TENTATIVE

# TM 11-2253

WAR DEPARTMENT TECHNICAL MANUAL



# OPEN WIRE CONSTRUCTION FOR FIXED PLANT APPLICATION

*WAR DEPARTMENT* *20 MARCH 1944*

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*TENTATIVE TM 11-2253*

# OPEN WIRE CONSTRUCTION FOR FIXED PLANT APPLICATION

*WAR DEPARTMENT* *20 MARCH 1944*

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WAR DEPARTMENT,

WASHINGTON 25, D. C., 20 MARCH 1944.

Tentative TM 11-2253, War Department Technical Manual, Open Wire Construction for Fixed Plant Application, is published for the information and guidance of all concerned.

[A.G.300.7 (17 March 1944).]

BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL,
*Chief of Staff.*

OFFICIAL:

J. A. ULIO,
*Major General,*
*The Adjutant General.*

DISTRIBUTION: IBn 11(2); IC 11(10).
(For explanation of symbol see FM 21-6.)

TECHNICAL MANUAL

# OPEN WIRE CONSTRUCTION FOR FIXED PLANT APPLICATION

Changes No. 1

WAR DEPARTMENT
Washington 25, D. C., 2 February 1945



TM 11-2253, 20 March 1944, is changed as follows:

The designation TENTATIVE is removed from this manual.

**2. SCOPE.**

*  *  *  *  *  *  *

*b*. The **fixed plant** lines described in this manual consist of pole lines suitably guyed and carrying not more than two crossarms on each of which a maximum of four pairs of 104 copper-clad steel wires will be placed.

(1) (Added.) The use of 104 copper-clad steel wire is specified for Signal Corps fixed plant lines because of several factors involved. One important consideration is the conservation of copper as a critical material. Copper-clad steel wire also has additional advantages in strength which permit longer span lengths to be used with consequent saving of material and labor, while at the same time sags may be decreased in order to prevent hits (swinging contacts) between line wires during high wind velocities. The transmission loss in copper-clad steel lines is greater than in copper lines of the same gauge. However, at the higher frequencies used in carrier operation, the characteristic tendency of alternating currents to flow near the surface of a conductor increases to such an extent that the larger part of the current-carrying capacity of the wire is in its copper covering. Hence, the transmission loss is not as great as might be expected. When these factors together with maintenance problems are properly evaluated, it will be found that the 104 copper-clad steel line is the best all-around type to be used for military open wire fixed plant.

(2) (Added.) The fixed plant lines described in this manual are to be used in preference to tactical open wire lines as described in TM 11-368 in all cases where conditions permit. These fixed plant lines will be more satisfactory than tactical open wire lines from the standpoint of maintenance, crosstalk, and transmission. However, during tactical operations, or in other situations where conditions exist such

as a shortage of shipping space, limited time available for construction, or the probability that the lines will be dismantled or relocated within a short time, tactical open wire lines will usually be found more satisfactory than fixed plant, providing of course, that the length of line is not greater than that for which tactical open wire is designed. The nominal maximum lengths of line for tactical open wire lenes are listed in TM 11–368 and the nominal maximum length of fixed plant lines described in this manual will be found in paragraph 3. These maximum lengths of line are not to be construed as a hard and fast rule that lines up to some specified length are to be tactical open wire, and lines of greater length are to be fixed plant. Instead, all factors involved must be given careful consideration and a decision made as to the most satisfactory line to be constructed. In some instances fixed plant lines may be found more desirable even for short lines less than 100 miles in length. The probability that tactical open wire lines will later be converted to fixed plant should always be given consideration in planning, and where such probabilities exist, a type of tactical open wire line should be chosen from which conversion will involve a minimum amount of labor and material.

* * * * * * *

**3. LINE REQUIREMENTS** (Superseded).—*a.* The fixed plant lines described in this manual, all of which use Crossarms PF–92A, transposition Insulators IN–128, and 104 copper-clad steel wire, will provide on the first crossarm, facilities for four C Carrier systems 3,000 to 4,000 miles in length, and on the second crossarm, facilities for additional C Carrier systems not over 1,000 miles in length. These C Carrier systems will provide 9-db circuits, and, with some penalty in crosstalk, may be operated as low as 6 db. The transmission characteristics of these lines require that repeaters be placed at approximately 100-mile intervals.

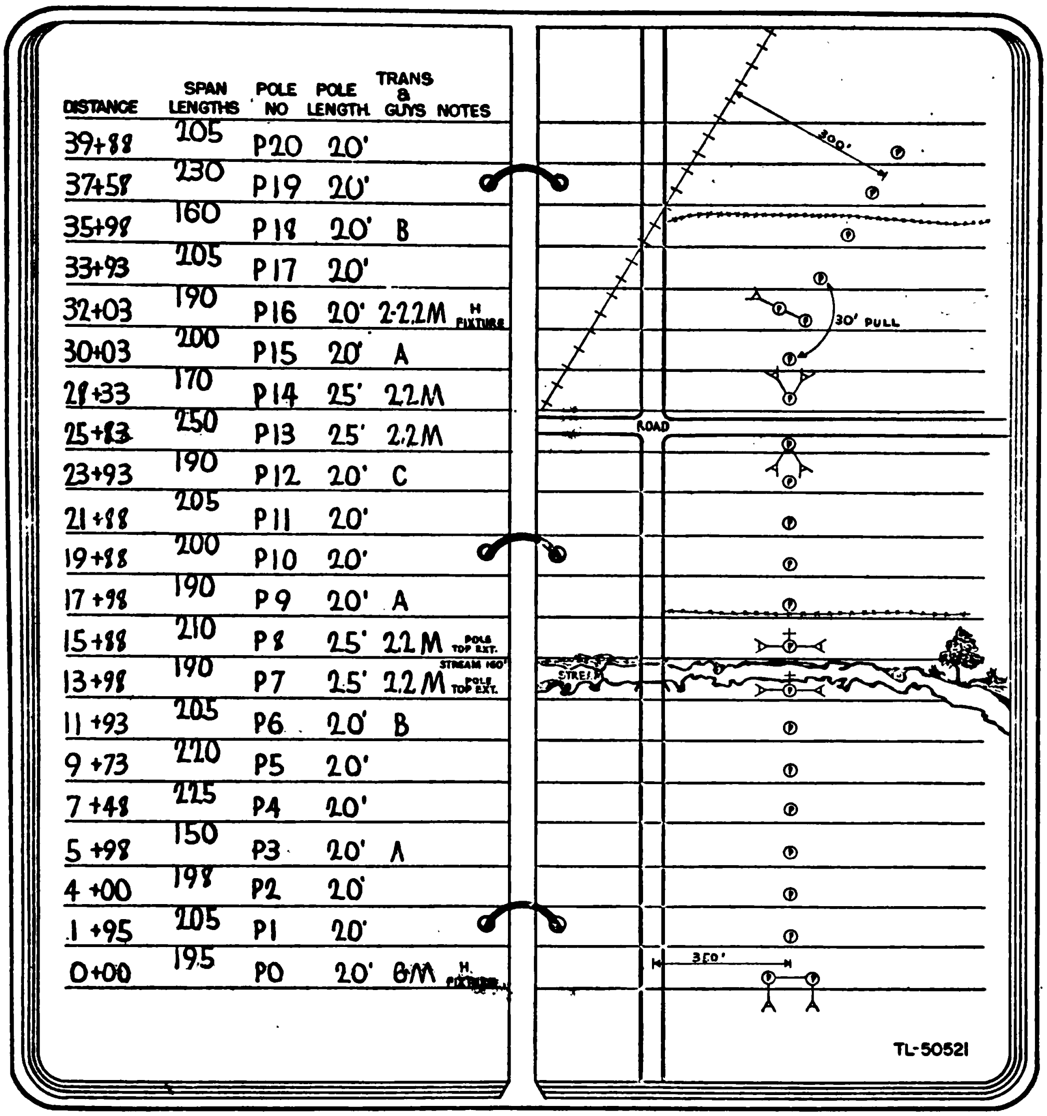
*b.* The design of the fixed plant lines described in this manual has been simplified as far as possible without sacrifice of performance. If constructed strictly in accordance with instructions, these lines will be structurally sound and reliable electrically.

**8. TRANSPOSITIONS FOR FIRST CROSSARM: FULL SECTION.**

* * * * * * *

*b.* The transportation poles * * * or top, crossarm. Thus, at each A pole, a transposition Insulator **IN–128** (which has two wire grooves) will be placed on pin 7 to serve 7–8 and non-transposition insulators (which have only one wire groove) will be placed on pins 1, 2, 3, 4, 9 and 10; at each B pole, transposition insulators will be placed on pins 2 and 9 to serve pairs 1–2 and 9–10 and non-transposition insulators will be placed on pins 3, 4, 7 and 8; at each C and D pole, transposition insulators will be placed on pins 2 and 4 to serve pairs 1–2 and 3–4 and non-transposition insulators will be placed on pins 7, 8, 9 and 10; at each S pole, transposition insulators will be placed on pins 4 and 9 to serve pairs 3–4 and 9–10 and non-transposition insulators will be placed on pins 1, 2, 7 and 8. In a full * * * will be made.

* * * * * * *



| DISTANCE | SPAN LENGTHS | POLE NO | POLE LENGTH | TRANS & GUYS | NOTES |
|---|---|---|---|---|---|
| 39+88 | 205 | P20 | 20' | | |
| 37+58 | 230 | P19 | 20' | | |
| 35+98 | 160 | P18 | 20' | B | |
| 33+93 | 205 | P17 | 20' | | |
| 32+03 | 190 | P16 | 20' | 2-2.2M | H FIXTURE |
| 30+03 | 200 | P15 | 20' | A | |
| 28+33 | 170 | P14 | 25' | 2.2M | |
| 25+83 | 250 | P13 | 25' | 2.2M | |
| 23+93 | 190 | P12 | 20' | C | |
| 21+88 | 205 | P11 | 20' | | |
| 19+88 | 200 | P10 | 20' | | |
| 17+98 | 190 | P9 | 20' | A | |
| 15+88 | 210 | P8 | 25' | 2.2M | POLE TOP EXT. |
| 13+98 | 190 | P7 | 25' | 2.2M | STREAM 160' POLE TOP EXT. |
| 11+93 | 205 | P6 | 20' | B | |
| 9+73 | 220 | P5 | 20' | | |
| 7+48 | 225 | P4 | 20' | | |
| 5+98 | 150 | P3 | 20' | A | |
| 4+00 | 198 | P2 | 20' | | |
| 1+95 | 205 | P1 | 20' | | |
| 0+00 | 195 | P0 | 20' | 6M | H. FIXTURE |



Figure 23.—Form of notes to be kept by the pilot.

## 71. POLE TRAILERS.

* * * * * * *

***h. Coupling trailer to truck.***—Attach the trailer * * * of the load. If the poles to be loaded are so long that the tongue cannot be attached to the towing hook, use Draw Bar **LC-44** on the king pole, as shown in figure 52. **Attach the wire rope safety connection between the truck and trailer.**

Figure 52.—Use of Draw Bar **LC-44.**

* * * * * * *

Figure 53, Safety connections, page 65, is rescinded.

## 72. DISTRIBUTING MATERIALS ALONG THE LINE.

* * * * * * *

***c. Distributing other material.***—At each location * * * avoid breaking them. Particular care should be exercised to see that the proper length of pole is delivered and also that the proper number of Insulators **IN-128** are left at transposition poles.

## 74. DIGGING HOLES WITH EARTH BORING MACHINE (Superseded).—

***a. Preparations for boring.***—In moving the truck over difficult ground to get the earth borer in position, low or reverse speeds should be used. Skids can be used in crossing ditches and reaching embankment locations. It may be necessary to raise the rear of the truck by lowering the auger in reverse speed to place the skids under the rear truck wheels. If the truck becomes mired, chain skids can be used to obtain traction.

***b. Precautions.***—(1) When attempting to reach the pole or anchor hole location, or when leveling the earth borer to bring the auger and derrick to the plumb position, the auger and the top of the derrick must be clear of obstructions. No attempt should be made to move the truck or to plumb the rack shaft during the boring operation while the auger is still in the hole.

(2) The lever of the truck transfer case must be in the neutral position during all boring operations, to avoid movement of the truck.

(3) Wheel chocks will be used in addition to the truck brakes when working on side hills or at any location where the truck has a tendency to move during the boring operation. Place a crossarm against the front wheels if the chocks under the rear wheels are not sufficient to hold the truck.

(4) When it is necessary to drive the truck to the pole or anchor hole location, the front axle drive must be in the engaged or IN position at all times.

(5) Engage the rack lock (located on the left of the derrick tube support base) at all times when the auger is raised to stop the boring operation for any reason.

(6) When raising the auger, take care to stop it before the auger bumper spring is compressed. *Under no circumstances* clear the auger of soil by allowing the auger to compress the bumper spring fully and bump against the rack shaft carrier lower nut, thereby jarring the soil loose.

(7) No person other than the operator should stand close to the borer while it is in operation, as the soil which is spun off the auger sometimes contains objects which can inflict severe injuries.

(8) When using the derrick for placing or removing poles, do not stand under or close to the pole or between the pole and the truck body. Men guiding the movements of poles must be prepared to step aside quickly. Never permit any part of the derrick to come in contact with light, power, or trolley wires.

*c.* ***Preparation for boring.***—(1) When spotting the truck in position for boring a hole, drive the trucks so that the auger point will be over the stake which marks the hole location, raise the earth borer to the boring position from the traveling position, and line up the auger point directly over the stake.

(2) Set the truck brake and chock the wheels to prevent movement of the truck during the boring operation.

(3) When their use is required, such as when digging in heavy clay, unship the pole derrick supports at the rear of the truck from their fastenings and set them so that they are either directly in contact with the ground, or so that any load on the auger will bring the supports into contact with the ground with not more than 1 inch of travel.

(4) The power leveling drive is used to raise the rack shaft and derrick from the traveling position. A ratchet wrench is provided which fits over the squared end of the leveling worm shaft. Turning the worm in the direction desired will adjust the position of the machine.

*d.* ***Boring operation.***—(1) The earth Borer Equipment HD is operated by means of two levers mounted in the rear of the truck at the left of the machine. The two levers are mounted at a convenient position for observation of the work and to allow the earth borer operator to readily signal the truck operator. The speed required will be signaled by the earth borer operator to the truck operator, who will place the power take-off lever in the earth borer operating position and select the transmission speed requested. The truck operator will control the engine speed in accordance with the wishes of the earth borer operator. A high degree of cooperation is necessary between the driver and the operator.

(2) When boring holes in sandy, clay, or ordinary soil, the auger will be found to work best at a speed of approximately 125 revolutions per minute. In clay, take care to prevent overloading the auger. Load the auger to the bottom of the bumper spring only. In clay there is a tremendous suction and too heavy a load may strain the machine.

(3) When starting to bore a hole, regardless of the type of soil, keep the speed of rotation of the auger down to about 25 revolutions per minute until a depth of at least 16 inches is reached. If no serious obstructions have been encountered, higher speeds may then be selected. This procedure will prevent damage to the earth borer, since the nature of the soil may be more readily determined after the first 18 inches have been penetrated.

***e. Detailed instructions.***—For detailed operating instructions on Truck K-44-A and Truck K-44-B, see TM 11-364.

**78. FACING POLES CARRYING OPEN WIRE.—*a. Straight Sections of Line.***—In straight sections of the line, the poles are usually set so that adjacent poles face in opposite directions, as shown in figure 62.

* * * * * * *

**81. SETTING POLES WITH PIKES.—*a. Poles 35 feet or shorter length.***—Before starting to * * * proceed as follows:

* * * * * * *

(4) Lift the pole and deadman to position B.

* * * * * * *

***b.*** (Superseded) ***For erection of heavy poles.***—(1) ***A-frame.*** An **A**-frame is constructed of two poles, timbers, or crossarms bolted or lashed together near the top to form a rough barless **A**. The vertical height of this frame in place must be at least one-fifth the length of the pole to be raised. In operation, the **A**-frame acts to change the direction of the pulling force used to raise the pole.

(2) *Preparing the pole hole.* Prepare the pole hole by digging it to the proper depth and then digging an inclined trench into the hole from the direction from which the pole is to be set. This trench will normally be dug to at least half the depth of the hole and will extend from that point to the ground level at a distance equal to the depth of the hole. Place a heavy plank vertically in the pole hole. This plank should be about 2 inches thick and 10 inches wide, and long enough to reach the bottom of the hole and project about 2 feet above the top of the hole. Place this plank, known as the butt-board, facing the trench. Place the butt end of the pole that is to be erected in the trench. Ram the pole buttward until the butt of the pole is jammed tightly against the butt-board. The pole is now ready to be rigged with the necessary lines to raise and temporarily guy it in place.

(3) *Rigging the pole.* The pole may be pulled to the vertical position by a winch line or by multiple sheave blocks. To prevent the pole from falling sidewise, should it get off center in relation to the pulling force, it is necessary to attach side-guy lines to the pole. The length of the guy lines must be at least one and three-fourths times the height of the pole to be erected. This will provide enough line to safely and easily keep the pole in alignment during and after erection. Snub these guy lines to adequate anchorage, each at right angles to the pulling force that is to raise the pole. Use a timber hitch to attach the side guys to the pole. The point of attachment for these guys will be within a few feet of the top of the pole. Another guy line, the back guy, is similarly made fast to keep the pole from falling toward the pulling force after the pole is raised to the vertical position. The back guy is identical in size and method of attachment and is snubbed off from the pole in the opposite direction to the pulling force. Adequate anchorage for the back and side guys must be provided. Use trees of suitable size if they are available and happen to be at the right distance and angle from the pole to be raised. If natural anchorage is not available, use screw-type swamp anchors or log anchors. Place the anchors for the side guys at right angles to the pulling force and the anchor for the back guy opposite the pulling force. The distance from the anchorages to the pole hole should be greater than the height of the pole to be raised. By means of a quick hook or rope sling attach the pulling line at a point above the balance point of the pole. This is the point along the pole at which the pole is balanced if picked up. Lift the pole so that the top will raise and the butt will remain on the ground.

(4) *Installing A-frame.* The A-frame is used to get the necessary purchase to start the pole to the vertical position. To accomplish this, place the A-frame astride the pole at a 45° angle, the top of the A-frame inclined toward the top of the pole and over and even with the point of attachment of the pulling line. Place the A-frame at right angles to, and the legs equidistant from, the pole. Make a small excavation for each leg to prevent the frame from slipping. Place the pulling line over the top of the A-frame into the V at its top, and take the slack out of the pulling line. The frame will stay in position because of the downward force exerted on it by the pulling line.

***Caution:*** Place the winch truck at a safe distance, a distance equal to the height of the pole plus at least 25 feet, so that the pole could not hit the truck if it should fall. See that the truck is well chocked or anchored.

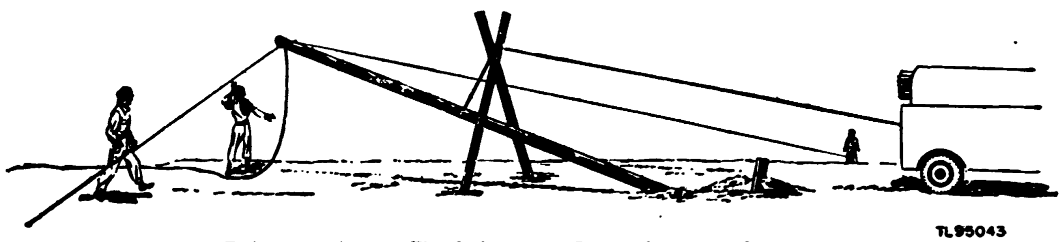



Figure 71.—Raising pole using A-frame.

(5) *Raising the pole.* When raising the pole by winch, four men, a noncommissioned officer, and one vehicle will be used. Other personnel, vehicles and tools will be kept clear of the area. A detail of three men will be necessary to control the three guy lines. One man will operate the winch. The noncommissioned officer will direct and coordinate the efforts of the men from his position near the butt of the pole where he can be seen by the winch operator and where he can determine that the pole is progressing upward as it should. As the winch line raises the pole, slack off the back and side guys simultaneously, or hold one side guy as the other is slacked off, to keep the pole from falling off to one side. The noncommissioner officer in charge will direct which man will slack or hold, as he can better determine the relative position of the pole as it moves upward. As soon as the pole has been raised to a point where the pulling winch line no longer touches the A-frame top, remove the A-frame and place it in the clear to prevent possible interference as the pole is raised. The noncommissioned officer directs the continued pulling by the winch line until the pole is vertical and then directs the men on the guy lines to make their

lines fast. If a winch truck is not available, use a log anchor to anchor a set of blocks to raise the pole. Attach one end of the blocks to the log anchor, the other end to a pulling line, and proceed the same as when using a winch. Several pulls may be necessary, depending on the length of the line in the blocks used. If the pole is very heavy, attach a second set of blocks (commonly called luffing tackle) to the fall line of the blocks attached to the pole, and have the man pull on the fall line of the luffing tackle.

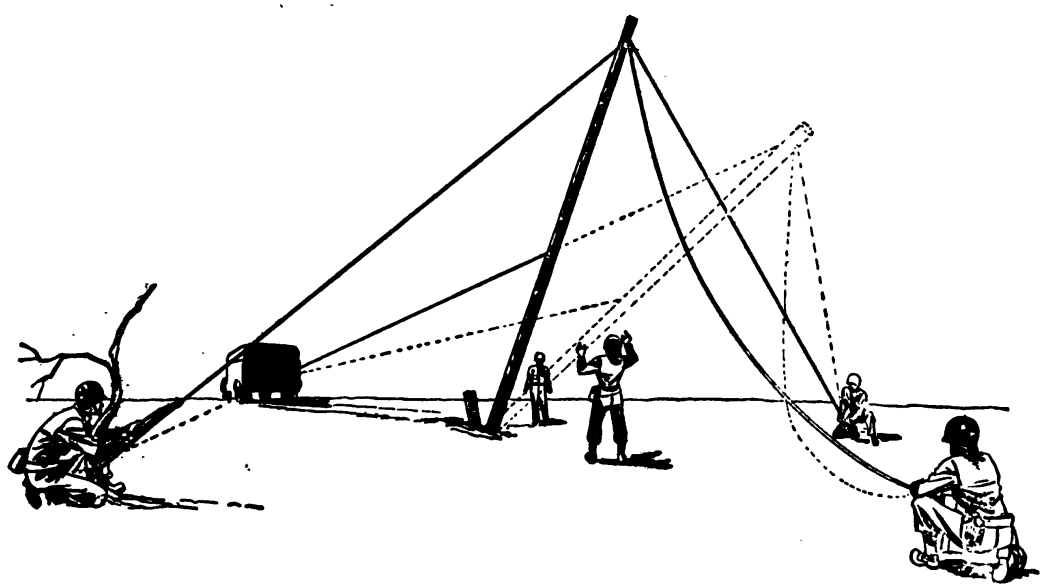



Figure 72.—Guying as pole is raised, A-frame removed.

(6) *Plumbing, backfilling, and tamping.* Remove the butt-board and, by using the four guy lines, plumb the pole to true vertical. Backfill the hole around the pole and tamp each shovelful well. When the backfilling is finished, slack off the guy lines and pulling line so that a lineman can climb the pole and remove the lines.

**120. INSULATORS.**—The insulators to be used on the PF-59 pins are made of glass and are of **three** types, the SG DP **Insulator IN-128, and Insulator IN-15.** The SG DP insulator has only one wire groove and a **double petticoat,** and is used at all locations except the pins where transpositions are to be made. **Insulator IN-15 has only one wire groove and a single petticoat. It can be used in place of the SG DP insulator on short lines or as a substitute in case of an emergency.** The Insulator **IN-128** has two wire grooves and is for use only on pins where transpositions are to be made. **Insulator SG DP and Insulator IN–128** are shown in figure 111.

On figure 111, page 122, change reference to TW INSULATOR to read: INSULATOR IN–128.

Figure 111.—SG DP and Insulator **IN–128** insulators.

## 121. GENERAL.

*    *    *    *    *    *    *

***b. Pins.***—Place PF–59 pins * * * damage the threads. Then drive a 6d. common (**galvanized preferred if available**) wire nail through the side of the crossarm, half-way between the top and bottom, and into the middle of the pan. At transposition poles, * * * from the center. **Where climbing space is a consideration, use the transposition pin farther from the pole.** Before placing pins * * * proper wire positions.

*    *    *    *    *    *    *

***d. Insulators.***—Place glass insulators * * * they are tight. Be careful to place glass Insulators **IN–128** on pins at which transpositions are to be made and SG DP glass insulators on the other pins.

On figure 113, page 125, change reference, Crossarm Brace, to read: PF–4 Crossarm Brace.

On figure 114, page 126, add reference: PF–4 Crossarm Braces.

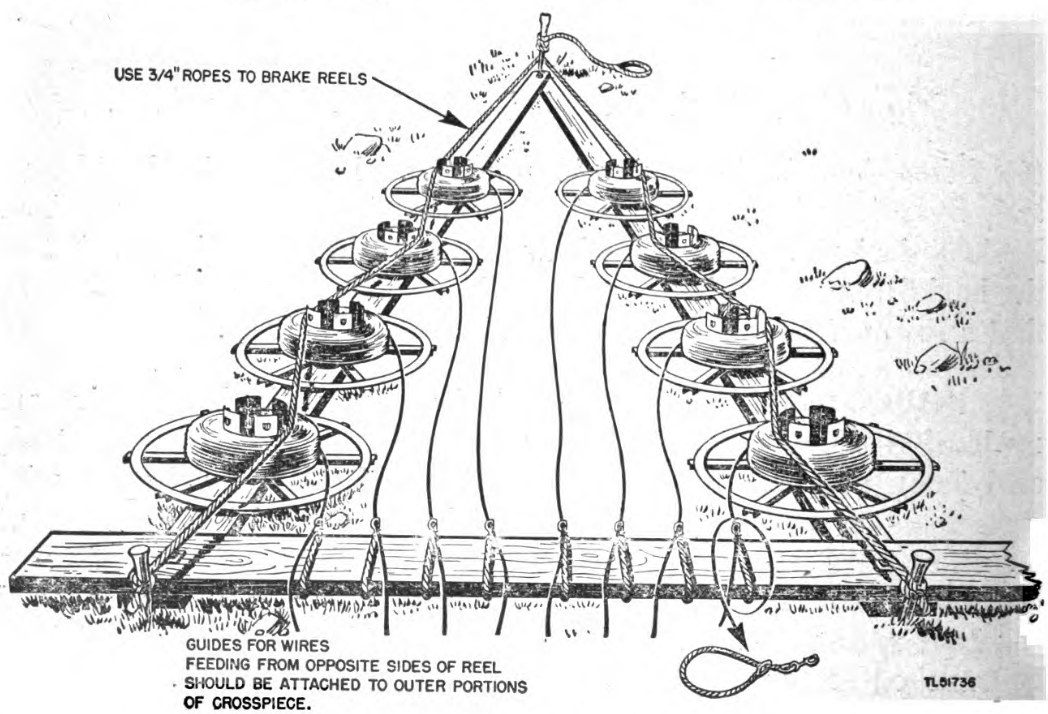



Figure 118.—Reel setup on ground.

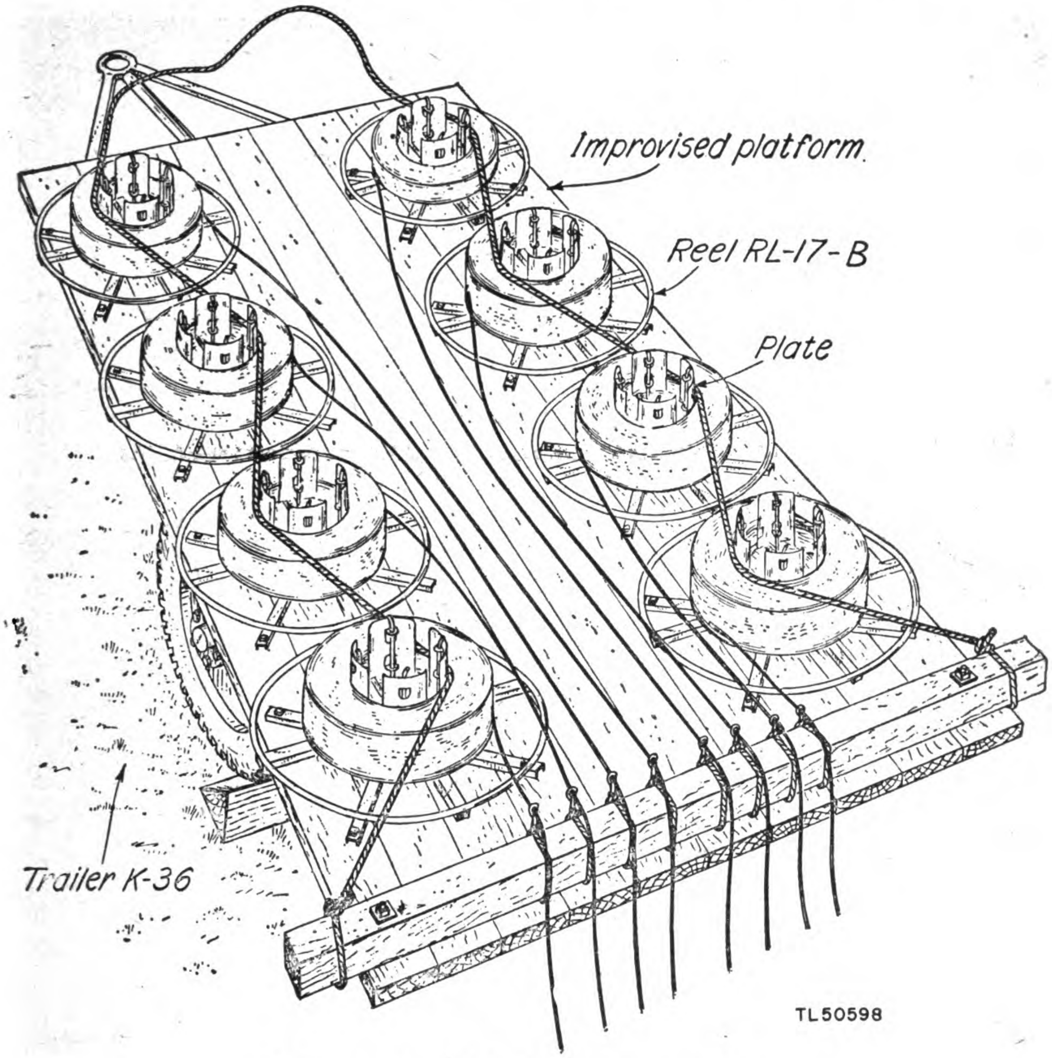



Figure 119.—Reel setup on trailer.

**130. PAYING OUT WIRE.—*a. Stringing Wires in One Direction Only.*—** Where pole lines * * * stop the pull. **For visual or sound signaling see paragraphs 64 and 65.**

* * * * * * *

**131. PULLING WIRES.—*a.*** In pulling out * * * a running board. A pulling line of ¾ inch manila rope, free from metallic strands and about 1,500 feet long, is fastened to the front of the running board and used to pull the wires along the pole line. **Two pulling ropes may be used to save time. The two ropes are strung end to end over the crossarms along the pole line. When the wire has been pulled to the beginning of the second rope, the running board is attached to the second rope and the pull continued.**

**The first pulling rope is taken ahead and relaid for the next pull.** If the wires * * * in figure 123.

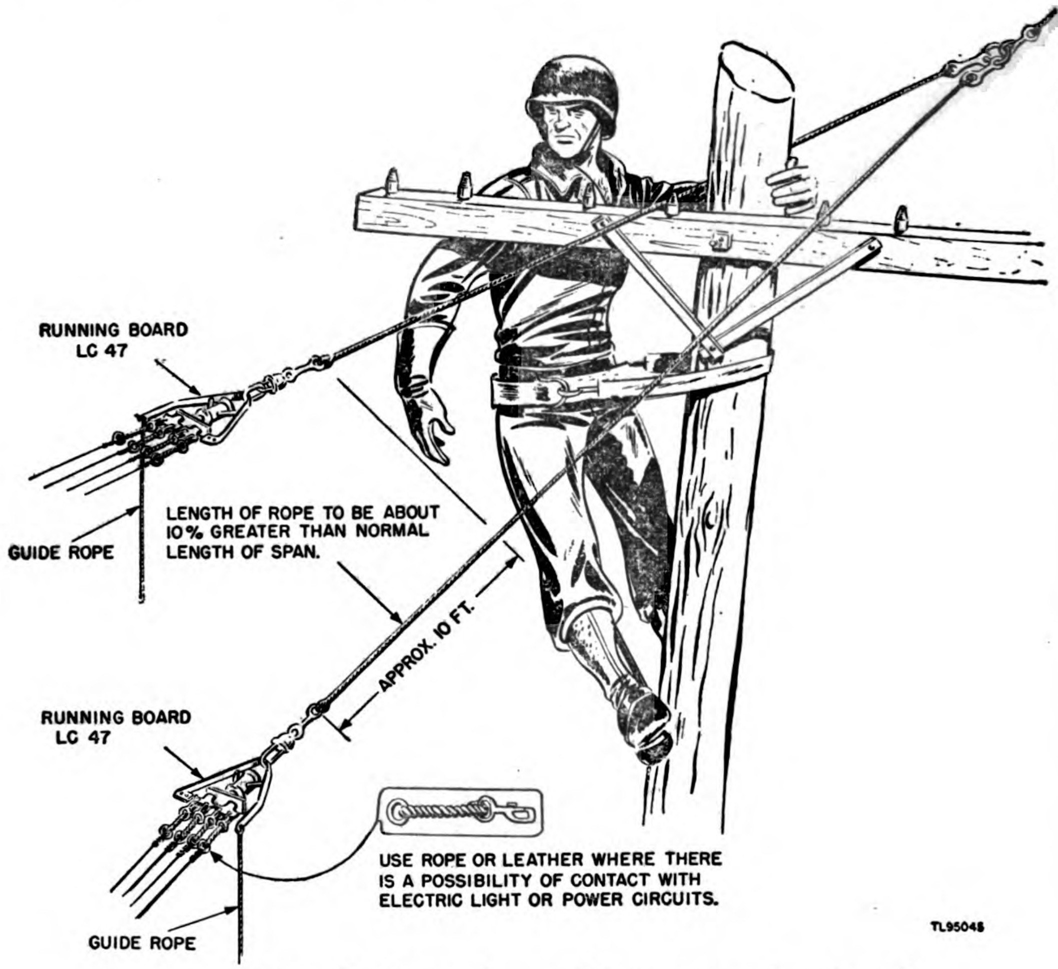



Figure 123.—Pulling wires with two running boards.

**136. STRINGING SAGS.—*a*.** After wires have * * * forms on them. **Proper sagging of wires cannot be overemphasized in line construction with the present use of carrier systems for communication, if high transmission efficiency is to be obtained and maintenance kept low.** The proper sag * * * is 6 inches.

* * * * * * *

**137. METHODS OF OBTAINING SAGS.**

* * * * * * *

***d. Tension Method of Measuring Sag*** (Added).—In this method, the tension is measured with Scale LC–64, a dynamometer, or spring balance of suitable range, such as an ice scale, in series with the tensioning blocks. The method of tensioning is illustrated in figure 133.1. The desired sag and corresponding tension are determined from the sag tables. (See figs. 133 and 133.2.) The wire is then brought to the desired sag by applying the specified tension.

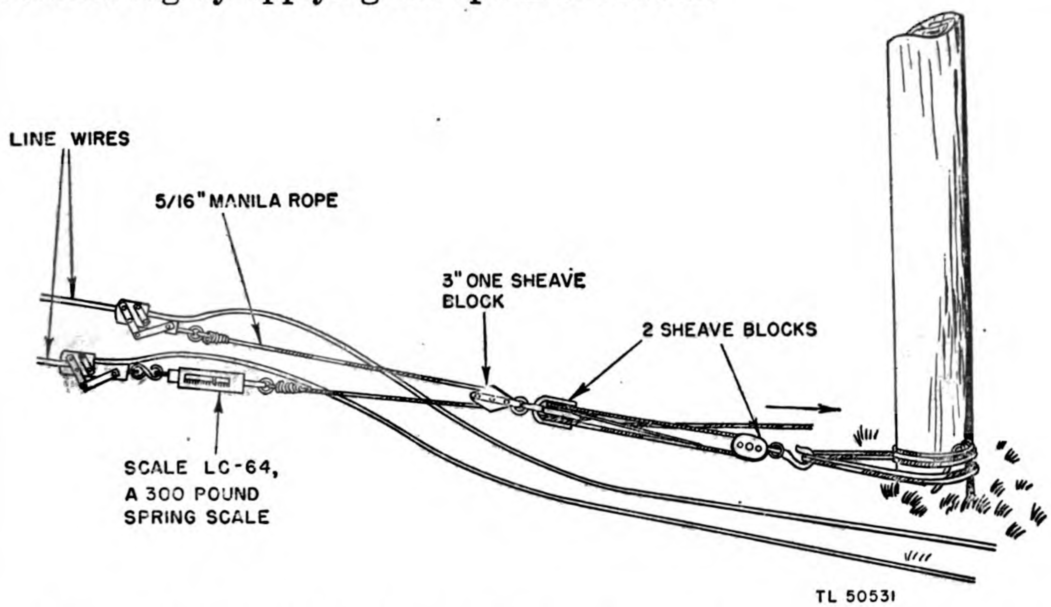



Figure 133.1.—Method of applying measured tension to line wires.

WIRE STRINGING TENSIONS* FOR 104 COPPER-CLAD STEEL LINE WIRES

[Span length: 120 to 170 feet]

| Temperature—Degrees Fahrenheit | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 100 | 90 | 80 | 70 | 60 | 50 | 40 | 30 | 20 | 10 | 0 | −10 |
| Tension—Pounds | | | | | | | | | | | |
| 125 | 135 | 145 | 155 | 170 | 185 | 200 | 215 | 230 | 250 | 270 | 295 |

*Average value for 150-foot ruling span.

Figure 133.2.—Table of tensions for various span lengths and temperatures.

Figure 135.—Sleeve **compressing Tool TL-217.**
Figure 137.—Operation of sleeve rolling **Tool TL-143.**

**150. METHOD OF MAKING STANDARD TIE.**—Use a 22-inch length of 104 CU tie wire and make the tie as shown in figure 143.

**161. GENERAL.**—Signal Corps Stock * * * in stock numbers.

| Stock No. | Unit | Description |
|---|---|---|
| * | * | * |
| 1A809.104 | foot | Wire (bare) .104 inch diameter, single conductor, steel core, copper clad (4% conductivity) Copperweld Steel Co., or equal. |
| 1A812 | foot | Wire, #12, BWG, G. I. (Spec. 71-360; ½-mile coils). To be used for protection of poles against lightning. |
| **1A812.2** | **1 lb** | **Wire, bare, copper, s. d., #12 NBS (22″ pieces, tie wire approx 16 per lb).** |
| * | * | * * * * * |
| **3G1815-1** | each | Insulator, Glass, SG DP (Hemingray #45 or Whitehall Tatum #1). |
| 3G1815-53 | each | Insulator **IN-128,** Glass, transposition, double groove (Hemingray #52 or Whitehall #15). |
| **3G515** | **each** | **Insulator IN-15, Glass, toll-line, single groove, single petticoat (Hemingray #16).** |
| * | * | * * * * * |
| 5A1592A | each | Crossarm PF-92A * * * or creosote treated). |
| **5B2126** | **each** | **Brace, crossarm; G. I., 26 inches long.** |
| **5B2104** | **each** | **Brace PF-4, crossarm; G. I., 20 inches long.** |
| * | * | * * * * * |
| 5B308-6 | each | Anchor, guy, Matthews, * * * * 6 feet long). |
| **6R56200** | **each** | **Wrench, Matthews #567; 5′-4″ over-all, for installing nevercreep anchors.** |
| **5B512** | **each** | **Anchor Screw, steel; 12 inch diam, Joslyn #J-2872 (less rod, suitable for use with 2-inch pipe as swamp anchor).** |
| **6R56727** | **each** | **Wrench, pipe chain; Vulcan #12; 27 inches long; flat link chain; takes pipe ¼ to 2½ inches diam.** |

**[AG 300.7 (8 Nov 44)]**

BY ORDER OF THE SECRETARY OF WAR:

OFFICIAL:
J. A. ULIO
*Major General*
*The Adjutant General*

G. C. MARSHALL
*Chief of Staff*

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For explanation of symbols, see FM 21–6.



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# TABLE OF CONTENTS

# Open Wire Construction for Fixed Plant Application

## CHAPTER I
## GENERAL



## *Section I*
## *General*

**1. OBJECT.—** The object of this manual is to describe the methods used in the planning for and the construction of open wire lines suitable for the operation of voice and carrier telephone and telegraph circuits for fixed plant use.

**2. SCOPE.—** ***a.*** These instructions relate to fixed open wire plant of a semi-permanent or permanent nature serving military requirements.

***b.*** The lines described in this manual consist of pole lines suitably guyed and carrying not more than two crossarms on each of which a maximum of four pairs of 104 copper clad steel wires will be placed.

***c.*** Planning the line, surveying the route and staking out the line are covered in this manual. In order to secure the best operation of the circuits it is important that these instructions be followed as closely as possible. Minor deviations, when required to meet conditions of terrain which make strict adherence to the rules impossible, are permitted. Such deviations should not be made unless necessary, as they tend to disrupt the proper functioning of the circuits.

***d.*** The information in this manual is suitable as a text for training construction personnel as well as for the guidance of personnel experienced in line construction methods.

**3. LINE REQUIREMENTS.— *a.*** The lines described in this manual are designed to give satisfactory telephone and telegraph transmission over distances up to about one thousand miles, provided that repeaters are installed at approximately 100 mile intervals.

***b.*** The design of these lines has been made as simple as possible and if properly constructed should be structurally sound and reliable electrically.

**4. DESCRIPTION OF LINES.—** The poles used will usually be Class 7 and 30 feet long. Longer poles may be required in sections of the line crossing gullies in order to provide proper grading of the line. The spans between adjacent poles will be 150 feet. The lines are designed for heavy storm loading conditions (½ inch radial thickness of ice on the wires and a wind pressure of 8 pounds per square foot, which corresponds to a wind velocity of almost 60 miles per hour).

**5. LINE TREND.—** It is important that each line be assumed to have a specific direction because the numbering of pin positions (and thus of pairs) and the layout of the transposition system depend upon the line direction or "trend." The term "line direction" might be confused with compass direction and therefore the term "line trend" is used in fixing the direction of the line.

***a. Definition of line trend.—*** The line trend is from the post of higher command to the post of lower command. In the case of a line between two posts of equal command the line trend is from left to right when the line is viewed from the post of common higher command.

***b. Examples of line trend.—*** A line from army headquarters to corps headquarters is taken to start at the post of higher command (army) and the line trend is toward the post of lower command (corps). If a line runs between two corps headquarters which are approximately on an east and west line and the army headquarters is south of this line, the line is taken to start at the corps headquarters to the west and the line trend is toward the corps headquarters to the east (left to right when viewed from the post of higher common command).

***c. Applications.—*** Determination of line trend is necessary to fix the direction in which poles are to be numbered. The numbering of pin positions, and therefore of wires, is from the left to the right of the crossarm when the observer is facing in the direction of the line trend. For example, the outside left pin is number 1, the next number 2, and so on to number 10 on the extreme right, numbers 5 and 6 being omitted on an 8-pin crossarm.

# Section II
# Transpositions

**6. GENERAL.—** Transpositions are used to reduce or prevent crosstalk which is the result of current on one pair of wires inducing current on the other pairs of wire on the line. A transposition is made by turning the pair over so that the wire on the odd numbered pin is placed on the even numbered pin and vice versa. It is very important that these transpositions be made in each pair of wires at each of the points shown in the transposition diagrams. If this is not done, conversation on one pair is likely to be heard on the other pairs, particularly in the case of the high frequency carrier circuits.

**7. TRANSPOSITION SECTIONS.—** A transposition is made in some of the wires at very fourth pole in a full transposition section and usually at every second pole in a short transposition section. The same pair of wires, however, is transposed not more frequently than every eighth pole in a full transposition section nor every fourth pole in a short section. The transposition poles are indicated in the diagrams as A, B, C, D or S poles. The S poles occur only at the end of each transposition section. A full transposition section contains 128 spans. The S pole at the end of a transposition section becomes the first pole of the next transposition section. In general, as many full sections as possible are to be used. If the length of the line is not a multiple of 128 spans, it will be necessary to use a short transposition section or a combination of short sections, to complete the line. For various numbers of spans up to 128, the table in figure 1 shows the proper short sections or combinations of short sections to be used.

**8. TRANSPOSITIONS FOR FIRST CROSSARM: FULL SECTION.—*a.*** The transpositions for the first, or top, crossarm are shown in figure 2. The transpositions in each pair are indicated by the crosses in the horizontal lines which represent the wires. The pin positions are shown at the left of the drawing, opposite the lines representing the wires. Thus, the top two lines show the transpositions for pair 1-2. It will be seen that the transpositions for each pair are made at fixed intervals and are repeated regularly throughout the full transposition section. The only exception to this occurs at every 32nd transposition pole which is known as an S pole. The transpositions at S poles are shown in figure 3.

***b.*** The transposition poles are indicated by the letters A, B, C, D and S in figure 2. At every A pole a transposition is made in pair 7-8 but not in any of the other pairs. At every B pole transpositions are made in pairs 1-2 and 9-10 but not in pairs 3-4 and 7-8. At every C and D pole transpositions are made in pairs 1-2 and 3-4 but not in pairs 7-8 and 9-10. At every S pole transpositions

## COMBINATIONS OF SHORT TRANSPOSITION SECTIONS

| No. of Spans | Use Short Sections |
|---|---|
| 2 - 7 | 2 - 7 |
| 8 - 9* | 8 |
| 10 - 15 | 8 and 2 - 7 |
| 16 - 17* | 16 |
| 18 - 23 | 16 and 2 - 7 |
| 24 - 25* | 16 and 8 |
| 26 - 31 | 16 and 8 and 2 - 7 |
| 32 - 33* | 32 |
| 34 - 39 | 32 and 2 - 7 |
| 40 - 41* | 32 and 8 |
| 42 - 47 | 32 and 8 and 2 - 7 |
| 48 - 49* | 32 and 16 |
| 50 - 55 | 32 and 16 and 2 - 7 |
| 56 - 57* | 32 and 16 and 8 |
| 58 - 63 | 32 and 16 and 8 and 2 - 7 |
| 64 - 65* | 64 |
| 66 - 71 | 64 and 2 - 7 |
| 72 - 73* | 64 and 8 |
| 74 - 79 | 64 and 8 and 2 - 7 |
| 80 - 81* | 64 and 16 |
| 82 - 87 | 64 and 16 and 2 - 7 |
| 88 - 89* | 64 and 16 and 8 |
| 90 - 95 | 64 and 16 and 8 and 2 - 7 |
| 96 - 97* | 64 and 32 |
| 98 - 103 | 64 and 32 and 2 - 7 |
| 104 - 105* | 64 and 32 and 8 |
| 106 - 111 | 64 and 32 and 8 and 2 - 7 |
| 112 - 113* | 64 and 32 and 16 |
| 114 - 119 | 64 and 32 and 16 and 2 - 7 |
| 120 - 121* | 64 and 32 and 16 and 8 |
| 123 - 127* | 64 and 32 and 16 and 8 and 2 - 7 |

* No transpositions made in last span.

Figure 1.

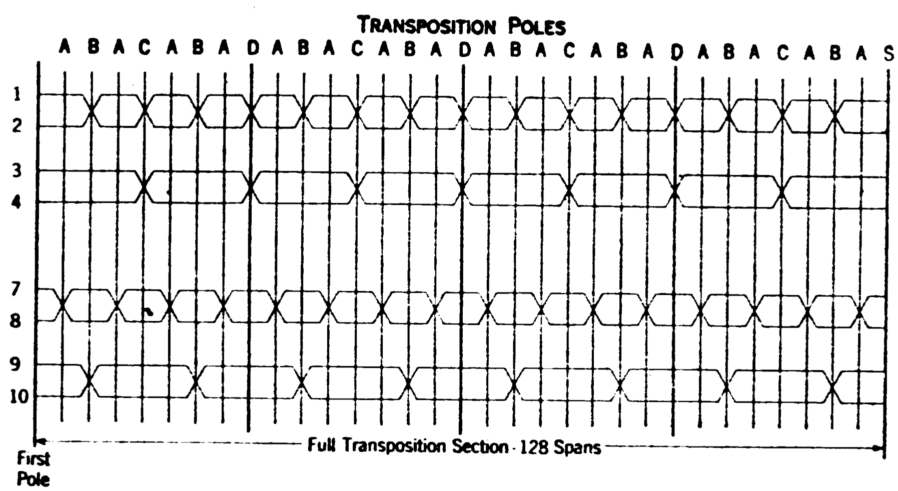
are made in pairs 3-4 and 9-10 but not in pairs 1-2 and 7-8. Memorizing this arrangement of transpositions will help in providing the proper insulators on each first, or top, crossarm. Thus, at each A pole, a TW transposition insulator (which has two wire grooves) will be placed on pin 7 to serve pair 7-8 and non-transposition insulators (which have only one wire groove) will be placed on pins 1, 2, 3, 4, 9 and 10; at each B pole, transposition insulators will be placed on pins 2 and 9 to serve pairs 1-2 and 9-10 and non-transposition insulators will be placed on pins 3, 4, 7 and 8; at each C and D pole, transposition insulators will be placed on pins 2 and 4 to serve pairs 1-2 and 3-4 and non-transposition insulators will be placed on pins 7, 8, 9 and 10; at each S pole, transposition insulators will be placed on pins 4 and 9 to serve pairs 3-4 and 9-10 and non-transposition insulators will be placed on pins 1, 2, 7 and 8. In a full transposition section of 128 spans there are 16 A poles, 8 B poles, 4 C poles, 3 D poles and 1 S pole. At the poles between the transposition poles, no transpositions will be made.

**c.** The transpositions arrangement is the same in each full transposition section. In other words, when an S pole is reached, the transpositions will be repeated in the same order in which they were made in the first transposition section.

**9. TRANSPOSITIONS FOR FIRST CROSSARM: FULL SECTION: S POLES.—** At the S poles at the ends of the full transposition sections the transpositions should be made as shown in figure 3.

**10. TRANSPOSITIONS FOR FIRST CROSSARM: SHORT SECTIONS.—** If the short section is 2 to 7 spans long, a transposition is made in pairs 3-4 and 9-10 at the middle pole and no other transpositions are made in this section. If there are an even number of poles between the last S pole and the end pole, the pole nearer the middle should be used as the transposition pole. If the short section is 8 or more spans long, every *second* pole (except D poles) becomes

TRANSPOSITIONS FOR FIRST CROSSARM
FULL TRANSPOSITION SECTION

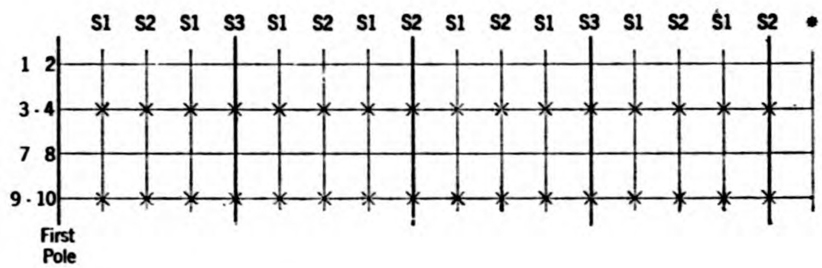



NOTES: 1. For transpositions at S poles see Figure 3.
2. Nominal distance between transposition poles is 600 ft. (4 spans).

Figure 2.

a transposition pole and the transpositions are made as shown in figure 4. This figure also indicates the transposition arrangements to be used in other standard short sections of 16, 32 and 64 spans. It will be noted that *the transposition arrangements at B and D poles in short sections differ from those used on similarly designated poles in full sections.* Therefore it is recommended that reference be made to figure 4 before placing insulators on crossarms in short sections so as to determine the proper transposition arrangement.

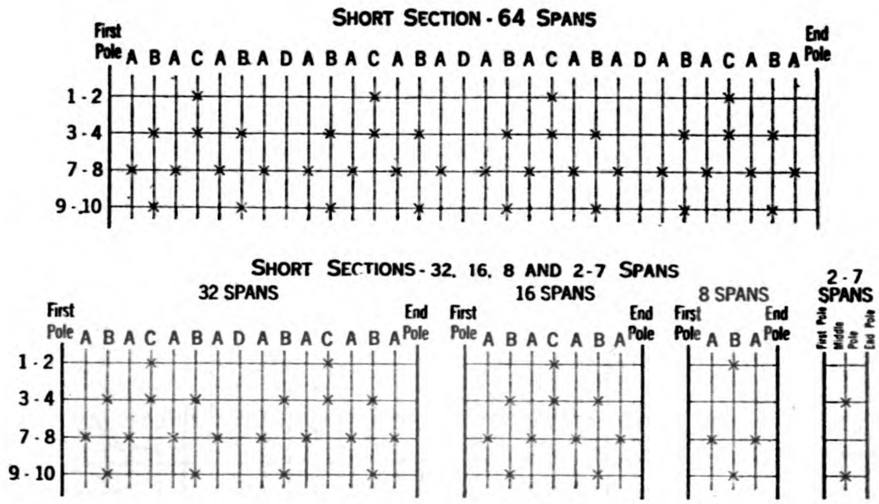
TRANSPOSITIONS AT S POLES
FIRST CROSSARM




NOTES: × Indicates transposition.
* Repeat sequence starting with S1 at extreme left of diagram.

Figure 3.

TRANSPOSITIONS FOR FIRST CROSSARM
SHORT SECTIONS




NOTES:

(1) Short sections should be combined as shown in Figure 1.
(2) When short sections are combined the End Pole of one section serves as the First Pole of the adjacent section.
(3) At the end of a short section when no other short section follows, or at the end of a combination of short sections, transpose at the End Pole so that the wires on this pole occupy the same pin positions as they had upon leaving the S pole at the end of the last full transposition section. This will result in the wires entering the next full section in the same pin positions they would have occupied if the short section or sections did not exist.
(4) Nominal distance between transposition poles in short sections is 300 feet (2 spans), except in 2-7 spans where the distance will be from 1-4 spans.

Figure 4.

**11. TRANSPOSITIONS FOR SECOND CROSSARM: FULL SECTION.—** **a.** The second crossarm will generally be placed 3 feet below the first crossarm. (The pole is bored to permit the second crossarm to be placed 2 feet below the first crossarm but the second crossarm should not be placed at this point unless special orders have been received to do so.) When the second arm is added, the transpositions on the first arm are not changed. The transpositions for the second crossarm are not the same as for the first crossarm, nor are they as simple.

**b.** The transpositions for the second crossarm except at S poles, are shown in figure 5. The notations on this drawing have the same meaning as those in figure 2 for the first crossarm.

**12. TRANSPOSITIONS FOR SECOND CROSSARM: FULL SECTION: S POLES.—** Transpositions at S poles are shown in figure 6. On the first crossarm the transpositions at S poles are all alike but on the second crossarm there are three types which are shown in figure 6 as S1, S2 and S3. It will be noted in figure 6 that at S1 poles there are transpositions in pairs 11-12 and 19-20 but not in pairs 13-14 and 17-18; at S2 poles there are transpositions in pairs 11-12 and 13-14 but not in pairs 17-18 and 19-20; at S3 poles there are no transpositions in any of the pairs on the second crossarm.

**13. TRANSPOSITIONS FOR SECOND CROSSARM: SHORT SECTIONS.—** If the short section is 2 to 7 spans long, a transposition is made in pairs 11-12 and 17-18 at the middle pole and no other transpositions are made in this section. If there are an even number of poles between the last S pole and the end pole, the pole nearer the middle should be used as the transposition pole. If the short section is 8 or more spans long, every *second* pole (except A poles) becomes a transposition pole and the transpositions are made as shown in figure 7. The transposition arrangements shown in this figure are to be followed regardless of the type of S pole (S1, S2 or S3) which is the first pole in the short section.

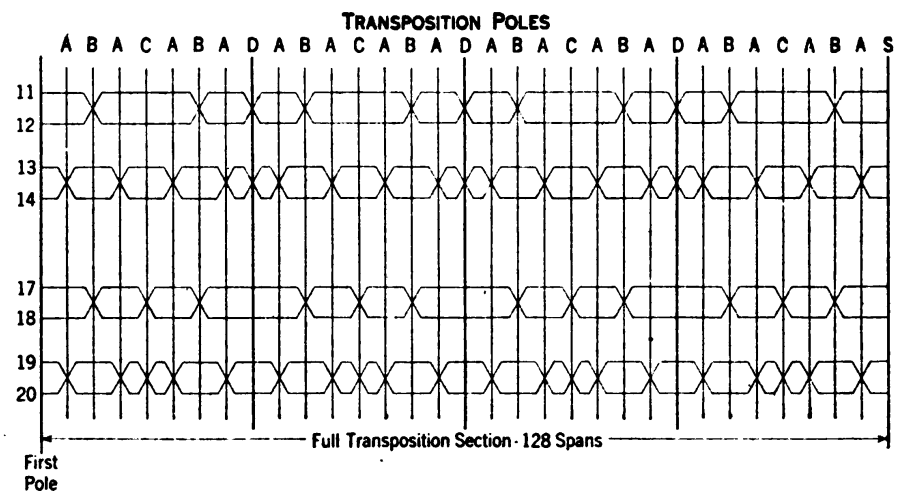
**14. BRANCHES IN AN OPEN WIRE LINE.—** When pairs employed in carrier operation branch off from a main lead, the branching must take place at an S pole or the end pole of a short section. This may mean that a short section, or a combination of short sections, would be necessary between the end of the last full transposition section and the branch point. However, if only voice frequency circuits branch off from the main lead the branch may occur at any point.

If a branch in carrier facilities is made from only one arm, and does not occur at an S pole, short section transposition arrangements must be adopted for both arms between the S pole of the last full section and the branch point.

**15. JUNCTIONS BETWEEN OPEN WIRE AND INTERMEDIATE CABLE.—** When the continuity of an open wire lead is interrupted through the introduction of cable, such as submarine or buried cable, the junction pole between the open wire and cable should be an S pole or the end pole of a short section. This may mean that a short section, or a combination of short sections, will be necessary between the end of the last full transposition section and the junction point.

At the junction pole at the far end of the cable where the open wire is resumed, the open wires shall occupy the same pin positions as they had upon leaving the S pole of the last full transposition section.

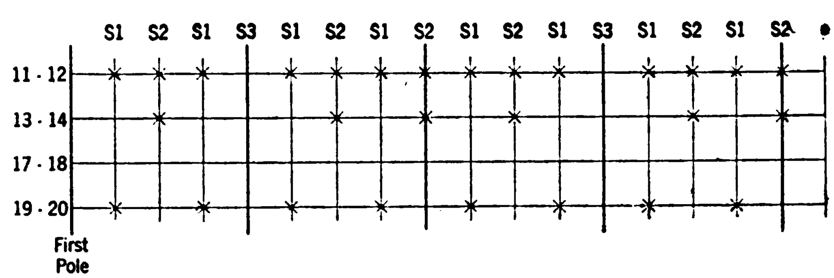
TRANSPOSITIONS FOR SECOND CROSSARM
FULL TRANSPOSITION SECTION




NOTES: 1. For transpositions at S poles see Figure 7.
2. Nominal distance between transposition poles is 600 ft. (4 spans).

Figure 5.

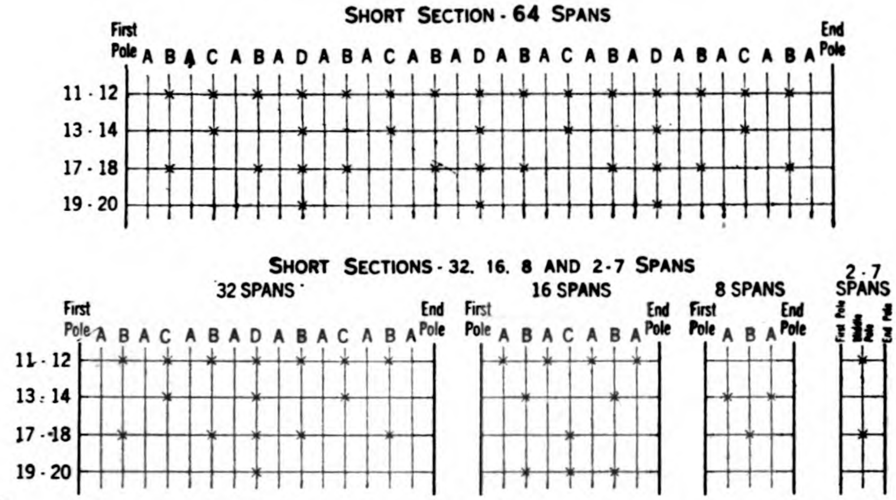
TRANSPOSITIONS AT S POLES
SECOND CROSSARM




NOTES: × Indicates transposition
*Repeat sequence starting with S1 at extreme left of diagram.

Figure 6.

TRANSPOSITIONS FOR SECOND CROSSARM
SHORT SECTIONS




NOTES:

(1) Short sections should be combined as shown in Figure 1.

(2) When short sections are combined, the End Pole of one section serves as the First Pole of the adjacent section. At this pole transpose pair 19-20.

(3) At the end of a short section when no other short section follows, or at the end of a combination of short sections, transpose at the End Pole so that the wires on this pole occupy the same pin positions as they had upon leaving the S pole at the end of the last full transposition section. This will result in the wires entering the next full section in the same pin positions they would have occupied if the short section or sections did not exist.

(4) Nominal distance between transposition poles in short sections is 300 feet (2 spans), except in 2-7 spans where the distance will be from 1-4 spans.

Figure 7.

# CHAPTER II
# PLANNING



## *Section I*
## *Advance Planning*

**16. PURPOSE.—** The successful completion of a long open wire line that may form a main axis of communication or an important branch line requires careful advance planning, a survey of the proposed route, the preparation of detailed plans and marking the route on the ground.

**17. GENERAL PROCEDURE.—** Ordinarily the general route, the number of wires and other necessary features of the proposed line will be specified. The plan of construction will be based on tactical requirements, nature of the terrain, the number and types of circuits needed, the relation of the proposed line to other lines in the communication system and on other factors. The general features of the line thus planned will be shown on a route map. A copy of this map, together with any other necessary information or instructions will be given to the construction commander who will be directly responsible for making the route survey, completing detailed plans, marking the route and building the line.

**18. TERRAIN CONSIDERATIONS.— *a.*** In planning the route information as to terrain conditions will be obtained from topographical maps or aerial photographs if they are available. Inspection of the route, either from an automobile or aeroplane flying at low level, is desirable.

***b.*** If it can be done, the route should be laid out to avoid terrain where construction would be difficult.

(1) Forests, swamps, jungles, very rocky ground, ravines, steep grades, irregular contours or large streams add to the difficulty of construction and should be avoided as much as possible.

(2) Places where trees or bushes would come in contact with the wires should be especially avoided because these contacts would interfere seriously with transmission during wet weather.

(3) The soil along the route should be suitable for digging pole and anchor holes and firm enough to give good support.

(4) The route should be accessible from roads so that material can be hauled into it and so that maintenance personnel can get to any part of it with as little difficulty as possible.

(5) The line should not be built along roads so close to the traffic lanes that trucks running off the road would crash against the poles.

(6) Lines should not be built close to and along roads, canals or railroads where enemy bombing would damage the pole line.

(7) Locations close to industrial plants, power houses, railroad terminals, switchyards, storage areas, depots, troop concentration points, air fields or towns should be particularly avoided as they are likely to be the object of enemy bombing.

**c.** Where it is possible, the route should be laid out so that the line will not be easily seen from the air. This can sometimes be done by routing along the edge of a forest or by following a fence line or stone wall. By keeping the line as inconspicuous as possible, the danger of damage by air attack and casualty to personnel will be reduced.

**19. AVOIDING POWER LINES.— *a. Parallel lines.—*** The line should not be built parallel to a power line unless the separation between the two lines will be at least ¼ mile. If built closer together, the power line is likely to induce noise currents or dangerous voltages on the communication line.

***b. Intersecting lines.—*** Where the route of the communication line must cross a power line, the intersection should be made as nearly at a right angle as possible. The communication line should always cross under the power line, never over it unless special approval is obtained, from the signal officer, to place the communication conductors over the power conductors. If practicable, the communication line should cross within 50 feet of one of the power line poles so that the power wires will be less likely to sag down on the communication wires.

**20. ESTIMATE OF MATERIALS.—** The advance planning will include a preliminary estimate of the materials needed for the line so that it can be determined whether the proper amounts and types of material are available. Allowance should be made for loss, breakage, defective material and errors in measurement. This estimate is, of course, subject to change when the detailed estimate is made after the line survey.

**21. ROUTE MAP.**— In drawing up plans for the line a route map showing the general features of the line and such details as are considered necessary will be prepared. This map may be an aerial photograph or mosaic, a topographic map or any other suitable map. It will show the origin and destination of the line, approximate route and mileage, location of repeaters, type and number of circuits, and any other necessary details. A copy of this map will be given to the construction commander for use in the route survey and detailed planning. This map, or a copy of it, will be resubmitted to the signal officer showing any changes which are considered warranted as a result of the route survey and more detailed study of the project.

## *Section II*
## *Route Survey*

**22. GENERAL PROCEDURE.—*a. Route Survey.*—** (1) When the advance plan of a proposed open wire line has been decided and mapped out, the construction commander is provided with a copy of the route map and such other information as is necessary to enable him to arrange for a detailed survey of the route and to complete plans for construction. A proper route survey is a very important step in the orderly organization of a construction project. It reveals necessary modifications in the advance plan, establishes the most practical way of following the proposed route, provides a basis for completing the details of the construction plan and sets up landmarks for the guidance of the pilot who will later lay out the line in detail.

(2) The route survey should be made by experienced personnel capable of arriving at sound decisions as to details of route and type of construction required, as frequently it will be necessary to modify the advance plan in certain respects. In view of the importance of the survey, the best talent available should be assigned to carry it out and enough time should be taken to make sure that a thorough job is done. Time so spent will be more than regained in orderly progress of the construction work.

***b. Completion of line planning.*—** The route survey will provide information that will help in the completion of line planning. Knowledge gained and notes taken by the survey party should be in enough detail to provide a basis for making estimates of materials and setting up delivery schedules, for solving special construction problems and for organizing the personnel and equipment required for the project.

***c. The pilot.*—** (1) The survey party should include at least one man who will be available to act later as pilot for line layout crews. Anyone who is to act in this capacity should be experienced in line layout, as one of his major duties will be the supervision of the measurement and staking of the pole line ahead of the construction team. It will be important that he have a thorough understanding of grading, guying, clearances and other general requirements covering open wire line design.

(2) In some cases it may be found that two or more pilots can be used advantageously to speed the work. Where this method is used, the route is divided in advance into sections, with a pilot assigned to each section. Each pilot then takes part in the survey until his section has been completely covered, after which he returns to the starting point to stake out the line over his part of the route.

**23. NOTES TO BE TAKEN DURING THE SURVEY.**— The survey party should be equipped to take notes during their survey. These notes will serve several purposes: they will make sure that all factors revealed by the survey are available for consideration in the detailed planning; they will record information necessary to the solution of special problems which may require reference back to the signal officer responsible for the advance plans; they will provide a record of terrain information and other data for future reference; and they will be of assistance to the pilot when he retraces the route to mark it out for the construction team. All notes taken should be legible, complete and understandable. It will often be found advantageous to supplement the notes with sketches. Particular attention should be paid to associating the notes with landmarks, locations and compass directions. Suitable bivouac sites for construction teams should be selected and noted.

**24. ROUTE MARKING DURING THE SURVEY.**— The survey crew will mark the route so that it can be retraced accurately. Route markers may be of any convenient type such as stakes and tags, tree blazes or rock piles. In general, the marking should be distinctive enough to be found easily, and frequent enough to afford continuity. These markings shall be used at points where direction changes are proposed, at road or other crossing sites, at the top of hills or cliffs, and elsewhere as good judgment will dictate. A good plan is to number or otherwise identify each marker as placed and to provide suitable reference in the notes. A tag at a marking point may be used to give specific information such as compass direction and distance to the next reference point. In marking the route it is well to keep in mind that any device used is much easier to find if it is in contrast with its surroundings; for example, a stake driven at a considerable angle with the vertical would be easier to find among saplings than would one driven vertically; in stony ground a vertical stake may be seen more easily than a rock pile, etc.

**25. ACCURATE MEASUREMENT OF DISTANCES.**— The route should be measured with reasonable accuracy and stakes showing the distance to some reference point (preferably the origin of the line) should be placed at given intervals. A recommended spacing of distance stakes is 3.6 miles to conform to the length of transposition sections. Distances measured by a speedometer which is known to be accurate (with allowances for detours, etc.) are satisfactory. A piece of field wire of measured even length (300 feet is a good length) provides a measuring line which will be useful if the vehicle is not able to follow the course of the line exactly. Before a vehicular speedometer is used, it should be checked by driving over a measured course of at least one mile.

**26. ESTABLISHING ROUTE DETAILS.—** The survey party, following the general course indicated on the route map, will select the exact route of the line, taking into account such considerations as the following:

***a. Route for favorable construction conditions.—*** This will include attention to avoiding swamps, forests, rocky ground, ravines, steep grades or rough, irregular contours. The route should be so selected as to cross large streams or rivers at right angles. Reasonable grades should be selected and sharp corners avoided as much as possible so that the least amount of guying will be required.

***b. Blending the line into the terrain.—*** The route selection during the survey should take account of terrain features which will help in making the line hard to see at a distance or from the air. Routing along the edge of forests or along fence lines will help in accomplishing this.

***c. Highways, power lines and active areas.—*** The survey party will pay attention to proper separation from highways, railroads, power transmission lines and areas of activity such as industrial plants, power houses, railroad terminals, switchyards, storage areas, depots, troop concentration points, air fields and towns. This is very important so as to avoid damage to the line and also to prevent enemy planes which may follow the line from discovering the active areas.

***d. Need for extra length poles, swamp footings, etc.—*** (1) At crossings over roads, railroads or streams where long poles will be needed, the survey party should decide the length and number of such poles and make notes of this information for use in final planning, scheduling delivery of materials and laying out the line.

(2) If swamp footings or other special materials are found to be needed, notes should be made to show quantities and kinds of materials needed and delivery points.

**27. SELECTING AN ACCESSIBLE ROUTE.—** The route selected by the survey party should be one that can be reached at frequent points by vehicles used in line construction and maintenance. It is desirable to so select the route that vehicles can be driven along it with as few detours as possible. Points at which access to the line can be made from roads and railroads should be noted and marked. The quantities and kinds of materials to be delivered at various points along the line should be decided and noted. The delivery points should be marked on the route map.

**28. EQUIPMENT NEEDED BY THE SURVEY PARTY.—** The equipment which the survey party will require in doing its work will depend mainly upon the type of terrain to be traversed and the conditions under which the work must be done. The following list suggests items which will always be required and other equipment which will frequently be found useful:

*Required Items*

Notebook and pencil
Wooden stakes, preferably with orange tops
Linen or wooden tags
Measuring tape, 100 foot, steel (part of TE-11) or cloth
Hand ax LC-1 or ax LC-36
Compass I-1
Ranging rods

*Other Useful Items*

Knife TL-29
Shovel LC-19
Pliers TL-13, or similar
Belt LC-23
Climbers, Lineman's LC-5, or similar
Flashlight TL-122
Gloves LC-10, or similar
Handline
Small nails
Strips of cloth
Measured lengths of field wire
Folding ruler
Binoculars
Digging bar
Brush hook or brush scythe

**29. MODIFYING THE ROUTE MAP.—** Upon completion of the survey a copy of the route map will be marked to indicate all significant changes from the route shown on the original map and such other information as may be considered desirable. This copy will be returned to the signal officer for his information or approval, as required.

**30. OBTAINING RIGHT-OF-WAY.—** In rear areas and in the zone of communications, it is desirable that reasonable effort be made to obtain consent of property owners over whose ground lines are to be routed. The agencies for obtaining permits will be specified by the signal officer.

**31. DETAILED PLANNING SUBSEQUENT TO THE SURVEY.— *a.*** When the route survey information is available, the construction commander will direct completion of the line construction plan. This will involve dispatching pilots and layout crews as early as possible, organizing and assigning construction teams, estimating amounts of material and scheduling deliveries, arranging for rights-of-way where necessary, planning for right-of-way clearing and preparation, deciding details of any special construction, and, in general, completing administrative and technical work preparatory to actual construction. The complete plan thus made will take into account the requirements of the advance plan, the disclosures of the route survey, and any supplementary directions or suggestions by the signal officer to whom the complete plan will be submitted for approval.

***b.*** Particular attention should be given in construction planning to the scheduling of work assignments where the line is being laid out in two or more parts or sections. Under this plan of procedure it is especially important that layout and construction assignments be carefully coordinated.

# Section III
# Engineering Requirements

**32. GENERAL.**— This section covers general engineering requirements for the construction of open wire lines. It contains information as to required clearances, guying and grading of such lines.

**33. THE TERMS SPAN AND SAG,** as used in this manual, are illustrated in figure 8.

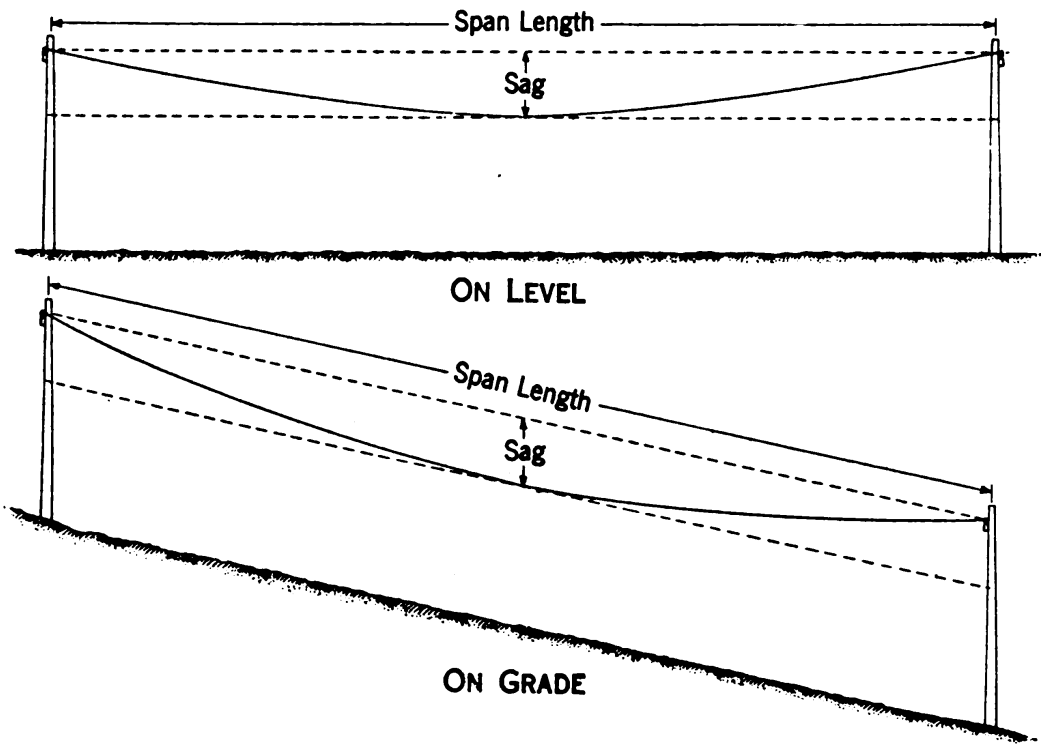



Figure 8.— Span and Sag illustrated.

**34. CLEARANCE REQUIREMENTS.**— *a.* The term "clearance" means the distance between the wires and ground or other objects. This paragraph gives the minimum clearances, both vertical and horizontal, that should be obtained in constructing open wire lines. The vertical clearances stated are those which should exist at a temperature of 60° F. with no wind. The sag in a conductor increases as the temperature rises and this must be taken into account when placing wires. If it is not practicable to obtain the desired minimum clearance, the officer in charge will decide what clearance is to be obtained.

***b. Vertical clearances.***— The minimum vertical clearances of telephone wires and stub guys (at 60° F.) should be as given in figure 9.

| Location | Minimum Vertical Clearance | Remarks |
|---|---|---|
| Above ground in open country | 14 ft. | May be reduced to 8 ft. when the line runs along a fence, if there is no possibility of vehicular cross traffic. |
| Above ground along a highway | — | Clearance should be sufficient to clear the type of equipment likely to use the highway. |
| Over highways or driveways | 18 ft. | — |
| Over railroads | 27 ft. | — |
| Over waterways | — | As specified by the command. The clearance is dependent upon the types of craft that navigate the waterway. |
| Between communication circuits and all power circuits | 4 ft. | — |
| Between guys and all power circuits | 2 ft. | A clearance greater than the 2 foot minimum is desirable. |
| Between nearest metal parts (such as machine bolts or guys) of communication and power circuits on the same pole | 40 in. | — |
| Between military communication lines and guys and those of other communication systems | 2 ft. | — |

Figure 9.— Vertical Clearances.

*c.* ***Horizontal clearances.***— The minimum horizontal clearances for communications poles and stubs are as follows:

(1) ***Railroad tracks.***— Poles should be set at least 12 feet from the nearest rail of railroad tracks and much further, if practicable. If the communications line parallels the railroad tracks a separation much greater than 12 feet is desirable. The line should not be built close to railroad yards. At loading sidings, ample space for Army purposes should be provided between the open wire line and the siding.

(2) ***Highways.***— Try to lay out the line at least 100 yards away from paralleling highways or roads. This should be done so that the line will not be damaged by vehicles running off the highway or by enemy bombing of supply routes. When crossing highways, the nearest poles to the highway should be set at least 12 feet from the shoulder of the road.

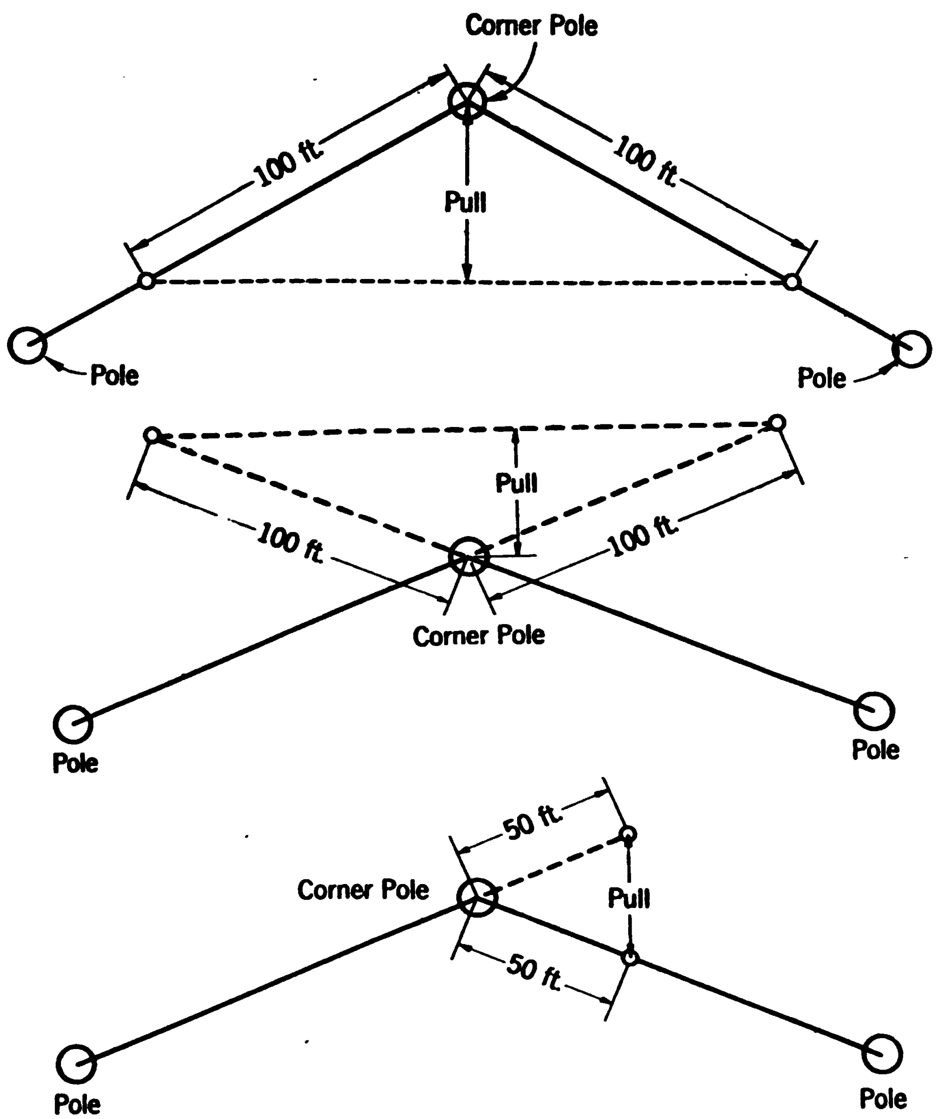



Figure 10.— Measurement of pull.

(3) **Power lines.**— On account of the danger to personnel and because of the noise which might be induced in the communication circuits, do not locate communication lines close to electric power or light lines if it can be avoided. At least ¼ mile separation between communication lines and paralleling power lines should be obtained, if practicable.

**35. GUYING: DEFINITIONS.— *a.*** Poles may be subjected to stresses other than those imposed by the vertical load of the wires. High winds, storms, ice, changes in grade and changes in the direction of the line are some of the factors that increase the stress on a pole. It is therefore necessary to stabilize poles likley to be subjected to unbalanced loads. Guys are generally used for this purpose.

***b.* Pull.**— The pull at a corner pole is the distance in feet measured as illustrated in figure 10. (Note that 50 foot measurements are used in the third method whereas 100 feet are used in the other two.)

Pull may also be measured by means of the scale on pull-finder LC-45, as shown in figure 11.

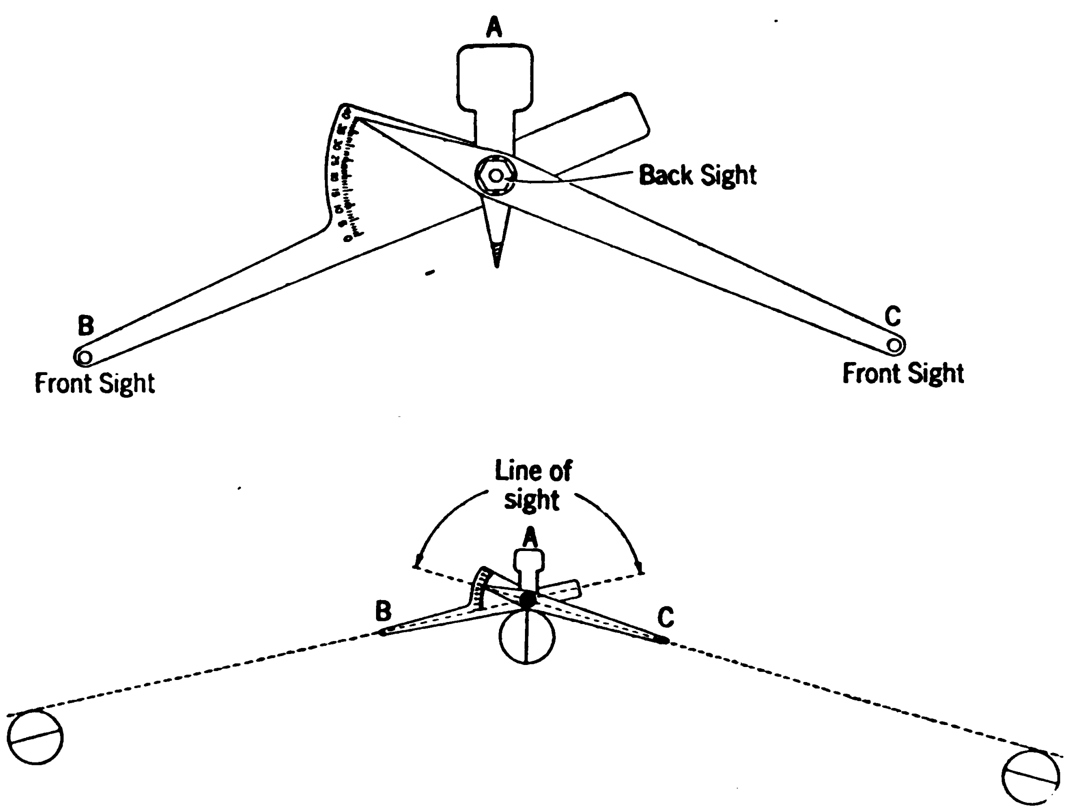



Figure 11.— Method ot using pull-finder LC-45.

**36. TYPES OF GUYS.**— The various types of guys used in open wire line construction are as follows:

***a. Side guy.***— A side guy is a guy placed in a direction transverse to the direction of the line which it supports. (Figure 12.)

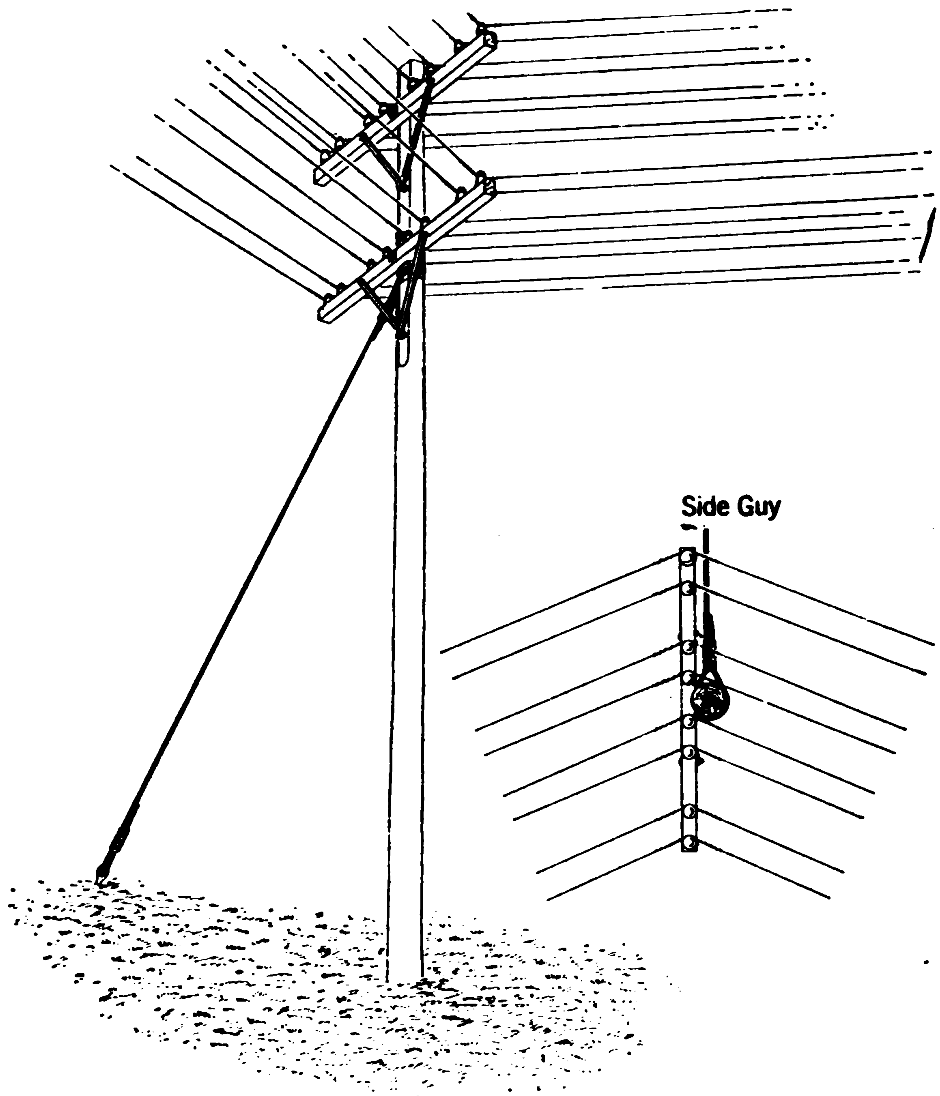



Figure 12.— Side guy.

***b. Head guy.***— A head guy is a guy which is placed in the direction of the line which it supports. (Figure 13.)

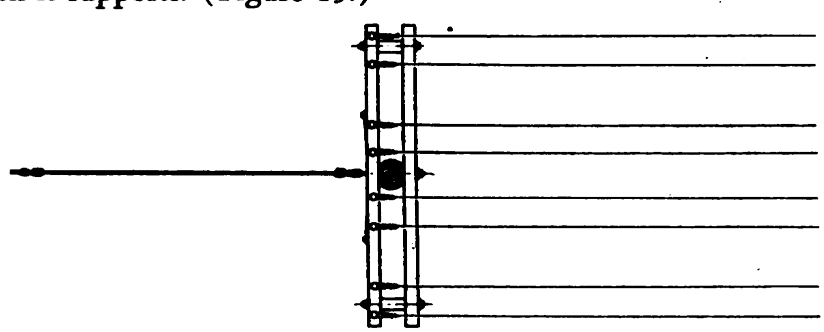


Figure 13.— Head guy.

***c. Anchor guy.***— An anchor guy is a guy extended directly from a pole or stub to an anchorage in the ground.

***d. Pole-to-stub guy.***— A pole-to-stub guy is a guy used for transferring the load supported by a pole to the top of a guy stub. When a pole-to-stub guy is used, the stub should be anchor guyed.

***e. Pole-to-pole guy.***— A pole-to-pole guy is a guy used for transferring the load supported by one pole to the lower part of another pole.

***f. Storm guy.***— Storm guys are guys placed in straight sections of line for the purpose of stabilizing the line, particularly during periods of storm

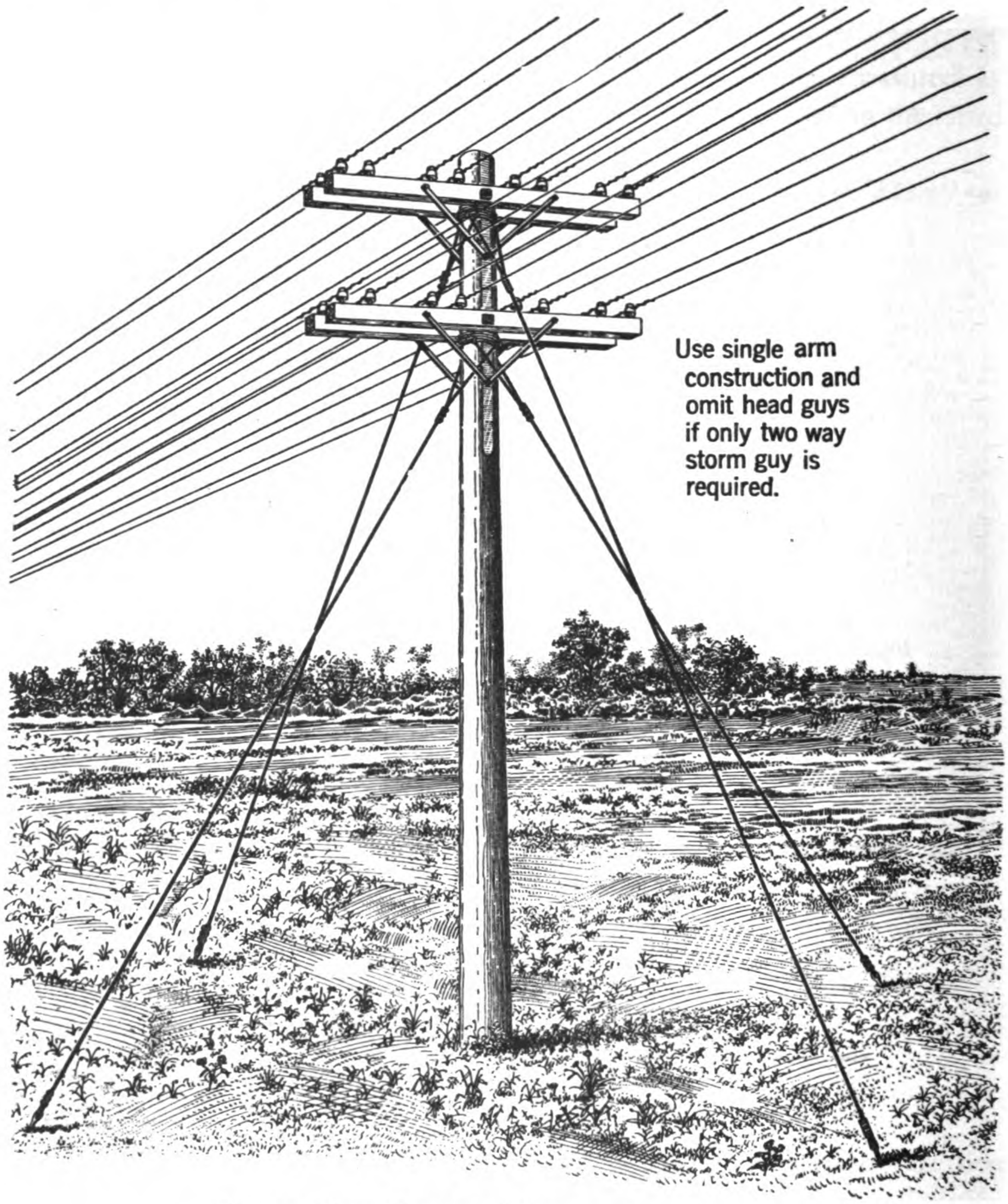



Figure 14.— Two- and four-way storm guys.

loading. Under normal conditions these guys do not contribute materially to the support of the pole. Storm guys consist of two opposing side guys placed at every twentieth pole and 4 opposing guys at every fortieth pole. These are known as two-way and four-way storm guys, respectively. Figure 14 illustrates storm guys. Anchor guys, pole-to-pole guys or pole-to-stub guys may serve as storm guys; H-fixtures may also be employed instead of side guys.

**37. GUYING AT CORNERS.— *a.*** The importance of avoiding sharp corners is indicated by the following table. It will be noted from the table that the load on a corner pole at which there is a 30-foot pull is 60 per cent. of that at a deadend pole; at a corner where the pull is 50 feet, the load on the pole equals that at a deadend.

| Pull (feet) | Interior Corner Angle (degrees) | Resultant Force (per cent. of load at deadend) |
|---|---|---|
| 10 | 168 | 20 |
| 20 | 158 | 40 |
| 30 | 146 | 60 |
| 40 | 132 | 80 |
| 50 | 122 | 100 |

***b.*** All corner poles on which the pull is 4 feet or more should be guyed; all deadend poles should be head guyed; and all line poles on which there is a downward change in grade exceeding 10 per cent. should be side guyed in both directions. A corner guy should be installed so that it bisects the external angle of the line at the corner pole as shown in figure 15. If the pull at a corner pole would exceed 50 feet an effort should be made to make the change in direction of the line at two consecutive poles with approximately equal interior angles at both poles. If a corner with a pull of more than 50 feet must be made at a pole, the line should be head guyed in two directions, as shown in figure 15.

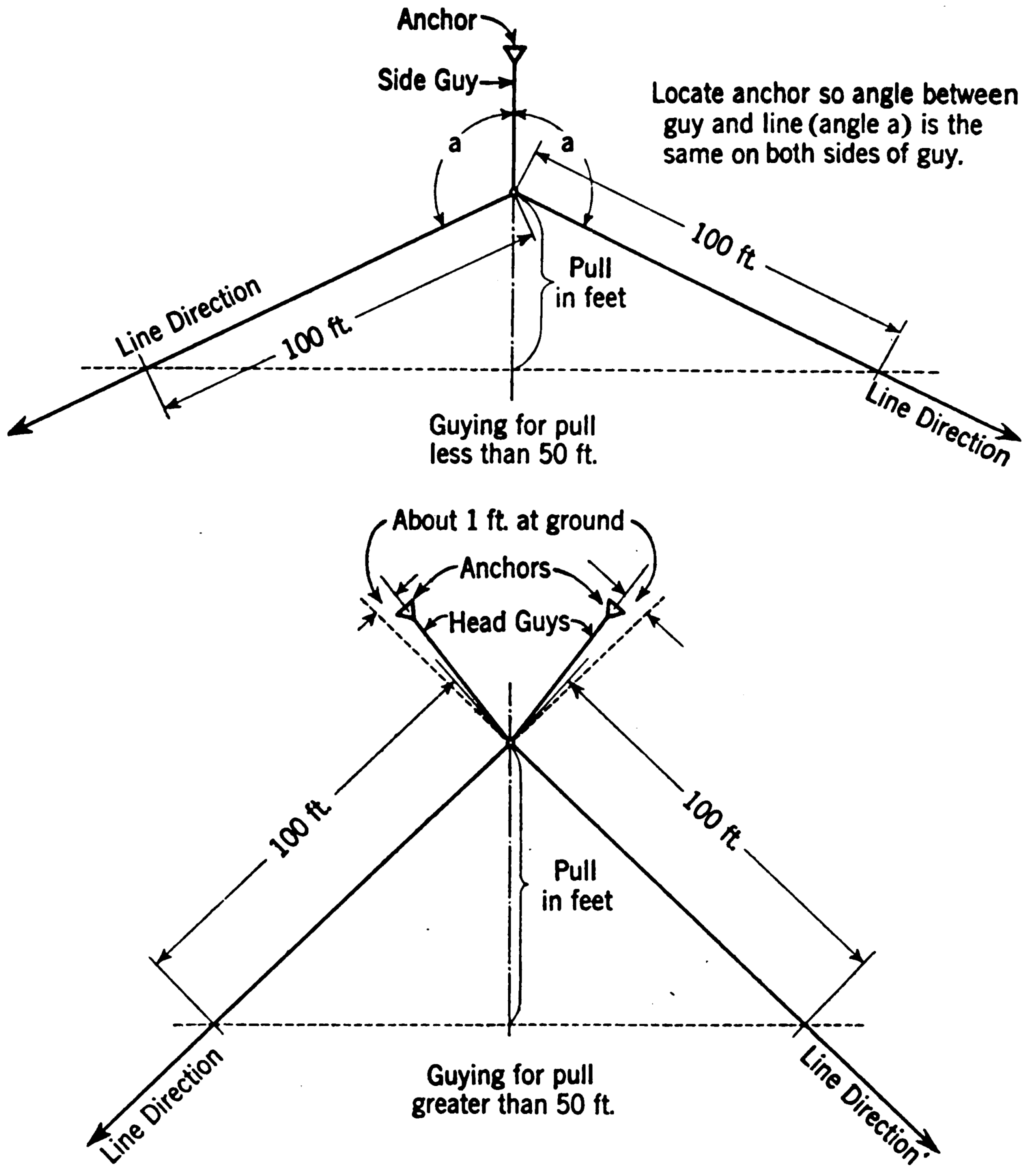



Figure 15.— Diagram of guying at corners.

**38. SIZES OF GUYS.—** Guy all corner poles on which the "pull" is four feet or more. The size and number of guys shall be in accordance with the following table.

| Amount of Pull (Feet) | Size of Guy Required | |
|---|---|---|
| | One crossarm line | Two crossarm line |
| 4 to 35 | One 6M | One 6M |
| Over 35 to 50 | One 6M | Two 6M |
| Over 50 | Two 6M head guys | Two 10M head guys |
| Deadend | Two 6M head guys | Two 10M head guys |

**39. GRADING THE LINE.— a.** Lines should be graded in approaches to marked changes in ground contour and at river, highway and railroad crossings if the difference in height of points of attachment of the conductors at adjacent supports would cause excessive downward or upward pull on the tie wires and associated materials.

**b.** When grading a line, the clearances specified in paragraph 34 should be maintained if it is possible for tanks or other mobile equipment to operate in the locality. When necessary to use longer supports in grading the line, the change can be made with fewer non-standard length poles if a rounded grade rather than a flat grade is used. This difference is illustrated in figure 16.

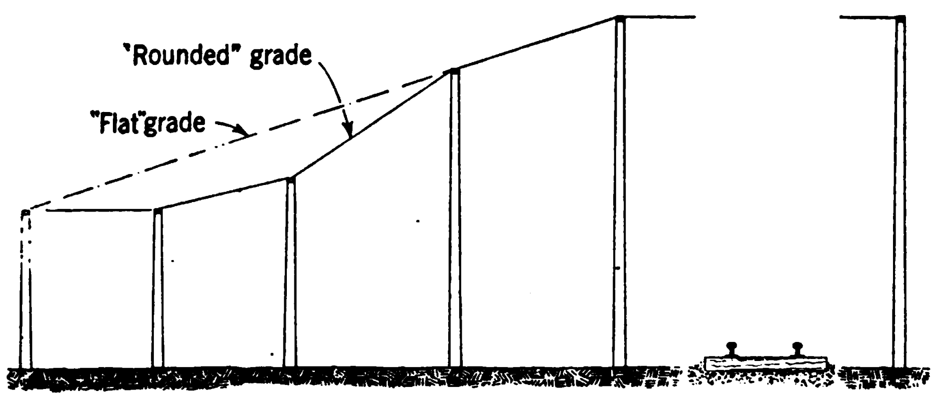



Figure 16.— Flat and rounded grades.

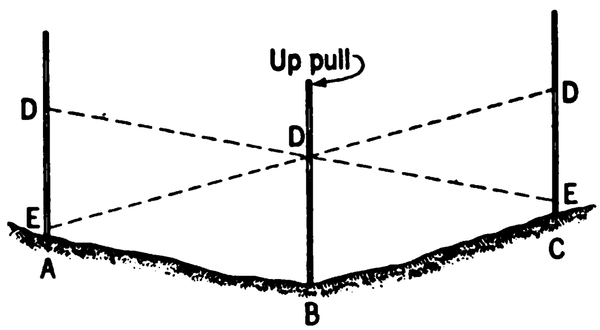
**c.** It is advantageous from the standpoint of clearance and the use of fewer abnormally high poles to locate the poles on mounds rather than in depressions, even if this introduces spans slightly shorter or longer than 150 feet.

**d.** When abrupt changes in ground contour occur, the location of poles can usually be adjusted so as to avoid concentrating the line grade change at one point. If such changes are made, however, compensating changes should be made in an adjacent span so as to maintain the correct transposition spacing.

**e. *Allowable changes in grade.*—** It is recommended that the change in grade be limited to 20 per cent. of the longer of the adjacent span lengths. The limitation in grade change is designed to relieve the crossarms of excessive vertical stresses. Reduction in the amount of change in grade can usually be made by using a shorter or longer pole or by placing an extra pole and dividing the change in grade between the two poles. When an extra pole is used, the spans should be shortened so as not to change the distance between transposition poles.

**40. MEASURING CHANGE IN GRADE: USUAL METHOD.— a.** In the following description of methods of measuring changes in grade, it is assumed that the attachments to all supports will be made at a uniform distance from the tops of the poles. If these distances are to be different in any case, suitable allowances should be made in selecting the points on the range rods or poles when sighting. In the majority of cases, the measurement of the change in grade is taken at the adjacent stake or pole rather than at the point where the change in grade of the line will occur.

***b. Up pull.***— The measurement of change in grade at "up pulls" may be made in the following manner: Sight from point D on rod A or C (fig. 17) through D on rod B and locate point E on the far rod where the line of sight passes it. The distance DE is the measure of the change in grade at B. When range rods are employed, the sighting points may be selected on each rod at the same distance above ground (5 feet is usually used).

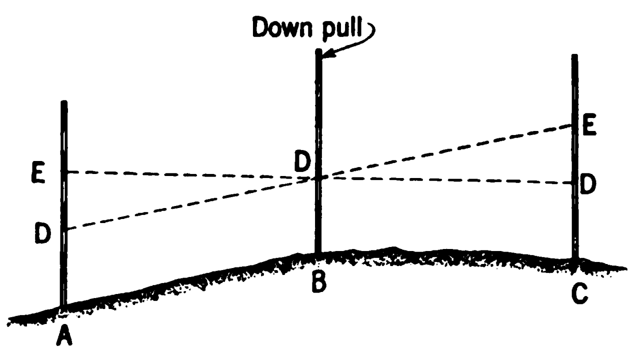



$$\text{Per Cent change in grade at Pole B} = \frac{DE}{\text{Length of Span}} \times 100$$

Figure 17.— Measuring change in grade at up-pull in line.

***c. Down pull.***— At "down pulls," the change in grade may be measured as follows:

(1) Locate points D on rods A, B and C (fig. 18) at the same distance from the top of each rod. Point D should be close enough to the ground at rod B so that point E will fall on the rods at A and C.




$$\text{Per Cent change in grade at Pole B} = \frac{DE}{\text{Length of Span}} \times 100$$

Figure 18.— Measuring change in grade at down-pull in line.

(2) Sight from D at either A or C through point D on rod B and locate E on the far rod where the line of sight passes it.

(3) Measure distance DE; this distance is the measure of the change in grade at B.

**41. MEASURING CHANGE IN GRADE: ALTERNATIVE METHOD.**— Over rough terrain and where long spans are employed, it may be difficult or impracticable to determine the change in grade by sighting on rods at A, B or C only. In such cases, the following alternative method of measuring change in grade may be used to advantage:

***a.* Down grade.**— Place one range rod at each proposed pole location A, B and C (fig. 19). Ten feet from B, toward C and in line with C, place a rod at R. All rods should be held vertically and the bottom of each rod at A, B and C should be approximately at the ground level of the pole to be set at that location. The man at rod R should be in charge.

***b.*** Man at A sights at corresponding points, say the 5-foot mark, on rods A and B, and locates point where line of sight passes rod R. Man at R locates this point in accordance with directions from man at A.

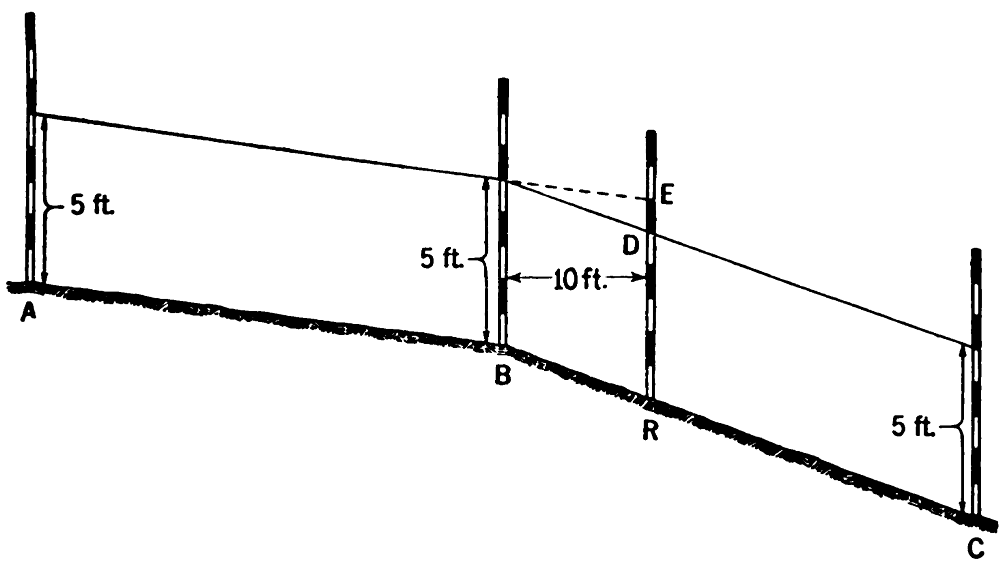



Figure 19.— Use of four range rods (down grade).

***c.*** Man at B sights through same points (5-foot mark) on rods B and C and locates point where line of sight passes rod R. The per cent. change in grade at pole B is $\frac{DE}{10}$ x 100.

***d.*** If the change in grade is found to be excessive, the effect of changing the heights of poles at the various locations can be determined by sighting through points on rods A, B and C that correspond to the proposed lengths of poles. For example, the effect of a 5-foot shorter pole at B can be determined by sighting through the 6-foot mark on A, 1-foot mark on B and 6-foot mark on C.

***e. Up Grade.***— When it is apparent that there will be an up pull at pole B the rods are arranged in a similar manner except that rod R will be located 10 feet from B toward A as shown in figure 20.

***f.*** Sight from A to B to locate point D on rod R.

***g.*** Sight from C through B to locate point E on rod R. $\frac{DE}{10}$ x 100 is the per cent. change in grade at pole B.

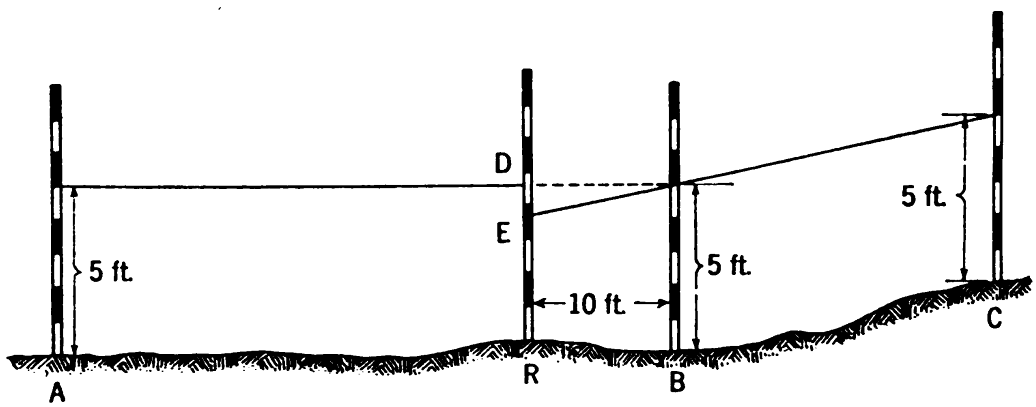



Figure 20.— Use of four range rods (up grade).

# *Section IV*
# *Marking and Layout*

**42. GENERAL.**— When plans for all or part of the construction have been completed, a line layout crew under the direction of the pilot proceeds to stake out the line. This crew, following the route established during the survey, places stakes at each pole and anchor guy location, clears minor obstructions along the right-of-way, and in general, prepares the route for the construction teams which will follow.

**43. THE PILOT AND THE LINE LAYOUT CREW.**— ***a. The pilot.***— It is assumed that in participating in the route survey the pilot will have been alert to landmarks, locations of route markers, soil and terrain conditions and to have engaged in mental planning of the layout job as the survey progressed. His responsibilities include both supervision and guidance of the line layout crew.

***b. The line layout crew.***— The number of men assigned to a line layout crew will depend largely upon the nature of the terrain. In open country a crew of four or five men can be expected to make rapid progress. Where conditions are less favorable, it may be necessary to add men to the crew to clear a way for vehicles, cut brush around pole locations, and otherwise assist in expediting the layout work.

**44. TIMING LAYOUT WITH REFERENCE TO CONSTRUCTION.**— It is ordinarily not advisable to start construction before the layout crew has a reasonable length of line (several miles) staked. Because of the likelihood of introducing irregularities in the wire transposition system, it is particularly important to avoid starting wire stringing at intermediate points in the line before the layout is complete from the origin to any such intermediate starting point. *Line layout should therefore be started as soon as circumstances will permit.* Where the route has been sectionalized for two or more pilots, those assigned sections nearest the origin of the route will usually be able to start line layout work without waiting for the survey to be completed. The type of terrain will have considerable influence on the speed with which both surveying and laying out can be accomplished and therefore must be taken into account in scheduling these operations.

**45. THE REFERENCE POLE AND SPAN LENGTHS.**— ***a. The "zero" pole.***— The usual reference point for a given open wire line will be the dead-end pole at the origin of the line, hereafter referred to as the zero pole. The trend of the line will always be from this pole. The location of the zero pole will usually be specified by the signal officer, as it may be desirable to have the open wire line end some distance from the command post to be served, the line to be extended to the terminal equipment by means of insulated wire or cable, which is less evident to hostile observation. Line measurements will originate at the zero pole.

***b. Span lengths.***— The nominal pole spacing is 150 feet. Individual span lengths may be as long as 180 feet, but in general it is desirable that they be near the nominal value. Excluding occasional extra poles inserted at corners or elsewhere, every fourth pole is a transposition pole and the *average* distance between these transposition poles should not exceed 600 feet except in unusual cases; the closer it is kept to the nominal value of 600 feet, the better. In short transposition sections, every second pole is a transposition pole and in these short sections the distance between transposition poles should be kept as close to 300 feet as possible.

**46. SELECTING POLE LOCATIONS.**— ***a.*** In selecting pole locations, ground contours must be taken into account. If there is any choice, poles should be placed on high points of ground rather than in hollows to give added ground clearance to the line. Span lengths may be varied within recommended limits to accomplish this. It may be necessary to plan modification of several span lengths in order to avoid or take advantage of particular contours. The pilot should be alert to the need for such adjustments in order that they can be made without resetting several stakes. Wherever possible, corner poles in the line are to be located so as to take advantage of existing anchorages for guys (trees, etc.).

***b.*** Pole locations should be selected to provide as favorable soil conditions as possible for digging holes and to provide firm support for the poles. Where anchors will be installed, attention should be given to soil conditions at anchor hole locations. Minor shifts of pole stakes from the measured location may be found necessary to get more favorable pole locations or to avoid small obstacles.

***c.*** To avoid trees or other obstacles, it may be necessary to introduce minor direction changes in a line which could otherwise be straight. Such deviations can sometimes be planned so that the adjustment is made some distance away from the obstacle and thus be much less abrupt.

***d.*** Before starting to lay out the pole locations, the pilot should select an intended average spacing between transposition poles. This will ordinarily be the nominal spacing of 600 feet (300 feet in short transposition sections). In particular cases where local conditions indicate an advantage in doing it, the intended average may be selected at any value between 500 and 600 feet (250 to 300 feet for short transposition sections). Then the locations of individual transposition poles should be so chosen that the distances between successive transposition poles are kept as close as practicable to the intended average value. Any necessary long or short spans should be compensated for before passing a transposition pole, whenever practicable. The maximum deviation between the intended average spacing and the actual spacing between any two successive transposition poles should not exceed 100 feet; only a very small percentage of the deviations should be near this value; and the average deviation should not exceed about a third of this value. If the average deviation is computed, all individual deviations should be counted positive, no matter whether the actual individual spacing is greater or less than the intended average. A more precise rule, which will permit a few very large deviations when necessary, is that the sum of the squares of the deviations in a given length of line should not exceed three times the given length of line, all distances being measured in feet. The length of line considerd may be any length not greater than a repeater section. In order to take care of local conditions when necessary, the intended average spacing may be changed at an S pole. The average spacing of transposition poles over an entire repeater section should not be less than 500 feet; short sections of line may have a smaller average spacing when necessary.

**47. MARKING POLE LOCATION.—** ***a.*** Each pole location is to be marked with a stake driven firmly into the ground. In straight sections of line, these stakes are to be in good alignment, as judged by eye. Stakes are to be of such length as to project above ordinary vegetation. In case of doubt as to easy visibility, a strip of cloth may be attached to the stake, or vegetation may be cleared from a reasonable area around the stake.

**b.** At points of line direction change where the next location stake will not be readily visible, a second stake is driven approximately three feet from the corner pole stake and in the line of the new or changed course, as shown in figure 21.

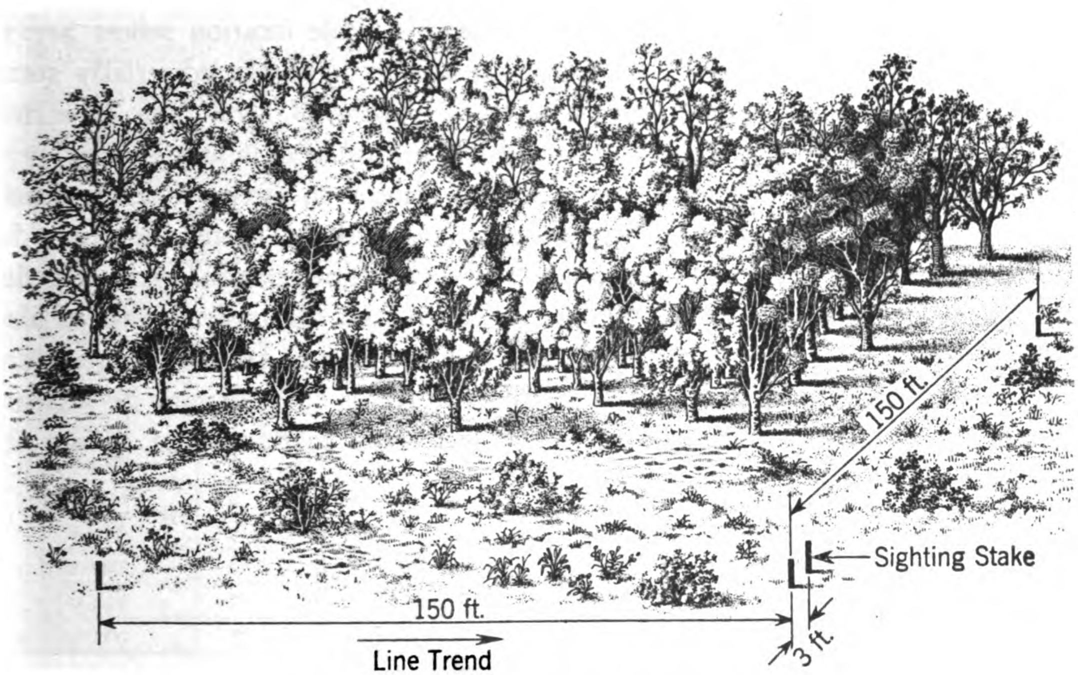



Figure 21.— Sighting stake at line corner.

By sighting over the two stakes, the construction team will be able to determine the new line direction and find the next stake.

**48. MEASURING SPAN LENGTHS.— a.** Span lengths must be laid out accurately in order that the transposition spacing will be correct and to avoid unnecessary unbalanced loads on poles. The only satisfactory method of laying out spans is by actual measurement. Pacing cannot be depended upon for consistently accurate results because of variations due to terrain and walking conditions, the effect of speed and fatigue on length of pace, and the likelihood of errors in counting.

**b.** Measuring by tape is, of course, a satisfactory and accurate method, but cloth tapes are not durable under this type of use and steel tapes may not always be available. A piece of field wire of measured length is recommended as a convenient measuring device. The length of field wire recommended for measuring spans of nominal 150-foot length is 180 feet. Both ends of such lines for a distance of at least 50 feet should be marked off in five-foot lengths by knots, bosses of friction tape, wire servings, or combinations of these, to provide means of judging actual span lengths accurately.

**c.** If it is necessary to increase or decrease a given span length from nominal spacing, an attempt should be made to compensate for the deviation in other spans within the transposition spacing of 600 feet (300 feet for short transposition sections).

**49. MARKING POLE LOCATION STAKES.—** Pole location stakes are to carry the line number or designation and are also to be numbered serially starting from the reference pole, *which is to be numbered zero.* Line direction changes are indicated by a bent arrow and guy information is provided by type and size. Additionally, each transposition pole stake is to carry a letter designation, A, B, C, D or S, denoting the type of transposition. The markings can be made with a heavy pencil, preferably one of the "lumber crayon" type. If poles of special length are required at any given location, the pole length is also designated on the stake. Stakes are driven with the marked face toward the zero pole at the origin of the line. Special information of any sort may be written on a tag and attached to the stake. Typical stake markings are shown in figure 22.

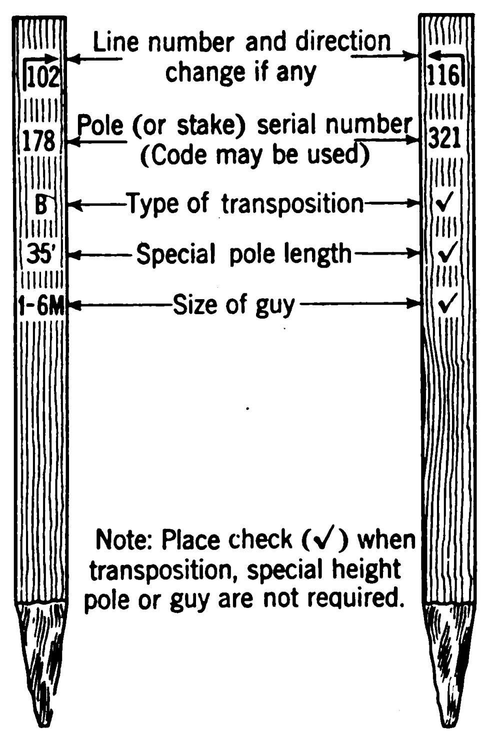



Figure 22.— Typical pole location stake markings.

**50. NOTES TO BE MADE BY THE PILOT.—** In order to avoid errors and in the interest of providing a complete record the pilot should keep a notebook of data indicating cumulative line length, span lengths, pole heights, transposition and guy locations and other pertinent information. This record, if kept carefully, will make it possible to clear up any questions that may arise in the layout or construction work. Figure 23 shows a suggested form of data sheet which is simple and concise. It will be noted that the first column shows cumulative length of line; the second, span lengths; the third, pole numbers; the fourth, pole lengths; the fifth, transpositions and guys; and the sixth, supplementary notes. Such data will prove to be of great value both during layout and subsequently, so every effort should be made to have them complete and accurate. The data entered in this notebook will be used to make up the list of materials, for each stake location, which will be furnished to the crew that will distribute materials.

| Distance | | Pole No. | Pole Length | Transp. Guys | Notes |
|---|---|---|---|---|---|
| 0+00 | 150 | 0 | 30' | | |
| 1+50 | 148 | 1 | 30' | | |
| 2+98 | 150 | 2 | 30' | | |
| 4+48 | 152 | 3 | 30' | | |
| 6+00 | 145 | 4 | 30' | XA | |
| 7+45 | 155 | 5 | 30' | | |
| 9+00 | 150 | 6 | 30' | 1-6M | |
| 10+50 | 150 | 7 | 30' | | |
| 12+00 | 146 | 8 | 30' | XB | |
| 13+46 | 150 | 9 | 30' | | |
| 14+96 | 152 | 10 | 30' | | Road Crossing |
| 16+48 | 152 | 11 | 30' | | |
| 18+00 | 141 | 12 | 30' | XA | |
| 19+41 | 154 | 13 | 30' | | Stream—75' |
| 20+95 | 153 | 14 | 30' | | |
| 22+48 | 152 | 15 | 30' | | |
| 24+00 | 150 | 16 | 35' | XC | |
| 25+50 | 150 | 17 | 35' | | |
| 27+[illegible] | 148 | 18 | 35' | | |
| 28+48 | 152 | 19 | 30' | | |
| 30+00 | 150 | 20 | 30' | XA Both 6M | |
| 31+50 | 150 | 21 | 30' | | |
| 33+00 | 150 | 22 | 30' | | |
| 34+50 | 150 | 23 | 30' | | |

| Distance | | Pole No. | Pole Length | Transp. Guys | Notes |
|---|---|---|---|---|---|
| 36+00 | 150 | 24 | 30' | XB | |
| 37+50 | 150 | 25 | 30' | 1-6M | |
| 39+00 | 150 | 26 | 30' | 1-6M | |
| 40+50 | 150 | 27 | 30' | | |
| 42+00 | 145 | 28 | 30' | XA | |
| 43+45 | 155 | 29 | 30' | | |
| 45+00 | 160 | 30 | 30' | | |
| 46+60 | 140 | 31 | 30' | | |
| 48+00 | 155 | 32 | 30' | XD | |
| 49+55 | 150 | 33 | 35' | | |
| 51+05 | 148 | 34 | 35' | | |
| 52+53 | 147 | 35 | 30' | | |
| 54+00 | 150 | 36 | 30' | XA | |
| 55+50 | 150 | 37 | 30' | | |
| 57+00 | 148 | 38 | 30' | | |
| 58+48 | 152 | 39 | 30' | | |
| 60+00 | 150 | 40 | 30' | XB All 1/6-M | |
| 61+50 | | 41 | 30' | | |

Figure 23.— Form of notes to be kept by the pilot.

**51. SPECIAL PROBLEMS IN LINE LAYOUT.— *a. River and other crossings— normal spans.—*** Where the line crosses watercourses, roads, railways, etc., pole locations should be adjusted to provide span lengths within the usual limitations and with good pole setting and guying conditions on each side of the crossing. If possible, rail crossing spans should be limited to 150 feet maximum length. Pole locations on embankments which may wash are to be avoided and, near watercourses, poles should be set far enough from the banks to be reasonably safe from washouts due to banks cutting away in high water. At road and rail crossings if there is any choice, the pole locations should be selected on high ground to improve vertical clearances. Poles should not be located within 12 feet of highways and railroads.

***b. Long spans.***— Where very wide rivers, chasms, or other obstacles are to be crossed, special construction will be required. The line layout crew will select and stake the approximate location for long span supports and resume layout beyond the obstacle. The pilot will determine the long span length, calculate and record in his notes the number of normal span lengths included in the long span, and assign a correspondingly higher pole number to the far side support stake. For example, if a 450-foot crossing is encountered, two succeeding pole numbers will be discarded and the far side stake will carry a pole number three units higher than the near side pole.

***c. Repeater locations.***— (1) Repeater locations will have been indicated either generally or specifically by the signal officer. If only a general location has been specified, it will be necessary from a transmission standpoint to locate the repeater at the end of a normal transposition section (S pole) or at least at the end pole of a short section or a combination of short sections. *Whatever the location of the repeater, a new transposition section should be started at the far side of the repeater; that is, the first pole beyond the repeater should be the first pole of a new transposition section.*

(2) If a short section arrangement is required, it will be evident to the pilot as he completes the last full transposition section before reaching the repeater location. He should then select the appropriate short section arrangement for the number of spans between the S pole and the repeater location. (Example:— If there are 70 spans between the last full transposition section and the repeater location, a combination of short sections for 64 and 2-7 spans would be used in this portion of the line.)

**52. LOCATING POLES AT CHANGES IN GRADE.**— Changes in grade should not be more than 20 per cent. (30 feet for a 150-foot span). The line layout crew should be equipped with ranging rods to use in measuring changes in grade. It may be found necessary to adjust pole locations or make minor alterations in the route to obtain grade changes within the required limits.

**53. PROCEDURE WHEN TWO OR MORE LAYOUT CREWS ARE USED.**— If a line route has been divided into sections to speed layout and construction, it is extremely doubtful that the survey can be depended upon to provide sufficiently accurate measurements to make sure that the division points will correspond to the S poles at the ends of transposition sections. If wire stringing should be undertaken at an intermediate point in the line before the layout is complete from the origin to such intermediate point, it would often be necessary to resort to short transposition sections or other less satisfactory adjustments where the two pieces of line are joined. Such breaks in the regularity of the transposition section pattern degrade the transmission appreciably and are, therefore, to be avoided. By observing the following method the continuity of the transposition pattern can be maintained and pole location stakes will be numbered in sequence throughout the length of the line.

**a.** The pilot and layout crew starting from the origin of the line proceed with their work in the regular manner.

**b.** The pilot and layout crew who are to start farther along the line begin work at the predetermined location and proceed to stake out pole locations in the usual manner, except that *pole numbers and transposition letters are not placed on the face of the stake* toward the zero pole, or origin of the line. Line number, pole height, guy and corner information is provided on the stake in the proper location. This pilot should pencil his own pole number series on the other face of the stake, *starting with No. 1.* This measure is taken to assist in keeping the usual layout data in the field notes.

**c.** When the pilot who started at the origin of the line arrives at the beginning of the next pilot's section, he will make such adjustments in span lengths as are necessary to join the two series of line stakes without exceeding usual pole spacing limitations.

**d.** (1) The pilot who started at the origin of the line then proceeds along the next pilot's section of line and marks all stakes serially, extending his own numbering system for the purpose. In addition he will mark the stakes with proper transposition letters, *continuing the pattern established in his own section.*

(2) This pilot will probably have no further need for his layout crew (except possibly an assistant) so his crew may be directed to return from the junction point to their base.

**e.** If the pilot who is numbering stakes serially overtakes the advance layout crew, he will arrange for the advance pilot to pick up the numbering and transposition system and carry it on, unless by previous direction he is ordered to cover the entire line or follow other specified procedure.

**f.** The foregoing procedure will be used at the junctions of all pilots' sections, so that when the layout is complete the entire staking system will be serially numbered and the transpositions will be in continuous regular pattern and marked from origin to destination.

**g.** If the first layout crew completes its part of the line before the next crew starts, a prominent marker will be left at the junction point. If there is an incomplete transposition section at the end of the line a note will be provided to instruct the next pilot on its completion. This note should give the location of the last stake placed with reference to the preceding S pole. The pilot of the intermediate layout crew will pick up the numbering and transposition systems from the last stake placed by the preceding crew and will continue them through his part of the line.

**54. CLEARING RIGHT-OF-WAY.—** Layout crews should not be expected to undertake major right-of-way clearing duties. However, they should be prepared to cut through small patches of brush or thicket and trim out interfering trees or tree limbs to expedite their own work. It is assumed that any major right-of-way preparation activities required, such as cutting brush or trees which would interfere with the wires, will have been assigned to work crews organized for the purpose.

**55. TOOLS AND EQUIPMENT REQUIRED BY THE LAYOUT CREW.—** The tools and equipment needed by the line layout crew will be similar to those recommended for use in surveying the route except for the addition of hand tools for use in clearing right-of-wav. The supply of stakes should be ample for the proposed work and may be calculated at about 50 per mile. To minimize splitting, a wooden or composition mallet is the preferred tool for driving wooden stakes.

# *Section V*
# *Symbols*

**56. GENERAL.—** This section shows the symbols and abbreviations which are suitable for use in the preparation of written material, data, sketches, plans, and route maps for open wire lines. Other symbols may be used where necessary, provided they do not conflict with authorized symbols and are accompanied by an explanation under the heading, "Special Legend."

**57. WIRE AND STRAND MATERIALS.—**

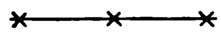
| Material | Diameter (Mils) | Abbreviation |
|---|---|---|
| Copper clad steel wire (Copperweld) | 104 | 104 CCS |
| 6000-pound Strand | — | 6 M |
| 10000-pound Strand | — | 10 M |

## 58. TYPES OF WIRE.—

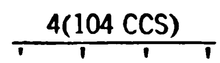
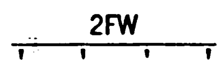
| Material | Abbreviation |
|---|---|
| Open wire | OW |
| Field wire | FW |

## 59. LINE SYMBOLS.—

*a.*

| Meaning | Symbol |
|---|---|
| Wire line, open (on pole line) |  |
| Line to be removed |  |

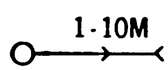
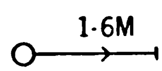
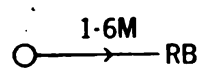
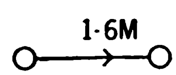
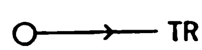
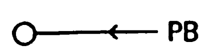
*b.* The number of physical pairs in a wire line may be indicated by a small number placed on the line; additional appropriate designations of wire sizes or material may also be given. Examples:

| | |
|---|---|
| (1) 4 pr. 104 copper clad steel open wire |  |
| (2) Field wire (2 pr.), on pole line |  |

## 60. SUPPORTS.—

| Type of Support | Symbol |
|---|---|
| Proposed pole and length | ○ 30′ |
| Existing pole and length | ● 30′ |

## 61. GUYS.—

| Type of Guy | Symbol |
|---|---|
| One 10M guy to metal anchor |  |
| One 6M guy to log anchor |  |
| One 6M guy to rock bolt |  |
| One 6M guy, pole to stub |  |
| One 6M guy, pole to tree |  |
| Push brace |  |

**62. SYMBOLS FOR USE ON LINE STAKES.—** These symbols are to be placed on the stake in the sequence listed.

| | |
|---|---|
| Line number and direction change, if any | ⌈102→ or ←116⌉ |
| Pole (or stake) serial number, as | 321 |
| Type of transposition, as | B |
| Special pole length, as | 35′ |
| Size of guy, as | 1 — 6M |

# CHAPTER III
# CONSTRUCTION PRELIMINARIES



## Section I
## Signals for Construction Teams

**63. GENERAL.**— This section covers a system of signals for the use of teams constructing open wire lines in directing the operations of pole derricks, winches, trucks and in stringing wire. Both visual and sound signals are included. Sound signals should be used only where it is not practicable to use visual signals and only when it is certain that the person to be directed by the signals is within hearing distance. In some situations it may be advisable to use both visual and sound signals.

**64. VISUAL SIGNALS.**— ***a.*** The system of visual signals is shown by diagrams accompanied by a brief description of each signal.

***b.*** The person doing the signaling should face the operator or person signaled, if signals are being transmitted directly from one to the other.

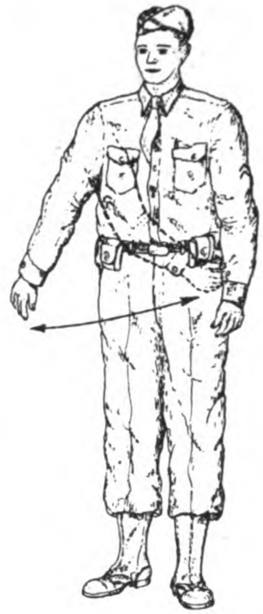
***c.*** Obstructions or intervening distance may require that the signals be relayed through intermediate signalmen. Such signalmen should take positions that will enable the person signaled to see the signals clearly and unmistakably; the eyes of the intervening signalmen should be focused upon the person from whom the signals are being received. Signals should not be relayed through more men than is absolutely necessary, in order to minimize the time required for transmission, and reduce chances of error.

***d.*** White, yellow or checkered signal flags can frequently be used to advantage if the distance over which signals are transmitted is great or if visibility is poor. A red flag should not be used for this purpose because of the likelihood of drivers of passing vehicles mistaking it for a danger signal.

***e.*** As far as practicable, signalmen should take positions from which the view will not be obstructed by pedestrians or passing vehicles.

*f.* The visual signals and their meaning are as follows:

(1) Go ahead



Swing right arm, extended downward full length, in arc across front of body.

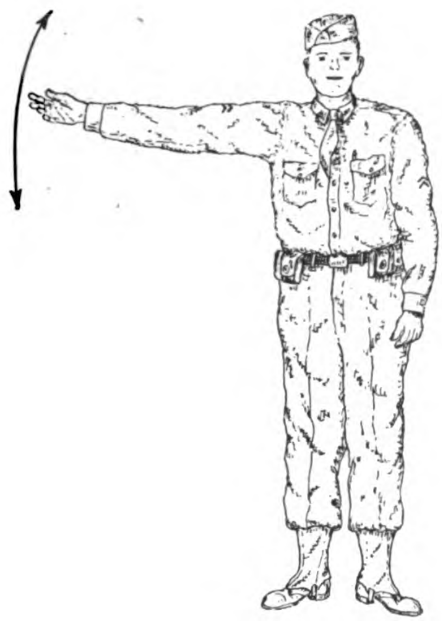
Figure 24.

(2) Go ahead slowly

Swing right arm, extended downward full length, in arc across front of body. Extend left arm horizontally in plane of body.

Figure 25.

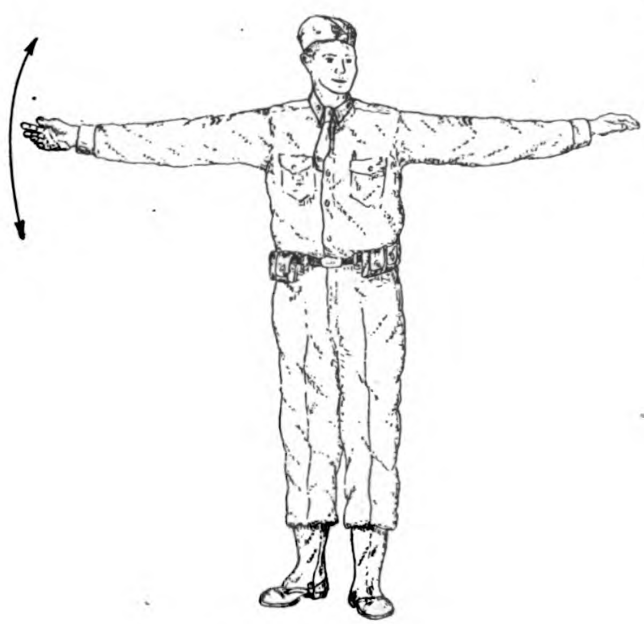
(3) Back up



Extend right arm horizontally in plane of body and execute vertical arc.

Figure 26.

(4) Back up slowly



Extend both arms horizontally in plane of body, and execute vertical arcs with right arm.

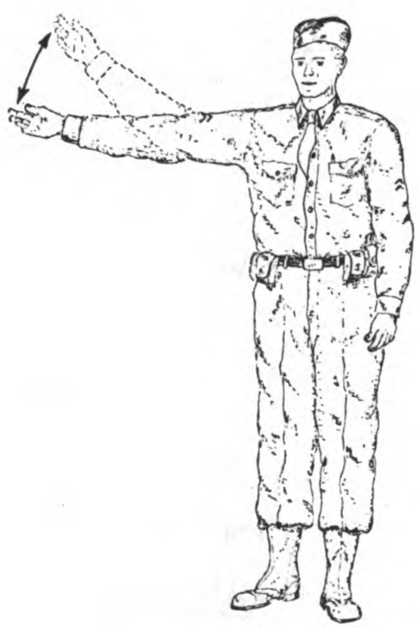
Figure 27.

(5) Stop

Extend both arms full length above head.

Figure 28.

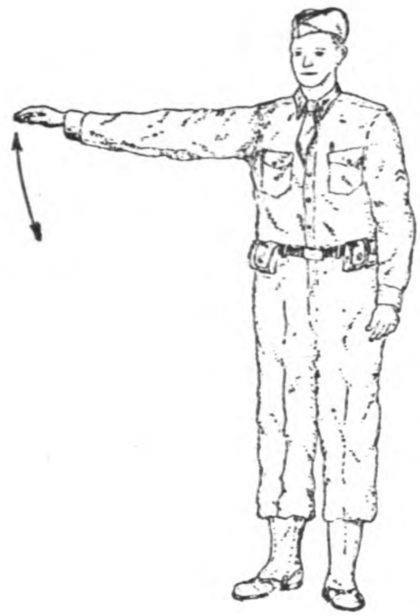
(6) Up



Extend right arm horizontally in plane of body. Execute short swings with forearm upward and back to horizontal.

Figure 29.

(7) Down



Extend right arm horizontally in plane of body. Execute short swings with arm downward, and back to horizontal.

Figure 30.

(8) Hold

Extend arms full length in plane of body to an angle of 45°.

Figure 31

(9) Release or cut off

Extend both forearms to horizontal position on one side of body. Swing hands and forearms in opposite directions in short vertical arcs.

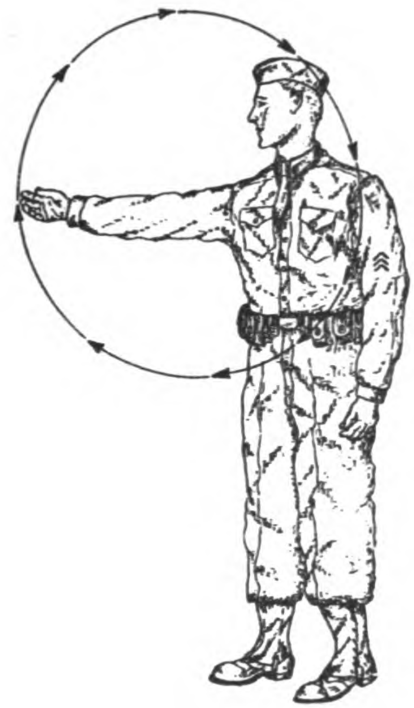
Figure 32.

(10) All O.K.

Extend both arms above head. Swing both arms in short arcs in plane of body.

Figure 33.

(11) Return, or go back



Extend right arm full length horizontally in plane of body. Swing in circle extending across front of body.

Figure 34.

**65. SOUND SIGNALS.**— ***a.*** A whistle having a distinctive tone should be used for sound signals to avoid possible confusion with other whistles.

***b.*** The number of blasts to be used for various operations are as follows:

(1) Go —Two short sharp blasts.

(2) Stop —One long blast.

(3) Back—Three short sharp blasts.

***c.*** Field telephone sets can sometimes be used to advantage in place of signals.

**66. SIGNALS TO TRAFFIC.**— Where it is necessary to station a man to warn traffic, he shall use a red warning flag and make the warning conspicuous by swinging the flag up and down, whenever vehicles are approaching.

## *Section II*
## *Delivery of Materials*

**67. UNLOADING POLES FROM TRAIN ALONG ROUTE.**— ***a. General.*** — If the line is to be built along a railroad, it may be desirable to unload poles from cars of moving trains. If conditions will permit, however, it is preferable to unload poles at sidings and distribute them by means of trucks, rather than from moving trains, because all work can be performed from the ground and with the aid of power equipment or block and tackle.

Two methods may be used for unloading poles from cars of moving trains. In the first method the train is stopped each time a pole is to be unloaded, whereas in the second method poles are unloaded while the train is in motion. The factors governing the choice between these methods will be:

(1) The time available in order to avoid interference with railroad traffic.

(2) Length of poles to be unloaded. (Poles longer than 35 feet should not be unloaded while the train is in motion.)

It is preferable to stop the train at each location where a pole is to be unloaded, provided satisfactory arrangements can be made with the railroad authorities, because the movement of poles can be controlled to better advantage.

Regardless of which method is used a tarpaulin should be placed between the ends of all cars on which men will be working and the adjacent cars in order to prevent men accidentally falling between cars.

Peavies can be used to better advantage than cant hooks in moving and shifting poles on cars.

If the poles to be distributed vary as to length, poles should be loaded in such manner that each pole can be unloaded at the proper location without necessity of sorting the poles. If necessary, poles should be reloaded as shown in figure 35 at some convenient point so as to arrange them in the order in which they are to be distributed.

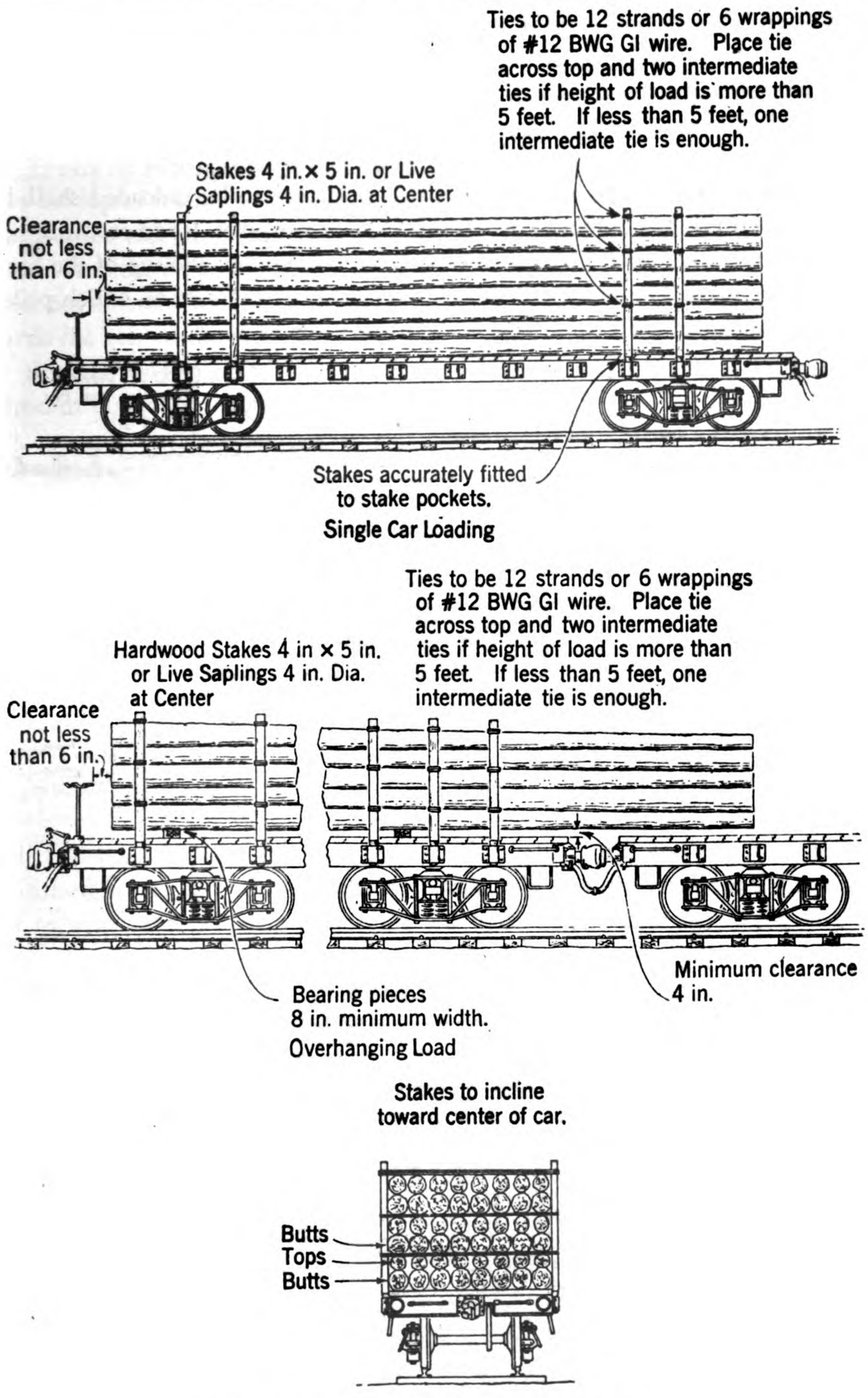



Figure 35.— Loading poles on flat cars.

A careful inspection should be made of stakes and ties on loads of poles which it is proposed to unload as received from the railroad authorities. If there is any question regarding the safe condition of the load, additional stakes or ties should be placed or, if necessary, the poles shall be reloaded.

***b. Train stopped.—*** Cars from which poles are to be unloaded shall be equipped with skids in order to prevent damage to the poles. Upon reaching the destination at which unloading is to commence the wire on the top of the load shall be removed. The pole in the uppermost layer on the side on which poles are to be unloaded shall be snubbed as shown in figure 36.

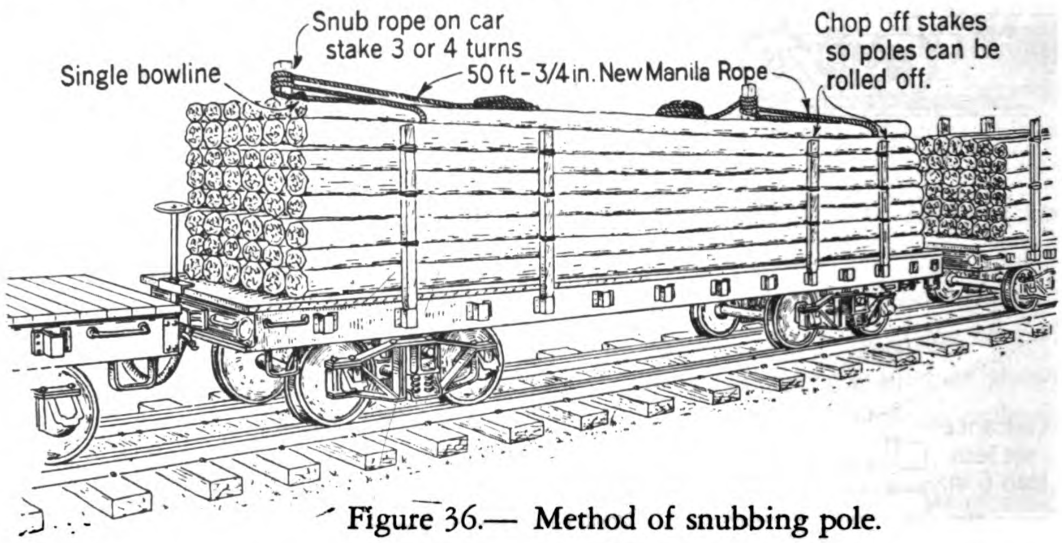



Figure 36.— Method of snubbing pole.

Stakes on the unloading side shall then be cut off to a level such that the poles in the top layer can be rolled past them. Poles shall be unloaded from the cars as shown in figure 37. Before the train is started the next pole to be unloaded shall be snubbed as previously described.

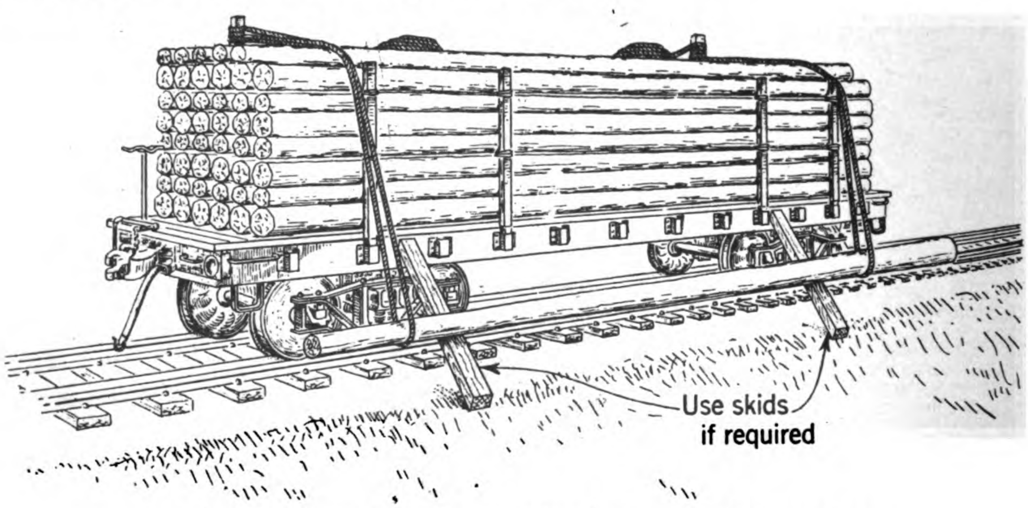



Figure 37.—Unloading poles from a stationary car.

After the unloading of one layer of poles has been completed the point of attachment of each snubbing rope shall be lowered and the stakes on the unloading side should again be cut so as to permit of unloading poles in the next layer.

**c. Train in motion.—** When unloading is to commence the wire ties across the top of the load should be cut and those stakes at the rear of the car on the unloading side should be chopped off so that poles may be rolled past them. The stakes at the front end, that is, the end towards which the train is moving, should not be cut. These stakes afford a means of causing the ends of the poles towards the rear of the train to drop to the ground first and it is essential that they drop in this manner to prevent accidents and breakage of poles. The method of unloading poles from the car is illustrated in figure 38.

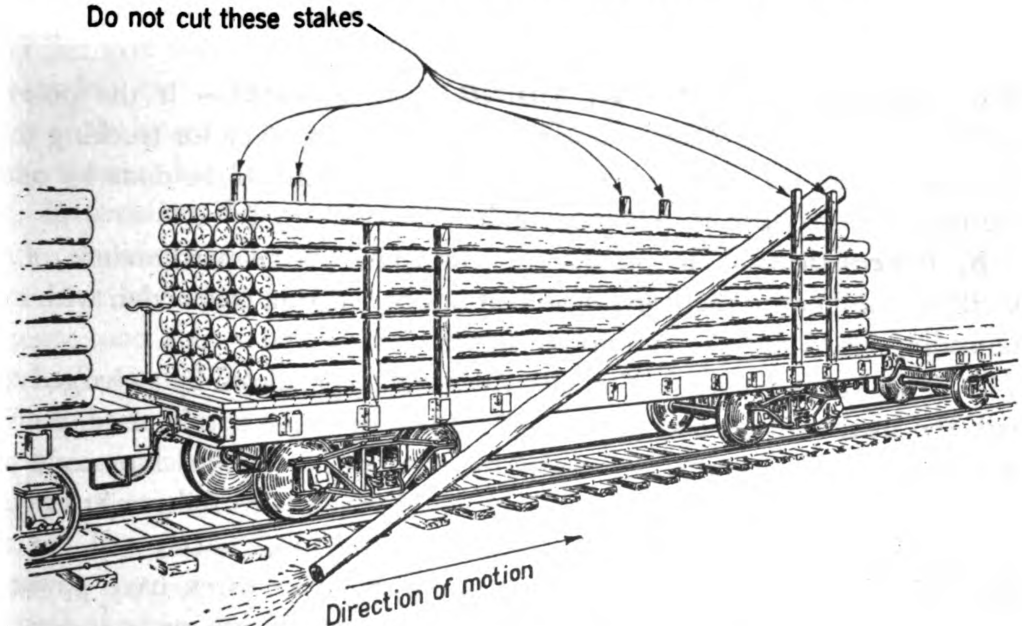



Figure 38.— Unloading poles from moving cars.

It will usually be necessary to fasten the first pole in each layer by means of a rope sling around the end toward the rear of the car, as the stakes at this end of the car are chopped off. This will prevent poles from accidentally rolling off the load. Poles can be secured as illustrated in figure 36 except that not more than about 20 feet of rope will be required.

When poles are shifted from one side of the load to another, men should stand in such a position that poles are moved *away* from them and not toward them. If this practice is followed at all times there will be little likelihood of injury to feet resulting from poles being rolled on them, or of men being knocked from the top of the load. Men should stand away from the front end of the cars as poles are being pushed off at the rear in order to avoid being struck as the poles fall to the ground. (See figure 39.)

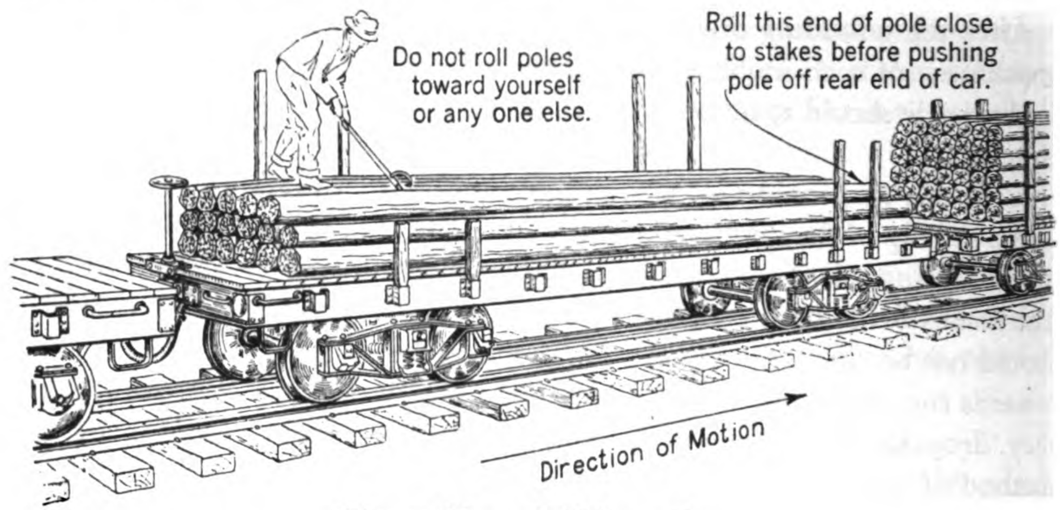



Figure 39.— Shifting poles.

**68. UNLOADING POLES AT SIDING.— *a. General.*—** If the poles are to be unloaded from freight cars at a siding for storage or for trucking to the locations where they are to be used, the unloading should be done by one of the methods described in this paragraph.

***b. Precautions.*—** In order to insure safety in the performance of this work, it is important that certain precautions be taken in connection with every unloading job. These precautions are summarized below:

(1) If the car is delivered at an electrified siding paralleled by a charged third rail, the method described in (c), (d) and (e) must not be used. At such a siding, the poles should be unloaded by means of a pole derrick or a gin pole, as described in (f). If it is definitely known that the third rail power has been cut off and will remain so, the methods described in (c), (d) and (e) may be used. At electrified sidings having overhead power wires, have power cut off if practicable. If impracticable to have power cut off, use methods described in (c), (d) or (e), but exercise special care to avoid interference with power wires.

(2) The binding line, ropes and stakes to be used in this work should be in perfect condition. Under no circumstances should the work be undertaken with a binding line which has broken wires or with ropes which have broken strands.

(3) Strong skids should always be placed against the car.

(4) The unloading crew should preferably be a small one. Three or four men can unload a car satisfactorily. The man in charge of the work must be thoroughly acquainted with all the details of the unloading operations.

(5) All of the orders should be given by the man in charge of the work.

(6) Only one operation should be in progress at a time and the various operations should follow each other in the order indicated in Parts (c) to (f).

(7) Nobody should be permitted on the top of the load at any time, except as provided in (f).

(8) If blocks and tackle are to be used for pulling up the binding line, the anchorage to which they are attached should be very substantial. A sound tree or stub whose circumference is 30 inches or more is considered satisfactory. Attachments should be made as close to the ground as practicable. If a motor truck and winch line are to be used for pulling up the binding line, the wheels of the truck should be chocked. The winch clutch should always be engaged. The winch used for this work should preferably be of a type that will not reverse except under engine power. If a winch having a reversible worm is the only type available, it may be used, provided that the winch brake can be depended upon to hold the load.

(9) If stakes at the back of the load are broken or the load leans toward the main track, place extra stakes in unoccupied pockets at back of load to reinforce that side.

(10) Be sure that the space on the unloading side of the car is clear of old wire, stakes, etc.

(11) If the space in front of the car is likely to be crossed by passersby, rope off the space to keep it clear.

***c. Unloading flat cars—Method No. 1.—*** This method is to be used where conditions make it advantageous to pull up the binding line from a point in a line approximately at right angles to the siding tracks. For convenience, one side of the car is designated as the "unloading" side, and the other side as the "far" side. The various steps to be taken and the order in which they should be taken are as follows:

(1) If necessary, move the car along the siding to the most suitable unloading position. This may be done by means of the winch line or by jacking it along the track. Set the brakes of the car and, if necessary, place chocks under the wheels to prevent the car from further moving along the tracks. Place substantial skids against the car on the unloading side. The tops of the skids should preferably be at the level of the floor of the car so that the poles will roll off without interference. The lower ends of the skids should be set in the ground so that there will be no possibility of their slipping. The skids should be set close to and on the center side of the stakes nearest the center of the car so that they will not interfere with cutting the stakes. The skids should also be placed at right angles to the side of the car, so that there will be no tendency to slip along the car. (See figure 40.)

(2) Pass the two ends of the binding line under the car from the unloading side. In some cases, it may be necessary to pass the ends of the line over the brake rod so as to avoid bending the rod when the line is pulled up tight. Throw a hand line over the load from this side and by means of it draw the ends of the binding line over the top of the load. Connect the eyes of the binding line to the hooks of the snatch blocks and pass the bight of the line over the sheaves of these blocks. If the line is equipped with choker hooks, pass the

bight over the hooks. Slide the blocks or hooks into a position on top of the load about one foot back from the nearest pole on the top layer. They should be approximately in the position shown in figure 40. This work must be done from the ground. Place a wire rope snatch block in the bight of the binding

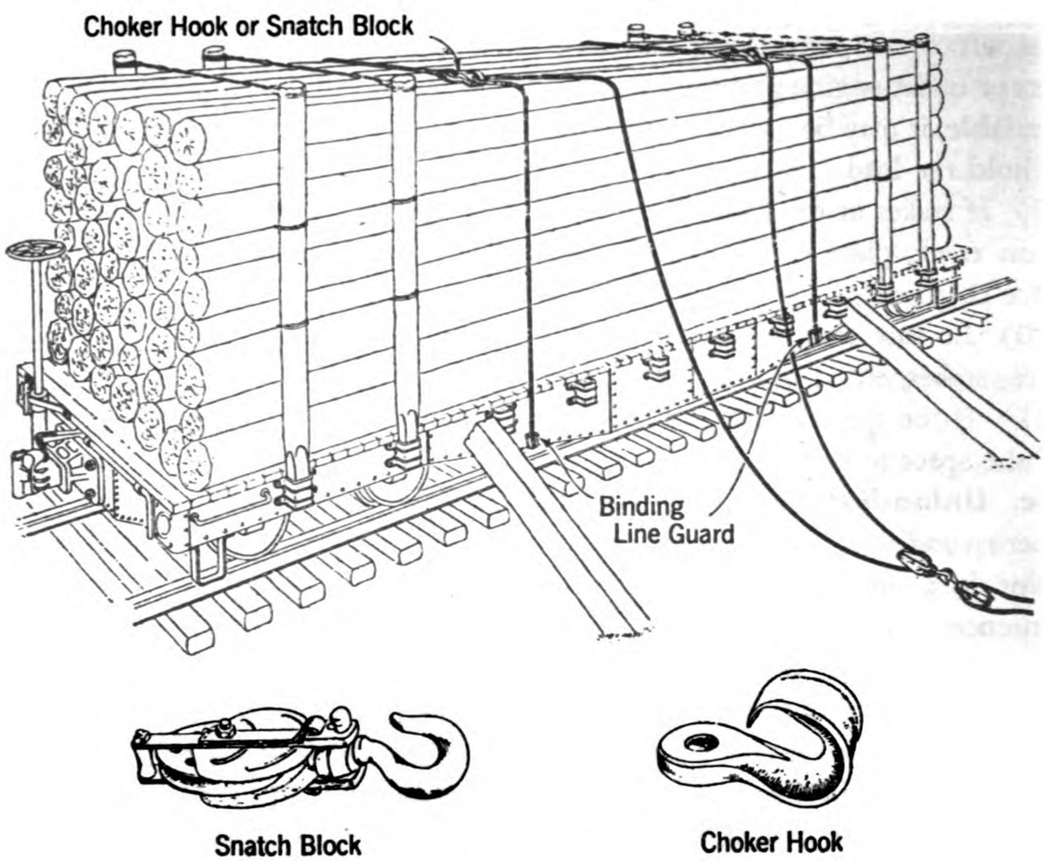



Figure 40.— Placing binding line.

line and pull up the binding line by means of a motor truck winch line, or a set of 3-sheave, 8-inch blocks, until the load is tightly bound. If a truck winch line is used, make fast the eye end of the line to the truck and run the line through a second wire rope snatch block hooked to the first one, as shown in figure 41, in order to permit easier control of the tension in the line. The truck should be placed about 100 feet away from the car and in such a position that the winch line will pull in line with the center of the car and approximately at right angles to the tracks. Place chocks under the rear wheels of the truck.

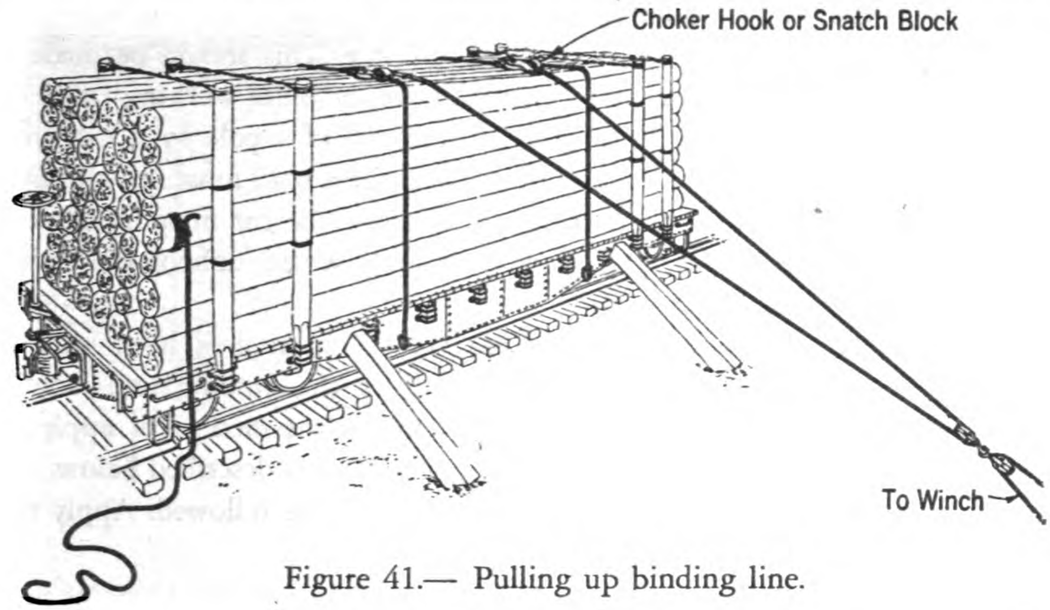



Figure 41.— Pulling up binding line.

If a set of blocks is used instead of a winch, be sure that the anchorage against which the pull is to be made is sufficiently substantial to withstand the pull. A sound tree or stub whose circumference is 30 inches or more at the ground line is considered satisfactory. The blocks should be equipped with at least 200 feet of rope and when the binding line is pulled tight the blocks should be close together, so as to reduce the amount of stretch and afford plenty of slack when the binding is released. If necessary, use another set of blocks on the luff of the main blocks, in order to make the binding tight.

(3) Tie a 50-foot length of 1-inch or larger rope securely to the end of a key pole on the unloading side and lay the rope out of the way at the end of the car. This rope is for use later, in case it becomes necessary to start the load.

(4) Cut the lower tie wires on the unloading side of the car by means of a strand cutter, working from the center towards the ends of the car. If each set of stakes is held by three cross ties, cut the middle and then the lower ties at each set of stakes. *In no case should the top tie wires be cut.*

(5) Chop each stake completely off on the unloading side as close to the stake pocket as practicable, working from the center toward the ends of the car. *Before the last few blows of the axe are struck, stand clear of the stake, so that in case the bottom of the stake should spring out, it will not strike the chopper. Do not cross in front or in back of the load after this operation.*

(6) Let off the tension in the binding line slowly. If the poles start to roll, the tension should be released gradually so as to let the load roll slowly off the car. If the load does not start to roll, hold the binding line with a small amount of slack in it, and start the load rolling by means of the pull rope tied to the key pole or by means of pike poles, working from the ends of the car.

(7) After the poles have completely settled, remove the snatch block from

the binding line. Roll a number of the remaining poles off the car so as to relieve the pressure on the stakes at the far side. This should be done by means of the winch line, a separate piece of rope, or pikes working from the ground. The line may safely be attached to the end of a pole by a workman standing clear of the poles at the end of the load. This man must not climb on the remaining poles for any reason, nor walk along the car floor in front of the poles. After the remaining poles have completely settled, unhook the choker hooks or snatch block, one at a time.

***d. Unloading flat cars—Method No. 2.—*** This method is to be used where conditions make it advantageous to pull up the binding line from a point along the siding tracks. With the exception of the method of applying the binding line, pulling it tight and releasing it, which is described below, the same practices as are described in Method No. 1 shall be followed. Apply the binding as described below:

(1) Throw the hand line over the load from the unloading side at a point near one end of the car. This line is to be used for pulling the hooks of the binding line over the load.

(2) Attach the hand line to the eye of the binding line or choker hook on the far side of the car and draw the binding over the load. Pass the end of the binding line around one of the car axles, making at least one complete turn around the axle, and secure the line in place by means of the choker hook or a winch rope hook. Slip the line around the axle so that when the binding is pulled tight, the wrapped line will be close to the wheel on the unloading side of the car and so that there will be no sharp bend where the line leaves the hook.

(3) Repeat the operation at the other end of the car with the other end of the binding line.

(4) At the far side of the car place two chain wrappings around the track rail, one at each end of the car close to the wheels and between the center of the car and the wheels. Each of these chains is to serve as a convenient point to attach the hook of a wire rope snatch block.

(5) Attach a wire rope snatch block to each chain close to the rail and pass the binding line through the blocks as shown in figure 42.

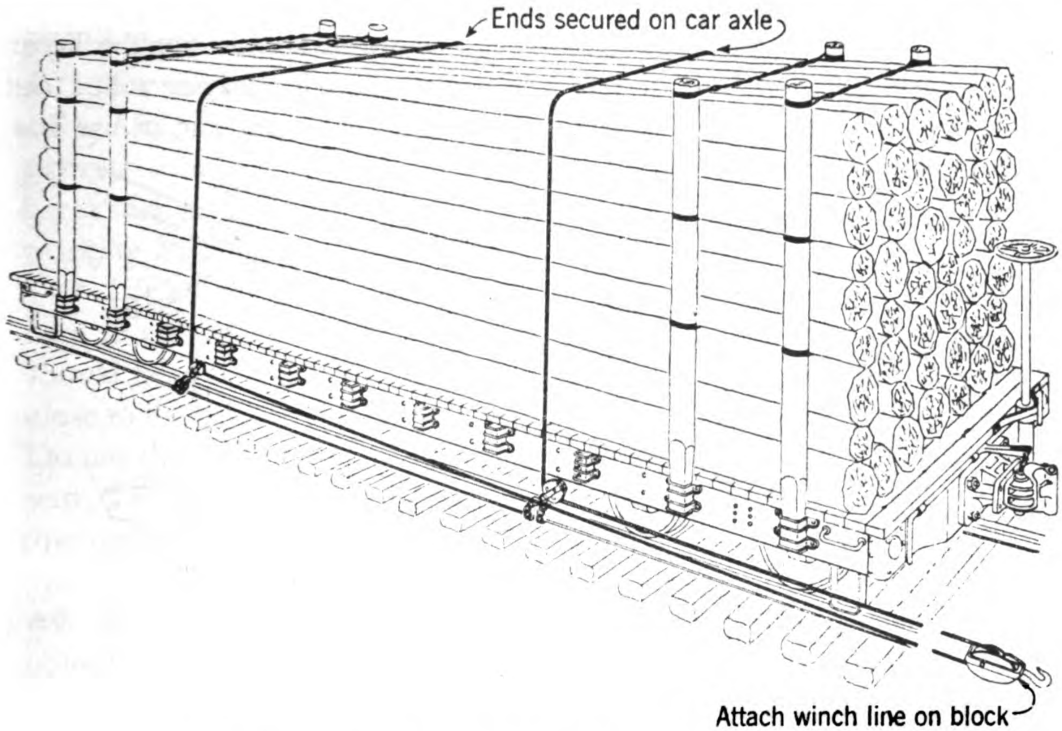



Figure 42.— Placing binding line—pull parallel to tracks.

(6) Lay the loop of the binding line along the rail and place a third wire rope snatch block in the loop to act as an evener when the binding is pulled up. This block should be at least 15 feet from the end of the car.

(7) Place a third chain around the rail about three feet in advance of the hook of the evener snatch block to serve as an anchorage for attaching a set of blocks to be used in pulling up the binding line.

(8) Place a set of 3-sheave, 8-inch blocks between the chain and the evener block and pull up the binding line until it is tight. If necessary, use another set of blocks on the luff of the main blocks. It is desirable that the main blocks be equipped with about 200 feet of rope and that after the line has been pulled tight the main blocks be close together, so as to reduce the amount of stretch in the binding and afford plenty of slack when the binding line is released. If a truck with winch equipment is available and conditions permit, the winch line can be used instead of the set of blocks for pulling up the binding line.

(9) As provided for in Method No. 1, tie the pull rope on the key pole, cut the tie wires and chop off the stakes; then let off the tension in the binding line.

(10) After the poles have completely settled, the snatch blocks and the ends of the binding line may be released. Do not, in any case, approach the load until the poles have completely settled and there is no further possibility of the poles moving.

***e. Unloading gondola cars.—*** Follow the same general method as in unloading a flat car, for the layers of poles above the top of the sides of the car. The skids should preferably be longer and be placed with the upper ends as close to the top of the side of the car as conditions permit. For the layers below the level of the tops of the sides of the car the poles may be rolled out, by means of a rope cradle, as shown in the following illustration, or use may be made of a pole derrick or gin pole.

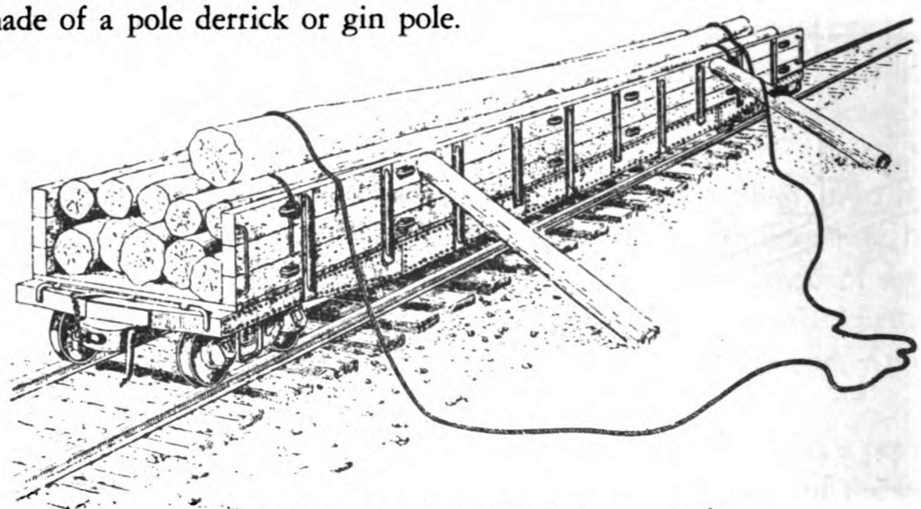


Figure 43.— Unloading gondola cars.

***f. Unloading with pole derrick or gin pole.***— A pole derrick or gin pole can be used to advantage when unloading poles from either a flat car or a gondola car at an electrified railroad siding paralleled by a charged third rail. At electrified sidings having overhead power wires, do not start to use a pole derrick or gin pole unless the power has been cut off on the siding. To use a derrick or gin pole, proceed as follows:

(1) If there are any stakes broken or if any appear to be of doubtful strength, place additional stakes on the side of the car on which the broken stakes are found. With only one man working on top of the load, place temporary 1-inch rope cross ties between each pair of end stakes as shown below, making two

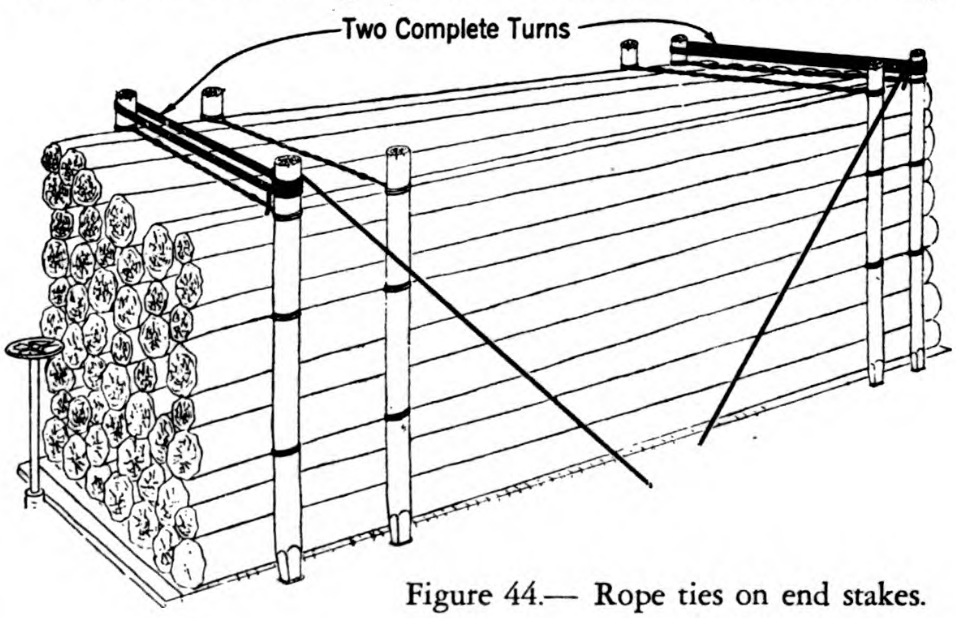



Figure 44.— Rope ties on end stakes.

complete turns around the stakes, pulling the rope tight and holding tension in the ropes until after the top tie wires are cut and the man is off the load.

(2) Cut the top wires between each pair of stakes.

(3) After the man is off the load, release the rope ties cautiously so as to prevent a sudden load on the stakes. A sudden load is much more likely to break the stakes than a gradually applied load. Snap the lines off the stakes, working from the ground and away from the car.

(4) Lift off the poles one at a time by means of the derrick line, exercising care to avoid hitting the stakes as the pole is raised. The head of the derrick should be approximately in the plane of the stakes. Attach the derrick line as close to the balance point of the pole as practicable, so as to facilitate handling. Do not allow the end of the pole to swing out over the main track and interfere with a passing train. No more than two men are required on the load during this operation.

**69. CLEARING POLES FROM CARS AND PILING POLES.—** Clearing poles from the car and placing them in the storage pile will be greatly facilitated if two lines of skids are placed on the ground between the car and the storage pile. The poles can be rolled or dragged along the skids by means of a winch line much more easily and with less injury to the poles than they can be moved over bare ground or by hand tools. Care should continue to be exercised in clearing the car and piling the poles, in order to avoid personal injury. The following precautions will do much to prevent accidents:

(1) Do not climb on top of the poles. Work from the ends of the poles, in so far as practicable.

(2) Use the winch line for doing the heavy work, particularly pulling the poles off the car.

(3) In connection with sliding a considerable number of poles along the skids, it will frequently be advantageous to make us of a "V" sling, such as is shown in figure 45. The "V" sling should be attached to the poles by men working at the end of the poles. The winch line should be attached to the sling at its center point.

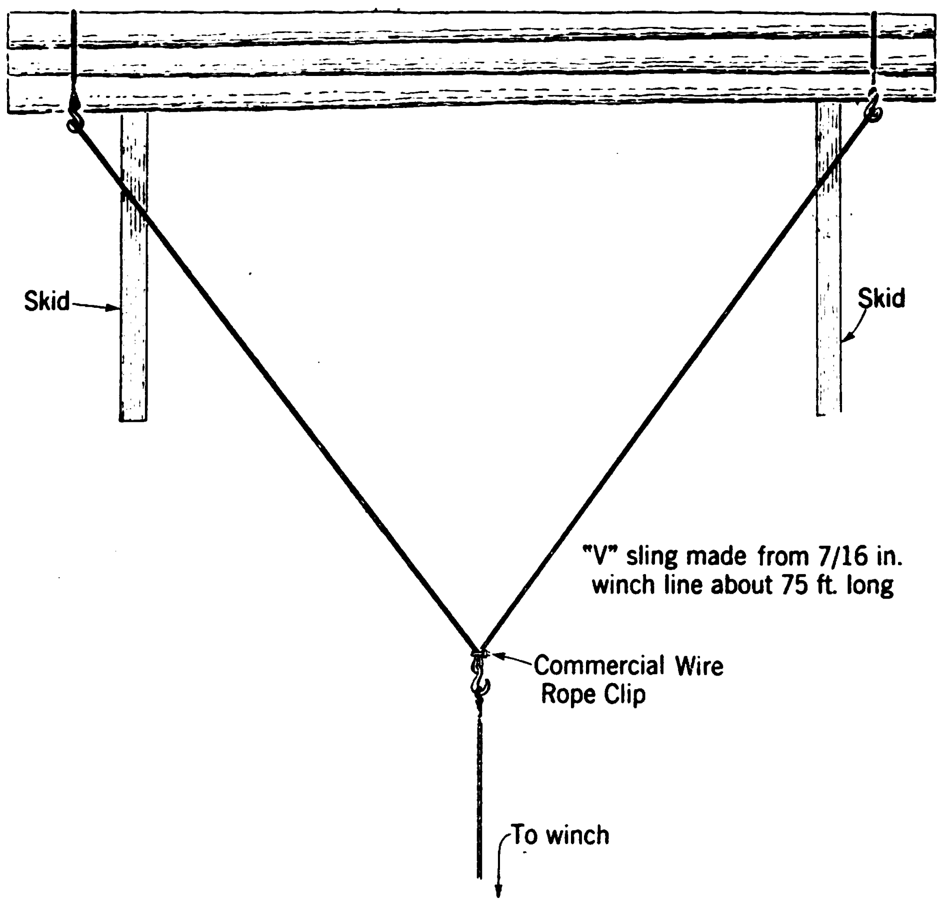



Figure 45.— V sling.

If a "V" sling is not readily available, attach the winch line at approximately the center of a pole. A loop of rope around the light end of the pole will be useful in keeping the pole guided properly on the skids.

(4) When engaged in rolling poles by means of cant hooks or peavies, look out for the man at the other end of the pole, so as to avoid personal injury.

**70. STORING POLES.—*a*** Poles that are to be stored for more than two weeks shall be stacked on creosoted timber, iron rails, or equivalent material, so that they will be at least one foot above the surface of the ground. The storage skids should ordinarily be spaced about 15 feet apart. Remove decayed and decaying wood from beneath and around poles that are to be stored for more than two weeks.

***b.*** The location of the storage yard should be selected with due consideration of the following points:

(1) Accessibility to trucks.
(2) Convenience of handling poles.
(3) Freedom from fire hazard.
(4) Drainage conditions.

**c.** Where considerable quantities of poles are to be stored, it is usually advantageous to have the poles separated into piles according to lengths. In stacking poles, care should be exercised to have the poles stacked regularly, that is, without any poles crossing over others and locking them in. The end poles of the pile shall be prevented from rolling by means of blocks spiked to the skids, or stakes driven into the ground. Where piles are more than one pole high, each layer shall be carefully nested on the layers beneath. Butts of poles should be reversed on alternate layers when the pile will be four or more layers high.

**71. POLE TRAILERS.—*a. General.*—** Pole trailers may be available for hauling poles. The following practices are applicable to the various types and outline methods for their operation.

***b. Balanced loads.*—** In loading poles on a two-wheel trailer, the position of each pole, fore and aft, should be such that the total load on the trailer is balanced. When thus loaded, one man can easily raise the front end of the load when the pole ends rest on the ground. The balance should be tested as every third pole is loaded, in order that it can be corrected as desired, by the additional poles loaded. The butts are usually loaded forward, in order that the shortest possible tongue length can be used. However, when the tongue of the trailer is not long enough to connect directly to the truck with the length of poles to be hauled, a long straight pole is loaded first and is placed directly over the tongue, with the top forward. This pole is known as the "king pole." Where various sizes of poles are to be loaded on the trailer, the poles should be loaded in the reverse order to that in which they will be unloaded so that the first poles to be delivered will be on top of the load.

***c. Using pole derrick to load poles on trailer.*—** If a truck mounted derrick is available, erect it and maneuver the truck to the position shown in figure 46. Place the trailer at right angles to the truck with the derrick head over the center line between the bolsters.

Place two skids between the bolsters and the ground at about a 45° angle, to guide the poles as they are raised by the derrick. Attach winch line to the pole to be loaded. One man at the end of the pole shall guide it as it slides up the skids and into place on the trailer.

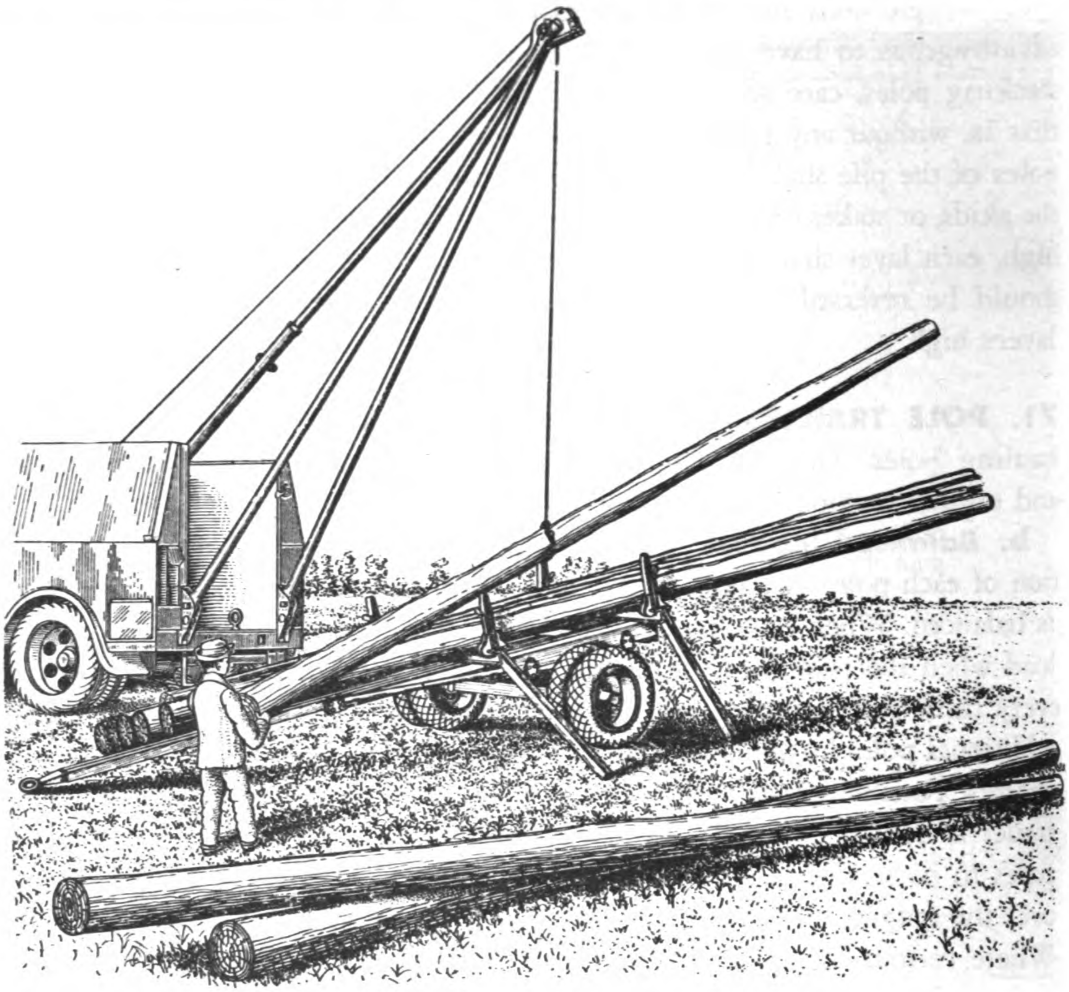


Figure 46.— Use of pole derrick in loading trailer.

***d. Using skids to load poles on trailer.***— Attach the trailer tongue to the truck towing hook. Block the wheels of the trailer and move the truck forward or backward to adjust the length of the tongue. Be careful not to get hands caught between the tongue end and the towing hook. Attach a snatch block to the trailer frame and pass the winch line over the sheave and over the pole to be loaded and then back to the frame of the trailer near the snatch block. (See figure 47.) Take up on the winch line. As the pole rolls up to the skids, two men should guide the ends, keeping the pole parallel with the trailer. These men should stand at the ends of the pole, so that they will be in the clear if the pole should get out of control.

In loading a semi-trailer, attach the trailer tongue to the truck towing hook and adjust to the proper length by moving the truck with the trailer wheels blocked. Keep hands away from the end of the tongue and the hook when attaching the trailer to the towing hook. Attach a wire rope or chain between the bolster on the trailer and the bolster on the truck, leaving a little slack as

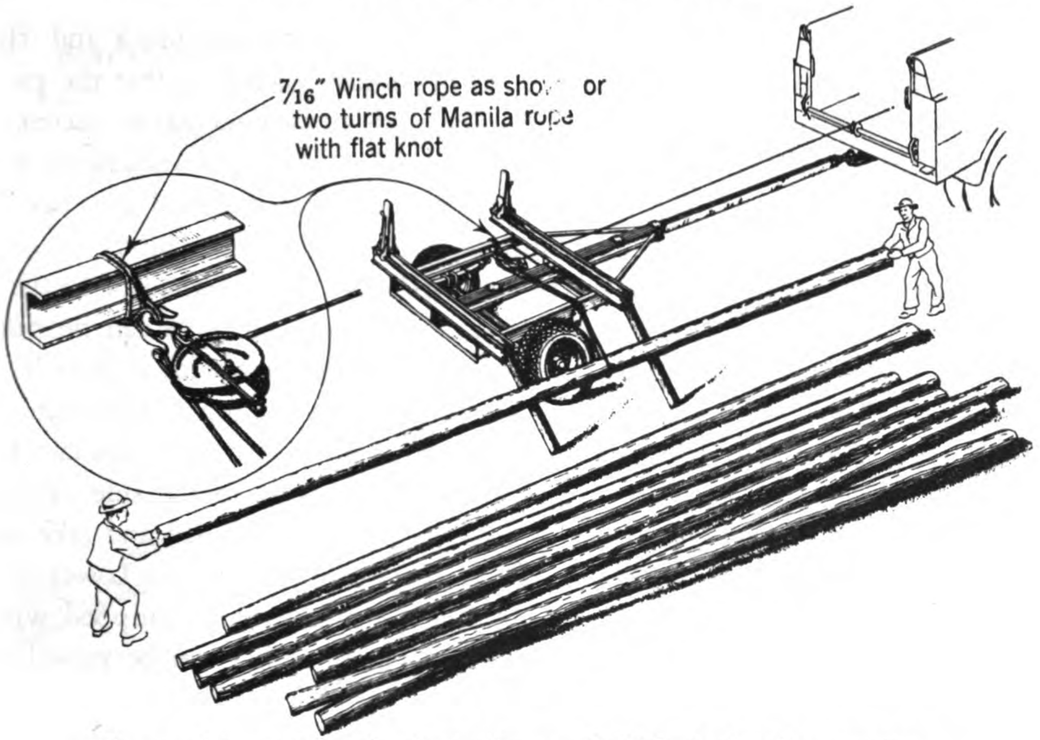



Figure 47.— Use of winch line and skids in loading trailer.

shown in figure 48. Attach a snatch block to this connection. Then proceed in the same manner as when loading poles on an ordinary trailer.

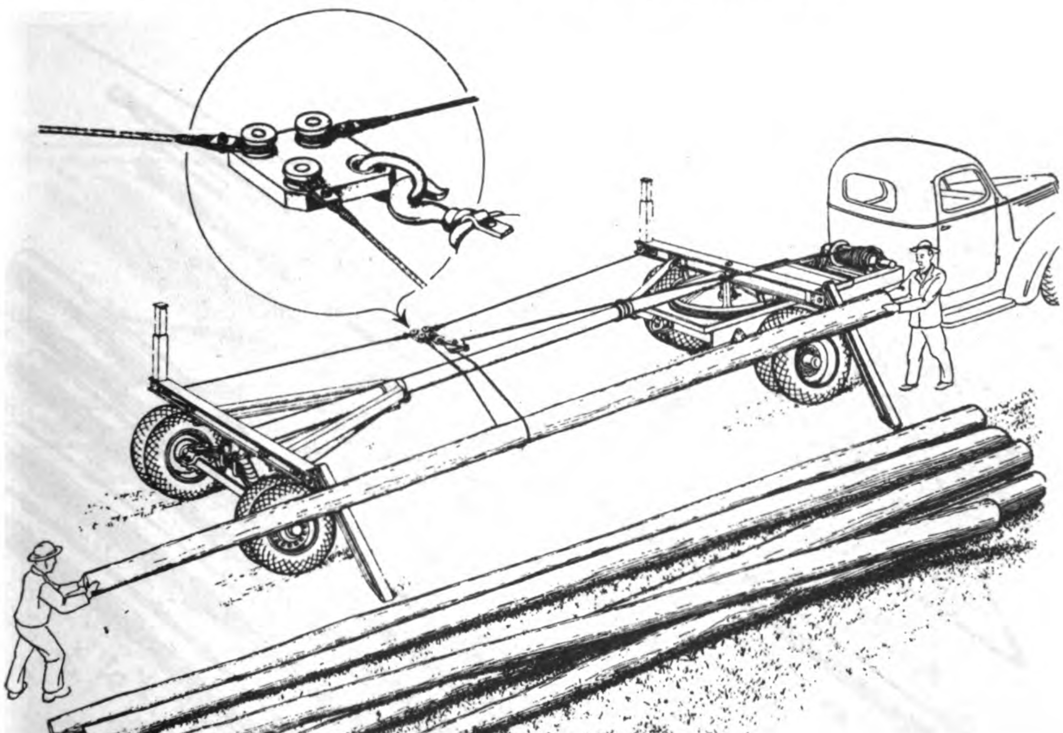


Figure 48.— Loading semi-trailer.

In loading the second or succeeding poles locate the snatch block and the deadend of the winch rope above the poles previously loaded, so that the pole being loaded can be rolled into position. The skids for the second or succeeding layers can be attached to the top of the stanchions when the stanchions are designed for this purpose. When the stanchions are not so designed, it is necessary to use cant hooks to assist in rolling the poles over the stanchions.

**e. *Using gin pole to load poles on trailer.*—** This method of loading trailers can be used to advantage at pole yards where a gin pole can be permanently installed at a convenient point and where a truck with a derrick is not avaiable. Rope is threaded through snatch blocks at the top and bottom of the gin pole. The trailer is located under the gin pole so that the poles can be lowered to the proper position on the trailer. Place skids to the side of the trailer. Attach the lifting end of the rope to the pole to be loaded and take up on the pulling end, raising the pole above the trailer stanchions. Lower the pole to its desired position on the trailer. When a pole yard is equipped with special derrick equipment, the method of loading the trailer can be varied to suit the equipment used.

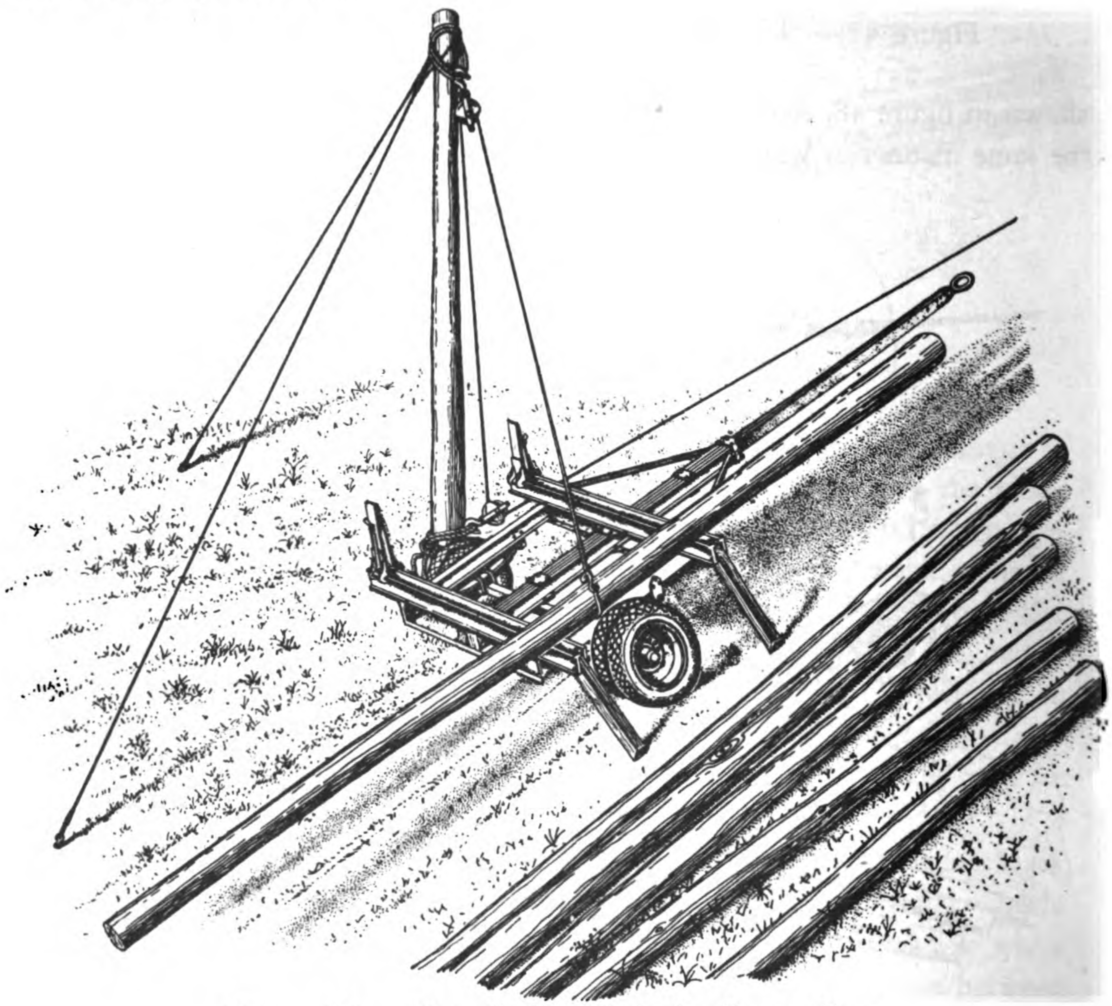


Figure 49.— Use of gin pole in loading trailers.

***f. Binding king pole.***— If a king pole is required, bind it securely to the tongue, near the front, as shown in figure 50, so that it will not change its position when the other poles are loaded.

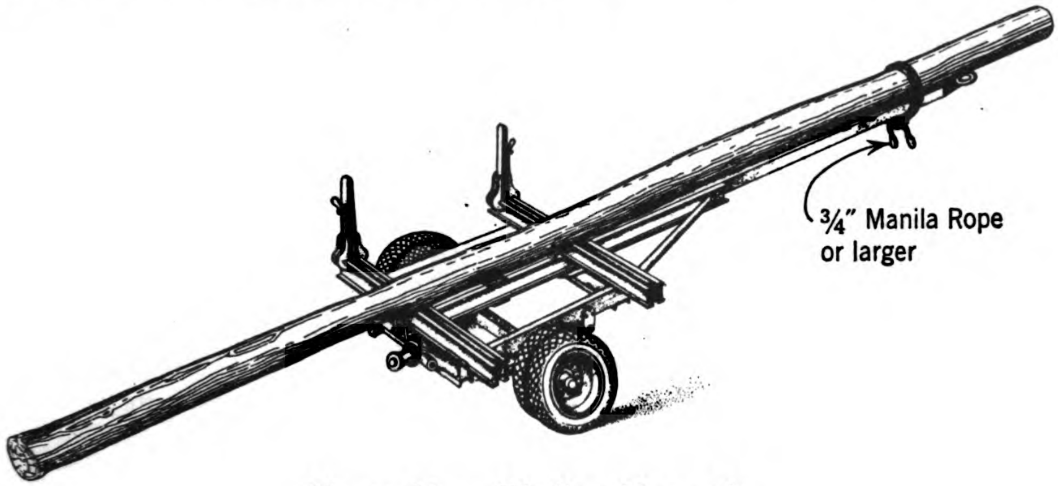



Figure 50.— Binding king pole.

***g. Binding completed load.***— Bind a balanced load at the rear of the trailer frame and near the front end of the tongue. Use the binder attached to the trailer for binding at the rear. (See figure 51.) Use a portable load binder for binding near the front end of the tongue.

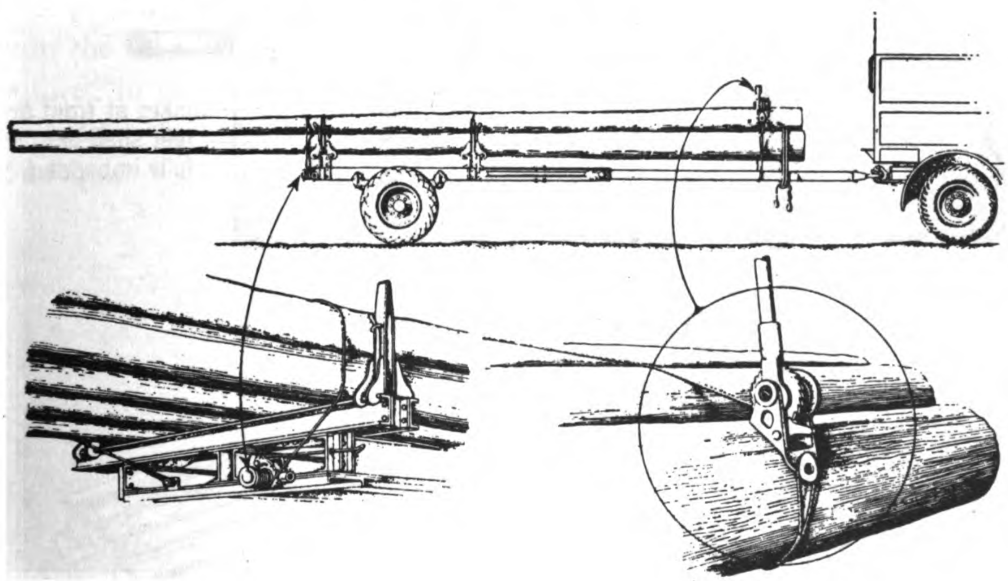


Figure 51.— Binding completed load.

Steel rope, $\frac{5}{16}$ inch diameter, will be satisfactory for binding the load. If this size rope is not available, $\frac{7}{16}$ inch steel rope can be used. Do not rely on the stanchions to hold the load while traveling. Always bind the load as outlined above in addition to the use of stanchions.

***h.* Coupling trailer to truck.**— Attach the trailer tongue direct to the towing hook on the truck if the poles are short enough so that the load can be balanced on the trailer and the trailer tongue extends about four feet ahead of the load. If the poles to be loaded are so long that the tongue cannot be attached to the towing hook, use the type H or L draw-bar on the king pole, as shown in figure 52. The H draw-bar should be used with 1½ ton or larger trucks. The L draw-bar should be used with lighter vehicles.

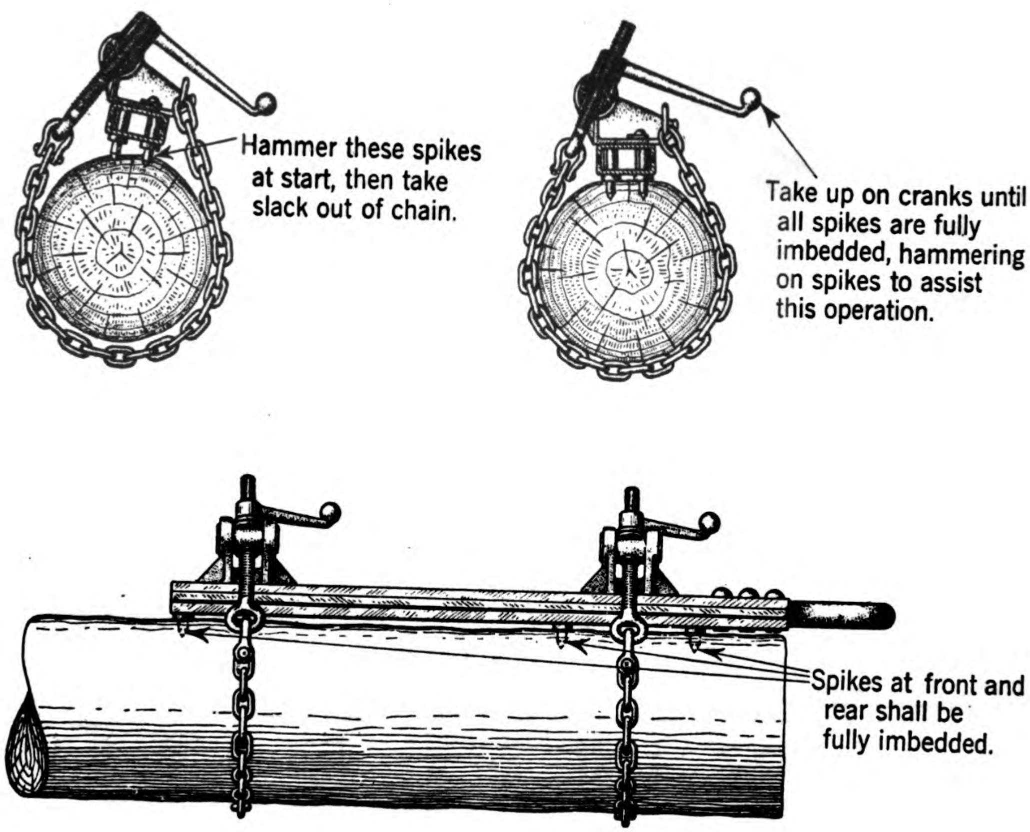



Figure 52. Use of draw-bar.

Attach a safety connection between the truck and the trailer as outlined in figure 53.

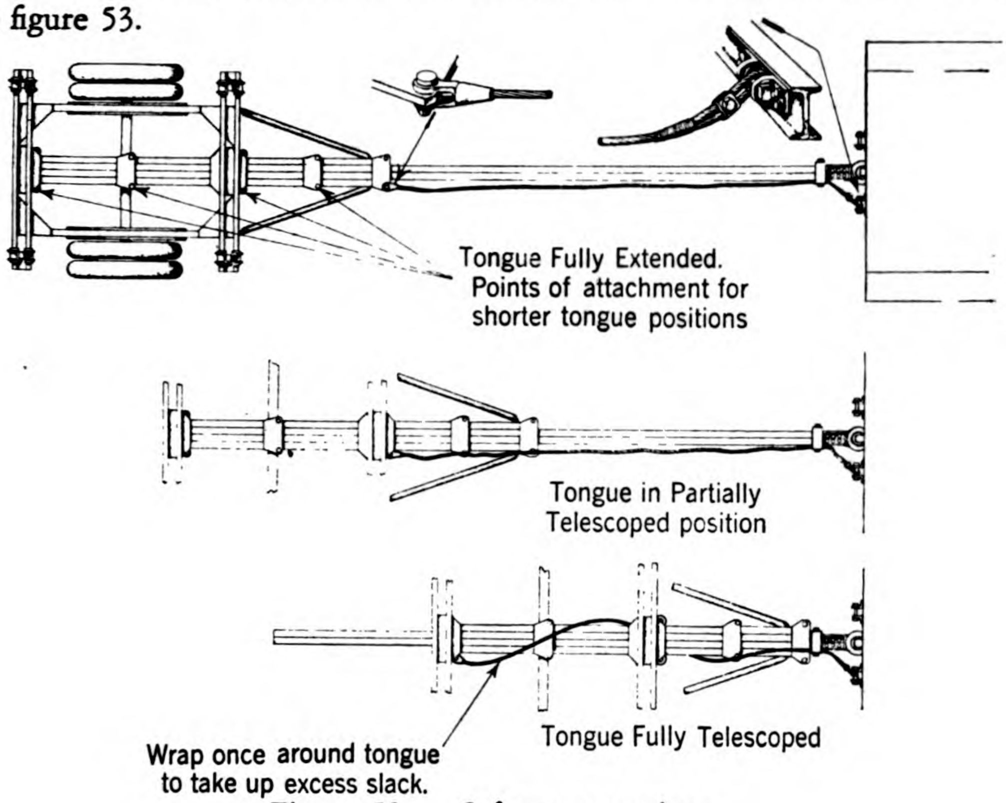



Figure 53.— Safety connections.

***i. Unloading trailer by rolling poles off side.***— Poles can be removed from the load by rolling over the side of the trailer. Skids are not generally required in unloading. One man should stand on the ground at each end of the pole to be unloaded and use a cant hook to roll the pole off the trailer. (See figure 54.)

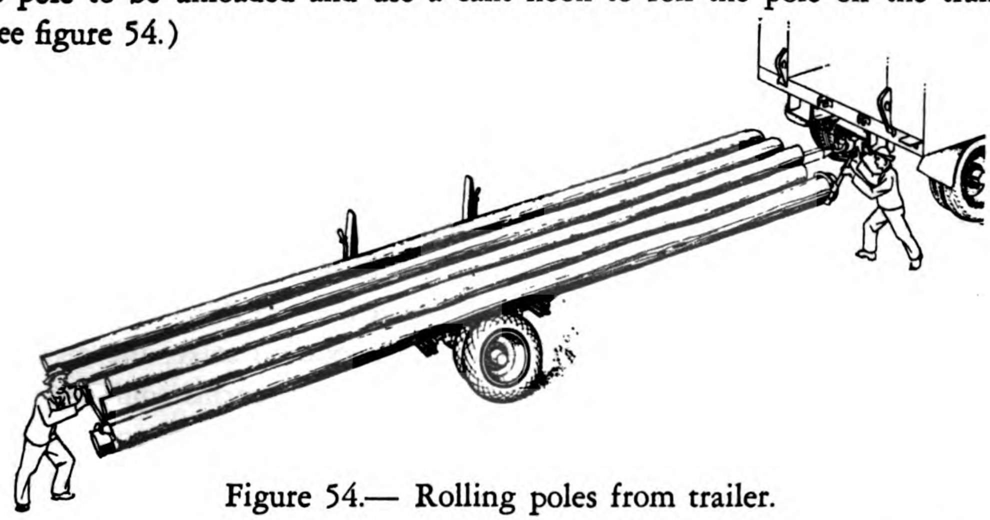


Figure 54.— Rolling poles from trailer.

After removing the top layers, the stanchions can be removed and the bottom layer removed in a similar manner. In removing the top layers before the stanchions are removed, and when it is necessary to stand on the load, be careful to have a firm footing and to roll the pole away from and not toward yourself. Make sure that when moving one pole, the other poles are not dislodged by taking away the support provided by the pole being moved.

***j. Unloading trailer by dragging out poles.—*** When there are trees along the route, a line can be attached to the pole to be unloaded and the other end of the line snubbed around one of the trees about 50 feet away from where the pole is to be unloaded (see figure 55). A distance of 50 feet or more is desirable to lessen the side pull on the pole. By driving the truck slowly, the pole will be dragged out of the load and will drop to the ground when the pole clears the load on the trailer.

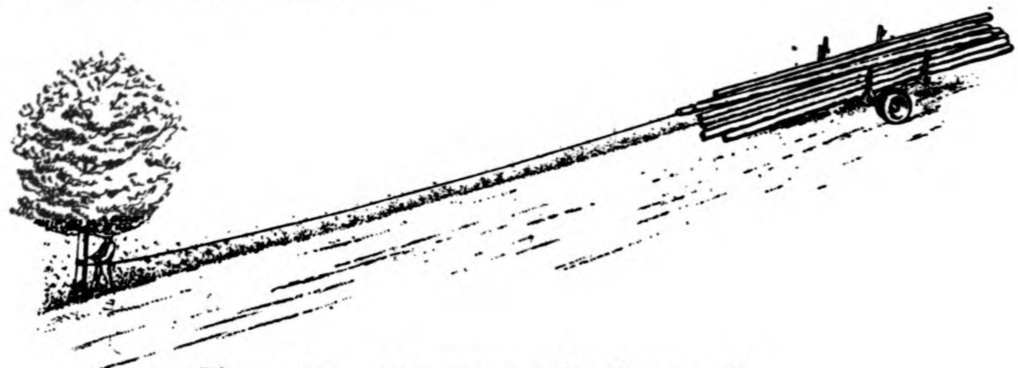


Figure 55.— Dragging poles from trailer.

**72. DISTRIBUTING MATERIALS ALONG THE LINE.—*a. General.—*** The crew distributing materials will usually be equipped with a cargo truck and pole trailer and a list of the materials required at each stake location. The crew will proceed along the staked out line, leaving at each stake location a pole, crossarms, and any other materials called for on the materials list. Materials other than poles are carried in the cargo space on the truck. The quantities of these materials should be sufficient to equip all the poles carried on the trailer.

***b. Distributing poles.—*** Lay the poles on the ground so that they will be parallel to the line and with the butt near the location stake. They should all be laid with their tops pointing in the same direction from the location stake; that is, all pointing toward the zero pole or all pointing toward the far end of the line. This will help the construction team in identifying pin positions at transposition poles. Poles and crossarms should be laid on the ground, not thrown, so that they will not be broken or cracked.

***c. Distributing other material.—*** At each location stake, the materials distribution crew leaves, in addition to the pole and crossarms equipped with pins and crossarm braces, a machine bolt and washers, lag screw and washers, the proper number and type of insulators, as well as any other materials such as anchors that may be indicated on the materials list or markings on the stake. These materials should be placed on the ground near the top end of the pole. Insulators should be handled carefully to avoid breaking them. Particular care should be exercised to see that the proper length of pole is delivered and also that the proper number of TW insulators are left at transposition poles.

# CHAPTER IV
# PLACING POLES



## *Section I*
## *Pole Holes*

**73. GENERAL.—** ***a.*** Holes will be dug by hand or by means of an HD earth boring machine. If a pole is to be set in rock it will be necessary to blast the hole. Blasting should be done by personnel experienced in the use of dynamite. The hole should be dug at the location of the stake. If, because of obstructions, the hole cannot be dug at the stake, a new location should be selected as close as possible to the stake and in line with the other stakes. Holes are to be of such size that the pole can be set easily and with enough space around the pole so that the back-fill can be well tamped around the entire circumference of the pole. Hand dug holes should be of the same diameter from top to bottom.

***b. Depth of Holes.—*** (1) The depth of holes in level ground should be as given in the following table:

| Length of Pole | Depth of Setting—Feet Firm Soil | Sand | Rock |
|---|---|---|---|
| 20 | 4 | 5 | 3 |
| 22 | 4 | 5 | 3 |
| 25 | 5 | 6 | 3 |
| 30 | 5½ | 6½ | 3½ |
| 35 | 6 | 7 | 4 |
| 40 | 6 | 7 | 4 |
| 45 | 6½ | 7½ | 4½ |

(2) The depths of setting in rock shown in the foregoing table are for solid rock which extends up to the surface of the ground. If the rock does not reach the surface, or if the diameter of the top of the hole is more than 2 feet, set the pole to the full depth shown for firm soil.

(3) Poles set in steep slopes or within 4 feet of the edge of a bank and unguyed corner poles should be set 1 foot deeper than shown in the foregoing table. When a pole is to be set in sloping ground, the depth of the hole should be measured on the low side.

***c. Pole holes in wet ground or loose earth.***— (1) In loose earth or swampy or wet soil, pole holes should be 1 foot deeper than shown in the foregoing table for firm soil. If at least 1 foot of firm soil cannot be reached by making the hole 1 foot deeper, swamp footings and ground braces should be used.

(2) In loose or light sandy soil and in very wet unstable soil, where the earth caves or slides as the hole is being dug, the walls of the hole should be shored with plank, barrels or drums with the ends knocked out. The shoring is placed when the earth begins to slide or cave into the hole and is forced down as the hole is dug deeper. The shoring need not be removed.

**74. DIGGING HOLES WITH EARTH BORING MACHINE.— *a. Preparations for boring.***— In moving the truck over difficult ground to get the earth borer in position, low or reverse speeds should be used. Skids can be used in crossing ditches and reaching embankment locations. It may be necessary to raise the rear of the truck by lowering the auger in reverse speed to place the skids under the rear truck wheels. If the truck becomes mired, chain skids can be used to get traction.

***b. Plumbing rack shaft.***— (1) The dial on the top of the intermediate gear case indicates the arrangement of levers for applying power to swing the rack shaft in the direction indicated by the arrows. The letter U on the dial indicates that the shift lever on top of the intermediate gear case should be pulled up; the letter D means that it should be pushed down. R indicates that the truck transmission should be in reverse speed, L indicates it should be in low speed. For example, in order to move the rack shaft in the direction of the arrow pointing to UR on the dial, engage the truck transmission in *reverse* speed, release the lever lock, push the right-hand control lever (leaving the left-hand lever in neutral) and at the same time pull *up* on the shift lever. The rack shaft will then swing in the direction of arrow UR. When the plumb bob is in the plumb position, release the right-hand control lever and place the shift lever in the center hole, which is the neutral position. When plumbing the rack shaft, low or reverse speeds only should be used with the engine running slowly. The plumbing of the rack shaft can also be done by using the hand ratchet wrench on the worm shafts.

***c. Boring operation.—*** (1) The boring machine can be operated either from the truck or from the ground. The truck position has the advantage that the operator is out of range of stones or other objects thrown from the auger while spinning off drillings.

(2) To release the rack lock, signal for first speed and then release the control lever lock. Pull hard on the right-hand control lever and push easy on the left-hand control lever until the rack shaft begins to rise. Then release the rack lock.

(3) There is a lock for the right truck spring operated by a lever at the rear end of the chassis frame. Engage the truck spring lock and use reverse speed. Pull hard on the right-hand control lever, push easy on the left-hand control lever and raise the truck until the spring lock snaps in place. Leave the spring lock engaged while boring holes and until necessary to move the truck a considerable distance.

(4) To bore, signal for boring speed which is usually high speed of the transmission, or one speed lower. Pull hard on the left-hand control lever, push easy on the right-hand control lever until the auger is near the ground, then push hard on both levers and bore until the auger is buried to a depth of 18 inches. To raise the auger, pull hard on the right-hand control lever, push easy on the left-hand control lever until the auger rises 18 inches above the ground and then push on both levers to throw off drillings. Repeat this operation until the hole is bored to the required depth.

(5) When boring in clay, sand or ordinary soil, the auger should revolve at fairly high speed, about 125 r.p.m. When boring in sandstone, shale or frozen ground, the speed of the auger should be much slower, about 25 r.p.m., changing to high speed to raise the auger and throw off the drillings.

(6) When boring in soil containing loose stones care should be taken to avoid damaging the machine. If the stones are more than 10 or 12 inches in diameter, they should be loosened and removed by hand. Smaller stones can be removed with the auger by lowering the auger into the hole at low speed, turning it very slowly until it comes in contact with the stone or works underneath it. If the stone is not over 10 or 12 inches in diameter, it can probably be dislodged by pushing on both levers to make the auger rotate in the hole or by pushing the left-hand lever easy and pulling the right-hand lever hard to raise the auger slightly and thus loosen the stone.

(7) After completion of each hole, disengage the control lever lock and pull the operating levers into the locking position. This will make it unnecessary to use the rack lock when moving the truck between successive holes. The rack lock should, however, be used as a safety precaution when traveling longer distances.

**75. DIGGING HOLES BY HAND.—** Use a long handled shovel, digging spoon and digging bars. Place the soil removed from the hole to one side where it will not interfere with erecting the pole. If the excavated soil is partly rock, separate the rock from the dirt to facilitate the back filling.

**76. BLASTING HOLES WITH DYNAMITE.— *a.*** If the rock in which the hole is to be blasted is covered with soil, dig the hole down to the surface of the rock.

***b. Soft rock or shale.—*** Drill a hole for the dynamite charge, about 18 to 24 inches deep in the center of the location of the pole hole, as shown in figure 56.

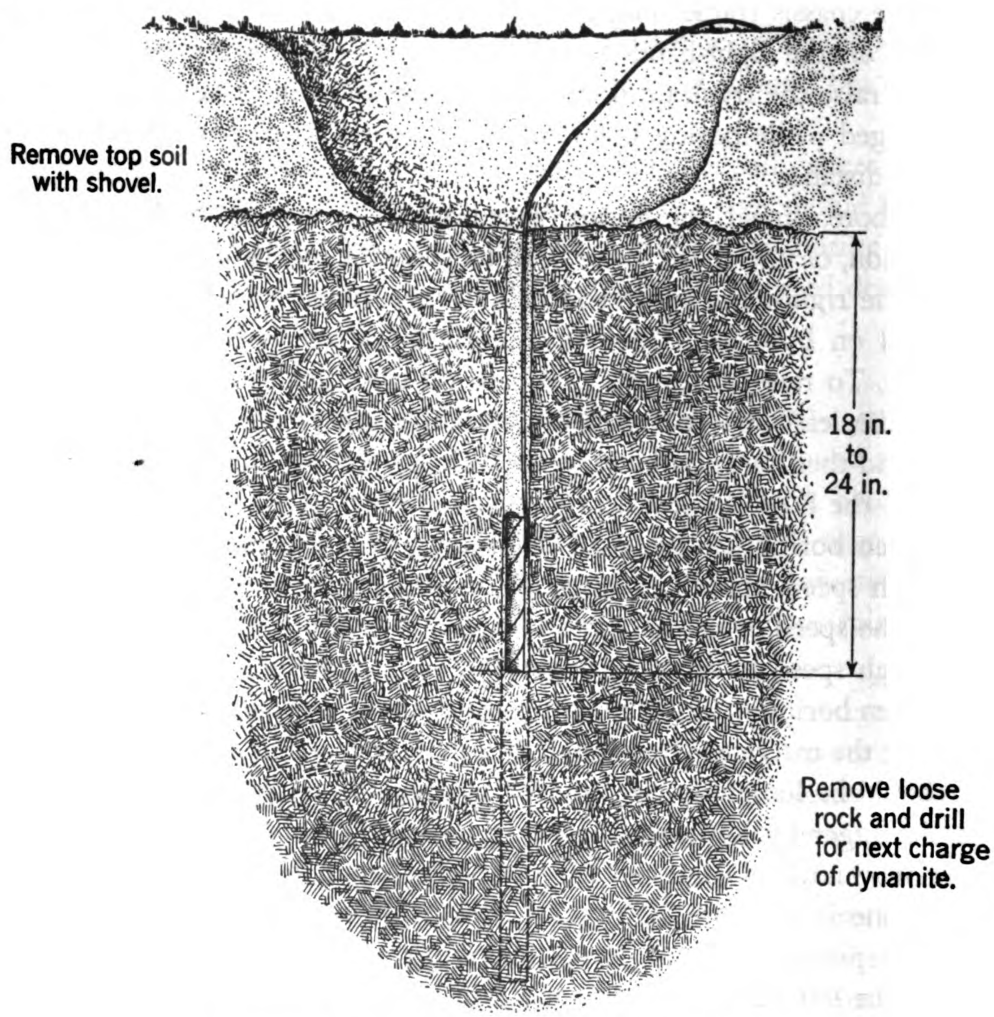



Figure 56.— Blasting soft rock or shale.

Place a charge of one or two 40 per cent. dynamite cartridges and fire. If the dynamite charge is sufficiently heavy, the rock will be shattered to the full depth of the drilled hole. Remove the loose rock, drill another hole 18 to 24 inches deep, charge with dynamite and fire as before. This should be repeated until the required depth of the pole hole has been reached.

***c. Hard rock.***— If the rock is hard, drill three or four holes about a foot apart, sloping them toward the center as shown in figure 57.

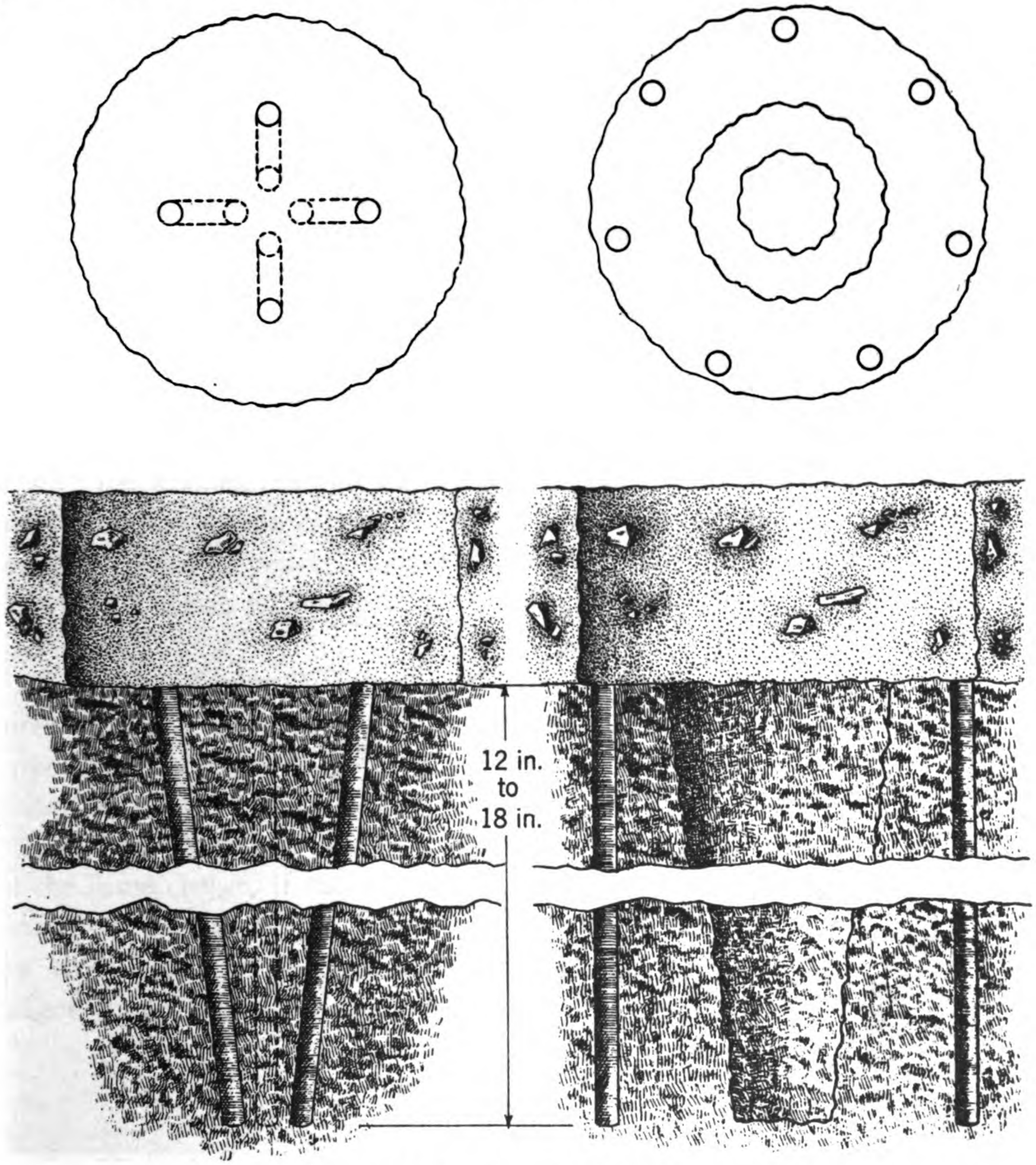



Figure 57.— Blasting hard rock.

These holes should be 12 to 18 inches deep. Charge each hole with a cartridge of 60 per cent. dynamite, pack and tamp firmly to the top of the holes and then fire them all at once. This will usually lift out the core of the rock. If, however, the sides have not been loosened so that the rock can be pried out, drill two or more holes down as close to the sides of the pole hole as possible and charge and fire them. Repeat this operation until the required depth of pole hole has been reached.

***d. Priming dynamite cartridge.***— Never prepare a charge of dynamite until just before it is to be used. Punch a slanting hole through the side of the dynamite cartridge, using a pointed round stick of wood or skewer, as shown in figure 58. Pass the lead wires on the blasting cap through this hole and

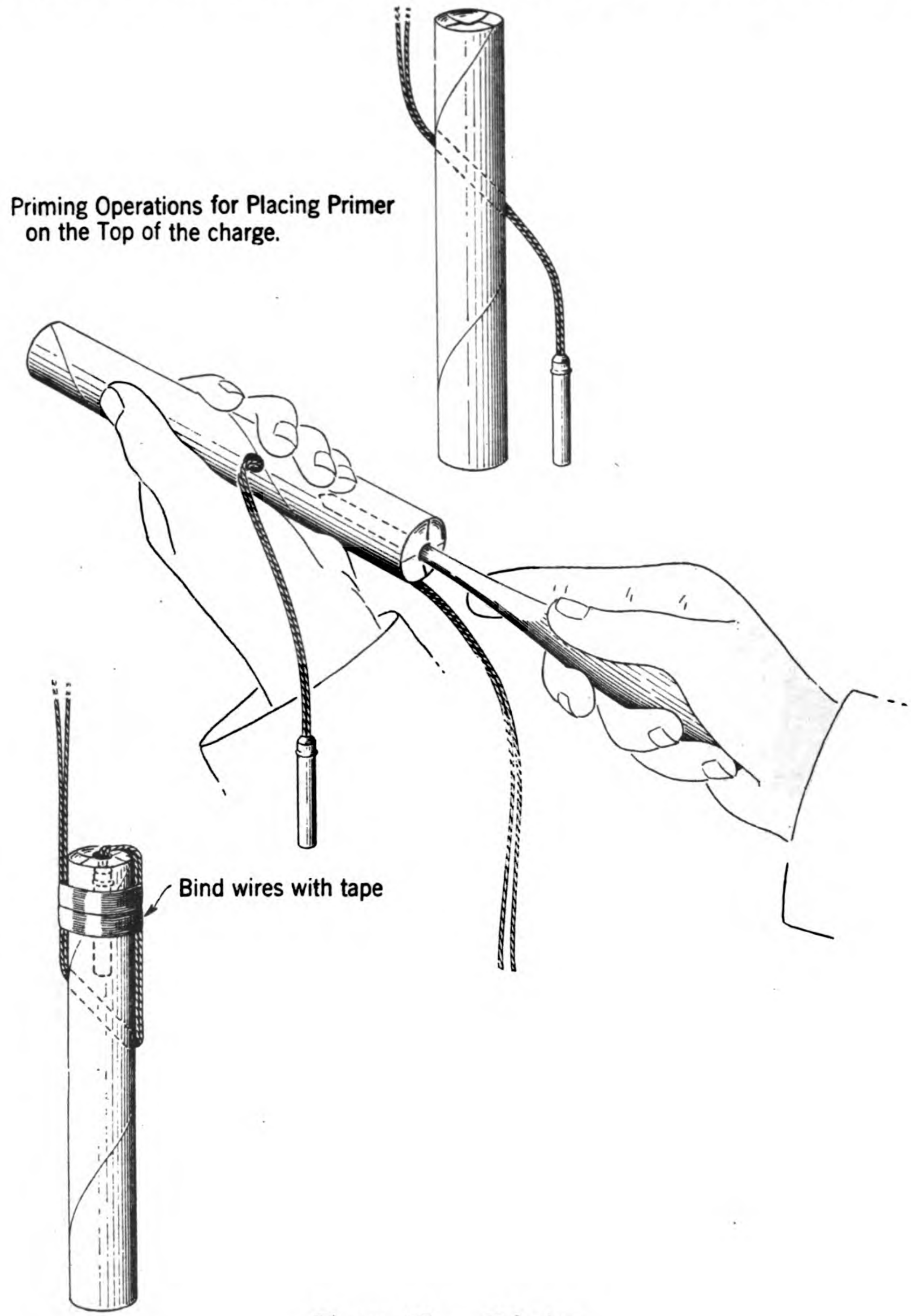



Figure 58.— Priming.

punch a hole in the center of the end of the cartridge straight down and deep enough to receive the full length of the blasting cap. If the charge is to be primed at the bottom, the hole for the blasting cap should be punched at the end of the cartridge opposite to that shown in figure 58. Insert the cap in this hole. Pull the loose end of the lead wires until the wires are tight and then bind them to the cartridge with friction tape.

***e. Charging hole with dynamite.***— (1) ***One cartridge:*** Placing the dynamite cartridge in the hole drilled in the rock is called charging the hole. Clean out the hole enough to remove any loose pebbles, dirt, etc. Insert a wooden tamping rod to measure the depth of the hole and mark the depth on the rod. Place the primed dynamite cartridge in the hole with the blasting cap on top and press it gently into place with the wooden tamping rod. Be careful not to disturb the blasting cap and do not pound on it or handle it roughly, as it is more dangerous than the cartridge of dynamite. Measure the depth of the top of the cartridge, using the wooden tamping bar, to make sure that the cartridge has been seated at the bottom of the hole. Drop moist clay, free from gravel, sand or loam over the cartridge and tamp lightly by pressing it with the wooden tamping bar. Repeat until a covering of about 6 inches has been placed over the cartridge. Then fill the hole with earth, taking care to see that stones or pebbles do not fall into the hole. Tamp this earth hard so that no air spaces will be left and be careful not to damage the insulation on the wires.

(2) If the diameter of the hole is so large that the cartridge will not form a fairly tight fit in it, slit the paper covering of the cartridge lengthwise, on opposite sides, with a sharp knife. This will allow the dynamite to expand under the pressure of the tamping rod and thus fill the cross-section of the hole.

(3) ***Two cartridges:*** Never combine 40 per cent. and 60 per cent. dynamite in the same charge. If the hole is to be charged with two dynamite cartridges, prime the bottom of the lower cartridge only with a blasting cap. The hole for the cap should be punched as described in paragraph ***d.*** The two cartridges should be taped together with friction tape as shown in figure 59.

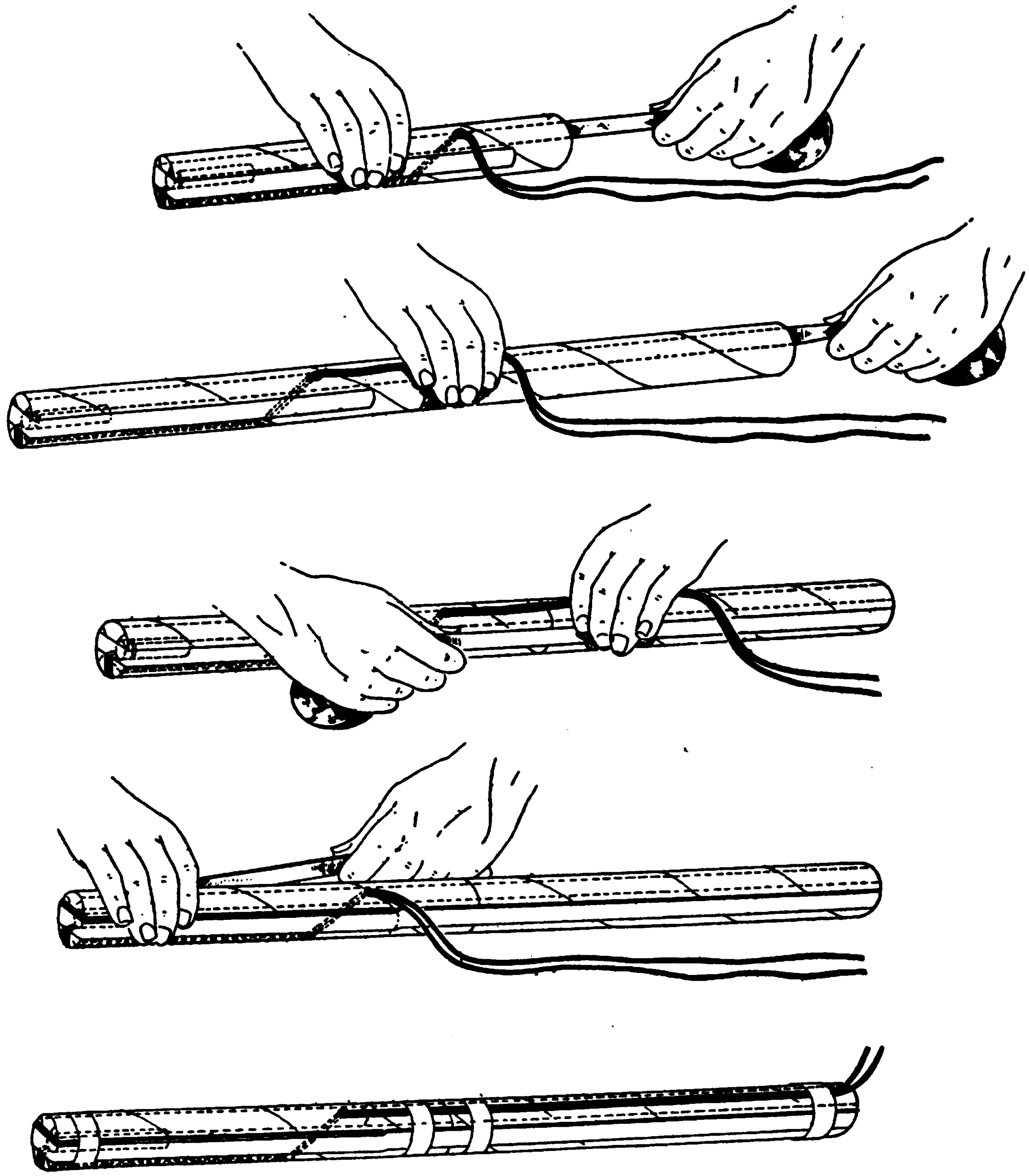


Figure 59.— Taping two cartridges together.

After taping the cartridges together, use friction tape to strap them to a narrow wood lath or slat so that the charge may be placed at the bottom of the hole without tamping.

**f. Connecting lead wires.—** (1) See that the insulation on the lead wires from the blasting machine is in good condition and that the wires are at least 200 feet long; then connect them to the lead wires from the blasting cap. This should be done by removing the insulation from the ends of the wires for a length of about 1 inch, scraping the wires until they are bright and then twisting them tightly together with a pair of pliers. The twisted joints should be covered with friction tape.

(2) When two or more charges are to be fired at the same time, connect the

wires from the blasting caps to each other and to the lead wires of the blasting machine as shown in figure 60. Never try to fire more than 10 charges (blasting caps) at one time.

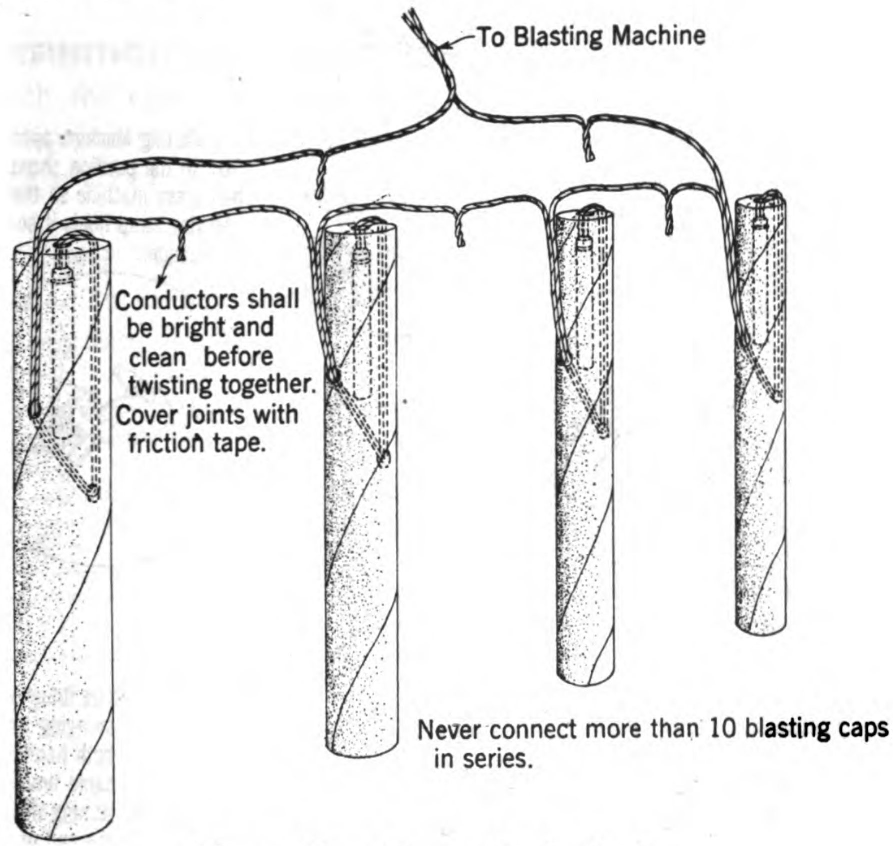



Figure 60.— Connecting lead wires.

**g. *Firing charge.*—** The operator of the blasting machine should take up a position at least 200 feet from the hole to be blasted and with the location of the hole in sight. See that nobody else is within 200 feet of the hole. Hold the blasting machine in readiness, yell "Fire!" and after waiting about 4 seconds, operate the blasting machine as shown in figure 61, with a sharp, vigorous twist. After the dynamite has been fired, disconnect the lead wires from the blasting machine and also from the lead wires that were on the blasting caps.

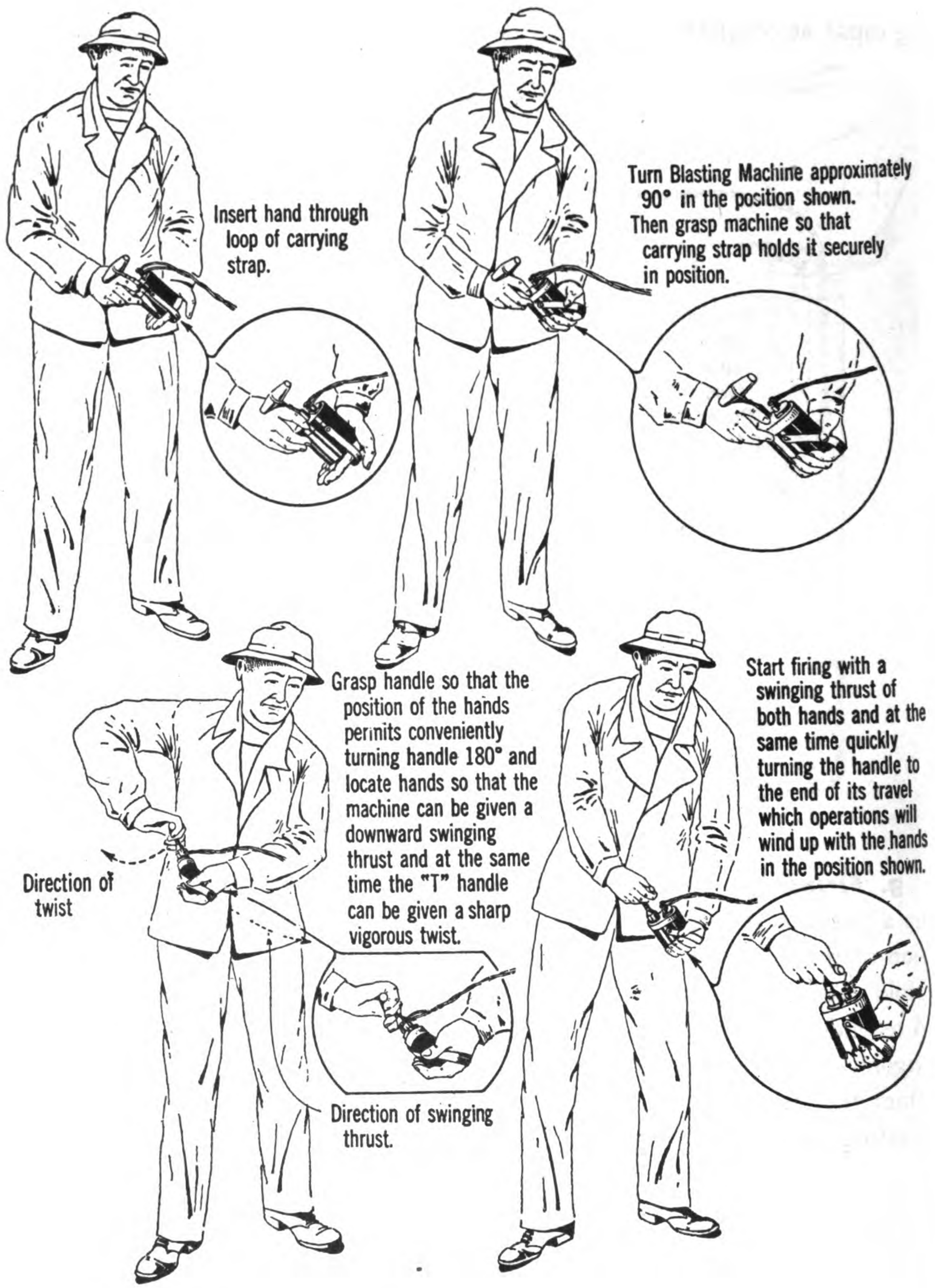



Figure 61.— Operation of blasting machine.

# Section II
# Facing Poles

**77. DEFINITION OF FACE.**— The face of the pole is the side of the pole on which the crossarms are attached. Poles will generally have a flattened surface (gain) on one side on the upper part of the pole to which the crossarms are attached. This side is the face.

**78. FACING POLES CARRYING OPEN WIRE.**— ***a. Straight Sections of Line.***— In straight sections of the line, set the poles so that adjacent poles face in opposite directions, as shown in figure 62.

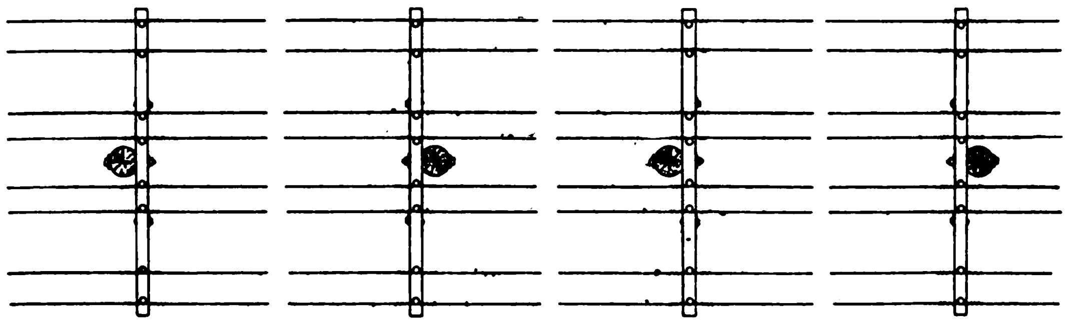


Figure 62.— Facing poles in straight sections.

***b. Single pole corners.***— At a single pole corner, face the pole toward the shorter straight section of the line and so that the crossarms will bisect the angle in the line. The two poles adjacent to the corner pole should face toward the corner pole. (See figure 63.)

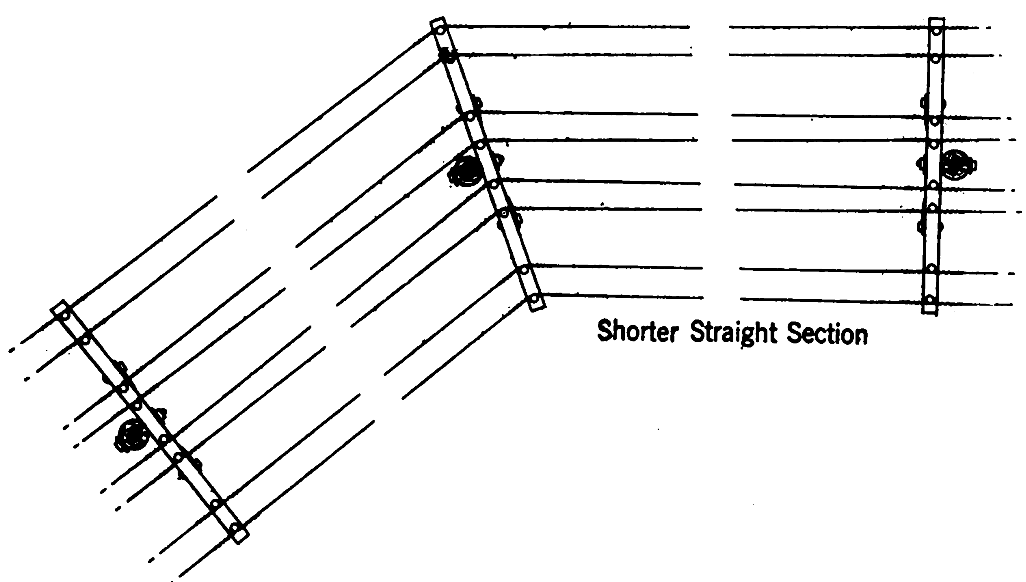



Figure 63.— Facing poles at single pole corner.

Note: A crossarm bisects the angle in the line when it points to the mid-point of a tape line stretched between two points at the same distance (50 feet, for example) along the line from the corner pole. (See figure 64.)

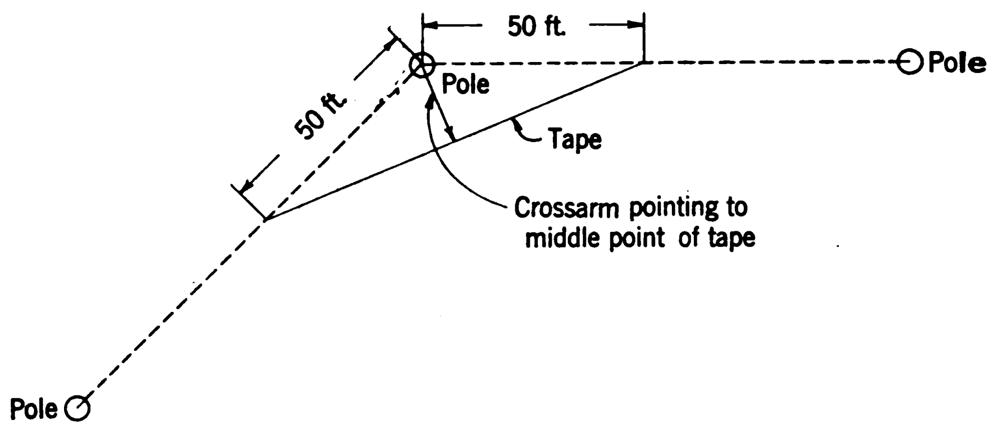



Figure 64.— Bisecting angle in line.

**c. Two-pole corners.—** Where the corner in the line is formed by two adjacent poles, face the poles so that the crossarms will bisect the angle at each pole and so that the crossarms will be on the side of the pole away from the adjacent straight section of the line. The next pole on each side of the corner poles should be faced toward the corner poles, as shown in figure 65.

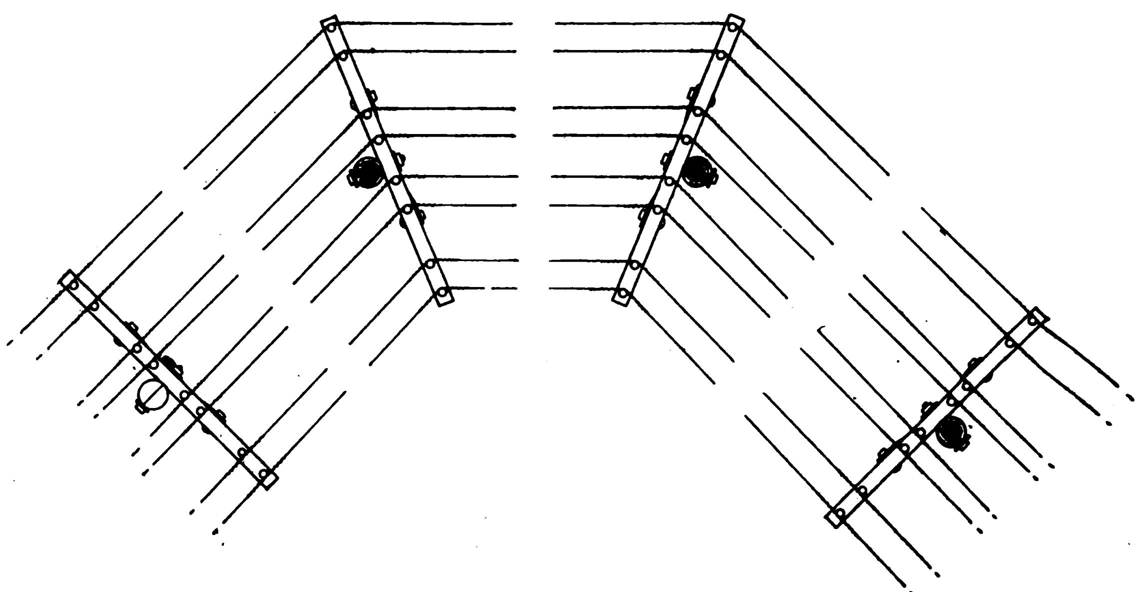


Figure 65.— Facing poles at two-pole corner.

**d. At ends of long span.—** Where it is necessary to construct a long span (over 200 feet) to cross a river, ravine, etc., the poles at the two ends of the long span should be faced away from the long span as shown in figure 66.

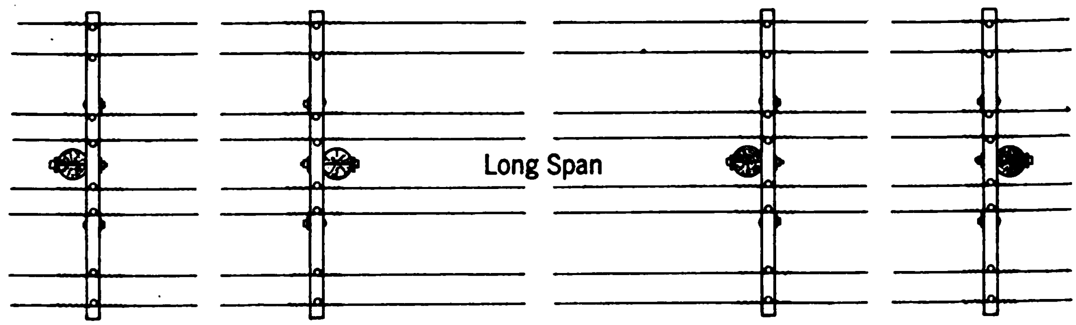



Figure 66.— Facing poles at long span.

**e. On steep grades.—** On steep grades, where the rise is 20 feet or more in each 100 feet along the line, face all the poles on the grade toward the top of the grade. (See figure 67.)

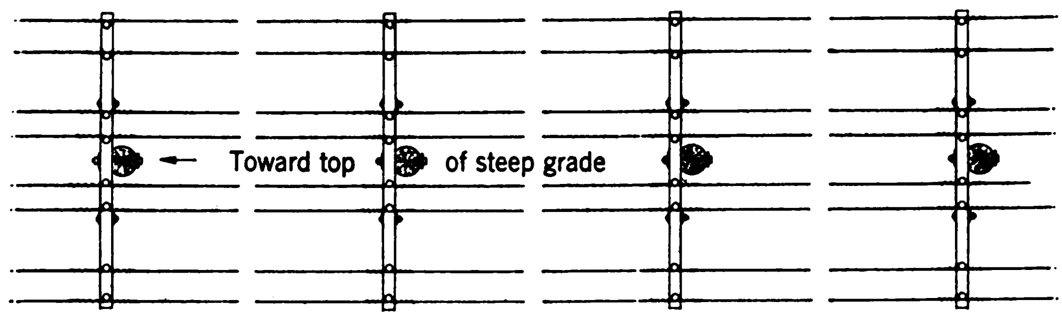



Figure 67.— Facing poles on steep grade.

**f. At deadends.—** At deadends, face the pole away from the last span. The pole next to the deadend pole should always be faced toward the last span, as shown in figure 68.

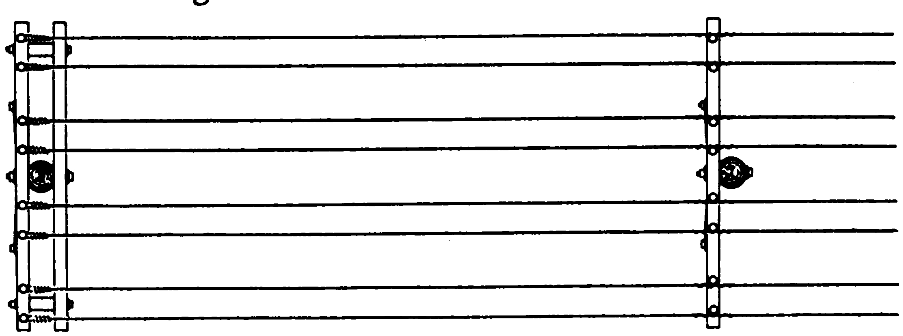


Figure 68.— Facing poles at deadend.

# Section III
# Placing Poles

**79. GENERAL.—** The method to be used in erecting poles depends upon the size and weight of the pole, the equipment available and upon conditions encountered at the pole locations. Where practicable, the crossarms, crossarm braces, pins and insulators should be placed before the pole is erected. Where poles which are to be stepped are set with pikes, do not place the pole steps before the pole is erected, on account of possible interference with the pike poles.

**80. SETTING POLES WITH POLE DERRICK.—** The pole derrick method is the quickest, most convenient and safest way of erecting poles in practically all cases. The truck should be placed so that the head of the derrick will be

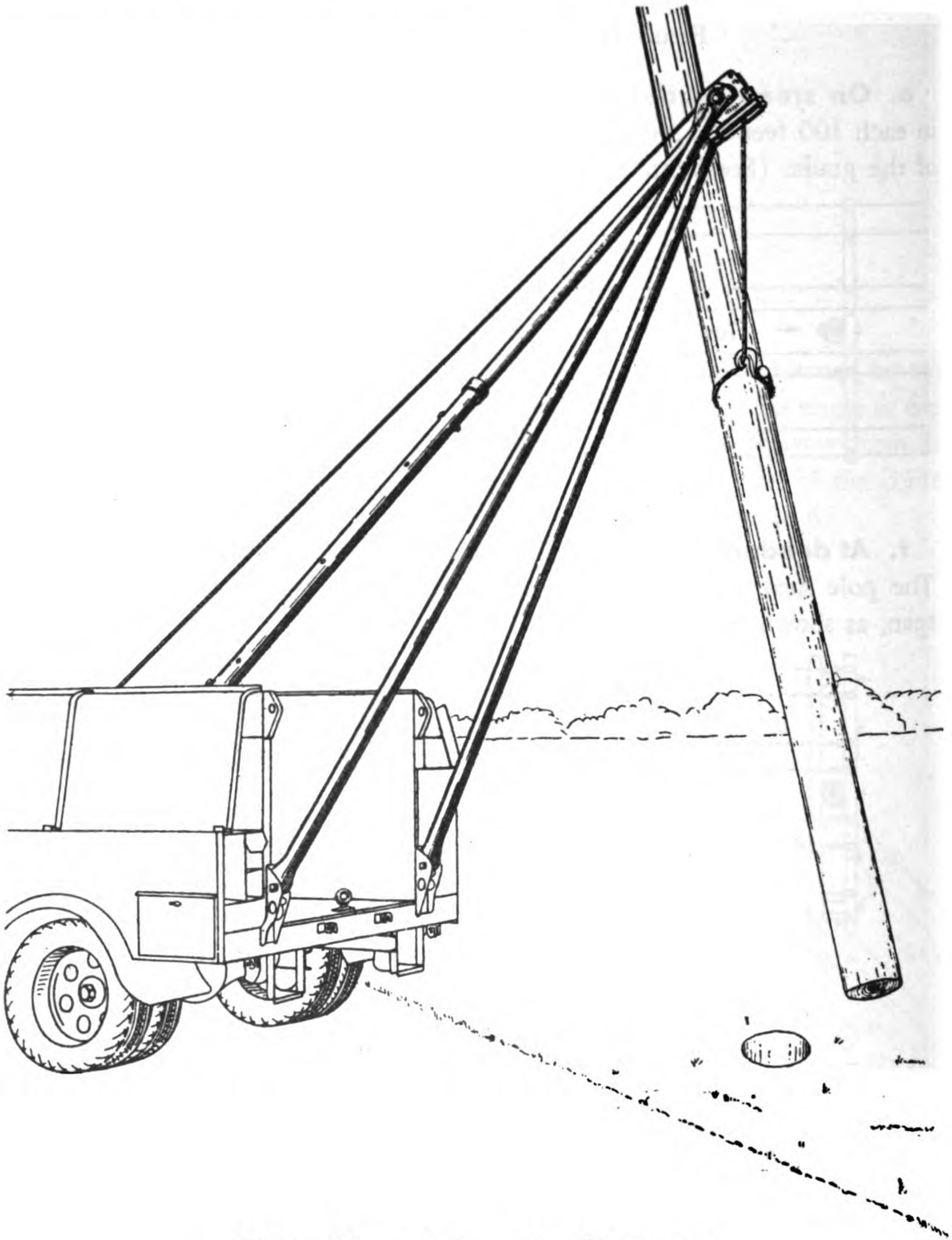


Figure 69.— Setting pole with derrick.

directly above the pole hole and at a height so that it will be just below the bottom crossarm braces when the pole is set in the hole. The main leg of the derrick should be telescoped to the lowest position that can be used to handle the pole. By alternately backing the truck and raising the derrick with the boom line, the proper derrick position can be reached. When in final position to lift the pole, the main leg of the derrick should not be at a greater angle from the vertical than is necessary to handle the pole. Attach the fall line to the pole just above the balance point, so that it is slightly butt heavy. (See figure 69.) Guide the butt of the pole into the hole as the pole is raised. Always stop pulling on the fall line when the hook on the sling around the pole comes within 1 foot of the sheave on the end of the boom. If the hook reaches this position before the pole has been raised enough to set it in the hole, the boom should be raised by taking up on the boom line and, if necessary, backing the truck toward the hole.

After the pole has been set in the hole it should be turned with cant hooks until it is faced in the proper direction.

**81. SETTING POLES WITH PIKES.— *a. Poles 35 feet or shorter length.—*** Before starting to set a pole with pikes, make sure that there are no loose stones or other objects lying around where men might trip or stumble over them while erecting the pole. Then proceed as follows:

(1) Place a butting board (used in soft soil) or digging bars (used in firm soil) in the hole on the side away from where the pole lies.

(2) Move the pole into position with the butt against the butting board or bars.

(3) Place a deadman on the ground near the top of the pole and approximately at right angles to the pole. The fork of the deadman should be against the pole and the footing should be at a point where it will not slip when the pole is lifted and the weight is supported by the deadman. (Position A in figure 70.) Station a man to guide the deadman as the pole is lifted and prevent it from slipping along the pole or at the foot. The man handling the deadman should, at all times, avoid standing directly under the pole.

(4) Lift the pole and deadman to Position B. If the pole is brought into place on a dinkey, lift the top of the pole and place the deadman underneath.

(5) Place 2 cant hooks or peavies, one to pull against the other, so as to serve as a means of preventing the pole from turning as it is being raised. Place the cant hooks or peavies about 2 feet above the point which will be at the ground line when the pole is set. Station a man to hold the hooks as the pole is being raised.

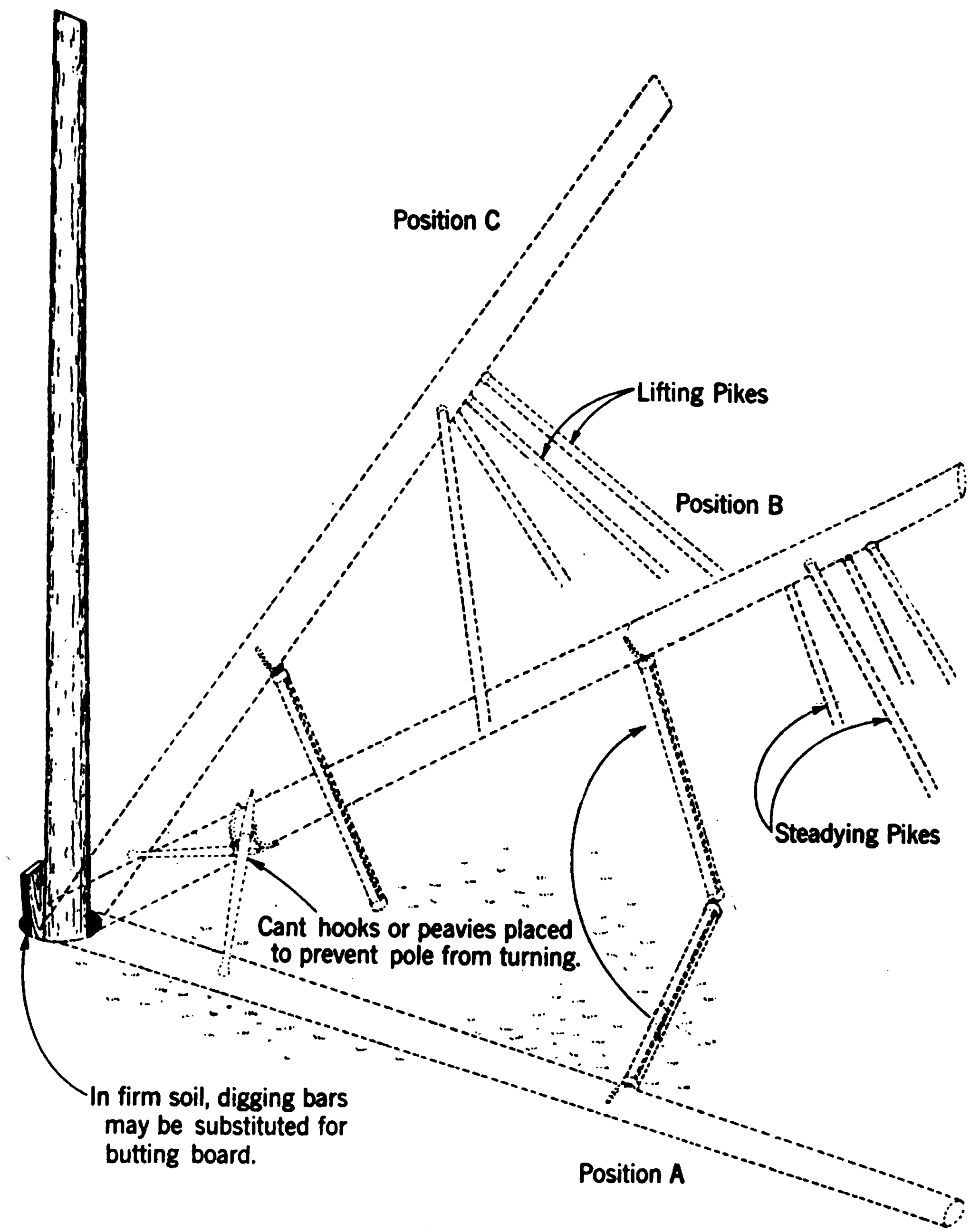



Figure 70.— Setting pole with pikes.

(6) Place pike poles near the top of the pole, one considerably to each side to steady the pole and to assist in the lifting, and the others slightly to the sides to do the greater proportion of the lifting. At this stage, the steadying pikes should be held with the two hands separated and the lift pikes should be held in the hollow formed by clasping the hands.

(7) Raise the pole, then move the deadman down until it supports the pole again. (Position C.) In changing the location of the deadman, keep it in instant readiness to support the entire weight of the pole.

(8) Apply pikes further down the pole. (Position C.) Shift the pikes one at

a time. Raise the pole again. When the pole passes the 45° angle, the men on the lift pikes may work to better advantage if they use one hand to support the butt of the pike at the level of the shoulder and the other hand to guide the pike.

(9) Repeat this operation until the pole can be piked directly into the hole. When the pole commences to slide into the hole, remove the deadman so that it will not interfere with the movement of the pole.

(10) Line up the pole with cant hooks or peavies and steady it with pikes while backfilling and tamping.

***b. Heavy poles.***— Where heavy poles are to be set, proceed as follows:

(1) Move the pole into position with the butt against the butting board, preferably using a pole dinkey.

(2) Place a deadman under the end of the pole at right angles to the pole and at an angle from the vertical (Position A in figure 71.)

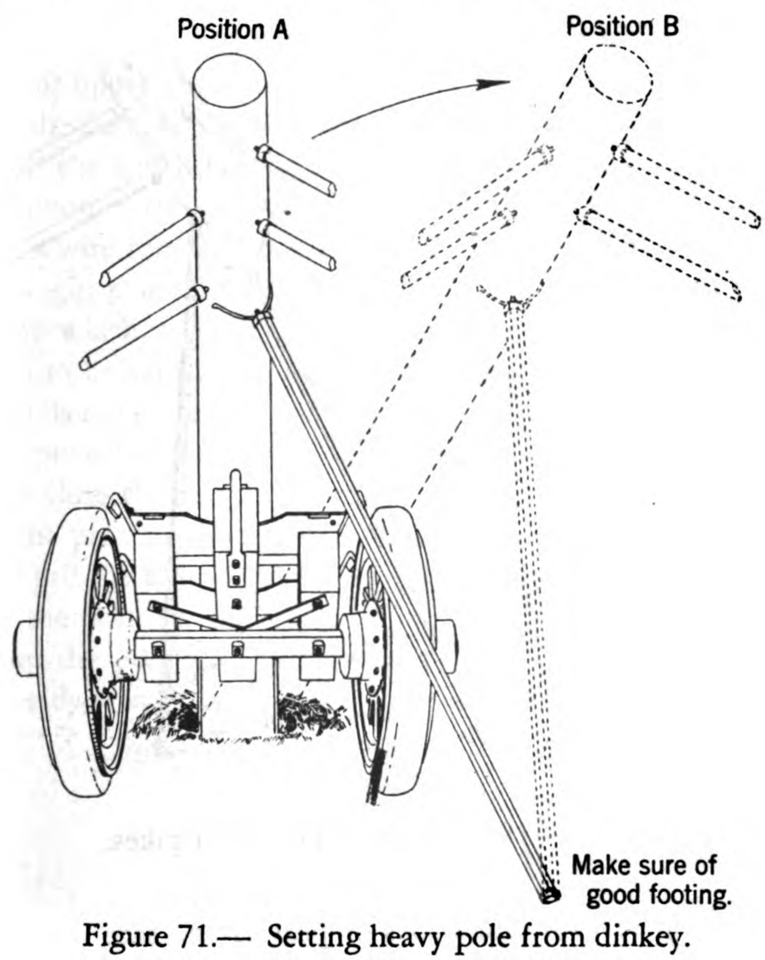



Figure 71.— Setting heavy pole from dinkey.

(3) Distribute men with pike poles evenly along both sides of the pole.

(4) Place 2 cant hooks or peavies near the butt about 2 feet above the future ground line to prevent the pole from turning and station a man to tend them.

(5) Pike the pole toward the leaning deadman until the pole is in Position B shown in figure 71.

(6) Remove the dinkey.

(7) Place a second deadman nearer the butt at an angle from the vertical and pike the pole toward this deadman till the pole is in Position C as shown ir figure 72.

(8) Remove the first deadman and place it below the second deadman at about the same angle as before.

(9) Repeat the process. The pole is thus swayed back and forth, rising each time, till it can be piked directly into the hole.

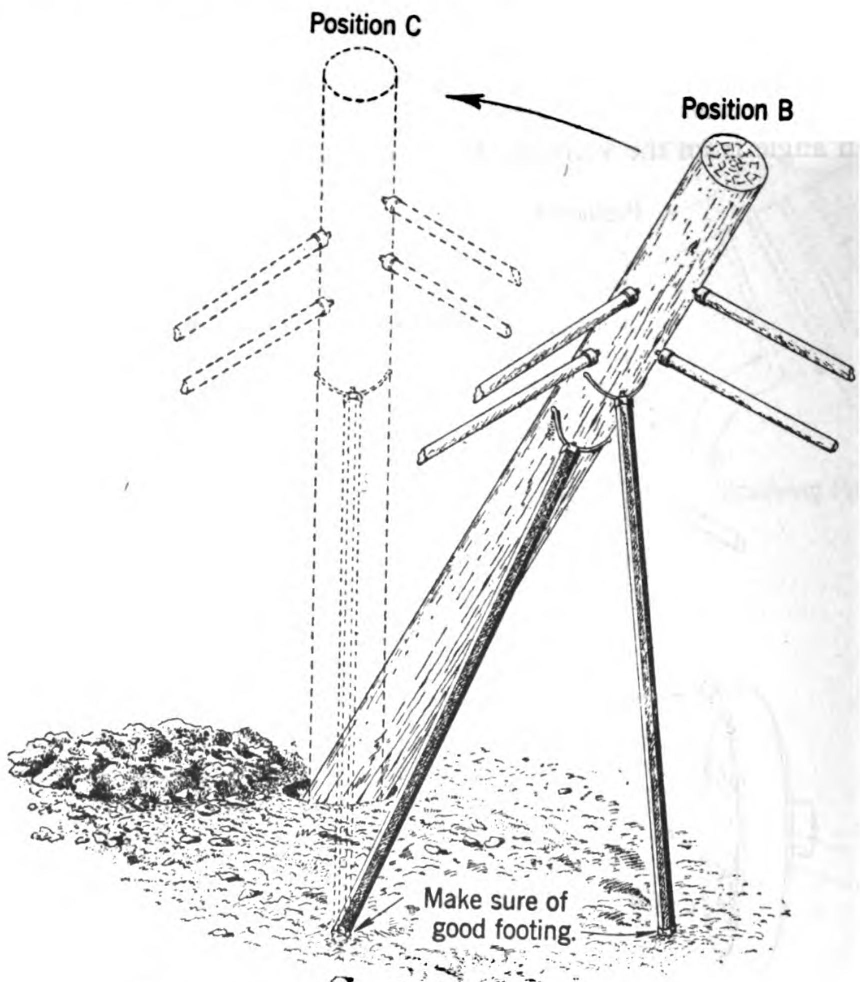



Figure 72.—Setting heavy pole with pikes.

(10) Line up the pole with cant hooks or peavies and face it in the proper direction; steady it with pikes while backfilling and tamping.

**82. SETTING POLES WITH GIN POLE.— *a.*** The gin pole method may be used to advantage under the following conditions:

(1) When the pole is too long or too heavy to permit the use of the pole derrick or pike poles.

(2) When the team is too small to use the pike pole method or a pole derrick is not available.

**b.** The use of a power winch is recommended for setting a pole with a gin pole, on account of the greater convenience, and in order to avoid the use of the large amount of rope that would be required if pulley blocks were used. Proceed as follows:

(1) Erect a gin pole of suitable length and of as large diameter as the pole to be set. Place it as close as practicable to the hole which has been dug for the line pole. Where conditions permit, the butt of the gin pole should be set in a shallow hole to prevent it from slipping. Where conditions make it preferable, the butt of the pole should be guyed rather than set in a hole. Where there will be no tendency for the butt to slip, it may be set on the ground, or on a plank if the soil is soft. The butt should, in all cases, be supported if the pulling line runs through a snatch block near the base of the gin pole. The length of the gin pole should be sufficient to permit attaching the snatch block or upper pulley block at a distance above the ground about 2 feet greater than the distance between the butt of the line pole and the point on the pole at which the winch line or sling will be attached.

(2) Guy the top of the gin pole as shown in figure 73.

(3) Attach a wire rope snatch block or one of the pulley blocks at the proper height on the gin pole to permit the line pole to be raised clear of the ground.

(4) Run the winch or pulley line through the snatch block and attach it to the line pole to be raised at a point just above the balance point of the pole. If rope tackle is to be used, attach the lower block just above the balance point. It is usually preferable to run the winch line or pulling line through a snatch block placed close to the ground on the gin pole.

(5) Raise the pole, guiding it as it rises, either by pressure on the butt or by pike poles, until the butt is directly over the hole.

(6) Lower the pole into the hole.

(7) Line up the pole with cant hooks or peavies and face it in the proper direction; steady it with pikes while backfilling and tamping.

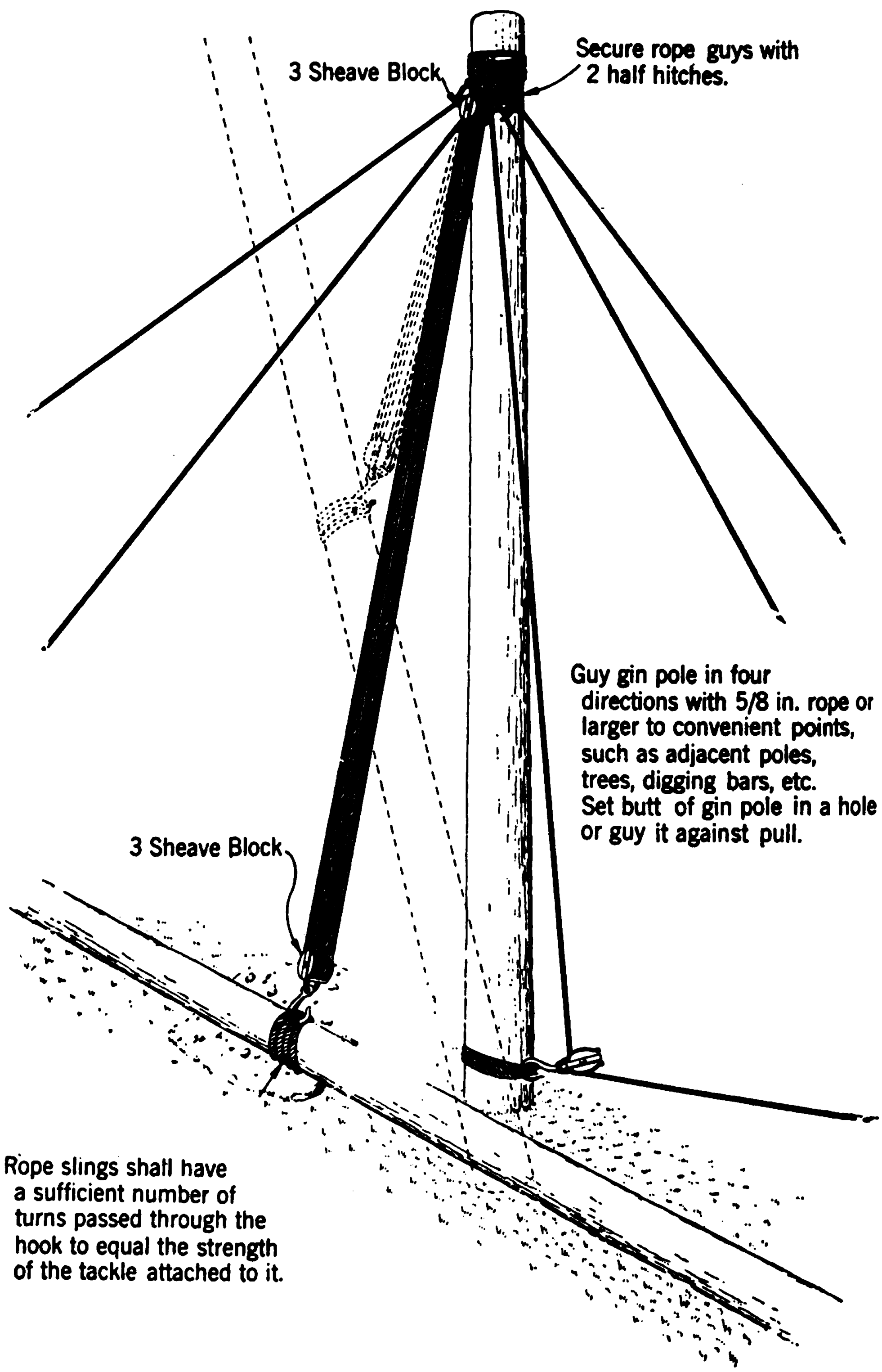



Figure 73.— Setting pole with gin pole.

**83. RAKING POLES.—** Guyed or unguyed corner poles shall be raked. The amount of rake that is recommended for guyed or unguyed corner poles is one foot for all lengths of poles. Provide the rake, if possible, by "setting-in" the butt of the pole by an amount equal to the rake as shown in figure 74.

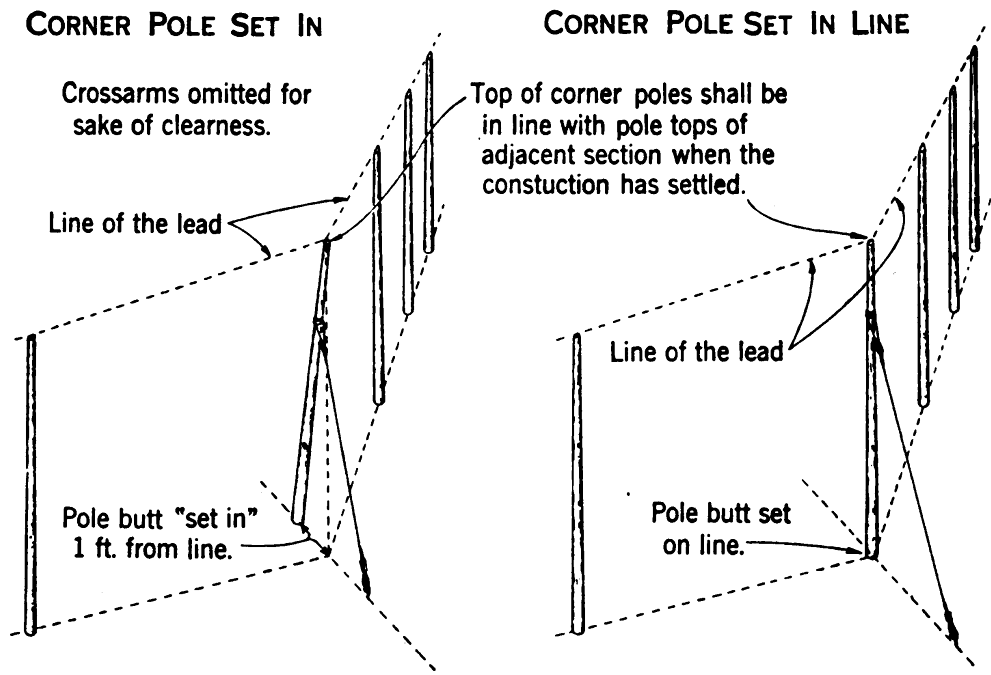



Figure 74.— Setting corner poles for rake.

When placing guys, pull over the tops of corner poles approximately one foot, as shown in figure 75, so that when the load comes on the poles and the anchors and poles have settled, the pole tops will come back into line.

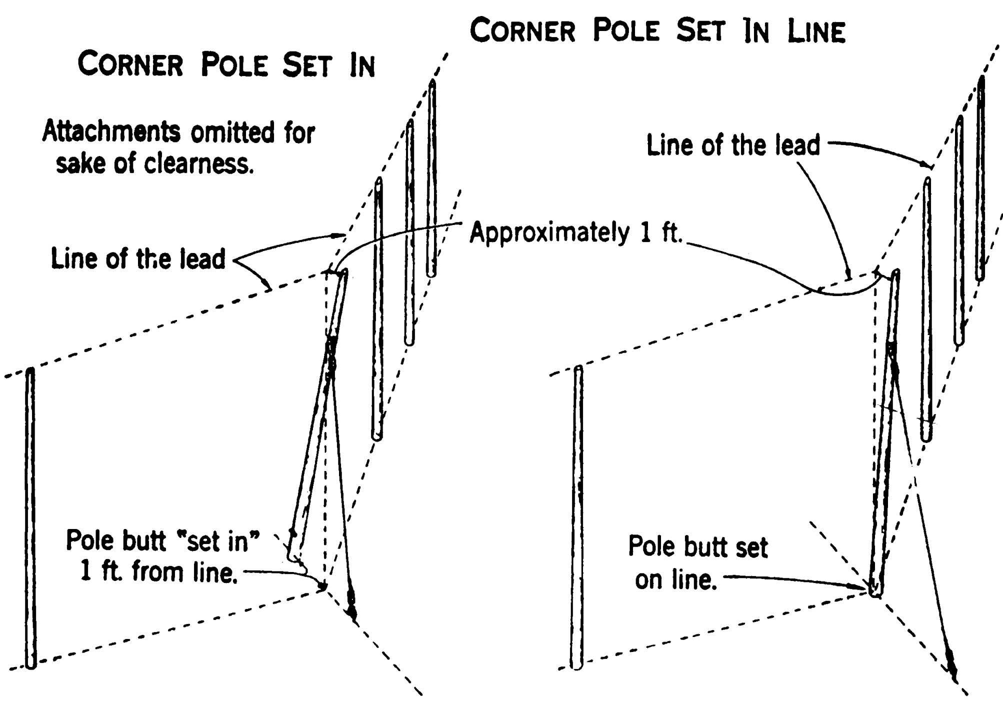



Figure 75.— Raking poles for guying.

If a pole is to be ground braced or held in line by means of a push brace, instead of placing a guy, the amount of rake should be the same as for a guyed pole. Such poles should be set with the butt of the pole in line so that when the wire load is placed on it, the top of the pole will be pulled back in line. Guy stubs should be set with a 4 foot rake, if possible. Deadend poles should be set vertically, with no rake.

**84. BACKFILLING AND TAMPING.—** After the pole is placed in position, fill in the hole with earth. It is important that the earth be tamped thoroughly for the full depth of the hole. Avoid backfilling with frozen ground if practicable. Where there is snow on the ground, take precautions to keep snow from mixing with the earth that is tamped back into the hole. Where conditions permit, use coarse soil or gravel for filling the top of the hole. Wedge rock firmly around poles that are set in solid rock. Bank the earth around the pole above ground level and pack it firmly.

**85. REPAVING.—** Where poles have been set in pavements make arrangements with the proper authorities for repaving around poles. Where practicable, the repaving should be so done that the base of the pole just below the ground line will be accessible for future pole inspections; bricks can frequently be used for this purpose. Permanent repaving shall not be done until the backfill has completely settled.

## *Section IV*
## *Placing Poles in Soft Soil*

**86. GENERAL.—** The fixtures and construction described in this section are for use where the soil conditions or the loads to be supported are such that the usual type of single pole construction will not afford the required stability.

**87. SOFT SOIL AND SWAMP CONSTRUCTION.—** The type of construction to be employed in swampy locations or in unstable ground will vary with conditions. The following general description of types of fixtures will be of assistance in selecting the type to be employed.

***a. Anchor plank ground bracing.—*** This type of construction is intended for use where the poles are set in earth which may be soft or unstable at certain seasons and the pole itself would not provide sufficient bearing area against the earth to remain vertical when exposed to cross-winds. This type of bracing is not suitable for use in cases where the loads to be supported are so heavy and the ground so soft that there would be a tendency for the poles to sink. Where such conditions exist, it is desirable to place an anchor plank under the pole to provide an additional footing, or to use a platform support.

**b. Pole with platform support and plank bracing.—** This is suitable for use where additional earth bearing is required to prevent the pole from sinking and the exposure to cross-winds is not severe.

**c. Poles guyed with swamp guys.—** When the exposure to cross-winds is great, the required stability against overturning can be obtained by the use of swamp anchors. If the load on the pole would be so heavy as to cause it to sink, it will be necessary to provide additional platform support.

**d. Poles with platform support and swamp anchors.—** These are suitable for use where additional earth bearing is required to prevent the pole from sinking and the exposure to cross-winds is severe.

**88. ANCHOR PLANK GROUND BRACING.—** The method of using anchor planks for ground bracing is shown in figure 76. The use of an anchor plank under the pole to provide additional footing in order to keep the pole from sinking is also shown in figure 76.

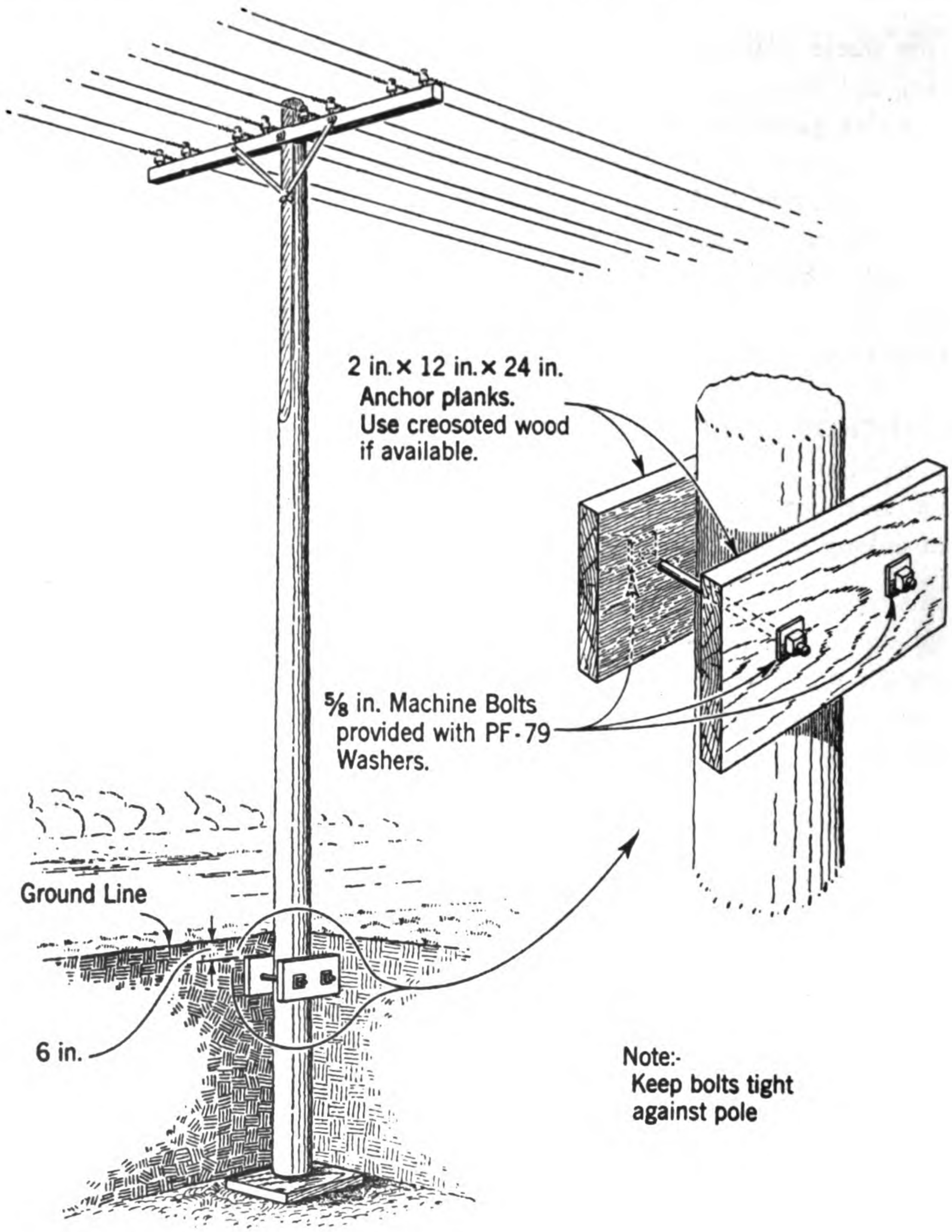



Figure 76.— Anchor plank ground bracing.

**89. POLE WITH PLATFORM SUPPORT AND PLANK BRACING.—** The construction of a platform support to prevent a pole from sinking in swampy ground is shown in figure 77.

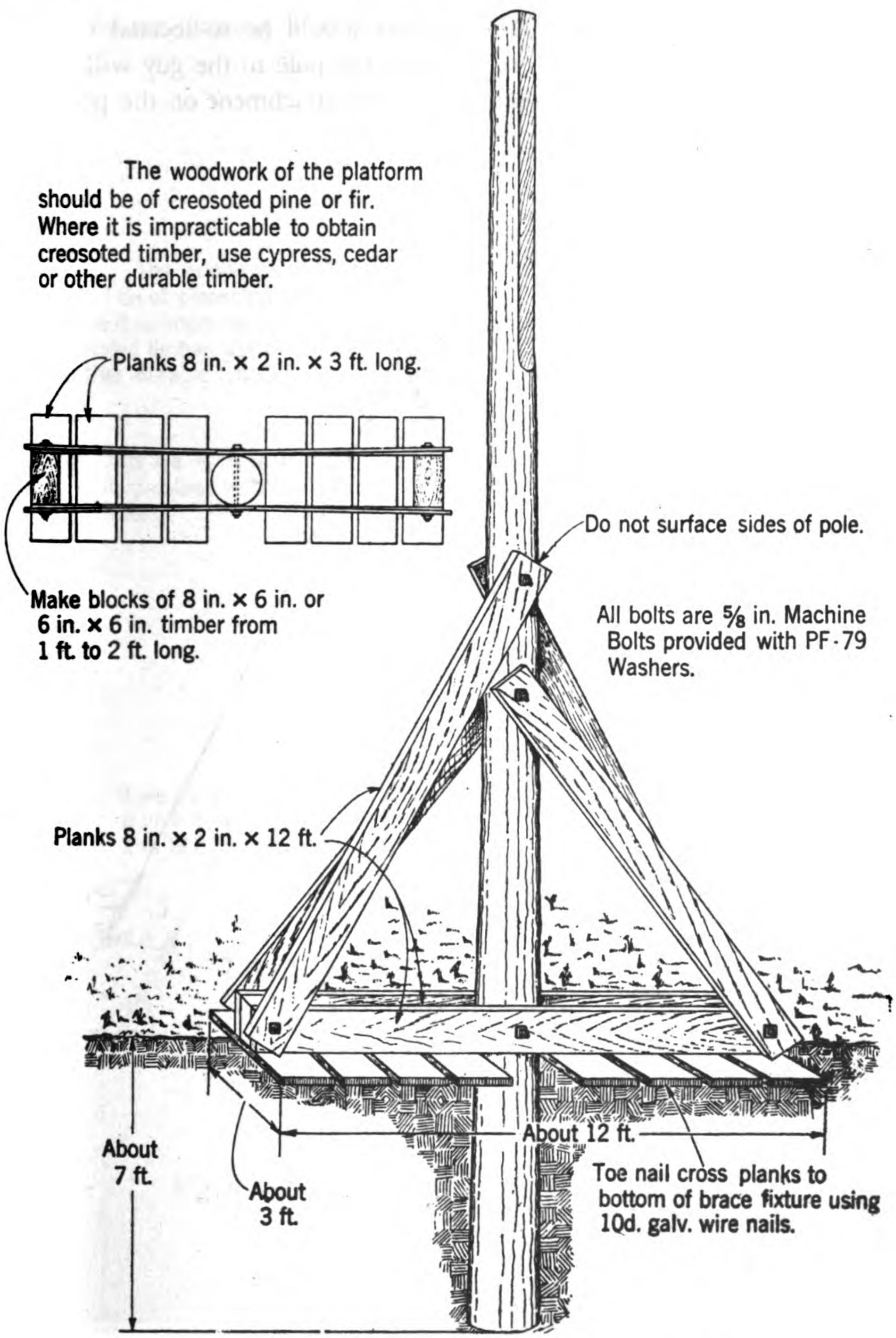



Figure 77.— Platform support and plank bracing.

**91. POLES WITH PLATFORM SUPPORT AND SWAMP ANCHORS.—** This type of construction is a combination of the platform support (Par. 89.) and swamp anchors and guys (Par. 90.), except that the plank braces shown in Par. 89 are omitted. This combination is shown in figure 79.

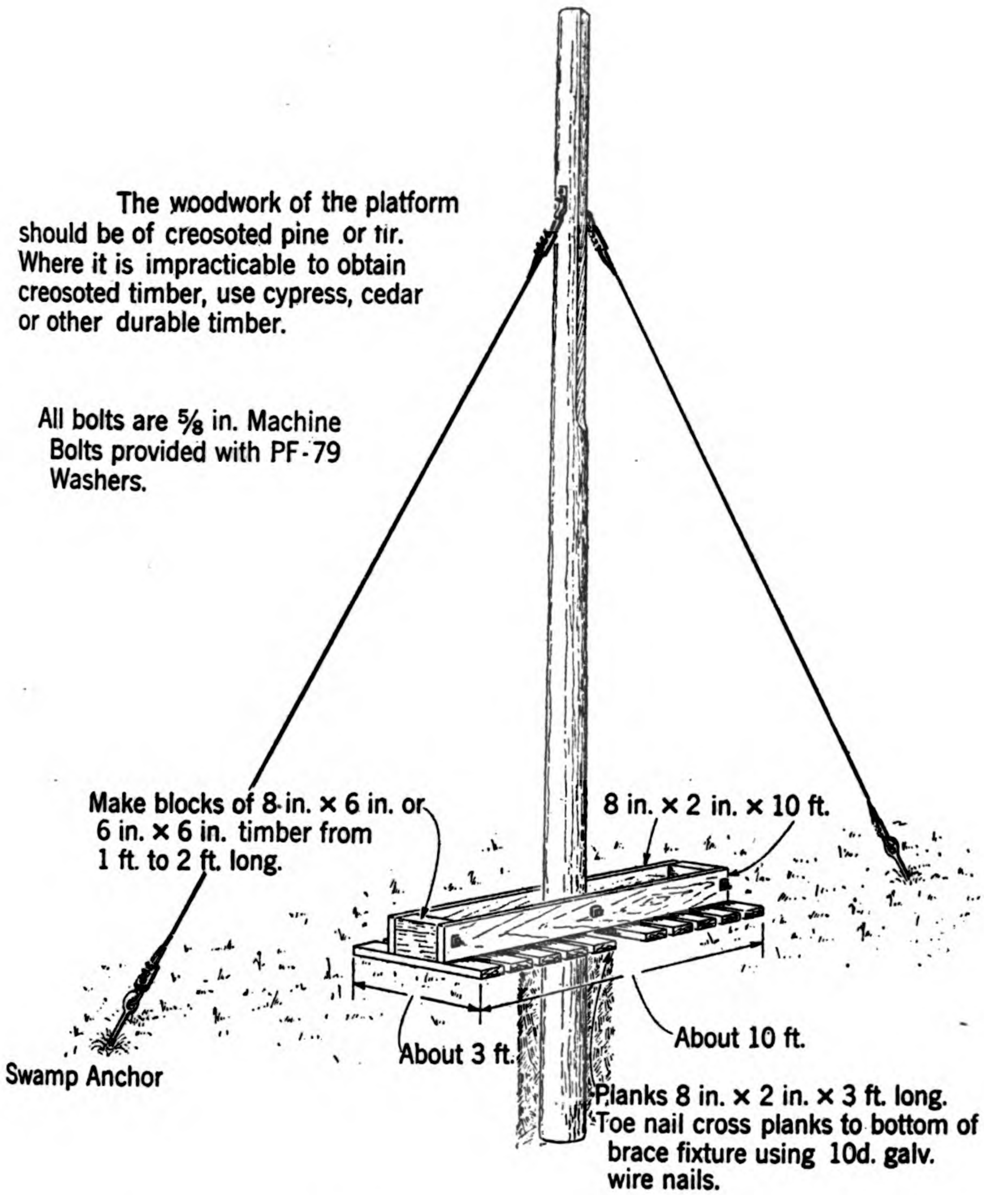



Figure 79.— Platform support and swamp anchors.

**92. H FIXTURES.—** H fixtures are not usually required, but may be used in place of double side guyed poles where it is not practicable to place side guys. An H fixture is shown in figure 80. If an H fixture is to be head guyed, the head guys should be placed on each pole.

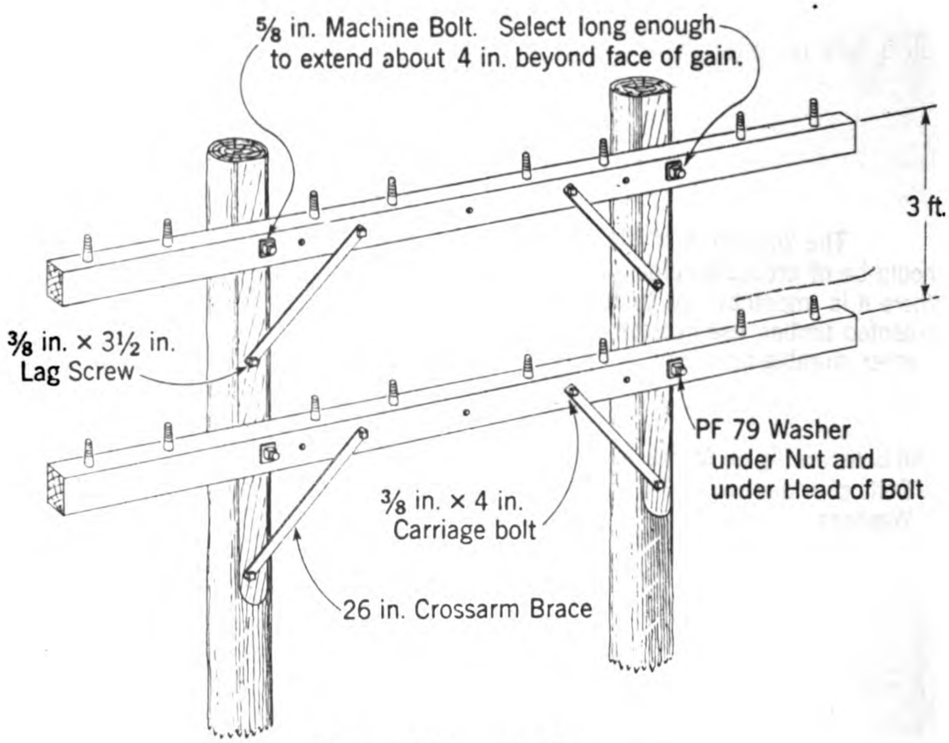



Figure 80.— H fixture.

# *Section V*
# *Pole Braces*

**93. GENERAL.—** Pole braces are sometimes used in place of guys where the installation of guys would be especially difficult or impossible.

**94. PUSH BRACE.—** A push brace may be used in place of a single side guy where it is not practicable to place an anchor or under other conditions as called for in the detail plans.

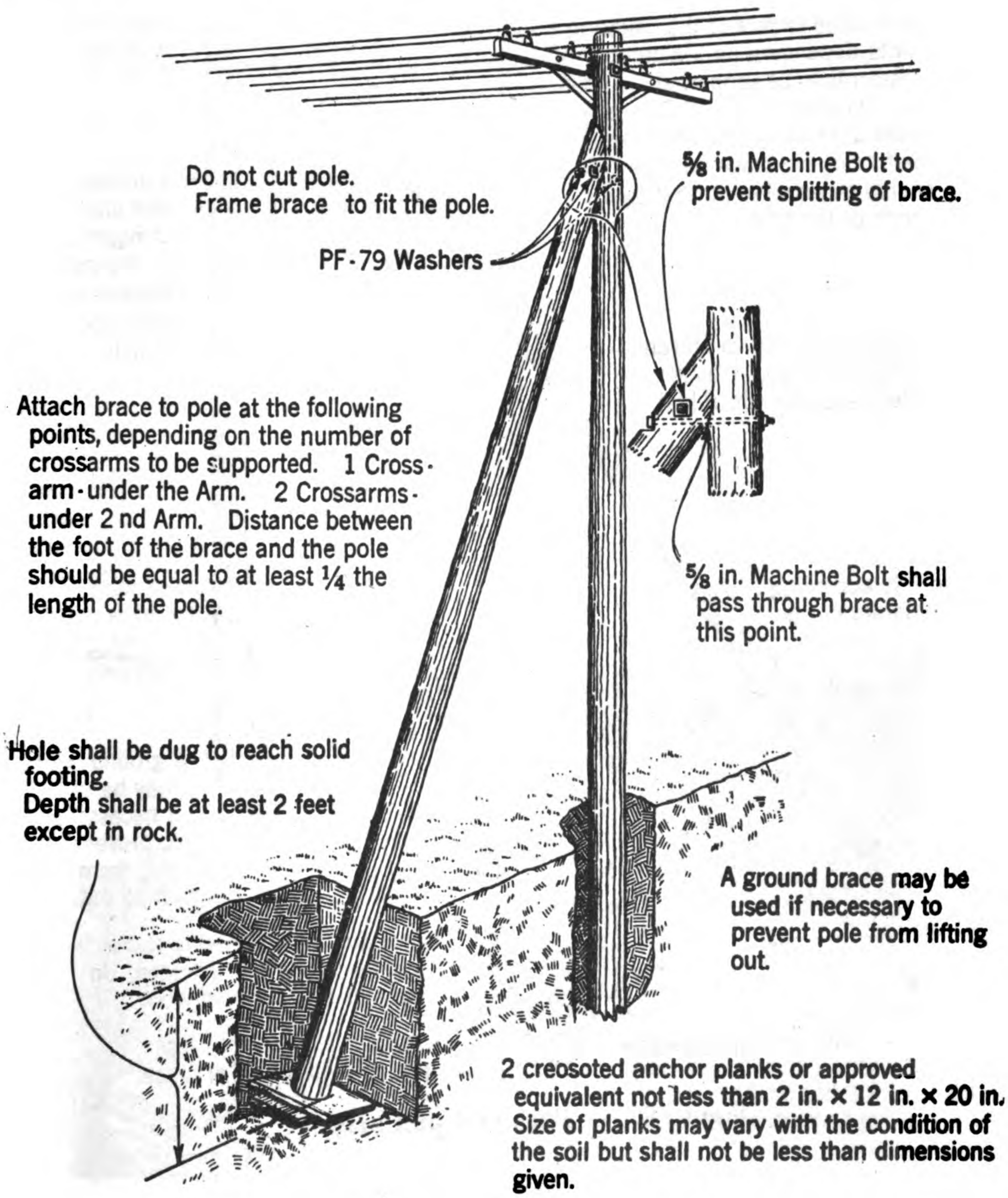



Figure 81.— Push brace

**95. PUSH AND PULL BRACE.—** A push and pull brace may be used in place of two-way side guys in marshy ground or where it is impracticable to set a stub or anchor.

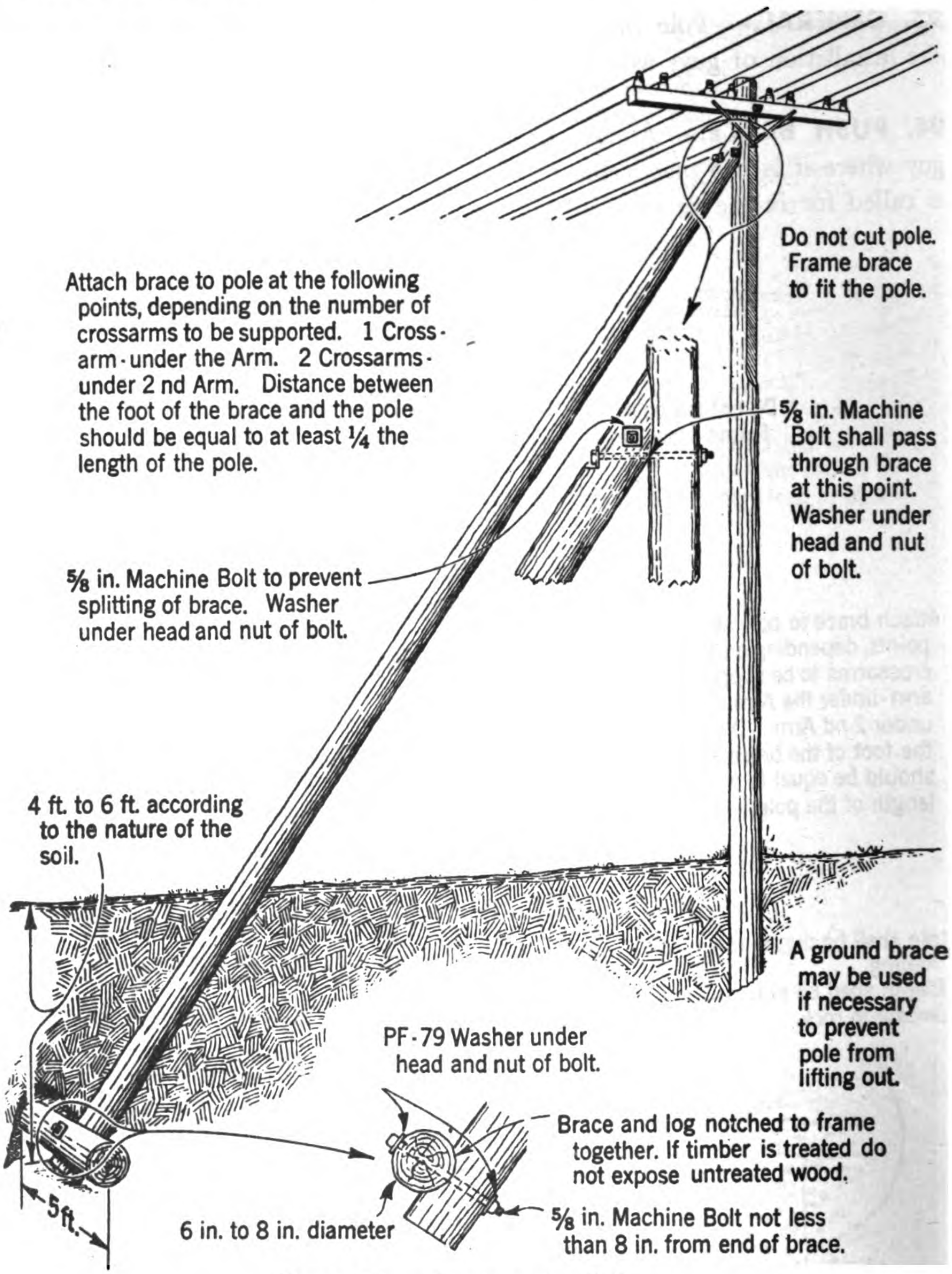



Figure 82.— Push and pull brace.

**96. DOUBLE POLE BRACE.**— A double pole brace may be used to reinforce an existing pole line in marshy ground. This construction should be used only where it is not convenient to install swamp or other type of anchors or to install a push and pull brace.

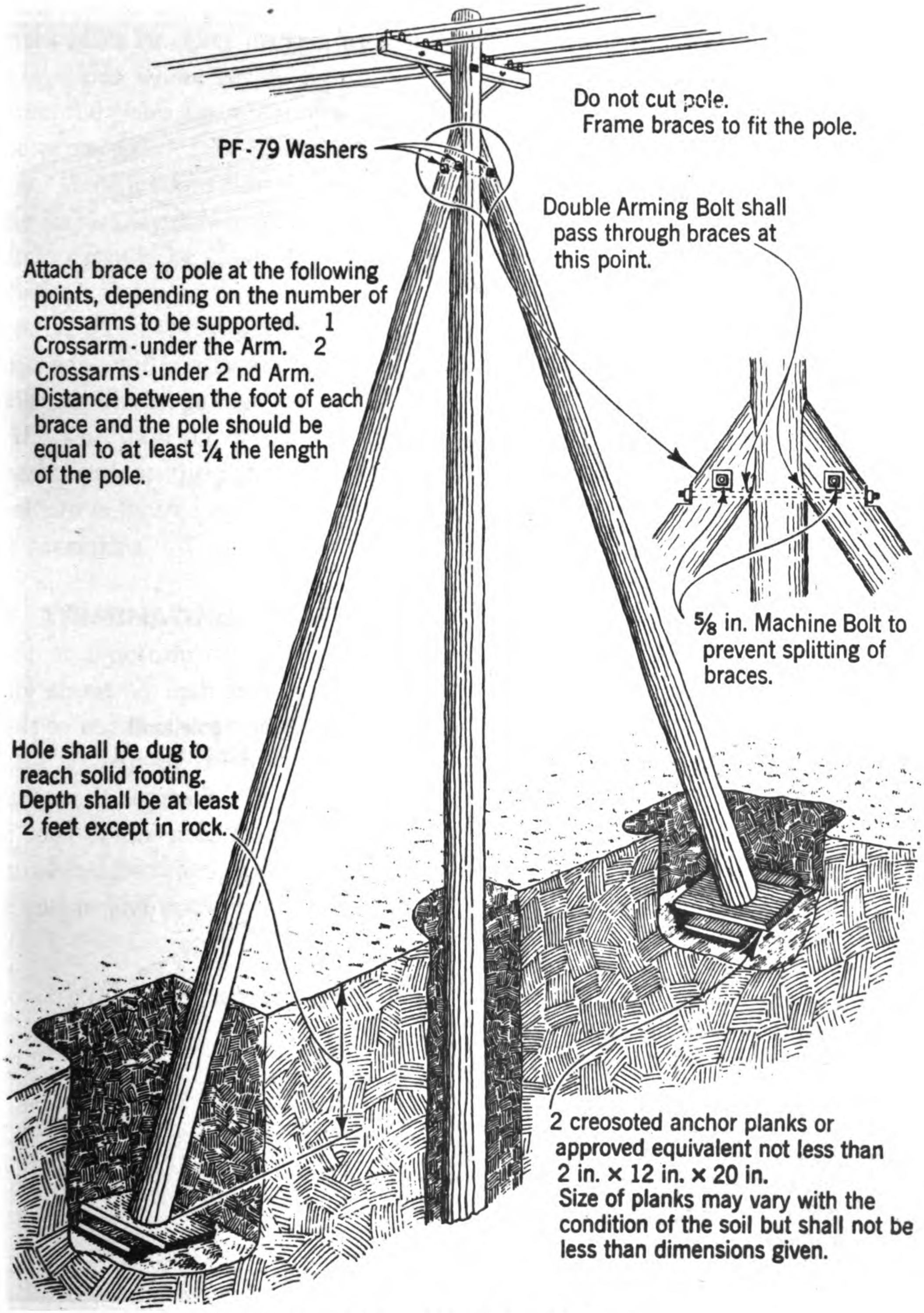



Figure 83.— Double pole brace.

**97. GROUND BRACING.–** Ground bracing may be used in place of a guy at corners or at deadends only if it is not practicable to place a guy or push brace and the use of ground bracing is approved by the officer in charge. The proper construction of the ground bracing is shown in figure 84.

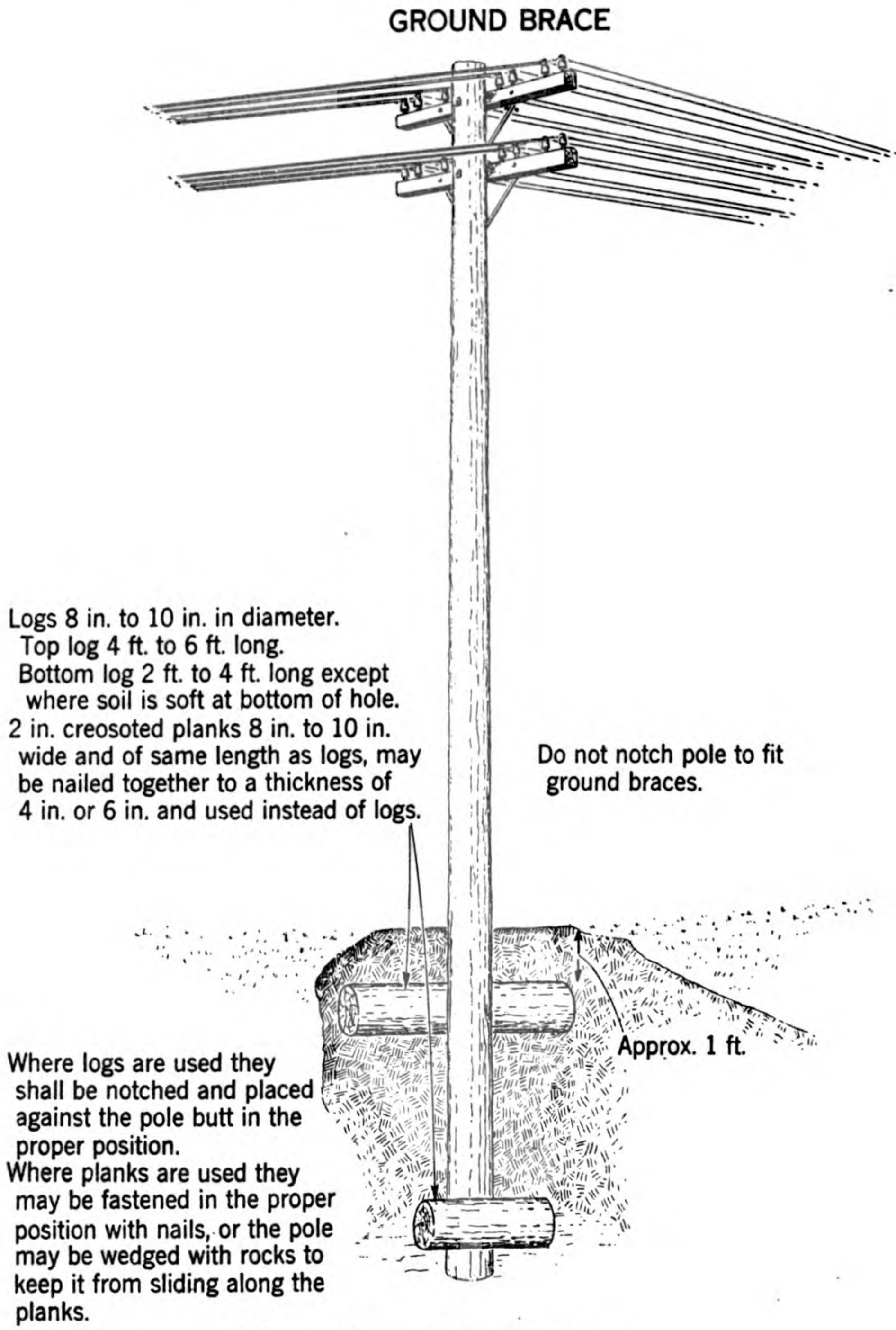



Figure 84.— Ground bracing.

# Section VI
# Protecting Poles Against Lightning

**98. GENERAL.—** ***a.*** This section describes the installation of lightning protection wires on poles. Place protection wires only where authorized by the detail plans or other instructions. These installations will generally be confined to localities where severe lightning occurs at certain seasons of the year and where the poles are so exposed that damage could be expected if the poles were not protected.

***b.*** Attach protection wires to poles by means of 1½ inch galvanized staples. The staples should, in general, be spaced at intervals of about 18 inches. The spacing should be closer, however, where required to keep the wire securely in position.

***c.*** A gap is provided in the protection wires so that a man working on the open wire will not be connected to ground through the protection wire. Lightning will discharge over the protection wire even when there is a gap in it.

***d.*** The location of the vertical run on the pole depends on the types of attachments on the pole. In general, on poles carrying open wire only, the vertical run is located on the face portion of the pole in such a position as to clear the crossarms.

**99. TERMINATING PROTECTION WIRE.—** ***a.*** Wherever the protection wire or a portion of it terminates, a right angle bend should be made in the wire about ½ inch from the end and the end should be driven into the pole so as to reduce the possibility of injury to men climbing the pole.

***b. At top of pole.—*** The termination of the wire at the roof of the pole is shown in figure 85. In terminating the protection wire, pass it directly across the roof of the pole from the point at which the vertical run meets the roof, extend it down the opposite side of the pole a distance of about 2 inches, turn the end in and staple it.

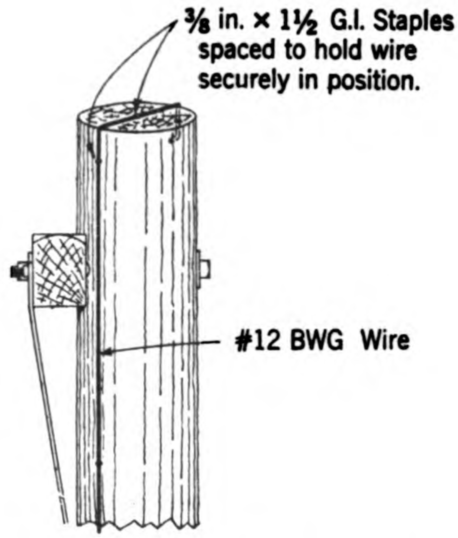



Figure 85.— Terminating protection wire at top of pole.

**c. *At base of pole.*—** The protection wire should be terminated about 2 feet above the ground line as shown in figure 86.

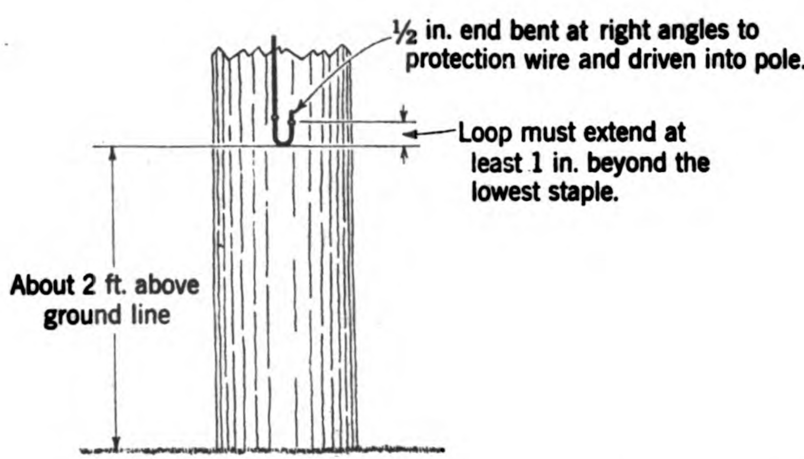



Figure 86.— Terminating protection wire at base of pole.

**100. INSTALLING PROTECTION WIRE.— *a. No anchor guy on pole.*—** Figure 87 shows the arrangement of the protection wire on poles which are not guyed.

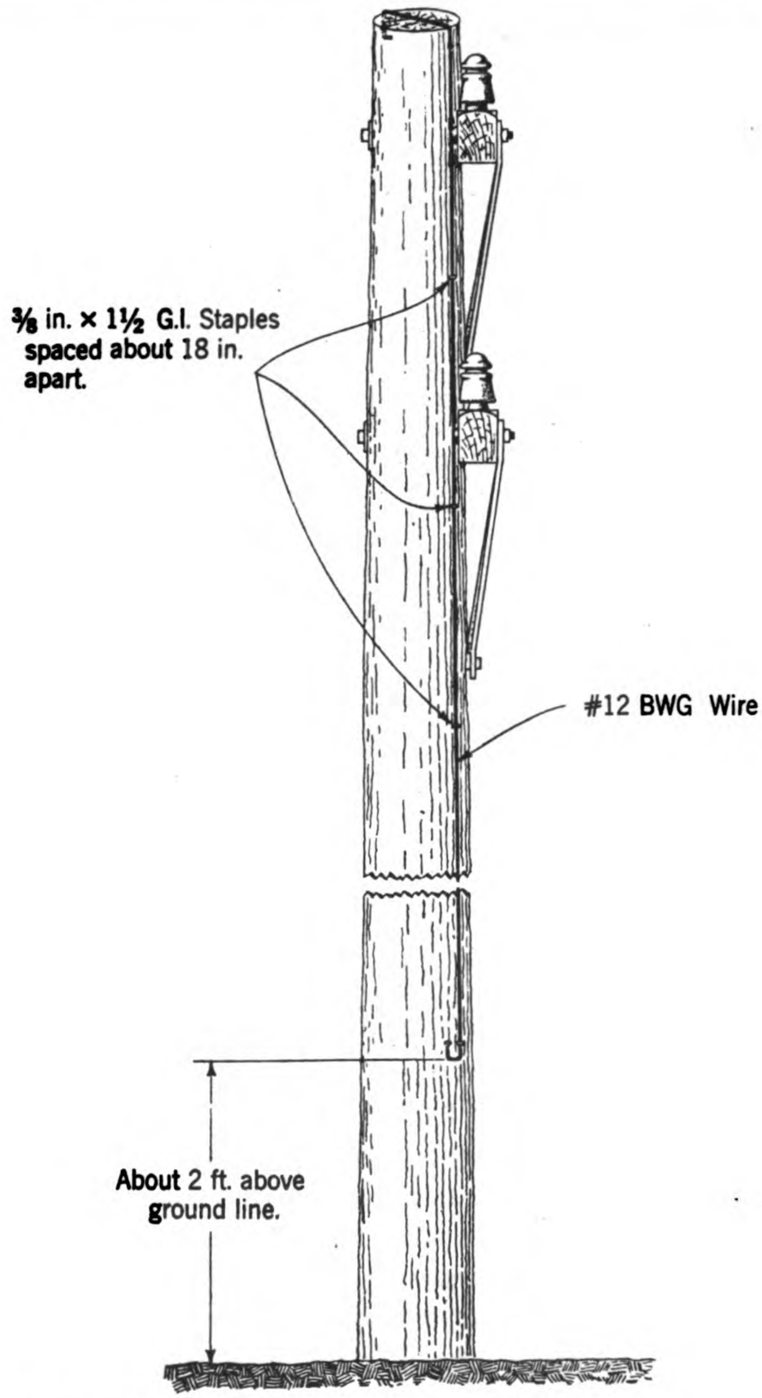



Figure 87.— Protection wire on unguyed pole.

***b. Anchor guy on pole.—*** If the guy or the hardware in contact with the guy is above the second crossarm position, no protection wire is required. If the guy and associated hardware are below the second crossarm position, locate the vertical run directly above the portion of the guy hardware that is highest on the pole. Terminate the protection wire so as to provide approximately a 4-inch separation from the guy hardware, as shown in figure 88.

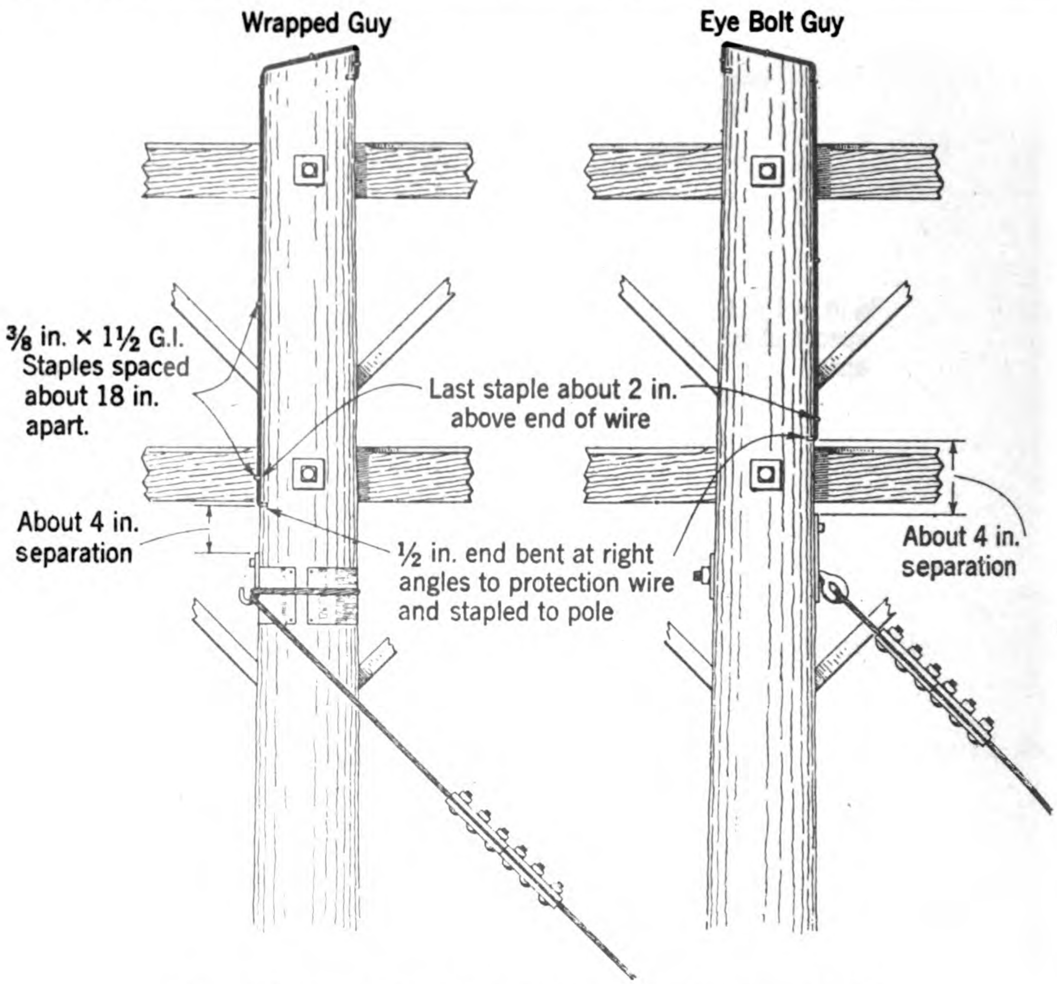



Figure 88.— Protection wire on anchor guyed pole.

**101. GUYED OR BRACED POLES OTHER THAN ANCHOR GUYED POLES.— *a. Pole with guy-to-stub and stub-to-anchor guy.—*** If there is 4 inches or less separation between the stub-to-anchor guy and the pole-to-stub guy, place the protection wire on the guyed pole in the same manner as if the pole itself were anchor guyed. If the separation on the stub between the pole-to-stub guy and the stub-to-anchor guy is more than 4 inches, connect the protection wire to the guy hardware on the guyed pole by placing it behind a washer, guy strap, etc., and continue it toward the ground and terminate it as shown in figure 87. No protection wire is required on the stub which carries the anchor guy.

***b. Pole-to-tree guy.—*** Install the protection wire in the same manner as if the pole were unguyed. The protection wire may be in contact with the guy or guy hardware as it passes down the pole.

***c. Pole-to-pole guy.—*** Install the protection wire in the same manner as for an unguyed pole.

***d. Push braced pole.—*** Install the protection wire on the pole only.

# Section VII
# Marking Poles

**102. REASON FOR MARKING.**— Rapid location of line faults by maintenance personnel will be facilitated if the distance from the zero pole is marked on selected poles at regular half mile intervals and, in addition, at landmarks such as roads, highways, railroads or streams crossing the line. Such markings should extend from the zero pole to the end of the line or, if preferred, to some fixed location beyond which the number system may be repeated. A one hundred mile length may be considered a suitable numbering section. However, due to the fact that under certain conditions information might be imparted to the enemy even though the markings were in code, it will be necessary that the signal officer specify whether or not any marking of poles is to be done.

**103. TYPE AND LOCATION OF MARKING.**— The marking may be placed on the pole in one of several ways depending upon the availability of materials. It is desirable, where possible, to use figures about three inches high and to place them on the pole about 5 feet from the ground in a vertical position reading from top to bottom. Some of the methods which may be used to mark the poles are as follows:

(1) Stenciled or painted freehand, using red or Signal Corps orange paint.

(2) Marked on the pole with a lumber marking crayon. These markings may need to be renewed from time to time to keep them legible.

(3) Written on a tag or board tied or nailed to the pole.

# Section VIII
# Guying

**104. GENERAL.**— The strength and stability of a pole line depend to a considerable extent upon proper guying. The guying specified in this manual is heavier for a pole line carrying two crossarms than for a line carrying only one crossarm. If, when a pole line is constructed, only one crossarm is to be installed initially, but it is planned to add a second crossarm later, the guying should be installed initially for a two-crossarm line. It is also important that guy anchors be so located that the angle between the pole and the guy will be at least 45 degrees. In locating guy anchors, make sure that the guys will not be in contact with the wires.

**105. SIZES AND TYPES OF GUYS.**— ***a. Guying at corner poles.***— All corner poles on which the "pull" is four feet or more should be guyed. The size and number of guys should be in accordance with the following table.

| Amount of Pull (Feet) | Size of Guy Required One Arm Line | Two Arm Line |
|---|---|---|
| 4 to 35 | One 6M | One 6M |
| Over 35 to 50 | One 6M | Two 6M |
| Over 50 | Two 6M head guys | Two 10M head guys |
| Deadend pole | Two 6M head guys | Two 10M head guys |

Corner poles with a pull less than four feet should be guyed with one 6M strand if the ground is soft so that there would be a tendency for the pole to lean. Guys should be so placed as to bisect the exterior angle of the corner, as shown in figure 89. Right angle corners should preferably be made on two poles as shown in figure 89, but may be made at one pole with two head guys on the corner pole.

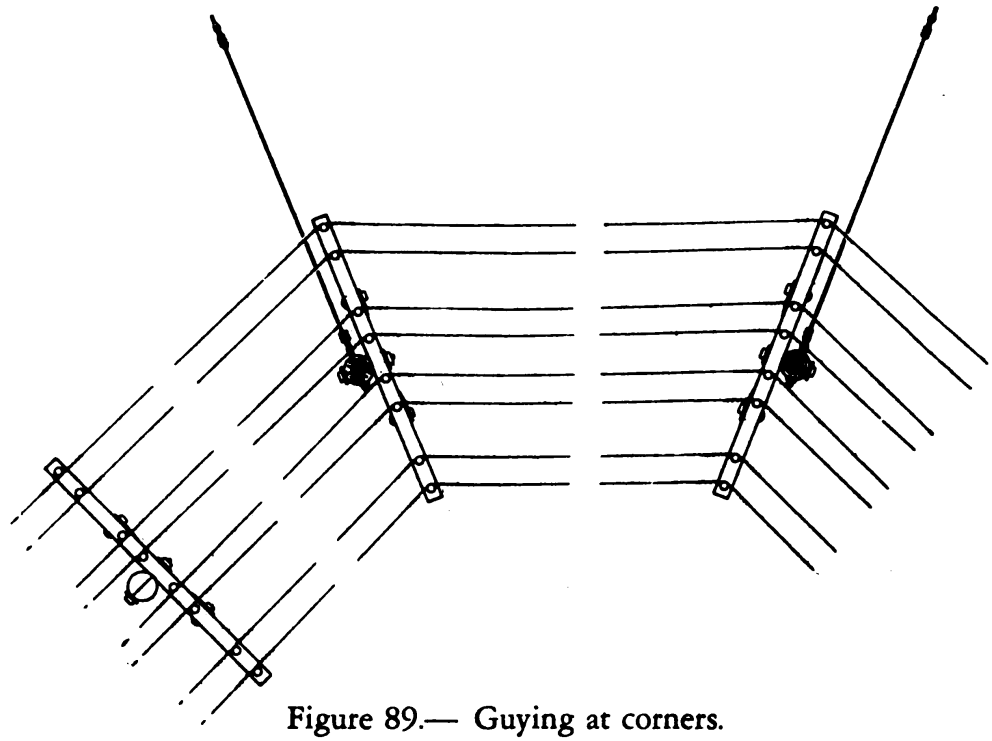


Figure 89.— Guying at corners.

***b. Deadend poles.***— Deadend poles are guyed in line with the poles.

***c. Guying at other points in the line.***— (1) At intermediate points in the line where one crossarm of open wire is terminated, the pole should be head guyed with one 6M strand.

(2) Where one to four pairs of wires branch off, the pole in the main line should be guyed with one 6M strand in line with the main lead and a second 6M strand in line with the branch lead.

**106. GUYING AT CHANGES IN GRADE.**— Any pole at which there is a down pull resulting from a change in grade of more than 10 per cent. should be double side guyed with 6M strand.

**107. STORM GUYING.—** Two opposing side guys should be placed at every twentieth pole and four opposing guys (two side guys and two head guys) at every fortieth pole to stabilize the line under storm loads. All storm guys should be of 6M strand.

**108. SWAMP GUYS.—** All swamp anchor guys should be of 6M strand.

**109. GUYING LONG SPANS.—** Spans longer than 225 feet should be avoided wherever practicable. If it is necessary to construct a span longer than 225 feet, special long span construction should be used. If a transposition point falls well within a long span, catenary long span construction will be required. Inasmuch as such construction is difficult, the use of the long span should be resorted to only when other possibilities such as rerouting the line, setting poles in unusual locations, etc., have been found impracticable. Poles at both ends of long spans should be equipped with four-way storm guys of 6M strand.

**110. TYPES OF ANCHORS.—** Anchors may be made from sections of poles, logs or planks. Several types of metal anchors which are described in this manual are also suitable.

**111. ANCHOR GUY RODS.—** ***a.*** Anchor rod AH-6-A, $\frac{5}{8}$ inch in diameter and 8 feet long and equipped with a 4 x 4 x $\frac{3}{16}$ inch washer and a nut is suitable for log or plank anchors. If more than one guy is to be attached to one log anchor, a separate guy rod is used for each guy.

***b.*** Guy rods are set in line with the point on the pole where the guy will be attached, so that when the guy is pulled up, the line of pull will be straight from the anchor to the point of attachment on the pole, without bending the rod.

**112. BEARING SURFACE OF ANCHORS.—** The effective bearing surface of an anchor in ordinary soil should be at least three square feet for one guy and four square feet for two guys. For example, a log or section of pole 8 inches in diameter and 5 feet long is suitable for one guy but for two guys, the length should be increased to six feet or the diameter should be 10 inches if the 5 foot length is to be used. Log anchors should not be less than 8 inches in diameter and 5 feet in length.

**113. DEPTH OF SETTING ANCHORS.—** The depths at which the various types of anchors should be set is shown on the figures in Paragraph 114.

**114. METHOD OF PLACING ANCHORS.—** ***a. Log anchors.—*** (1) In excavating for the anchor log, dig the hole so that, where practicable, the log will be set horizontally and at a right angle to the guy. Dig a trench for the guy rod so that it will be in line with the point of attachment of the guy on the pole. The length and width of the excavation should be as small as possible, especially at the surface of the ground. Frame and set log anchors as shown in figure 90.

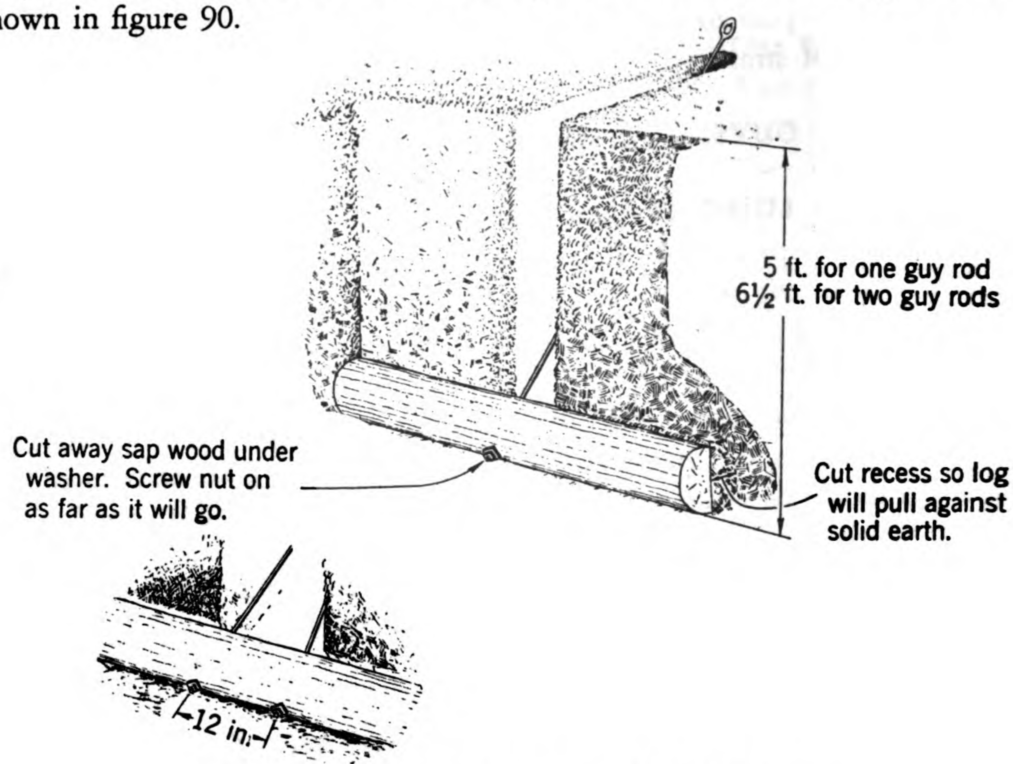



Figure 90.— Log anchor at right angle to guy.

(2) If obstacles prevent the anchor log from being set at a right angle to the guy, it may be set in line with the guy as shown in figure 91.

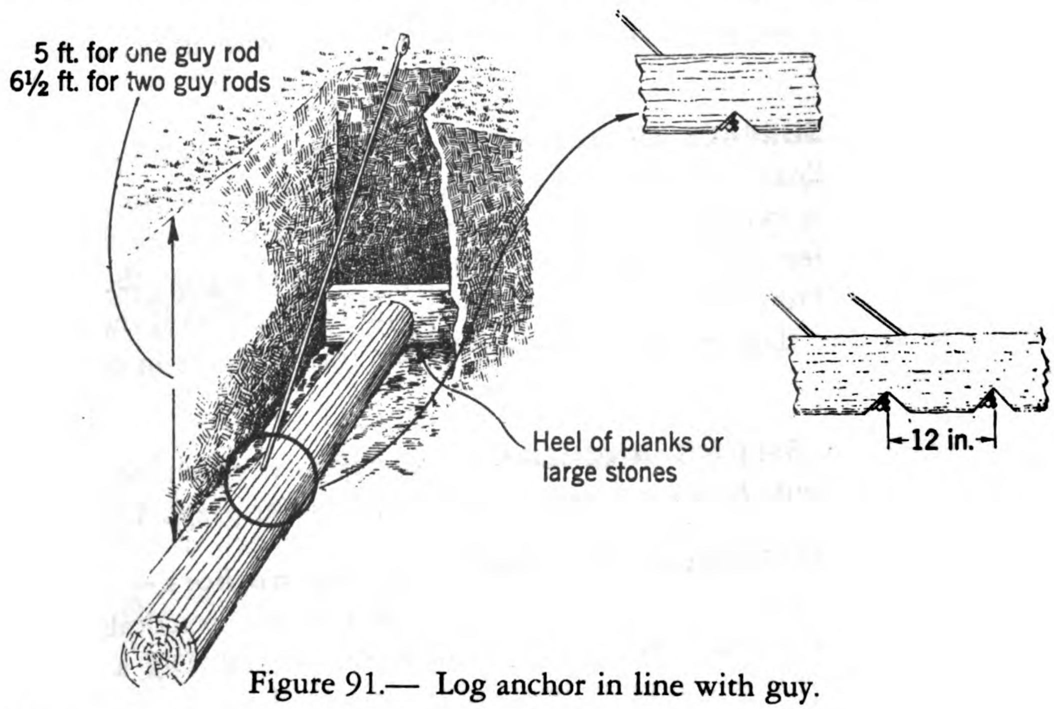



Figure 91.— Log anchor in line with guy.

(3) In soft ground place heavy planks or logs across the anchor log as shown in figure 92. The length of these planks or logs should be at least twice the diameter of the anchor log. Tamp all backfill firmly.

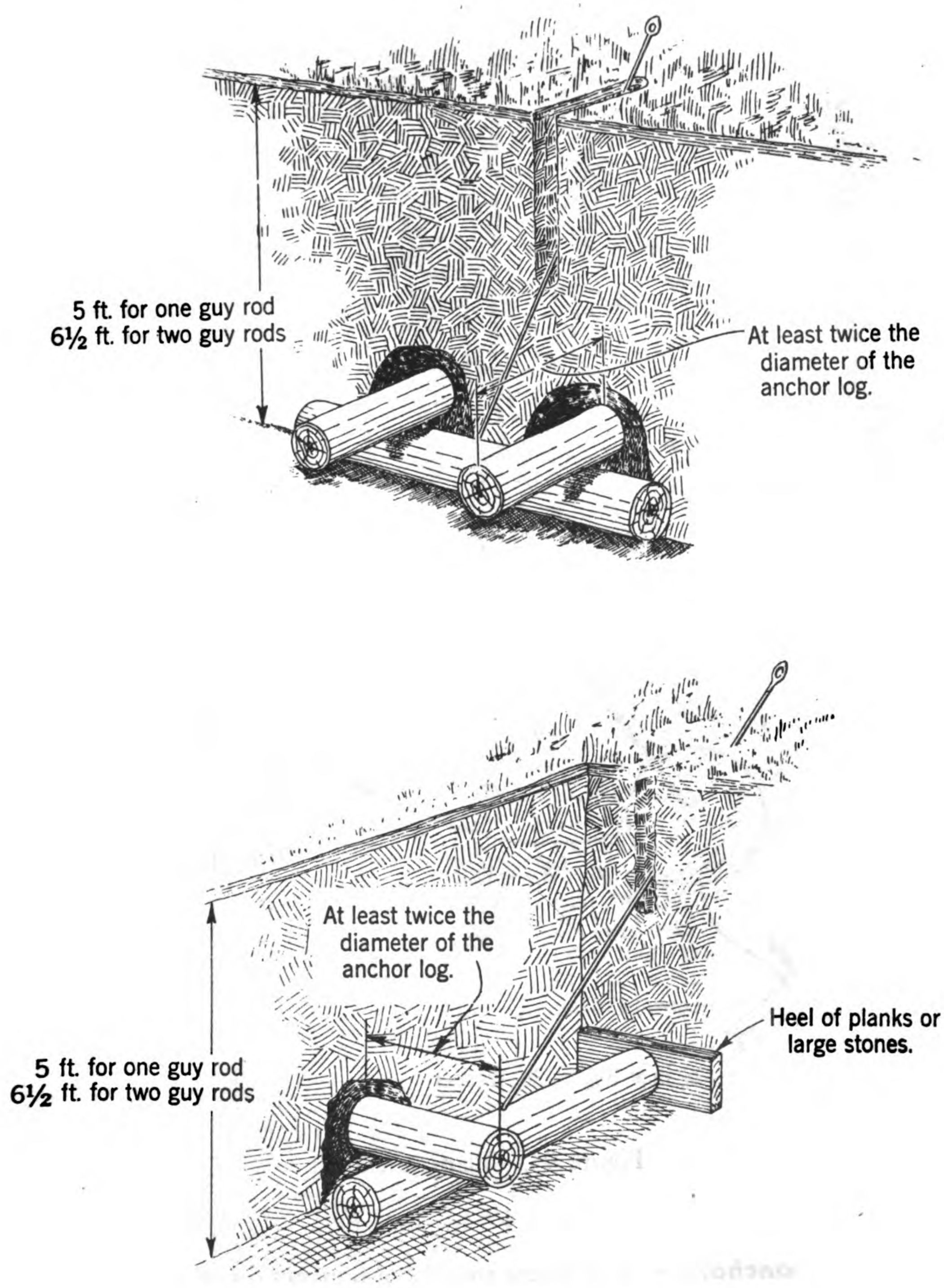



Figure 92.— Log anchors in soft ground.

***b. Plank anchors.***— Plank anchors should be made and placed as shown in figure 93.

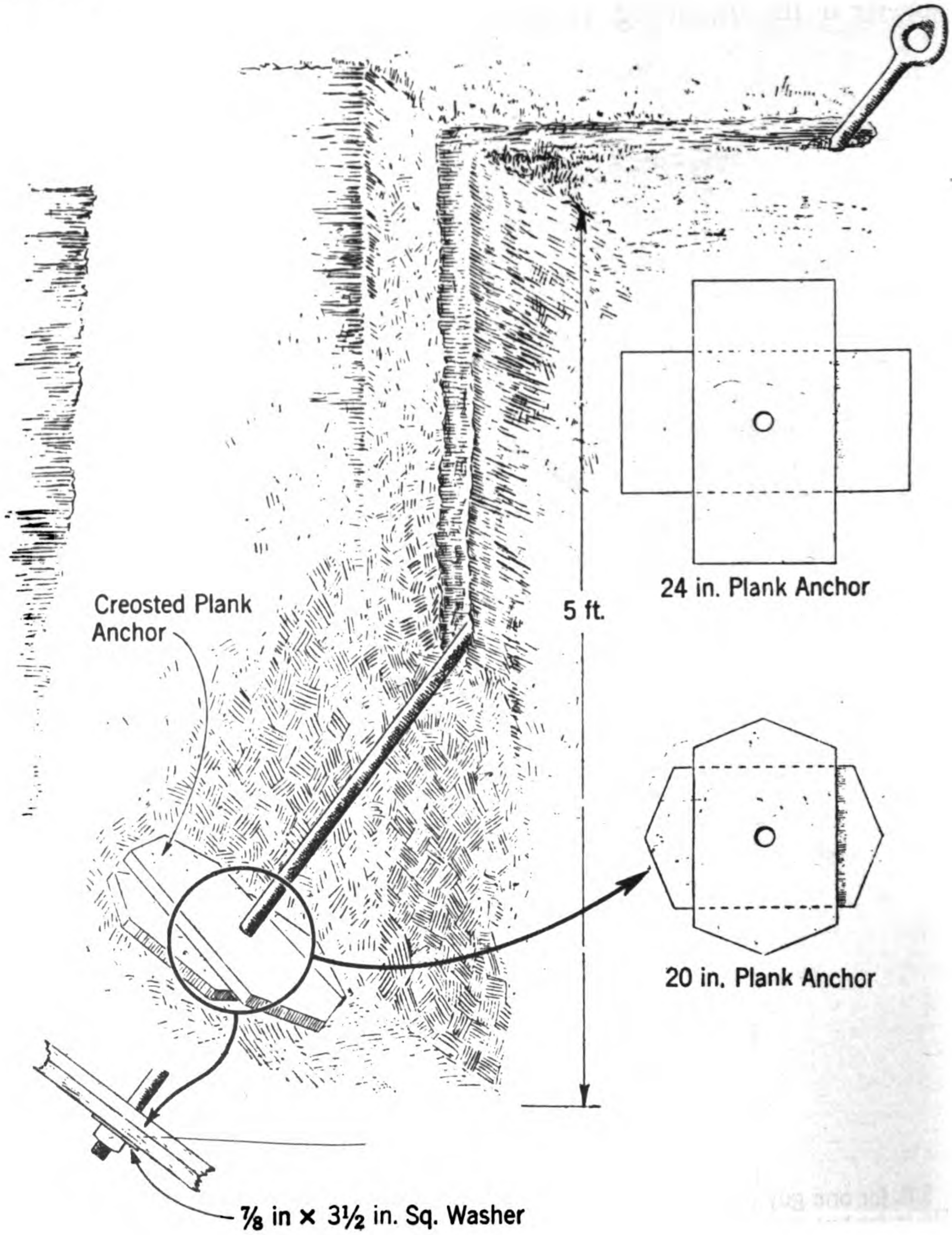



Figure 93.—Plank anchors.

***c. Screw anchors.***— (1) Screw anchors of 8 inches diameter may be used in firm soil for side guys and for corner guys if the pull of the corner does not exceed 35 feet. Install 8 inch screw anchors as shown in figure 94. In hard clay soil it will be easier to install the anchor if a 3 inch pilot hole is first drilled with an earth auger to a depth of 4 feet. The anchor should then be screwed beyond the depth of the pilot hole to the full depth of setting permitted by the rod.

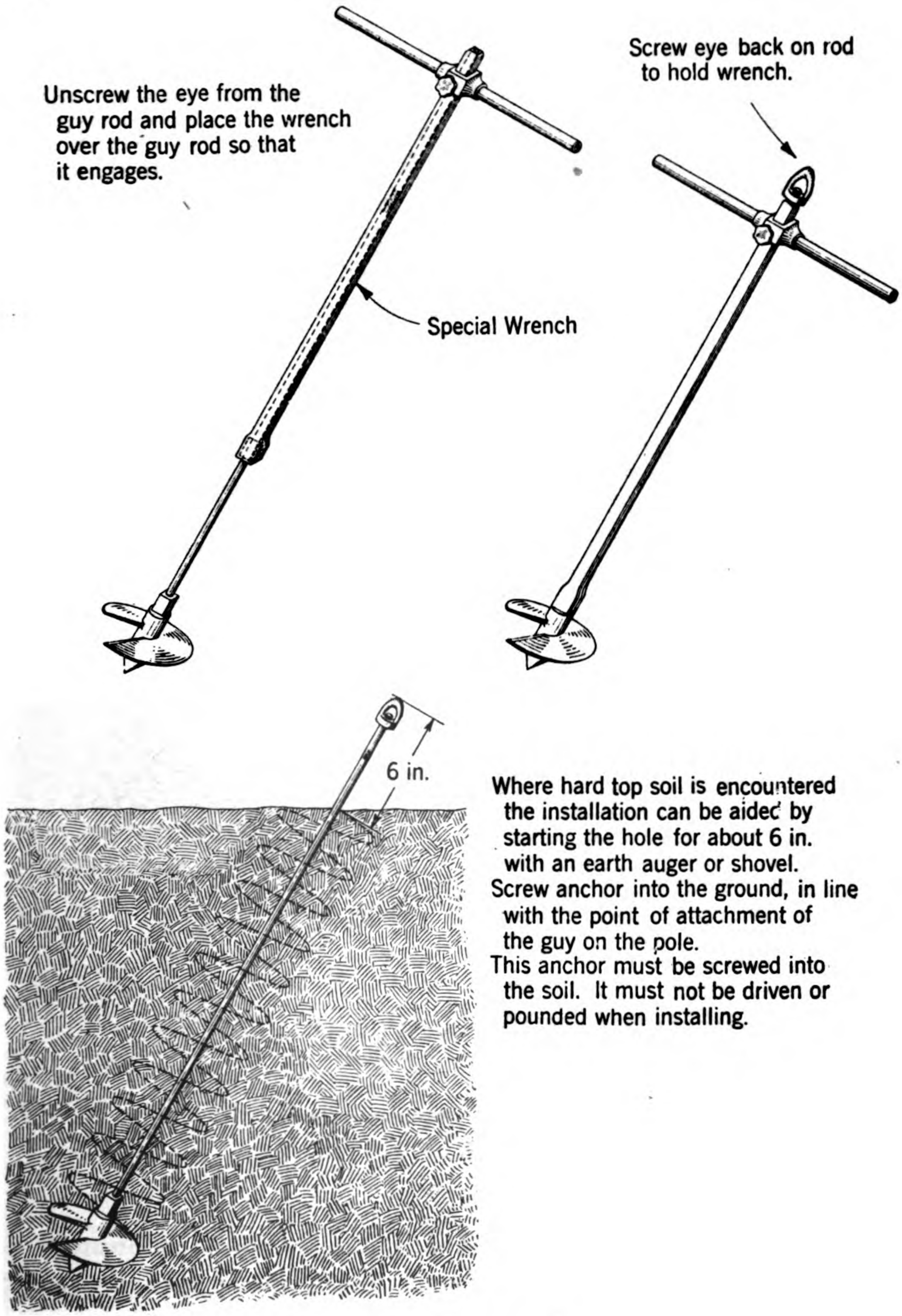



Figure 94.— Screw anchor.

(2) In swampy ground or at corners having a pull greater than 35 feet or at deadends, 12 inch diameter screw anchors may be used but should be equipped with 2-inch diameter extra strong pipe and couplings. To install the 12-inch screw anchor, first dig a hole about 1 foot deep and large enough to take the screw plate. Then place the screw plate in the hole, line the pipe up with the point on the pole where the guy will be attached, screw the pipe into the plate and then screw the plate into the ground with pipe wrenches, as shown in figure 95. The anchor should be screwed down until the pipe can no longer be turned by four men operating the two pipe wrenches. If this point is not reached with one length of pipe, attach a second length with a pipe coupling and continue the operation, placing additional lengths of pipe until the anchor can no longer be turned by four men on the wrenches. When the anchor has been set, screw a pipe eye nut on the end of the pipe to provide a means for attaching the guy.

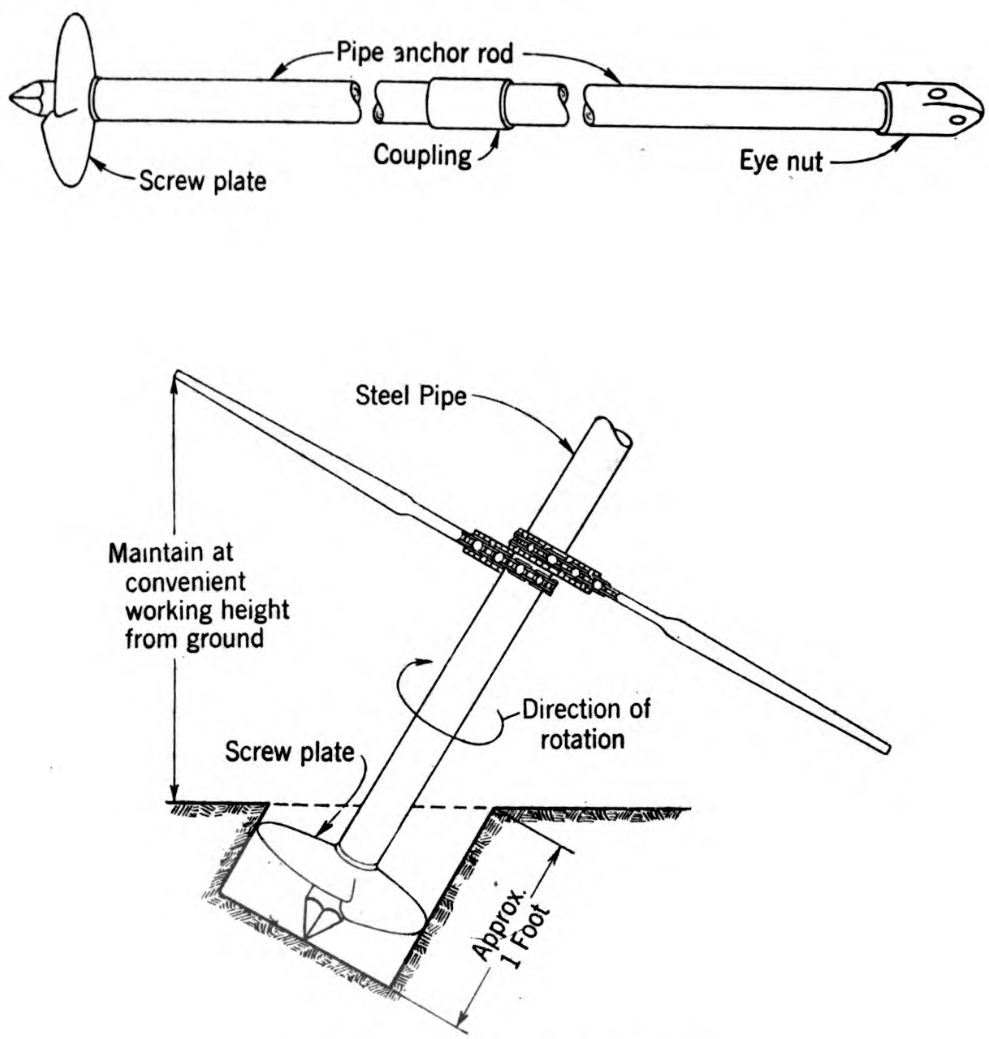



Figure 95.— Swamp anchor.

**d. Cone anchors.–** Cone anchors of 8 inches diameter may be used in firm soil where the pull on the corner pole does not exceed 35 feet. If the pull is greater or if the soil is soft or the anchor is to hold a deadend pole, the cone anchor should be of 12 inches diameter. The method of installing cone anchors is shown in figure 96.

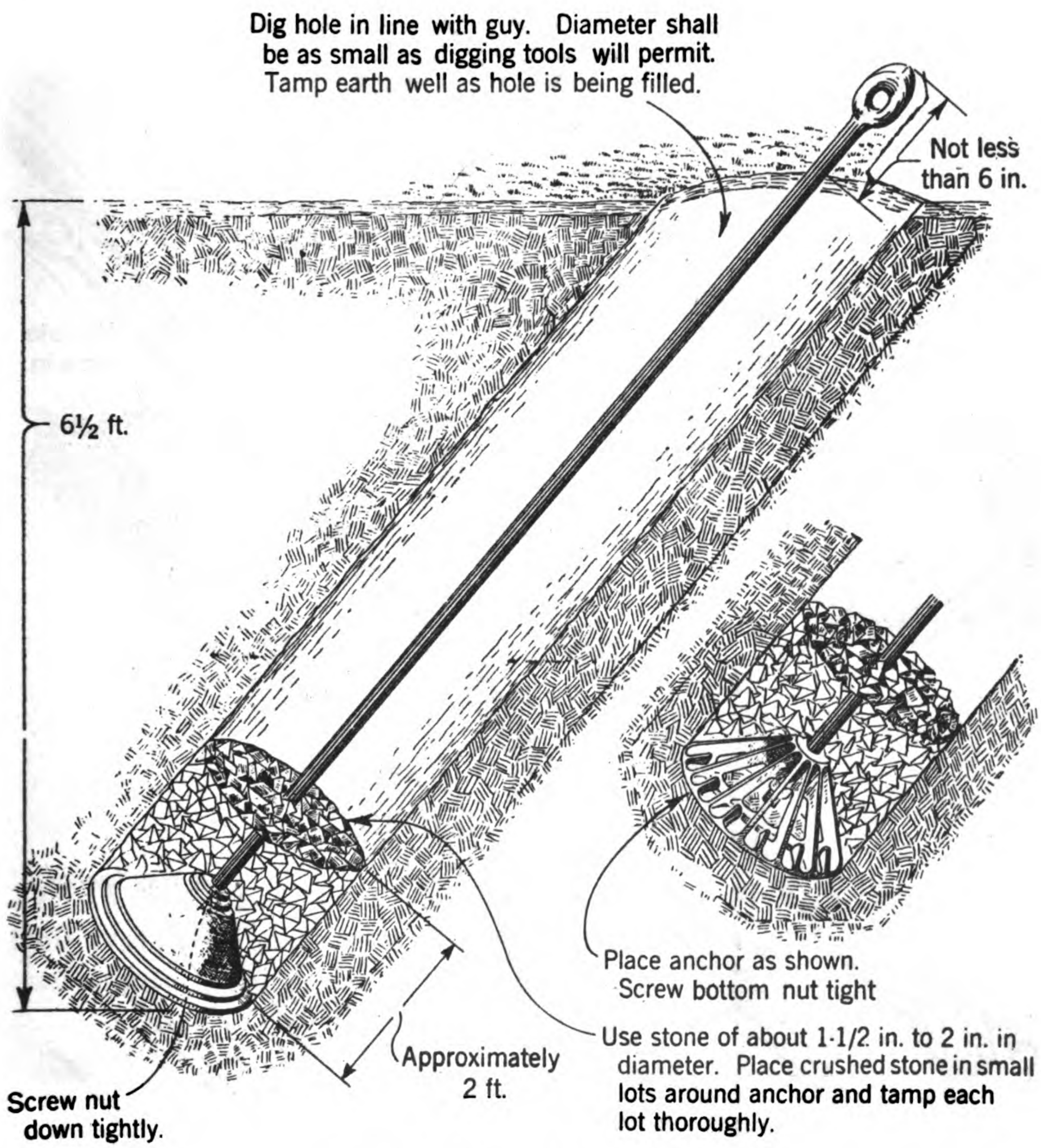



Figure 96.— Cone anchor.

**e. Expanding anchors.–** In firm soil, 2-way 8-inch expanding anchors, AH-2, may be used for side guys or corner guys if the pull on the corner pole is not more than 35 feet. For all other conditions a 4-way 8-inch expanding anchor may be used. The method of placing expanding anchors is shown in figure 97.

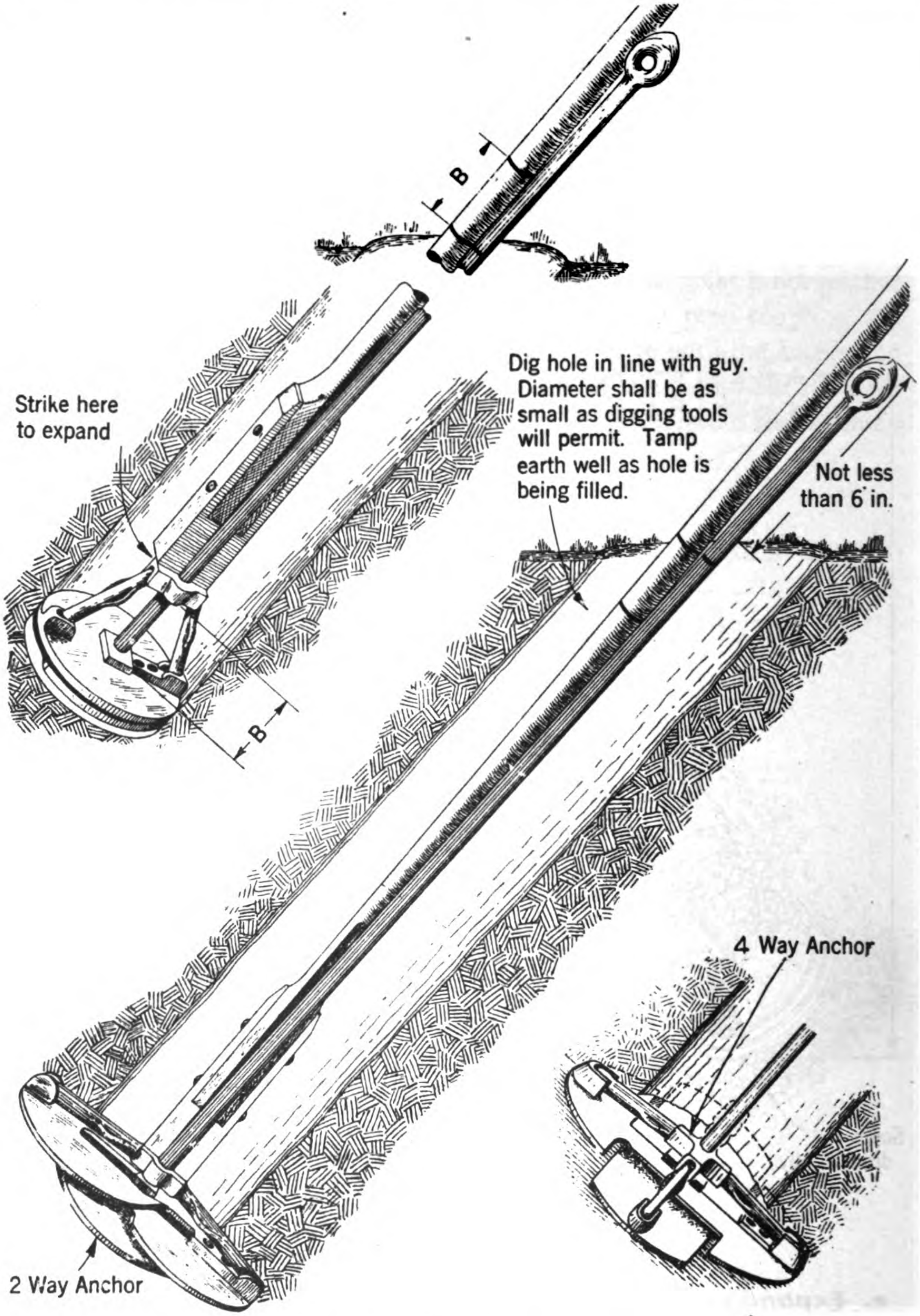



Figure 97.— Expanding anchor.

***f. Rock anchors.***— Where it is impracticable, because of rock, to install one of the other types of anchors, a rock guy anchor can be used, if the rock is hard and solid enough to give good anchorage. Rock anchors should be placed as shown in figure 98.

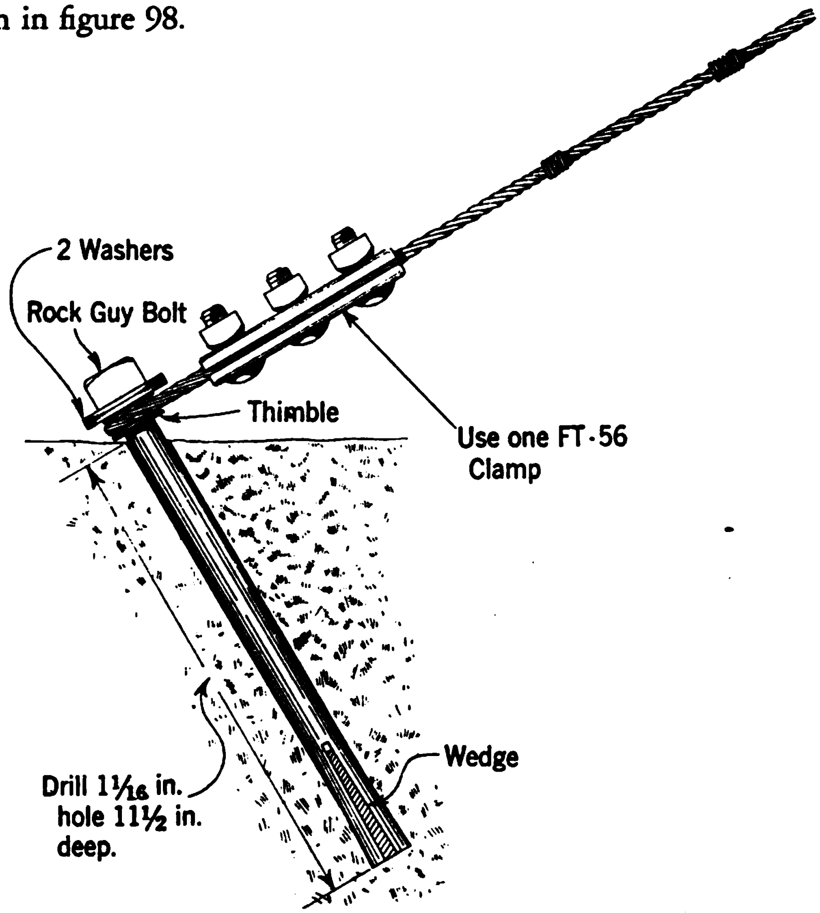



Figure 98.— Rock anchor.

**115. ATTACHING GUYS TO POLES, STUBS AND TREES.**— ***a. Eye bolt method.***— (1) Attach anchor guys to poles as shown in figure 99. The attachment to the pole should be made 4 inches below the upper crossarm.

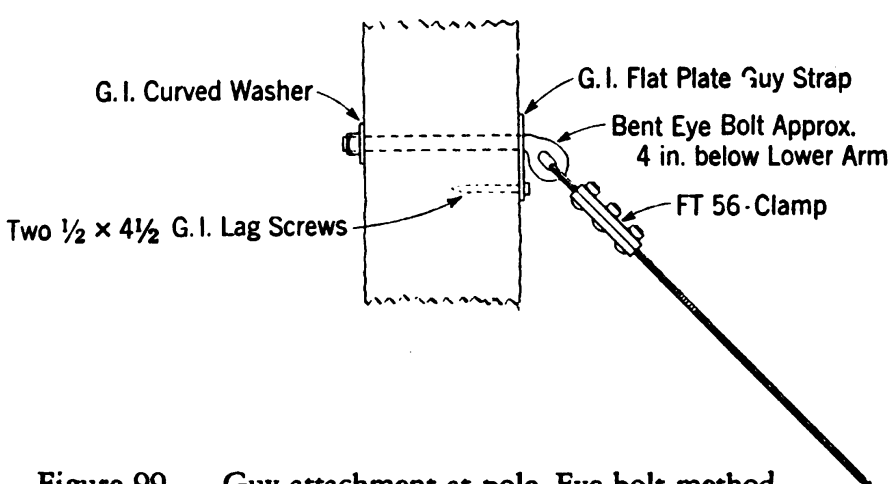



Figure 99.— Guy attachment at pole. Eye bolt method.

(2) If two guys are placed opposite each other, as when a pole is double side guyed or storm guyed, make the attachment as shown in figure 100. In the case of 4-way storm guys, the two side guys should be attached 4 inches below the lower crossarm and the two guys in line with the pole should be attached 4 inches below the upper crossarm.

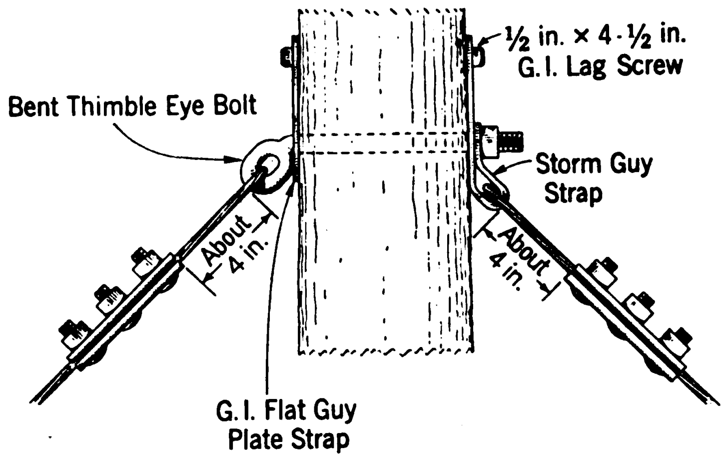



Figure 100.— Double side or storm guy attachment at pole. Eye bolt method.

(3) At poles where two guys are to be placed in the same direction one guy should be attached 4 inches below the top crossarm and the other 4 inches below the bottom crossarm. If only one crossarm is to be placed on the pole, one guy should be attached 4 inches below the crossarm and the other, 4 inches lower.

(4) Guys to stubs should be attached as shown in figure 101.

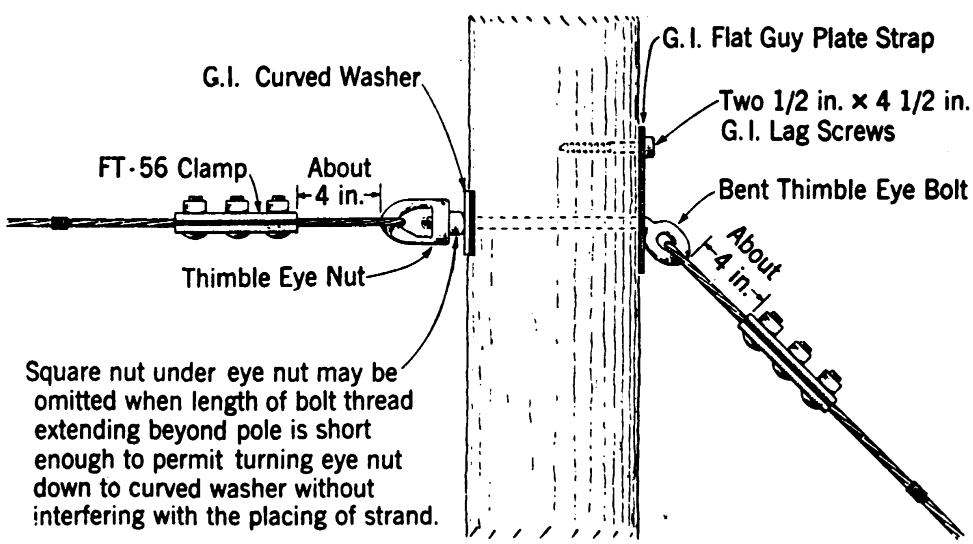



Figure 101.— Guy attachment to stub. Eye bolt method.

(5) Guy attachment to trees should be made as shown in figure 102.

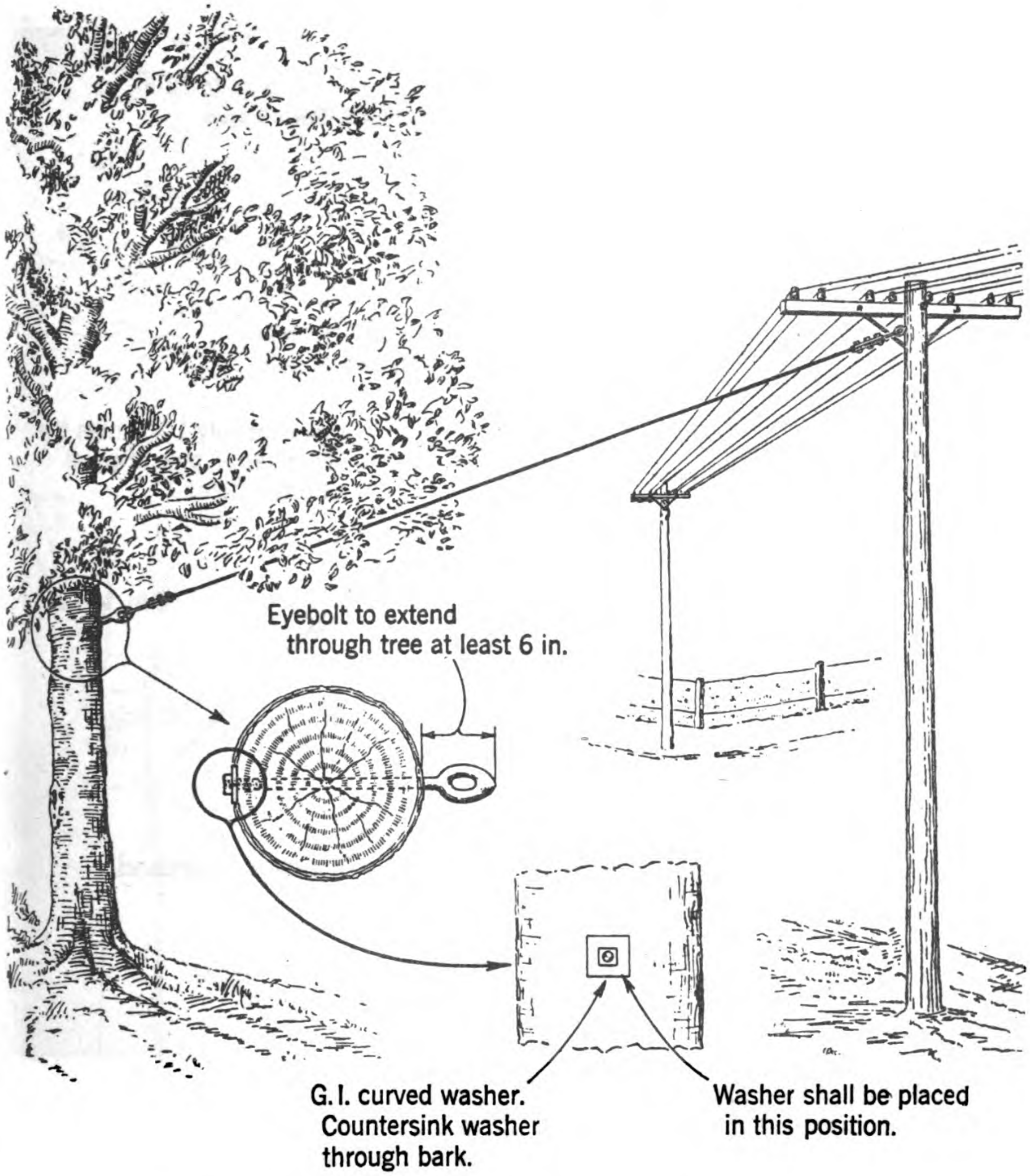



Figure 102.— Guy attachment to tree. Eye bolt method.

***b. Wrapped method.—*** The wrapped method of attaching guys to poles, stubs and trees may be used instead of the eye bolt method. Such attachments are shown in figures 103, 104 and 105.

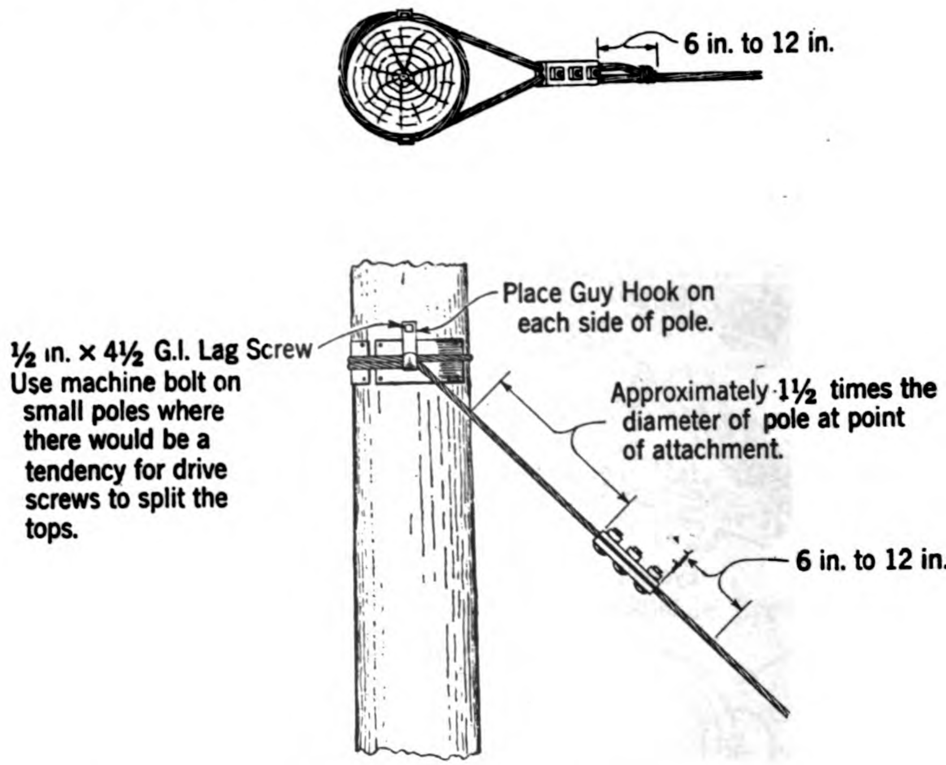



Figure 103.— Guy attachment to pole. Wrapped method.

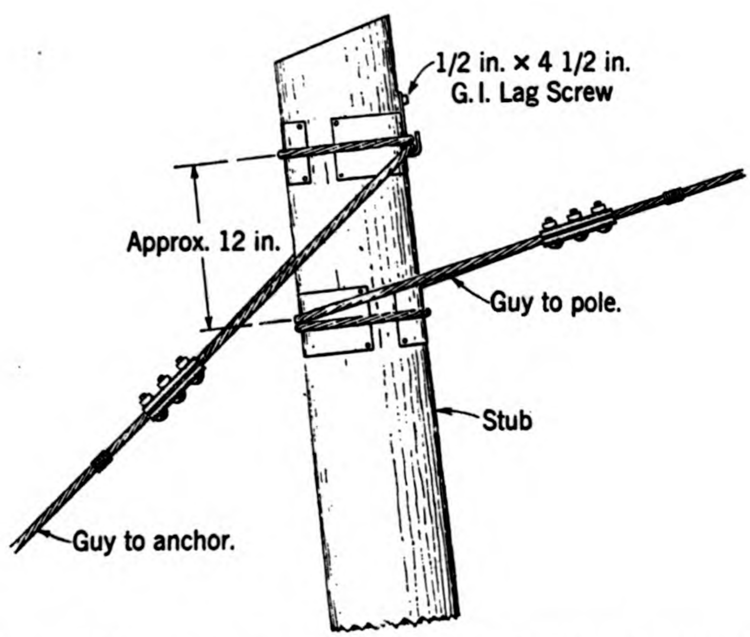



Figure 104.— Guy attachment to stub. Wrapped method.

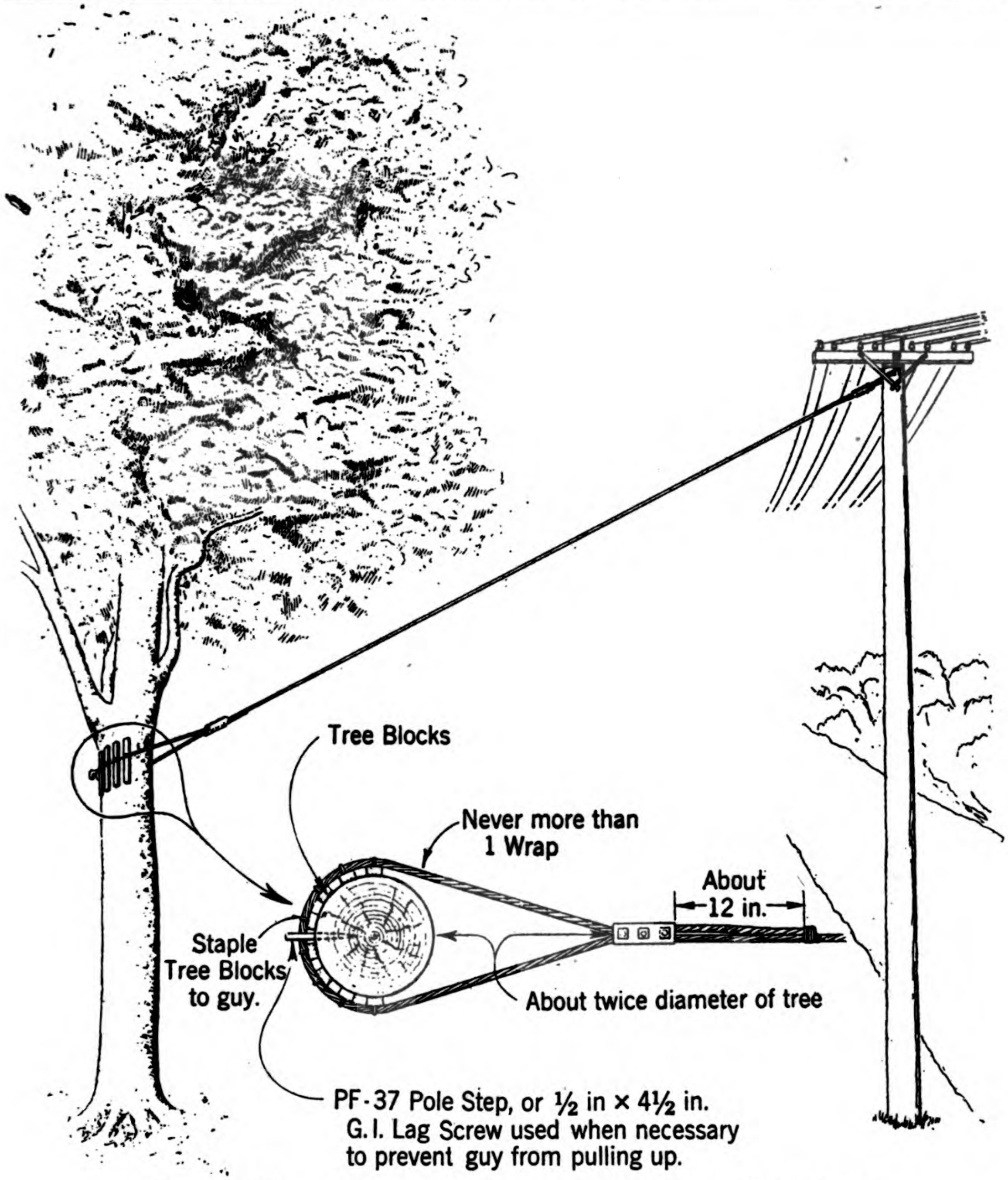



Figure 105.— Guy attachment to tree. Wrapped method.

**116. TERMINATING STRAND.— *a. FT-56 clamp.*—** When using the FT-56 clamp, bend the main part of the guy and the tail so that they are parallel and place the clamp over them, after first loosening the nuts. From 6 to 12 inches of the end of the tail should extend beyond the end of the clamp. Then tighten up on each nut. After all three nuts have been turned down, go over them a second time, turning each nut down as far as it will go. Fasten the end of the tail to the main part of the guy with a wrapping of No. 12 BWG GI wire, wrapping 5 turns around the tail and main part of guy together and then extending the wrapping with 2 turns around the main part of guy only.

***b. Serving strand.*—** If FT-56 clamps are not available, the guy strand may be terminated by serving the individual wires of the tail around the main part of the guy with pliers, as shown in figure 106. Each turn of wire must be drawn tightly and the pliers must be handled carefully, to avoid nicking or breaking the wires as they are served. If this method is used in order to conserve a limited supply of guy clamps, it should be used at the guy rod and a clamp used at the pole end. The guy clamp at the pole end of the guy will allow for adjusting the tension in the guy later, if this becomes necessary.

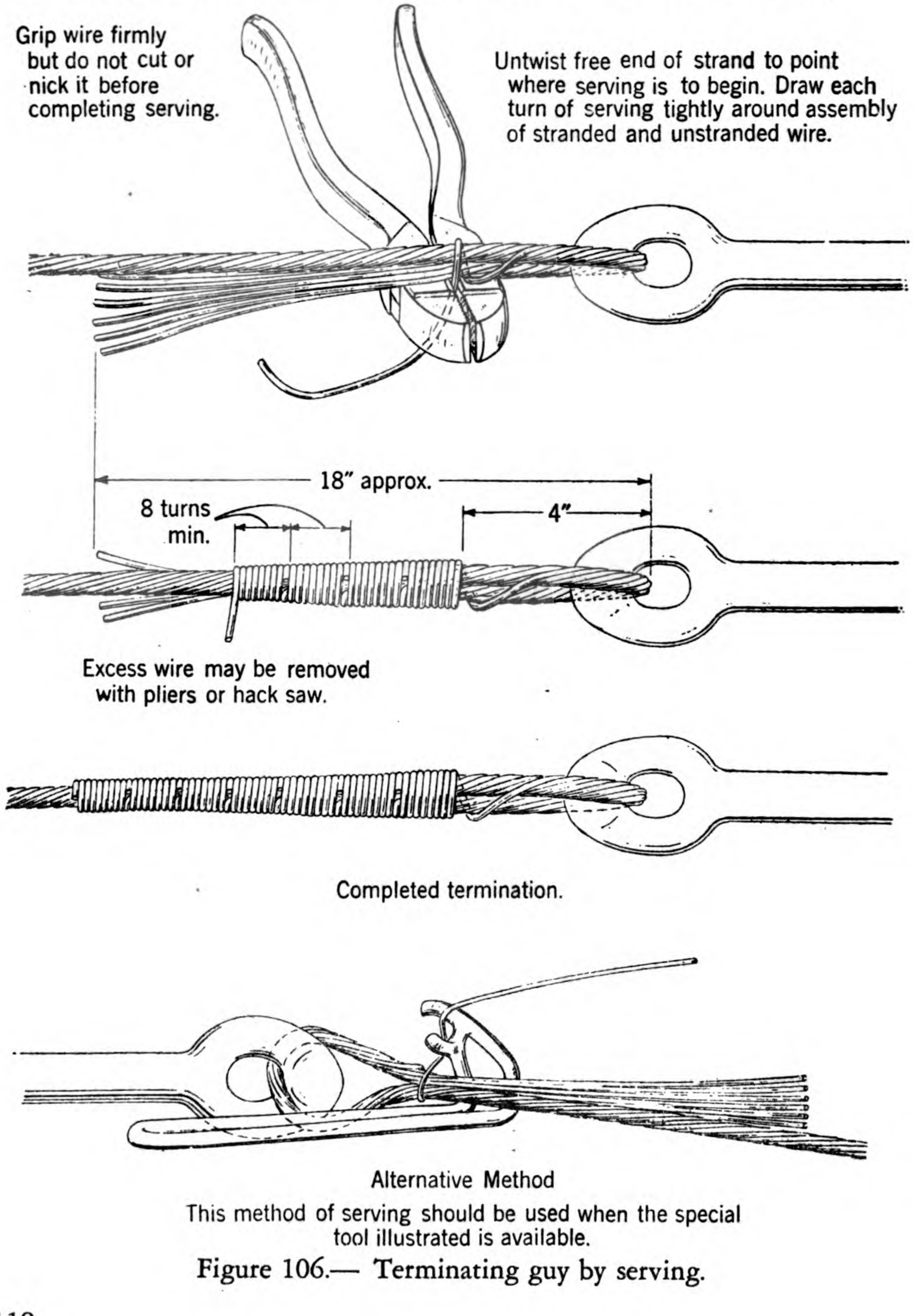



Figure 106.— Terminating guy by serving.

**117. PULLING UP GUYS.— *a. Anchor guys.*—** Pull up anchor guys as shown in figure 107, after first terminating the strand at the pole.

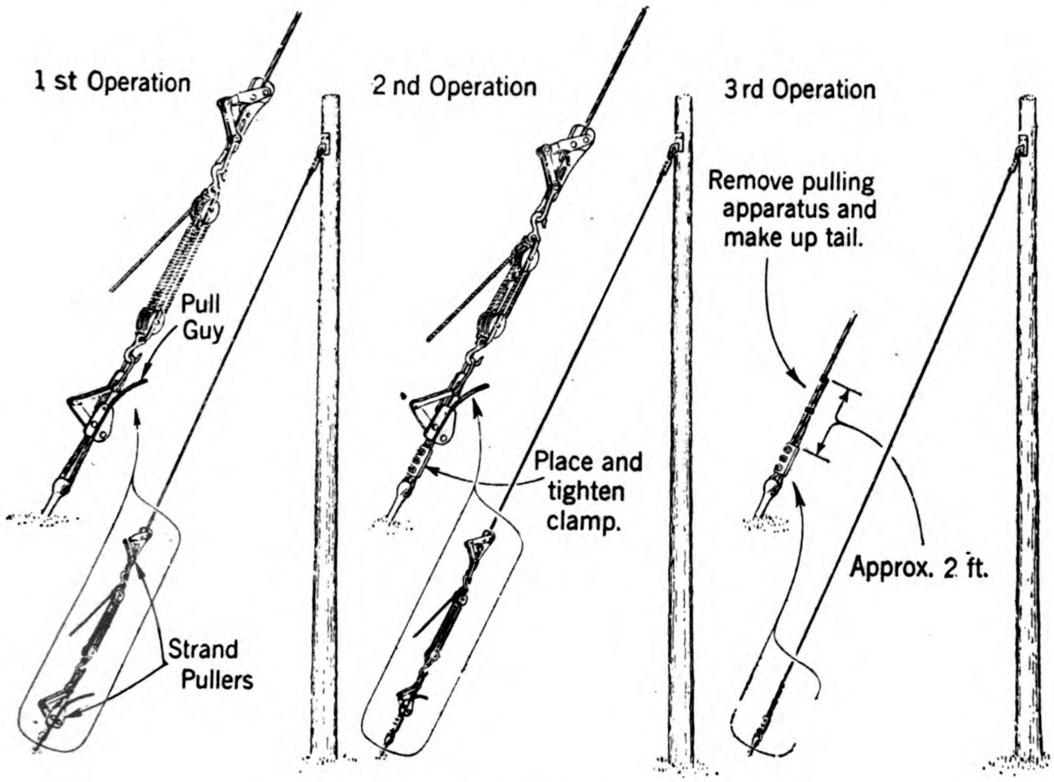



Figure 107.— Pulling up anchor guys.

***b. Guys to stubs or trees.*—** If the stub is to be guyed to an anchor, this guy should be installed before placing the guy from the pole to the stub. To place a guy from a pole to a stub or tree, terminate the guy at the pole end and then pull up the guy at the stub or tree end as shown in figure 108. The guy should be pulled up until the top of the pole is pulled out of line one foot so that when the wires have been strung and the poles have settled, the top of the guyed pole will return to its original position.

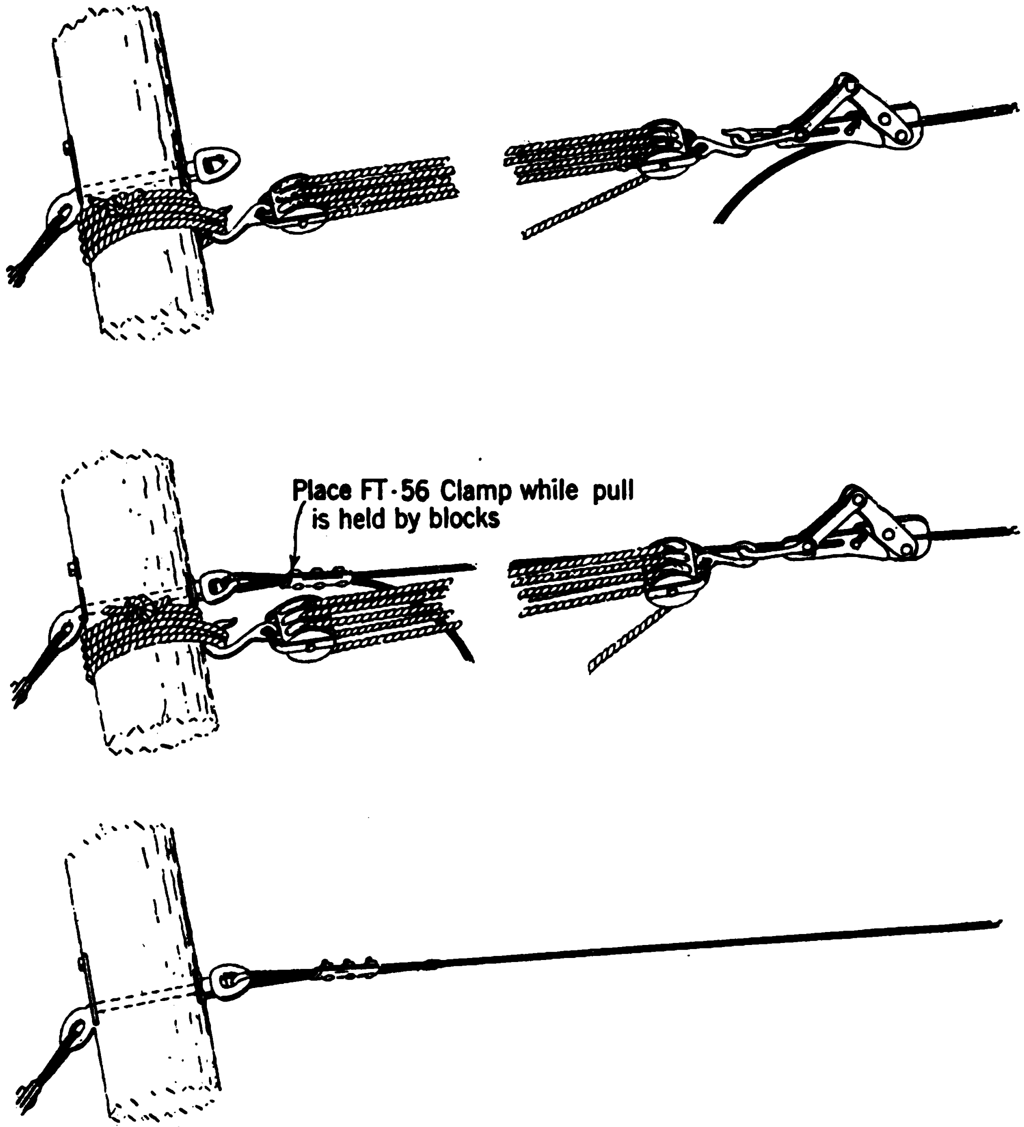



Figure 108.— Pulling up stub or tree guys.

# CHAPTER V
# CROSSARMS, PINS AND INSULATORS



## Section I
## Description of Crossarms, Pins and Insulators

**118. CROSSARMS.—** The PF-92-A crossarm is to be used for fixed plant. It is provided with eight holes for pins to support insulators to which the open wires are attached. The crossarm is bored with a hole at the center for the bolt to attach the crossarm to the pole and also with a hole on each side of the center for bolts to attach the crossarm braces. (See figure 109.)

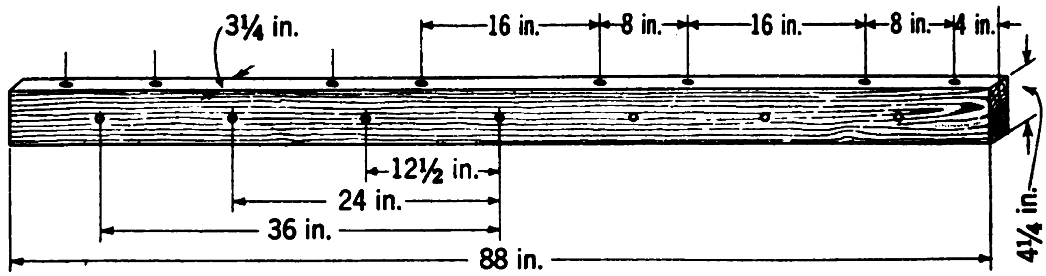



Figure 109.— PF-92-A crossarm.

**119. PINS.**— The PF-59 pin is used with the PF-92-A crossarm. It is illustrated in figure 110.

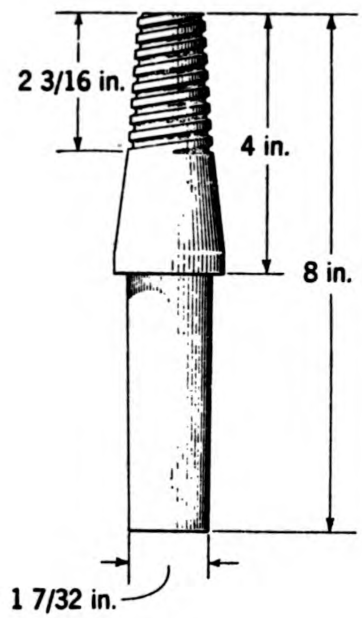



Figure 110.— PF-59 pin.

**120. INSULATORS.**— The insulators to be used on the PF-59 pins are made of glass and are of two types, the SG DP and TW. The SG DP insulator has only one wire groove and is used at all locations except the pins where transpositions are to be made. The TW insulator has two wire grooves and is for use only on pins where transpositions are to be made. These two insulators are shown in figure 111.

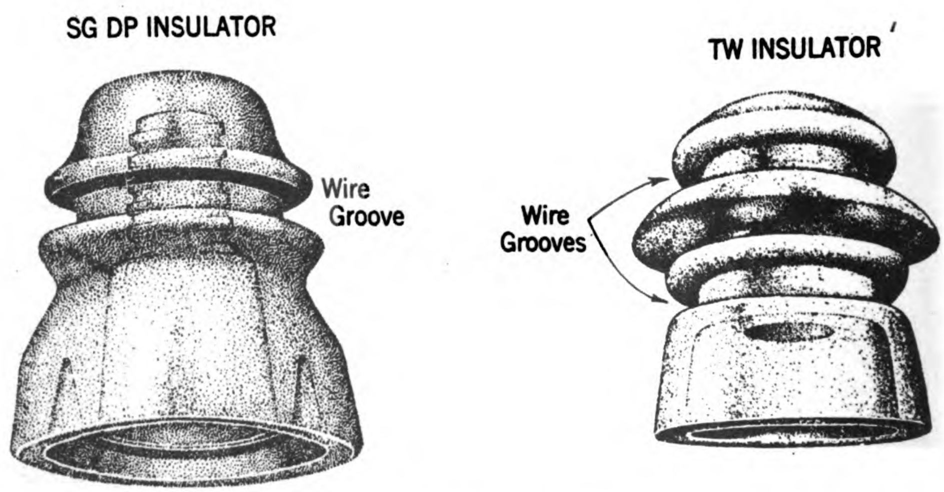



Figure 111.— SG DP and TW insulators.

# *Section II*
# *Placing Crossarms*

**121. GENERAL.— *a.*** As a general rule crossarms should be attached to the pole before the pole is set, as it is easier to do the work on the ground than aloft. Before the crossarm is attached to the pole it should be equipped with pins, crossarms braces and insulators.

***b. Pins.—*** Place PF-59 pins by pushing them into the pin holes in the crossarm until the shoulder of each pin is flush with the top of the crossarm; if necessary, tap the top of the pin to drive it down into the hole, but be careful not to damage the threads. Then drive a 6d. common wire nail through the side of the crossarm, half-way between the top and bottom, and into the middle of the pin. At transposition poles, only one pin need be placed for each pair of wires to be transposed; this pin should be the one nearer to the center of the crossarm, omitting the pin further from the center. Before placing pins at transposition poles determine the direction in which the pole will be faced, so that the transposition pins will be placed at the proper wire positions.

***c. Crossarm braces.—*** Fasten two 20-inch crossarm braces to the crossarm with 3/8 inch x 4 inch carriage bolts. Place the heads of the bolts on the opposite side of the crossarm from the braces. Be sure to attach the end of the brace with the smaller hole to the crossarm. (The larger hole at the other end of the brace is for the lag screw that will be used to fasten the braces to the pole.)

***d. Insulators.—*** Place glass insulators on the pins, screwing them down on the pins until they are tight. Be careful to place TW glass insulators on pins at which transpositions are to be made and SG DP glass insulators on the other pins.

**122. RAISING CROSSARMS.—** If the crossarm is to be placed after the pole has been set, it should be raised by means of a handline and snatch block as shown in figure 112.

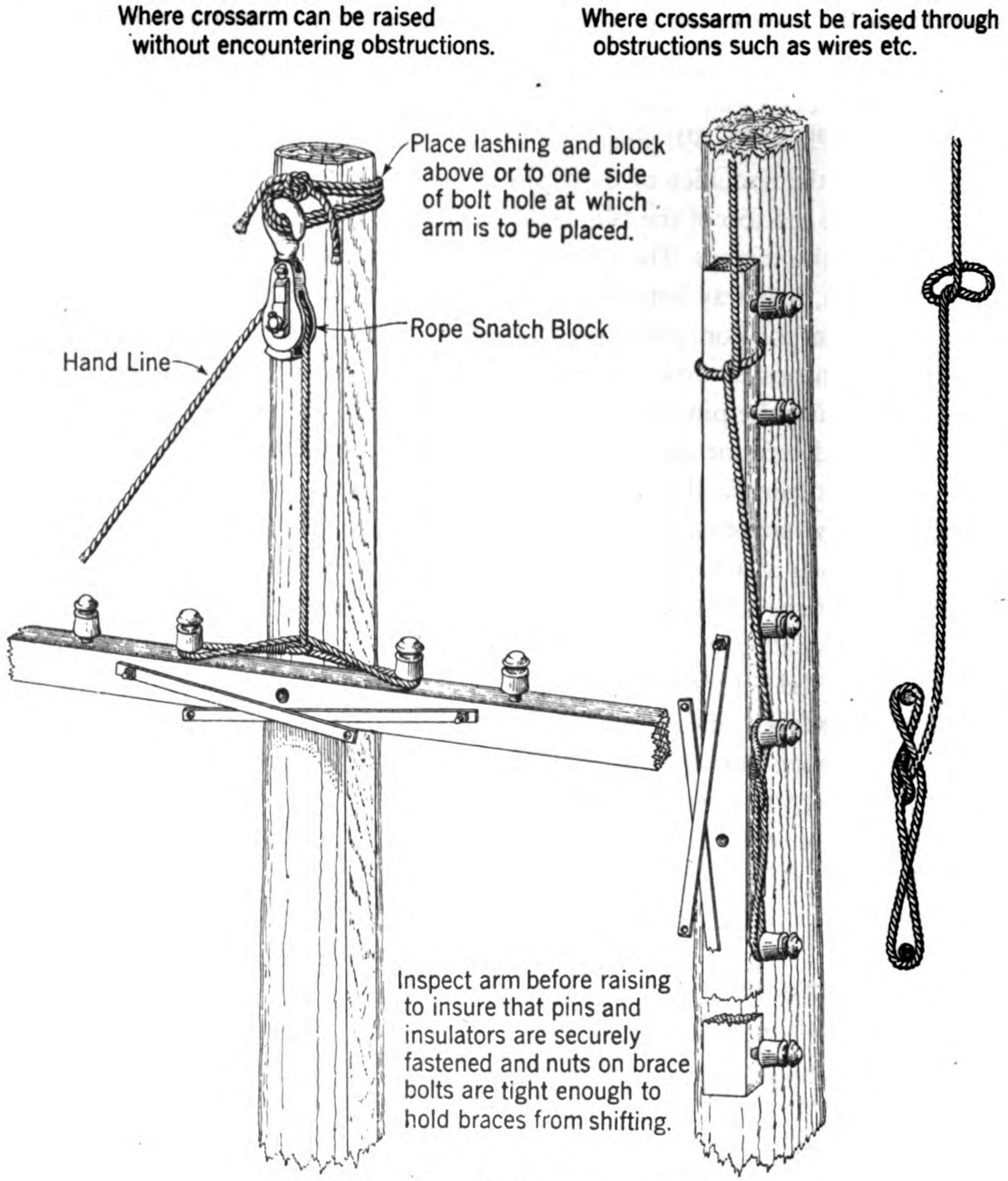



Figure 112.— Raising crossarm.

**123. ATTACHING CROSSARMS TO POLES.—** ***a.*** In general, attach crossarms to poles as outlined below:

(1) Select a 5/8 inch machine bolt long enough to extend about 5 inches beyond the face of the gain.

(2) Place a square washer on the bolt and drive the bolt into the hole from the back of the pole.

(3) Place the crossarm over the bolt with the braces away from the pole.
(4) Place a square washer over the projecting end of the bolt and turn the nut firmly into place with a wrench.

***b.*** Line up the crossarm so that it is at right angles to the axis of the pole. This may be done by using one of the following methods:
(1) If the pole is on the ground, place the short leg of a steel square on the bottom side of the crossarm in such a position that the outer edge of the long leg points along the center line of the pole toward the butt. Place a nail or otherwise mark the center line of the pole at a point 6 feet from the butt and move the crossarm until the long leg of the square points toward the nail or mark.
(2) If the pole is erected and the arm is the first to be placed, line up the crossarm by sighting from the ground a short distance away or from an adjacent pole. Arms other than the first may be lined up by placing them so that they will be parallel to the existing arms.

***c.*** Bring the lower ends of the crossarm braces together so that the holes register, and attach the braces to the pole with a ½-inch x 4½-inch lag screw.

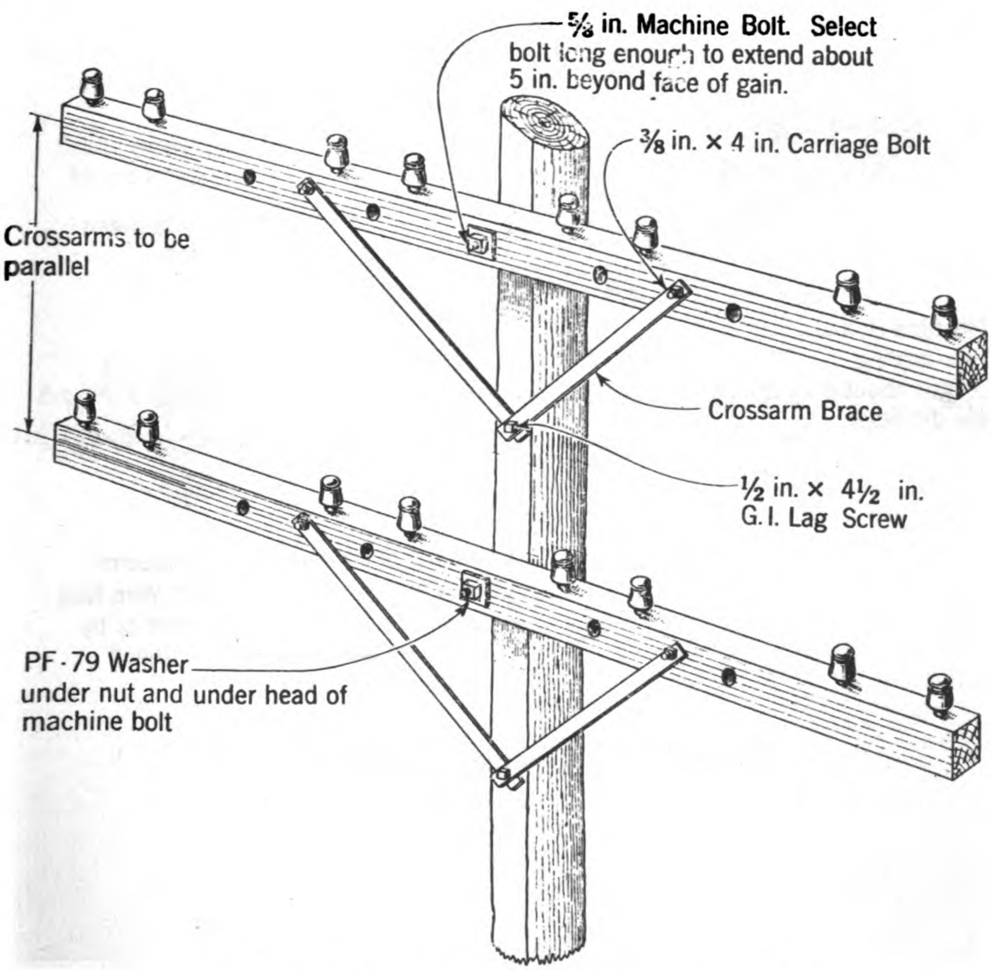



Figure 113.— Attaching crossarms to pole.

**124. DOUBLE CROSSARMS.—** ***a.*** Place double crossarms at the following locations.

(1) Railroad crossings other than street railways.

(2) Poles supporting spans, the length of which exceeds the normal pole spacing by 50 per cent. or more.

(3) Storm head guyed poles or head guyed H fixtures.

(4) At corner poles where the pull is 20 feet or greater.

(5) At deadends of six or more wires.

(6) At poles where there is a change in grade of more than 10 per cent.

***b.*** Attach double crossarms as outlined below:

(1) Select a ⅝ inch machine bolt having a length about 8 inches greater than the pole diameter.

(2) Place a square washer under the head of the bolt and drive the bolt through the crossarm. Hold the crossarm in place on the gained side of the pole with the bolt entering the hole in the pole. Complete driving the bolt through the pole.

(3) Place the other crossarm over the projecting end of the bolt. Place a square washer and nut on the bolt.

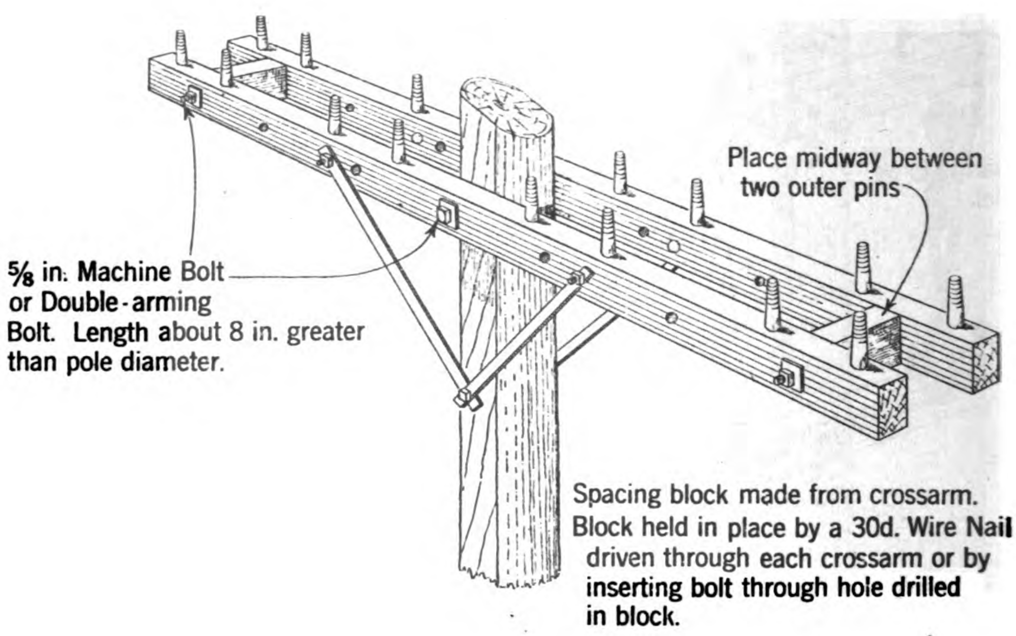



Figure 114.— Double crossarm.

**125. BUCK CROSSARM CONSTRUCTION.—** Buck crossarm construction as shown in figure 115, may be used at:

(1) Side leads where it is not practicable to branch off on a two-pole corner.

(2) Right angle corners in the pole line where the turn cannot be made on two or more poles.

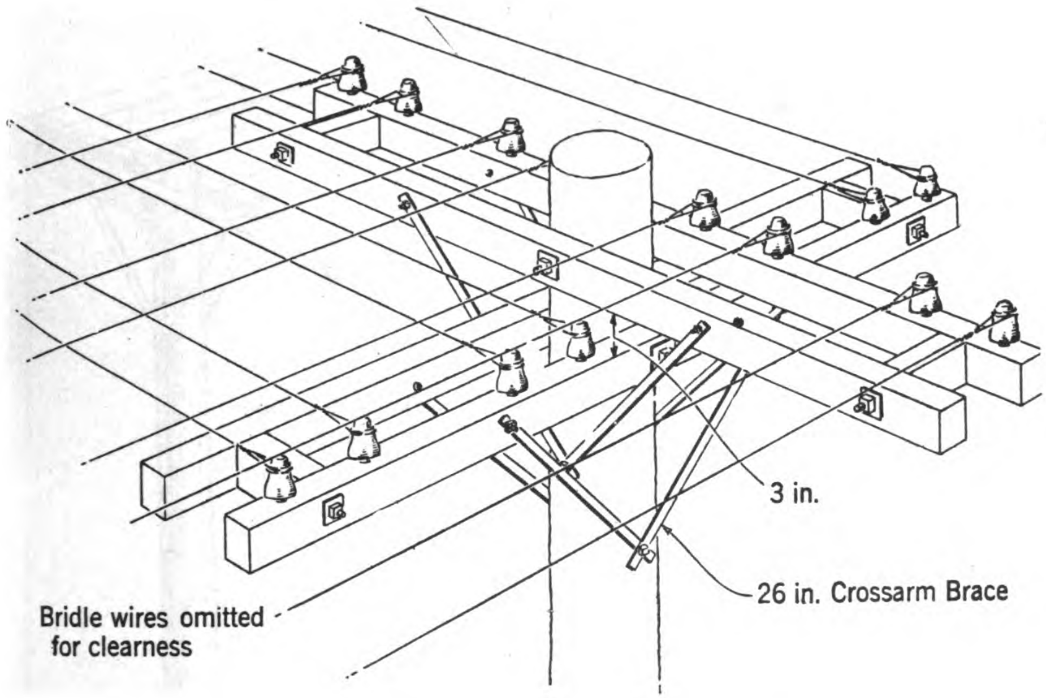



Figure 115.— Buck crossarm construction.

At buck crossarms it will be necessary to deadend the wires in both directions and make connections between them by means of bridle wire.

**126. CROSSARM GUY.—** Where wires terminate on the outside pins of only one end of a crossarm, guy the crossarm as shown in figure 116.

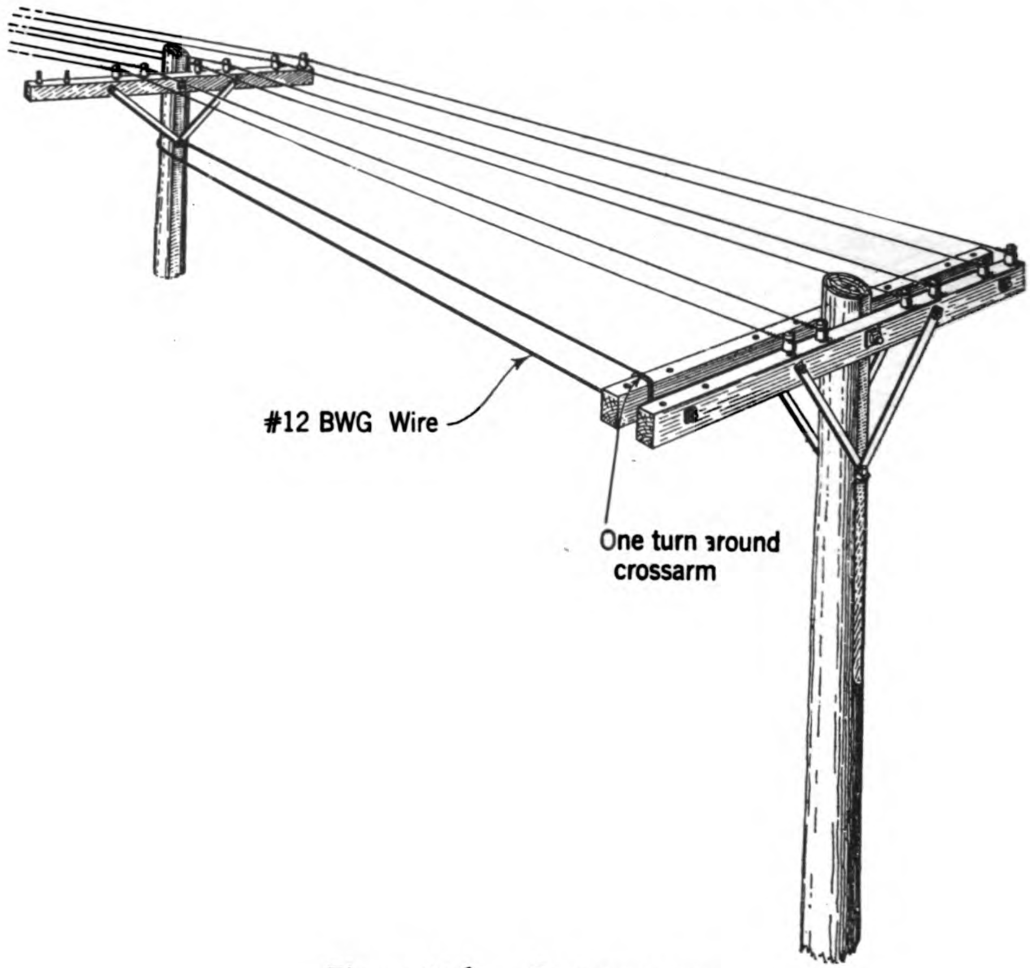



Figure 116.— Crossarm guy.

**127. CROSSARM CONSTRUCTION ON STEEP GRADES.**— On steep grades, that is, grades in excess of 20 per cent. (a rise of 20 feet for each 100 feet of horizontal distance), the crossarms should be set in notched gains, as shown in figure 117.

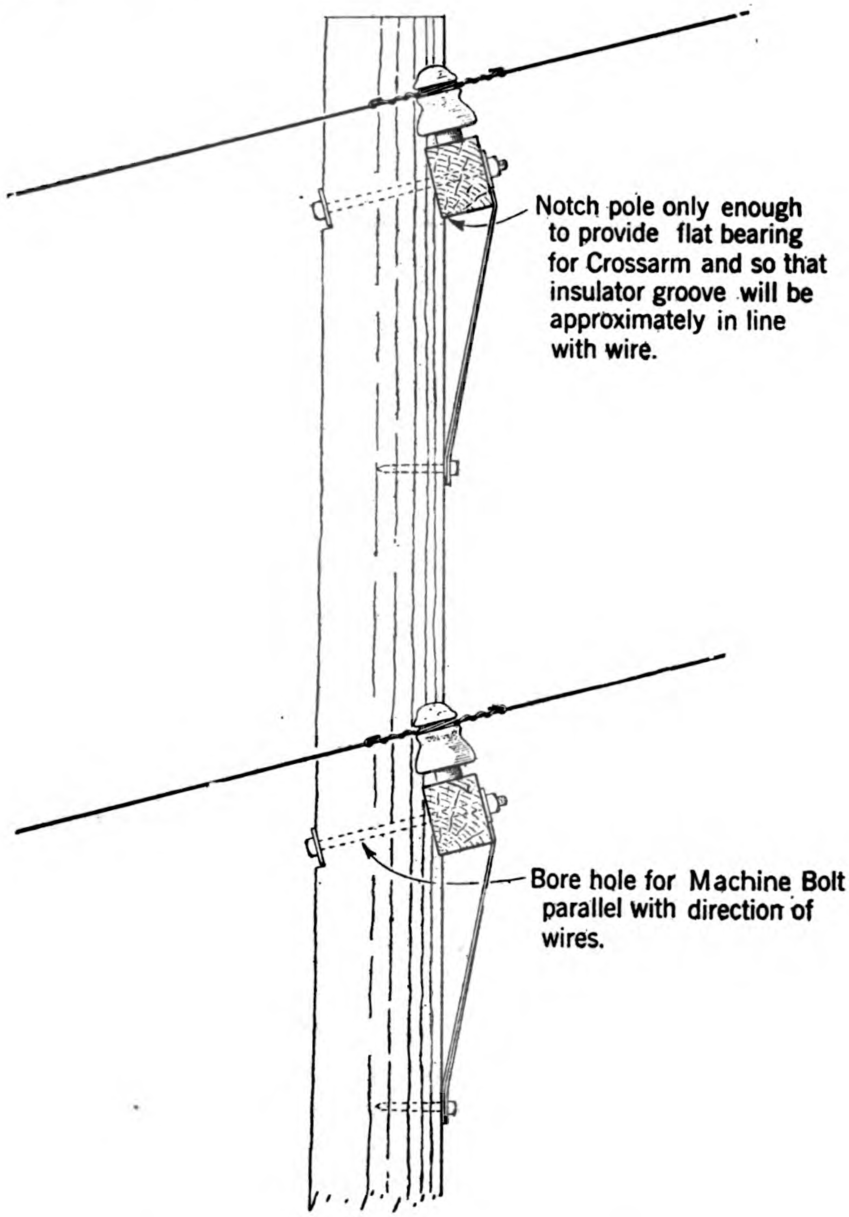



Figure 117.— Steep grade construction.

# CHAPTER VI
# PLACING OPEN WIRE



## *Section I*
## *Stringing Wire*

**128. GENERAL.–** The wire to be used will be 104 copper clad steel. It weighs about 160 pounds per mile and has a breaking strength of 1170 pounds. The strength of the wire is greatly reduced by nicking or kinking it. Care should be taken to avoid such damage when handling the wire. If kinks or nicks occur, cut them out before placing the wire.

**129. REEL SETUPS.–** ***a.*** Typical reel setups are shown in figures 118 and 119. The coils of wire should be placed on the reels so that the wires will feed from the tops of the coils. In some cases the wires will feed from the opposite side of the reel instead of the side shown in figures 118 and 119. When this occurs, if there is interference between the wire and the reel in front of it, the loops and snap hooks used as guides should be attached as indicated in these figures.

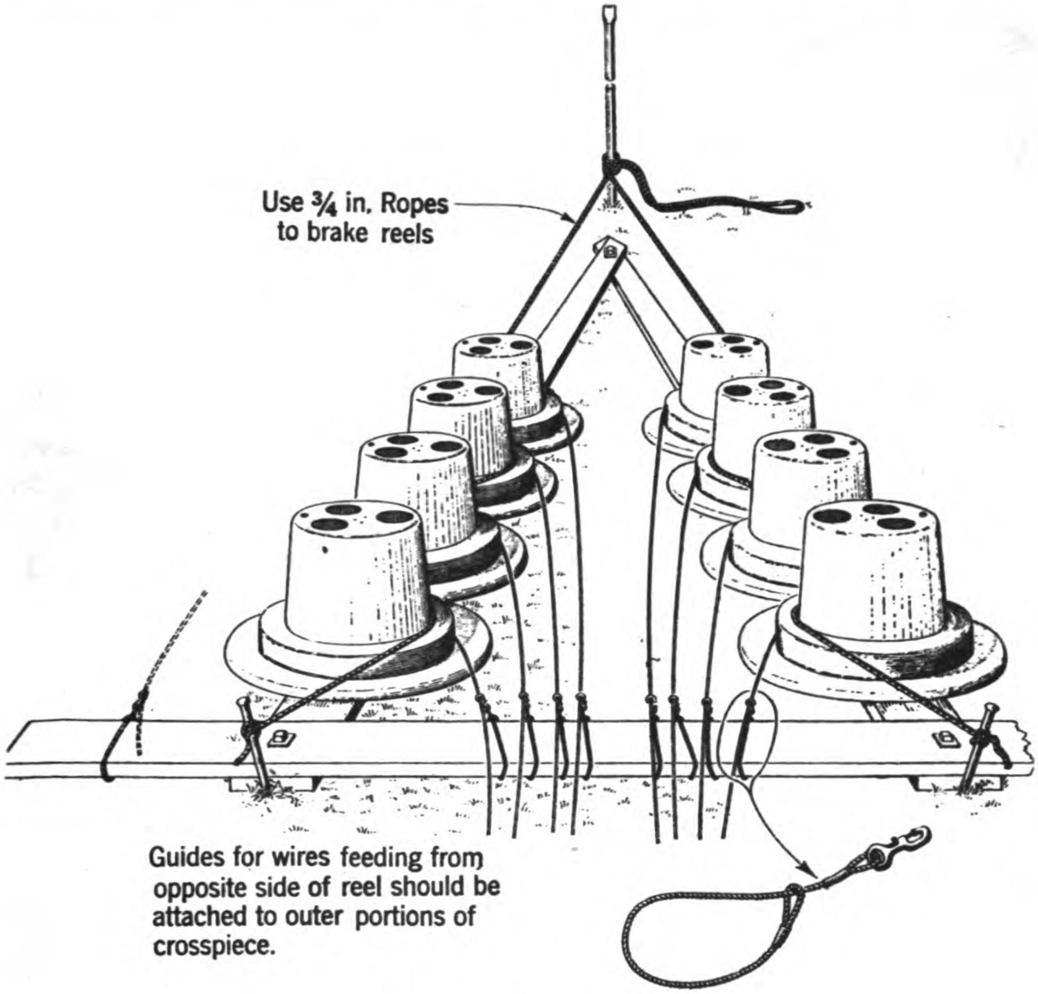



Figure 118.— Reel setup on ground.

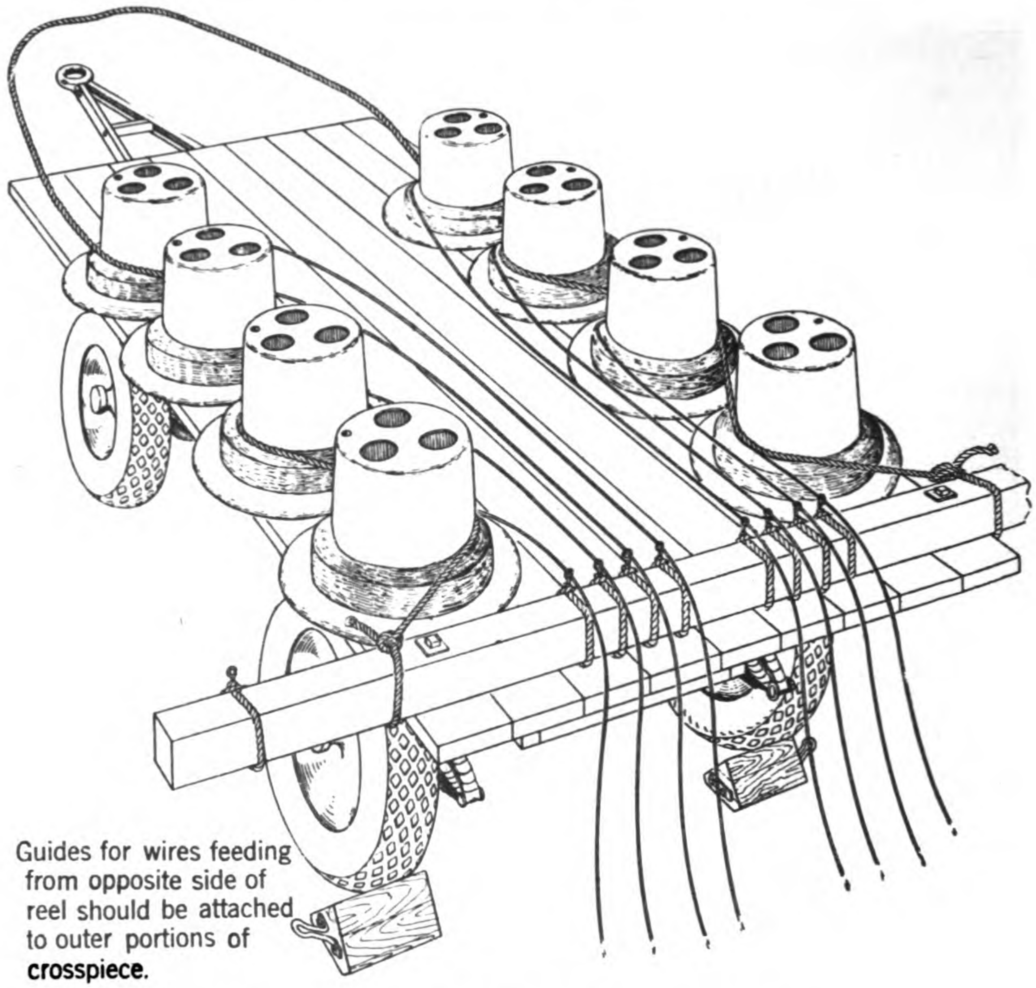



Figure 119.— Reel setup on trailer or wagon.

***b.*** If the wires tend to run out too freely, the reels should be braked by pulling on the brake rope behind the reels.

***c.*** If there is a possibility of the wires coming in contact with power wires along the line, the men tending the reels and all men handling the wires along the line should wear rubber gloves.

***d.*** When it is necessary to splice the end of a new coil of wire to the end of one of the coils which has been paid out, the man at the reels should signal ahead to have the pull stopped. After the pull has been stopped, place the new coil of wire on the reel, splice the ends of the wire and signal ahead to have the pull started again.

**130. PAYING OUT WIRE.— *a. Stringing wires in one direction only.—*** Where pole lines are so located that the reels may be set up practically anywhere along the line, the stringing of the wire is usually started at the beginning of the line and the wire pulled out as far as practicable; then a new setup is made, as shown in figure 120. Where conditions do not permit this procedure, the locations for setting up the reels should, in so far as practicable, be selected in advance so that the maximum length of wire can be strung in one pull. In all stringing jobs, organize the work so that signaling to the source of pull will promptly stop the pull. Each signalman must be seen by the next man.

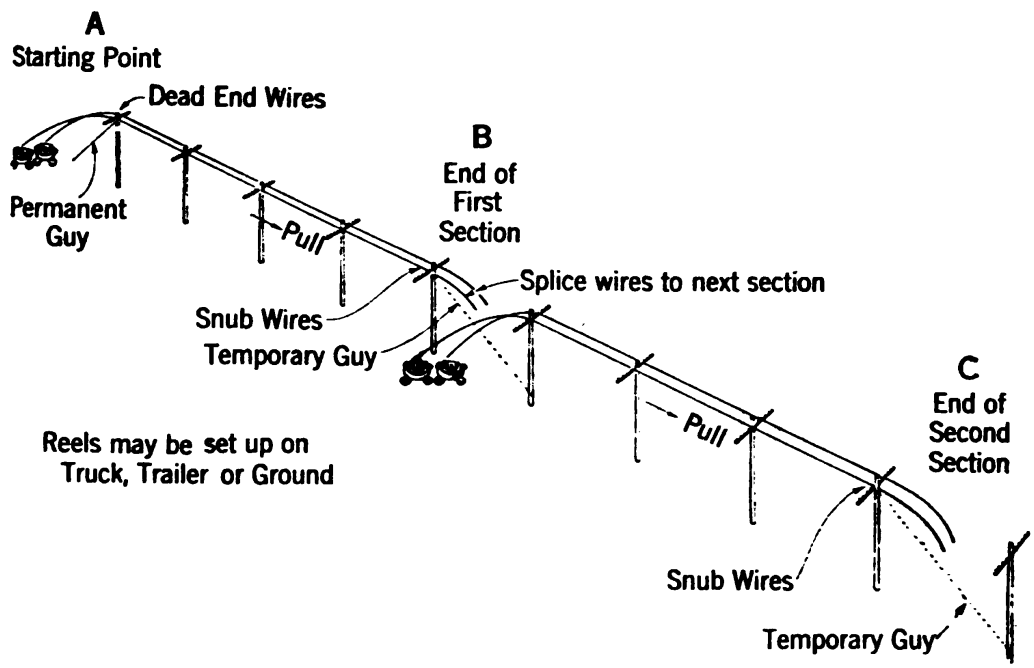



Figure 120.— Stringing wires in one direction only.

The order in which the operations should be performed is as follows:

(1) Set up the reels at a starting point, "A."

(2) Pull the wires out through the first section, the length of which is determined by the conditions encountered.

(3) Deadend the wires at the starting point "A," and where necessary, place a temporary guy on the pole at the end of the first section, "B."

(4) Pull the wires to the proper sag in the first section, locating the apparatus for pulling at the end of the section "B," and snub the wires at "B."

(5) Tie in the wires after they have been pulled up to the proper sag and snubbed.

(6) Continue the operation in the succeeding section in the same manner, except that the wires should be spliced to the wires of the preceding section instead of deadending them as at the starting point.

(7) Remove temporary head guys as the job progresses.

***b. Stringing wires in both directions.***— Where the conditions are such that only specific points are available for setting up the reels and it is practicable to select points from which the wire can be run out in both directions, the order in which the operations of stringing wire should be performed is as follows. (See figure 121.)

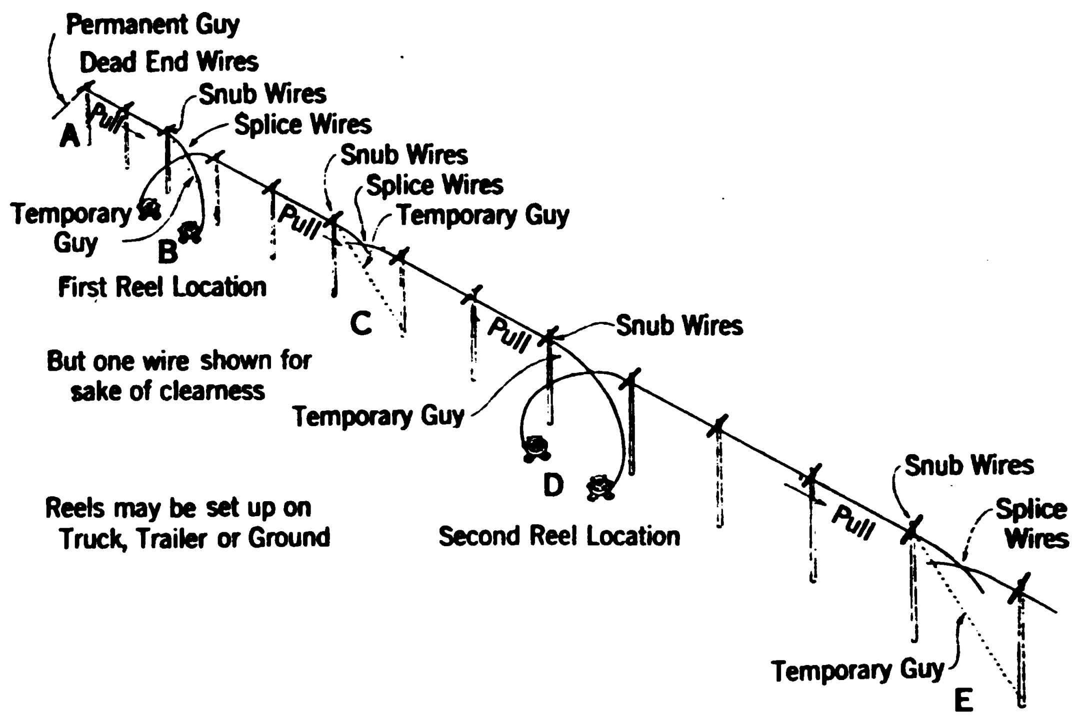



Figure 121.— Stringing wires in both directions.

(1) Select the first reel location, "B," near enough to the starting point "A," to permit pulling the wire back to the starting point, and at a point which will permit pulling out the wire in both directions.

(2) Set up the reels at the first reel location "B."

(3) Pull wires out from "B" toward "A" and deadend the wires at "A."

(4) Where necessary, place a temporary guy at "B."

(5) Pull the wires in the section "A-B" to the proper sag from "B" and snub the wires at "B."

(6) Pull the wires out from "B" to "C."

(7) Splice the wires at "B."

(8) Where necessary place a temporary guy at "C."

(9) Pull the wires in section "B-C" to the proper sag from point "C" and snub the wires at "C."

(10) Tie in the wires after they have been pulled to the proper sag and snubbed.

(11) Move the reels to the second reel location "D" and proceed as outlined for the first reel location, except that the wires shall be spliced at "C" instead of deadended.

(12) Remove temporary head guys as the job progresses.

**131. PULLING WIRES.— a.** In pulling out the wires, each wire is fastened to a snap fastener and attached to a running board. A pulling line of 5/8 inch manila rope, free from metallic strands and about 800 feet long, is fastened to the front of the running board and used to pull the wires along the pole line. If not more than four wires are to be placed, and they are all to be placed on pins on the same side of the pole and on the same crossarm, only one running board need be used. (See figure 122.) If the wires are to be on opposite sides of the pole or on different crossarms, separate running boards should be used for the wires on each side of the pole on each crossarm; as shown in figure 123.

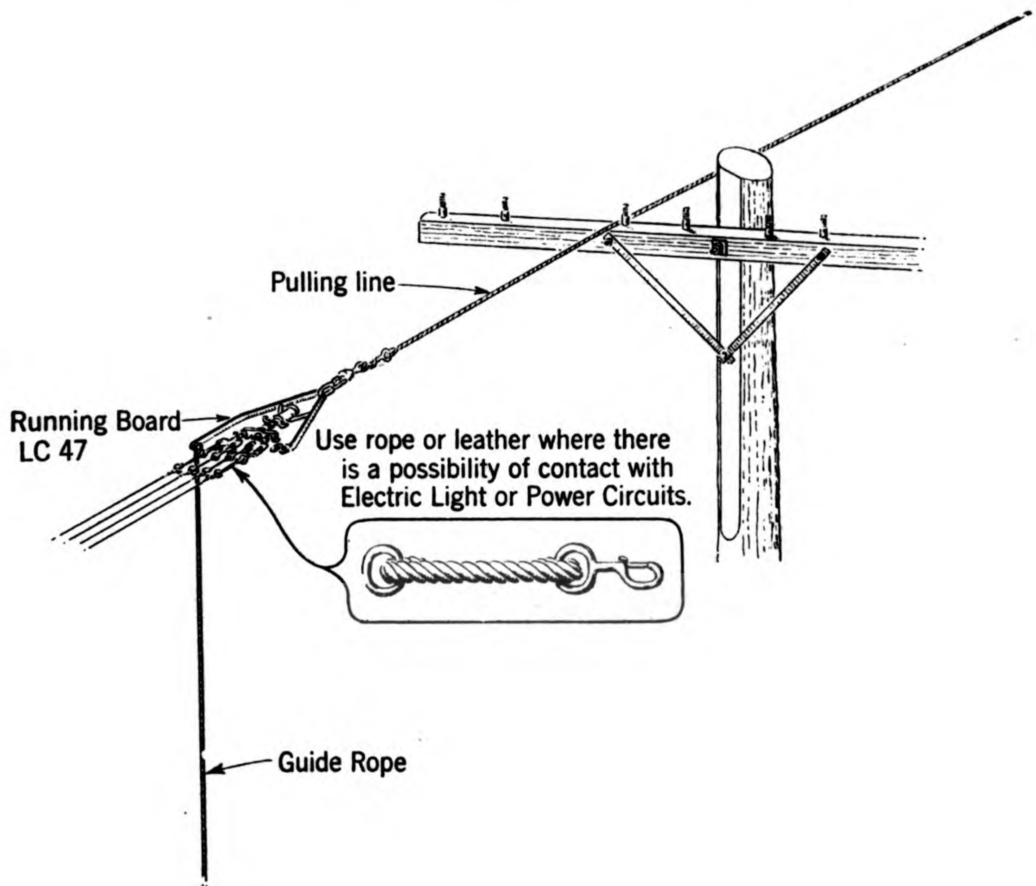



Figure 122.— Pulling wires with one running board.

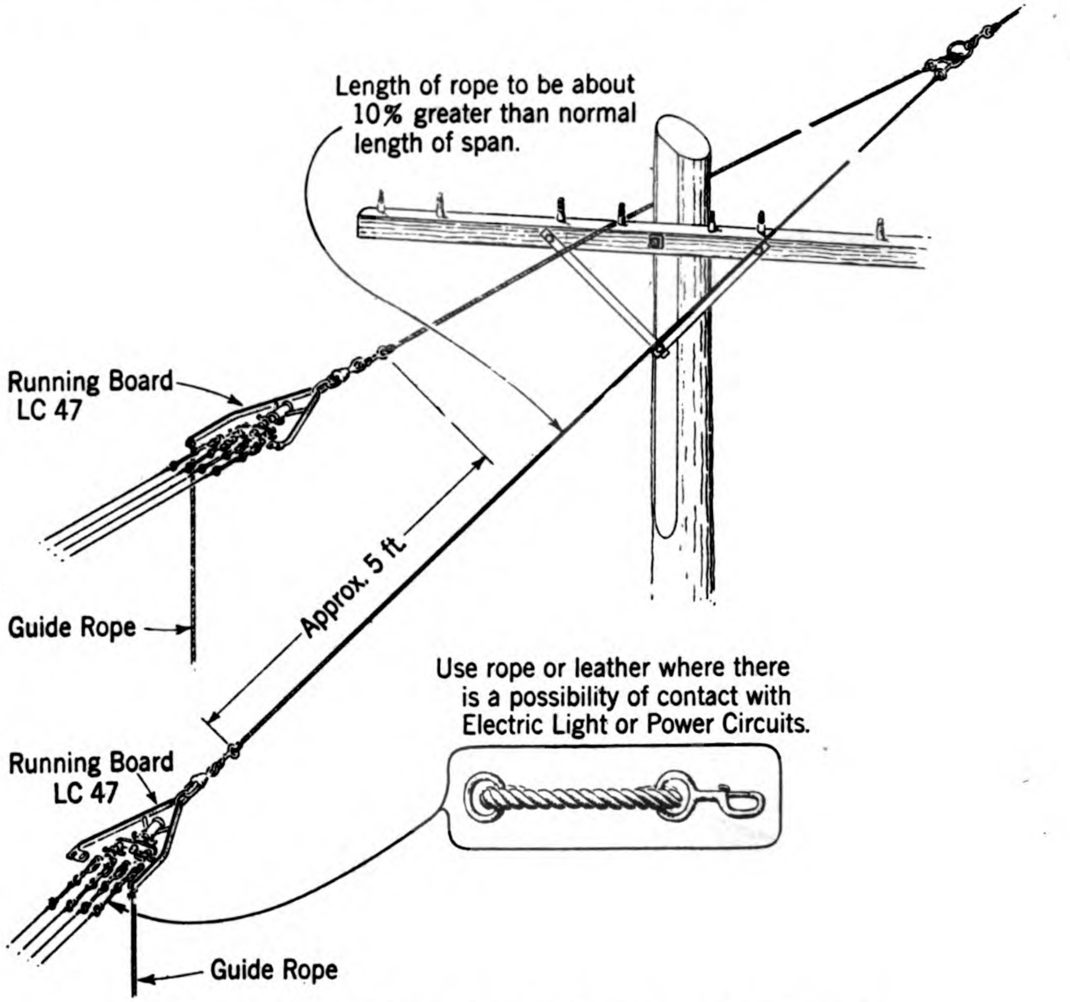



Figure 123.— Pulling wires with two running boards.

***b. Guide rope.—*** A guide rope should be fastened to the knob on the frame of each running board, as shown in figures 122 and 123, to help in keeping the running board from turning. If the running board should turn over, the position of the rope will show the direction in which the running board should be turned back.

***c. Arranging wires on crossarm.—*** As each pole is passed by the men on the end of the pulling line, one man should climb the pole and place the pulling line over the crossarm on the proper side of the pole. He should take a position on the pole on the side opposite the approaching running board and facing toward the location of the reels. As the running board reaches the pole, the man on the pole should lift it over the crossarm. If transpositions are to be made in any of the pairs of wires he should turn the pair over at the back of the running board as it is lifted over the crossarm, signaling for the pull to be stopped while this is being done. After the running board has passed the pole and before the pulling is started again, the wires should be placed in their proper pin positions. If there is an up pull on the wires at the pole, so that the wires will tend to pull out of their proper positions, a rope should be placed to hold them in place, as shown in figure 124.

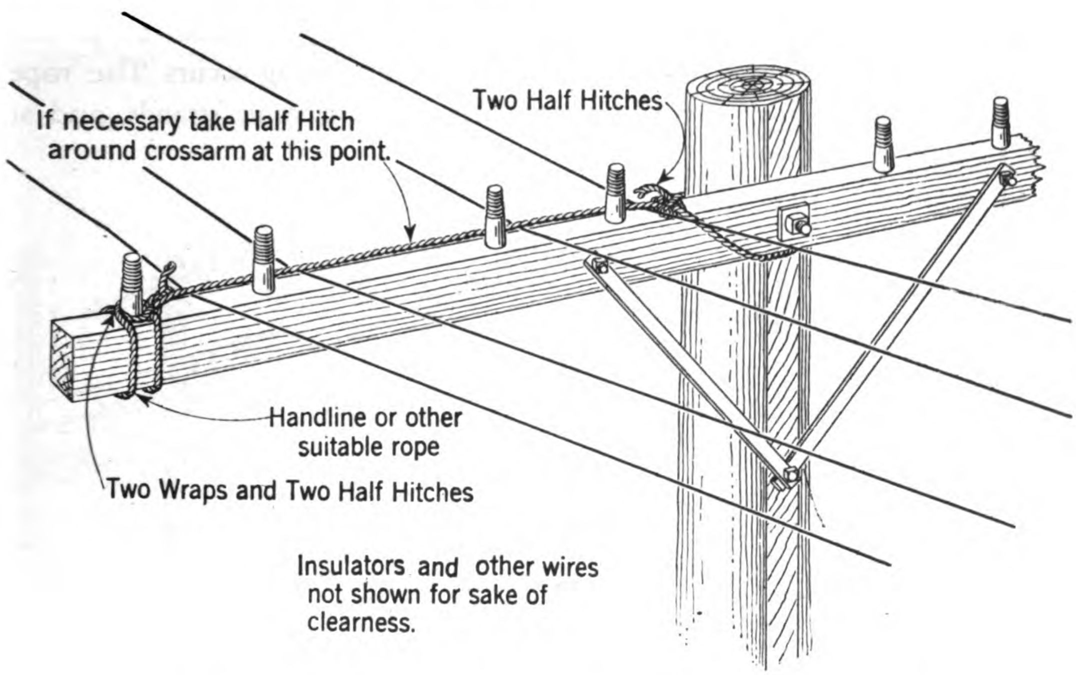



Figure 124.— Holding wires in position while stringing.

***d.*** If two running boards are being pulled at the same time, the line to each running board will have to be passed over the proper crossarm on the proper side of the pole. This should be done by the man on the pole when the pull is stopped, by unsnapping the line to one of the running boards from the main pulling line and passing it around the other side of the pole and then reconnecting it to the main pulling line. If no transpositions are to be made at the pole, it will not be necessary to stop the pull to handle the running boards, as the shorter line on the first running board to reach the pole will make it possible to lift it over the crossarm before the running board with the longer line reaches the crossarm.

**132. STRINGING WIRES OVER ROADS OR RAILROADS.—** When stringing wires over streets, roads or railroads the reels should be braked enough to keep the wires from sagging down where they might be hit by vehicles or trains. The pulling line should be held taut at all times. A man should be stationed at the crossing while the wires are being strung to warn vehicles in case anything happens to let the wires sag down too far.

**133. STRINGING WIRES OVER ELECTRIC POWER LINES.—** Before wires are pulled over electric light or power wires, special precautions should be taken to keep them from getting into contact with the power wires. All men handling the wires must wear rubber gloves until the wires have been tied in and spliced through to the next section. To keep the wires from sagging down on the power wires, a rope screen, as shown in figure 125, should be placed before the wires are pulled into the span where the crossing occurs. The rope screen should be made of dry manila rope, free from metallic strands, and at least ½ inch in diameter.

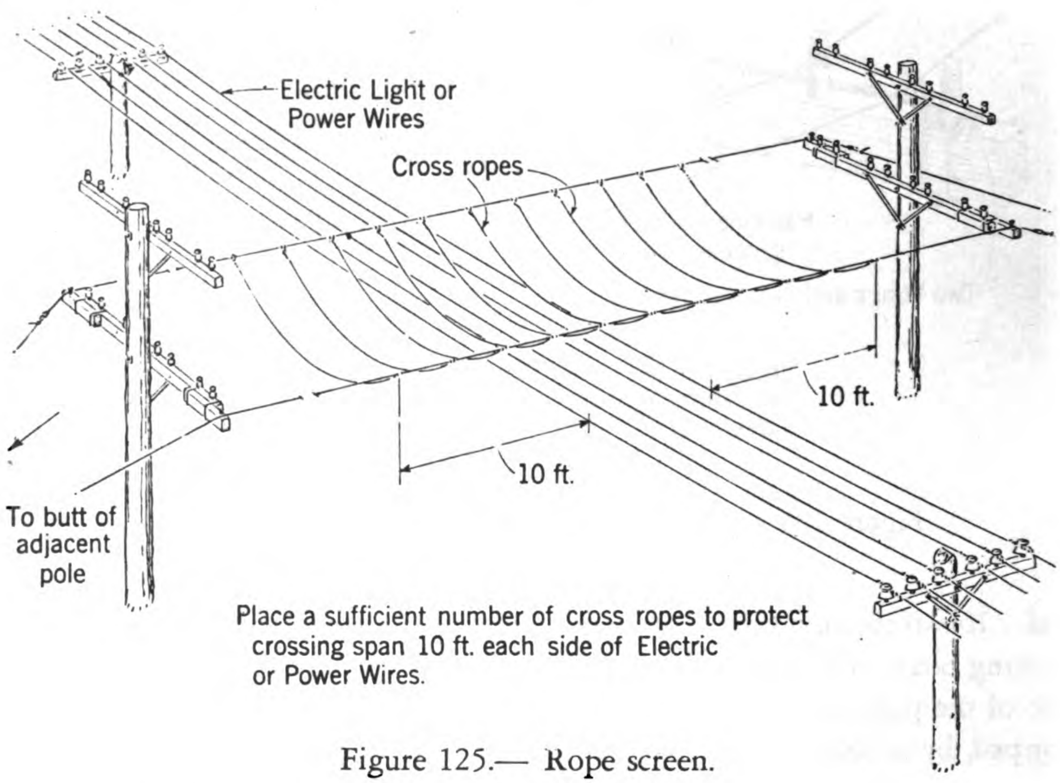



Figure 125.— Rope screen.

**134. SNUBBING WIRES.—** ***a.*** After the section of wire has been strung, it will be necessary to pull the wires to the proper sag and then snub them until they are tied in at the insulators and spliced to the next section of wire. By using equalizing blocks, all the wires being strung on the same crossarm can be pulled up so that they will have the same tension. The use of equalizing blocks is shown in figures 126, 127, and 128.

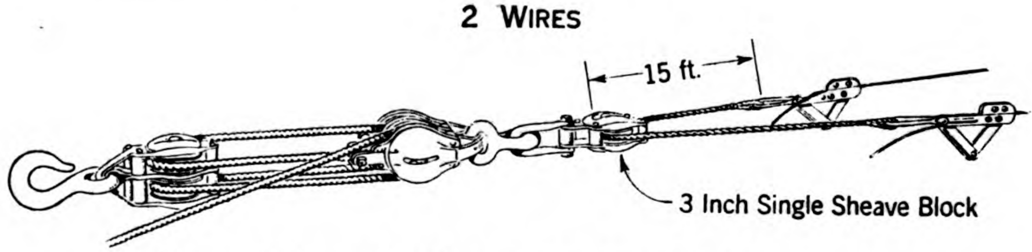



Figure 126.— Use of equalizing blocks for two wires.

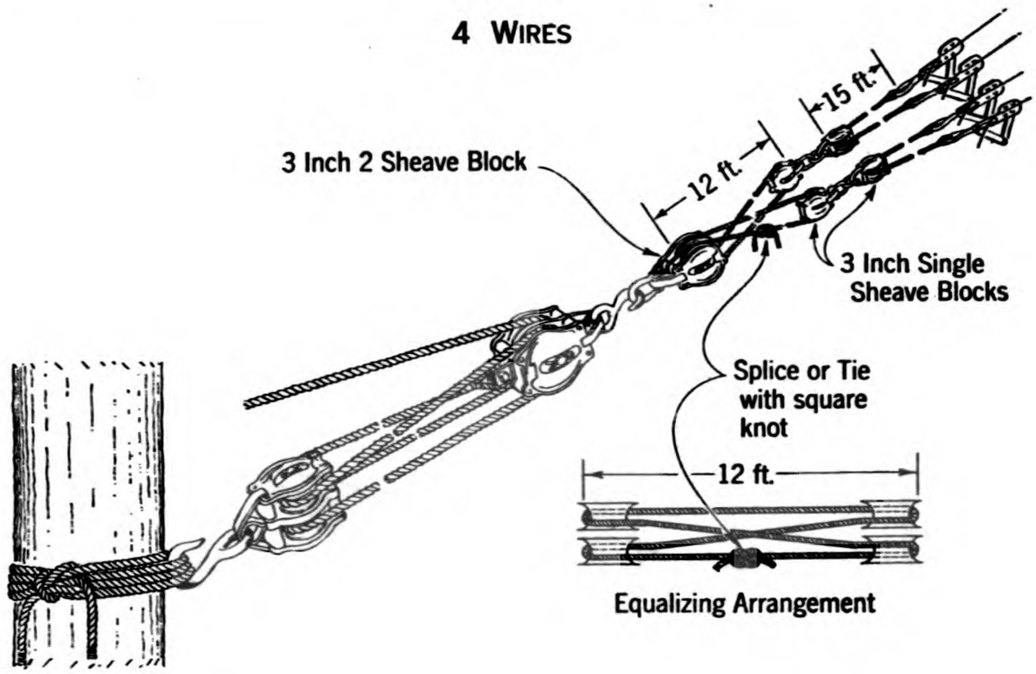



Figure 127.— Use of equalizing blocks for four wires.

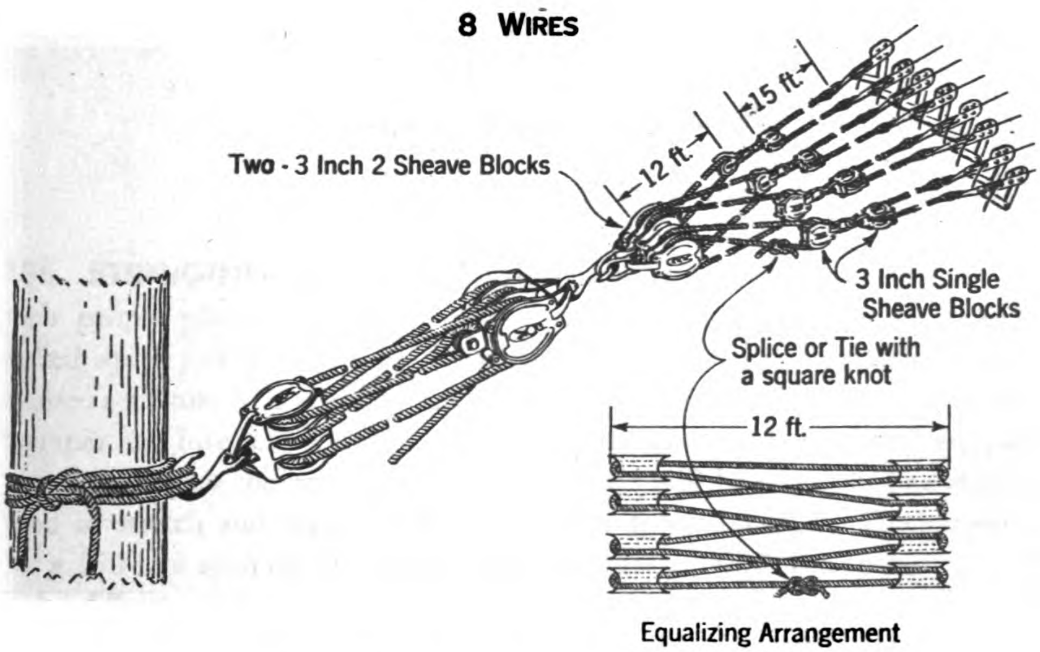



Figure 128.— Use of equalizing blocks for eight wires.

*b.* After the wires have been pulled to the proper sag, they should be snubbed by means of the method shown in figure 129.

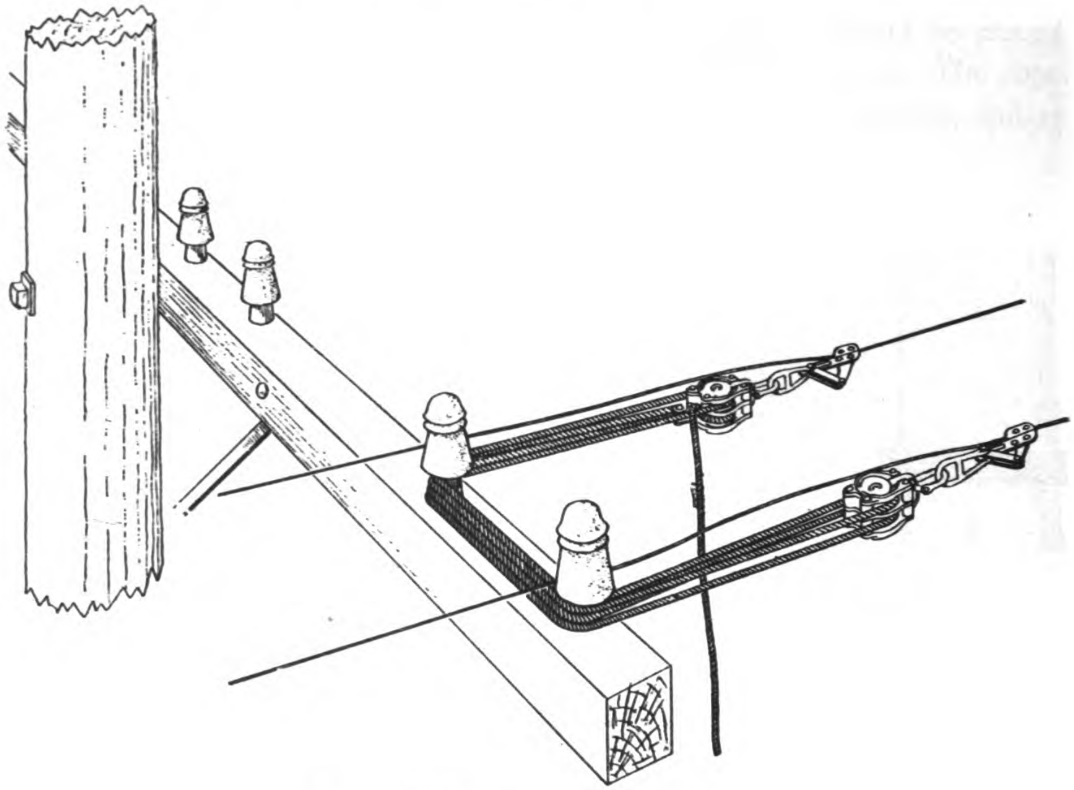


Figure 129.— Snubbing wires.

# Section II
# Open Wire Sags

**135. DEFINITION.—** The sag of a span of open wire is the vertical distance between a straight line joining the two ends of the span and the wire at the point where its separation from the straight line is greatest. This is illustrated in figure 130.

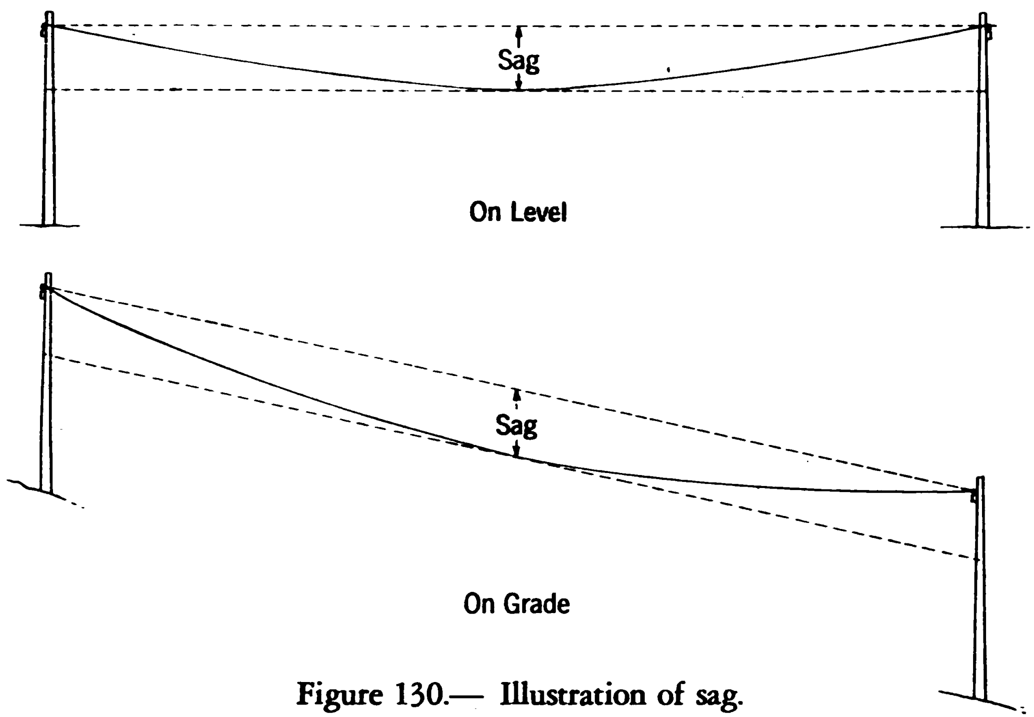



Figure 130.— Illustration of sag.

**136. STRINGING SAGS.— *a.*** After wires have been strung and placed in their proper places on the crossarms, it is important that the wires should be pulled up to just the right sag before they are snubbed or deadended and tied to the insulators. If too much sag is left in the wires they will tend to swing together and interfere with the operation of the circuits. If the wires are pulled up so much that the sag is too small, the wires will be too tight and they will tend to stretch and break, particularly if ice forms on them. The proper sag for a 150-foot span of 104 copper clad steel wire at 60° F. is 6 inches.

***b. Effect of temperature on sag.—*** Inasmuch as the wire expands when the temperature rises, and contracts when the temperature drops, the temperature at the time the wire is pulled up must be taken into account in order to get the proper sag. If the wires were pulled up to a sag of 6 inches when the temperature is considerably higher than 60° F., the sag would be much less than 6 inches when the temperature later dropped to 60° F. On the other hand, if the wires were strung with a sag of 6 inches at a temperature lower than 60 °F., the sag would be greater than 6 inches when the temperature later rose to 60° F.

***c. Effect of span length on sag.***— The sag in a long span has to be greater than the sag in a short span in order to have the same tension in the wire. If the wires in a span longer than 150 feet were pulled up until the sag is 6 inches at 60° F., the wires would be too tight. On the other hand, if the wires in a span shorter than 150 feet were pulled up just enough to give a sag of 6 inches at 60° F., the wires would be too loose. Consequently, in stringing wire, the length of the span in which the sag is measured must be taken into account, allowing greater sag for long spans and less sag for short spans.

***d. Sag table.***— The table in figure 131 shows the proper sags for 104 copper clad steel wire for various span lengths and various temperatures. Deviations of not more than one inch from these specified sags are permissible when stringing wires. This maximum deviation ensures that the difference in sag between the two wires of any pair will not be more than two inches. This is important in order to prevent excessive crosstalk and noise in the circuits.

WIRE STRINGING SAGS FOR 104 COPPER CLAD STEEL LINE WIRES

| Span Length Feet | Temperature - Degrees Fahrenheit | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100 | 90 | 80 | 70 | 60 | 50 | 40 | 30 | 20 | 10 | 0 | −10 |
| | Sag-Inches | | | | | | | | | | | |
| 120 | 5 | 5 | 4 1/2 | 4 | 4 | 3 1/2 | 3 | 3 | 3 | 2 1/2 | 2 1/2 | 2 |
| 130 | 6 | 6 | 5 | 5 | 4 1/2 | 4 | 4 | 3 1/2 | 3 1/2 | 3 | 3 | 2 1/2 |
| 140 | 7 | 7 | 6 | 5 1/2 | 5 | 4 1/2 | 4 | 4 | 4 | 3 1/2 | 3 1/2 | 3 |
| 150 | 8 1/2 | 8 | 7 | 6 1/2 | 6 | 5 1/2 | 5 | 5 | 4 1/2 | 4 | 4 | 3 1/2 |
| 160 | 9 1/2 | 9 | 8 | 7 1/2 | 7 | 6 1/2 | 6 | 5 1/2 | 5 | 4 1/2 | 4 1/2 | 4 |
| 170 | 11 | 10 | 9 | 8 1/2 | 8 | 7 | 6 1/2 | 6 | 6 | 5 1/2 | 5 | 4 1/2 |

Figure 131.— Table of sags for various span lengths and temperatures.

**137. METHODS OF OBTAINING SAGS.**— ***a. Test span.***— The span selected for testing should be one of average length, preferably with the crossarms at both poles on the same level and about 10 spans away from the end of the stringing section. Measure the length of the test span from the center of the pole at one end of the span to the center of the pole at the other end of the span and use the line in figure 131 showing the nearest span length. Use a thermometer to obtain the temperature of the air and use the column in figure 131 showing the nearest temperature to that shown on the thermometer.

***b. Sighting method.***— (1) Pull the wires slightly tighter than required and then slack them back slightly. Hang a sag gauge on the crossarm at each end of the test span. Set the target on each gauge so that the top of it coincides with the figures corresponding to the amount of sag specified in figure 131 for the particular length of span and temperature. The best results can be obtained by offsetting the targets on the crossarms. For example, in sighting on No. 3

wire, set one target against pin No. 1 and the other target against pin No. 4 at the opposite end of the span. Sight across from the top of one target to the top of the other and with the wire resting on the top of the crossarms, adjust the sag in the wire by pulling up or slacking back, until the lowest point in the span is in line with the tops of the targets. (See figure 132.)

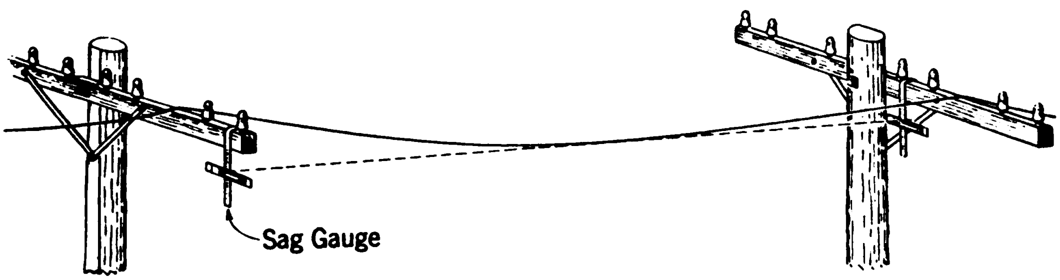



Figure 132.— Measuring sag with sag gauge.

(2) Select another span about ten spans nearer the pulling end of the stringing section and adjust the sag in the same wire, as outlined above. In sections of line containing corners, more frequent sag measurements should be obtained in the spans beyond the corners.

***c. Oscillation method.***— This method has been developed for determining when wire has been pulled to the proper sag and can be used as a means of checking the tensions in the wires. The oscillation method consists of determining the actual sag by oscillating the wire vertcially or horizontally and counting the oscillations, the number of which indicates the sag. It is necessary to make the oscillation test on only one wire on each crossarm. If the wires are pulled up with pulling blocks, strain equalizing blocks and tackle, all the wires should have the same sag and the same number of oscillations. Where strain equalizing blocks and tackle are not used, the sag of the other wires may be obtained by sighting relative to the tested wire. The wire should be free to oscillate without contact with tree limbs or other objects. In order that the sag may be adjusted in all sections, it is desirable to select the spans for testing, starting from the deadend point and advancing toward the pulling end. In straight sections, for each stringing section, it will be satisfactory to have a test made once every ten spans, the first test being made about ten spans from the deadend. In sections of line containing corners, more frequent tests may be necessary. After the test span has been selected:

(1) Determine the number of oscillations for 15 seconds from the table in figure 133.

(2) In preparing to oscillate the wire the man on the pole shall signal for pulling the wires. The wires shall be pulled, until in his judgment they are slightly tighter than required and then slacked back slightly, as better results are obtained by testing the wire in that manner.

OSCILLATIONS IN 15 SECONDS

| Span Length Feet | Temperature - Degrees Fahrenheit | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100 | 90 | 80 | 70 | 60 | 50 | 40 | 30 | 20 | 10 | 0 | −10 |
| | Oscillations | | | | | | | | | | | |
| 120 | 23 | 23 | 24 1/2 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 36 |
| 130 | 21 | 21 | 23 | 24 | 24 1/2 | 26 | 27 | 28 | 29 | 30 | 31 | 33 |
| 140 | 19 | 20 | 21 | 22 | 23 | 24 1/2 | 25 | 26 | 27 | 28 | 29 | 30 |
| 150 | 18 | 18 1/2 | 20 | 20 1/2 | 21 | 22 | 23 | 24 | 24 1/2 | 26 | 27 | 28 |
| 160 | 17 | 17 1/2 | 18 1/2 | 19 | 20 | 20 1/2 | 21 | 22 | 23 | 24 1/2 | 25 | 26 |
| 170 | 15 1/2 | 16 1/2 | 17 1/2 | 18 | 18 1/2 | 20 | 20 1/2 | 21 | 21 1/2 | 22 | 23 | 24 1/2 |

Figure 133.— Table of oscillations.

(3) The wire should be made to oscillate by a man on the pole striking the wire with his hand at the crossarms. Where the number of oscillations is small, the wire should be made to oscillate sidewise. Where the number of oscillations is large the wire should be made to oscillate up and down. By "oscillations" is meant the complete motion of the wire either from one side to the other and back, or vertically from the highest position to the lowest position and back again at the particular point at which the measurement is made. The oscillation can also be measured by the travel of the wave along the wire from a point at one end of the span to the other end and back to the starting point.

(4) The number of oscillations shall be counted by the man on the pole, holding the wire on the insulator with one hand and holding a finger of the other hand near the wire at the crossarm and counting the number of times in 15 seconds that the wire hits the finger. This is the number of oscillations of the wire which should correspond to that selected from the table. If the number of oscillations is less than required, the wire shall be pulled up. If the number is more, slack off the wire. The count shall always be checked.

# *Section III*
# *Splicing Wire*

**138. SPLICING MATERIALS AND TYPES OF SPLICES.— *a.*** Splices in line wire are made by means of either rolled or pressed sleeves. Splices of this type are made by inserting the ends of the wire to be spliced in a single tube sleeve and constricting the sleeve by means of either a hand operated rolling or a pressing tool. The inner surface of the sleeve is coated with an abrasive to increase its holding power. Rolled and pressed splices made with these sleeves will be as strong as the line wire itself. Also, the close contact obtained between sleeve and wire prevents the entrance of moisture or gases and this prevents corrosion and the development of high resistance joints. The sleeve rolling tool TL-143 is illustrated in figure 134 and the sleeve pressing tool in figure 135. As will be noted in the illustrations, the rolling tool has three grooves and the pressing tool two grooves to accommodate sleeves for various sizes of line wire.

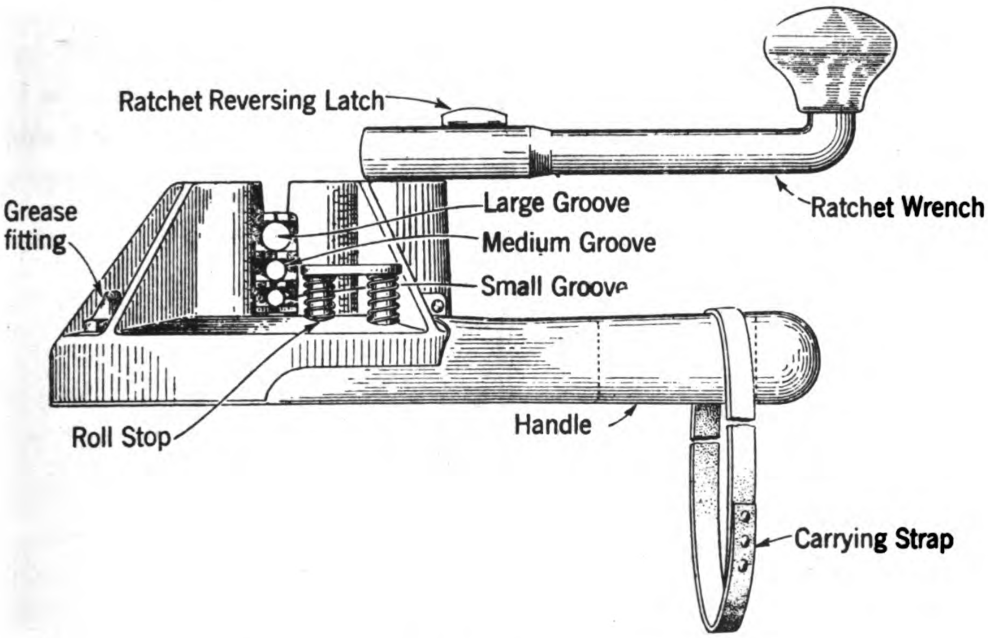



Figure 134.— Sleeve rolling tool TL-143.

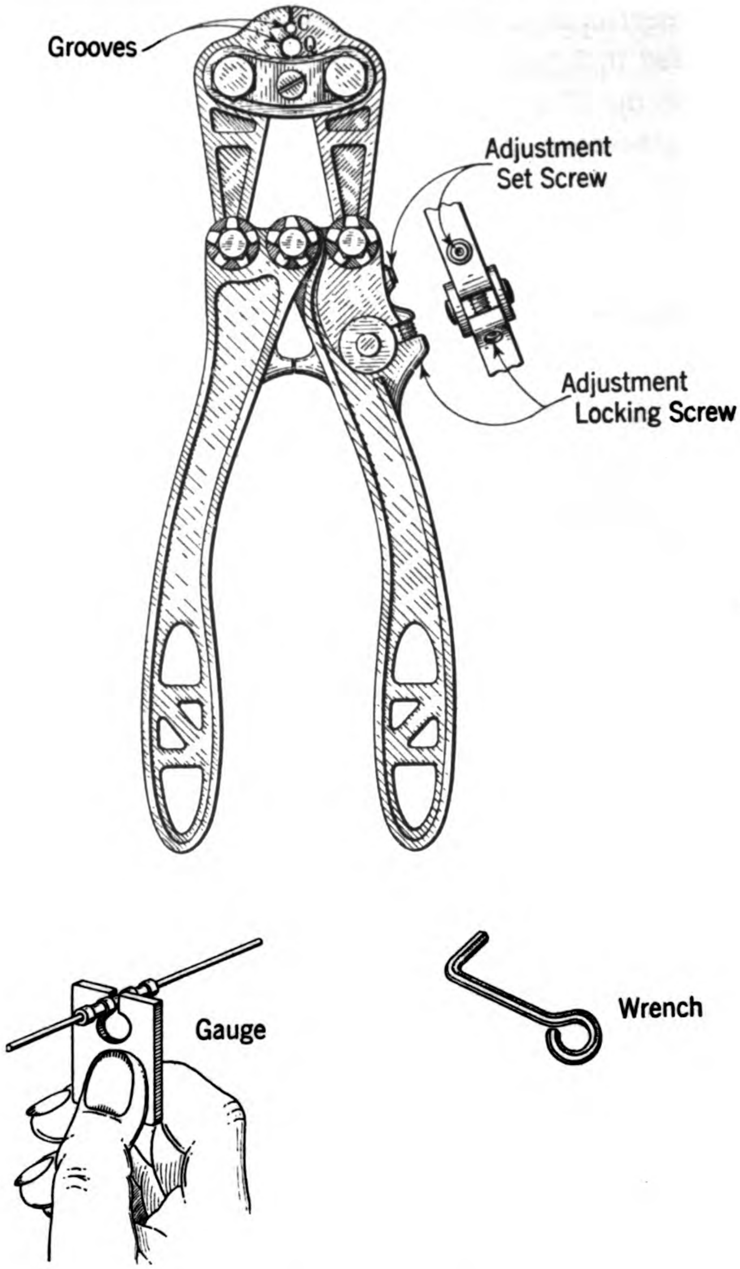



Figure 135.— Sleeve pressing tool.

***b.*** The C-104Q copper sleeve is used for making rolled or pressed sleeve joints in 104 CCS line wire. This sleeve is $2\frac{5}{16}$ inches long. If a rolled sleeve joint is made, use the medium groove of the TL-143 tool. If a pressed sleeve joint is made, make 4 presses in each half of the sleeve with the pressing tool, using the groove marked "Q."

**139. MAKING ROLLED SLEEVE SPLICES.**— The procedure for making a rolled sleeve splice is as follows:

***a.*** Clean the ends of the wires with emery cloth until they are bright and shiny. Remove any burrs on the ends of the wires.

***b.*** Place the end of one of the wires in the bore of the sleeve, pushing it in until it is stopped by the indentation at the middle of the sleeve.

***c.*** To hold the sleeve on the wire, crimp the sleeve about ¼ inch from the end with the cutting edge of 8-inch side cutting pliers, TL-107, as shown in figure 136. Place the second wire in the other end of the sleeve and repeat the operation.

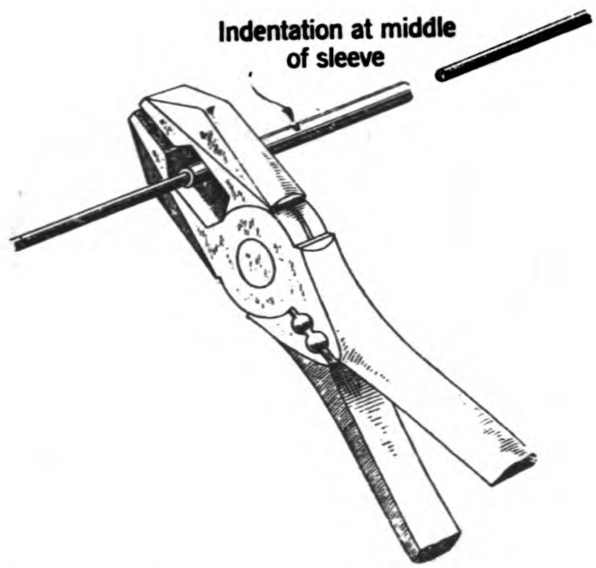



Figure 136.— Crimping sleeve to hold wire before rolling.

***d.*** Before placing the tool on the wire, turn the ratchet wrench until the flat portions of the rolls are opposite each other. (See figure 137.) This may be done by depressing the roll stop and turning the wrench slowly until the roll stop slides into place. Do not spin the wrench when doing this as the sudden stop which would then result when the roll stop engages the gear inside may damage the tool. Also, do not force the wrench when the roll stop is engaged.

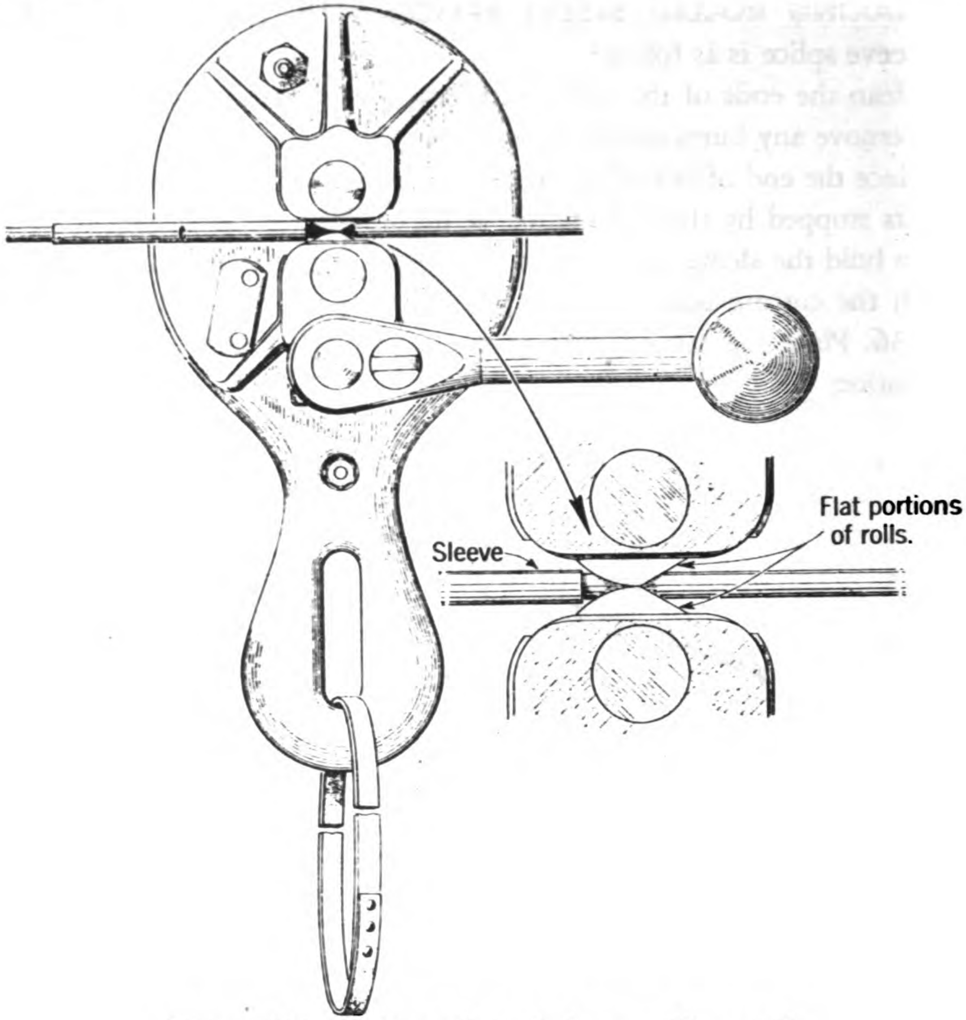



Figure 137.— Operation of sleeve rolling tool.

**e.** Hold the rolling tool beyond the end of the sleeve and place the line wire between the flat portions of the rolls with the medium sleeve groove ahead of the sleeve. In order to make sure of an airtight joint at the end of the sleeve, turn the wrench so that the flat portions of the rolls will be in the position shown in figure 137 as the sleeve enters the groove.

**f.** Roll the sleeve by operating the ratchet wrench or by turning the wrench without ratcheting. In the position shown in figure 137, the down or clockwise, stroke applies the force to roll the sleeve. The handle of the tool should be held at right angles to the line wire in order to form a straight splice. If the sleeve is slightly bent or curved after it has been rolled, do not try to straighten it.

**g.** Rolling should start at one end of the sleeve and be continued without stopping to the other end of the sleeve. The sleeve should not be passed through the rolls more than once. After the sleeve has passed completely through the rolls, depress the roll stop and turn the wrench slowly until the roll stop engages the gear. The roll flats are then in the proper position to permit the tool to be removed from the wire.

*h.* If more convenient, the sleeve may be fed into the rolls from the side opposite to that shown in figure 137, by reversing the ratchet latch and turning the wrench in the opposite, counter-clockwise, direction.

**140. CARE OF SLEEVE ROLLING TOOL.—** Handle the tool carefully so as not to damage it. Do not drop it on the ground or throw it into the truck. The leather strap on the handle should always be placed over the wrist when carrying or using the tool to prevent it from falling. In order to prevent rusting, wipe the tool with an oily rag occasionally and after each time it is used in damp or rainy weather. The tool should be lubricated with heavy grease about once or twice a year, using a grease gun. The tool should be tested occasionally by making a splice in a short length of wire and then pulling on the wire until the wire breaks. If the joint pulls apart before the wire breaks, the tool is defective.

**141. MAKING PRESSED SLEEVE SPLICES.—** ***a.*** Place the ends of the wires in the sleeve and crimp the ends of the sleeve to hold the wires in the sleeve, in the same way as when starting to make a rolled sleeve splice. Then place the sleeve in the "Q" groove of the sleeve pressing tool.

*b.* Squeeze the sleeve by pressing the tool closed until the handle bumpers meet. Make four presses in each half of the sleeve, making the first presses nearest to the center and working out to the ends of the sleeve.

**142. ADJUSTMENT OF SLEEVE PRESSING TOOL.—** ***a.*** It is important that the sleeve pressing tool be kept clean, the joints well oiled and the amount of sleeve pressure kept constant. The splices should be checked occasionally with the gauge provided for the purpose. (See figure 135.) The compressed portion of the sleeve should enter the gauge with only a small amount of clearance. If the sleeve does not enter the gauge, the pressing tool needs adjustment.

*b.* To adjust the tool, loosen the adjustment locking screw one or two turns with the wrench provided. Then turn the adjustment screw a fraction of a turn. Be sure the tool handles are open when turning the adjustment screw. Test the adjustment by pressing a sleeve and checking it with the gauge. If the pressed portion of the sleeve enters the gauge with a small amount of clearance the adjustment is satisfactory. If the sleeve does not enter the gauge, continue the adjustment until the sleeve gauges properly. When the correct setting has been obtained, lock the adjustment with the locking screw so that the tool will hold its adjustment.

**143. MAKING TWISTED SLEEVE SPLICES.—** ***a.*** An alternative method of splicing line wire is the twisted sleeve method shown in figure 138. This method makes use of 104 FT-88 copper sleeves 4¾ inches long. About 7 inches of the end of each wire should first be cleaned with emery cloth and the wires placed in the sleeve and twisted with clamps LC-24, as shown in figure 138.

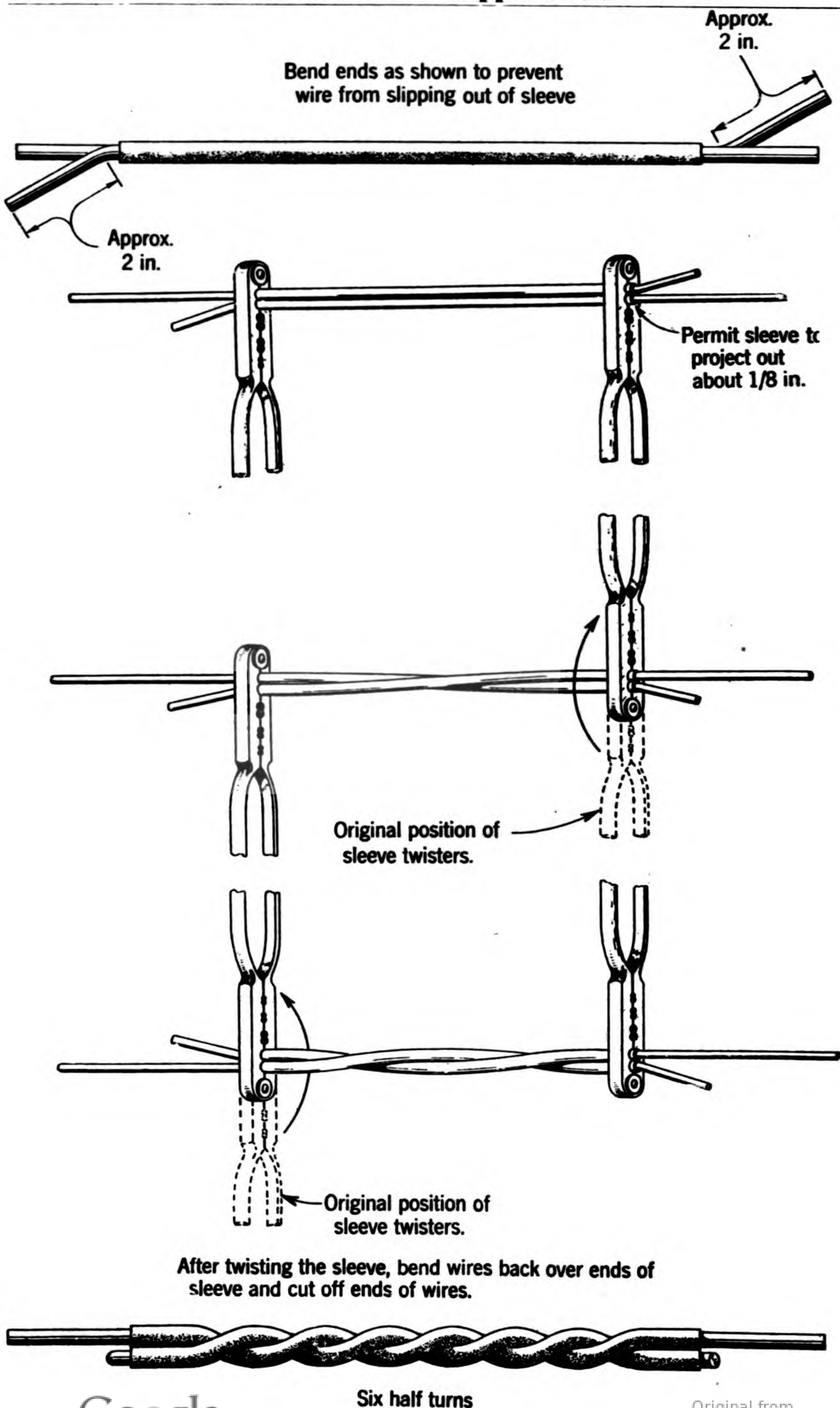
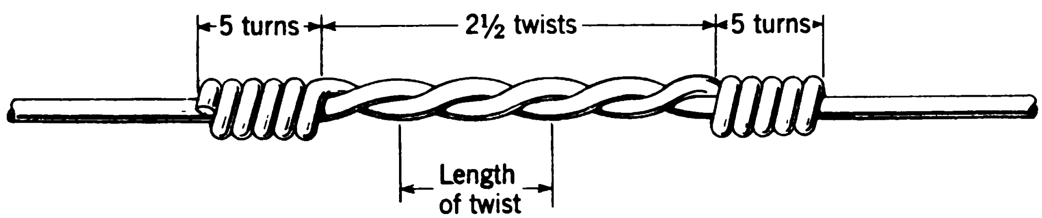





Figure 138. Making twisted sleeve joint.

*b.* If the wires are spliced as they are being run out from the payout reels, tie a piece of binder twine, marline, tape or burlap in front of each twisted sleeve splice so that it will not catch on the edges of the crossarms as it is pulled along.

**144. MAKING TWISTED CONDUCTOR SPLICE.—** If neither tools nor sleeves are available, line wires may be spliced by twisting them together as shown in figure 139. This splice is neither as strong nor as good electrically as the other types of splices described in this section and therefore should not be used except in case of necessity. They should be replaced with one of the other types of splices as soon as conditions permit.




Caution: Be sure both wires are twisted equally.

Figure 139.— Twisted conductor joint.

# *Section IV*
# *Deadending Wires*

**145. GENERAL.—** There are three approved methods of deadending wire, the pressed sleeve method, the twisted sleeve method and the wrapped wire method. The pressed sleeve method is the most desirable of these methods and the wrapped wire method is the least desirable. All types of deadends are made after the wires have been pulled to the proper sags and snubbed at the deadend pole.

**146. PRESSED SLEEVE DEADEND.—** The method of making the pressed sleeve deadend is shown in figure 140. As will be noted, the deadend is made with a deadend sleeve, with two presses made on each end of the sleeve by means of the sleeve pressing tool.

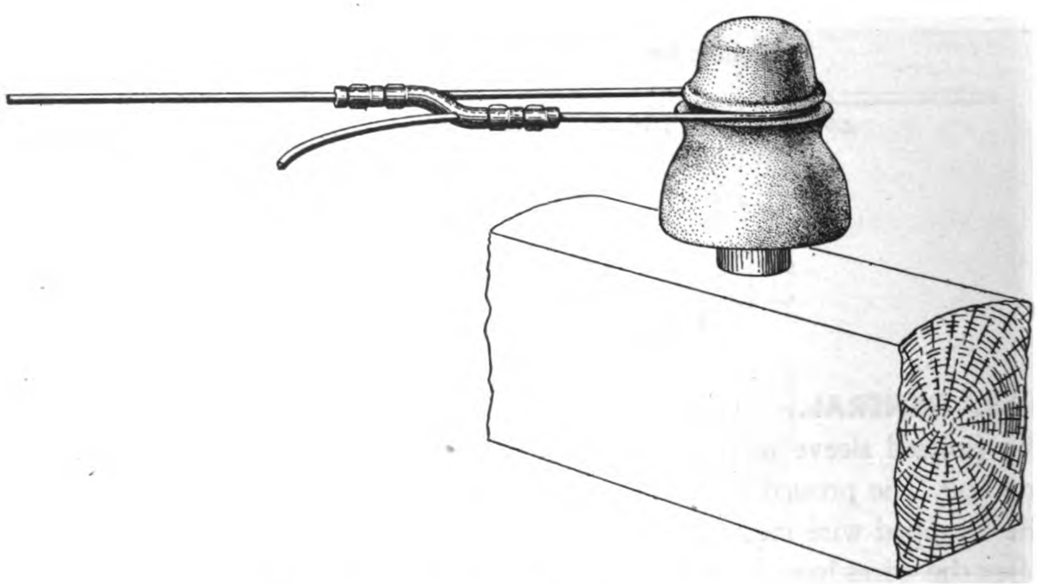


Figure 140.— Pressed sleeve deadend.

**147. TWISTED SLEEVE DEADEND.–** The twisted sleeve deadend is made with a 104 FT-88 copper sleeve. If desired, the full length (4¾ inches) sleeve can be used, or the sleeve can be sawn in half. If the full length sleeve is used it should be given six half twists, but if the half-length sleeve is used, only three half twists are required. The sleeve is twisted by means of clamps LC-24. The twisted sleeve deadend is shown in figure 141.

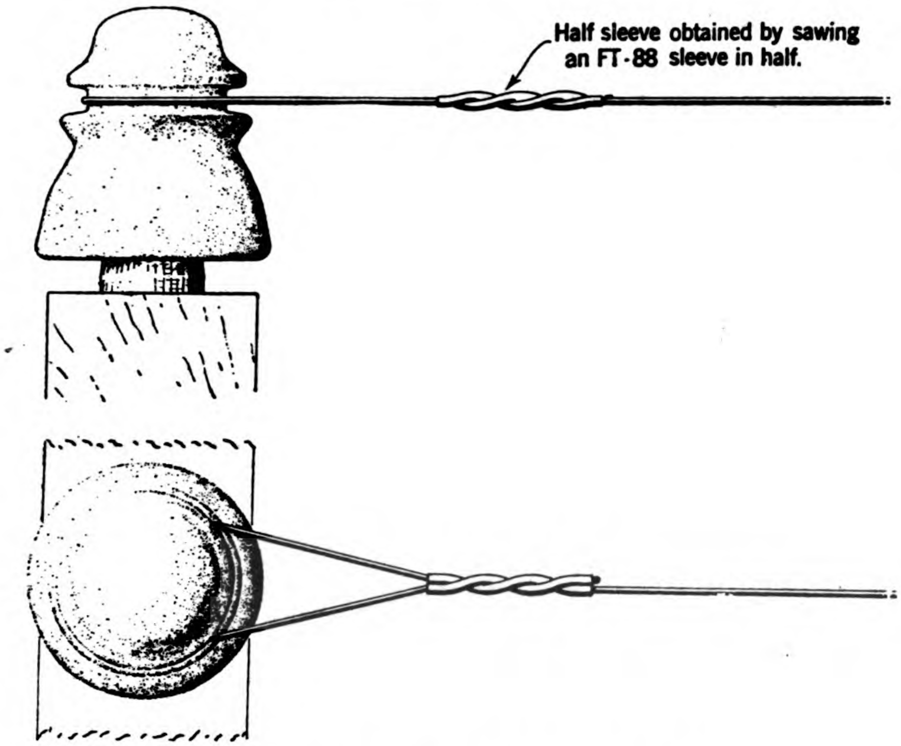



Figure 141.— Twisted sleeve deadend.

**148. WRAPPED WIRE DEADEND.**— The wrapped wire deadend, which is illustrated in figure 142, is made as follows:

(1) Wrap the line wire around the groove in the insulator, making one complete turn.

(2) Pass the free end of the line wire *over* and around the wire in the span, close to the insulator, and make 2½ close wraps around the wire in the span.

(3) Carry the end of the wire around the insulator groove a second time, in the opposite direction to the first wrap.

(4) Wrap the free end of the wire around the line wire close to the first serving, in the opposite direction to the first wrap. At least four tight turns should be made around the line wire. (See figure 142.) A straight length of wire about 1½ inches long should be left for the bridle wire connection.

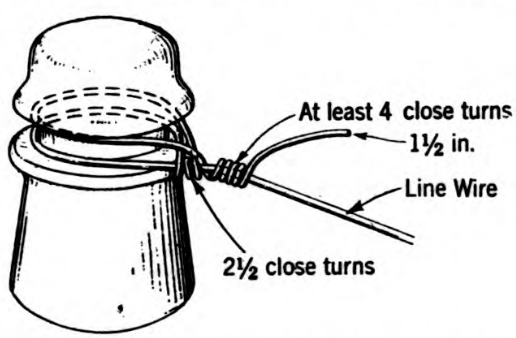



Figure 142.— Wrapped wire deadend.

# Section V
# Tying Open Wire

**149. KINDS OF TIES.—** Two kinds of ties are used to tie the line wire to the insulators, as follows:

***a. Standard tie.—*** The standard tie is used generally except where there is a change in grade of 20 per cent. or more.

***b. Modified horseshoe tie.—*** The modified horseshoe tie is used at all poles where there is a change in grade of 20 per cent. or more.

**150. METHOD OF MAKING STANDARD TIE.—** Use a 19-inch length of 104 CU tie wire and make the tie as shown in figure 143.

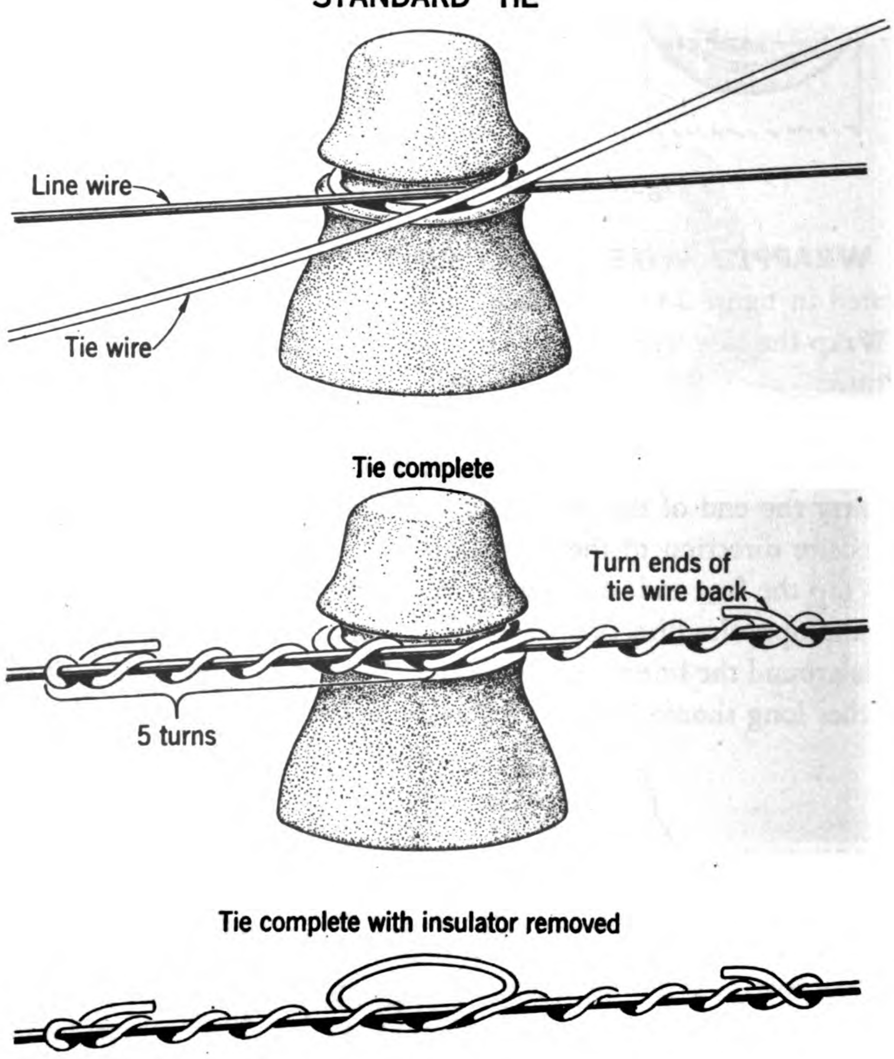



Figure 143.— Method of making standard tie.

**151. METHOD OF MAKING MODIFIED HORSESHOE TIE.—** Use a 19 inch length of 104 CU tie wire and make the tie as shown in figure 144

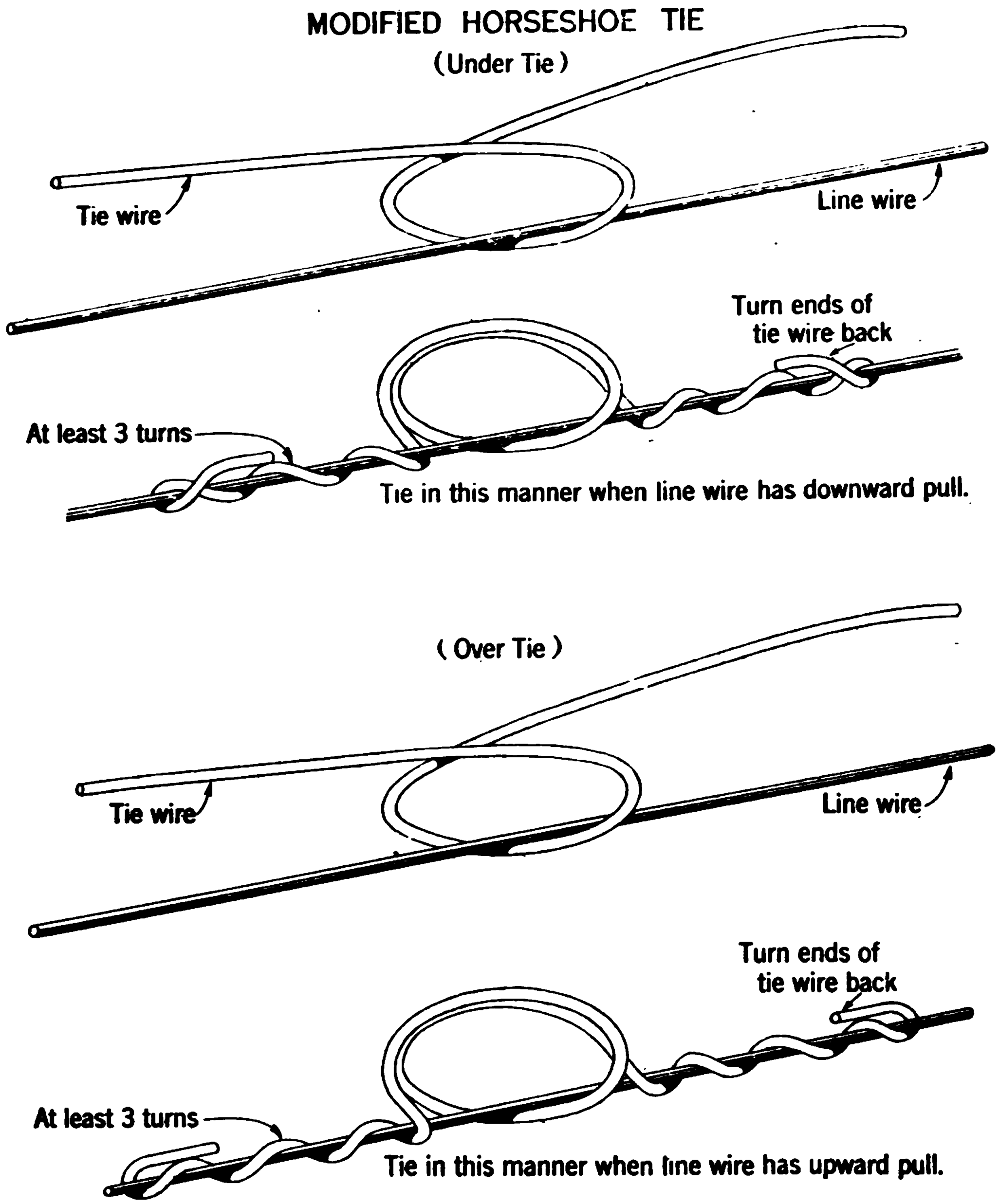



Figure 144.— Method of making modified horseshoe tie.

**152. POSITION OF WIRES ON INSULATORS.—** ***a.*** At poles in straight sections of the line, tie the line wires to the outside of the insulators as shown in figure 145.

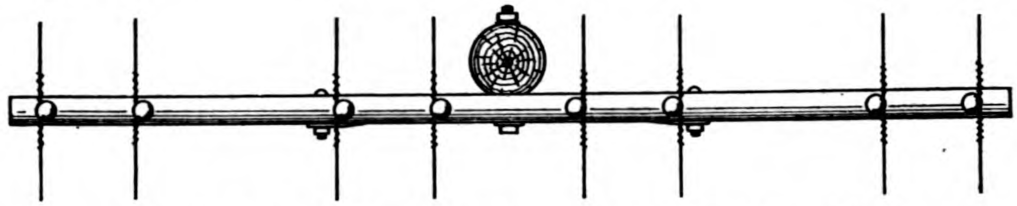


Figure 145.— Tying line wires in straight sections of line.

***b.*** At corner poles the wires should be tied to the side of the insulators on the outside of the corner, so that the line wires will bear against the insulators, as shown in figure 146.

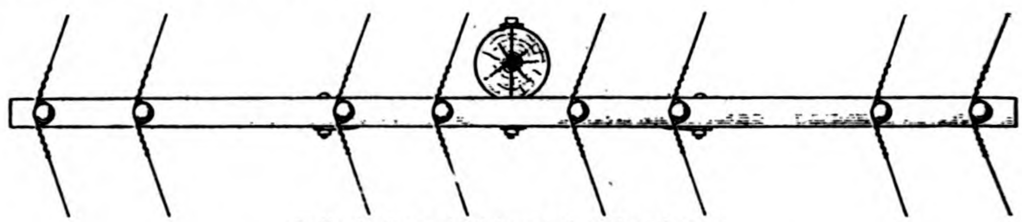



Figure 146.— Tying line wires at corners.

**153. TIES AT DOUBLE CROSSARMS.—** At poles at which double crossarm construction is used, tie each line wire to an insulator on each crossarm. If the double crossarm construction is used because of a corner in a level section of the line, use standard ties. If the double crossarm construction is used because of a change in grade, use modified horseshoe ties on both insulators, as shown in figure 147.

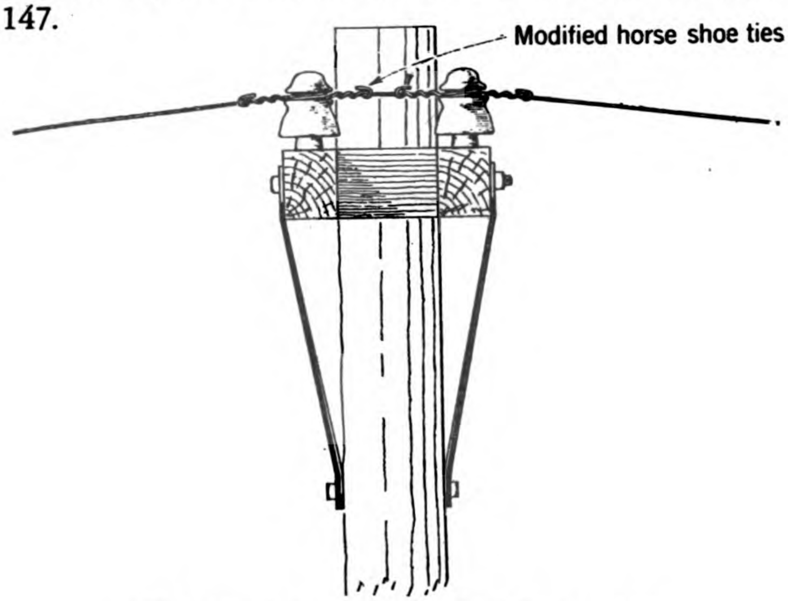



Figure 147.— Ties at double crossarm.

# CHAPTER VII
# TERMINATING OPEN WIRE LINES



## *Section I*
## *Bridling*

**154. BRIDLE WIRE.**— W-50 bridle wire is a rubber insulated twisted pair wire with soft copper conductors of # 14 gauge. The braid covering over the rubber insulation on one wire of the twisted pair has a raised thread which is used as a tracer to distinguish one wire from the other. Bridle wire is used for connecting the ends of open wire lines to telephone line protectors and cable terminals and also to connect the open wires deadended on one crossarm to those deadended on another crossarm at poles where buck crossarm construction is used.

**155. CONNECTING BRIDLE WIRE TO OPEN WIRE.**— Connections between bridle wire and open wire are made by means of a soldered joint. Before making the connection, remove the insulation from the end of the bridle wire, being careful not to nick the conductor. Clean the exposed end of the conductor with emery cloth. The method of making the soldered connection is shown in figure 148.

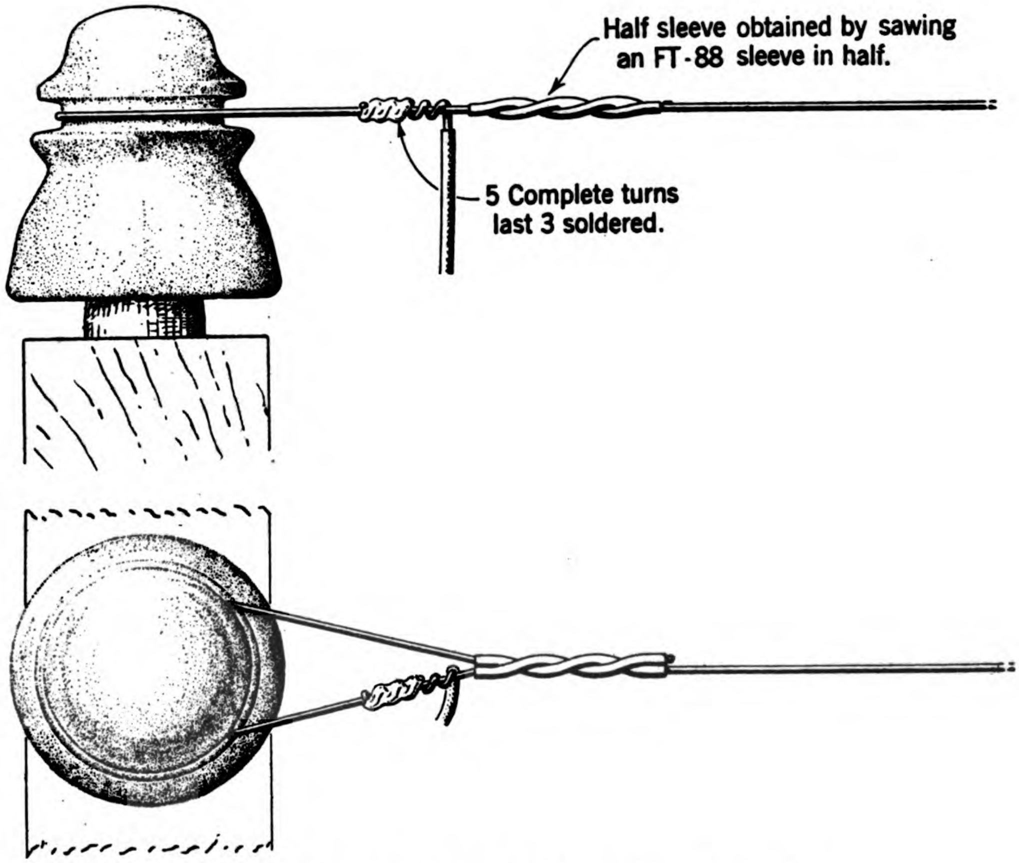



Figure 148.— Soldered bridle wire connection.

**156. BRIDLE WIRE RUNS.— *a.*** The bridle wire is run along the bottom of the crossarm and down the pole to the protector and cable terminal as shown in figure 149. The bridle wire should be supported by means of rings, PF-73 for two pairs of wire and PF-74 for more than two pairs.

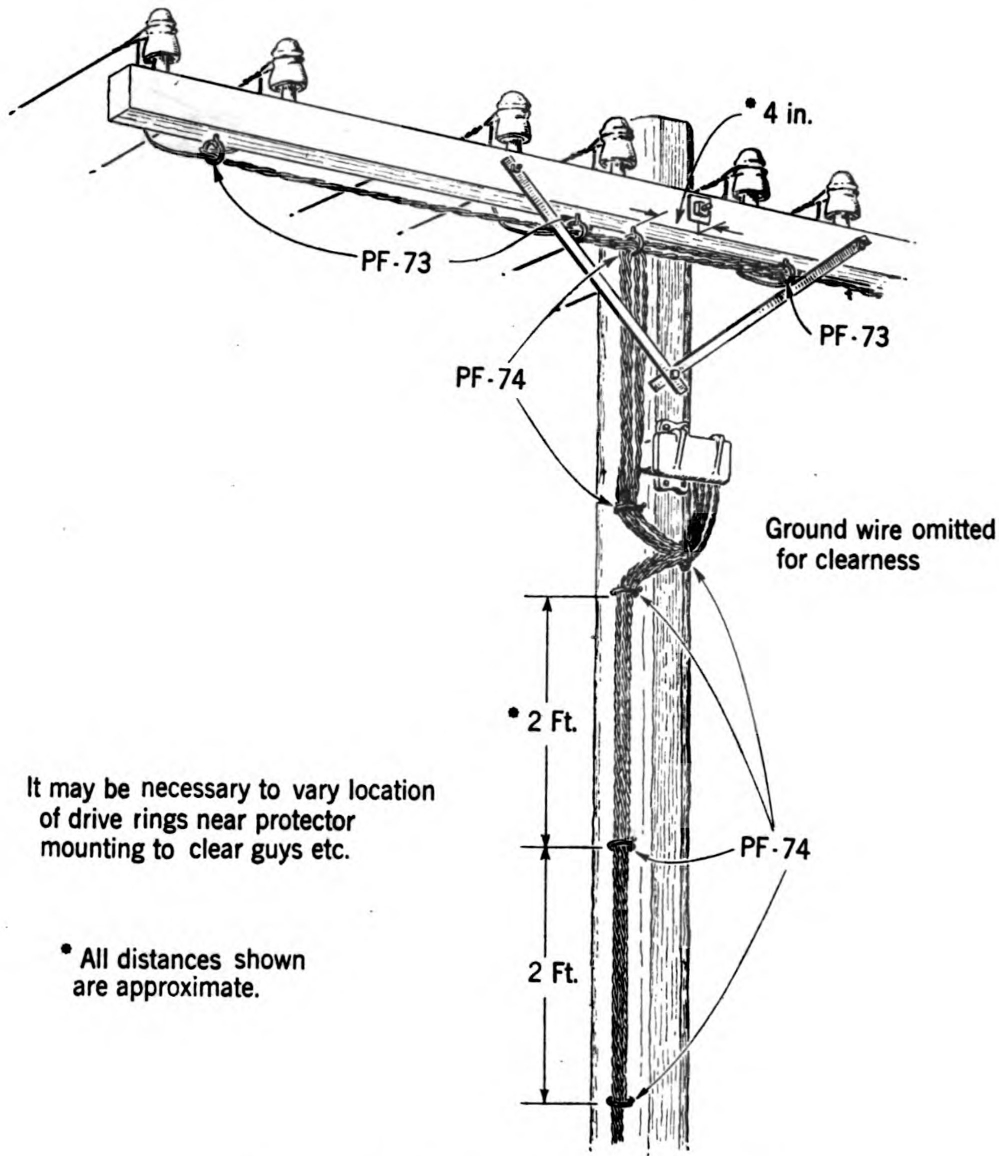



Figure 149.— Bridle wire run on pole.

***b.*** At buck crossarm poles, the bridle wires should be run from one crossarm to the other as shown in figure 150.

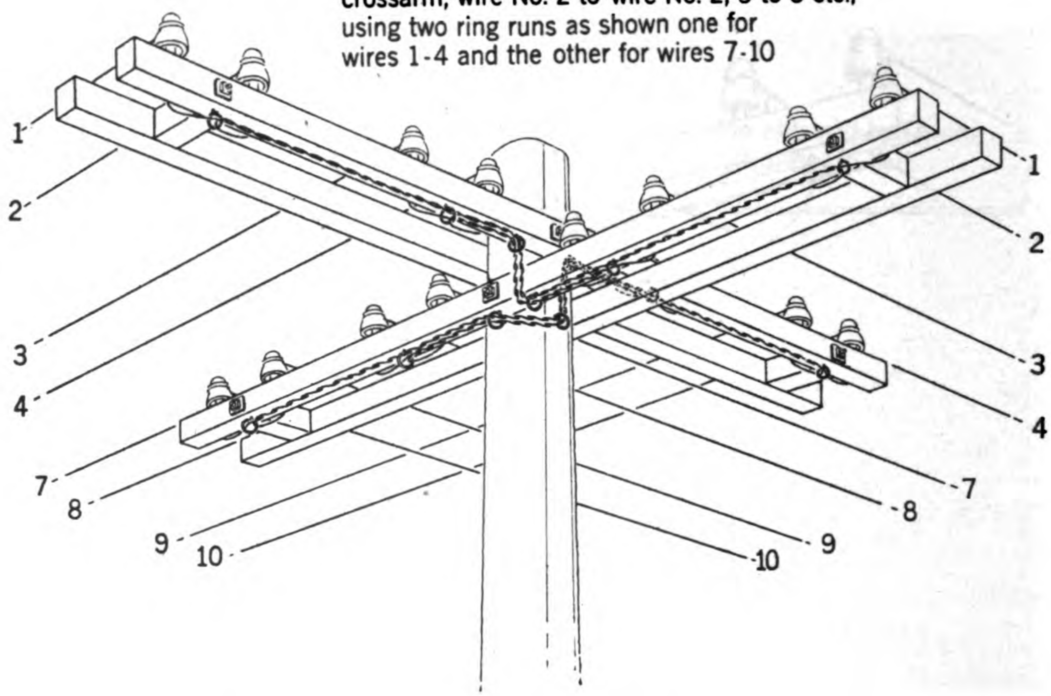



Figure 150.— Bridle wire run on buck crossarms.

**157. CONNECTING BRIDLE WIRE TO CABLE TERMINAL.—** The bridle wire should be brought into the cable terminal as shown in figure 151 and terminated between the two washers on the lock nuts as shown in figure 152. The ends of the bridle wire should be cleaned with emery cloth before terminating them on the lock nuts. The lock nuts should be turned down tight to make sure of a good contact.

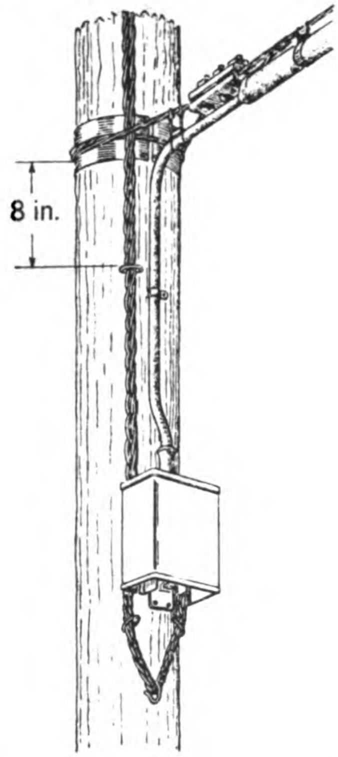



Figure 151.— Bridle wire arrangement at cable terminal.

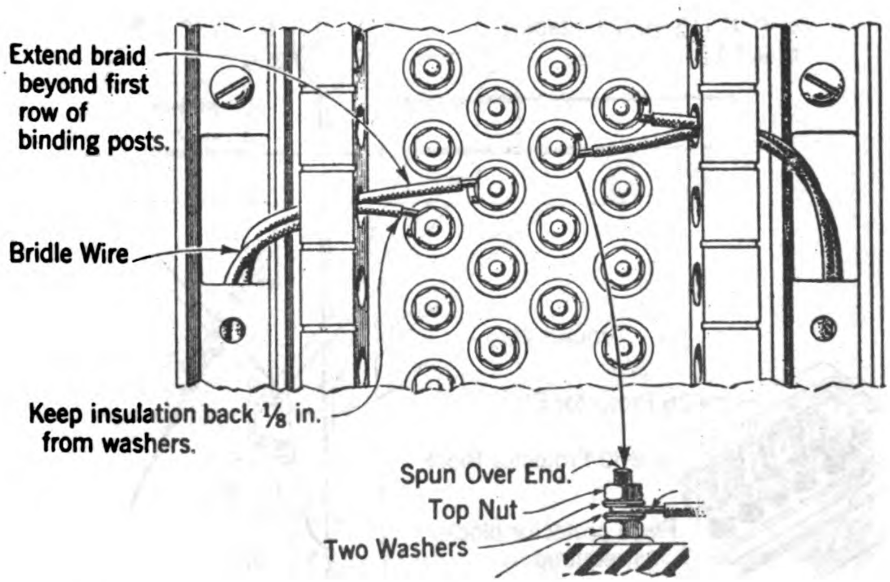



Figure 152.— Terminating bridle wire in cable terminal.

# Section II
# Protectors

**158. GENERAL.—** Telephone line protectors are required at the junction between open wire lines and cable so that if lightning strikes the open wire line it will not travel along the open wires and enter the cable. The telephone line protector consists of a porcelain terminal block equipped with springs for holding protector blocks, enclosed in a galvanized iron box. A pair of protector blocks, one No. 26 (carbon) and the other No. 30 (blue), is installed for each open wire. A separate line protector is installed for the open wires terminated on each crossarm.

**159. INSTALLING TELEPHONE LINE PROTECTORS.—** The telephone line protectors should be installed on the deadend pole as shown in figure 153.

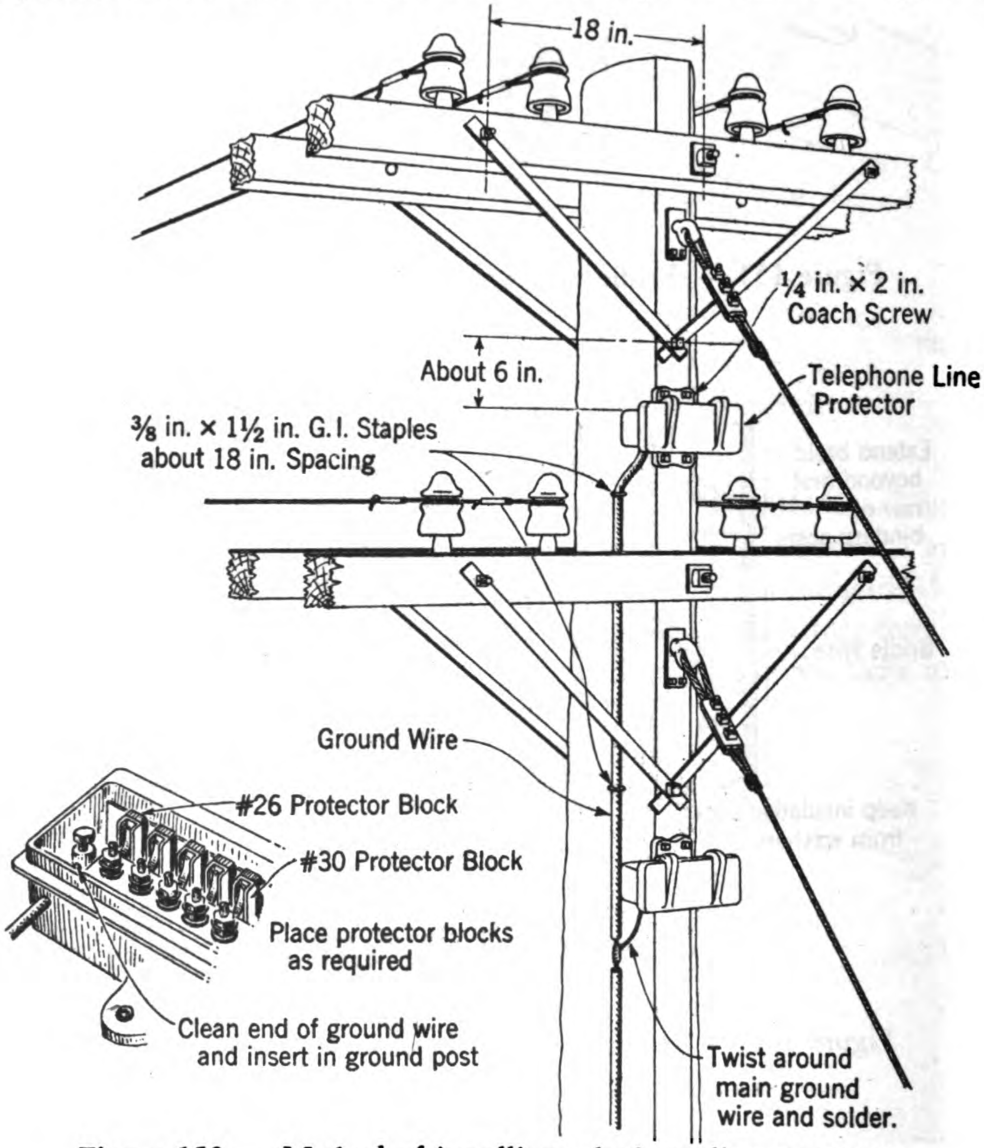



Figure 153.— Method of installing telephone line protectors.

**160. PROTECTOR GROUND CONNECTION.— *a. Aerial cable.*—** If the cable to which the open wires connect is aerial, a ground connection should be run from the ground post of each protector to the strand supporting the aerial cable. A separate ground wire of solid RC # 14 ground wire may be run from each protector to the strand or a single # 6 wire, bare or insulated, may be run from the ground post of the top protector to the strand and a solid RC # 14 ground wire from the ground post of the lower protector soldered to it. If the aerial cable suspension strand is deadened by the wrapped method, the connection of the ground wire to the strand should be made as shown in figure 154. If an eye bolt is used to deadend the strand, the ground wire should be connected to the strand as shown in figure 155.

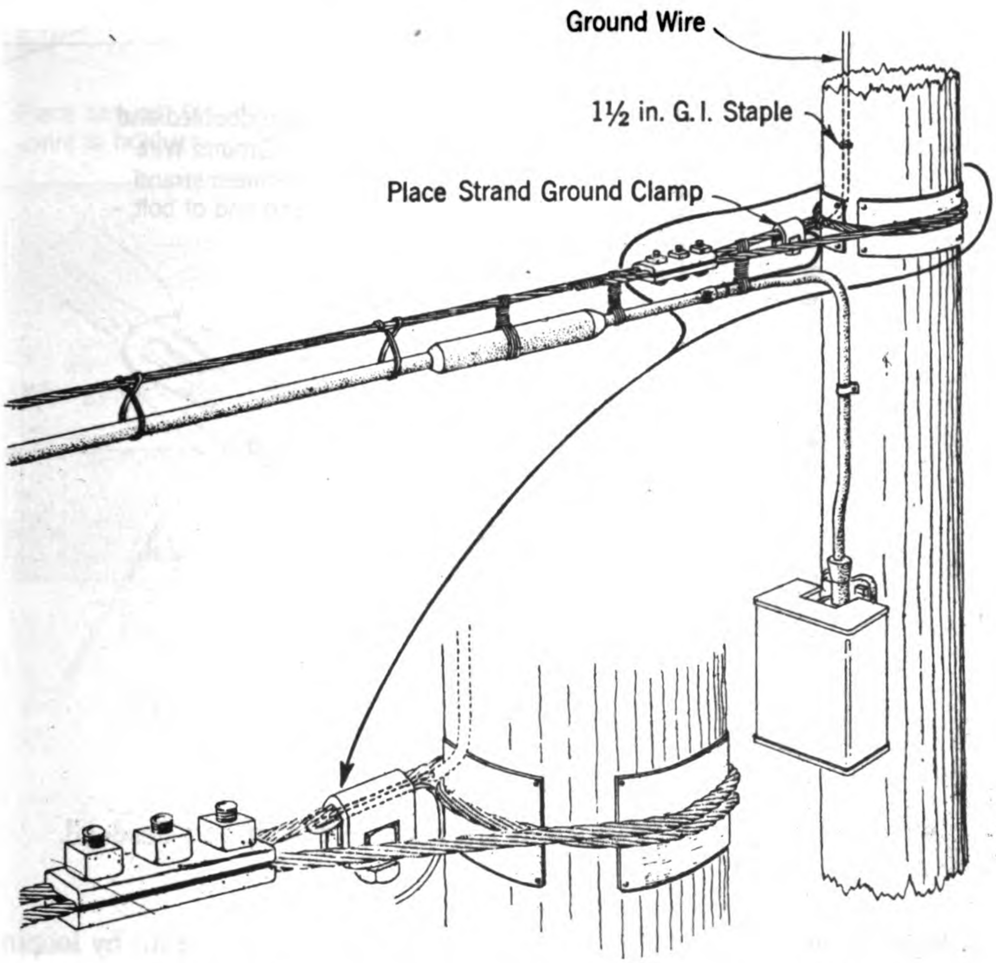



Figure 154.— Ground wire connection at wrapped strand deadend.

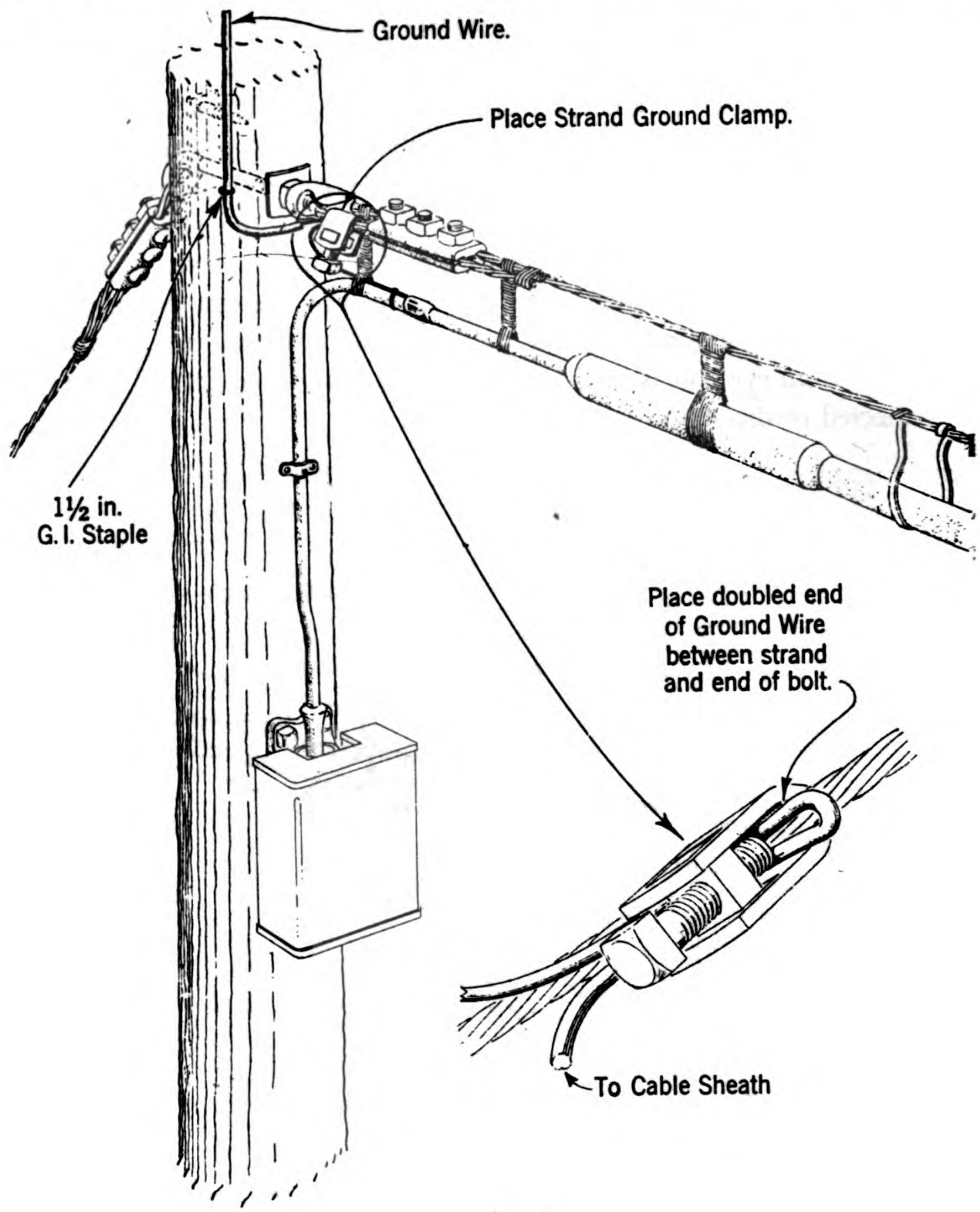



Figure 155.— Ground wire connection at eye bolt strand deadend.

The suspension strand should be bonded to the aerial cable sheath by looping the end of the ground wire from the strand ground clamp and soldering it to the sheath.

***b. Underground cable.***— If the cable to which the open wires connect is underground, either buried or in conduit, the protector ground wire should be soldered to the cable sheath.

***c. Soldering ground wire to cable sheath.***— Ground wire connections to cable sheath should be made by means of a wiped joint, as shown in figure 156.

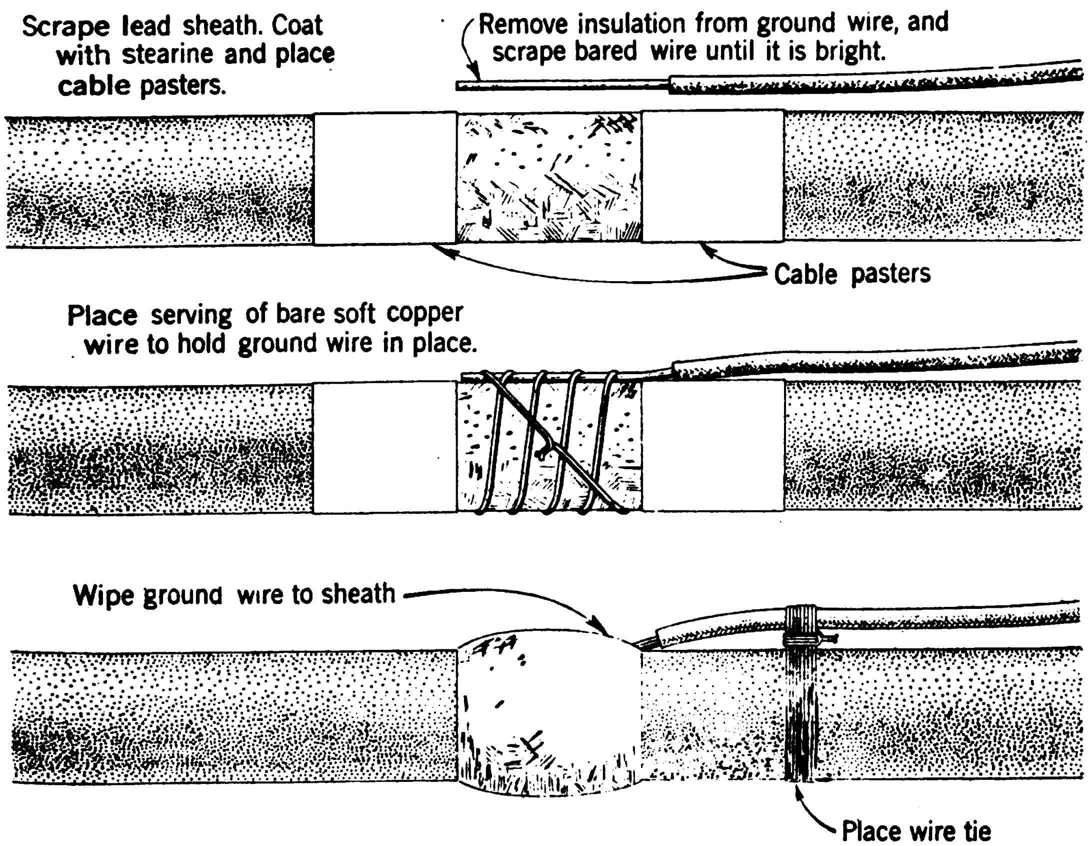



Figure 156.— Soldering ground wire to cable sheath.

# CHAPTER VIII
# MATERIALS



## Section I
## List of Materials

**161. GENERAL.—** Signal Corps Stock Numbers and Nomenclature of materials required for use in the construction of open wire fixed plant are outlined in this section. These items are listed in the order of Signal Corps Catalogue listing and should appear in such order on bills of material or requisitions, where practicable, in order to facilitate handling by supply branches. It is not necessary to list the nomenclature in full on bills of material or requisitions, but sufficient nomenclature should be listed to identify the item in case of typographical errors in stock numbers.

| Stock No. | Unit | Description |
|---|---|---|
| 1A90 | foot | Wire W-90 (3/8 inch messenger, 7-strand, G.I.; 10M). |
| 1A115 | foot | Wire W-115 (5/16 inch messenger, 7-strand, G.I.; 6M). |
| 1A809.104 | foot | Wire (bare) .104 inch diameter, single conductor, steel core, copper clad (40% conductivity) Copperweld Steel Co., or equal. |
| 1A810T | each | Ties for 104 copper clad steel wire. |
| 1A812 | foot | Wire, #12, BWG, G.I. (Spec. 71-360; ½ mile coils). To be used for protection of poles against lightning. |
| 1B50 | foot | Wire, W-50 (AT&T Spec. #AT-6308, #14 twisted pair). To be used for bridle wire on carrier circuits. |
| 1B110BX | foot | Wire W-110-B in 1000-foot coils. |

| Stock No. | Unit | Description |
|---|---|---|
| 1B806.1 | foot | Wire, #6, weather proof, triple braid, solid, h.d. |
| 1B814.16 | foot | Wire, #14, ground, RC, solid, 600-volt, single white braid. |
| 3G1815-45 | each | Insulator, Glass, SG DP (Hemingray #45 or Whitehall Tatum #1). |
| 3G1815-53 | each | Insulator, Glass, transposition, double groove TW (Hemingray #52 or Whitehall #15). |
| 4E926 | each | Block, protector; carbon; W.E. Co. #26. |
| 4E930 | each | Block, protector; W.E. Co. #30 (used with #26 block in #83A mounting). |
| 5A1592A | each | Crossarm PF-92-A (wood, 8 pin, SC-D-7089D, 7 feet 4 inch by 3¼ inch by 4¼ inch, bored for 1¼ inch pins; five ⅝ inch bolts and two ⅜ inch brace bolts, salt or creosote treated). |
| 5A3059 | each | Pin, PF-59 (Locust wood, 8 inches long, fits 1¼ inch hole in crossarm). |
| 5A3710 | each | Step, pole, wood, 1¾ inch x 2¾ inch x 7 inch. |
| 5B101 | each | Anchor AH-1 (guy, cone shaped, 8 inch). |
| 5B102 | each | Anchor AH-2 (two-way; expanding, 8 inch). |
| 5B109 | each | Anchor AH-9 (four-way; expanding, 8 inch). |
| 5B308-6 | each | Anchor, guy, Matthews, Scrulix; 8 inch (with rod 6 feet long). |
| (Under procurement, Stock Number not yet assigned) | each | Anchor, swamp, screw type 12 inch for use with 2 inch galvanized pipe which is not included (includes screw Anchor and Pipe thimbleye nut). |
| 5B706A | each | Anchor Rod AH-6-A (⅝ inch by 8 feet; Hubbard #8418 or equal). |
| 5B816-1.5 | each | Anchor Rod, Rock Guy, 1 inch x 18 inches, thimbleye bolt and wedge, G.I. (Hubbard 7547T). |
| 5B1106-4 | each | Bolt, carriage, ⅜ inch x 4 inch, G.I. |
| 5B1210-20 | each | Bolt, double arming, ⅝ inch x 20 inch, G.I. |
| 5B1310-10 | each | Bolt, eye, ⅝ inch x 10 inch, G.I. |
| 5B1310-12 | each | Bolt, eye, ⅝ inch x 12 inch, G.I. |
| 5B1310-14 | each | Bolt, eye, ⅝ inch x 14 inch, G.I. |

| Stock No. | Unit | Description |
|---|---|---|
| 5B1410-10 | each | Bolt, bent eye, 5/8 inch x 10 inch, G.I. |
| 5B1410-12 | each | Bolt, bent eye, 5/8 inch x 12 inch, G.I. |
| 5B1410-14 | each | Bolt, bent eye, 5/8 inch x 14 inch, G.I. |
| 5B1510-10 | each | Bolt, machine, 5/8 inch x 10 inch, G.I. |
| 5B1510-12 | each | Bolt, machine, 5/8 inch x 12 inch, G.I. |
| 5B1510-14 | each | Bolt, machine, 5/8 inch x 14 inch, G.I. |
| 5B1510-16 | each | Bolt, machine, 5/8 inch x 16 inch, G.I. |
| 5B2104 | each | Brace PF-4 (flat crossarm; 20 by 1 7/32 by 7/32 inch; Hubbard #8020, or equal). |
| 5B3349 | each | Clamp, ground, strand, Hubbard #8956, or equal. |
| 5B3450 | each | Clamp, FT-56 (guy; 3-bolt Hubbard #7450, or equal). |
| 5B4305 | each | Eye-Nut, thimbleye; G.I.; for 5/8 inch bolt (Hubbard #7510, or equal). |
| 5B5284 | each | Hook, Guy, "J", G.I., 4 inch (medium, Hubbard #7584, or equal). |
| 5B8504-8 | each | Plate, strain; G.I., 4 by 8 inches (Hubbard #7575, or equal). |
| 5B9310 | each | Ring PF-73 (bridle, G.I. Hubbard #2953½ or equal; 5/8 inch diameter eye, 5/16 inch opening, 7/8 inch long shank with wood screw threads) |
| 5B9320 | each | Ring PF-74 (bridle, G.I. Hubbard #2956 or equal; 1¼ inch diameter eye, 5/16 inch opening, 1¼ inch long shank with wood screw threads). |
| 5B9326 | each | Ring PF-75 (bridle, G.I. Hubbard #2957½ or equal; 1 5/8 inch diameter eye, 5/16 inch opening, 1¼ inch long shank with wood screw threads). |
| 5B10004-2.5 | each | Screw, Lag, G.I., ¼ inch x 2½ inch. |
| 5B10005-2.5 | each | Screw, Lag, G.I., 5/16 inch x 2½ inch. |
| 5B10006-3.5 | each | Screw, Lag, G.I., 3/8 inch x 3½ inch. |
| 5B10008-4.5 | each | Screw, Lag, G.I., ½ inch x 4½ inch. |
| 5B17001.5 | each | Staple, G.I., 3/8 inch x 1½ inch. |
| 5B17137 | each | Step PF-37 (pole, G.I. standard hook; Hubbard #7125, or equal; 5/8 inch diameter, 10 inch long overall) |

| Stock No. | Unit | Description |
|---|---|---|
| 5B17511 | each | Strap, storm guy, hot galvanized, steel, Hubbard #6001 (has rounded wire groove, 7 inch overall length, 1½ inch wide, ¼ inch thick). |
| 5B17591 | each | Strap (plate), guy; flat, G.I. (Hubbard #8891, or equal; 7 inch long, 2½ inches wide, $\frac{5}{16}$ inch thick). |
| 5B20078 | each | Washer PF-78 (square; G.I., 3½ by 3½ by ⅜ inch with $\frac{15}{16}$ inch hole, Hubbard #7826, or equal). |
| 5B20079 | each | Washer PF-79 (square; G.I., 2¼ by 2¼ by $\frac{3}{16}$ inch, with $\frac{13}{16}$ inch hole, Hubbard #7814, or equal). |
| 5B20209-11 | each | Washer, square; G.I.; Hubbard #7813, or equal (2¼ by 2¼ by $\frac{3}{16}$ inch, with $\frac{11}{16}$ inch hole). |
| 5B20310 | each | Washer, curved; G.I.; for ⅝ inch bent eye bolt (2½ by 2½ by $\frac{3}{16}$ inch, with $\frac{11}{16}$ inch hole; Hubbard #7822 or equal). |
| 5C2200 | each | Protector, telephone line, 5-pair (for pole mounting, W.E. Co. 84A in 83A mounting, complete with protector blocks). |
| 6G1510 | gal. | Paint, ready mixed, orange, lead base, Signal Corps. |
| 6L1406 | lbs. | Nail, common wire, 6-d (or 2 inch, 181 per lb., in kegs each containing 100 lbs.). |
| 6L1430 | lbs. | Nail, common wire, 30-d (or 4½ inch, 24 per lb.; in kegs each containing 100 lbs.). |
| 6L1460 | lbs. | Nail, common wire, 60-d (or 6 inch, 11 per lb.). |
| 6N5588 | each | Sleeve, FT-88 (copper #10 B&S, double tube, 4¾ inch long). |
| 6N5610.3 | each | Sleeve, splicing copper, SCL-696-A, Nicopress C-104-Q (for .102 inch or .104 inch copper clad steel wire). |
| 6N5621-2 | each | Sleeve, offset deadend Nicopress 91-102J (for #10AWG or .104 inch copper clad steel wire). |
| 6N7531 | lb. | Solder M-31 (resin core, 1 lb. spools). |
| 6N7533 | lb. | Solder M-33 (wiping, in bars). |

| Stock No. | Unit | Description |
|---|---|---|
| 6N8583 | roll | Tape TL-83 (friction, ¾ inch, ½ lb. roll). |
| 6Z2000-1 | sheet | Cloth, emery, #1, 9 by 11 inches. |
| 6Z7557-2.2 | feet | Pipe, carbon steel, Fed. Spec. WW-P-403A (Class A, Type 1 except less coupling, standard weight, 2 inch IPS; Zinc-coated. threaded both ends in 10 feet lengths) |

The following items which are not carried in Signal Corps Stock should be obtained locally from the Quartermaster Corps or Corps of Engineers or by local procurement as the case may be:

- Cap, Blasting
- Cloth, Strips
- Crayon, Lumber
- Dynamite, Cartridge (40 per cent.)
- Dynamite, Cartridge (60 per cent.)
- Kerosene
- Stakes, Wooden
- Tags, Linen or Wooden (for use in marking poles)

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