found useful in opening the end of the sleeve.

(6) At branch splices the straight joint should be unwiped before the "Y" joint. After the joints have been unwiped the sleeve should be pulled toward the straight end.

4. CLEARING DEFECTIVE CONDUCTORS—NO MOISTURE

4.01 After removing the muslin, the splice should be boiled out with paraffin. During cold weather splicing oil should be added to the paraffin to avoid excessive hardening. No work should be done in a splice until all cotton sleeves are thoroughly heated. Identification tone should be connected to the defective conductors at the main distributing frame, at a cross-connecting terminal or at a distribution terminal, depending on which is most convenient. After the defective pairs have been identified, they should be examined carefully and repaired, piecing out conductors, if necessary.

4.02 Ordinarily, conductor faults in underground exchange cables will not be cleared unless it can be done in connection with other splicing work or unless a sheath break is involved, in which case the trouble should be repaired immediately. Faults involving conductors in toll or long loaded trunk cables may also require immediate attention. If the defect is in a section between manholes, the trouble can usually be cleared by opening the sleeves at either side of the trouble and transferring the pair in trouble to a pair which is good in the section involved but which is connected to one of the universal bad pairs of the cable. The pair numbers of the universal bad pairs in the cable can be obtained from plant records.

4.03 The lead sleeve used to cover the opening should be about one inch longer than the sleeve which was removed and in case a sleeve is to be reused, the width of the joints should be increased in order than the joints will extend beyond the old wipes.

5. RAISING INSULATION RESISTANCE — EXPELLING MOISTURE FROM CABLE

5.01 The use of nitrogen gas as a supplementary means of locating sheath openings and of clearing moisture troubles is outlined in Section G73.225.

5.02 Remove the sheath to expose all the core affected by the moisture. Balloon the splice, and repair any conductors having badly charred or otherwise damaged insulation in order to minimize the possibility of arcing. The moisture should be removed by pouring hot paraffin on the sheath beginning approximately six inches beyond the ends of the opening and gradually working toward the center of the opening. Continue to boil the conductors until the bubbling or frying sound ceases. After boiling the insulation the conductors should again be examined and all damaged insulation repaired. In extreme cases it may be necessary to cut in a new piece of cable.

6. EXCAVATING CABLE TO CLEAR TROUBLE

6.01 Where a sheath fault develops in a cable at a location other than in manholes, it is frequently advantageous to clear the trouble by excavating, particularly if expensive paving restoration would not be involved. The exact location of the fault should be determined by Wheatstone bridge measurements, or by means of pressure tests. The point of excavation should be marked on the ground or pavement, referring to a drawing of the conduit layout, if necessary, to determine the line of the conduit. Where required, a permit to open the street should be obtained.

6.02 After the cable has been exposed, the sheath should be removed and defective conductors repaired in the usual manner. The length of the lead sleeve should be three inches longer than the length of the opening. The diameter of the sleeve should be only slightly larger than the diameter of the cable but where practicable it should not exceed 2-3/4 inches for a cable in standard clay conduit. For creosoted wood duct and other conduit having a smaller bore, the diameter of the sleeve should be proportionately smaller, increasing the length if necessary to accommodate the splice. The repaired cable should be tagged as outlined in paragraph 9.13.

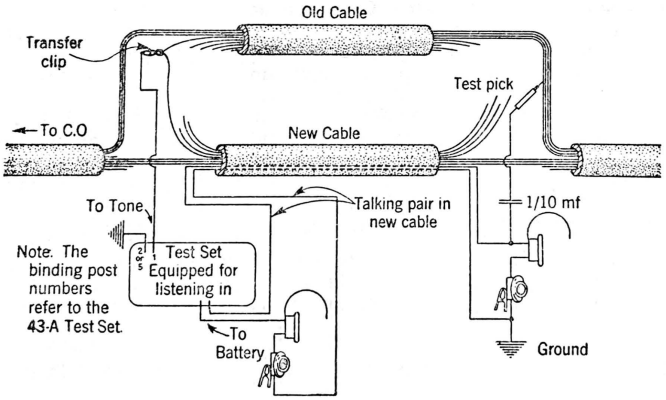
6.03 The conduit should be repaired as outlined in the Underground Conduit Practices.

7. SECTIONAL CABLE THROWS—EXCHANGE CABLE

7.01 There are two general methods which may be employed in replacing one or more sections of a working cable. The method to be used in making a particular throw will depend on the nature of the failure and the amount of moisture present. The method described below should be employed when the pairs can be readily identified. If the trouble is due to appreciable moisture in the cable, and the pairs cannot be identified by the "Working Section Throw" method then one of the procedures described in paragraph 7.09 should be followed.

Section Throw of Working Cable

7.02 Two splicers will be required to work together in making a section throw. If the new cable is more than one section long, make random intermediate splices in the new cable. Where intermediate splices have been made in the new cable, it may be desirable to test it for defective conductors before starting the throw. Establish a talking pair in the new cable and connect the testing apparatus, as shown below.



7.03 The splicer at the end nearer the central office will select the pairs. In order to avoid service interruptions, or possible damage to the equipment, particularly in the

case of working dial system, trunk, and toll pairs, it is important that the splicer selecting the pairs listen in on each pair in the working cable before cutting it. Pairs on which conversation is heard shall not be cut while the conversation is in progress.

7.04 The splicer selecting the pairs shall select one in the new cable and another pair in the old cable. The pairs selected should be in the same relative positions in both cables so as to give the splice a neat layup when finished. If the pair selected in the working cable is not busy the splicer cuts it and then sends out tone on one side of this pair as well as on one side of the pair in the new cable.

7.05 The other splicer connects a test pick to the talking pair, as shown in the diagram in paragraph 7.02, and identifies the pair in the new cable and the pair in the old cable on which tone has been placed. He then cuts the pair in the working cable and both splicers check the sides of both pairs and then splice the pair in the new section to the pair in the working cable.

7.06 After transferring the first pair, transfer the other pairs of the working cable to pairs in the new cable in the same way. The splicer at the end of the section nearer the central office, where practicable, should select the pair in both the new cable and the working cable adjacent to the last pair transferred and in the same layer or unit. This will, when there are no intermediate splices, enable the other splicer to pick out the pairs with minimum delay.

7.07 If there are intermediate splices in the section to be replaced, the pairs will not follow each other around the core or unit in the same order at both ends of the section; in such cases the identification of the pairs may be facilitated by fanning the pairs in flexible test strips.

7.08 Working pairs in the old cable shall not be spliced to defective pairs in the new cable. Where practicable, defective pairs should be spliced to the universal bad pairs in the corresponding color group or unit.

Section Throw of Wet Cable

7.09 If the cable is so wet that the tone does not pass the trouble, or the tone may be heard with equal intensity on all pairs, so that it is impracticable to identify with the usual tone method, then the balance test or receiver methods of identifying conductors through a single section of cable may be employed.

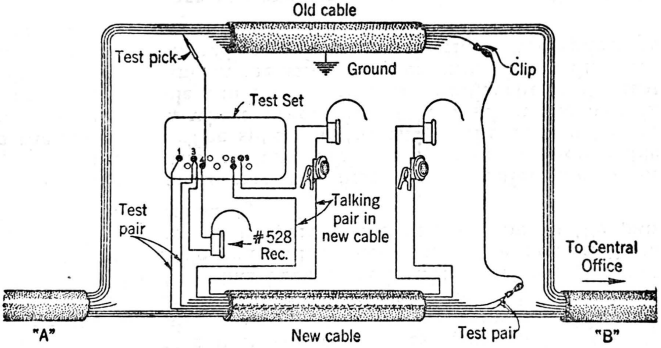
Balance Test Method

(1) The balance test method of identification is a variation of the Balance Test used in detecting shorts, crosses and grounds. This method of identification is applicable when the insulation is not thoroughly wet.

(2) The "Test Pair" should be one of the pairs in the new cable, preferably of the same gauge as the pairs to be thrown and it should be free from trouble. The test pair should be shorted at the end away from the set as indicated in the diagram in the paragraph below. All connecting leads should be kept free from ground.

(3) To identify wires proceed as follows:

Make the connections as indicated in the following diagram. When the buzzer is operating there will be a continuous tone in the receiver because of the unbalanced condition of the circuit.



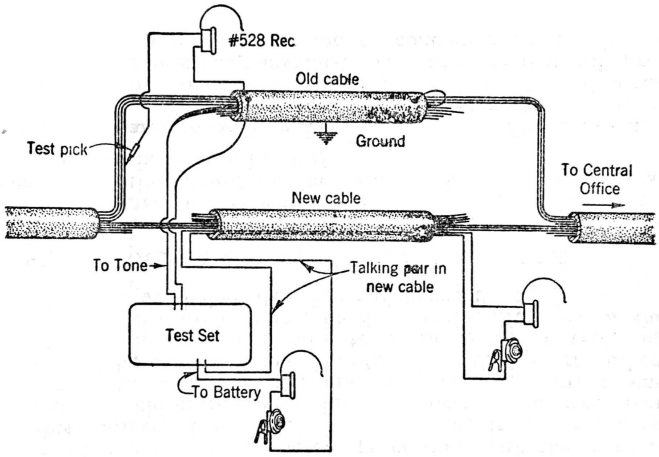
Note: This shows connections using the 43-A Test Set. The connections with other sets will depend on the circuit wiring

At end "B," the splicer should cut the pair to be identified and connect the test clip to one of the wires. At end "A," the splicer should pick through the pairs in the corresponding layer or group. When the proper pair is found the receiver will be silent provided the wire being identified is of the same gauge as the test pair. Even with a difference in gauge, however, there should be a decided reduction in the intensity of the tone heard.

Receiver Method

(1) The method of identification operates on the principle that if a pair is grounded at one end, a noise or hum will be heard in the receiver whenever a pair is touched which is not grounded. The absence of a noise or hum indicates a grounded pair.

(2) The pair to be identified should be opened and grounded at the splice nearer to the central office. At the other splice, one side of a No. 528 receiver is connected to the sheath as indicated on the circuit diagram below. The lead from the other side of the receiver is used to pick through the conductors. The pair on which no noise is heard is the pair which was grounded at the end nearer the central office. A retest can be made by opening and closing the ground connection to see that the right pair has been chosen.



(3) As in other methods of testing over a single length of cable, the splicer should pick pairs in order around the layer or in the unit so as to facilitate identification.

(4) If the noise heard in the receiver is not sufficiently strong because of the character of the fault or because a large portion of the conductors have been transferred, the noise can be increased by connecting identifica-

tion tone from the splicer's test set between several of the wires in the defective cable and the sheath, as indicated in the preceding diagram.

Out-of-Service Replacement

(1) If identification of pairs by one of these methods is impracticable it may be necessary to make an out-of-service replacement. The approval of the supervisor should be obtained, however, before proceeding with the work in this manner. The end of the cable away from the central office should preferably be identified from one or two large terminals, if practicable, and boarded. The other end should be identified and boarded from the central office. If there is a random splice to be made in the replacing section, this work should be done while the ends of the old cable are being identified and boarded.

8. SECTIONAL CABLE THROWS—TOLL CABLE

8.01 If practicable, the circuits in a toll cable should be rerouted by the central office forces to minimize service interruption, unless specific authority is obtained to transfer the pairs in some other way.

8.02 **Preparation of New Length of Cable:** The quads and pairs should be boarded or bunched at both ends of the new section in the same manner as that followed when the cable was originally installed. This arrangement will provide for the proper segregation of conductor groups in the new section.

8.03 **Splicing to Existing Cable:** Where cotton sleeves with colored tracers were used at the time the existing cable was installed, the identity of the conductor groups can be established by these sleeves.

8.04 Where the new section is placed in a cable in which colored cotton sleeves were not employed at the time of installation or where existing splices are not involved, it will be necessary to determine the layer formation of the quads to obtain proper segregation of conductor groups. This should be done at each end of the section to be replaced by cutting back on the sheath in the direction of the defect. The selection of conductor groups in the replacing cable should correspond with the grouping arrangement in the existing cable.

9. CUTTING IN SLACK—DUCT SPLICES

9.01 Conditions may at times make it advisable to splice in a short piece of cable at a manhole to effect repairs satisfactorily. Such a procedure may be desirable (a) when replacement of a long section of cable might otherwise be required, and (b) when replacement of a section might lead to an unsatisfactory maintenance condition. When the section of cable involved is short or when an unsatisfactory manhole condition can be corrected, it is usually desirable to replace the section. The supervisor should be consulted before proceeding with work of this nature.

9.02 If slack is to be cut into a cable, a test pull should be made on the sections involved, to ensure that the cable can be pulled later.

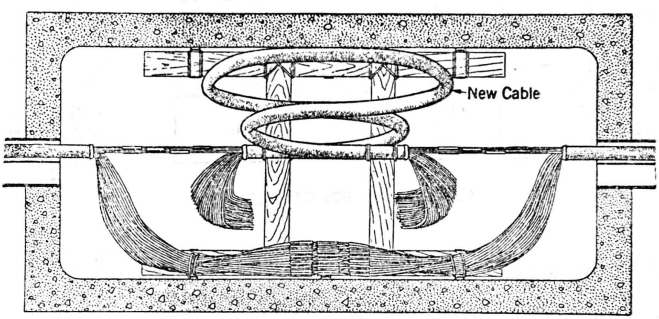
9.03 **Sleeves for Duct Splices:** The completed splice must be small enough to permit covering it with a lead sleeve 2-3/4 inches in diameter, which is the largest size that can be pulled conveniently into or out of the usual clay conduit. The following table indicates the lengths and diameters of the lead sleeves necessary to cover duct splices in the larger sizes of 19, 22, 24 and 26 gauge cables.

LEAD SLEEVES FOR DUCT SPLICES

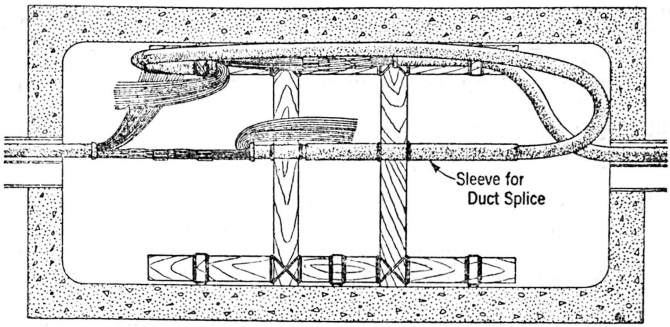
Size of Cable (Pairs)	Gauge	Diameter of Sleeve (in inches)	Length of Sleeve (in inches)
303	19	2 3/4	33
455	19	2 3/4	40
404	22	2 1/2	33
606	22	2 3/4	33
909	22	2 3/4	40
404	24	2 1/4	30
606	24	2 1/2	33
909	24	2 3/4	40
1212	24	2 3/4	45
606	26	2 1/4	30
909	26	2 1/2	33
1212	26	2 3/4	40
1818	26	2 3/4	45

Use as many rows of cotton sleeves as practicable.

9.04 **Two Duct-Splice Method:** Below is illustrated a typical splicing arrangement in a manhole where slack is to be cut into a cable due to the removal of a large portion of the sheath as a result of a cable failure. The new cable should be formed into a figure "8" before it is placed in the manhole. The cable should be fastened securely in position so that the ends are in alignment with the old cable at the ducts. The length of the opening should be made three inches less than the length of the lead sleeves shown in the preceding table. Two splicers can be employed to advantage in making the splices. The conductors in the new cable should be spliced by test to pairs which have been traced without testing in the old cable. Pairs over which conversation is heard should not be cut until the circuits have been released.



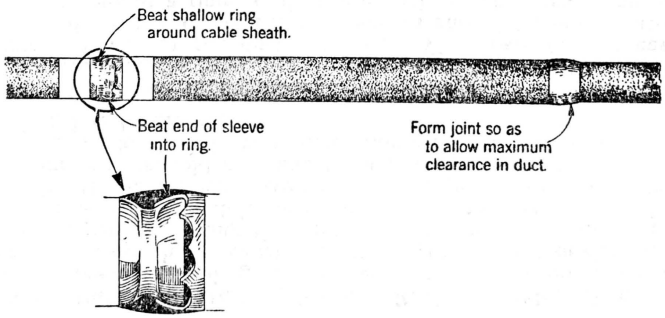
9.05 **Single Duct-Splice Method:** Where the sheath has been removed from the cable at only one side of the splice or where slack is required in only one direction, repairs can be effected by cutting in a piece of cable between the splice and the manhole wall at either end of the section. The setup of the cable is illustrated on the following page. The sleeve for the duct splice should be placed over the cable before splicing where practicable.



9.06 **Making Duct Splice:** Make the splice with as many rows of cotton sleeves as practicable. Keep all wires taut; excessive slack will make it impossible to place the lead sleeve over the splice.

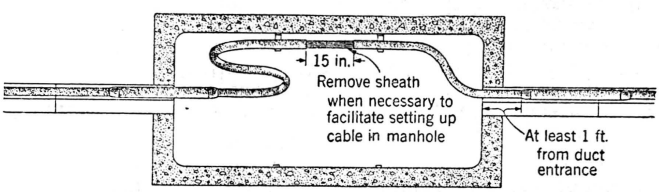
9.07 When the wires have been spliced, boil the conductors in the usual manner and wrap the splice with freshly boiled muslin or cotton tape.

9.08 Beat shallow rings around the cable sheath at the points where the lead sleeve is to be beaten in. This will permit a reduction in the diameter of the wiped joints. Place the lead sleeve over the splice (tack the seam, if a split sleeve is required), and beat the ends into the rings, as shown below. Thin joints should be wiped, as it is important to allow as much clearance in the duct as practicable. The solder work should be tested with gas pressure before the sleeve is pulled into the duct, to ensure that the joints are tight.



9.09 **Pulling in Duct Splice and Racking Cable:** A hand operated pulling device such as the tension splicing jack, the chain hoist, capstan pulley or other local device can be employed for pulling the duct splice into position where the section is approximately three hundred fifty feet or less in length. If the section is too difficult to pull in this manner, arrangements should be made to pull the section with a cable placing truck. A split cable grip should be used to attach the pulling line to the cable.

9.10 The duct splice should be pulled into the duct so that the nearer joint of the splice is not less than one foot from the face of the duct entrance. When two duct splices are made in the cable, the duct splices should be pulled into the duct one at a time, as illustrated below. The sketch shows one duct splice in its final position and the other, pulled partly into the duct.



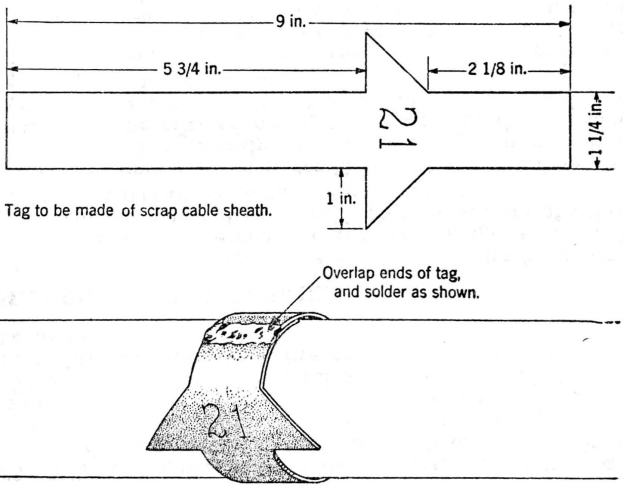
The cable in the manhole should be racked as the second splice is being pulled. On large size cables where the replacing length is formed into a figure "8," an opening may be made in the sheath as illustrated, if necessary to facilitate racking. This opening should be located so that it will occupy one of the splicing positions when the cable is racked. A standard length lead sleeve should be used to cover the opening, but the diameter of the sleeve required will be less than that needed to cover a straight splice and may be reduced accordingly.

9.11 **Pulling Cable into Adjacent Manhole and Racking:** When pulling in the duct splice, an excess amount of slack cable will usually accumulate in the manhole where the pulling apparatus is located. Pulling and racking in this manhole can be facilitated by removing the sheath from the excess length of cable during the pulling operation. When this is done, the core should be protected from moisture by wrapping it with freshly boiled muslin and supporting it away from the manhole walls with houseline lashings. A lever cable

bender can be employed to advantage in setting up the cable in the manhole.

9.12 If slack is to be cut out after the cable is racked in position, it can be done in the usual manner, by making a sheath opening in the desired racking position, boiling out the core, and splicing the conductors beginning with those at the back of the splice so as to give a neat layup when finished. A standard size sleeve should be used to cover the splice.

9.13 **Tagging Duct Splices:** After the duct splice has been pulled into the duct, a tag of the design shown in the sketch below should be soldered around the cable at each end of the section to indicate the presence of the duct splice. Each tag shall be stamped to show the distance in feet from the end wall of the manhole to the duct splice. The tag should be made of cable sheath. Prepare and forward in accordance with company routine a sketch showing the location of duct splices so that the plant cable records can be revised.



10. PROTECTING UNCOMPLETED SPLICES

10.01 Local routines should be followed with regard to leaving splices uncompleted.

10.02 When, because of a storm or other reasons, it is impossible to provide shelter for a splice after it has been started, lay the unspliced wires in the splice and wrap it from end to end with two layers of boiled muslin. Cover the muslin with several layers of rubber bandage applied under tension and extended well back on the sheath.

10.03 Where a splice will not be completed for some time, additional protection should be applied. Wrap a layer of muslin over the rubber bandage and then apply several layers of friction tape, paying particular attention to the crotch if a "Y" joint is involved. A liberal application of asphalt paint should be brushed over the entire covering. The splice should not be moved.

11. MISCELLANEOUS REPAIRS

11.01 Where it is impracticable to effect repairs by pulling the cable into the manhole and the damage is not such as to warrant cutting in slack or replacing the section of cable, the following alternatives should be considered:

(1) If the conduit is not under pavement and the damaged cable is conveniently located in the group of ducts, repairs can be effected by digging outside of the manhole and breaking out the conduit so as to give access to the damaged portion of the sheath.

(2) If the street is paved or if the cable is in an inaccessible part of the bank of ducts, and the sheath is damaged at the duct entrance of the manhole it may be advisable to break out the duct from the inside of the manhole sufficiently to permit repairing the cable.

11.02 Upon completing the work, inspect any cables which have been disturbed during the progress of the work. Cable tags and bonds which have been moved shall be replaced. Fallen cable hooks should also be restored to their proper position. Make a report to the supervisor of any further work which should be done to put the cables and manhole in good condition.