# TM 11-371

WAR DEPARTMENT TECHNICAL MANUAL



# CABLES WC-534 (5-PAIR), AND WC-535 (10-PAIR), AND CABLE ASSEMBLIES CC-345 AND CC-355-A

*WAR DEPARTMENT • 12 OCTOBER 1944*

WAR DEPARTMENT,
WASHINGTON 25, D. C., 12 OCTOBER 1944.

TM 11-371, Cables WC-534 (5-pair) and WC-535 (10-pair), and Cable Assemblies CC-345 and CC-355-A, is published for the information and guidance of all concerned.

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BY ORDER OF THE SECRETARY OF WAR:

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IC 11 (2): T/O & E 11-500, 40 Line Switchboard Team (GA); 1 Position Switchboard Team (GB); 2 Position Switchboard Team (GC); 3 Position Switchboard Team (GD); 200 Sta Automatic Switchboard Team (GE); Switchboard Instal Sec (GF); Small Teletype Team (GI); Medium Teletype Team (GF); Large Teletype Team (GK); Telephone Carrier and Repeater Sec (GW); Telephone and Telegraph Instal Sec (GO); Spiral 4 Cable Sec (GP); Heavy Wire Construction Team (GS); Submarine Cable Sec (GR).

For explanation of symbols, see FM 21-6.

WAR DEPARTMENT TECHNICAL MANUAL

TM 11-371

*This manual supersedes TM 11-371, Cable Assemblies CC-345 (5-pair), CC-355-A (10-pair), and Associated Equipment.*

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*Washington: 1944*

## LIST OF ILLUSTRATIONS

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## DESTRUCTION NOTICE

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**WHY** —To prevent the enemy from using or salvaging this equipment for his benefit.

**WHEN**—When ordered by your commander.

**HOW** —1. Smash—Use sledges, axes, handaxes, pickaxes, hammers, crowbars, heavy tools.

2. Cut—Use axes, handaxes, machetes.
3. Burn—Use gasoline, kerosene, oil, flame throwers, incendiary grenades.
4. Explosives—Use firearms, grenades, TNT.
5. Disposal—Bury in slit trenches, fox holes, other holes. Throw in streams. Scatter.

### USE ANYTHING IMMEDIATELY AVAILABLE FOR DESTRUCTION OF THIS EQUIPMENT

**WHAT**—1. Smash—Connectors, terminal strips, reels and reel units, A-frames, X-frames, loading coils.

2. Cut—Cable, guy wires, messenger strands, poles, wiring of terminal equipment.
3. Burn—Insulation, rubber cable sheath, reels, A-frames, X-frames, connectors.
4. Bend—Axles for reels, connector terminals.
5. Bury or scatter—Cable, reels, insulation, terminal equipment.

### DESTROY EVERYTHING

*This manual supersedes TM 11-371, Cable Assemblies CC-345 (5-pair), CC-355-A (10-pair), and Associated Equipment.*

# SECTION I

# DESCRIPTION

**1. PURPOSE.** This manual describes Cables WC–534 (5-pair) and WC–535 (10-pair), and Cable Assemblies CC–345 (5-pair) and CC–355–A (10-pair). It describes the standard and recommended methods of using Cables WC–534 (5-pair) and WC–535 (10-pair), for the guidance of personnel responsible for the installation and maintenance of wire circuits using these cables.

**2. CABLE AND CABLE ASSEMBLIES. a. Cable WC–534 (5-pair).** Cable WC–534 (5-pair) has 10 No. 19 AWG tinned, solid copper conductors, each of which has a colored, rubber insulation. The conductors are paired according to the following color code:

| *Pair No.* | *Color Code* |
|---|---|
| 1 | Red—natural |
| 2 | White—natural |
| 3 | Blue—natural |
| 4 | Black—natural |
| 5 | Green—natural |

The conductors of each pair are twisted together with a left-hand lay. With cotton cord as the center and as filler between the pairs, the five pairs are twisted together with a right-hand lay. A cotton yarn separator is applied over the assembled conductors, and black, vulcanized rubber or synthetic rubber is molded around the outside to form the cable jacket. The physical characteristics of the cable are given in table I.

**b. Cable WC–535 (10-pair).** Cable WC–535 (10-pair) is similar to Cable WC–534, except that it is made up of 10 pairs of conductors which are paired according to the following color code.

| *Pair No.* | *Color Code* |
|---|---|
| 1 | Red—natural |
| 2 | White—natural |
| 3 | Blue—natural |
| 4 | Black—natural |
| 5 | Green—natural |
| 6 | Red—white |
| 7 | Red—green |
| 8 | Blue—white |
| 9 | Black—green |
| 10 | Green—white |

The physical characteristics of the cable are given in table I.

**c. Cable Assembly CC–345 (5-pair).** Cable Assembly CC–345 (5-pair) consists of a length of Cable WC–534 (5-pair) equipped with a connector (Plug

PL–163) on each end. The cable conductors are connected identically to the plugs and sockets of each connector, the rubber compound of which is vulcanized securely to the cable jacket. This cable assembly is available in present procurements in nominal lengths of 100 feet, 200 feet, and 500 feet. Procurement of Cable Assembly CC–345 in lengths of ½ mile has been discontinued.

**d. Cable Assembly CC–355–A (10-pair).** Cable Assembly CC–355–A (10-pair) consists of a length of Cable WC–535 (10-pair) equipped with two staggered connectors (Plug PL–163) on each end. The conductors connected to the plugs and sockets of the long connector at one end are then connected identically to the plugs and sockets of the short connector at the other end. The rubber compound of the two connectors on each end is vulcanized securely to the cable jackets of the two short pieces of Cable WC–534 (5-pair). The jackets of their short pieces are vulcanized at their opposite ends to the jackets of Cable WC–535 (10-pair) in a pothead, where the two short Cables WC–534 (5-pair) are spliced to Cable WC–535 (10-pair). This cable assembly is available in present procurements in nominal lengths of 100 feet, 200 feet, and 500 feet. Procurement of Cable Assembly CC–355–A in lengths of 1,000 feet has been discontinued.

*Note.* Some of the first 5- and 10-pair cable produced was not completely color-coded. In this old cable, the rubber insulation of only one pair is color-coded and this pair has one black conductor. This fact should be kept in mind when opening cable for repair and when matching conductors for splicing.

*Table I. Physical characteristics of 5-pair and 10-pair cable*

| Characteristics | Cable WC–534 | Cable WC–535 |
|---|---|---|
| Size of conductors | * | * |
| Number of conductors | 10 | 20 |
| Thickness of conductor insulation, inches | 0.015 | 0.015 |
| Thickness of cable jacket, inches | 1/16 | 1/16 |
| Outside diameter of cable, inches, maximum | 0.5 | 0.7 |
| Weight, pounds per 1,000 feet | 125 | 250 |
| Minimum tensile strength, pounds | 425 | 750 |
| Conductor resistance, maximum, per loop mile, at 68° F | 92.0 ohms | |

*Solid No. 19 AWG annealed copper (1,290 cm area).

**e. Cable Stub CC–344 (5-pair).** Cable Stub CC–344 (5-pair) is identical with Cable Assembly CC–345 (5-pair), except that it consists of 10 feet (nominal length) of Cable WC–534 (5-pair) with Plug PL–163 on one end. The free end may be fanned out and connected to suitable terminals.

**f. Cable Stub CC–354 (10-pair) and Cable Assembly CC–355 (10-pair).** Cable Stub CC–354 (10-pair) and Cable Assembly CC–355 (10-pair) are no longer produced. They consist of Cable WC–535 (10-pair) with a 10-pair connector, rather than the present termination of two 5-pair connectors.

**g. Expedient splices and Terminal Strip TM–184.** When access for testing is not required, and, wherever feasible, sections of field cable may be spliced by expedient methods in order to obtain trouble-free circuits by removing instead of cleaning and joining connector Plugs PL–163. Terminal Strip TM–184 with improved weatherproof covers may be used as a means of joining sections of Cable WC–534 (5-pair) or WC–535 (10-pair).

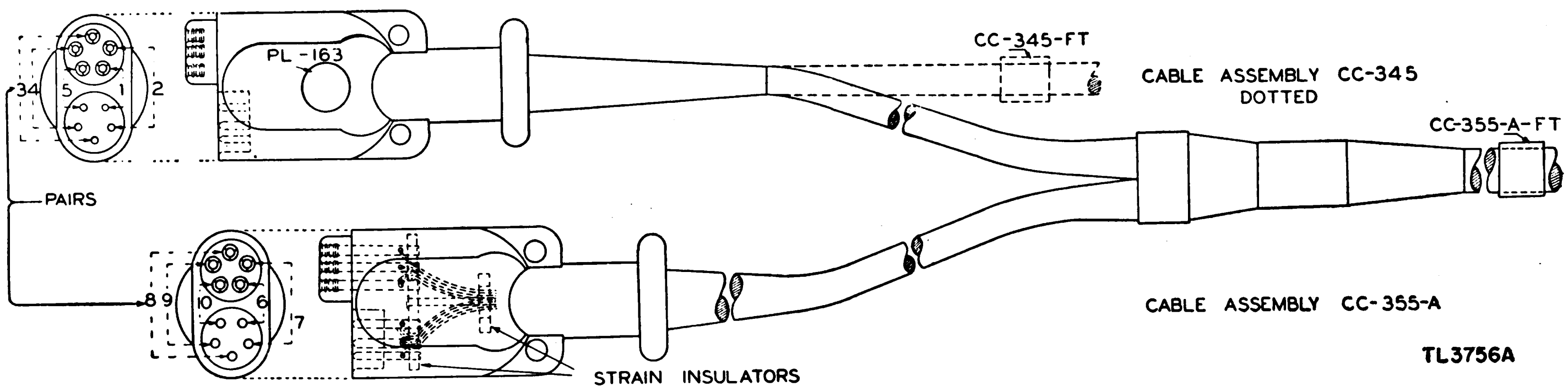


*Figure 1. Method of terminating Cable Assembly CC–355–A (10-pair) and Cable Assembly CC–345 (5-pair) and Cable Stub CC–344. The complete illustration represents the termination of CC–355–A, and the upper molded terminal with dotted-line extension represents the termination of CC–345 and CC–344.*

**3. SHIPPING REELS.** Cable WC–534 (5-pair) is furnished in ½-mile lengths on Reel DR–7 and 1,000-foot lengths on Reel DR–5 also Cable WC–534 is furnished with terminals as Cable Assembly CC–345 in nominal lengths of 100 feet, 200 feet, and 500 feet. Lengths of 500 feet are furnished on wooden reels, while the short lengths are furnished in wrapped coils. Cable WC–535 (10-pair) is furnished in 1,000-foot lengths on Reel DR–7 and with terminals as Cable Assembly CC–355–A (10-pair) in nominal lengths of 100 feet, 200 feet, and 500 feet.

**4. CAPABILITIES. a. Telephone.** The satisfactory transmission distance or talking range for both 5- and 10-pair cable is given in table II. Each connection which is improperly made reduces the talking range considerably, since crosstalk and noise are introduced. Considered from the standpoint of attenuation variation, 5- and 10-pair cable is very much more stable than field wire such as Wire W–110–B, for example. The heavy insulating jacket is kept well away from the conductors, and any given pair is effectively stabilized by the other pairs, with respect to capacitance to ground. The attenuation in wet weather is the same as in dry weather, and is also the same for all three methods of construction: aerial, surface, and underground. Temperature change is the major cause of normal attenuation variation. Underground construction is less adversely affected by temperature variations than either aerial or surface construction. Attenuation variations due to temperature fluctuation will amount to about 5.3 percent for a temperature change of 50° F. This side-to-side capacitance unbalance and the side-to-ground capacitance unbalance are relatively low. Thus, with connectors removed, the noise level of a nonrepeatered circuit having a net loss of 30 db will not exceed the maximum allowable limit of 36 dbrn * when either phantom or simplex telegraph circuit arrangements are utilized up to the full capacity of the cable. With connectors removed, the crosstalk coupling will not exceed the maximum allowable limit of 2,400 crosstalk units on circuits having a net loss of 30 db.

*Table II. Maximum nonrepeatered circuit lengths at 1,000 cycles*

| Loading | Attenuation | Net Circuit Loss | | | | |
|---|---|---|---|---|---|---|
| | db per mile | 3db | 6db | 12db | 18db | 30db |
| Nonloaded...... | 1.8 | 1.6 | 3.3 | 6.6 | 10.0 | 16.6 |
| 5280–44 *mh*..... | 0.9 | 3.3 | 6.6 | 13.3 | 20.0 | 33.3 |
| 5280–88 *mh*..... | 0.76 | 3.9 | 7.9 | 15.8 | 23.7 | 39.5 |

**b. Telegraph and teletypewriter.** Cross-fire limits the length of cable or the distance over which more than one teletypewriter circuit may be satisfactorily operated. However, under ideal conditions, teletypewriter circuits may be operated over simplexed cable pairs up to the full capacity of Cable WC–534 (5-pair) for a distance of 10 miles, and five circuits may be operated in Cable WC–535 (10-pair) over the same distance. Moreover, by selecting pairs which give the minimum cross-fire, two or three teletypewriter circuits may be operated in either

* dbrn is an abbreviation of "decibels above zero reference noise level." It refers to the power level of the noise in a circuit, as measured with a standard noise meter, with reference to a standard zero noise level.

Cable WC–534 (5-pair) or Cable WC–535 (10-pair) up to the distance limited by telephone use. This distance is such that the circuit has a net loss of 30 db. Short sections of Cable WC–534 (5-pair), up to 4 miles in length, are suitable for teletypewriter operation up to the maximum capacity of the cable. For example, such sections would be used as entrance cable in congested areas around higher headquarters or construction centers or for short distances in open wire lines.

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## SECTION II

## INSTALLATION

**5. GENERAL. a.** The use of these cables permits the laying of 5 or 10 circuits simultaneously with a minimum of men, vehicles, and equipment. At command posts of higher headquarters and in other areas where there is a tendency for wire communication lines to become congested, these cables may be used to reduce the time of installation and to consolidate overhead circuits into one or more cables. Figure 2 is a diagram showing how such cable may be used at a division command post. This example represents the use of cable at the command post or rear echelon of any unit to which cable is available. If carrier system terminal equipments are located at the switchboard instead of at the construction center, these cables are not to be used as part of the trunk lead-in line. Spiral-four cable (WC–548) or Wire W–143 will provide more satisfactory circuits under these conditions.

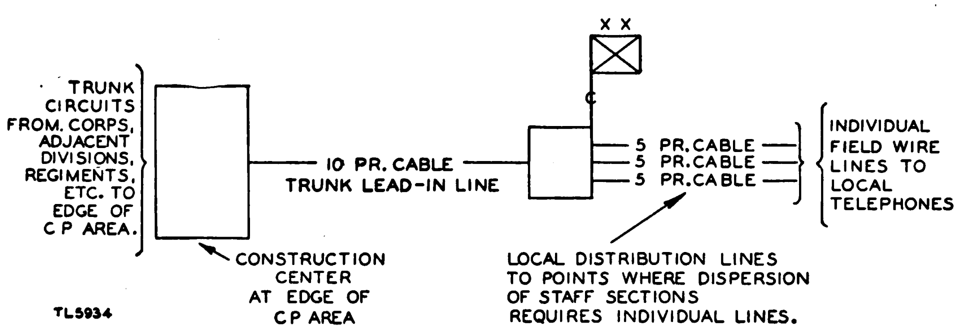


*Figure 2. Examples of use of 5- and 10-pair cable.*

**b.** A short section of line of either of these cables may be used through a wooded area as part of an open wire line. It may also be used for the rapid restoration of service in damaged sections of open wire lines. These uses of cable are an expedient, and such sections should be replaced with open wire as soon as there is time to clear trees, reroute the line, or repair damages. If carrier systems are to be operated over the line, cable should not be used, but the method described in TM 11–368 and 11–369, should be followed.

**c.** These cables should not be used for trunk circuits except in certain special cases, for example in jungle operations where a short point-to-point trunk of five or more circuits may be required.

**6. INSTALLATION PROCEDURES. a.** Cables WC–534 (5-pair) and WC–535 (10-pair) are suitable for use when laid on the ground, buried, or suspended from poles or trees. Cable lines are connected directly to switchboards, switchboard main frames, construction center and test station frames, and terminal strips. Sections of cable are spliced together and connected to terminal strips at convenient intervals to provide test points. The conductors are fanned out at their terminals, and are connected to terminal strips at these points according to the color code. (See fig. 3.) Pair 1 (red-natural) is connected at the top, and successive pairs are connected down the terminal strip. If the terminal strip is outdoors, provision is made for protecting the connection from the rain in order to prevent leakage between conductors or between pairs.

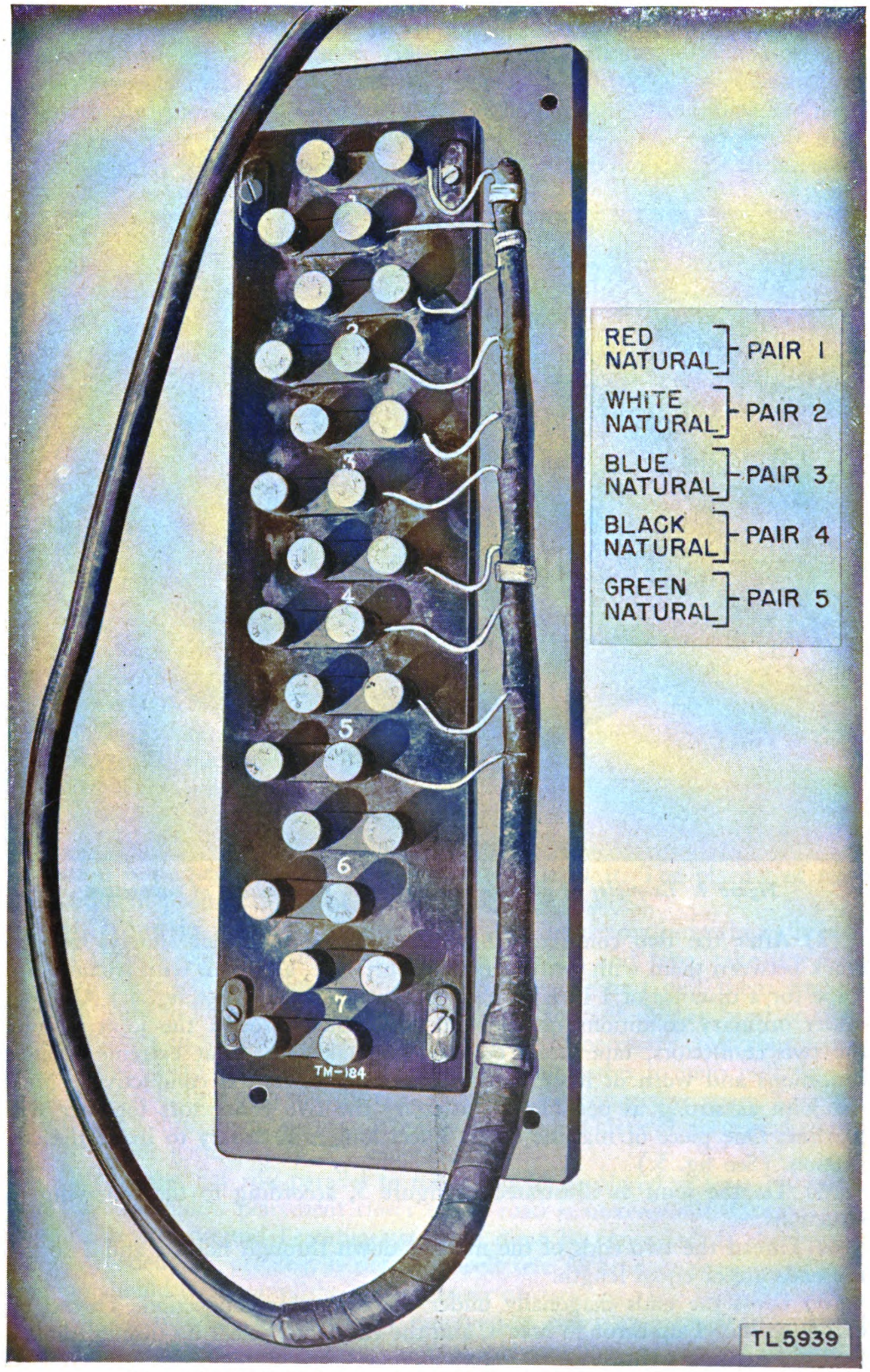


*Figure 3. Method of connecting Cable WC–534 to terminal strips.*

**b.** Much of the trouble occurring on lines using cable assemblies results from carelessness during the connection and disconnection of the connectors. The following instructions and precautions must be observed if the cable assembly is to do the job that it is supposed to do.

(1) First remove the protective tape placed on the connector to keep out dirt. With a connector in each hand, match the plugs and sockets and push the two connectors together. If the two connectors do not go together snugly, push harder or put the hands between the knees to get more leverage. Always push the connectors straight together. Do not bend them from side to side or twist them with a circular motion. Do not use grease or oil as a lubricant, for these substances will ruin the electrical connections as readily as dirt.

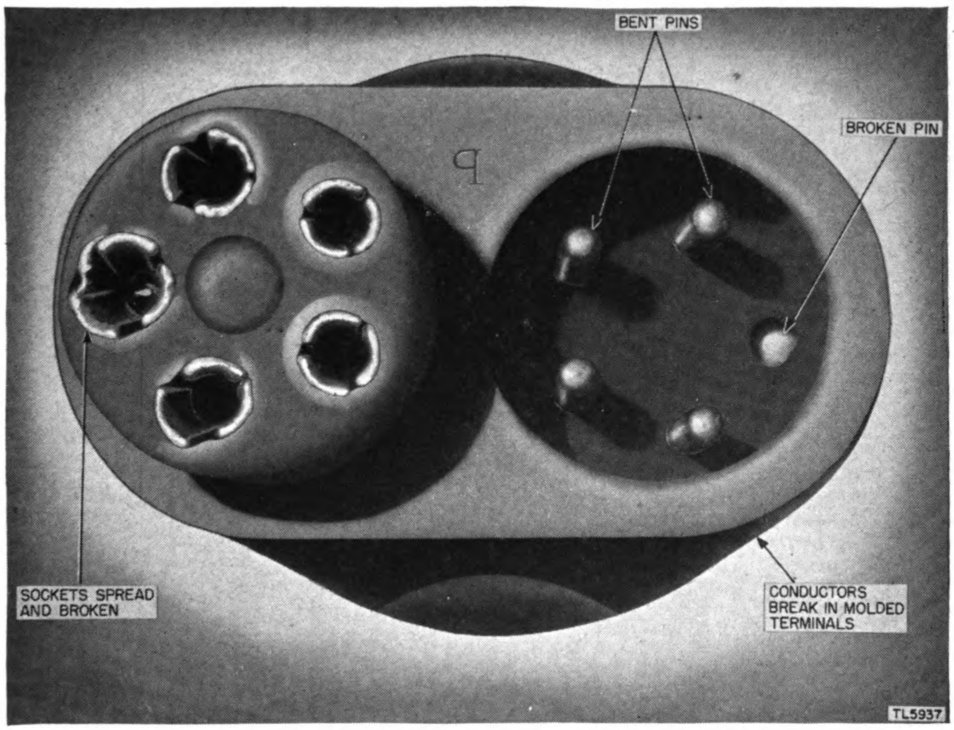


*Figure 4. Examples of damage resulting from mishandling of connectors.*

(2) After the two connectors have been pushed together snugly, tape the crack between them with two layers of rubber tape, and then with friction tape. Tape for a distance of 1 inch on each side of the crack. (See fig. 5.) Although under ordinary conditions no moisture will enter through the joint between the two connectors, tape must be used to make sure that extreme weather conditions and worn or loose parts do not affect electrical conductivity. Make the joint as strong as possible by fastening the two connectors together with marline. One piece of marline about 3 feet long is necessary to make the connection. (See fig. 5.)

(3) Tie the joint as illustrated in figure 5, according to the following instructions:

(*a*) Thread the two ends of the marline down through holes 1 and 2 so that the ends are of equal length.

(*b*) Cross the ends diagonally under the connector connection. Thread the end from hole 1 up through hole 4, and the end from hole 2 up through hole 3. Pull the marline tight.

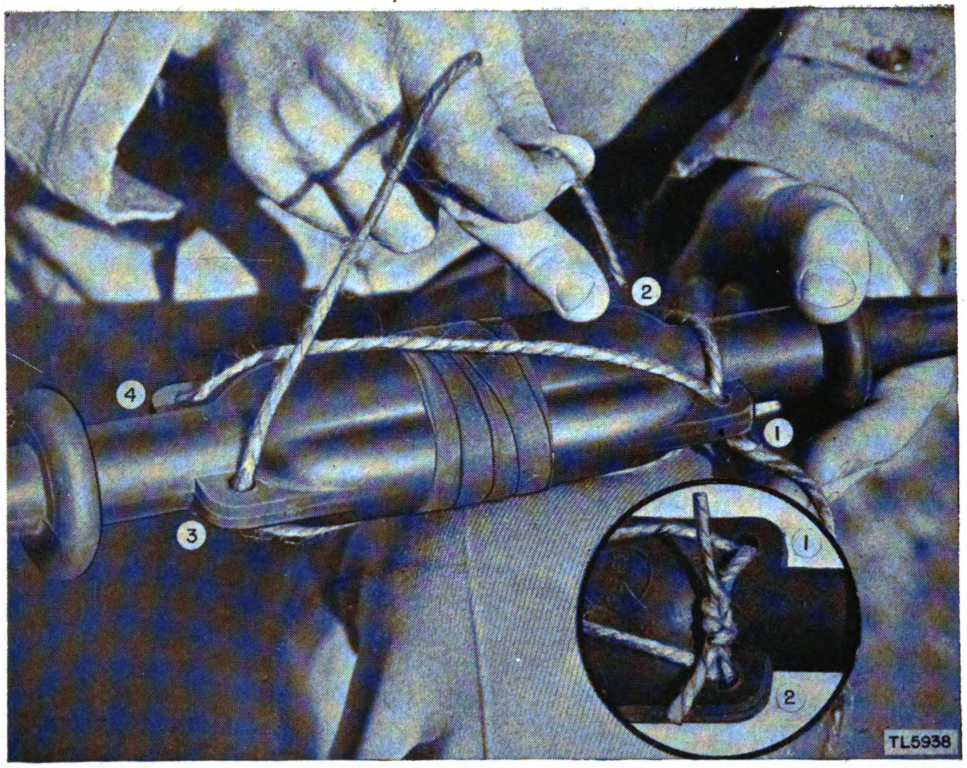


*Figure 5. Method of connecting connectors of cable assemblies.*

(*c*) Cross the ends diagonally over the connector connection. Thread the end from hole 4 back down through hole 1, and the end from hole 3 back down through hole 2.

(*d*) Pull the marline as tight as possible and tie the ends together with a square knot, as shown in the insert in figure 5.

(4) If the connectors are in good condition and the connection is properly taped, it should be moisture-proof. To prevent moisture from collecting at the joint, each connection should be tied to a fence, tree, pole, or stake so that the connection is higher than the cable on either side of it. The placing of such connections in pools of water or streams should be avoided.

(5) It is just as important to disconnect two connectors properly as it is to connect them properly. After removing the marline and tape, take one connector in each hand as close to the joint as possible and pull them straight apart. Be sure to hold the connectors, not the cable itself. Never bend or twist the conductors in an attempt to break the joint. If necessary, put your hands behind your knees from the outside and use your knees to help pull. If this is not successful, two men may be needed to pull the connectors apart. Tape the end of each connector as soon as it is disconnected. This will prevent dirt and moisture from gathering in the connector.

**c.** Cable lines that run parallel to roads should be placed at least 100 yards from the road unless placement closer to the road is unavoidable. Construction activities in and around headquarters areas must be concealed. If the area is heavily wooded, the problem is not a difficult one. Whenever possible, all construction should be accomplished under cover of darkness. The lines themselves must be camouflaged against enemy observation. Such camouflage must blend into the surroundings well enough to make certain that no change in terrain may be noted from aerial photographs taken before and after the installation has been completed.

**d.** All cable should be tested and tagged before installation. These tests can be made at the construction center or supply point prior to installation. Such tests on the cables should cover short circuits, open circuits, and crosses. As each section of cable is installed, it should be tested back to the start of the line.

**e.** This type of cable must be handled with great care, as the soft solid-wire conductors are easily damaged and faults may be difficult to locate. The following precautions should be observed.

(1) Avoid jerky loads or excessive pulls at all times. Vehicles from which cable is being laid should always be accelerated gradually during laying operations. The reel operator should start the reel turning by hand at the beginning of operations to save the cable from having to overcome the inertia of the whole reel through exercise of its tensile strength. If there is evidence of abnormal tension in the cable after the truck has been set in motion and the cable is being paid out, the vehicle should be immediately slowed down or stopped so that the cause of the excessive tension can be found and eliminated.

(2) In pulling cable by hand, never apply tension greater than the pull one man can exert against the anchored or supported cable with one turn taken about his waist or hips. Never use tackle blocks or hitch directly to a vehicle to tension cable.

(3) Install special guys with great care to avoid pinching the cable.

(4) Make every effort to prevent the cable from kinking. When kinks do occur, they should be straightened out by hand and never forcibly pulled out.

(5) Do not roll reels of cable over ground or other surfaces where stumps, stones, or other hard projections may come in contact with the layers of cable on the reel.

(6) Do not pull cable across sharp edges or corners, and take particular care to avoid pulling the cable across the reel flanges or sharp-edged parts of the laying vehicle and equipment.

(7) Since the cable may be crushed by hard or heavy falling objects, by the weight of a vehicle, or by dragged or rolled materials, do not throw tools and empty reels where they may strike the cable, and do not drive vehicles over the cable, especially when it is lying on a hard or stony surface.

(8) When working near a cable with digging tools, be careful not to strike it. When shovelling around or over buried cable, use a scooping rather than a digging motion so that, if the shovel comes in contact with the cable, it will tend to slide along its surface instead of cutting into or through its jacket.

(9) Be careful to avoid dropping a reel of cable when unloading or removing reels from stock piles.

**7. GROUND SURFACE INSTALLATION. a. General.** The basic principles for constructing lines with 5-and 10-pair laid on the ground surface are similar to those which govern construction practice where field wire is being used. The general rules of tying, tagging, and testing field wire lines during construction also apply to cable lines. Reel Unit RL–31 with Reels DR–4, DR–5, or DR–7 is best adapted for use with 5- and 10-pair cables, while Axle RL–27 and Reel Cart RL–16 are also suitable for use with these cables. Reel DR–7 or a wooden shipping reel must be used for long lengths of cable, and an improvised reel unit should be constructed for use with the wooden reel. Reel units may be used either on the ground or mounted on a vehicle.

**b. Laying cable from vehicle.** To lay cable from a reel which is mounted on a vehicle, place a reel of cable on the reel unit and unreel and fasten the end of the cable to a stake, pole, or tree with a basket hitch. (See fig. 8.) Leave enough cable beyond the point of attachment to reach the terminal strip or terminating frame. As previously indicated, the truck should be started slowly and accelerated gradually, while the inertia of the reel is being overcome by hand and the rotation of the reel so controlled that the cable will be paid out under light, steady tension. This control may be accomplished through the application of the reel brake if one is provided, or by using an improvised brake on the reel flanges through the use of a piece of thick flat wood or even a well-gloved hand. Excessive slack is liable to cause kinks to appear in the cable, while over-running may cause a tangle to appear on the reel. Sudden or excessive braking may cause serious harm, even though it may not be sufficiently serious to cause an actual break in the cable or its jacket.

c. **Laying cable from ground.** In localities where a truck is not available or the terrain is impassable to such vehicles, cable can be hand-laid by mounting the reels on either Reel Unit RL-31 or Axle RL-27 and by arranging these along the route. The end of the cable should be secured at the starting point of the line as outlined in b above. When cable is pulled from a reel unit set up on the ground, station men at points not more than 100 yards apart (for 5-pair cable) along the length of the route to be covered. Although this method requires the services of a number of men, the nature of the terrain may sometimes render it the most feasible method of installation.

d. **Improvised reel units.** In cases where the use of wooden shipping reels is necessary, some type of reel unit with which to lay the cable must be improvised. Ordinarily such reel units will be used with a truck and, when so used, must be bolted to the bed of the vehicle. If a reel unit is not secured to the vehicle upon which it is mounted, the danger to the personnel and equipment will be great.

(1) A convenient reel unit may be improvised by using two Cable Reel Jacks LC–13 and an axle of 1-inch or 1¼ inch pipe at least 48 inches long. Bolt the reel jacks to the bed of the particular vehicle in use 25 to 29 inches apart at their closest points. As an additional safety precaution, weld two pieces of flat, slotted steel to the U-section of each jack, and provide a flat, tapered pin shaped like a wedge to fit into the two slots, to hold the axle in the jack. (See fig. 6.) Another safety measure which is necessary to prevent the axle from moving so

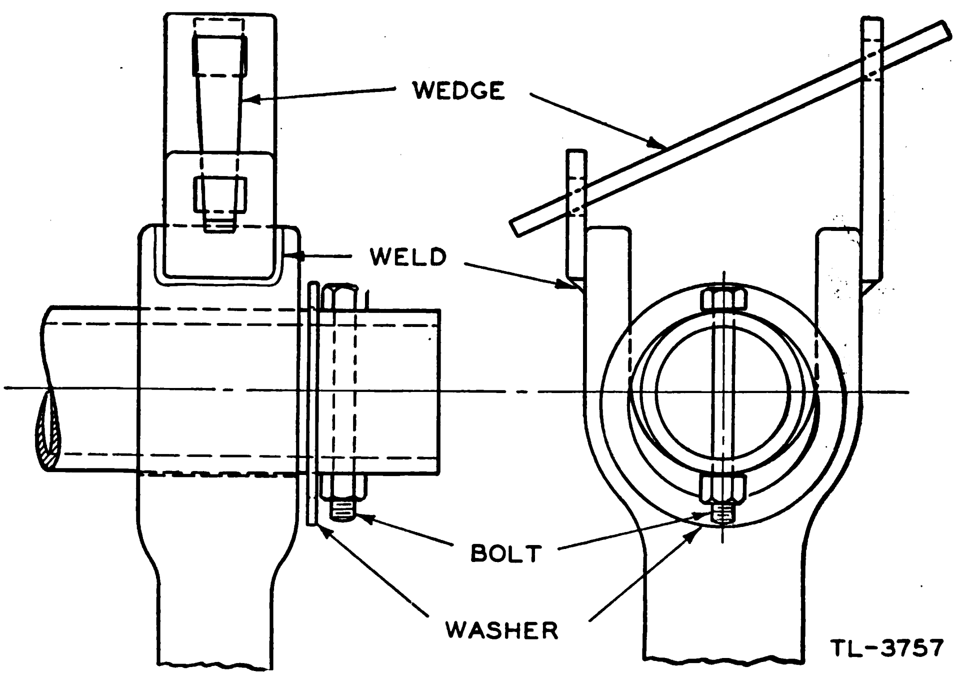


*Figure 6. Method of retaining axle (pipe) in Jacks LC–13.*

far laterally that it would fall from the jack and allow the wooden reel to drop, calls for the placing of a large steel washer over each end of the axle on the outside of the jacks and securing it in place with a bolt and nut. (See fig. 6.)

(2) Cable may be payed out from and wound on wooden reels by the use of a field-constructed wooden A-frame made of 2- by 4-inch material. (See fig. 7.) Bracing between the legs of the two A-frames is necessary, and adequate clearance for the reel must be provided. A 1-inch to 1¼-inch pipe at least 48 inches long will serve as an axle. Place straps over the cuts in the wooden pieces where the improvised axle is set, in order to hold the axle in place. Lateral movement of the axle and the reel can be prevented by the use of a washer, bolt, and nut, as previously described in d(1) above.

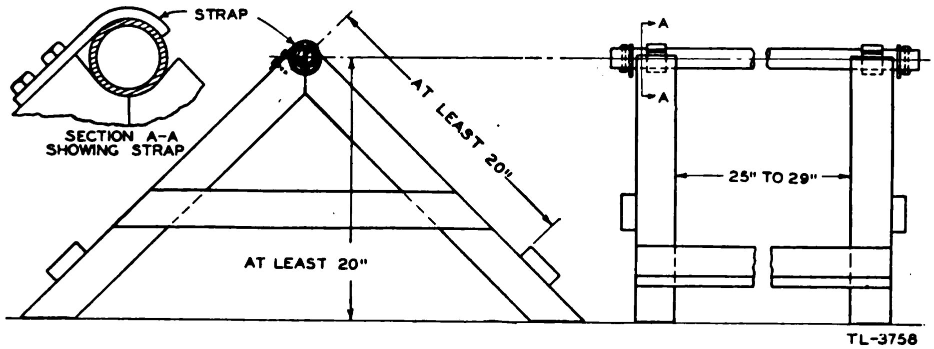


*Figure 7. Construction of wooden A-frame and axle for wooden cable reel.*

**e. Basket hitch.** A basket hitch (fig. 8) is the usual method of attaching cable to a stake or other anchorage. This hitch is made with field wire by using one insulated conductor of the pair. To make an attachment to a stake 7 or 8 feet of single insulated conductor ordinarily will be required. After doubling the wire to locate the center, start the attachment by making a clove hitch at the proper point on the cable, and weave on five or six crossovers. Bring the two ends together and take two full turns of both wire ends around the anchorage. Finish the hitch off by taking one of the ends over the standing part of the wire and the other under, bringing both ends around, and tying them with a square knot. The basket hitch is always tied so that the clove hitch is toward the expected pull. If tension in two directions is expected, use two basket hitches.

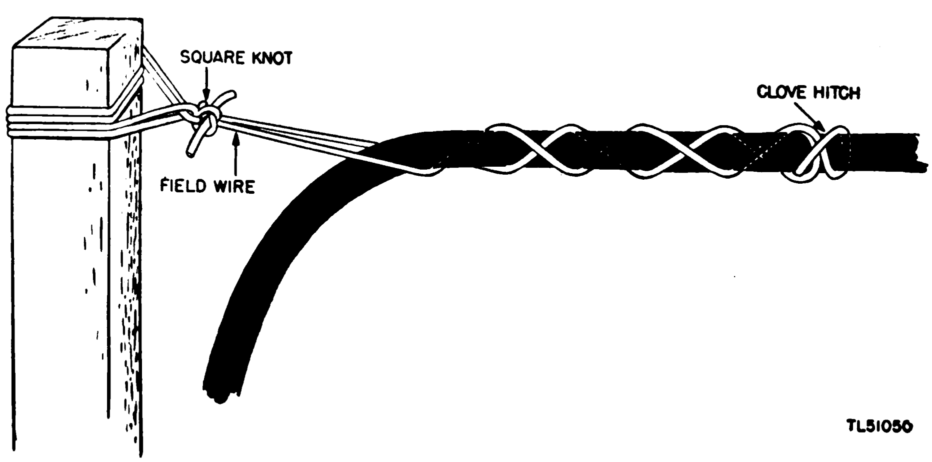


*Figure 8. Basket hitch made with field wire.*

**f. Stakes.** The cable-laying, testing, and policing crews should be equipped with a supply of stakes, field wire, and tools for driving the stakes to which the cable will be attached with basket hitches. Stakes must be strong enough to withstand pulls which may reasonably be expected, and they must be driven well into the ground. For maximum holding power, incline the stake slightly *toward* the expected pull. Cable laid on level ground in a reasonably straight line ordinarily does not need to be tied to the stakes or other anchorages; but, at the point of any substantial change of line direction, a stake should be placed outside the angle of change of direction and the cable fastened to it with a basket hitch. Locate the stakes and apply the hitch so that when laying in the new direction is resumed, the cable will tend to pull away from and not toward the stake. Where steep slopes are encountered, drive the stakes vertically into the ground at suitable intervals, depending upon the steepness of the hill, nature of the surface, and angle at which the cable ascends the hill. Do *not* drive the stakes at right angles to the hillside surface. Fasten the cable securely to the stakes to prevent it from creeping or sliding down the hillside. Place a stake and basket hitch on each side of any length of cable that is buried, where the cable crosses deep ditches, gullies, or other depressions, and where it goes through culverts or under railroad tracks. At any place where there is danger that the rubber jacket of the cable may be rubbed badly; for example, at the ends of culverts, wrap electric friction tape around the cable for protection.

**g. Tagging cable.** The cable should be tagged at both sides of any buried length, or of any length passing through a culvert or under a railroad; at the base of any pole or tree at which point the cable passes from surface or underground to overhead construction; at test points, and at any entrance to a switchboard or terminal frame. Figure 9 shows a 5-pair cable line tag. For a complete discussion of the methods of marking tags, see FM 24–5.

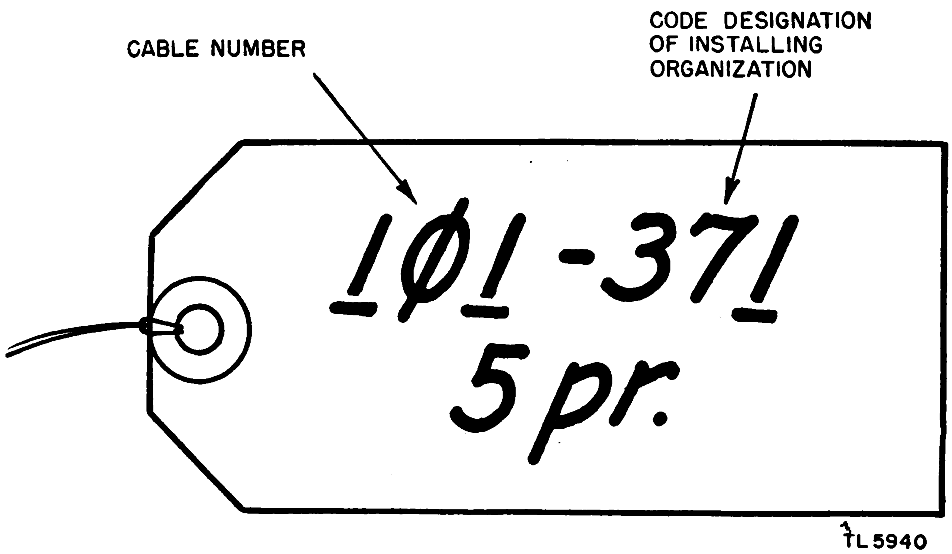


*Figure 9. Example of identifying tag for 5-pair cable line.*

**h. Crossing roads.** When the cable must be buried at road crossings, dig a trench at least 6 inches deep across the road for this purpose. If the road is not graveled or otherwise surfaced, the trench should be more than 6 inches deep so that the cable will not be damaged by passing vehicles during long periods of wet weather. It is important that the trench should be extended far enough on either side of the road so that the cable will be adequately protected from heavy vehicular traffic after it has been laid. After the cable has been laid in the trench, restore the road surfaces as nearly as possible to their original condition. Do *not* leave the cable on the ground surface, as the passage of even light traffic over it is likely to break one or more of the copper conductors, and such faults are extremely hard to locate because the rubber jacket may appear undamaged.

**i. Crossing railroad tracks.** When the cable line crosses a railroad track, pass it under the rails next to a railroad tie, the ballast being first removed and used as a cover for the cable after it has been laid. Bury the cable for several feet on each side of the railroad track as outlined for road crossings. (See h above.) This is necessary as a precaution against damage from hot locomotive firebox cinders which are discharged along the track. Railroad sidings, switch points, and other areas of intense surface activity should be avoided as installation points for cable whenever possible. If such areas must be covered, the cable should be buried at such points for a sufficient distance on either side of the tracks to provide adequately for its protection.

***Caution:*** When electrified railway lines are crossed, great care must be exercised by every one engaged in the cable-laying operations to avoid either personal contact or contact of the cable with the metallic structure of the railway. Only experienced men should be assigned to carry on work at railway crossings where there is a third rail.

**j. Passing through culverts.** In general, cables may be run through culverts under either railroads or highways; but, where there is evidence of a heavy

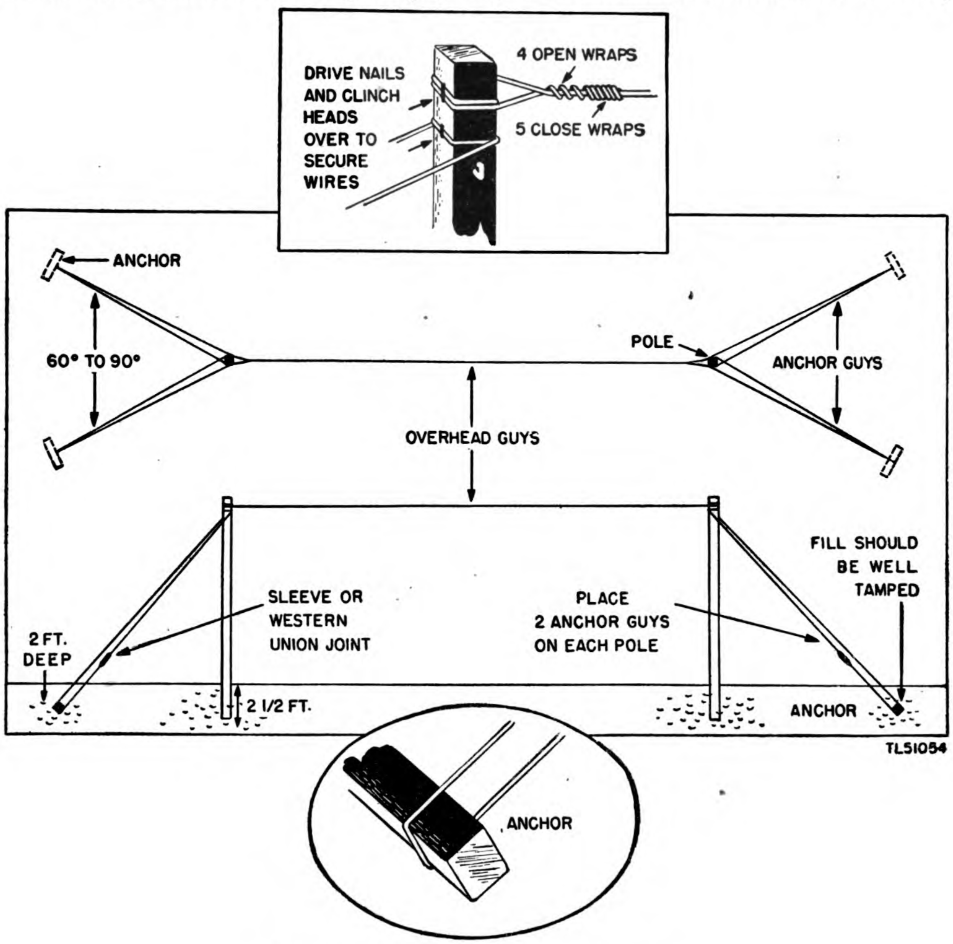


*Figure 10. Overhead crossing support.*

flow of water or the passage of stones or debris through a culvert, it should not be used as a passage for communication cable of any kind. Never pull the cable over rough stones or across sharp corners when it is being drawn through a culvert. Wherever the cable must rest against the sharp corners of the culvert, wrap it carefully with friction tape. Drive heavy stakes well into the ground at each end of the culvert at points well above the highest water level for the stream concerned. Make basket hitches in both directions from each stake. Pull the cable as high up as possible against the side walls of the culvert, and attach the basket hitches to the stakes. Place an identification tag on each stake.

**k. Overhead crossings.** Overhead crossings are made by stringing cable between trees, poles, or other substantial supports. Natural or previously installed means of support will be used if they are found suitable for the purpose. If satisfactory clearances can be obtained, suspend the cable like any ordinary aerial span. Figures 10 and 11 illustrate a method of making overhead crossings when the span length does not exceed 100 feet. See paragraph 9 for methods of making overhead crossings in excess of 100 feet and for the details of aerial cable line construction.

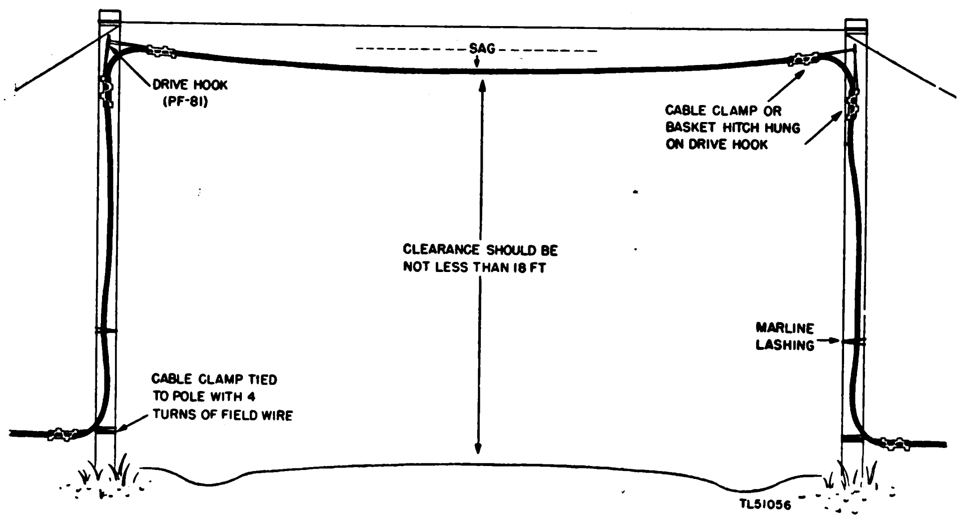


*Figure 11. Overhead crossing span.*

**8. BURIED LINES.** Cable can be installed underground by Plow LC-61 (Cable), by hand trenching, or by machine trenching. Trenching is usually confined to short distances. The use of a cable plow is the preferred method if a substantial length of cable is to be buried. Cable previously laid out on the ground surface can be directly picked up and plowed underground by the moving plow; or it can be buried directly from a reel mounted on the front of the plow, in a truck, or on a trailer. Follow instructions contained in section VI, TM 11-369 and TM 11-370 for the underground installation of 5- and 10-pair cable.

**9. AERIAL CABLE LINES. a. General.** Aerially constructed cable lines are those which are intentionally supported above ground level. A line attached to trees or other supports to provide the necessary clearance from the ground surface constitutes an aerial line. Cable casually supported by underbrush or thickets, if otherwise laid directly on the ground, is classified as ground surface construction. The aerial construction methods described in this manual are principally those in which poles or other supports can be erected rapidly. The methods of cable suspension used in this type of construction are also useful where other types of supports, such as trees, existing poles, etc., are available.

**b. Weather conditions.** The type of overhead line described in this paragraph is not designed to withstand unusually severe weather conditions. Aerial cable installations in areas subject to high winds or sleet (glaze) storms should be constructed with these weather hazards in mind. Increased resistance to damage by severe weather conditions can be gained by shorter span lengths, more frequent guying, and deeper setting of poles. When the clearance at aerial crossings is determined, the effect of any sleet load to which the line might be subjected should be taken into account. Particular care should be taken in designing and constructing aerial cable lines if trees are used as supports. Since the cable may be snapped or badly damaged through excessive tension set up as a result of tree movement under wind pressure, the trees selected as supports should be sturdy enough to withstand gales and stormy weather.

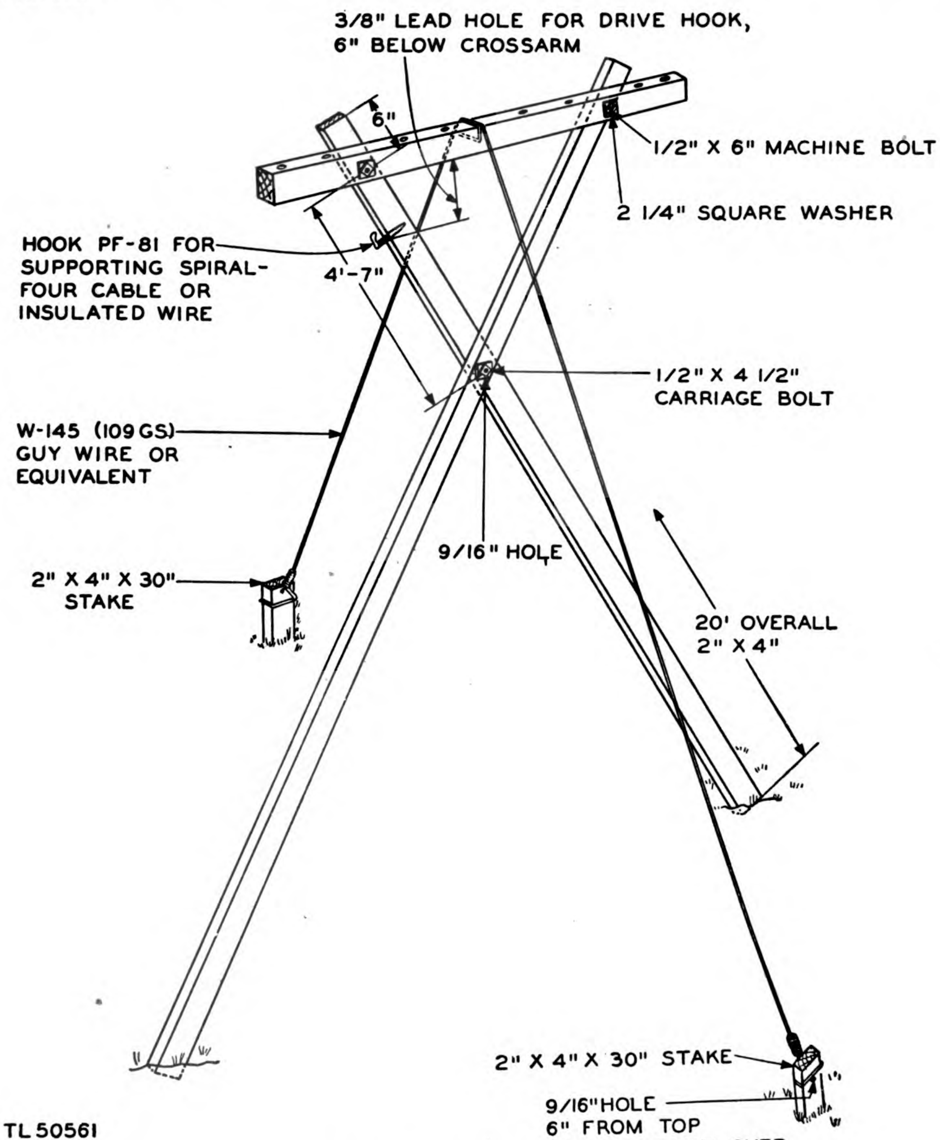


*Figure 12.* X-*frame assembly.*

**c. Items needed for installation.** Relatively few items of material are needed to install the types of cable lines previously discussed. These items, together with their functions, are indicated below.

(1) Poles used in overhead construction will consist of 4- by 4-inch sawed lumber or an equivalent section obtained by nailing two 2- by 4-inch pieces together. Whenever possible, use heart or grade 1 lumber. Select the sounder of the two ends of every piece of timber so used for placement in the ground. The usual length of the pole for such construction is 20 feet.

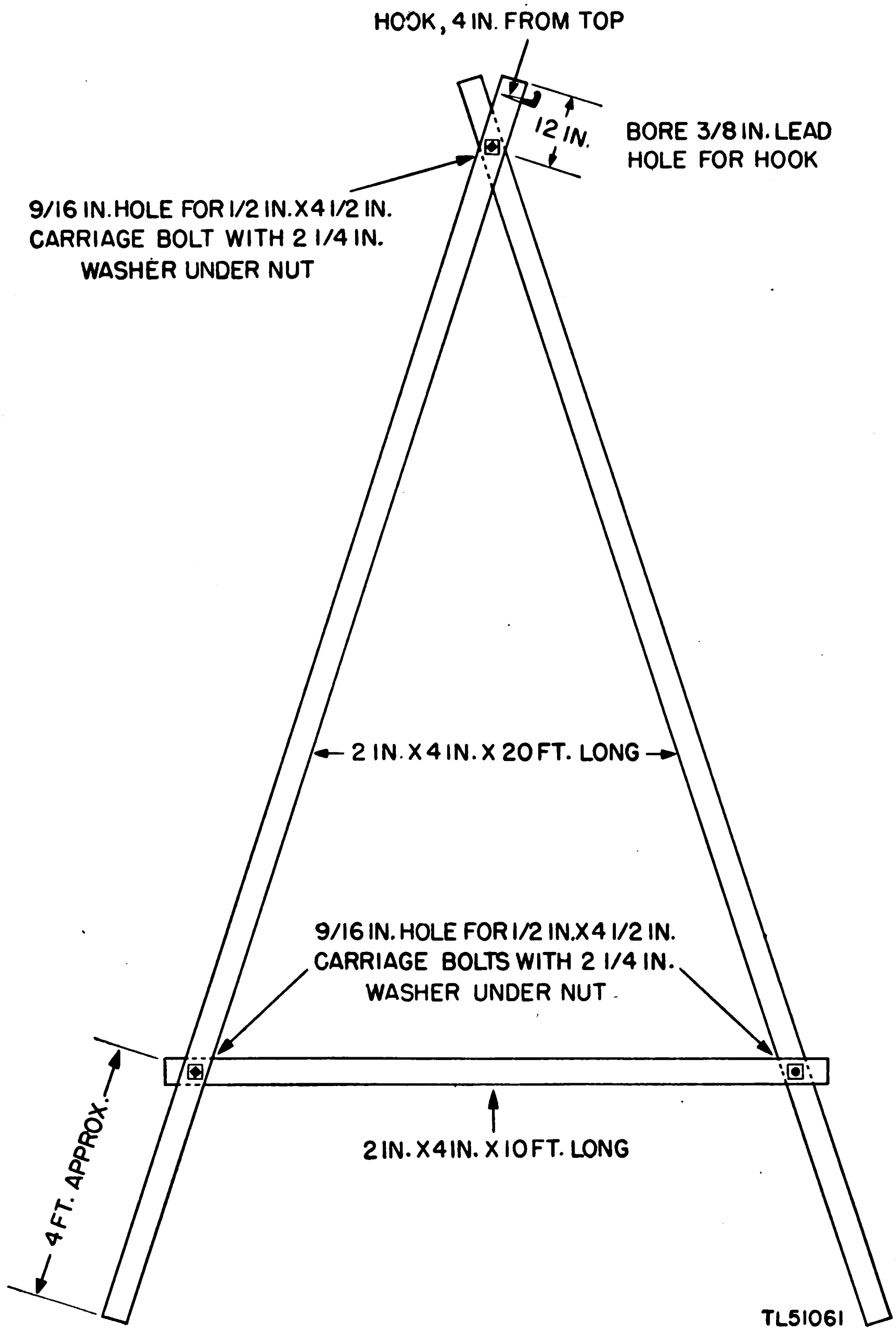


*Figure 13. A-frame assembly.*

(*a*) Where reasonable permanency is desired, a suggested method is to boil the end of the pole to be set in the ground in creosote oil at 225° to 235° F., for 6 hours. Allow the oil to cool to 150° F., while the end of the pole remains immersed in the oil to a point 1 foot above the pole surface contacted by the ground level. Where dipping is impossible or impractical, two or three coats of hot creosote may be applied with a heavy paint brush to thoroughly-seasoned cedar, chestnut, cypress, juniper, or other decay-resistant woods. When the latter method is used, take care to thoroughly saturate the lower (butt) end of the pole.

(*b*) Natural, rough poles, when locally obtainable with reasonably straight lengths of 20 feet and with top diameters of 4½ inches, are satisfactory substitutes. Other woods also suited, by natural growth, to use as poles for a cable line are pine and fir. The life of southern pine poles, without impregnation with a wood preservative, is very short. Therefore, it is common practice to treat the entire length of pine or fir poles by a standard pressure-applied preservative method, whereas butt-end treatment is usually sufficient where cedar and chestnut poles are used.

(*c*) X-frames and A-frames are made from pieces of 2- by 4-inch timber 20 feet long. (See figs. 12 and 13.)

(2) The cable hanger (fig. 24) is a single piece of galvanized steel wire, formed into two open helixes and separated by a supporting loop. Hangers of the proper size may be improvised from galvanized steel wire. Cable hangers are used as intermediate attachments at supports and to suspend cable from the suspension strand in long, open construction.

*Note.* The Signal Corps cable hanger whose stock number is 5B3459 was designed for use on spiral-four cable, and is too small to be used on 5- and 10-pair cable.

(3) A commercial type of clamp (fig. 14) known as the Kearney (Lay-cit) may be used with 5-pair cable on short spans for short periods of time. However, care must be taken when installing this clamp to keep its lacing from cutting into the rubber jacket of the cable. Cable clamps are used for dead-ending or for any other purpose which requires a nonslipping grip on the cable.

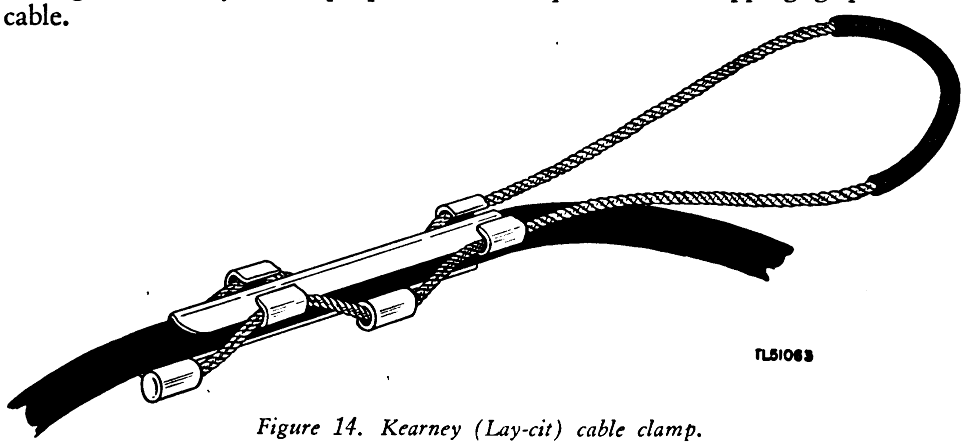


*Figure 14. Kearney (Lay-cit) cable clamp.*

(4) Drive Hook PF–81 is a drive hook driven in a ⅜-inch lead hole in the support to receive cable attachments.

(5) Clamp PF–61 is a strand clamp used for clamping 2,200-pound strand in long span construction.

(6) A 2,200-pound, 7-strand, galvanized steel messenger wire is used for the guys and messenger in long span construction.

(7) No. 12 BWG (109-inch) galvanized steel wire is used for guying and as a general-purpose wire.

(8) Anchors are made from halves of crossarms or other timbers or logs of equivalent or larger size.

(9) Carriage bolts, ½ by 4½ inches are used in the assembly of the X- and A-frames. Machine bolts, ½ by 6 inches, are used in assembling crossarms on X-frames. When long poles are fabricated, ⅝ by 10-inch machine bolts are used in splicing 4- by 4-inch timber.

(10) Common wire nails in sizes of 10–d, 12–d, and 20–d are used in fabricating 4- by 4-inch poles from 2- by 4-inch lumber.

(11) Field wire is used for making ties, tension bridges, and basket hitches, and for suspending cable hangers from trees.

(12) Friction tape and rubber tape may be used to protect the cable at points of pressure and to repair minor damage to its jacket.

**d. Spans.** Unsupported spans should not exceed 100 feet in length. Where a 100-foot span is used, a 3-foot minimum sag is required. In regions where ice-forming weather conditions are encountered, the maximum span must not exceed 50 feet; while the same 3-foot minimum sag used for 100-feet spans is required. The lowest point in any span in open country must be at least 14 feet above the ground surface, while a clearance at main traffic artery crossings must be at least 18 feet. Communication cable is always buried or carried through a culvert at railroad crossings (par. 7i and j), and a separation of at least 100 yards should be maintained between any cable line and parallel railway tracks, highways or electric power transmission lines.

**e. Guys.** (1) Guys are used to stabilize poles which must be set in soft ground and to offset an unbalanced pole load caused by changes in the direction of the cable line, unequal span lengths, or dead ends in the line. Such guys are usually attached to anchors which are buried in the ground or to trees, when available. Where buried anchors are used, the distance of the anchor from the pole should be at least equal to the height of the pole above the ground surface. When a tree is used as an anchor, the guy should be attached at a sufficient height on the tree trunk to form an angle (X) with the ground which will be at least as acute as the angle (X) would be were a buried anchor used. (See fig. 15.) Moreover, when a guy wire is attached to a tree, care must be taken to prevent the cable from cutting the tree. Do this by inserting narrow pieces of short boards vertically between the cable and the tree trunk to extend throughout the possible arc of contact between the tree trunk and the cable.

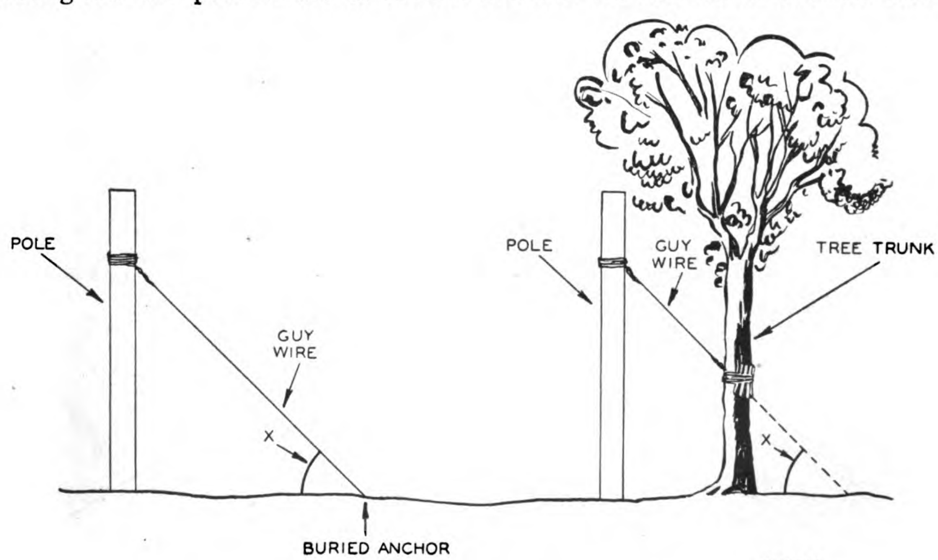


*Figure 15. Location of pole guy wire on tree trunk.*

(See fig. 16.) When the change in direction of an aerial cable line is less than 58°, the corner guy should bisect the exterior angle. (See fig. 17.) If the change in direction exceeds 58°, the line must be head-guyed as shown in figure 18. When sharp turns of approximately 90° are necessary, the cable should be dead-ended in each direction with basket hitches or clamps.

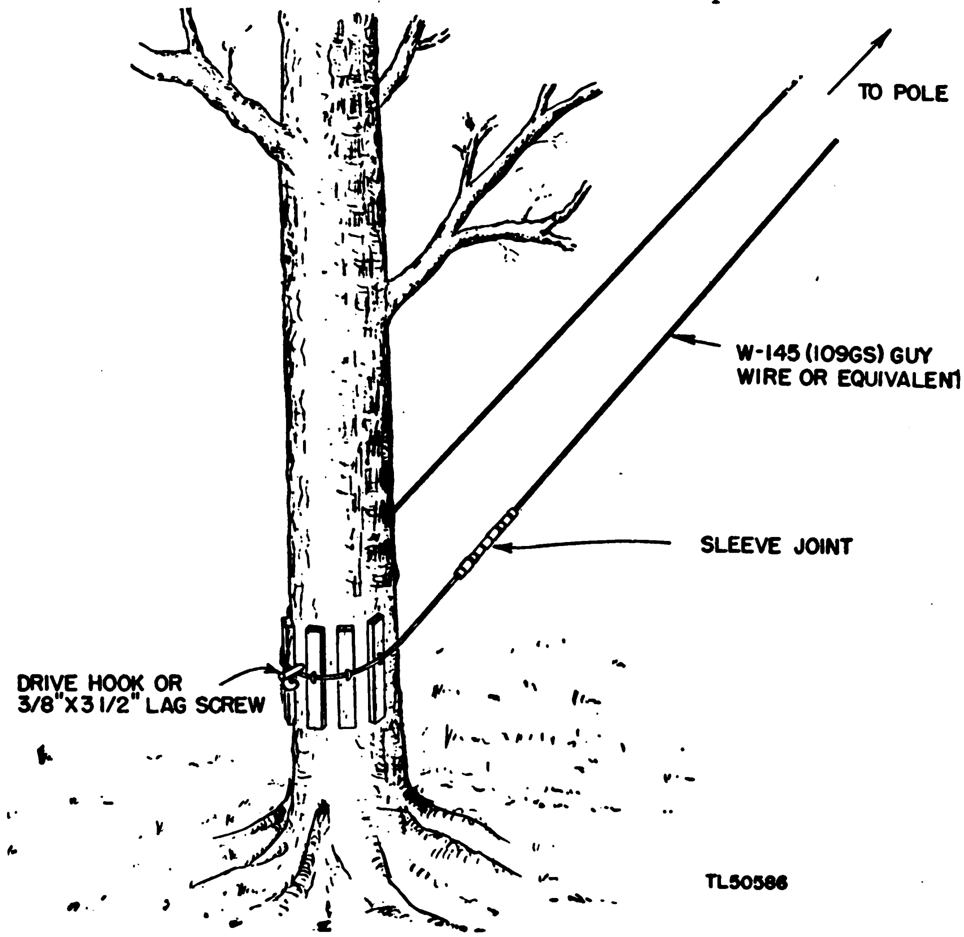


*Figure 16. Method of attaching guy wire to tree trunk.*

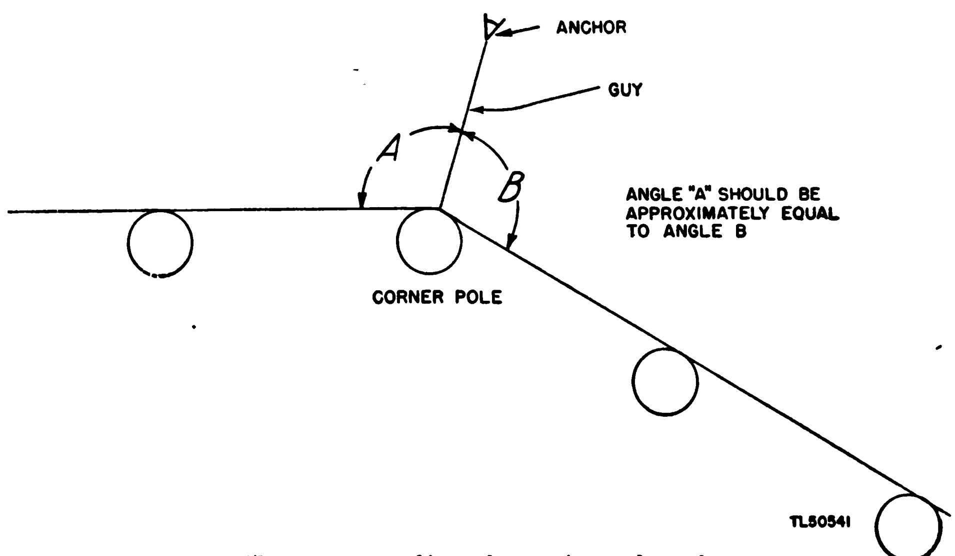


*Figure 17. Corner guys bisect the exterior angle at the corner.*

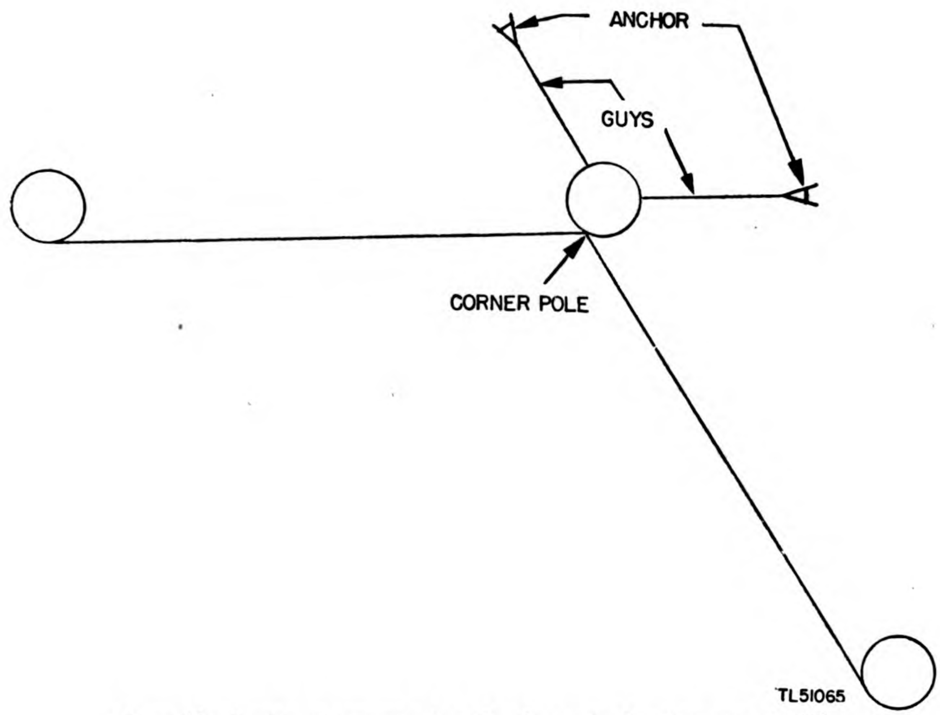


*Figure 18. Guying at corners when the change in direction exceeds 58°.*

(2) Usually the only equipment necessary on the pole is Drive Hook PF–1 which is screwed or driven into the pole top and to which guy wires are attached when required. (See fig. 19.) As a rule about 60 feet of guy wire is required for each anchor guy on a 20-foot pole. This wire is doubled back on itself at a point about 5 feet from its center, making one leg of the guy about 10 feet longer than the other. The wire is then wrapped once around the pole top (fig. 19) in a loop at the doubling point of the wire, and one or more nails are driven into the pole and clinched over the guy wire. The larger leg of the guy is passed around the anchor, and brought above the ground surface where it is spliced to the shorter leg. Care must be taken to maintain as much tension as possible in the guy wire during these last operations. A single guy wire about 60 feet long is attached to X- and A-frames (figs. 12 and 13) with legs of wire of equal length extending on each side of the frame.

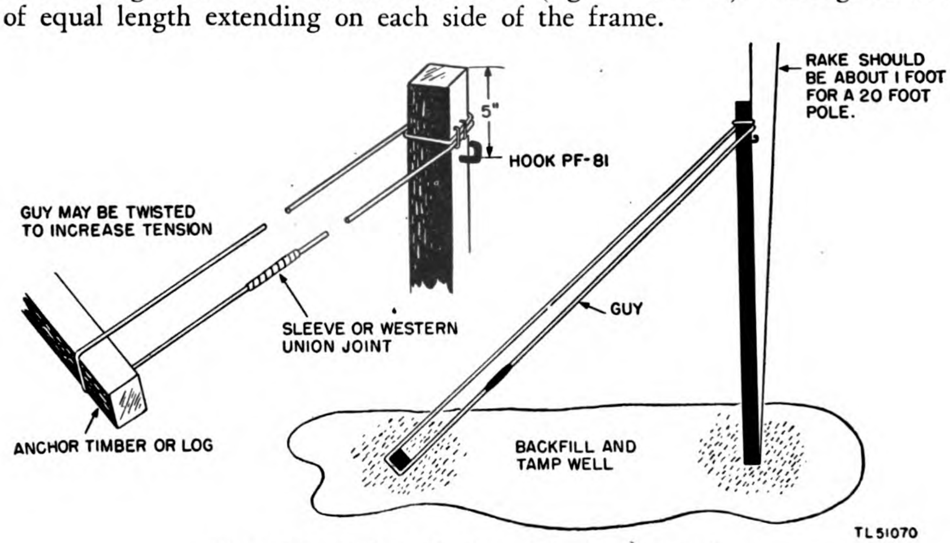


*Figure 19. Guying poles for aerial cable construction.*

**f. Erection of poles.** Holes for poles are dug with shovels, earth augers, post hole diggers, or other available mechanical digging devices to a depth of 2½ feet. Do not disturb the surrounding earth any more than is necessary. The diameter of the hole must be held to a minimum. Anchor holes should be of such depth that the top of the anchor is not less than 2 feet below the ground surface. Where light or sandy soil is encountered, greater depths may be necessary. Raise the poles by hand and set them in position in the center of the hole. Then align the poles by turning until the drive hook faces the proper direction, and hold them in a vertical position while the backfill is thrown in and tamped around the base of each pole. Because of the relatively shallow setting of these poles, the backfill must be tamped thoroughly as each shovelful is thrown into the hole around the pole so the soil will be well-compacted from the bottom of the hole all the way up to its top. Wherever stones or broken brick are available, break them into pieces of such size that they will fit snugly around the pole when tamped into the bottom of the hole and around the lower end of the pole before the backfill has been started. (See fig. 20.) When the strain on a pole will be in a predictable direction, stability may be added

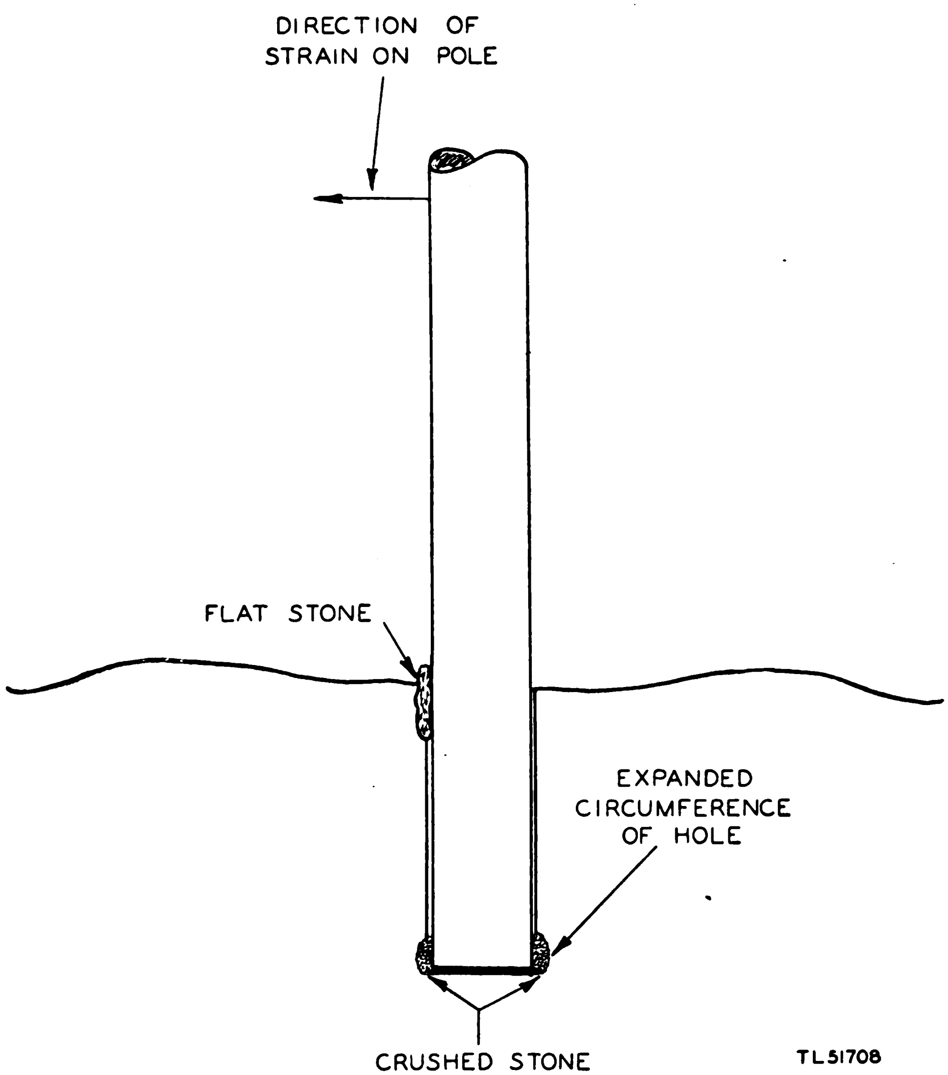


*Figure 20. Method of securing pole in hole with pieces of brick or broken stones.*

to it by driving a large flat stone edgewise into the backfill at the top of the filled-in hole and close against the pole's circumference in the direction of the predictable strain. Any pole which is to be guyed is given a rake (fig. 19) toward the anchor. Align corner poles so that the drive hook bisects the interior angle at these points, and erect X- and A-frame structures across the cable line right-of-way in such positions that their feet will be equidistant from the location stakes on each side. Drive an anchor stake vertically, or slightly inclined toward the location stake, about 20 feet from it on each side of the structure in the direction of the lead. With the frame held in a vertical position, the two guys are pulled tight and wrapped one and one-half turns around the stakes. A hole in the stake or a nail driven in the side opposite the structure will provide more reliable holding power. Wrap the end of the guy wire around the standing part of the guy with at least four complete turns. Use swamp footings if poles or frames must be set in swampy or other unstable ground.

*Note.* It is not advisable to use lineman's climbers on 4- by 4-inch poles because of their small size and the danger of gaff cut-outs. A scaling ladder should be used on this type of pole. In the absence of such a ladder, an ordinary ladder, when lashed to the side of a cargo or construction truck, is a satisfactory substitute.

**g. Anchoring.** (1) An anchor is usually made from pieces of 4- by 4-inch or 2- by 4-inch pole lumber. These materials will usually have been treated with a salt preservative and are, therefore, suitable for use in areas where termites are active or where untreated wood might rot rapidly. When other materials, such as sections of logs or timbers, are used as anchors, the upper bearing area must be at least equal to that of a half crossarm, and the possibility of decay or termite attack taken into account. A half-driven staple or a bent-over nail located at the longitudinal center of the anchor will hold the guy wire in position. The wire must be free to move freely through the staple or nail. Pass the guy wire over the anchor so the free end will come from its lower side. When a half crossarm is used, pass the guy through the bolt hole near its center and around the lower side of the anchor. Figure 21 shows various forms of anchors.

(2) Anchor holes should be 2½ feet deep, and the wall against which the anchor will pull should be cut clean in undisturbed earth to give maximum bearing and resistance to guy wire pull. A slight undercut in the wall of the anchor hole nearest the pole or structure being guyed adds effectiveness to the anchor by protecting it against being pulled out of the hole. Use a digging bar to cut a slanting slot in the ground to accommodate the guy wire. Backfill the hole and tamp it thoroughly after the anchor has been placed to provide for the latter.

(3) Pull the guy wires up with sufficient tension to hold the pole top in the desired position, and splice the wire by using a sleeve or a Western Union joint. A guy which is too slack after the wires have been spliced can be tightened by inserting two sticks between the two wires and twisting in opposite directions. Tie the ends of the two sticks together when the guy is tight enough.

**h. Installing cable on poles.** (1) To install the cable on the poles, lay it on the ground as was done for ground surface installation. (See par. 7.)

(2) Cable which has been in service over the same right-of-way as a ground surface line will generally have excess slack which must be worked ahead or taken care of at poles. When cable slack is to be stored at a pole, coil it in a figure 8 of convenient size, bind it at several points, including the crossover, and support it on the pole by bushings of field wire or marline. Where slack is stored in this manner, make a dead-end attachment to the cable in both directions using a basket hitch or a cable clamp.

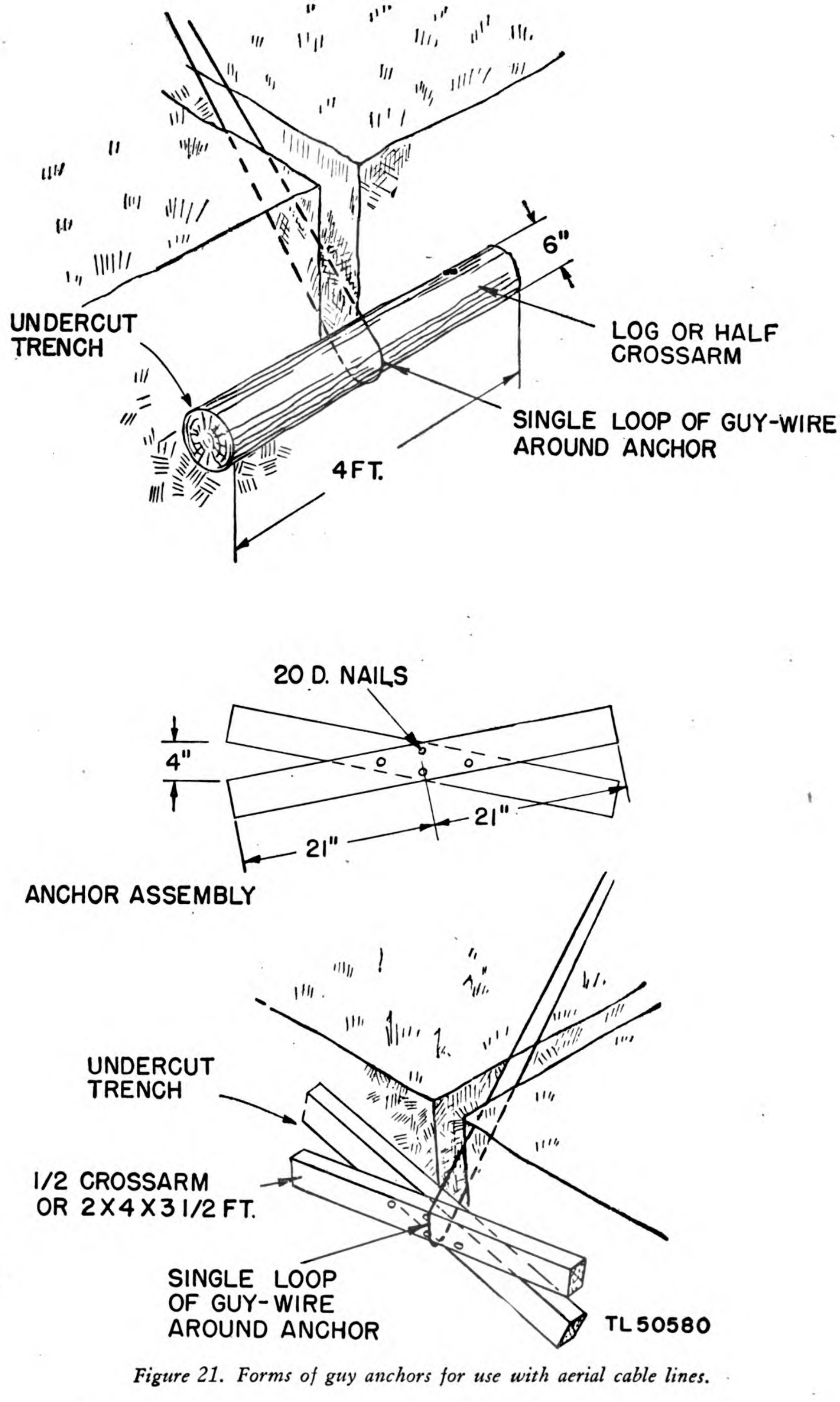


*Figure 21. Forms of guy anchors for use with aerial cable lines.*

(3) The end pole of the line where construction is started is referred to as the "zero pole" in the following description of the methods used in placing cable on poles. Leave enough cable at the base of the zero pole to reach the equipment to which the cable is to be connected. If the cable is to be buried or run on the ground from the zero pole to the equipment, fasten the end of the cable to the base of the pole with a basket hitch. Apply the basket hitch so it will relieve the cable of any strain at the point of attachment to the pole. Use two similar fastenings at the top of the pole, one to support the vertical run of cable, the other to dead-end the first aerial span.

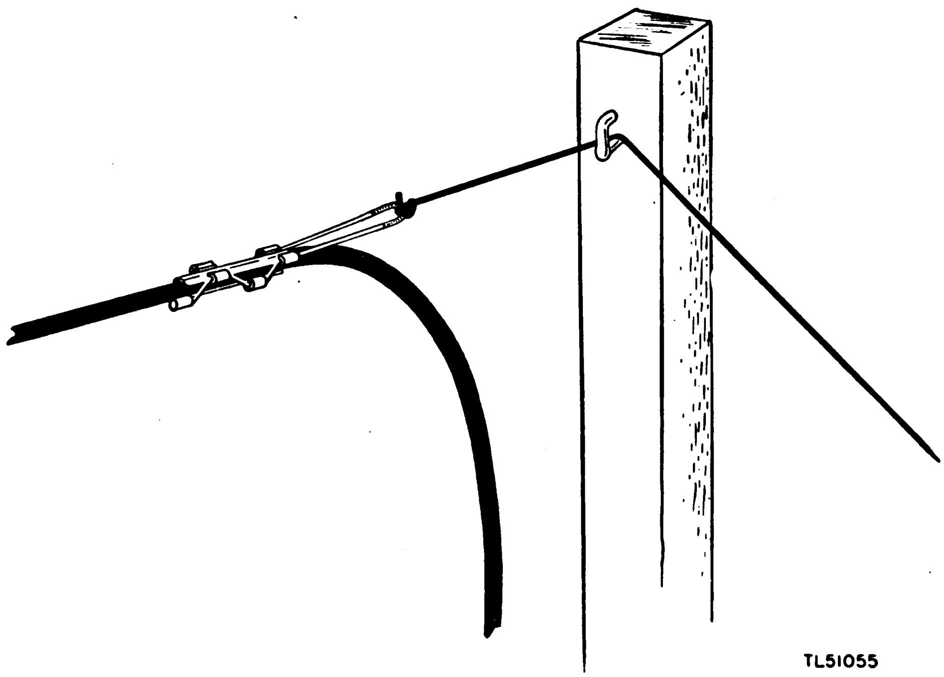


*Figure 22. Pulling cable to proper sag with hand line.*

(4) If the line is to remain in service for only 1 month or less, as many as 5 or 6 spans of cable may be tensioned at one time in straight sections of the line. Raise the cable with Wire Raising Hooks LC–65 or have a climber carry it up the pole. Place the cable over the drive hooks at poles 1 to 5 inclusive.

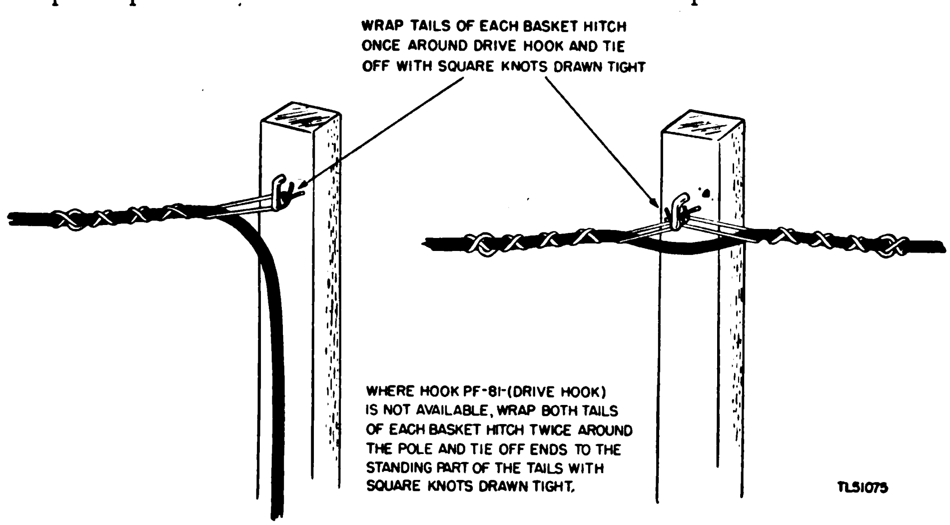


*Figure 23. Single and double dead-ends made with basket hitches.*

Apply tension by hand from a position near the base of pole 6. *Do not use block and tackle equipment.* Try to avoid pulling the cable at sharp angles when pulling it over the drive hooks. When it is necessary to pull at a sharp angle, use the method shown in figure 22. A lineman stationed on pole 5 estimates the sag and calls for more or less tension as required. When the sag is correct the lineman on pole 5 places a cable clamp or field wire basket hitch (figs. 8 and 23) to hold the tension in the section which has been sagged. Pole 5 is braced with a suitable timber or pole, or is guyed temporarily before the man on the ground near pole 6 releases the head tension. Repeat this procedure in succeeding sections.

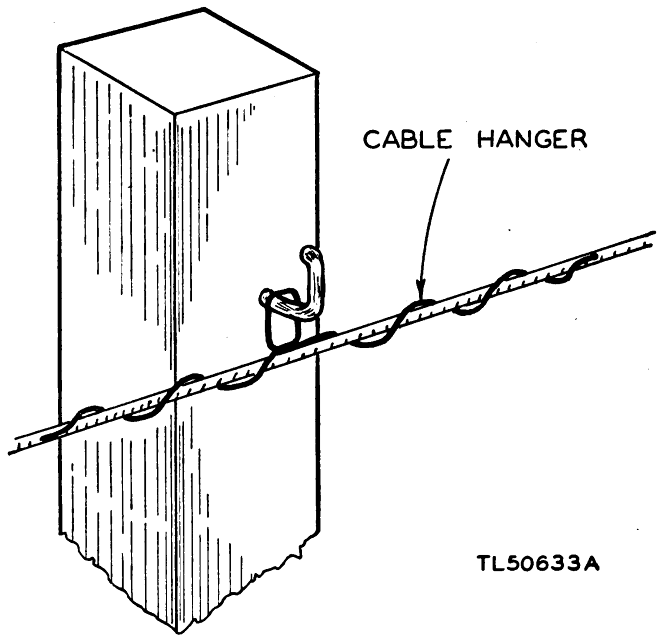


*Figure 24. Intermediate support for cable using hanger.*

(5) If the cable will be in service for a long time, tension each individual span and dead-end it in both directions with basket hitches. After a section of cable has been sagged, place cable hangers at each point of support. (See fig. 24.)

**i. Installing cable on trees.** (1) *General.* Poles are preferable to trees for aerial cable supports, and a different method of construction is required if trees are used for this purpose. The chief reason for this difference is that, when high winds are blowing, two trees supporting an aerial span may be swayed several inches in opposite directions at the points of attachment. A few inches movement of the support in a span with normal sag will cause enough increase in tension to break or damage the cable or its support attachments. There are two possible ways of compensating for this effect. More than the normal sag may be provided, or a floating suspension construction involving the use of slings may be adopted. The latter method requires extra care in policing and more maintenance than the former. Cable-supporting trees are so selected that a minimum amount of trimming will be required. When possible, a slight strain tending to pull the cable away from the tree is desirable. *Where the line changes direction, the cable is always on the side of the tree facing the direction of strain.* All trees to which cable is to be attached should be tall enough to provide the necessary standard clearances at the midpoints of the spans on each side of the tree. These various requirements may necessitate the occasional insertion of poles at points where suitable trees are not available, or where the exclusive use of trees would entail an indirect routing of the cable line.

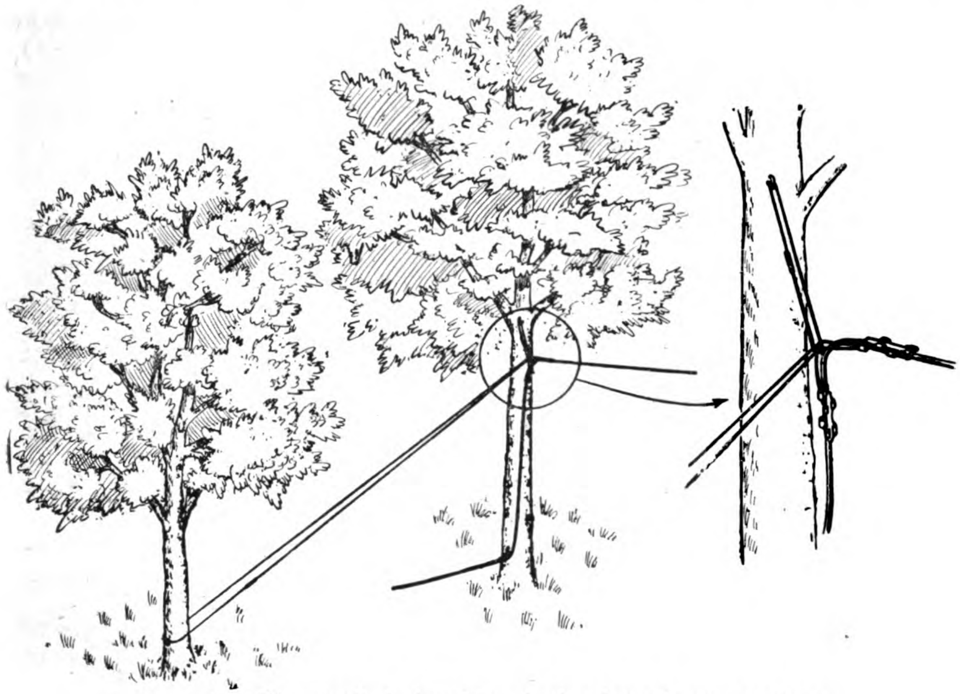

*Figure 25. Sling method of making dead-end attachments to trees.*

(2) *Dead-ends.* Figure 25 illustrates the method of making dead-end attachments to trees with slings.

(*a*) On the side of the dead-end tree which faces the cable, install a drive hook to support the sling. Locate the hook 3 or more feet above the point where the cable is to be suspended. Make a sling loop of the necessary length (usually about 3 feet), using 109 GS wire. Hang this sling loop over the drive hook.

(*b*) If the tree is too small and slender to take the strain alone, use 109 GS wire to make a guy in the form of a long loop. Thread this loop through the sling and pass it from that point to a convenient anchorage, such as a tree trunk or a heavy stake, at least 50 feet away from the dead-end tree and low enough to be relatively unaffected by the sway of the anchor tree. Choose such a location for the anchorage that the guy will oppose the load of the first span of cable, and the lower end of the sling loop will be pulled out about 6 inches from the dead-end tree when the cable is tensioned. Adjust the length of the guy so that, with the cable under tension, the sling will appear to hang almost vertically below the drive hook. Hang strips of cloth at frequent intervals on that part of the guy which will not clear pedestrian and usual vehicular traffic.

(*c*) Raise the cable and attach two basket hitches or cable clamps, one to take up the load of the first span and the other to support the vertical run of cable. The tails of these basket hitches or cable clamps are threaded through loops of both the sling and the guy.

(*d*) Place a cable or a basket hitch at the base of the dead-end tree to take up any pull put on the ground run of cable. Fasten this clamp or hitch to the


*Figure 26. Field wire sling for intermediate support of cable in trees.*

tree at head height or less with several turns of field wire. Lash the vertical run of the cable to the dead-end tree with a few turns of field wire.

(3) *Intermediate supports.* Use the construction illustrated in figure 26 at intermediate supports.

(*a*) In the side of the tree toward the cable, install a drive hook at a point 3 or more feet above the desired cable position. A man stationed 100 feet or more beyond this tree applies tension to the cable while a man on the tree checks the sag.

(*b*) When the sag is correct, mark the cable at a point where a hanger is to be placed. Lower the cable to the ground and put the hanger in place. Tie one end of a length of field wire, long enough to reach from the ground to the drive hook and back, securely to the edge of the hanger. Pass the wire over the drive hook.

(*c*) By pulling on the free end of the wire, the cable will be drawn up until the hanger is suspended not less than 3 feet from the drive hook. Tie the wire securely around the tree at a convenient height so that the cable is held in the proper position. This suspension allows the cable hanger to float as the tree sways in the wind, and thus minimizes the danger of damage to the cable.

(4) *Corners.* Use a sling at corners similar to the one described for use at dead-end trees (i(2) above), adding a second guy in such a position that the two guys will hold the lower end of the sling loop at least 6 inches away from the corner tree. This type of suspension is illustrated in figure 27.

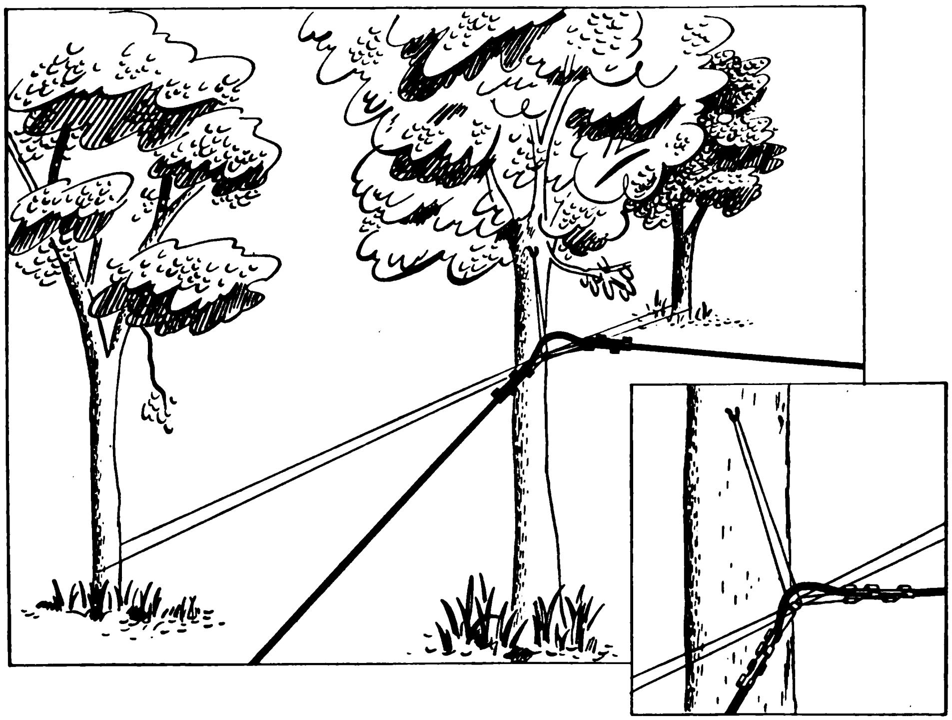


*Figure 27. Corner sling for use with cable supported by trees.*

(*a*) Place the drive hook so its location will approximately bisect the exterior angle of the line corner. This will insure that the cable will pull away from the tree, and will also allow the sling to swing out from the tree in a direction which will minimize stress on the cable due to tree sway.

(*b*) Make up the sling and guys as previously described (i(2)above), passing the latter through the sling loop. Adjust the two guys so the sling loop will appear to hang vertically when the drive hook is viewed head on.

(*c*) Tension the cable temporarily at the base of the corner tree, judging the proper tension by the alignment of the preceding suspension span. Place a cable clamp on the tensioned cable at a point 4 feet from the base of the tree; and attach a hand line to the tail of this clamp. Pass the hand line through the sling loop and again pull the cable up to tension. A man should be stationed on the tree side to ease the hand line through the sling.

(*d*) Place two basket hitches or cable clamps in such a position that the cable will be dead-ended in each direction at the sling. Pass the tail of each basket hitch or cable clamp through the sling loop as well as through the loop of the guy which leads in the opposite direction from the span being dead-ended.

(*e*) Release the hand line and remove the temporary clamp to which it is tied.

**j. Tension bridges.** Reinforce the cable by bridging splices with basket hitches or cable clamps as shown in figures 28 and 29.

**k. Long span construction.** Where long spans must be used or where the proper clearance in spans of normal length cannot be obtained by the methods ordinarily used, special construction methods must be used. A suspension strand is strung between two properly guyed poles of suitable height, and tensioned

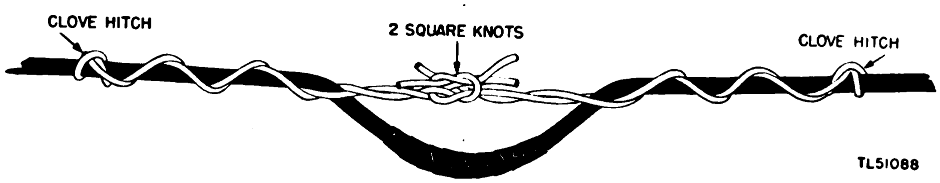


*Figure 28. Tension bridge with basket hitches at an expedient splice.*

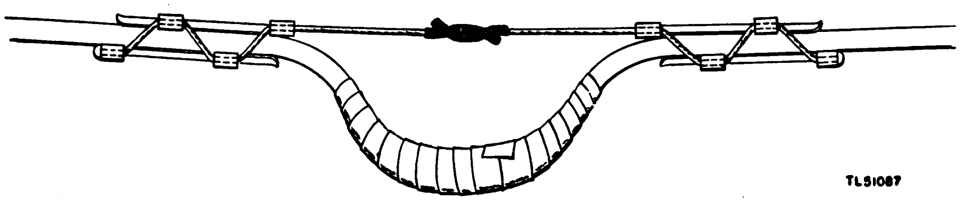


*Figure 29. Tension bridge with cable clamps at an expedient splice.*

to the proper sag. The cable is drawn onto the strand by coiling the entire span length at one pole, putting on hangers, and pulling the cable with its attached hangers into position along the strand. This use of suspension strands is illustrated in figure 30. The steps used in the construction are as follows:

(1) Dig a hole approximately 2½ feet deep in firm soil and somewhat deeper in sand or loose textured soil for sawed 4- by 4-inch poles up to 25 feet long. When 25-, 30-, and 35-foot natural poles are used, increase the depth of the hole to 4, 4, and 4½ feet, respectively. Do not raise poles until guys and suspension strands have been attached.

(2) Set all anchors so the top of the anchor timber will be 2 feet or more below the surface in firm ground. Greater depth will be required in sand or loose textured soil. Tamp the backfill thoroughly over all anchors. A plan view of the guying system is shown in figure 30②.

(3) Use 2,200-pound galvanized steel strand for guys and suspension strand. Use 2-bolt guy Clamp PF–61 to terminate the strand. For each anchor guy provide a piece of guy strand about twice the length of the pole to be guyed. The suspension strand should be about 20 feet longer than the span being erected.

(4) Attach the anchor guys to the tops of both poles and the suspension strand to the top of the near pole, making the attachment shown in figure 30. Now raise the poles. After the poles are set, tamp the backfill thoroughly around the base of all poles. Pull up the two anchor guys on each pole simultaneously with tackle blocks and wire Grips TL–28, until the pole has a slight rake away from the long span being constructed. Terminate the guys at the anchor end with Clamp PF–61. Tighten the clamp securely.

(5) Rig block and tackle to the top of the far pole, to which the free end of the suspension strand is to be attached. Pull the strand until the tension necessary to provide the desired sag has been attained. Terminate the strand with Clamp PF–61.

(6) Table III gives the sags for various long spans at representative temperatures. The temperatures and span lengths intermediate to those given in the table may be determined by interpolation.

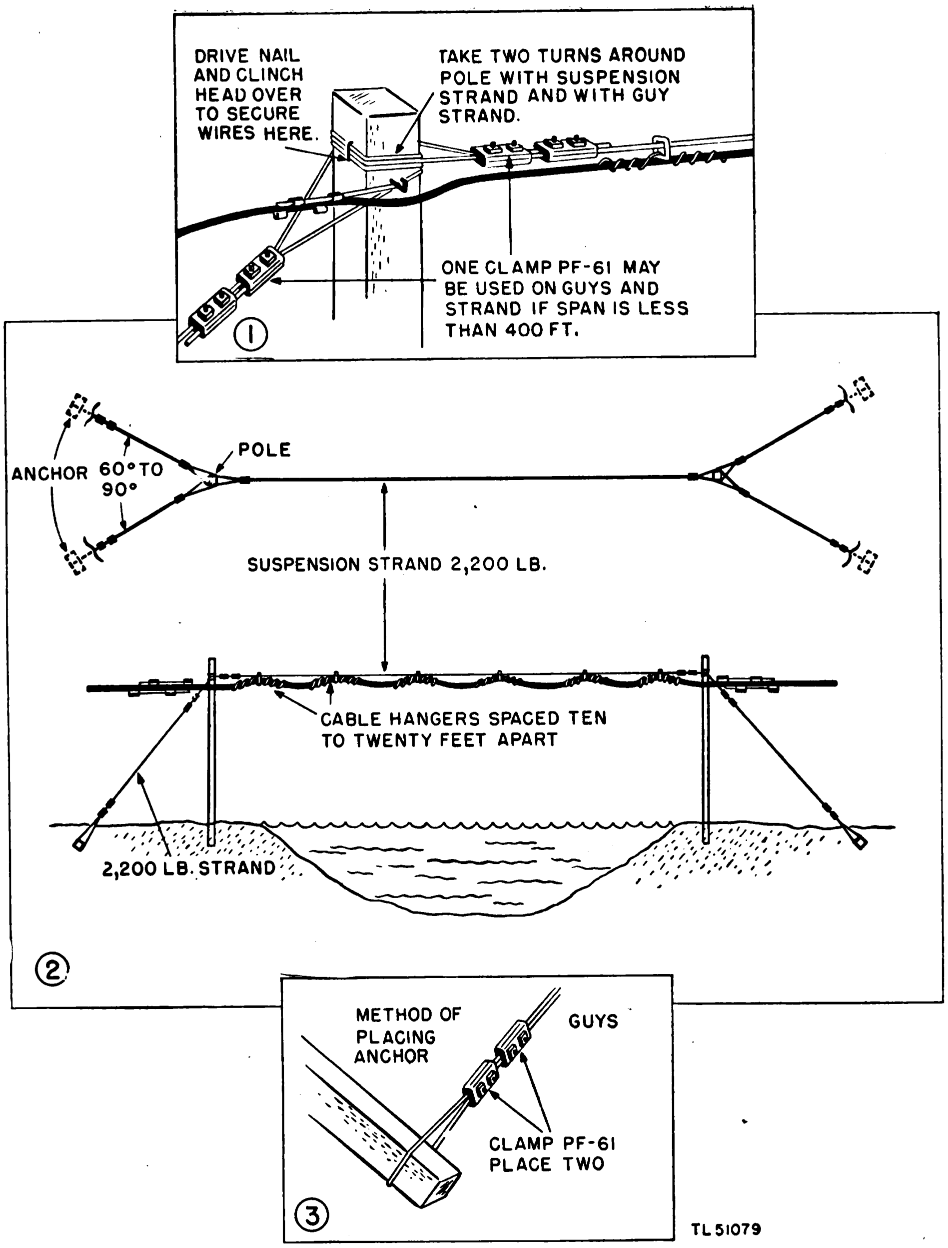


*Figure 30. Long span construction for aerial cable lines.*

*Table III. Minimum sag per span for different lengths of suspension span at various temperatures*

| Span Length (feet) | Sag (inches) in strand only | | |
|---|---|---|---|
| | 30° F. | 60° F. | 120° F. |
| 200 | 3¾ | 4¼ | 5 |
| 300 | 10¼ | 12 | 15½ |
| 400 | 31 | 36 | 44½ |
| 500 | 70 | 75 | 90 |

(7) Sag, in the suspension strand alone, may be measured by the oscillation method. However, this method is not applicable to strand-suspended cable. Table IV gives the time for 5 and 10 oscillations in spans of strand of given lengths, at proper sags, and at stated temperatures. If the actual time of oscillation exceeds that given in the table, increase the tension. If it is less than the table indicates, decrease it.

*Table IV*

| Span length (feet) | 30° F. | 60° F. | 120° F. |
|---|---|---|---|
| Time in seconds for 10 oscillations at various temperatures | | | |
| 200 | 5.5 | 5.9 | 6.5 |
| 300 | 9.3 | 10 | 11.4 |
| Time in seconds for 5 oscillations at various temperatures | | | |
| 400 | 8.1 | 8.6 | 9 6 |
| 500 | 12.1 | 12.5 | 13.7 |

(8) Draw the cable to the near pole of the long span, tension it to the proper sag, and secure it with a cable clamp.

(9) Bring the reel to the base of the near pole and pay out the cable until the length of slack cable between the reel and the top of the near pole is equal to the length of the long span. Form into a loop the part of this slack cable which is lying on the ground, and attach it to the base of the near pole. Carry the reel to the far pole, thus laying an extra span of cable across the ground or stream under the long span. If the long span is over a stream, a boat or amphibious conveyance may be necessary.

(10) Unfasten the loop of slack cable from the base of the near pole. This loop plus the cable hanging down the near pole, is the cable which will be attached to the suspension strand across the long span. Keeping this in mind, locate the point on the cable which will be attached to the far pole when the construction is completed. A lineman raises this part of the cable to the top of the near pole, and attaches the cable at the point thus located to the suspension strand with a cable hanger. Twist the edge of the hanger through an angle of 45° so the hanger will slide freely along the suspension strand.

(11) From the reel position at the far end of the long span, pull on the cable, sliding the hanger out along the suspension strand. When the hanger has advanced about 10 feet from the near pole, attach the cable to the suspension strand with another hanger. Pull the cable out another 10 feet and attach another hanger. Continue this procedure until the first hanger is a few feet from the far pole of the span.

(12) Attach the cable to the far pole with a basket hitch or cable clamp. Thus, the cable is supported by the suspension strand with cable hangers placed every 10 feet across the entire system.

**l.** The procedure for placing cable on existing poles is the same as that used when poles are erected especially for the cable concerned. Place Drive Hooks PF–81 in ⅜-inch lead holes at heights sufficient to give the required vertical clearance with specified sags. If drive hooks are not available, tie the tails of the basket hitches around the pole as shown in figure 8. Cable should be at least 6 inches from the lower crossarm of an open wire line. Do not use poles carrying power lines for aerial cable construction.

**m.** To facilitate the connection of cable assemblies to cable lacking connectors, provide facilities for making T-connections, and provide testing points without cutting the cable or disturbing circuits in use. A weatherproof Junction Box J–79/G which will provide these features is being developed but an approved model will not be available for issue for some time.

## SECTION III

## MAINTENANCE

**10. PREVENTIVE MAINTENANCE. a. General.** Minor troubles are easily overcome if checked in time. If allowed to progress, however, these troubles may cause line failures as serious as those caused by direct bomb hits. Ordinarily, aerial or surface-laid cable lines require more preventive maintenance than buried lines. Preventive maintenance consists of periodic inspection, tests, and repair operations aimed at the prevention of line failures. It is carried out by line patrol forces who make whatever preventive repairs and adjustments their time and equipment permit, and who tag points where repair needs to be done by more fully equipped crews.

**b. Inspection of aerial lines.** Observe the condition of the supports (trees, frames, or poles) and the points of contact of the cable with those supports. Note evidences of excessive wear of cable, strand, or guy wire. Ground clearances must be watched with care. Investigate any cutting or damage to the outside rubber jacket of the cable. Where superficial damage of this nature is found, tape it. The cable may be opened for local repairs as a temporary measure.

**c. Inspection of surface-laid cable.** Cable laid on the ground surface requires particular attention. Examine the cable at any point where there is evidence of disturbance by passing vehicles, pedestrians, or animals. Damage is particularly liable to occur where vehicles pass over the cable. If present or future traffic threatens damage to the cable, have the exposed section of the cable put underground or overhead, whichever is more practicable.

**d. Inspection of buried cable.** Buried cable is relatively safe, but is hard to inspect. The principal evidence of suspected mechanical injury is a disturbance of the ground surface over the cable. In such cases, dig the earth away, being careful not to injure the cable, and make an inspection. If the cable has been exposed by washouts or other earth disturbances, examine it for damage and repair it if necessary. When the cable is ready for operation, cover it again with earth, or protect it as conditions indicate.

**11. MOISTUREPROOFING AND FUNGIPROOFING.** Not required.

**12. LUBRICATION.** Not required.

## SECTION IV

# CABLE TESTING AND REPAIRING

*Note*. Failure or unsatisfactory performance of equipment will be reported on W.D., A.G.O. Form No. 468. If this form is not available, see TM 38–250.

**13. FAULT LOCATION.** Even when the most suitable material and location have been selected and the proper methods of construction adopted, cables will break down. It then becomes necessary to provide some means of locating and repairing the fault.

**a. Types of faults.** Faults may be divided into several classes, such as: opens, shorts, crosses, grounds, resistance unbalance, and split pairs.

(1) Opens are generally caused by corrosion, excessive strain on the cable, abrasive action, and kinking. Proper installation and handling of the cable will prevent a large percentage of trouble due to opens.

(2) Shorts may be caused by poor splicing, failure of insulation between conductors, etc. Proper splicing procedure, proper installation, and frequent inspection of terminals and connectors will assist in keeping this type of trouble at a minimum.

(3) Crosses between conductors of different pairs are generally caused by the same factors that cause shorts. Preventive procedure as outlined for shorts will keep this type of trouble at a minimum.

(4) Grounds may be caused by abrasive action on the cable, moisture forming leakage paths, etc. Keep terminals and connectors as dry as possible if they are not waterproofed and inspect likely points of trouble frequently.

(5) Resistance unbalance is usually caused by corrosion or loose connections. If allowed to become very large, the faulty circuit will cause crosstalk and interference in adjacent circuits.

(6) Split pairs result from improper identification and splicing when connecting cable lengths together. This will cause crosstalk and interference. Care must be taken in pairing the conductors. If in doubt as to the color coding due to fading of the colors, make a continuity test before completing the splice.

**b. Test equipment.** Different types of test equipment are available and may be used to determine the type of fault and its location. Keep in mind that the total or loop resistance of a circuit is used as a basis for comparison in determining the type of fault that exists in a circuit. A low ratio of measured resistance to the loop resistance of a circuit indicates a short. A high ratio of measured resistance to the loop resistance of a circuit indicates an open. A low value of measured resistance between a conductor and the ground or between conductors of adjacent pairs indicates a grounded circuit or a cross respectively.

(1) Telephone EE–8–(  ) may be used to localize faults existing singly but is of little value when a combination of faults exists in a cable.

(2) Test Set EE–65–(  ) can be used to determine what type of trouble exists and will accurately locate some of the faults encountered. For detailed instructions on the operation of Test Set EE–65–(  ), see TM 11–361.

(3) Test Set TS–26/TSM is a volt-ohmmeter for line testing. It can be used to detect grounds, crosses, shorts, opens, and to measure insulation and con-

ductor resistance as well as line and battery voltage. For detailed instructions on the operation of Test Set TS–26/TSM see TM 11–2017.

(4) Test Set TS–27/TSM is a form of a slide-wire Wheatstone bridge powered with self-contained batteries, designed for field use. It is direct reading and easy to use. This test set can be used to measure conductor and insulation resistance, and locate grounds, crosses, shorts, and opens without the use of auxiliary equipment. For detailed operating instructions, see TM 11–2057 (when published).

(5) Test Set I–49 is a Wheatstone bridge designed for field use and incorporating a number of features for field operation. It is a very accurate instrument and will be useful in bivouac areas or depots in repairing sections of cable. For detailed instructions, see TM 11–2019.

**14. EXPEDIENT SPLICE. a.** When another cable assembly cannot be laid immediately, the quickest method by which communication may be restored over a faulty circuit is to make a temporary field splice at the location of the fault. The faulty length of cable assembly may be replaced at a later date, and a permanent vulcanized splice can then be substituted for the temporary splice. Label every faulty cable assembly with a tag. On the tag, write the date, the nature of the fault, and the cause and location, if they are known.

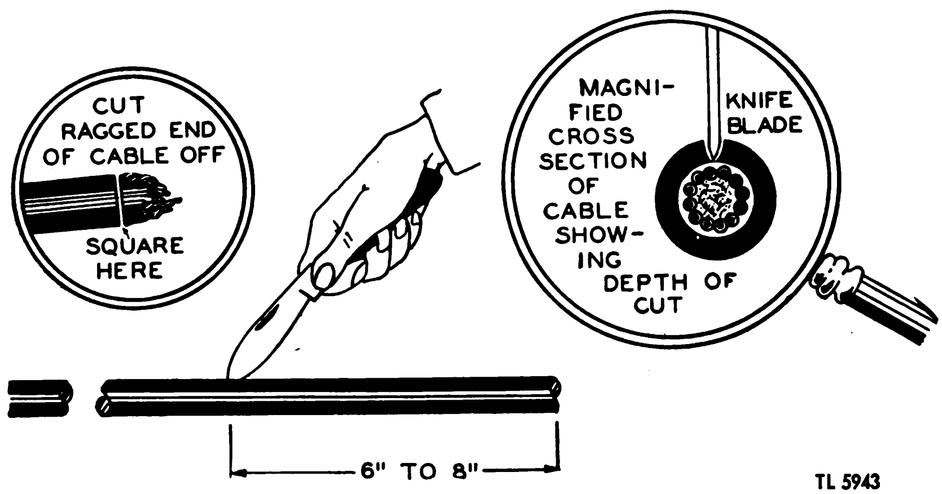


*Figure 31. Method of slitting rubber jacket of cable.*

**b.** If all circuits of a 5- or 10-pair cable assembly are faulty, cut the cable in two at the fault and square the ends. Strip the free ends of the rubber jacket for a length of 6 to 8 inches. When cutting the cable lengthwise, preparatory to stripping, the material can be slit readily if the knife blade is wet. Care must be taken not to get water into the cable. Figures 31 and 32 illustrate the method of stripping the rubber jacket from the cable. If the precise fault which is known to exist in the cable cannot be seen, it will be necessary to strip away the jacket for a greater length.

***Caution:*** Before stripping the jacket further in either direction, connect a Telephone EE–8–(  ) across the faulty circuit with test clips to determine the direction of the fault from the opening in the cable. Apply the color code in selecting the faulty pair so that communication on good circuits will not be interrupted. Cable lengths produced under an early specification were not color coded: consequently faulty circuits in such cable must be found by trial and error. Be sure to rub the conductor insulation with the fingers so that if there is any color coding, it will be seen. This will prevent unnecessary circuit interruption or taping of insulation which has been injured by the test clips. The number of rubber-insulated conductors which must be joined depends upon the number of faulty circuits. If all circuits are not faulty, use a short length of insulated copper wire as a patching length in joining each conductor affected.


*Figure 32. Method of separating rubber jacket from conductors.*

**c.** Separate the rubber jacket insulation from the conductors for the full 6 inches. (See fig. 32.) Pliers may be used to facilitate this operation. Cut off the rubber jacket (fig. 33) and separate the pairs from the jute (the string used as a filler). Do not cut off the jute string. (See fig. 34.)

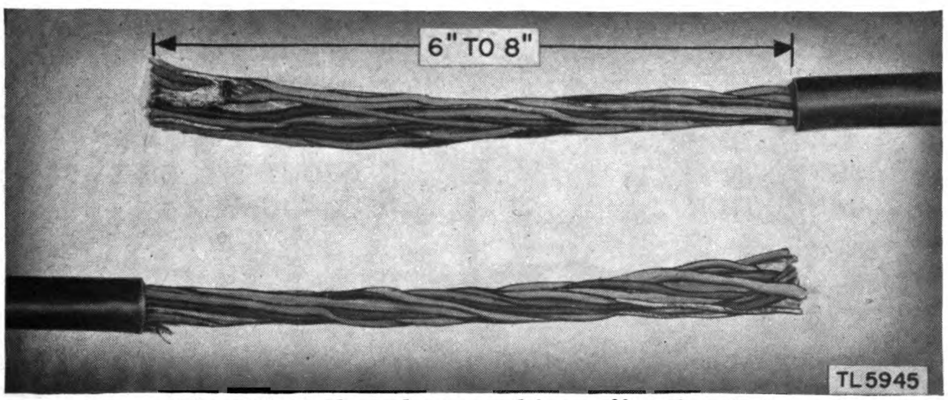


*Figure 33. Rubber jacket removed from cable to be spliced.*

**d.** Give both conductors of each faulty pair a single, full twist with the conductors of the other cable having the same color code or other identification. (See fig. 34.) Be sure to stagger the spliced joints on a particular pair about ½ inch (fig. 35), and on opposite sides of the cable from other pairs so twisted. If splicing sleeves of the proper size (for No. 19 AWG wire) are available, they may be used to join the loose ends of each conductor to be spliced. Otherwise, even up the ends so that equal strain is taken by each pair. Then strip the insulation from copper wire down as far as the single twist, and twist together the conductors thus exposed with at last three full turns. (See fig. 35.) A rotary motion of the thumb and forefinger (crank-handling) may be used.

Then clip off the pigtail thus formed to leave a total length of about ¾ inch of twisted conductors, give them an additional twist with pliers, and press it down flat on the conductor. (See figs. 35 and 36.)

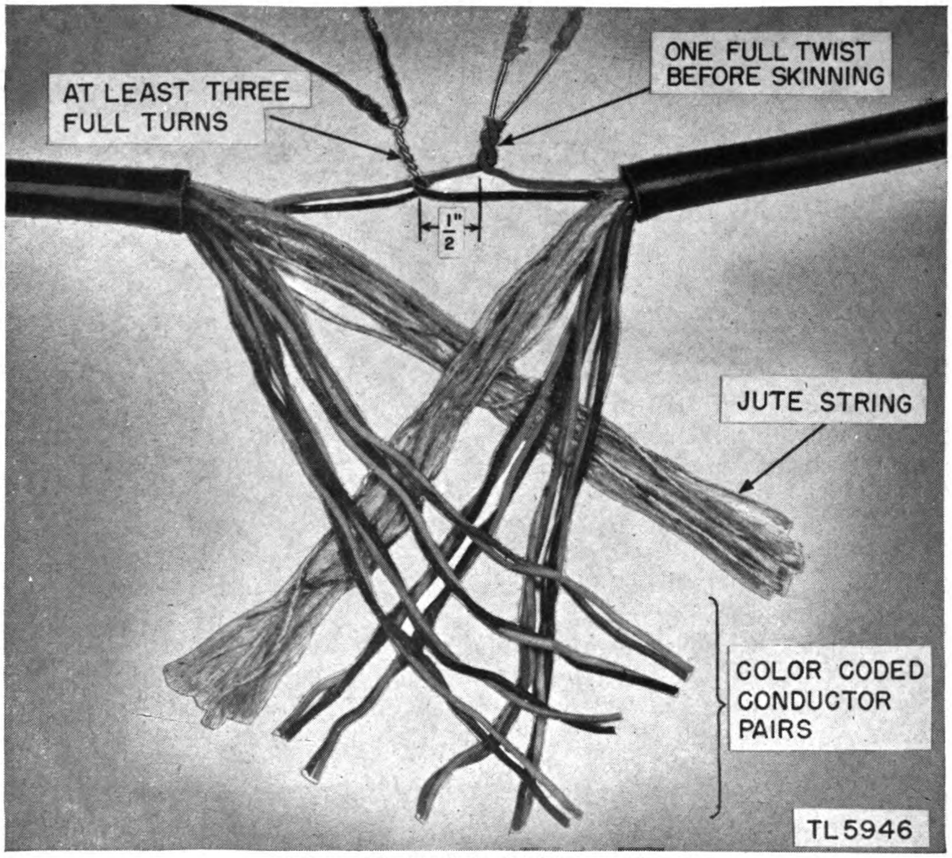


*Figure 34. Method of joining conductors.*

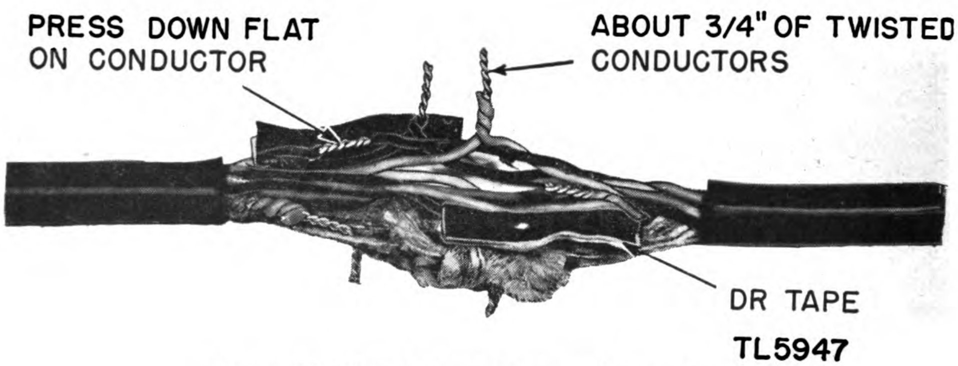


*Figure 35. Method of insulating conductor splices.*

**e.** If DR tape is available (DR refers to double rubber tape, made with a dark, cured rubber on one side and white uncured rubber (latex) on the other), fold about 1 inch of this tape in the shape of a trough and place it around the twisted pigtail. (See fig. 36.) Make sure that the tape covers that portion of the pigtail from which no insulation was stripped. After placing the tape on the joint, squeeze it together firmly. If only the more familiar type of rubber

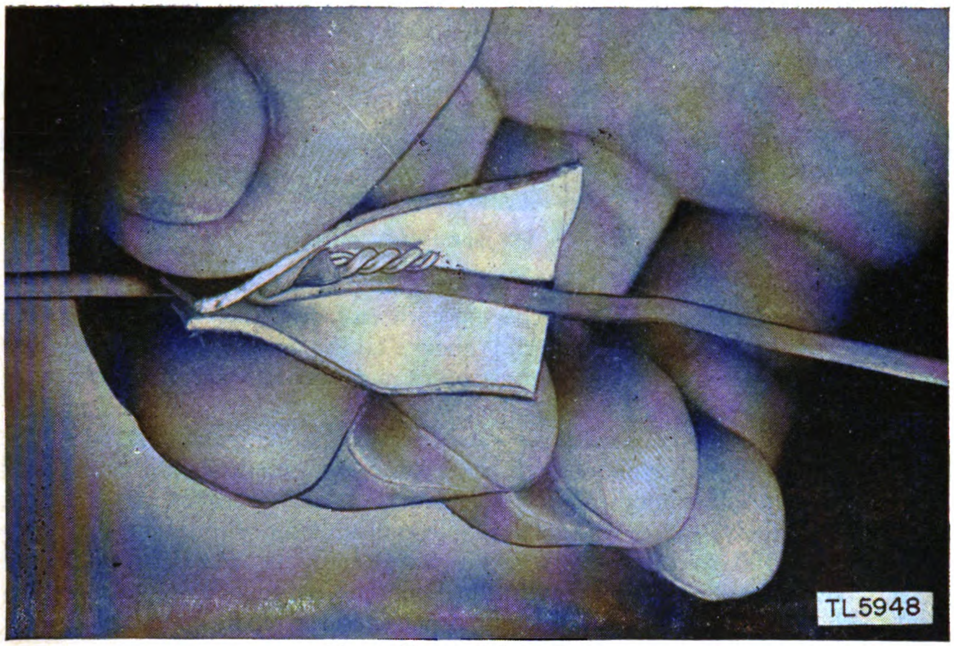

*Figure 36. Applying DR tape.*

tape (TL–94) used with field wire is available, the pigtail should be bent flat against the insulated conductor and the joint taped with a single serving of rubber tape. If neither DR nor standard rubber tape is available, friction tape may be used, but such joints may have more leakage than is desirable. Friction tape should not be used if rubber tape can be obtained.

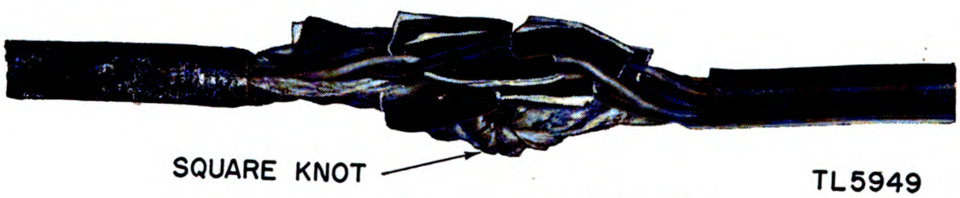

*Figure 37. Spliced cable prepared for taping.*

**f.** If the cable has been cut in two, twist together the ends of the jute core and the filling of each cable and tie the two cords thus formed into a square knot. The cord should be tied so that the over-all length after tying is slightly less than the length of the conductors. If this is done, the tension on the cable at the splice will be withstood by the cords instead of the conductors. The staggered conductor splices and the knotted cords provide a smooth splice of good conductivity and adequate strength. (See fig. 37.)

**g.** Then twist the cable to tighten the joined conductors.

*Figure 38. Rubber tape applied to splice.*

**h.** Before applying rubber tape to the spliced cable, rough the cable jacket on both sides of the splice with sandpaper, a knife, or hacksaw blade and coat it with rubber cement if this is available. Starting at the center of the splice, apply two layers of rubber tape half overlapped, covering the rubber jacket of the cable on both sides of the splice for 1 inch. (See fig. 38.) Apply one layer of friction tape half overlapped, extending 1 inch beyond the rubber tape at each end of the splice. (See fig. 39.)

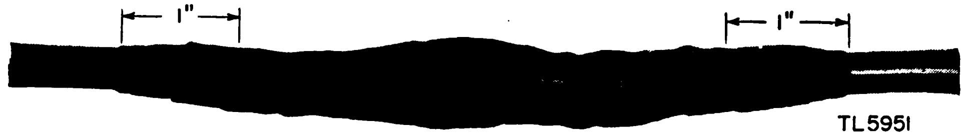


*Figure 39. Friction tape applied to splice.*

**i.** When splicing Cable WC–535 (10-pair), it may be necessary to strip the rubber jacket for a length of 10 inches on each end. Join the conductors in the manner as outlined in c, d, e, and f above, taking care that the conductor joints are staggered around the circumference and over the length of the splice to prevent lumping. Tape as outlined in h above.

**j.** Remember that the expedient splice is only a temporary repair. The services of competent personnel with the proper equipment should be secured at the earliest possible moment and the damaged cable permanently repaired with a vulcanized splice. Since available vulcanizing equipment requires approximately 500 watts at 110 volts, it will usually be necessary to replace cables having expedient splices with equal lengths of good cable, and return the defective cable to the bivouac area or depot shop for repair.

**15. PERMANENT VULCANIZED SPLICE.** Vulcanizing Equipments (rubber cable) TE–54–( ) and TE–55–( ) are made available to those organizations responsible for the construction and maintenance of cable lines and the repair of cable assemblies. Splicing of lengths of cable is accomplished by joining the conductors with individual pressed copper sleeves, insulating each splice with rubber tubing, and vulcanizing a covering of rubber over the sleeves. Each of the vulcanizing equipments includes all the parts, tools, and materials necessary for preparing a splice and vulcanizing a patch or a complete jacket, on both sizes of cable.

**a. Preparation of splices.** (1) The first step is to cut the ends of the cables squarely and remove the cable jackets so that about 6 inches of the conductors of each cable are exposed. (See fig. 33.) This is done in the same manner as described for the expedient splice in paragraph 12c.

(2) Separate the conductors from the jute core. (See fig. 42②.) Lay the conductors back along the cable. Twist the jute strands into a cord and tie a square knot in the two ends of the jute. (See fig. 42③.) When pulled tight the distance between the ends of the cable jacket should be approximately 2½ inches. Apply one layer of prevulcanized gray rubber tape (R–1476) over the knotted jute core. (See fig. 42④.)

(3) Cut off the conductors so that 1¼ inches of the conductor remain. Remove ⅜ inch of the insulation from each conductor. (See fig. 40.)

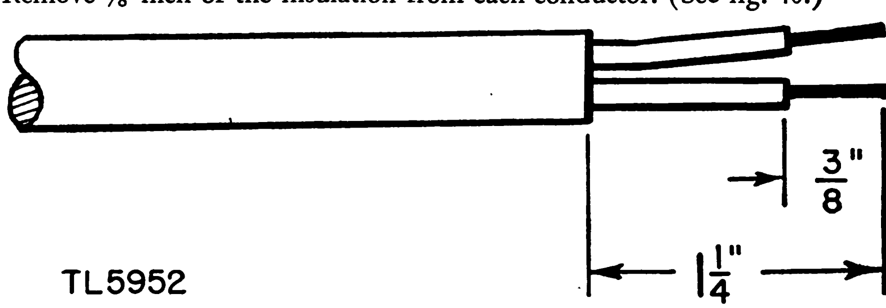


*Figure 40. Method of preparing the conductors for splicing.*

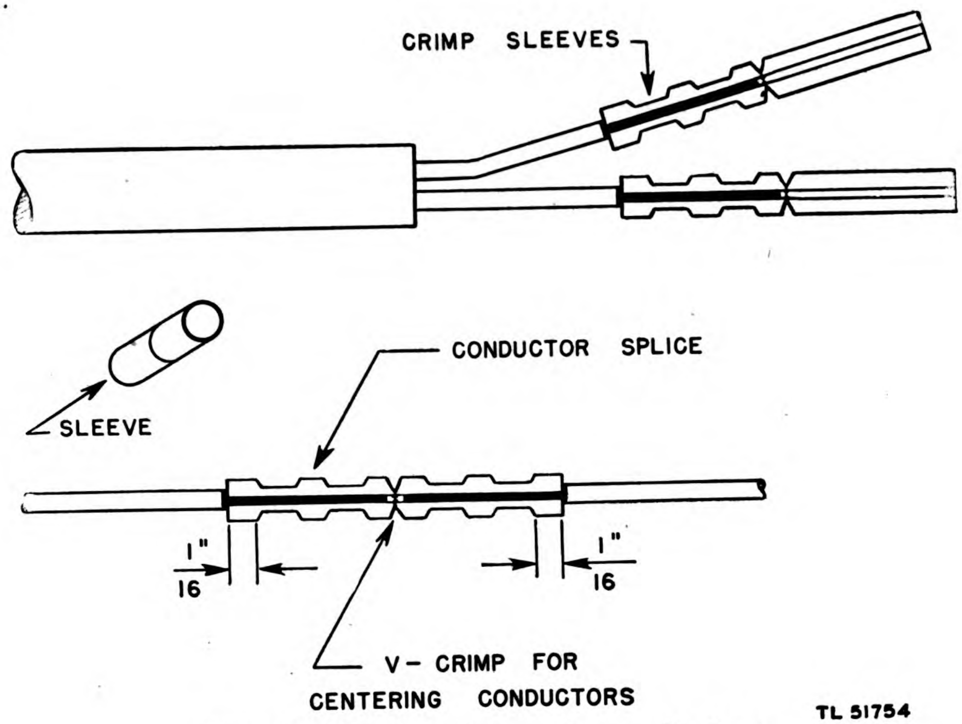


*Figure 41. Method of splicing conductors with sleeves.*

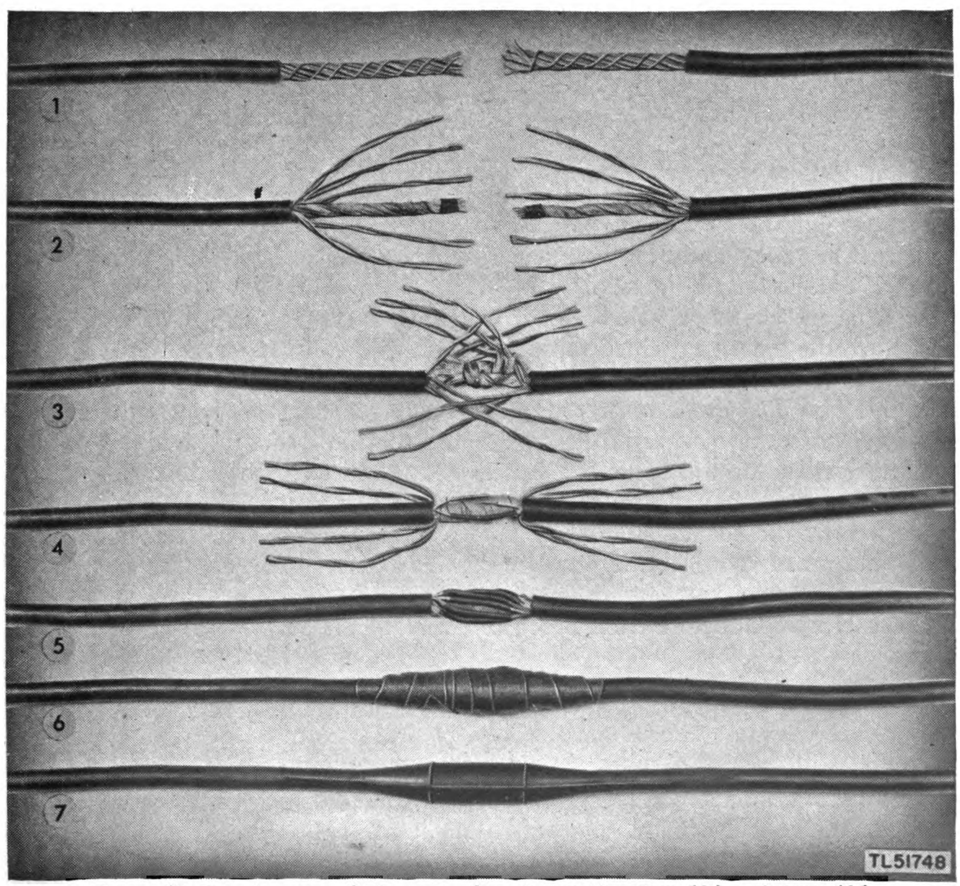


*Figure 42. Step-by-step splicing procedure for Cables WC–534 and WC–535.*

(4) To fasten the conductors together with the copper splicing sleeves (No. 036–A; 19–20–22 B & S gauge), place a sleeve on a conductor by inserting the conductor halfway into the sleeve and crimping the sleeve with crimping pliers No. 17–2. (See fig. 41.) Do not crimp closer than 1/16 inch from the end of the sleeve, lest the conductor be weakened. (See fig. 41.) Cut a length of prevulcanized rubber tubing 1¼ inches long and slip over the conductor and crimped half of the sleeve. Insert the matching conductor from the opposite end of the cable and crimp the sleeve on this conductor. Center the rubber tubing on the splicing sleeve and press the spliced conductor against the taped jute core. (See fig. 42⑤.) Repeat this procedure until all the conductors have been spliced and insulated.

(5) Bind the entire assembly of insulated conductors in place with a thin layer of gray vulcanizing tape (R–1476). Follow dimensions shown in figure 43.

(6) Scrape the rubber jackets of the two cables for 2½ inches on both sides of the splice with the roughing tool. Apply cement, rubber, vulcanizing, freely to the clean scraped portions of the cable jacket and allow it to dry. *Do not put this cement over the gray tape.*

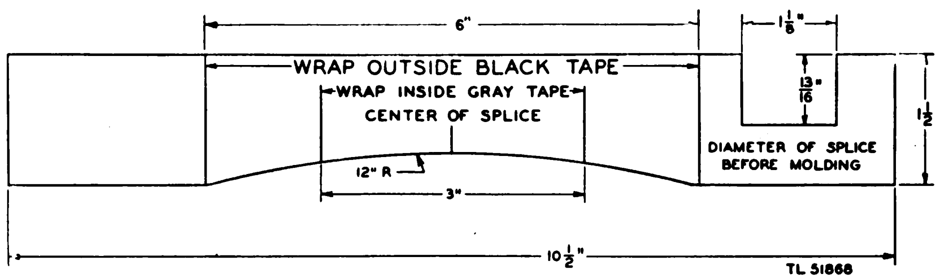


*Figure 43. Taping gauge for vulcanized splices.*

(7) Wrap tape, outside, black, vulcanizing (R–1451 or equal) around the entire splice to a distance as indicated on the taping gauge. (See fig. 43.) Do not wrap tape on the unscraped part of the jacket or where there is no rubber cement. The tape should be wrapped tightly, lapping one half the width of the tape in enough layers to fill the mold completely for the particular size of cable. The use of the 1⅛-inch slot in the end of the taping gauge will assure this. Also, the length to which the tape is wrapped must be great enough to fill the mold lengthwise. Use the large radius indicated on the taping gauge. (See fig. 43.) *The mold must be filled* so that sufficient pressure will be built up to vulcanize the rubber properly. Because the mold tapers, fewer layers will be needed as the distance from the center of the splice increases. (See fig. 42⑥.)

(8) The taping gauge illustrated in figure 43 was designed and dimensioned to allow only the correct amount of tape to be applied to the splice to make a good vulcanized splice. If the pressure on the splice is great enough and evenly distributed, airholes will be prevented and the splice will be symmetrical enough to prevent the conductors from being too close to the surface of the vulcanized jacket.

*Note.* If the taping gauge illustrated in figure 43 is not supplied with the vulcanizing equipment, one may be made by following the dimensions shown in the figure. Sheet metal, fiberboard, plywood, or heavy cardboard may be used.

Figure 42⑥ illustrates a splice prepared for vulcanizing.

(9) If a patch on the rubber jacket is being made, scrape all surfaces clean, brush on the rubber cement, allow it to dry, and apply enough black vulcanizing tape to fill the upper mold. The use of the taping gauge will facilitate this procedure.

**b. Vulcanizing.** (1) The vulcanizer made available to a particular organization may be one of several types. The operation of vulcanizing is very much the same with all units, although they vary in appearance and in the location of the heating element. Figure 44 illustrates one type of vulcanizer. Instruction sheets or technical manuals are furnished with each vulcanizing equipment.

(2) Before completing the preparation of the splice, place the proper molds in the vulcanizer and heat the vulcanizing equipment for 30 minutes. Just before placing the splice in the mold, apply the mold dressing furnished with the vulcanizing equipment sparingly to all surfaces of the mold. The use of mold dressing aids in the removal of the vulcanized splice from the mold.

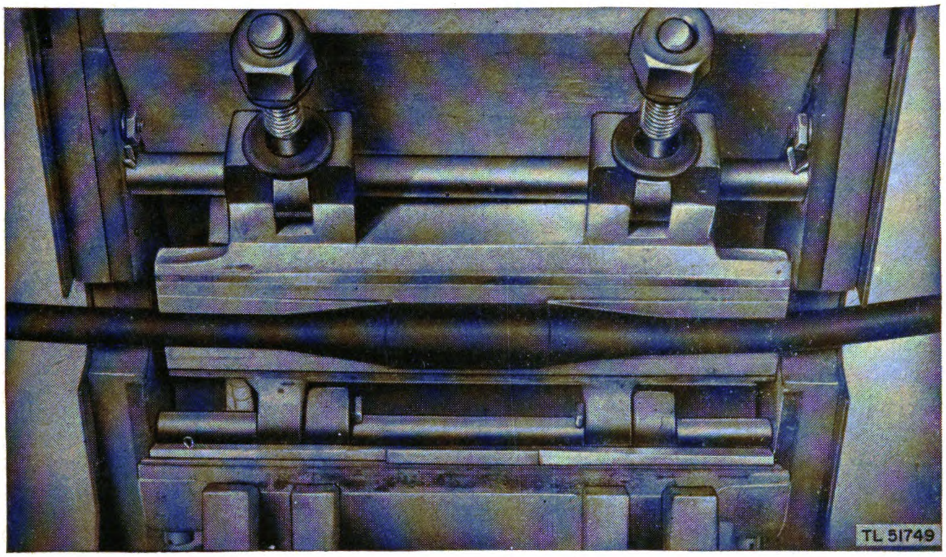


*Figure 44. Vulcanizer.*

(3) Place the splice in the mold and tighten the mold evenly until the two halves of the mold are separated by 1/16 inch. Allow the mold to remain in this position for about 5 minutes. This will allow the rubber to soften. Then close the mold until the two halves touch and let the splice vulcanize for 30 minutes. Remove the vulcanized splice and cut a slit crosswise in the fin on the edge of the vulcanized splice. (See fig. 42⑦.) This fin should appear along the full length of the vulcanized splice and consists of the small amount of excess rubber tape forced out by the pressure exerted on the mold during the vulcanizing operation. If the rubber fin tends to stick together when cut, the splice is undervulcanized and should be put back into the mold for additional vulcanizing. Complete the vulcanized splice by trimming off the fin with scissors. *Do not attempt to tear off the fin.*

**c. Additional information.** If the rubber tubing is not available for insulating the spliced conductors, it is possible to use cotton splicing sleeves in the same manner as used in splicing lead-covered cable. Suitable desiccant must be applied to the cotton sleeves after they are in place, to make sure that there is no moisture remaining in the sleeves. If copper splicing sleeves are not available for splicing the conductors, use the method described in paragraph 12d for joining the conductors in the expedient splice.

## SECTION V

## SUPPLEMENTARY DATA

### 16. LIST OF EQUIPMENT.

| Name and type No. | Signal Corps stock No. |
|---|---|
| CABLE STUB CC–344 | 1B1444 |
| CABLE ASSEMBLY CC–345 in 100-foot lengths | 1B1445–100 |
| CABLE ASSEMBLY CC–345 in 200-foot lengths | 1B1445–200 |
| CABLE ASSEMBLY CC–345 in 500-foot lengths | 1B1445–500 |
| CABLE ASSEMBLY CC–355–A in 100-foot lengths | 1B1455A–100 |
| CABLE ASSEMBLY CC–355–A in 200-foot lengths | 1B1455A–200 |
| CABLE ASSEMBLY CC–355–A in 500-foot lengths | 1B1455A–500 |
| CABLE WC–534 | 1B1534–( )* |
| CABLE WC–535 | 1B1535–( )* |
| CLAMP: dead end; G. I.; adjustable for 3/8 to– 5/8-inch diam. cable; Kearney (Lay-cit) clamp No. 6804–1 or equal | 5B3094 |
| TERMINAL STRIP TM–184 | 4E9304 |
| TERMINAL STRIP TM–184–A | 4E9304A |
| VULCANIZING EQUIPMENT TE–54–A | 6R47254A |
| VULCANIZING EQUIPMENT TE–55–A | 6R47255A |
| TAPE TL–83: friction; cotton; 3/4-inch; 1/2-pound rolls | 6N8583 |
| TAPE TL–94: rubber; 3/4-inch; 1/2-pound rolls | 6N8594 |
| TAPE TL–192: rubber; 3/4-inch; 15-foot rolls; white ply of unvulcanized plastic tacky compound tightly bonded to a thinner black ply of vulcanized rubber (U.S. Rubber Co. No. U–156–DR or equal) | 6N8692 |

* Indicate desired lengths when ordering.

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