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SIGNAL TRAINING PAMPHLET No. 4

CONSTRUCTION AND MAINTENANCE OF LINES

PART III—POLED CABLE AND MULTI-AIRLINE

1948

(This pamphlet supersedes Signal Training Pamphlet No. 4, Part III, Poled Lines, 1943)

Prepared under the direction of The Chief of the Imperial General Staff

THE WAR OFFICE,
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PREFATORY NOTE

Signal Training Pamphlet No. 4—Construction and Maintenance of Lines—is the main title of a series of pamphlets consisting of the following parts :—

Part I.	General Principles, 1945.
Part II.	Ground Cable, 1946.
Part III.	Poled Cable and Multi-Airline, 1948.
†Part IV.	Permanent Overhead Line.
*Part V.	Underground Cable.
†Part VI.	Indoor Wiring and Distribution Frames.
†Part VII.	Maintenance and Fault Control.
†Part VIII.	Long Lines Control.

The following abbreviations are used in the text of this pamphlet :—

VIR	Vulcanized india rubber.
PVC	Polyvinyl Chloride (plastic material).
ACV	Armoured command vehicle.
GI	Galvanized iron.
DC	Direct current.

* Revised edition of Part V to be issued, and will be entitled "Underground Cable."

† Not yet issued.

AMENDMENTS.

Amendment No.	By whom amended	Date of insertion	Amendment Number	By whom amended	Date of insertion

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SIGNAL TRAINING PAMPHLET No. 4

CONSTRUCTION AND MAINTENANCE OF LINES

PART III—POLED CABLE AND MULTI-AIRLINE

CHAPTER 1

GENERAL

SECTION 1.—TYPES OF AERIAL LINE

1. Aerial line is the term used to describe any type of route, whether of bare or insulated wire, elevated throughout its length on poles, trees, buildings or other supports.

2. The four types of aerial line dealt with in this pamphlet are as follows :—

(*a*) *Poled cable.*—Insulated cable (*eg*, "D" class cable, field and carrier quad cable, or 7-pair VIR) elevated on poles or other supports.

(*b*) *Spaced cable.*—Poled cable with the conductors of each pair spaced a fixed distance apart throughout the length of the line.

(*c*) *Tree slung cable.*—A method of construction primarily designed for the jungle and using a special type of insulated conductor, *eg*, cable electric cadmium copper 150 lb single PVC. Special insulators are used through which the insulated cable can run freely, and the cable is slung sufficiently loosely to allow a tree or branch falling on it to bear it down to the ground without breaking it, the sag being taken up in adjacent bays.

(*d*) *Multi-airline.*—A route of PVC insulated wire built with standard stores (insulators, spindles, arms, etc), of a light type.

3. The two remaining types of construction in the aerial line group—permanent line and aerial cable—are dealt with in *Signal Training Pamphlet No. 4, Part IV—Permanent Overhead Line.*

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Section 2.—CHARACTERISTICS OF AERIAL LINE

1. Aerial line will give a long period of useful service if properly built and regularly maintained. Its main advantages over ground cable are that :—

(*a*) It is less subject to damage by traffic.

(*b*) It does not deteriorate nearly so rapidly in bad weather, because it does not touch the ground. It is only likely to wear at points of support.

(*c*) Cables in the route can be readily identified and faults more easily detected.

(*d*) The insulation is not solely dependent on its insulating sheath.

Though its vulnerability varies with the type of construction and the conductor, no type of aerial line is suitable in areas subject to severe bombing or shelling.

2. It is often possible to build poled and spaced cable with material obtained locally, or improvised. Tree-slung cable is normally used in jungle.

Other types of aerial line can be used successfully in almost any type of country, and can usually be made reasonably inconspicuous, if the route is carefully chosen.

3. Electrically, all types of aerial line are superior to ground cable. (Their characteristics are given in *Signal Training Pamphlet No. 4, Part I*). If well constructed, aerial line remains relatively free from faults, and deteriorates very slowly.

Section 3.—USE OF AERIAL LINE

1. Aerial line can be put up quickly, and fills the gap between rapidly laid ground cable and the more permanent types of construction such as underground cable and permanent line, which require much time, labour and material to build.

2. Behind corps, aerial line is used extensively, until it can be replaced by permanent line, or buried cable.

Between corps and division, and where possible between division and brigade, aerial line should replace ground cable on all important routes, as soon as the situation permits.

Section 4.—SELECTION OF ROUTES

1. When selecting the route that the line is to follow, the following requirements must be considered :—

(*a*) Speed of building.

(*b*) Ease of maintenance.

(*c*) Safety.

(*d*) Economy of stores.

(*e*) Concealment.

2. The above requirements are dealt with in detail in Secs 5 to 7 below. Their relative importance in the construction of any particular line will depend on circumstances, and in particular upon :—

(*a*) The urgency with which the line is needed.

(*b*) The importance of the line in the system of communications.

(*c*) The length of time for which the line is expected to be in use.

(*d*) The materials available.

3. Obviously, too, these requirements will often conflict, and it will usually be necessary to make the best compromise possible. The first essential, however, in the selection of any route, whatever the type of construction, is a thorough reconnaissance. This is dealt with in detail in *Signal Training Pamphlet No. 4, Part I*.

Section 5.—SPEED OF BUILDING

1. The quickest method of building aerial line is on the poles of an existing route, but this method cannot be employed with multi-airline, which requires multi-airline arms and insulators.

2. When building aerial line across country, the line should follow a minor road or a track that vehicles can use ; if stores have to be man-handled over a distance the speed of construction will be greatly reduced. Building through woods will take a long time if there is much clearing to be done, but rides often provide a good route. Towns and villages delay progress considerably, and should be avoided whenever possible.

3. The secret of fast construction is steady and smooth progress, with no hold-ups. To achieve this, the commander must carry out a detailed reconnaissance and have plans ready to overcome obstacles which he finds in the way ; detachments must be carefully organized to deal with the particular task in hand.

Details of typical organizations are given at the relevant sections.

Section 6.—SAFETY

1. The safety of a line may be considered under three headings :—

(*a*) Safety from traffic.

(*b*) Safety from bombing and shelling.

(*c*) Safety from lightning.

2. Aerial line is comparatively safe from traffic provided that it is properly built, with adequate staying and clearances, and poles are set well back from the roadside. All that is necessary is to select a route where the line can be properly built with the materials available, and to see that full use is made of natural protection such as ditches and thick hedges to keep the poles and stays safe from traffic.

3. **Clearances.**—The clearance at a crossing is the height above the ground of the lowest wire, measured from the highest level of ground in the span. Whenever possible a clearance of 14 ft should

be reached across open country but for the types of crossings shown below the clearances given must be obtained.

*(*a*) *Across roads or tracks* ... At least 20 ft.
(*b*) *Across railways* ... ... At least 24 ft.

4. **Special precautions.**—Special safety precautions will often pay high dividends.

In very open country, for instance, where vehicles may turn off a main track anywhere to harbour, it is often worth while to increase the clearance of, say, two spans in every mile of a route. Notices reading, "Left/right turn for vehicles up to 22 ft—four poles ahead" can then be hung on the poles or other supports of the route. This precaution is particularly useful in areas where armoured vehicles are operating.

Normally aerial line will be converted to underground cable on air fields, or built to a height specified by the competent RAF authority; cut down multi-airline poles will then be used.

5. **Places to avoid.**—Aerial line cannot be made invulnerable to bombing or shell-fire, and the safest place for a route is across country away from all likely targets. If this is not possible, such places as important road junctions and bridges, main roads, railways, towns and villages must be avoided.

6. **Concealment.**—Concealment is a most important factor in the safety of a line, (*See Signal Training Pamphlet No. 4, Part I,*) but though a line is apparently well concealed, its whereabouts is often disclosed in aerial photographs by tracks made during building and maintenance. Such tracks must be obliterated, wherever possible.

7. **Safety against lightning.**—Lightning conductors should normally be fitted to aerial line routes at every eighth pole. The lightning conductor should be a length of bare wire of the same weight as that being used to construct the route. The wire should protrude about 6 ins above the highest point of the pole or any equipment on it and should be taken down the side of the pole opposite the arms (if any), and attached to the pole by means of staples. The bottom of the wire should be coiled and buried at the base of the pole. The wire should be led down the pole in a straight line and must not touch any metal equipment on the pole.

SECTION 7.—ECONOMY IN STORES

1. It is nearly always possible to economize in stores, by a careful choice of route. Poles, pickets and stay-wire can be saved by building on existing permanent line routes, trees or buildings; and arms, spindles and insulators can be saved by using bobbins or slotted slats, etc.

2. Economy in stores is particularly important when the line is a long way from a road and stores have to be man-handled for a considerable distance.

* In exceptional cases *eg*, for ACVs with aerial rods in position or tanks with aerial rods increase to 22 feet.

SECTION 8.—METHODS OF CONSTRUCTION

1. There are four main methods of constructing aerial lines :—

(*a*) On fir, hop or larch poles, or multi-airline poles.
(*b*) On the poles of existing permanent line routes.
(*c*) On trees.
(*d*) On buildings.

The chief advantages and disadvantages of each of these methods are summarized below.

2. **Fir, hop or larch poles, or multi-airline poles.**

Advantages

(*a*) Line can cross open country.
(*b*) Line can go direct to its destination, thus saving cable.
(*c*) Line can avoid places likely to be bombarded, *eg*, towns, bridges, cross-roads, etc.

Disadvantages

(*a*) Expensive in poles, arms, stays, pickets, etc.
(*b*) Difficult to conceal.

3. **Existing permanent line routes.**

Advantages.

(*a*) Fast progress.
(*b*) Economical in stores.
(*c*) Easy to maintain.

Disadvantages.

(*a*) Liable to bombing.
(*b*) Difficult to conceal.
(*c*) Liable to overload the route.

4. **Trees.**

Advantages.

(*a*) Very well concealed.
(*b*) Economical in poles, stays, etc.

Disadvantages.

(*a*) Slow progress, if clearing is required.
(*b*) Considerable maintenance required.

5. **Buildings.**

Advantages.

(*a*) Enables the line to be constructed through built-up areas.
(*b*) Economical in poles, stays, etc.

Disadvantages.

(*a*) Liable to bombing.
(*b*) Slow progress.
(*c*) Difficult to maintain.

6. **Conclusions.**—Generally, the line should be run along, or near minor roads and tracks, cutting across country to avoid unnecessary detours, and using poles or suitable trees wherever

possible. Permanent line poles of routes in use by the Army must not, however, be used to support aerial cable unless permission has been obtained from the proper authority. If speed is essential, or economy in stores is necessary, the line should follow main traffic routes; if safety from bombing or shelling is more important, the line must go across country, keeping well clear of all likely targets, but following existing paths and tracks where possible, to minimize the risk of enemy air observation. Natural features, such as woods, trees and hedges should be made use of for concealment.

Section 9.—LEADING-IN LINES TO SIGNAL OFFICES

1. A signal office is likely to have a considerable number of lines leading into it; it is most important that these lines should be well concealed in the neighbourhood of the office to avoid betraying the position of the headquarters.

2. An aerial line approaching a signal office should not lead directly towards it and should terminate at least 200 yds away from it. From this point it should be led in along a concealed route. A straight lead-in across open country must be avoided at all costs. In forward areas the lead-in should be buried, as soon as possible, to give protection against shell splinters.

The commander of a line detachment must get instructions from the duty signal officer or lines officer concerned as to where he is to terminate his lines. (*See Signal Training Pamphlet No. 4, Part II.*)

3. A large permanent signal office may have a number of buried cables radiating from it, terminated at test points about a quarter of a mile from the office. These test points are often joined by interconnected buried cables, to allow important circuits to be re-routed if one of the lead-in cables is damaged. Aerial routes should be terminated at one of these test points, and connected through pairs in the buried cable to the signal office.

Section 10.—SEPARATION OF ROUTES

Aerial routes should be at least 300 yds apart, to avoid several routes being put out of action by the same bomb. This is particularly important where routes carry a number of pairs, and also if they carry alternative circuits to the same destination.

Routes must not be allowed to converge at bottle necks such as bridges, etc., as these are likely targets for bombing.

Section 11.—OBSTACLES

1. **Planning ahead.**—To avoid delay, the line detachment commander must make his plan for crossing such obstacles as towns, rivers, railways, tramways, main roads, and swamps, before the detachment reaches them. He should, if possible, personally supervise the crossings or by-passing.

2. **Building through towns and villages.**—Towns and villages should be avoided wherever possible; they are likely targets for bombing and the work of building through them is difficult and slow.

If the route must pass through a town it is best constructed across open spaces, such as public parks, gardens and allotments; along footpaths running along the backs of houses; the tow-paths of rivers and canals; and roads bordered by trees, or having a permanent line route along them. Permanent line poles along a railway may be helpful, but obvious targets like bridges, stations and goods yards must be avoided. In general, the residential part of a town is more suitable than the manufacturing district or shopping centre.

3. **High and medium tension power poles must never be used.**—The voltage of power poles can best be determined by noting the size of the insulators; a power line will be low tension if it has spurs leading direct to houses or street lamps. High tension poles are usually fitted with several turns of barbed wire, to prevent climbing, and are marked "DANGER, ACHTUNG, DANGER DE MORT," etc.

4. **Treat power poles with care.**—Where no other form of support is possible, insulated cable may be attached to low tension power poles (below 250 volts) for short distances *in emergencies.*

If the power pole is of iron, a slotted wooden batten or a wooden slat with bobbins must be fastened to the pole. With wooden poles the bobbins may be fixed direct to the pole.

The cables should be slung *below* the power wires, and there should be a clearance of 4 ft. between the lowest power wires and the cable.

Rubber gloves *must* be worn by linemen when they are working on power poles, crossings, etc.

5. **Bare wires** must not cross over or below power wires of any voltage. Crossings over low and medium tension power lines must be made with *insulated* wire throughout the span. They should cross at right angles to the power route, the wires should be terminated on either side, and line stays (*see* Sec **14**) should be fitted to the poles.

6. **When crossing high tension power wires** the cable must be buried on each side of the crossing for a distance equal to the height of the pole carrying the power wires.

7. **Canals and rivers.**—The most satisfactory method of crossing a canal or river used by barges is by means of a bridge.

A small footbridge is best, as it will not be a likely target for bombing. If there is no bridge within a reasonable distance, the cable can be sunk to the bottom, and weighted every few feet. Such a crossing is very liable to produce faults, however, and can be considered permanent only when made with proper submarine cable. A system of laying and jointing quad cables under water to provide temporary communication is described in *Signal Training Pamphlet No. 4, Part II.*

A non-navigable river can be crossed overhead if there is no bridge available. Such a crossing is difficult to repair, however, and makes the line troublesome to patrol.

8. **Railways.**—The standard method of crossing a railway, where no suitable bridge is available, is to terminate the line, and pass the cable under the railway lines. If for any reason an overhead crossing is necessary it must be soundly constructed to avoid any danger of it falling on the railway line.

9. **Electric railways.**—When crossing electric railways, underground crossings should be made when the feeder system is overhead, and overhead crossings when the third rail feeder system is used. The commander must supervise the crossing personally, and warn his linesmen of the danger of the live rail.

Cable used for crossing electric railways and tramways must always be insulated.

10. **Electric tramways.**—When crossing electric tramways the cable must, of course, be passed above the overhead feeder.

The cable should have several feet clearance above the power wires, and should be securely attached to neighbouring buildings. It will not normally be possible to use tramway poles as supports, but when this can be done the line must be well insulated by fixing it on wooden battens and porcelain bobbins.

A light rope or sash line should always be used to build the crossing. The best way is for two men standing on ladders on either side of the feeder to pass the rope over it using crooksticks to prevent contact.

The cable is then attached to the rope and pulled across. The man on the ladder at the side of the crossing from which the cable is being paid out keeps the cable at roughly the same tension as the rope by allowing both to slide through his closed fingers.

11. **Main roads** should not be crossed at road junctions nor at blind corners. Crossings must be soundly constructed and should be kept as short as possible.

12. **Wet and swampy ground should be avoided.**—Poles are apt to sink, pickets tend to pull out of the ground, and lines are liable to damage by lightning. If swamps must be crossed, the route must be very well stayed, and lightning conductors should be fitted more frequently than in normal circumstances (*see* Sec **6**).

SECTION 12.—POLES AND POLE HOLES

1. **Standard poles.**—The standard poles used on military lines are :—

(*a*) Poles, telegraph, wood, 16 ft, octagonal, **Mark 1*.**
(*b*) Poles, telegraph, wood, 16 ft, light.
(*c*) Poles, hop, fir or larch, 20 ft.
(*d*) Poles, hop, fir or larch, 26 ft.

The holes for the first two types of pole are made with a hammer and jumper, and those for the other two with an earth auger, a bar and spoon, or a pick and shovel.

Use of hammer and jumper

2. One man holds the jumper vertically on the ground, while another man strikes a few light blows on it with the hammer until the jumper stands up by itself. Both men then strike the jumper alternately until it is about 2 ft deep in the ground, taking care to keep it absolutely upright. They must not stand opposite one another, or one may hit the other.

The jumper is then loosened by a few horizontal blows on each side of it, and one man withdraws it, keeping his heels together and close to the jumper, and grasping it with his hands low down to avoid tearing them on the sharp edges round the top.

In sandy ground it may be necessary to pour a little water into the hole before the jumper is withdrawn to prevent the sides of the hole collapsing.

3. The butt of a pole, telegraph, wood, either octagonal or light, is shaped like the jumper, and so can easily be dropped into the hole, where it should be a good fit. The earth round the base of the pole should be punned down, and, if the pole is still loose, it must be packed by ramming stones and pieces of wood beside it.

Using an earth auger

4. The holes for fir poles and hop poles can be made with an earth auger, or a bar and spoon, or pick and shovel. The turf or top soil should be removed, with a shovel or grafting tool (a spade with a narrow curved blade). An earth auger can then be used if the ground is soft, but for hard stony ground or shingle a bar will be needed.

5. Two men hold the auger vertically and screw it into the ground until it becomes full of earth ; they then lift it out and empty it. This process is repeated until the hole is the required depth.

Bar and spoon method

6. When the bar and spoon are used one man uses the bar to loosen the earth, and another man lifts out the loose earth with the spoon. This method is slower than using the earth auger. The bar must never be used as a lever, as this breaks down the walls of the hole.

7. The bar can be left in the hole until the pole has been erected The butt of the pole then slides down the bar instead of scraping earth from the side and filling up the bottom of the hole.

8. When the pole has been erected, loose earth and small stones should be rammed round its base with the blunt end of the bar, and the top soil should be beaten down with a punner.

SECTION 13.—ARMS, SPINDLES, INSULATORS AND OTHER SUPPORTS

Arms

1. The arms used in aerial line construction are *arms, multi-airline, 33-in.*, which is the standard arm ; and *arms, multi-airline, 15-in.*

2. The 33-in arm is made of wood, with four holes drilled in it to take multi-airline spindles, giving a spacing of 9 ins between the wires of a pair, and 12 ins between pairs. The 15-in arm, also made of wood, has two holes 12 ins apart for spindles. Both these arms are fitted with clips that clamp on to a multi-airline pole by means of threaded studs, nuts, washers and straps. The 33-in arm may be fitted with one clip at the centre for clamping to a single pole, or with two clips fixed at the centres of the positions of the pairs of wires for clamping to two poles in an H pole structure (*see* Sec **41**).

3. Both types of arm can be used on hop poles and fir poles. If the diameter of the pole is larger than that of the standard pole, the pole must be cut to fit the clip; if the pole is too thin, a tight fit can be obtained by inserting wooden wedges between the pole and the clip.

4. Where the route is straight, the arms are fixed at right angles to the line wires; at an angle pole where the angle is less than 60 degrees the arms should bisect the angle; and at an angle pole where the angle is more than 60 degrees a cross-armed pole is used.

Spindles

5. Two types of spindle are used in aerial line construction :—

(*a*) *Insulator field, bolt, single*—a straight spindle.
(*b*) *Insulator field, bolt, double-J*—a spindle in the shape of a double-J carrying two insulators horizontally, one at each side of the arm. It is used for terminal poles and double terminations, including transpositions.

6. Both types of spindle fit into holes in the arms, and are held in position by a nut and washer. The latest type of insulator field, bolt, single, has an unthreaded shank and is held in position by a piece of wire threaded through a hole in the shank.

Insulators

7. The *insulator field, cup, Mark 4** (*double-groove*) is the type of insulator used with aerial line.
It is made of black plastic material and fitted with a screw cap. It has two grooves cut around the body to allow single or double terminations to be made. A threaded socket enables it to be screwed on to a spindle.

8. Other methods of support used in aerial line construction are :—

(*a*) Bobbins.
(*b*) Spiral eyes.
(*c*) Weave ties.
(*d*) Clove hitches and barrel hitches.
(*e*) Insulators, hanging, No. 2 (*see* Sec **36**).

Methods (*a*) to (*d*) are dealt with in detail in *Signal training Pamphlet No. 4, Part II.*

Section 14.—STAYS

1. Stays are used to counteract the pull of the route on the poles, and the pressure of the wind on the route. These stays are made of stay wire BB11 or 60-lb GI wire. There are five main types of stay :—

(*a*) Terminal stays.
(*b*) Line stays.
(*c*) Wind stays.
(*d*) Box stays.
(*e*) Angle stays.

These stays are illustrated in Fig 1.

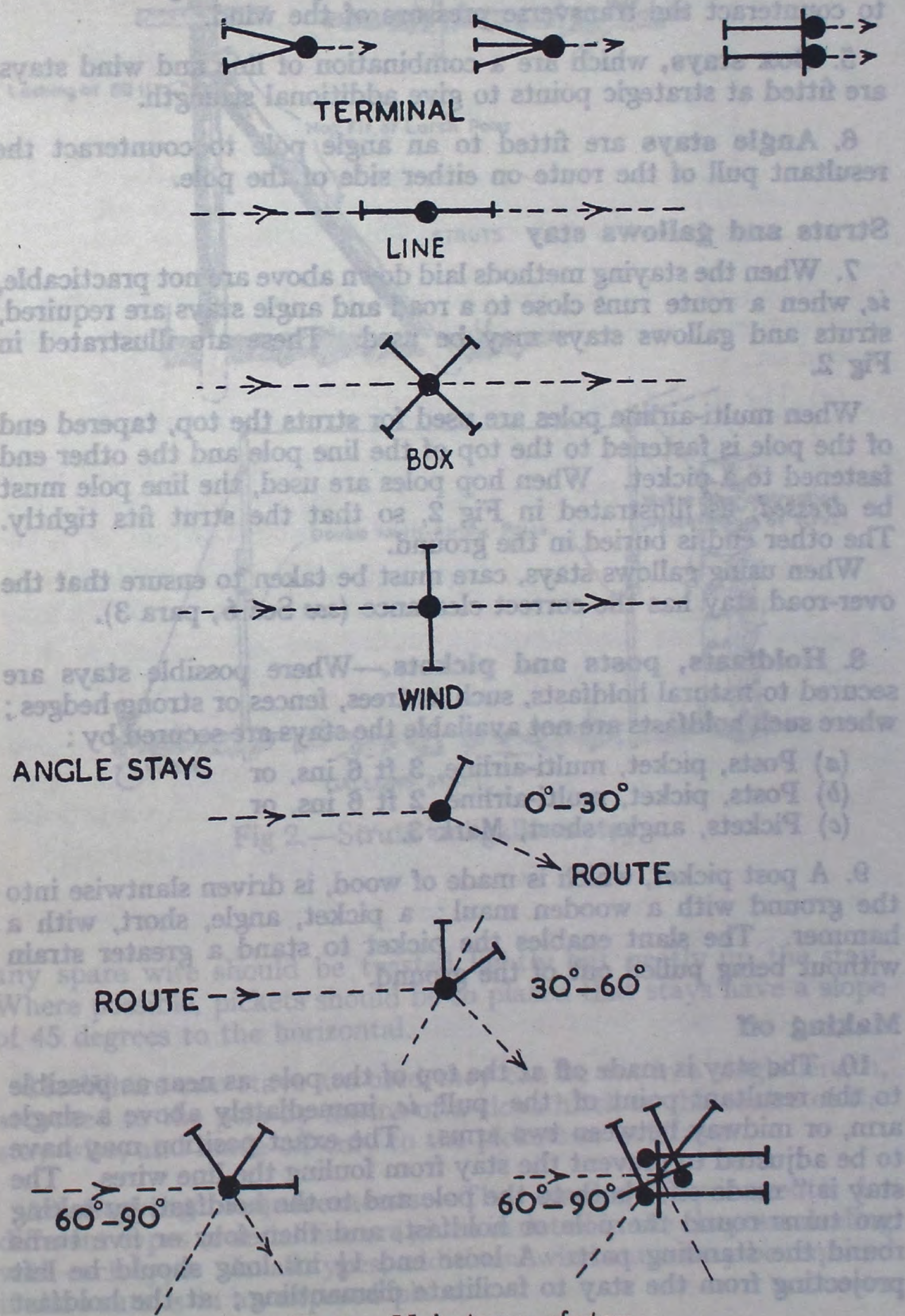

Fig 1.—Main types of stay

2. **Terminal stays.**—At a terminal pole, the line wires exert a pull on the pole in one direction only. Terminal stays are required to counterbalance this pull.

3. **Line stays,** *ie*, stays parallel to the route that are fitted to poles at regular intervals, and at these poles the wires are double terminated. This is to prevent a break in any one bay from causing the route to collapse for a considerable distance.

4. **Wind or rocker stays** are fitted to poles at regular intervals to counteract the transverse pressure of the wind.

5. **Box stays,** which are a combination of line and wind stays, are fitted at strategic points to give additional strength.

6. **Angle stays** are fitted to an angle pole to counteract the resultant pull of the route on either side of the pole.

Struts and gallows stay

7. When the staying methods laid down above are not practicable, *ie*, when a route runs close to a road and angle stays are required, struts and gallows stays may be used. These are illustrated in Fig 2.

When multi-airline poles are used for struts the top, tapered end of the pole is fastened to the top of the line pole and the other end fastened to a picket. When hop poles are used, the line pole must be *dressed*, as illustrated in Fig 2, so that the strut fits tightly. The other end is buried in the ground.

When using gallows stays, care must be taken to ensure that the over-road stay has the correct clearance (*see* Sec **6**, para 3).

8. **Holdfasts, posts and pickets.**—Where possible stays are secured to natural holdfasts, such as trees, fences or strong hedges; where such holdfasts are not available the stays are secured by :

(*a*) Posts, picket, multi-airline, 3 ft 6 ins, or
(*b*) Posts, picket, multi-airline, 2 ft 6 ins, or
(*c*) Pickets, angle, short, Mark 3.

9. A post picket, which is made of wood, is driven slantwise into the ground with a wooden maul; a picket, angle, short, with a hammer. The slant enables the picket to stand a greater strain without being pulled out of the ground.

Making off

10. The stay is made off at the top of the pole, as near as possible to the resultant point of the pull, *ie*, immediately above a single arm, or midway between two arms. The exact position may have to be adjusted to prevent the stay from fouling the line wires. The stay is " made off," both to the pole and to the holdfast, by taking two turns round the pole or holdfast, and then four or five turns round the standing part. A loose end 1½ ins long should be left projecting from the stay to facilitate dismantling; at the holdfast

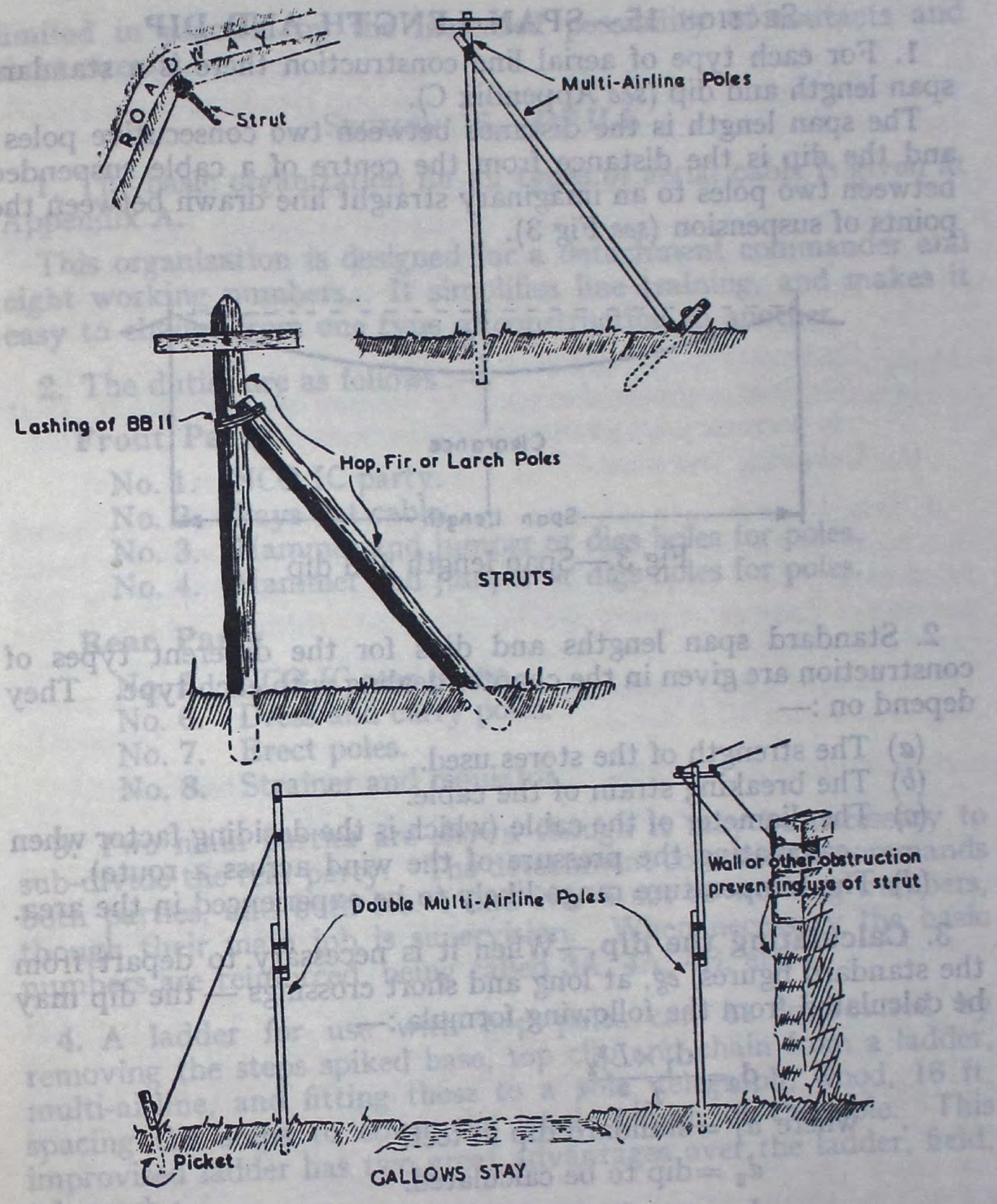

Fig 2.—Struts and gallows stay

any spare wire should be twisted lightly but neatly up the stay. Where possible, pickets should be so placed that stays have a slope of 45 degrees to the horizontal.

11. Where two stays are used they can be cut in a single length, attached to the pole by means of a clove hitch in the centre of the stay wire, and made off only to the pickets or holdfasts.

12. **Staying requirements.**—The staying requirements for different types of aerial line are given in detail in the chapters dealing with each type. In all types, additional wind stays may be required if the route is in an exposed place.

Section 15.—SPAN LENGTH AND DIP

1. For each type of aerial line construction there is a standard span length and dip (*see* Appendix C).

The span length is the distance between two consecutive poles; and the dip is the distance from the centre of a cable suspended between two poles to an imaginary straight line drawn between the points of suspension (*see* Fig 3).

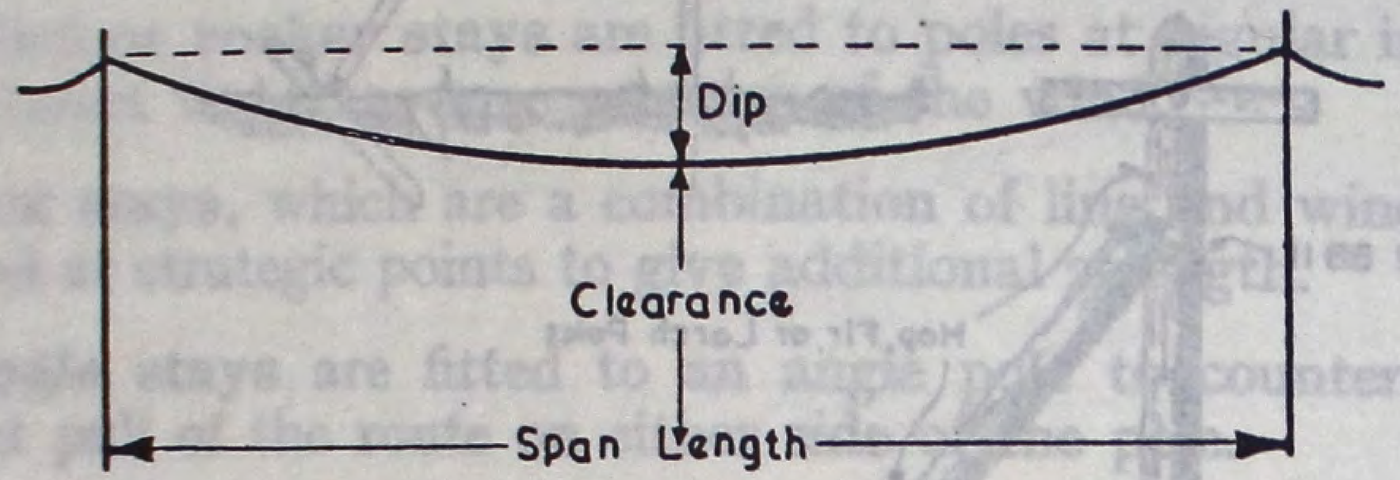

Fig 3.—Span length and dip

2. Standard span lengths and dips for the different types of construction are given in the chapter dealing with each type. They depend on :—

(*a*) The strength of the stores used.
(*b*) The breaking strain of the cable.
(*c*) The diameter of the cable (which is the deciding factor when calculating the pressure of the wind across a route).
(*d*) The temperature range likely to be experienced in the area.

3. **Calculating the dip.**—When it is necessary to depart from the standard figures, *eg*, at long and short crossings — the dip may be calculated from the following formula :—

$$d_2 = \frac{d_1 \times L_2^2}{L_1^2},$$

where d_1 = standard dip in feet.
d_2 = dip to be calculated.
L_1 = standard span length in yards.
L_2 = actual span length, in yards.

It will be seen that the dip in feet is directly proportional to the square of the length of the actual span.

Example

In a poled cable route the standard dip and span length is 3 ft, and 50 yds respectively. What should be the dip, if a span of 60 yds is required?

$$d_2 = \frac{3 \times 60^2}{50^2} = 4{\cdot}3 \text{ ft.}$$

4. In exposed places and where a number of cables are erected on the same pole span lengths should be reduced.

On insulated cable routes, an increase in dip will prevent cables being easily broken by blast; this also applies to bare wires but is

limited in practice by the increased possibility of contacts and short circuits.

Section 16.—DRILL

1. The basic organization for all types of aerial cable is given at Appendix A.

This organization is designed for a detachment commander and eight working numbers. It simplifies line training, and makes it easy to change from one type of construction to another.

2. The duties are as follows :—

Front Party

No. 1. NCO IC party.
No. 2. Pays out cable.
No. 3. Hammer and jumper or digs holes for poles.
No. 4. Hammer and jumper or digs holes for poles.

Rear Party

No. 5. NCO IC rear party.
No. 6. Dress and carry poles.
No. 7. Erect poles.
No. 8. Strainer and regulator.

3. Two main parties are shown though it may be necessary to sub-divide the rear party. The detachment commander commands both parties, and both No. 1 and No. 5 act as working numbers, though their main job is supervision. When necessary the basic numbers are reinforced, being called 3A, 4A, 4B, etc.

4. A ladder for use with hop poles can be improvised by removing the steps spiked base, top clip and chain from a ladder, multi-airline, and fitting these to a pole, telegraph, wood, 16 ft, spacing the steps to cover the whole length of the pole. This improvised ladder has two great advantages over the ladder, field, telegraph :—

(*a*) It is light and can be carried by one man.
(*b*) It makes contact with the hop pole from top to bottom whereas the ladder, field, telegraph does only so at the top. When using a ladder, the whole weight of man and ladder is applied to the pole near the top, with the result that the pole may be pushed over sideways.

Section 17.—TEST POINTS AND LABELLING

1. General information on test points is given in *Signal Training Pamphlet No. 4, Part I.*

The number of test points required on any route will depend on circumstances as well as the type of country, and ease of access to the route.

Test points

2. In a large line layout, test points are established at points where a number of lines converge. This enables lines to be tested, and circuits to be switched readily from one line to another.

3. The essentials in a test point are :—

(*a*) Sets of terminals and U-links for incoming and outgoing cables (standard frames should be used if available).
(*b*) Adequate testing instruments if the test point is permanently staffed.
(*c*) Under cover and dry.
(*d*) Suitable accommodation and feeding arrangements, if it is necessary to accommodate personnel.
(*e*) Labelling (*see* para 8).

4. Small test points can be made from terminal strips, mounted in a suitable box to protect them from the weather, the box being fixed to a pole. Terminal strips 8-pair are normally used for this purpose. Jumper wires must be provided, through which a line can be connected to any other line terminated at the test point. These jumper wires can be made from the conductors of a waste length of 7-pair VIR cable.

5. A double-termination pole makes an excellent test point.

The wires are terminated on a double-J multi-airline spindle fitted with two insulators, or on two bobbins, and connected between the two terminations by a bridge of wire, free from tension. The lineman can test by cutting the bridge, without disturbing the regulation of the wires on either side.

After testing the bridge must be jointed; each jointing will shorten the bridge, and eventually a new bridge will have to be made. This can be avoided by using *connectors, slotted, No.* 2 *small* (*see* Fig 4), after the bridge has been cut for the first time or during the initial construction.

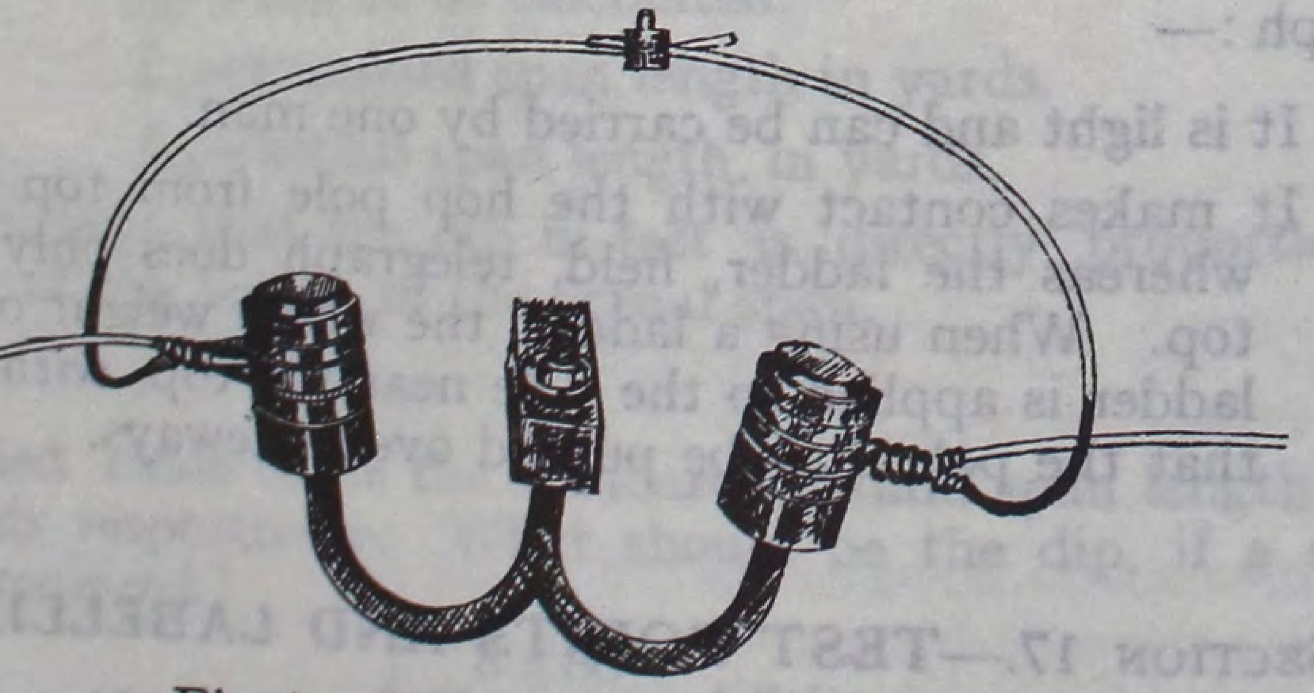

Fig 4.—Use of connectors, slotted

6. **The connectors, slotted, No. 2, small,** consists of a bolt, slotted down the centre, and a nut which drives a key down the slot.

The two ends of the bridge are placed in the slot from opposite sides, and clamped down firmly by means of the key. If the wires are insulated, about 1-in of the insulation must be stripped from the ends, and the conductors cleaned, before they are placed in the slot.

7. **Test points on carrier systems.**—Aerial lines will often have carrier equipment working over them. The number of test points on carrier routes must be reduced to a minimum as they are a source of loss. All joints must be permanent and the absolute minimum of lead-in cable provided.

8. **Labelling** is dealt with in detail in *Signal Training Pamphlet No.* 4, *Part II, Sec* 3. Aerial lines must be labelled at least every half-mile, and also at the following points :—

(*a*) All test points and junctions.
(*b*) All terminal points.
(*c*) At points where spurs leave the main route.
(*d*) Transposition poles.
(*e*) Joints, joint boxes and loading coils.

SECTION 18.—TRANSPOSITION

General

1. Telephone lines may have voltages induced in them that cause interference. There are two main sources of such interference :—

(*a*) Other telephone lines on the same route.
(*b*) External sources, such as power lines running parallel to the route.

2. It is not possible to screen telephone wires, and the only method of preventing interference is to arrange the wires so that equal voltages are induced into the two legs of the pair, with the result that they cancel out. This can be done by crossing the legs at intervals along the route, and the process is known as *transposition*.

3. Transposition is necessary in spaced cable and multi-airline construction. Transposition of multicore cables, *eg*, quad and 7-pr cables is provided for in the design of the cables by the lay, *ie*, the rate of twist of the group of wires.

Systems of transposition

4. Routes are built up of a series of sections, each section containing identical crosses between the legs, and the intervals between transposition poles must be the same whatever the length of the section; upon this depends the efficiency of any transposition system.

5. There are two general systems of transposition, one for audio routes and one for carrier. The latter is far more critical than the former in its requirements.

6. The standard section for audio routes covers two miles and for carrier routes a quarter mile. Within these sections mutual interference is neutralized.

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7. Standard transposition system for audio routes.—Each pair of wires is crossed separately every alternate mile (*see* Fig 5).

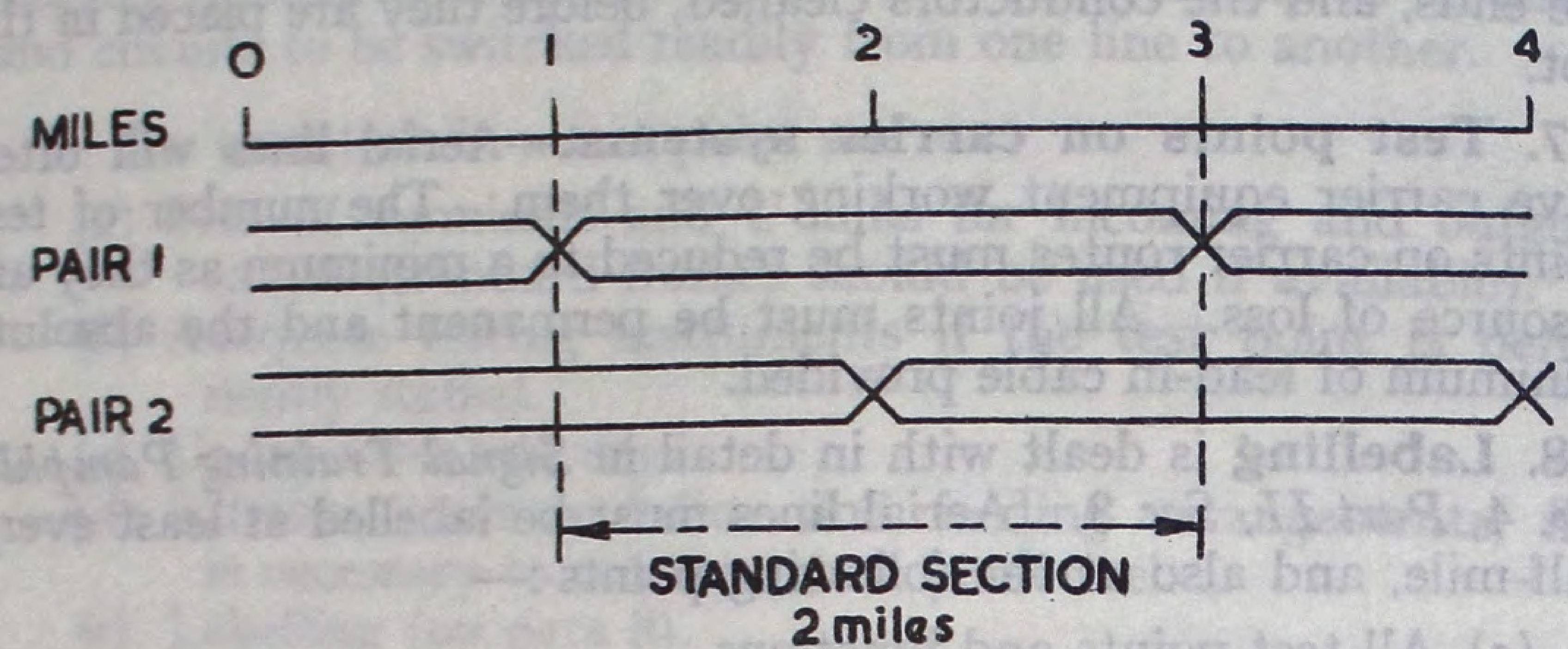

Fig 5.—Standard transposition section for audio routes

8. Standard transposition system for carrier routes.—One pair of wires is transposed every quarter-mile, and the other pair every half-mile (*see* Fig 6).

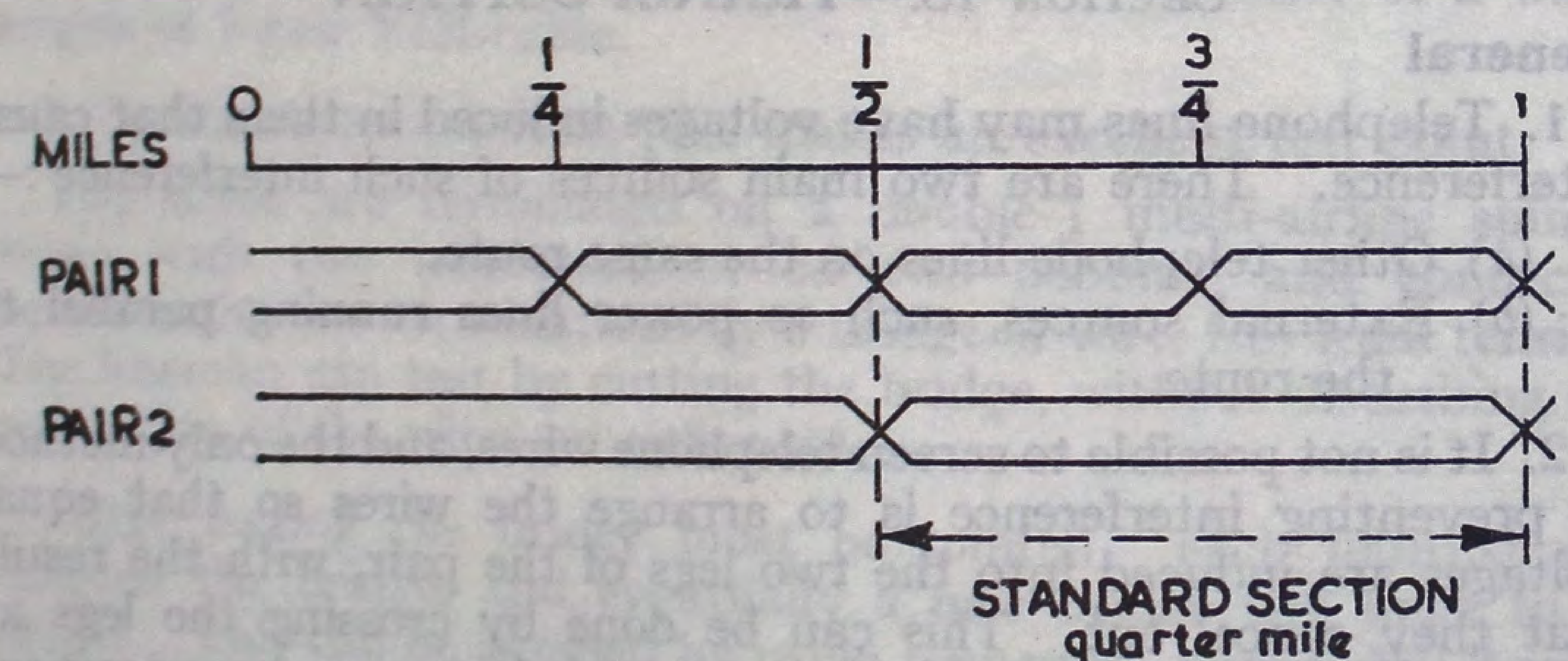

Fig 6.—Standard transposition section for carrier routes

9. Continuous twist system.—The continuous twist system is a third system of transposition that may be employed when 15-in arms are used, and in this system the diagonally opposite wires make up a pair. It is suitable for both audio and carrier routes, and phantom circuits can be worked on both pairs.

The standard section for this type of construction is 1 mile, and the normal span for 70-lb cadmium copper is 44 yds, *ie*, 40 spans per mile. The four wires then change position as follows :—

Poles 0–9	10–19	20–29	30–39	40–49
1 3	4 1	2 4	3 2	1 3
4 2	2 3	3 1	1 4	4 2

and so on.

To complete the transposition system the wires of a pair should be crossed every 2 miles, the pairs being dealt with alternately every mile.

External sources of interference

10. The systems outlined in paras 7, 8 and 9 above, will neutralize interference between wires on the same route, but if the line runs parallel to a power line for any distance, the voltage induced in the line may make it noisy. This form of interference can be overcome as follows :—

(*a*) Arrange that the end of a standard transposition section comes as near as possible to the point where the route approaches the power route. This can be done by dividing by two, or by four, all the distances in the section, to make it end at approximately the correct place.

(*b*) If the section in which the route runs parallel to the power wires is a quarter of a standard section or less, cross both pairs at the centre of the section, both in audio and carrier routes.

(*c*) If the section exceeds a quarter of a standard section, include all the crosses for one or more complete transposition sections, adjusting the lengths of the sections in the same way as in sub-para (*a*) above.

CHAPTER 2

POLED "D" CLASS CABLE

SECTION 19.—GENERAL

1. Poled cable is defined in Sec **1**, **2** (*a*). This chapter deals with poled cable using "D" class cables; and Chapters 3–5 deal with the same type of construction using quad cable, carrier quad cable, and 7-pair VIR cable respectively.

2. Whatever type of cable is used in poled cable construction, it will usually be supported on poles or natural supports by means of bobbins, slotted slats, spiral eyes, weave ties, or by a clove hitch in the cable and fastened to a support with a barrel hitch of spun-yarn (*see Signal Training Pamphlet No*. 4, *Part II*).

3. Although poled cable is susceptible to damage from bombing and shelling, the dip in the cable and its inherent strength will often prevent it being broken by blast; even if poles or supports are brought down, the insulation of the cable may keep the circuit through until repairs can be carried out.

4. Poled "D" class cable is normally used :—

(*a*) When the military position stabilizes, and ground cable is converted into poled cable because it is known that the lines will be required for some time.

(*b*) In static positions, where no great distances are involved, but where the safety of the line from traffic is of primary importance.

SECTION 20.—CONSTRUCTING THE LINE

General

1. When building poled "D" class cable, every advantage should be taken of trees, existing poles, etc., but *see* Sec **8**, para 6.

2. It may be possible to convert cable laid on the ground into a poled route, but a ground cable route is often most unsuitable for a poled route. It will then be better to abandon portions of the ground cable and to build a fresh route, rather than make a bad poled route by slavishly following the old one.

3. **Standard span length and dip.**—For one twisted cable the standard span length is 50 yds and the standard dip 3 ft. Spans may be longer, provided that the ground clearance is sufficient.

For comparative table showing span length and dip for all cables, *see* Appendix C.

4. **Spacing cables.**—When more than one twisted cable is attached to the same pole or support, the cables should be spaced so that they can be readily identified, and faults traced.

When attaching twisted cables by a clove hitch, the knot must

be made separately in each leg of the cable (*see Signal Training Pamphlet No*. 4, *Part II*).

5. **Building the line.**—When there is to be one cable only on the route, it should be attached before the poles are erected. With practice it is easy to judge the dip, and exact regulation is not essential. This makes ladders unnecessary, increases the speed of building, and reduces the number of men needed. When several cables are being put up at the same time, it is easier to erect the poles first, and then put up and regulate the cables. If bobbins are being used, they must be put on the poles before the poles are put up.

6. **Jointing.**—All joints in aerial cable must be soldered. When a ground cable route is being poled, all unsoldered joints must be re-made and soldered; each soldered joint should be marked with a turn of insulating tape a few inches on each side of the joint (*see Signal Training Pamphlet No*. 4, *Part* II).

Staying the line

7. The staying of the route depends largely on the number of cables. The following is sufficient for a route of not more than two cables :—

(*a*) The terminal pole should have two stays, not more than 2 ft apart on the ground, and set back about 10 ft.

(*b*) Line stays should be placed on every 8th pole, *eg*, on the 8th, 16th, etc.

(*c*) Wind stays should be placed on every 8th pole, alternating with the line stays, *eg*, on the 4th, 12th, 20th, etc.

(*d*) At angles of less than 30 degrees, one stay bisecting the angle is necessary. At angles between 30 and 60 degrees two stays must be used, 2 ft on either side of the bisecting line. At angles between 60 and 90 degrees three stays are necessary, one bisecting the angle, and one in line with each "leg" of the route.

Routes carrying more than two cables will require additional stays at termination and angle poles.

SECTION 21.—ORGANIZATION AND DUTIES OF DETACHMENT

1. **General.**—The most suitable working detachment comprises a commander and 17 men, but the duties are arranged in accordance with the basic organization, so that the numbers can be varied (*see* Appendix A).

The stores required for 1 mile of route are given in Appendix B.

2. **The detachment commander** will carry out the general duties of a detachment commander, as laid down in *Signal Training Pamphlet No*. 4, *Part II*.

3. In addition he will :—

(*a*) Survey the route, assisted by No. 1.
(*b*) Supervise the working of both parties.
(*c*) Indicate by a pre-arranged mark any natural supports that are to be used.
(*d*) Give orders about the staying and labelling to No. 5.
(*e*) Personally supervise the work at difficult parts of the route.

Front Party

4. No. 1 will :—

(*a*) Assist the detachment commander to survey the route.
(*b*) If time permits attach the bobbins, spiral eyes, *etc*, that are being used on the route to any natural supports that are available (*see* para **6** (*b*)).
(*c*) Deputize for the detachment commander as and when required.
(*d*) Test the cable.
(*e*) Line up the route by ensuring that Nos. 3 and 4 dig their holes in line.

5. No. 2, 2A, 2B, and 2C will :—

(*a*) Pay out the cable.
(*b*) Joint the cables at the end of the drums.

6. No. 3, 3A, 4 and 4A will :—

(*a*) Dig holes where indicated by No. 1.
(*b*) Fit whatever type of support is being used to any natural support marked by the detachment commander.
(*c*) Drive in the pickets.

Rear Party

7. No. 5 will :—

(*a*) Take charge of the rear party.
(*b*) Supervise the staying and regulation.
(*c*) Label the line.

8. Nos. 6, 6A and 6B will :—

(*a*) Dress and carry the poles.

9. Nos. 7 and 7A will :—

(*a*) Erect the poles.
(*b*) Pun the earth round the base of the pole.
(*c*) Adjust the stays.
(*d*) Put foliage on the stays to act as guards.
(*e*) Ensure that all pickets are holding.
(*f*) Clear the route of overhanging boughs.

10. Nos. 8 and 8A will :—

(*a*) Carry a ladder, and attach the cable to poles or supports by bobbins, spiral eyes, etc.
(*b*) Regulate the tension of the cable as directed by No. 5.

CHAPTER 3

POLED QUAD CABLE

SECTION 22.—GENERAL

1. Two types of quad cable are used in Army line construction ; quad, and carrier quad.

This chapter deals with quad cable ; carrier quad is dealt with in Chapter 4.

The make-up of these cables is described in *Signal Training Pamphlet No.* 4, *Part II*.

2. Quad cable is designed primarily for laying on the ground, and is not very suitable for poling, owing to its lack of mechanical strength ; but if it is to be left in the open for any length of time, it should be poled to prevent deterioration. It can be poled satisfactorily if it is not strained too much.

3. Quad cable is used in mobile warfare to provide junction lines from army to corps and from corps to division. The cable will normally be laid on the ground and then poled on hop poles as soon as the military situation stabilizes.

4. **Mechanical characteristics.**—If excessive strain is placed on the cable the sheath stretches, and throws the whole weight of the cable on to the conductors, which are then liable to break. For this reason the standard span length for quad is much less than for poled " D " class cable, and must not be exceeded.

Standard span lengths and dip are shown in Appendix C.

Poled quad cable will form a sound route, and will be little affected by weather conditions if these measurements are kept to.

5. **The electrical characteristics** of quad cable are excellent, provided that the line is soundly built, and that good joints are made at joint boxes.

Speech is possible over about 20 miles of unloaded quad cable, and this distance can be increased to about 45 miles by loading with *pots, loading, 2-coil No.* 3, of value 88 mH at intervals of one mile.

The electrical properties of the line should remain fairly constant for many months.

6. **Loading intervals start and finish of route.** When loading a route the interval between the commencement of the route and the first loading pot and the interval between the last loading pot and the termination of the route should be half the distance of the loading interval laid down for the type of cable used.

Section 23.—CONSTRUCTING THE LINE

1. **Poles.**—20-ft hop poles are required to maintain standard clearances (*see* Sec **6**).

When building the cable on existing permanent line poles (which are usually about 60 yds apart), hop poles must be placed between them to achieve the standard span length.

2. **Staying.**—The staying is the same as for poled " D " class cable (*see* Sec **20**).

Routes carrying more than one cable will require additional stays at termination and angle poles.

3. **Spunyarn chafers.**—When the cable is supported by bobbins the insulation must be protected from damage due to friction at the point of support. This is done by placing a spunyarn chafer (*see* Fig 7) on the cable, as follows :—

(*a*) Take a piece of spunyarn about 6 ft long, and form a bight about 4 ins long and 1 ft from one end.

(*b*) Lay the bight along the cable, and bind the longer end of the spunyarn closely round the cable and the bight, for a distance of 3 ins.

(*c*) Pass the long end of the spunyarn through the bight and, by pulling on the short end, drag the bight under the binding, thus forming the chafer and leaving about 1 ft of spunyarn at each end.

(*d*) Now place the cable on the bobbin, with the point of support in the middle of the chafer, and the ends of the spunyarn tied tightly round the pole. Thus the cable is secured to the pole itself, but its weight is carried by the bobbin and not by the spunyarn. Spunyarn chafers should be inspected frequently, and replaced where necessary.

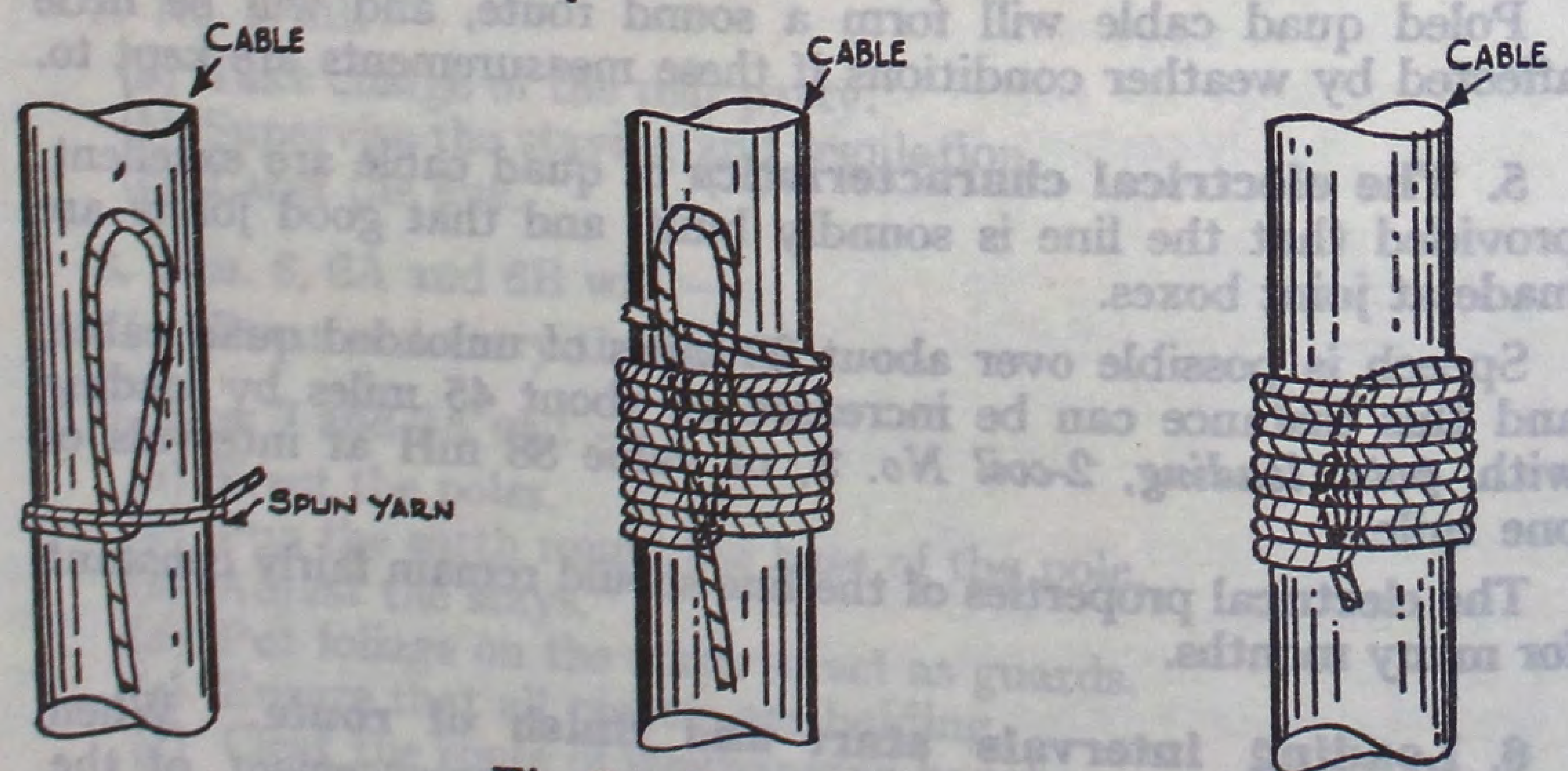

Fig 7.—Spunyarn chafer.

Jointing

4. Quad cable is jointed by means of a *box, joint quad cable, No.* 1 or a *box, joint, three-way, quad cable.* Both these boxes are described in *Signal Training Pamphlet No.* 4, *Part II.*

5. The cable must never be under tension at a joint box ; the boxes must therefore coincide with, and be mounted on the poles of the route. The ends of the two cables to be jointed should be strapped together with spunyarn as shown in Fig 8, about 2 ft from the ends, and supported in the middle of the strapping on a bobbin. The ends of the cable are jointed as laid down in *Signal Training Pamphlet No.* 4, *Part II*, and the box tied to the pole with spunyarn.

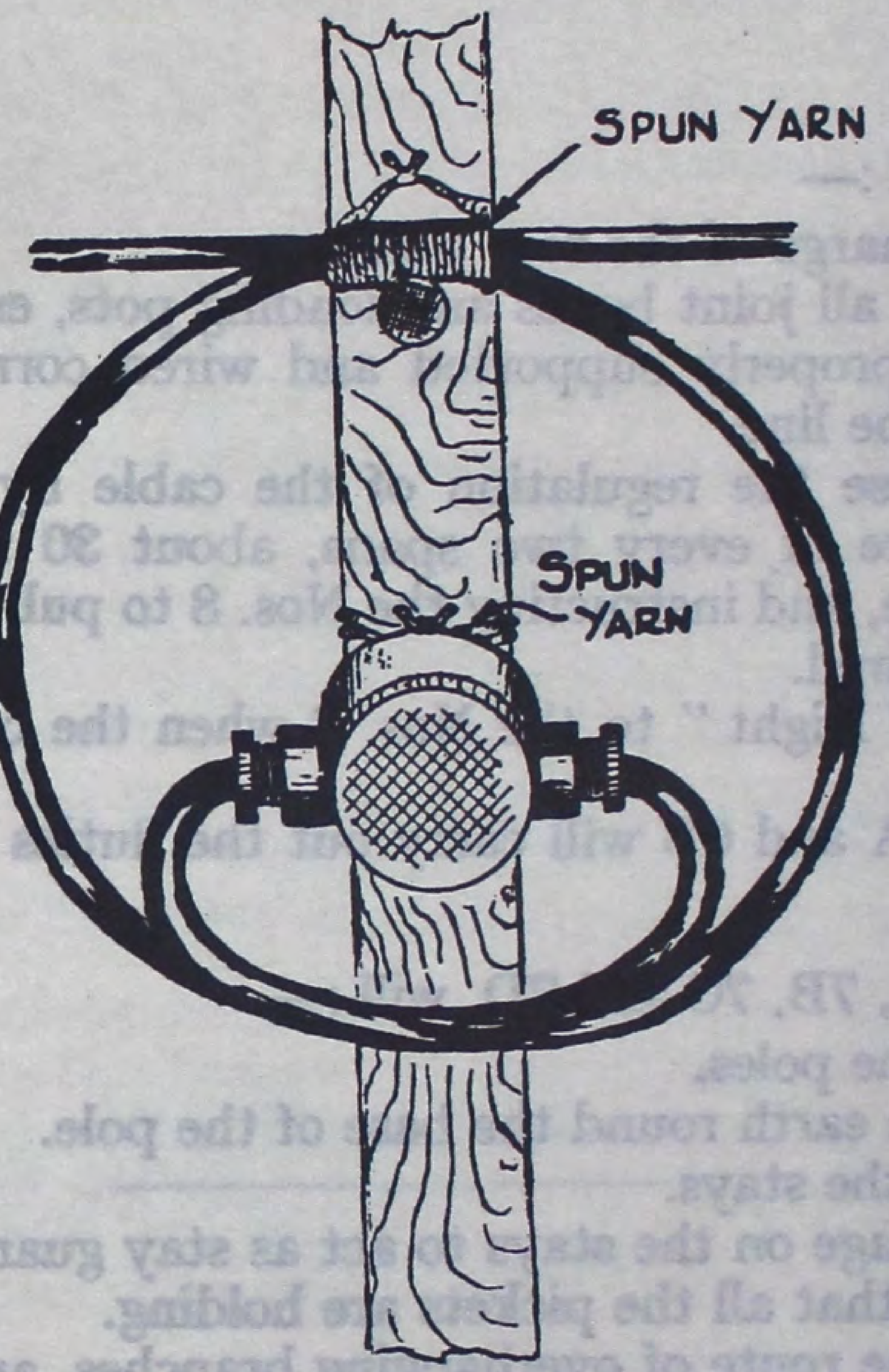

Fig 8.—Box, joint, quad cable, No. 1, mounted on a hop pole.

6. **Loading.**—The cable is loaded by means of a *pot, loading, 2-coil, No.* 3, which is described in *Signal Training Pamphlet No.* 4, *Part II*. The pot is inserted and suspended in the same way as a joint box.

Section 24.—ORGANIZATION AND DUTIES

1. **General.**—The most suitable working detachment comprises a commander and 20 men, but the duties are arranged in accordance with the basic organization so that the numbers can be varied (*see* Appendix A). When two quad cables are being erected two extra men are required to pay out.

The stores required for one mile of route are given in Appendix B.

2. The detachment commander will carry out the general duties of a detachment commander, as laid down in *Signal Training Pamphlet No.* 4, *Part II*, and the additional duties laid down in Sec **21**, **3**. His orders to No. 1 will include details of loading, when necessary.

Front Party

3. No. 1 will :—
(*a*) Carry out the duties laid down in Sec 21, 4.
(*b*) Load the line as directed by the detachment commander.

4. Nos. 2 and 2A will pull the drumbarrow and pay off the cable.

5. Nos. 3, 3A, 4, and 4A will carry out the duties laid down in Sec 21, 6.

Rear Party

6. No. 5 will :—
(*a*) Take charge of the rear party.
(*b*) Inspect all joint boxes and loading pots, ensuring that they are properly supported and wired correctly.
(*c*) Label the line.
(*d*) Supervise the regulation of the cable by standing in the centre of every two spans, about 30 ft back from the route, and instructing the Nos. 8 to pull up or slack off as required.
(*e*) Shout " Right " to the Nos. 8 when the cable is regulated.

7. Nos. 6, 6A and 6B will carry out the duties laid down in Sec 21, 8.

8. Nos 7, 7A, 7B, 7C and 7D, will :—
(*a*) Erect the poles.
(*b*) Pun the earth round the base of the pole.
(*c*) Adjust the stays.
(*d*) Put foliage on the stays to act as stay guards.
(*e*) Ensure that all the pickets are holding.
(*f*) Clear the route of overhanging branches, and other obstructions that may interfere with the cable.

9. No. 8, 8A, 8B and 8C will work in pairs.

10. No. 8 will :—
(*a*) Work at the first pole with No. 8A.
(*b*) Take the cable to the top of the pole by means of a ladder.
(*c*) When No. 5, standing at a distance from the route, has given instructions for the regulation of the cable, No. 8 will mark on it the position at which it is to be attached to the pole.
(*d*) When Nos. 8A and 8C who have been straining further along the route, slack off the cable, attach spunyarn chafer to it at the position marked.
(*e*) Signal to 8A and 8C when he is ready for the cable to be pulled up.
(*f*) Attach the cable to the pole when it is pulled up.
(*g*) Walk to the third pole down the route with the cable and then change duties with No. 8A and carry out the work laid down for No. 8A in para 11 below.

11. No. 8A will :—
(*a*) Work at the first pole with No. 8.
(*b*) Hold the ladder while No. 8 climbs the pole.
(*c*) Ensure that the cable is not caught up in any undergrowth, etc.
(*d*) Walk up the route and assist 8C in straining up the two bays.

12. Nos. 8B and 8C carry out similar duties to those laid down in paras 10 and 11 for 8 and 8A, except that they start work at the second pole.

CHAPTER 4

POLED CARRIER QUAD CABLE

SECTION 25.—GENERAL

1. Carrier quad is made up in lengths of 440 yds, usually wound on No. 7 drums. The cable should always be loaded by means of the *pot, loading, 2-coil, No. 2.*

2. The cable can be laid on the ground, or poled. When laid on the ground, the drill is the same as for laying quad cable on the ground (*see Signal Training Pamphlet No. 4, Part II*).

Cable laid on the ground should be poled at the first opportunity. The drill for poling is very similar to that for poling quad cable (*see* Chapter 3), the organization and duties of the numbers being the same, the difference being in the length of the span, and loading.

3. **Characteristics.**—Carrier quad is chiefly designed for use with multi-channel carrier telephone systems. It carries higher frequencies with less attenuation than other types of cable; range at 16 kc/s is about 40 miles, and the audio range about 50 miles.

Carrier quad is much stronger than ordinary quad, and a well-built route is little affected by the weather.

The standard span length and dip are given in Appendix C.

4. **Use.**—The cable is used to provide long-distance circuits over which carrier equipment can be worked. Generally speaking, it fulfils the same requirements as multi-airline, but has the advantages of being quicker to construct, and less liable to damage by bombardment. It cannot be worked over such long distances as multi-airline.

Loading

5. Carrier quad is loaded by inserting a 4·6 mH coil in the cable at intervals of 440 yds.

The first loading point should always be 220 yds from the start of the cable, subsequent points being at 660 yds, 1,100 yds, etc.

6. The loading pot used in the *pot, loading, two-coil, No. 2,* which is similar to the *pot, loading, two-coil No. 3* (*see Signal Training Pamphlet No. 4, Part II*) and can be distinguished by a broad red stripe on the outer case. The method of connecting the cable are exactly the same as for the No. 3 pot.

CHAPTER 5

POLED 7-PAIR CABLE

SECTION 26.—GENERAL

1. Cable, electric, VIR (vulcanized india-rubber), braided and compounded, 7-pair, consists of 14 tinned copper conductors, insulated with VIR, and twisted to form seven pairs. One pair is contained in a VIR former, around which the other six pairs are laid up. The core is wrapped with a proofed tape. The sheath of the cable is made of rubber, covered with a compound braiding.

2. Its main use is for leading-in and out of large signal offices. It also provides a rapid and efficient means of providing a number of pairs between two test points for the purpose of re-routing circuits in case of damage to other lines; for this reason, it is often termed interruption cable. The cable may be buried, poled, or laid on the ground but if laid on the ground, it should be poled later to avoid damage and deterioration due to weather conditions.

7-pair VIR cable is not normally loaded.

SECTION 27.—LAYING THE CABLE

1. The cable is made up in lengths of 440 yds. Each length is wound on a wooden drum, 2 ft 10 ins in diameter; the drum and cable together weigh 4¼ cwt. As the cable is heavy it is important that the route selected should be accessible to transport.

2. The minimum strength of a detachment for laying poled 7-pair is a commander and 22 men.

The stores required for 1 mile of route are given in Appendix B.

3. The best method of paying-out the cable is to put a crowbar through the hole in the drum, and to support the ends of the bar on cable jacks (if available), or wooden trestles, or other improvised supports, so that the drum is clear of the ground and can rotate freely. The crowbar must be firmly wedged, so that it does not slip off the supports when the drum starts to rotate.

4. If the materials needed for the method described above are not available, the drum can be laid on its side and the cable slipped off it, turn by turn. The drum must be reversed after about 10 turns, to counteract the twist imparted to the cable.

5. **Laying with a cable plough.**—This method is described in *Signal Training Pamphlet No. 4, Part V.*—Underground Cable.

6. **Laying from a lorry.**—When the cable is to be laid along the side of a road, much labour can be saved by laying it direct from the back of a lorry as follows:—

(*a*) The drum is mounted very securely in the back of the lorry on a crowbar and trestles or other supports, as described in para 3, above.

(*b*) The lorry is driven very slowly forward.

(*c*) Two men in the lorry steady the drum, while a third man walks behind the lorry pulling off the cable.

(*d*) Additional men, following close behind the lorry, take the cable to the side of the road, out of the way of traffic.

7. Laying from the ground.—When the cable is to be laid from the ground, the drum is unloaded from the lorry as close to the route as possible. It is mounted on a crowbar and trestles as before, and laid as follows :—

(*a*) One man steadies the drum, while another takes the end of the cable, puts it over his shoulder and walks away from the drum.

(*b*) When the man holding the end of the cable is about 20 yds from the drum, another man puts the cable over his shoulder and walks after him. When the second man is about 20 yds away, a third man starts, and so on.

(*c*) The cable is carried in this way to the place where it is to lie, the men carrying it being spaced about 20 yds apart.

SECTION 28.—DETAILS OF AERIAL CONSTRUCTION

1. Standard span length and dip.—The standard span length is 30 yds and the standard dip 2½ ft. (*See* Appendix C.) If a span of more than 30 yds is needed, a suspension wire must be erected, as described in *Signal Training Pamphlet No. 4, Part II.*

2. Poles.—The standard route is built on 20-ft hop poles. Existing permanent line poles can be used by placing hop poles halfway between them.

3. Angles.—If possible, the route should include no angle greater than 30 degrees, because the cable is heavy for the poles used, and because the conductors may be damaged if the cable is bent sharply. If a sharper angle than this is necessary it should be done on two or more successive poles.

4. Stays.—Routes are stayed as follows :—

(*a*) Box stays on every third pole and at both sides of all important crossings.

(*b*) Line stays on all other poles.

(*c*) Two stays at angles of less than 30 degrees, placed 4 ft apart, one on each side of the line bisecting the angle.

(*d*) Three stays at angles of more than 30 degrees, one bisecting the angle and one in line with the route on each side.

(*e*) A double stay in line with the route, and a single stay 4 ft on each side of it at a terminal pole.

5. Attaching the cable.—The cable is attached to the pole by bobbins and spunyarn chafers, or by weave ties.

When making chafers, about 8 ft of spunyarn is required because of the large diameter of the cable, and a second length of spunyarn must be bound twice round the cable, bobbin and pole to give additional security.

SECTION 29.—JOINTING

Colour scheme

1. The colour scheme of the pairs in the cable is as follows :—

No. 1 (centre)	**Black-Green.**
No. 2	**Red-White.**
No. 3	**Black-Brown.**
No. 4	**Red-Blue.**
No. 5	**Black-Yellow.**
No. 6	**Red-Green.**
No. 7	**Black-Blue.**

2. It will be noticed that several colours occur more than once. It is essential, therefore, that the conductors should be kept twisted up in their correct pairs throughout the operation of jointing, to ensure that each conductor in one cable is connected to the corresponding conductor in the other cable.

3. Preparing the cables.—To prepare the cables :—

(*a*) Tie a clove hitch of lacing twine or spun yarn over the braiding 10 ins from the end of one cable.

(*b*) Strip back the braiding to the clove hitch.

(*c*) Cut the rubber sheath longitudinally for 8 ins from the end of the cable, using a very sharp knife and taking great care not to cut into the insulation of the conductors.

(*d*) Open the portion of the sheath that has been cut and fold it back.

(*e*) Tie back the fold to the cable with twine or spunyarn.

(*f*) Prepare the end of the second cable in the same way.

4. Jointing the conductors.—To joint the conductor :—

(*a*) Fix the cables firmly opposite one another, so that the 8 ins which have been unsheathed on each cable are in contact along their length. Two clamps, mounted 1 ft apart on a wooden board, form a very useful means of holding the cables in position.

(*b*) Take the first (centre) pair of each cable and remove the rubber filling, up to the butt of the sheath.

(*c*) Cross the two black wires about 1 in from the butt of the sheath of one cable.

(*d*) Remove the insulation from both wires, from the point at which they cross to the ends of the wires.

(*e*) Cross the bared wires ½ in from the ends of the insulation.

(*f*) Bind each end in turn round the standing part of the opposite wire. Cut off the surplus wire and press the ends down with a pair of pliers, to prevent them from piercing the insulation.

(*g*) Solder the joint carefully.

(*h*) Cover the joint with one layer of rubber tape, overlapping the insulation by ¼ in on either side.

(*j*) Joint the other conductors in the same way. Each conductor must be connected to the corresponding conductor in the other cable, and the individual conductor joints must be staggered throughout the length of the joint.

5. Insulating the joint.—To insulate the joint :—

(*a*) Wrap one layer of rubber tape round the jointed core.

(*b*) Cover the layer of rubber tape with a thin coating of rubber solution.

(*c*) Bring the folded portion of the rubber sheath of the left-hand cable forward to enclose the core.

(*d*) Cut off the folded portion of the sheath of the right-hand cable at such a point that the remainder, when folded forward, just reaches the end of the sheath of the left-hand cable.

(*e*) Smear rubber solution along the cuts in the sheath.

(*f*) Bind the joint tightly with lacing twine, making a thumb knot every ½ in throughout its length (*see* Fig 9).

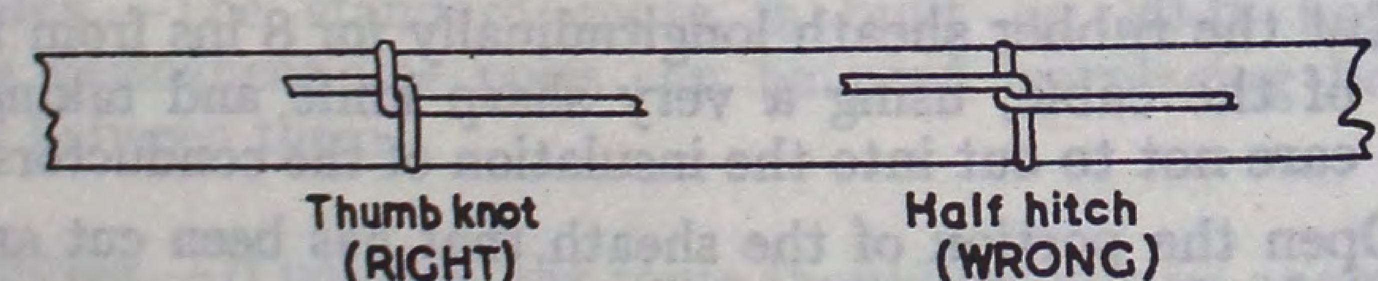

Fig 9.—Thumb knot.

(*g*) Cover the whole of the unbraided portion of the sheath with rubber solution, and cover it with one wrapping of rubber tape.

(*h*) Remove the clove hitch of twine or spunyarn at the edge of the braiding of each cable (*see* para 3 (*a*) above).

(*j*) Apply a wrapping of insulating tape, ¾ in over the whole joint, overlapping the braiding on each side by 2 ins.

6. Suspending the joint.—The joint must not be subjected to any strain. It is suspended as follows :—

(*a*) The cable is looped to form a bight at least 8 ins in diameter with the joint in the middle of the bight. The cables are bound firmly together with a spunyarn chafer at the point where they overlap at the top of the bight.

(*b*) The bight must be supported on a pole ; the cable rests on a bobbin and is tied to the pole with spunyarn. The joint, at the bottom of the bight, is tied loosely to the pole to prevent it swinging.

7. Vulcanizing outfit.—A wax bath vulcanizing outfit can be used to joint the sheath of the cable (*see Signal Training Pamphlet No. 4, Part II*).

CHAPTER 6

POLED CABLE USING SPIRAL EYES

SECTION 30.—GENERAL

1. This method of construction supports the cable, above the level of the traffic, in spiral eyes which are screwed into hop poles or natural supports.

Twisted " D " class cable is the best for this type of construction. Quad cable may also be used, but as the span length must not be more than 30 yds it takes longer to build.

2. A spiral eye route can only be regarded as temporary. The insulation of the cables tends to wear because of chafing on the eyes, which must be replaced by bobbins, weave ties, etc., if the line is to be used for a long period.

3. This construction which ensures :—

(*a*) Maximum speed.

(*b*) The immediate safety of the route from traffic.

(*c*) The dispersal of personnel so as to prevent traffic hold-ups can be used where roads are few and narrow and the ground is too rough for cross-country laying. Line construction personnel may, also, have to take their turn with other troops using the roads, because of the traffic congestion, and have only a limited time in which to complete the road section.

SECTION 31.—CONSTRUCTING THE LINE

1. Existing poles, trees, buildings, etc, should be made use of as supports wherever possible, and spiral eyes should be fitted before construction commences.

The cable should be strained by hand, and bound in with weave ties.

Staying is the same as for poled " D " class cable.

2. **Standard span length and dip.**—The standard span length and dip using " D " class twisted cable, is given in Appendix C. The standard span length and dip for " D " class twisted cable may be increased, when the cable is following a permanent line route, so that full use may be made of existing poles.

3. **Jointing.**—Field joints (*see Signal Training Pamphlet No. 4, Part II*), may be used during construction, but the joints must be soldered later. A convenient time is when the spiral eyes are replaced by bobbins, etc.

SECTION 32.—ORGANIZATION AND DUTIES

1. The organization given below is for the erection of a twisted " D " class cable, on fir poles or natural supports, by a detachment of a commander and 17 men.

The detachment may be enlarged to speed up the construction, or to build two cables instead of one, but the organization will remain the same. This detachment should lay two miles of route in one hour.

Two handcarts, wireless, Mark 3, are required in addition to normal line stores ; if they cannot be obtained, they should be improvised.

2. The reconnaissance party consists of the detachment commander and No. 1, both mounted on motor cycles. Their duties are the same as those laid down for the erection of poled " D " class cable (*see* Sec **21**) if all reference to methods of attaching the cables other than by spiral eyes is omitted.

3. The detachment works in three parties.

The front party drives down the route placing the stores ; the second party erects the poles and finally the third party lays the cable, lifts it into the eyes and binds in.

4. **Front party** comprising 6, 6A and 6B will :—

(*a*) Place all the stores for the line, except poles, at intervals of one mile along the route.

(*b*) Place the poles at places indicated by its detachment commander.

5. **Main party** comprises Nos. 1, 3, 3A, 4, 4A, 7 and 7A and with a handcart will :—

(*a*) Distribute the necessary stores by bays.

(*b*) Auger holes for poles where required.

(*c*) Erect poles.

(*d*) Drive in pickets and make off stays.

(*e*) Fix spiral eyes to natural supports if this has not already been done.

6. **Rear party** comprising No. 5, 2, 2A, 2B and 2C, 8 and 8A and with two drum barrows and a handcart, will :—

(*a*) Lay the cable.

(*b*) Lift the cable into the spiral eyes with a long crookstick.

(*c*) Pull up, regulate and link-in the cable at the end of every eighth span.

CHAPTER 7

SPACED CABLE

SECTION 33.—GENERAL

1. Spaced cable is poled cable with the conductors of each pair spaced throughout the length of the line, and for this type of construction D8 cable is normally used.

2. **Characteristics.**—Spaced cable is constructed similarly to poled cable but is only supported on bobbins, and at each point of support two bobbins are of course required—one for each conductor. In all other respects the mechanical characteristics are the same as those of poled cable.

The electrical characteristics, whilst not as good as those of multi-airline are, due to the spacing, much better than those of poled "D" class cables. The characteristics also remain more constant in the case of spaced cable.

The spacing of the cables should be kept as constant as possible throughout a route, and all joints *must* be soldered. D8 cables spaced 9 ins apart will give a speech range of 45 miles in dry weather.

3. **Use.**—Spaced cable provides a robust type of route, and is suitable for junction lines at, and in the rear of divisional level. It may also be used in the rear of corps, in areas where open wires and carrier quad cable are not available.

SECTION 34.—CONSTRUCTING THE LINE

1. **General.**—The organization and duties are similar to those for poled "D" class cable (*see* Sec **21**).

All numbers concerned with the dressing of poles or natural supports must know the distance at which the cables are to be spaced, and the detachment commander must inform No. 5 of the transposition scheme. The staying is the same as for poled cable using "D" class cable (*see* Sec **20**). The standard span length and dip are given in the comparative table in Appendix C.

The stores required for 1 mile of 2 pairs of D8 spaced cable are given at Appendix B.

2. **Attaching the cables.**—The cables may be attached by any of the methods laid down in Sec **13**, 8. The clove hitch method is quickest, but the spun yarn method gives protection to the insulation at the point of support. Bobbins provide the best means of maintaining the correct spacing.

3. **Transposition.**—The standard transposition sections laid down in Sec **18** can be made longer for audio routes, but must be adhered to in the case of carrier routes. Porcelain bobbins should be used whenever available.

The crosses are made as follows :—

(*a*) Take a length of BB11 stay wire 4 ft long.

(*b*) Wrap the wire once round the pole, with the cross at the back and with the tails equal.

(*c*) Staple the wire to the pole at the cross.

(*d*) Thread a bobbin on to each tail.

(*e*) According to the spacing of the wires, attach another length of BB11 under the first, thread on bobbins, and staple as above.

(*f*) Assuming, in Fig 10, that the route runs from left to right place the top wire round the top left bobbin, and the bottom right bobbin, leaving the bridge of cable fairly slack.

(*g*) Place the bottom wire round the bottom left bobbin, and the top right bobbin.

(*h*) Close both spurs by taking the tails once round the front of the pole, stapling where they cross, and stapling again where they meet at the back of the pole. Finally, staple each wire individually and twist the tails together.

(*j*) Bind the tails of D8 to the standing lines at each bobbin by means of spun yarn.

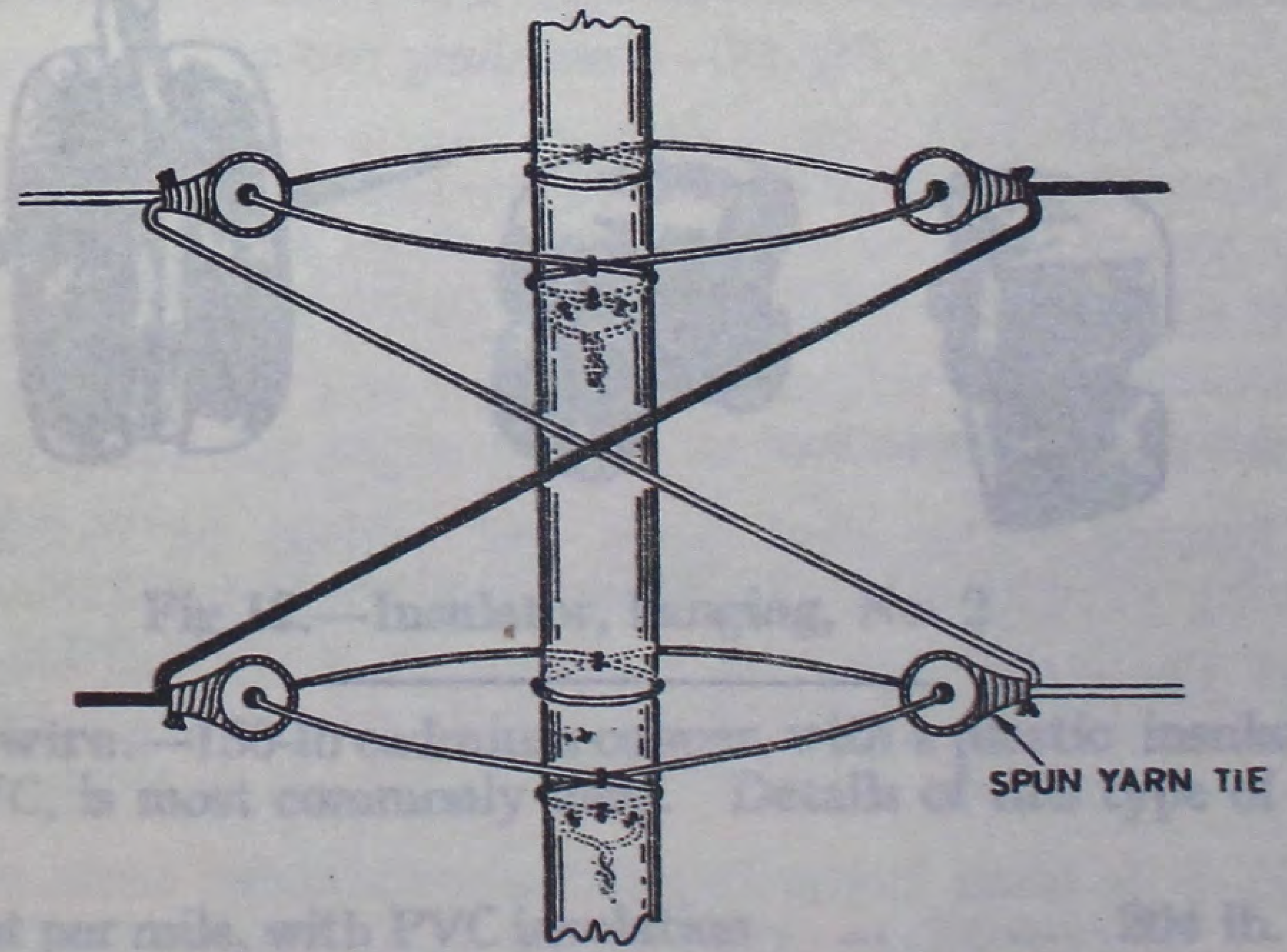

Fig 10.—Transposing spaced cable

4. **Terminations.**—Double terminations are made at the end of every 16 spans and at crossings, in the same way as shown in Fig 10, except that the wires do not cross. The same method is used for single terminations, at the ends of routes and at interruption points.

5. **Crossings.**—When building more than one pair of spaced "D" class cable, double poles will be necessary at most crossings in order to obtain minimum clearances. They can sometimes be avoided, however, by taking full advantage of high ground near the road and by fixing cross-arms to the two poles on either side of the crossing and changing the plane of the wires from the vertical to the horizontal, as shown in Fig 11.

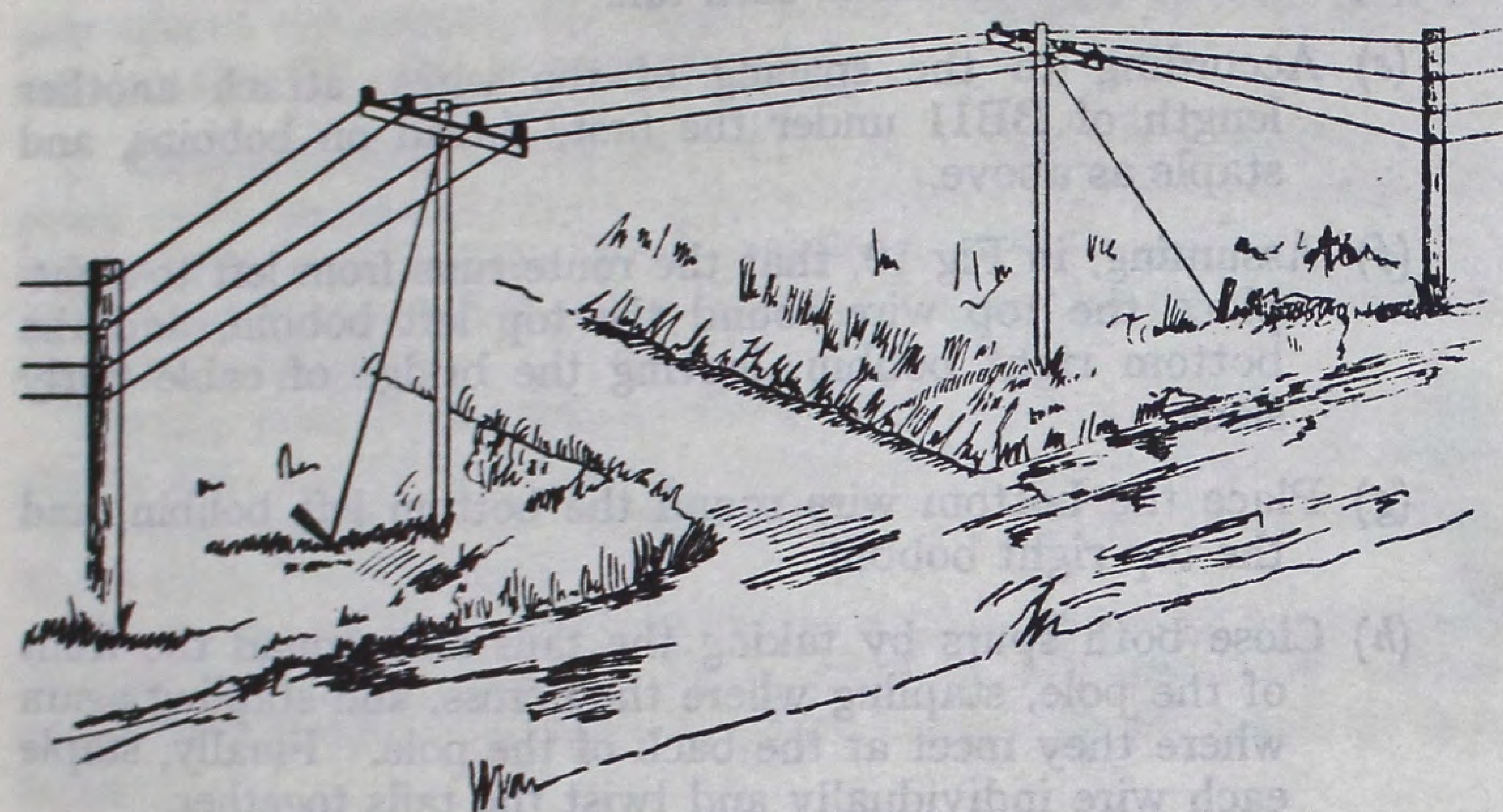

Fig 11.—Using cross arms to obtain extra height

CHAPTER 8

TREE SLUNG CABLE

SECTION 35.—GENERAL

1. Tree slung cable construction (defined in Sec 1, para 2 (*c*)), is primarily designed for jungle conditions. There are no rules, and construction must be planned to overcome local hazards, *eg*, rocks and rivers.

2. The object of this type of construction is to prevent the cable being broken by falling trees or branches ; it is therefore necessary to have short bays and a large dip. A further safeguard is to use slings made of wire thin enough to break under tension before the line wire does. The breaking of the sling does not then interrupt communication. All that happens is that the insulated cable is borne down to the ground by the falling tree, branch, *etc*.

SECTION 36.—CONSTRUCTING THE LINE

1. **Insulators.**—*Insulators, hanging, No.* 2 (*see* Fig 12) are used. Care must be taken to ensure that the two halves of the insulator are firmly bound together.

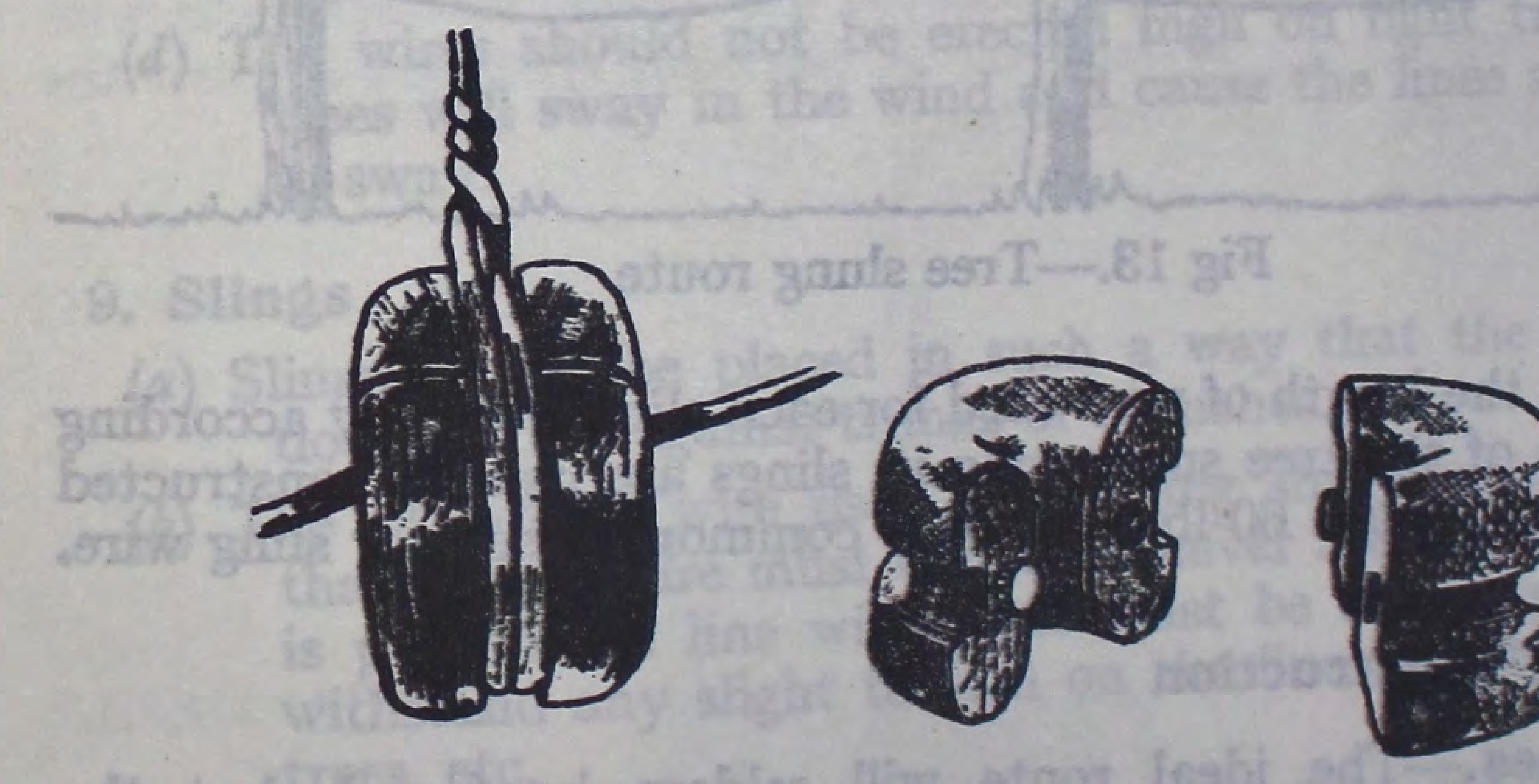

Fig 12.—Insulator, hanging, No. 2

2. **Line wire.**—150-lb cadmium copper, with a plastic insulation, usually PVC, is most commonly used. Details of this type of wire are :—

Weight per mile, with PVC insulation	204 lb.
Breaking strain	650 lb.
DC resistance per mile (single)	7 ohms.

3. There must be no soldered joints in the wire, since these have been found to break at a strain considerably less than the breaking strain of the wire. All joints must be made with sleeves, jointing, No. 19. The wire is supplied in hessian-wrapped coils of 660 yds, weighing approximately 80 lb.

4. PVC insulation has proved successful but :—

(*a*) It may strip when struck by a falling branch or tree.

(*b*) It may cut or tear if roughly or carelessly handled.

It is therefore important that maintenance parties should pay particular attention to overhanging trees and branches that may fall on the route, and that laying parties should handle the wire carefully.

5. **Tree slings.**—The line is constructed (usually as one pair of wires) by suspending it from trees by means of slings. The slings are made up of a pair of insulators suspended by wire. The line wire is passed through the hole in the insulator and hangs in loops between the slings (*see* Fig 13).

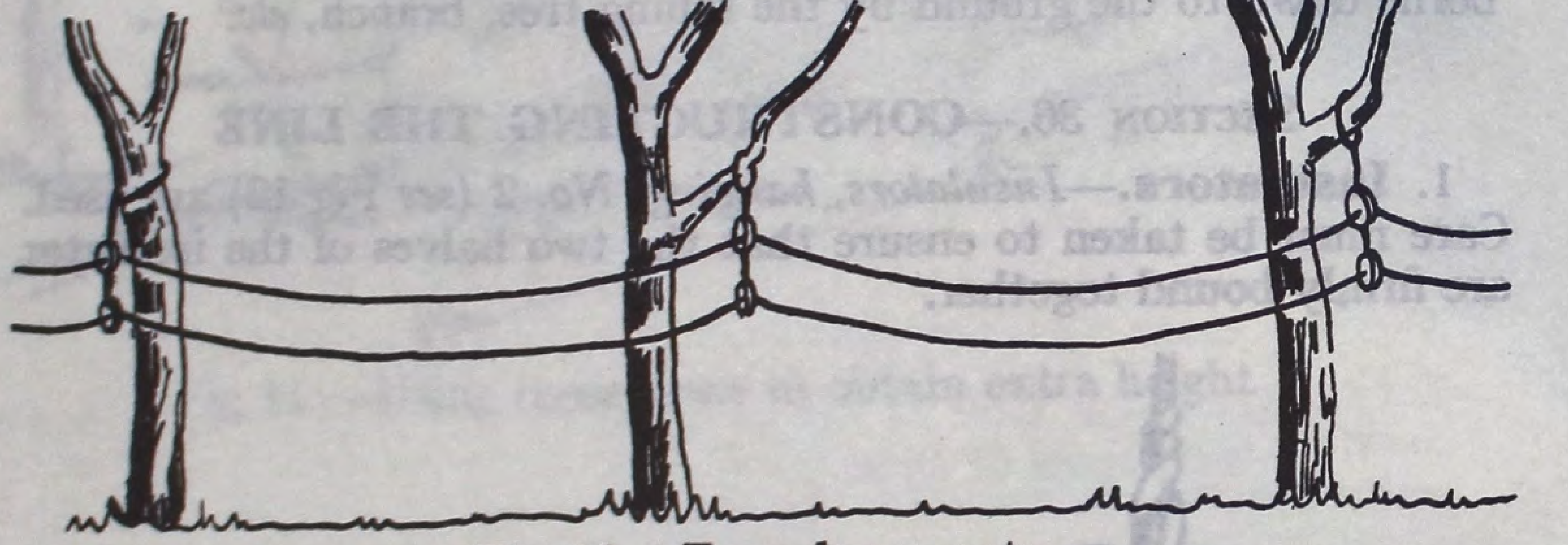

Fig 13.—Tree slung route

6. Since the length of wire used for each sling will vary according to the size of the tree supporting it, slings are usually constructed on the site. Single 60-lb GI wire is commonly used for sling wire.

Details of construction

7. **Routes.**—The ideal route will seldom be found, but the following principles should be applied where possible :—

(*a*) The route should be so chosen that the line wire does not deviate more than 25 degrees from the straight at any insulator.

(*b*) It is often better to select a roundabout route rather than cross swamps or penetrate deep jungle ; an extra mile of cable may save a multitude of maintenance problems.

(*c*) The route must easily be accessible for maintenance purposes, but the wires should never be placed so that personnel are tempted to use them as an aid to climbing steep slopes.

(*d*) Jungle clearance is unnecessary when the route must be built through undergrowth, but a track for maintenance personnel should be provided.

(*e*) Where possible trees should be chosen which are uniformly spaced and alternately offset from a centre line, so as to give a pull-away effect at each tree (*see* Fig. 14).

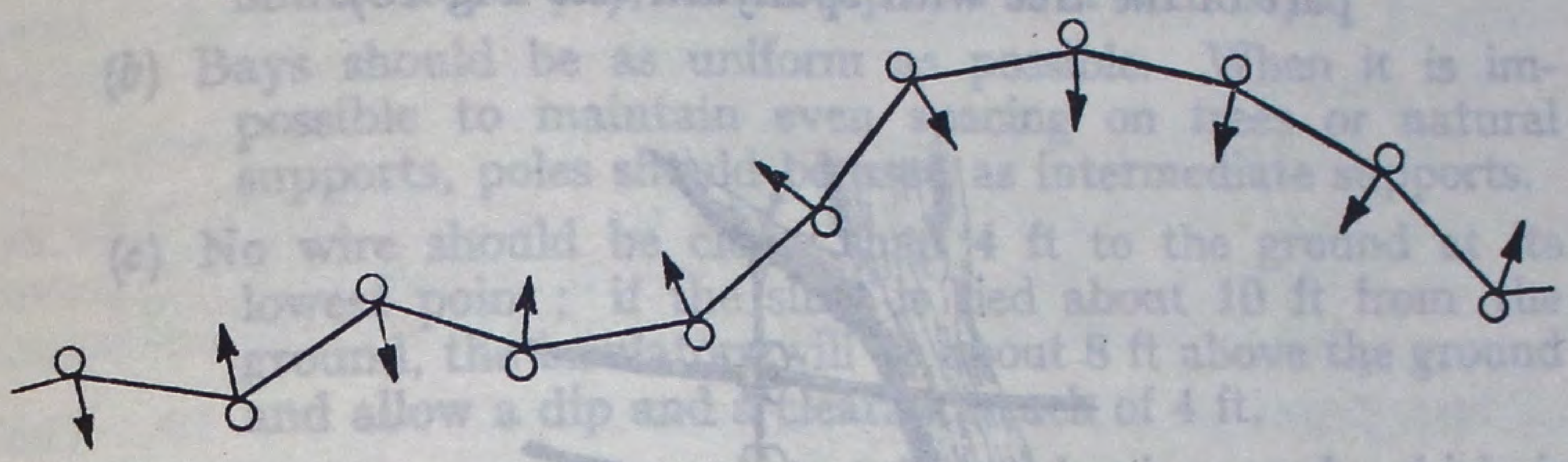

Fig 14.—Ideal tree line location

8. **Laying the wire**

(*a*) The wire is laid from a drum barrow or a carrying bar.

(*b*) If flaked off the coil by hand, the coil must be reversed after each six loops have been dropped off ; this eliminates spirals in the wire.

(*c*) The wires may be spaced 9 ins apart, but a spacing of 15 ins reduces the likelihood of the wires in a span twisting together if the regulation becomes uneven.

(*d*) The wires should not be erected high on light trees ; the trees will sway in the wind and cause the lines and slings to sway.

9. **Slings**

(*a*) Slings should be placed in such a way that the line wire does not rub against trunks or branches.

(*b*) The size of GI wire used for making slings must be such that the GI wire must break whenever a dangerous strain is put on the line wires, but must be strong enough to withstand any slight tension on the lines due to swaying trees, etc.

(*c*) The sling should be bound loosely round the trunk or limb of a tree (*see* Fig 15).

(*d*) Slings must not be attached directly to nails as the nails are liable to fall out of soft and sappy trees.

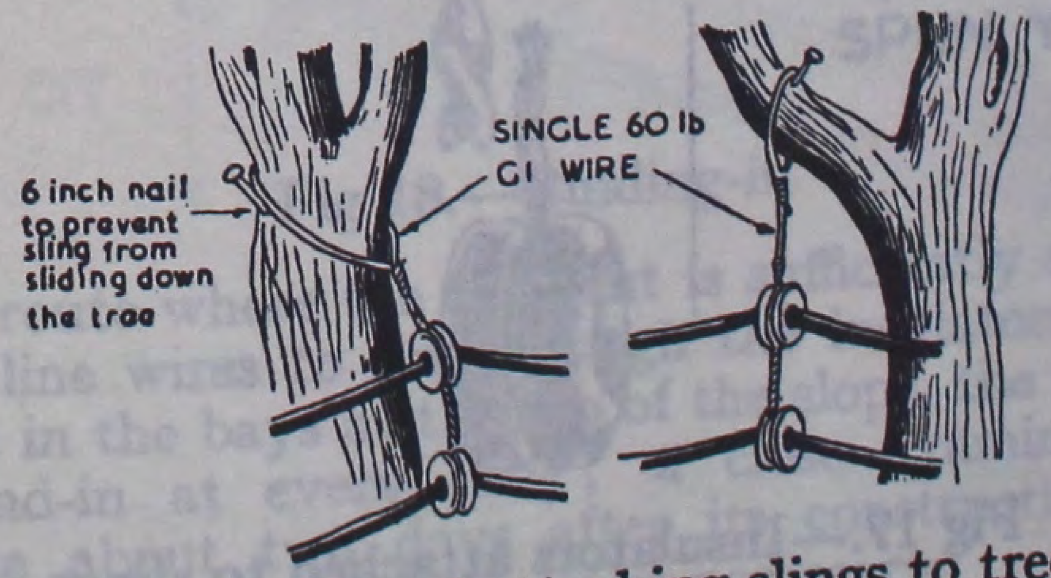

Fig 15.—Method of attaching slings to trees

(*e*) If the angle of divergence of the route from a straight line is other than slight, the sling should be fixed to the lower part of the tree with spunyarn (*see* Fig 16).

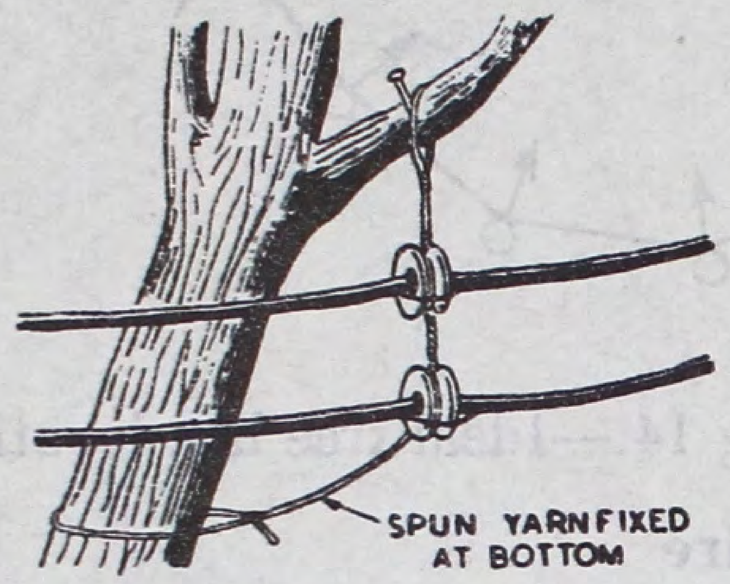

Fig 16.—Spunyarn tie-back

10. Insulators

(*a*) Insulators are attached to slings as shown in Fig 17.

(*b*) Double GI wire is used ***between*** the two insulators to ensure that, if the sling breaks, it will break at the single wire used in the upper part of the sling and not disturb the spacing of the insulators.

Fig 17.—Insulators attached to slings

11. Span length and dip

(*a*) Spans should not exceed 50 yds, and in general should be limited to 40 yds, with a dip of 4 ft in each bay.

(*b*) Bays should be as uniform as possible. When it is impossible to maintain even spacing on trees or natural supports, poles should be used as intermediate supports.

(*c*) No wire should be closer than 4 ft to the ground at its lowest point; if the sling is tied about 10 ft from the ground, the insulators will be about 8 ft above the ground and allow a dip and a clearance each of 4 ft.

(*d*) The above measurements refer to level ground, which is seldom met with, and in practice all heights and distances can only be determined on the spot, according to gradient, type of country, suitability of trees, etc.

12. Binding-in

(*a*) On fairly level ground the weight of the wires is sufficient to hold them in position once they are regulated, and they should be bound-in only at the end of eight to ten bays; the method of binding-in is shown in Fig 18.

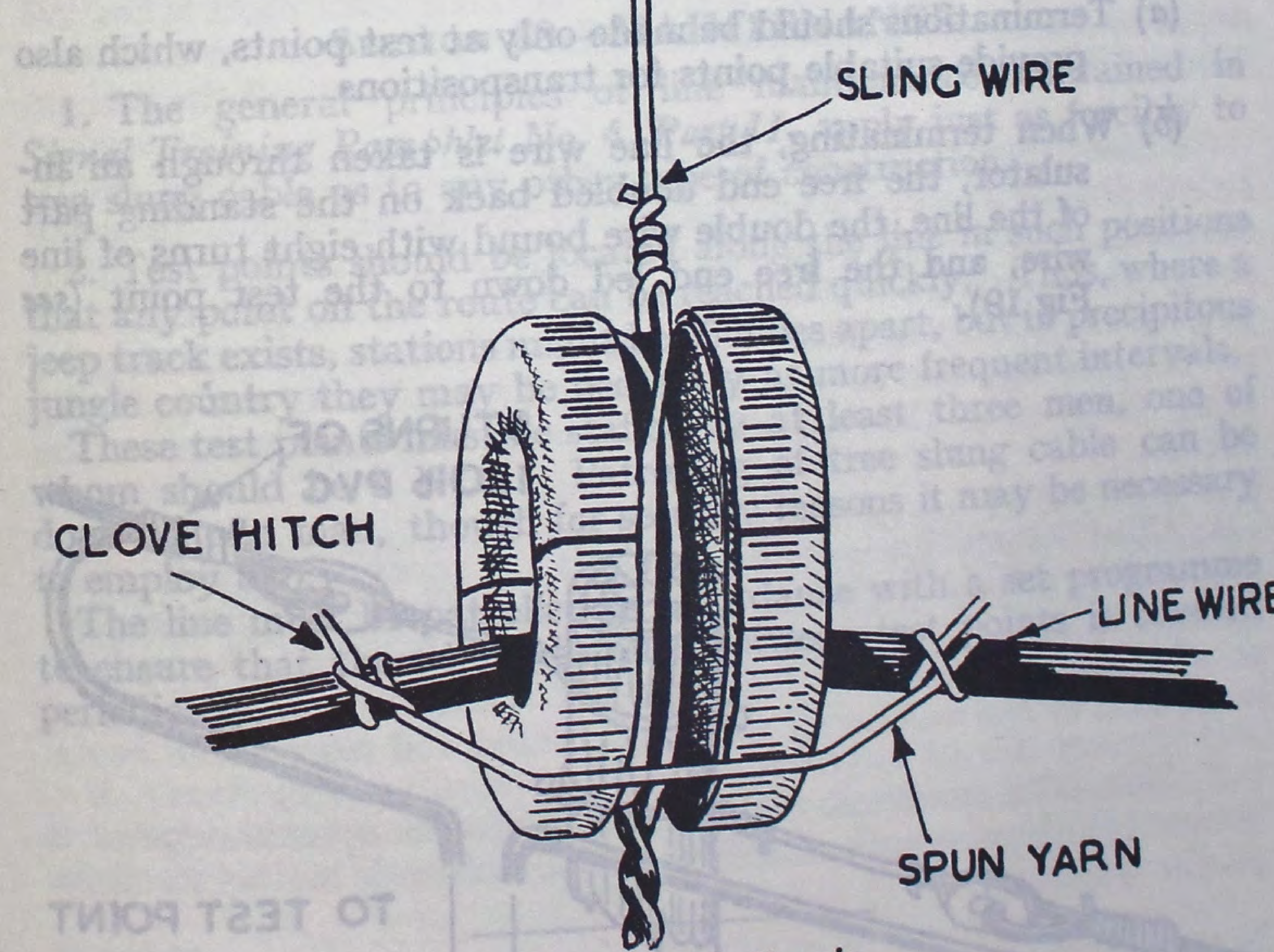

Fig 18.—Binding-in

(*b*) On a route where the gradient is sufficiently steep to cause the line wires to run through the insulators and become taut in the bays at the top of the slope, the wires must be bound-in at every sling; a close examination of the route about two days after its construction will show whether further binding-in is necessary.

(c) Spunyarn is used for binding in, so that if any undue strain is put on the line wire the spunyarn will break and allow the wires to run through the insulators.

13. Jointing

(a) All joints must be insulated.

(b) They should not be made near an insulator, but as near as possible to the centre of a bay to reduce to a minimum the possibility of the joint fouling the hole in the insulator.

(c) Joints should be made with sleeves, jointing, No. 19. The sleeve should be given five complete twists, using clamps, jointing, No. 1A.

(d) The joint should be wrapped tightly with rubber tape, wiped lightly with petrol or methylated spirits, and covered with one layer of plastic tape.

(e) All splits and flaws appearing in the PVC insulation should be taped.

14. Terminations and transpositions

(a) Terminations should be made only at test points, which also provide suitable points for transpositions.

(b) When terminating, the line wire is taken through an insulator, the free end doubled back on the standing part of the line, the double wire bound with eight turns of line wire, and the free end led down to the test point (*see* Fig 19).

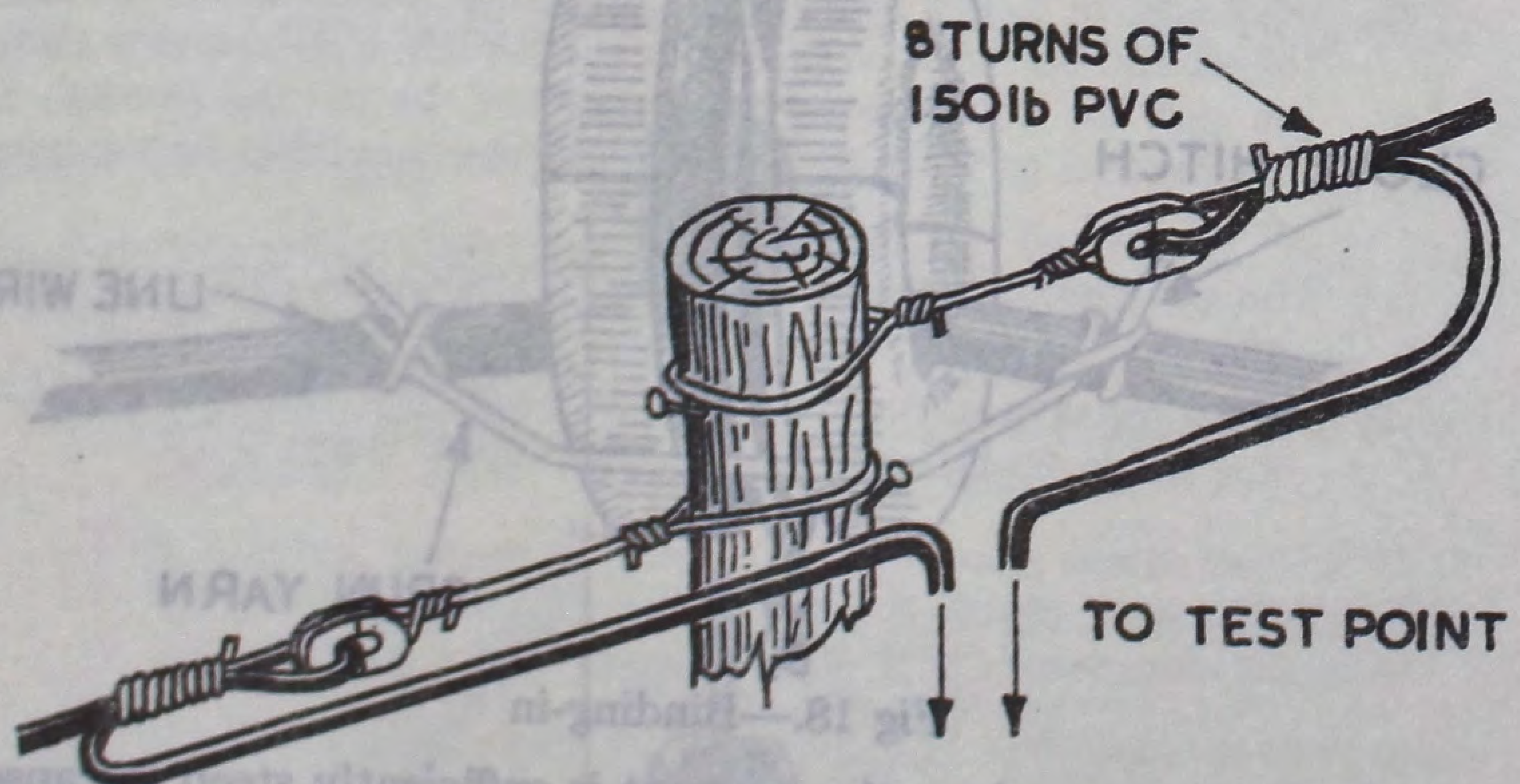

Fig 19.—Termination

(c) Transpositions should be made at approximately 440-yd intervals, in the same way as the termination in Fig 19.

Section 37.—ORGANIZATION OF DETACHMENT

1. For reasons already given it is almost impossible to lay down the strength of a detachment, and the speed at which they can work. As a guide, a detachment organized as below should be able to build 1 mile of route a day.

Supervisor	1 officer.
Assistant to officer	1 NCO.
Selecting trees for slings	1 NCO, 1 OR.
Depositing tree slings	6 pioneers or local labourers working in relays of 2.
Erecting tree slings	4 OR.
Running wires and jointing	2 OR.
Paying out wire	2 OR.
Manufacture of tree slings.	2 OR.
Control of stores dump	1 OR.
Supervision of clearing	1 NCO.

Total :—1 officer, 3 NCOs, 12 ORs, 6 pioneers or local labourers.

2. The stores required for 1 mile of route are given in Appendix B.

Section 38.—MAINTENANCE

1. The general principles of line maintenance, contained in *Signal Training Pamphlet No. 4, Part II*, apply just as forcibly to tree slung cable as to any other type of construction.

2. Test points should be located along the line in such positions that any point on the route can be reached quickly. Thus, where a jeep track exists, stations might be 20 miles apart, but in precipitous jungle country they may be necessary at more frequent intervals. These test points must be staffed by at least three men, one of whom should be a NCO. Patrolling of tree slung cable can be done by one man, though for security reasons it may be necessary to employ two.

The line must be patrolled in accordance with a set programme to ensure that the whole distance between test points is covered periodically.

CHAPTER 9

MULTI-AIRLINE

SECTION 39.—GENERAL

1. Multi-airline is defined in Sec **1**, 2 (*d*). It is usually built with the following major items of stores :—

Wire, electric, cadmium copper, 70-lb, PVC.
Drums, cable, No. 7, Mark 6.
Sleeves, jointing :—self soldering, No. 3.
WD pattern No. 1.
Arms, multi-airline, 33-inch.
Insulators, field :—bolt, single.
Double-J.
Cups Mark 4*, and Cups Mark 4* (double-groove).
Poles, telegraph, wood, 16 ft :—octagonal, Mark 1*.
light.

2. The standard route has four wires on one arm ; if more than four wires are required, an extra arm is added and the route must be strengthened with extra staying. If more than eight wires are required a second route should be built or an alternative construction (*eg*, Light PL Construction), employed to carry all the wires.

3. **Clearance.**—The standard route employing single multi-airline poles may not always provide sufficient clearance. In some circumstances it may therefore be necessary to use 17 ft or 21 ft poles, two standard poles clipped together or, exceptionally, fir poles to obtain the necessary clearance. When two standard poles are clipped together they must overlap at least 4 ft, one pole clip being fixed near the top of the overlap and another near the bottom.

4. **Characteristics.**—Multi-airline is the most vulnerable of all types of aerial line to damage by blast from shells and bombs, but electrically it is superior to any other type of line that can be built at a comparable speed. Point-to-point speech is possible up to a maximum of 165 miles on a well-constructed and maintained route.

5. **Use.**—To use such a route for, say, two speech circuits is obviously uneconomical, and hence multi-airline is mainly used for carrier telephony.

SECTION 40.—SELECTION OF ROUTES

1. **Safety essential.**—The first essential for a multi-airline route is safety (*see* Sec **6**).

Main roads should be avoided where possible, and at important crossings, bridges, etc, alternative routes should be reconnoitred.

2. Since poles are used throughout the construction, the weight of stores involved is considerable. Wherever possible, therefore, the route should be within 100 yds or so of a road or track fit for vehicles, so that any man-handling of stores is reduced to a minimum.

3. The route should be kept away from woods and overhanging trees, owing to the danger of falling or swinging branches.

SECTION 41.—DETAILS OF CONSTRUCTION

Pole structures

1. **Poles, telegraph, wood, 16 ft, light,** are used at intermediate positions.

2. **Poles, telegraph, wood, 16 ft, octagonal,** should be used, either in the form of H-pole or box-pole structures, at positions where a pole is under severe strain, *eg*, where the wires are terminated or change direction sharply.

3. **H-pole structure.**—H-poles consist of two octagonal poles strapped together at their tops by means of a 33-in arm fitted with two *straps, multi-airline*. The structure is assembled on the ground and then placed into two holes jumpered 21 ins apart. H-pole structures are used at termination positions (*see* Fig 20).

4. **Box-pole structure.**—Box-poles may consist of either three or four poles, assembled by means of two or four 33-in arms respectively.

The 3-pole structure is used at angles of 60 degrees and above. The four-pole structure is used at angles of 90 degrees and also at double terminations carrying a crossing that is longer than the standard length of 44 yds. The holes for box-poles structure are jumpered 21 ins apart, the position depending upon the angle (*see* Fig 20).

Crossings

5. To obtain the standard clearance laid down in Sec **6**, it will often be necessary to join two poles together. This is done by means of pole clips. The poles must overlap at least 4 ft, one pole clip being fixed near the top of the overlap, and another near the bottom.

6. Crossings should be made at right angles to the obstacle that is being crossed and the span should be shorter than the standard span. The line should never be angled on a crossing pole.

Staying

7. The routine staying for a standard quarter-mile section of multi-airline is shown in Fig 20. Points to note are :—

(*a*) The staying of the H-pole at pole 0.
(*b*) The box staying at the double termination at pole 5.
(*c*) The staying at the H-pole at pole 10 where the wires are again double-terminated (*see* Sec **42**).

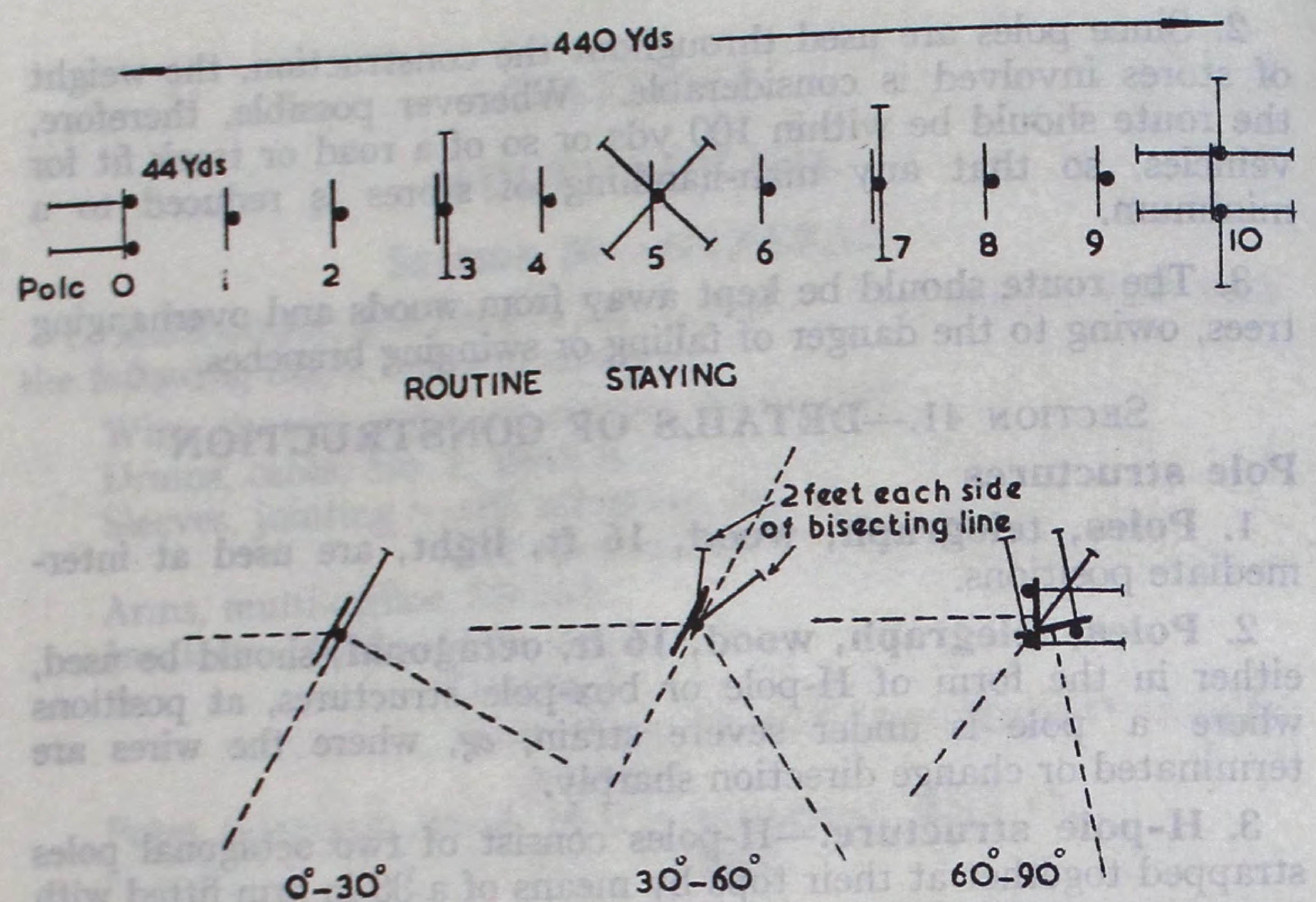

Fig 20.—Staying for multi-airline

(*d*) At major crossings box stays are fitted to the poles (*see* Fig 21).

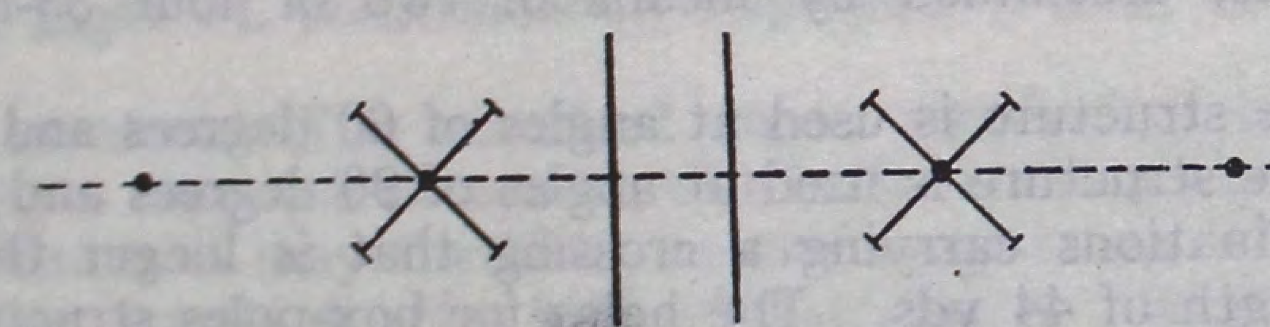

Fig 21.—Box stays at major crossings

Section 42.—THROUGH POSITIONS, TERMINATIONS AND BINDINGS

General

1. Insulators, field, cups, Mark 4 are mounted as follows :—

(*a*) *Through positions*—on an *insulator field, bolt, single*; the line wire placed in the vertical slot of the insulator, and the cap lightly screwed down.

(*b*) *Single termination.*—On one side of an *insulator, field, bolt, double-J.*

(*c*) *Double terminations* on both sides of the double-J spindle; or on an *insulator, field, bolt, single*, and the two grooves of the insulator used to double terminate.

Binding-in

2. Wires should be bound-in at all poles where they change direction, either horizontally or vertically, except when the wires are terminated.

3. To protect the PVC from chafing, use a piece of line wire, 18 ins. long, as a binder. Place the binder in the slot of the insulator, adjacent to the line wire, with equal tails on either side. Take each tail round one half of the insulator, in a clockwise direction and wrap it round the line wire for six turns. One tail must start underneath the line wire and the other over it for the actual binding-in, and the last half-inch of the binder should be left sticking out to facilitate dismantling.

Binding-in is illustrated at Fig 22.

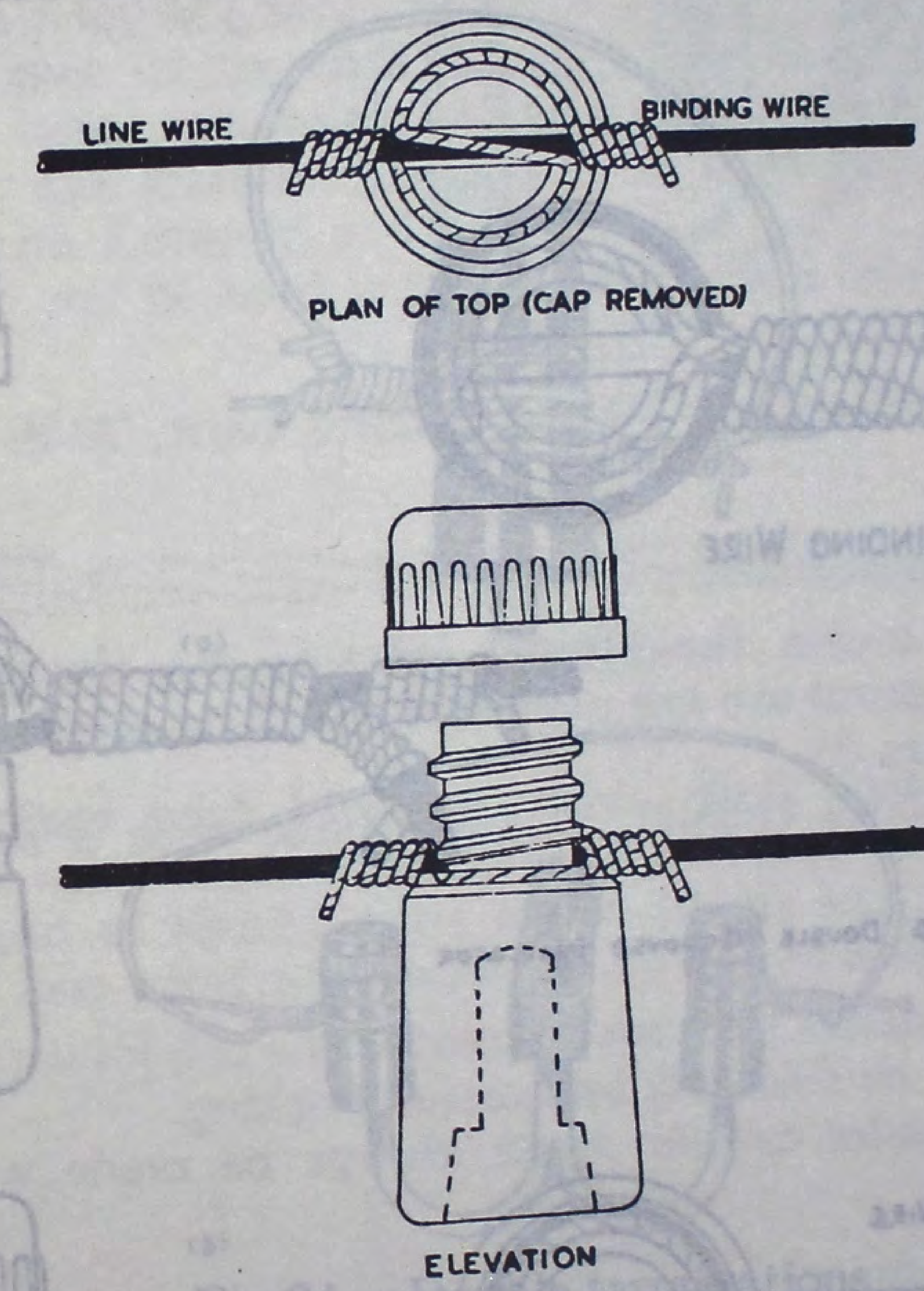

Fig 22.—Binding-in

Terminations

4. Terminations are made as follows :—

(*a*) Single terminations at pole O.

(*b*) Two single terminations where cross-arming is used, *ie*, at poles where the line wire changes direction by 60 degrees or more.

(*c*) Double terminations at :—

(i) Every fifth pole.

(ii) Every transposition pole.

(iii) Both sides of crossings.

5. A single termination (*see* Fig 23) is made as follows :—

(*a*) Place the line wire in the top groove of the insulator and bend it back on itself for 12 ins.

(*b*) Place a PVC binder, 30 ins long, centrally around the bottom thread of the insulator and pull one tail against and over the other to ensure a tight grip.

(*c*) Bring the two tails of the binder together, and make twelve turns round the line wire and the tail of the line wire.

(*d*) Separate the two tails of the binder.

(*e*) Make six turns round the line wire with one tail of the binder, and six turns round the tail of the line wire with the other.

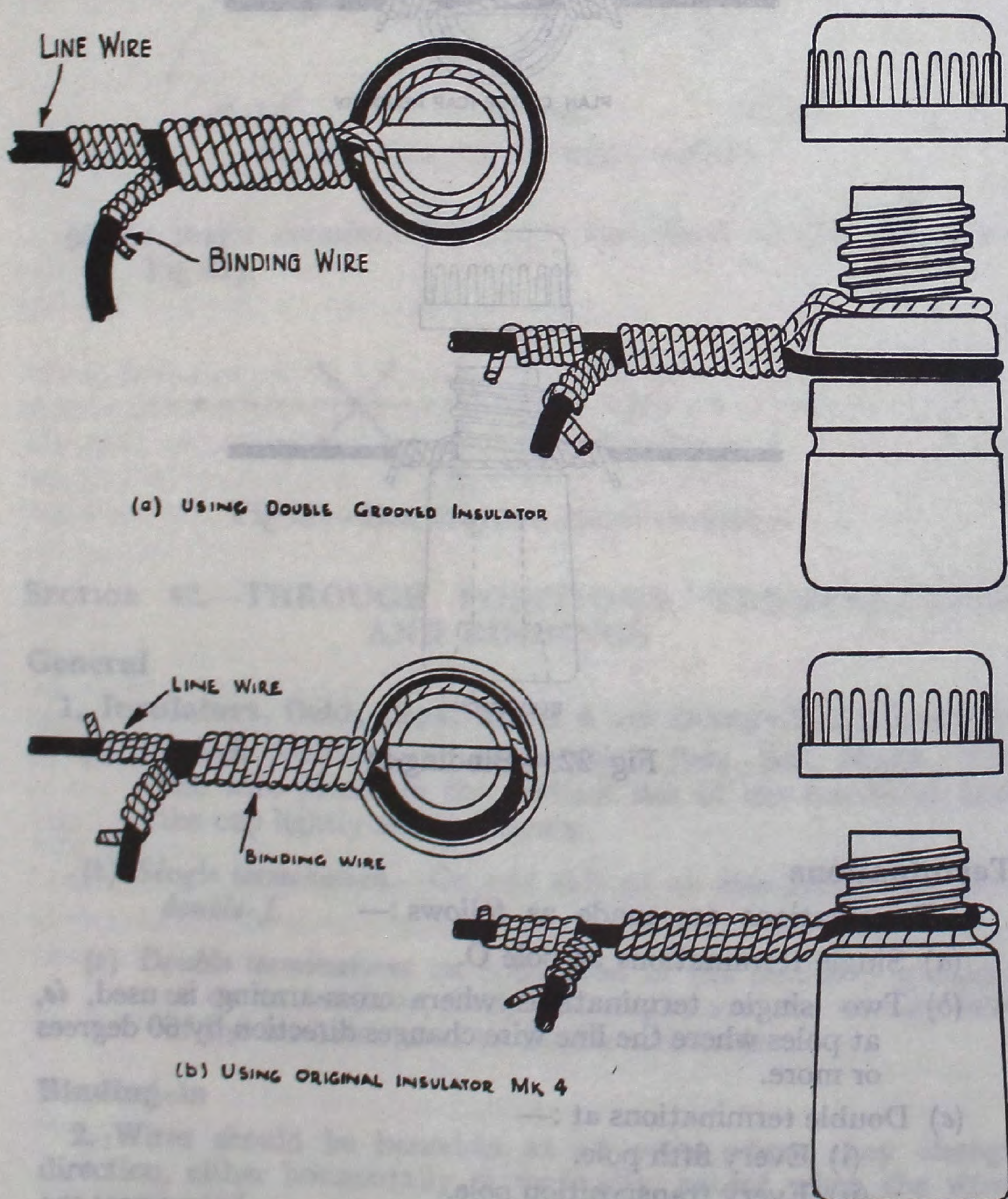

Fig 23.—Single terminations

6. A double termination (*see* Fig 24 (*a*)) is made in the same way as a single termination. The line wire from the left is laid in the top groove of the insulator ; the line wire continuing to the right is laid in the bottom groove, with its binder just above it, on the body of the insulator.

7. The method of terminating on the old type of *insulator, Field, cup, Mark* 4*, which has no grooves on the body, is illustrated in Fig 22 (*b*). On such insulators it is, of course, impossible to double terminate on a single insulator, and two insulators, mounted on each side of a double-J spindle, must be used (*see* Fig 24 (*b*)).

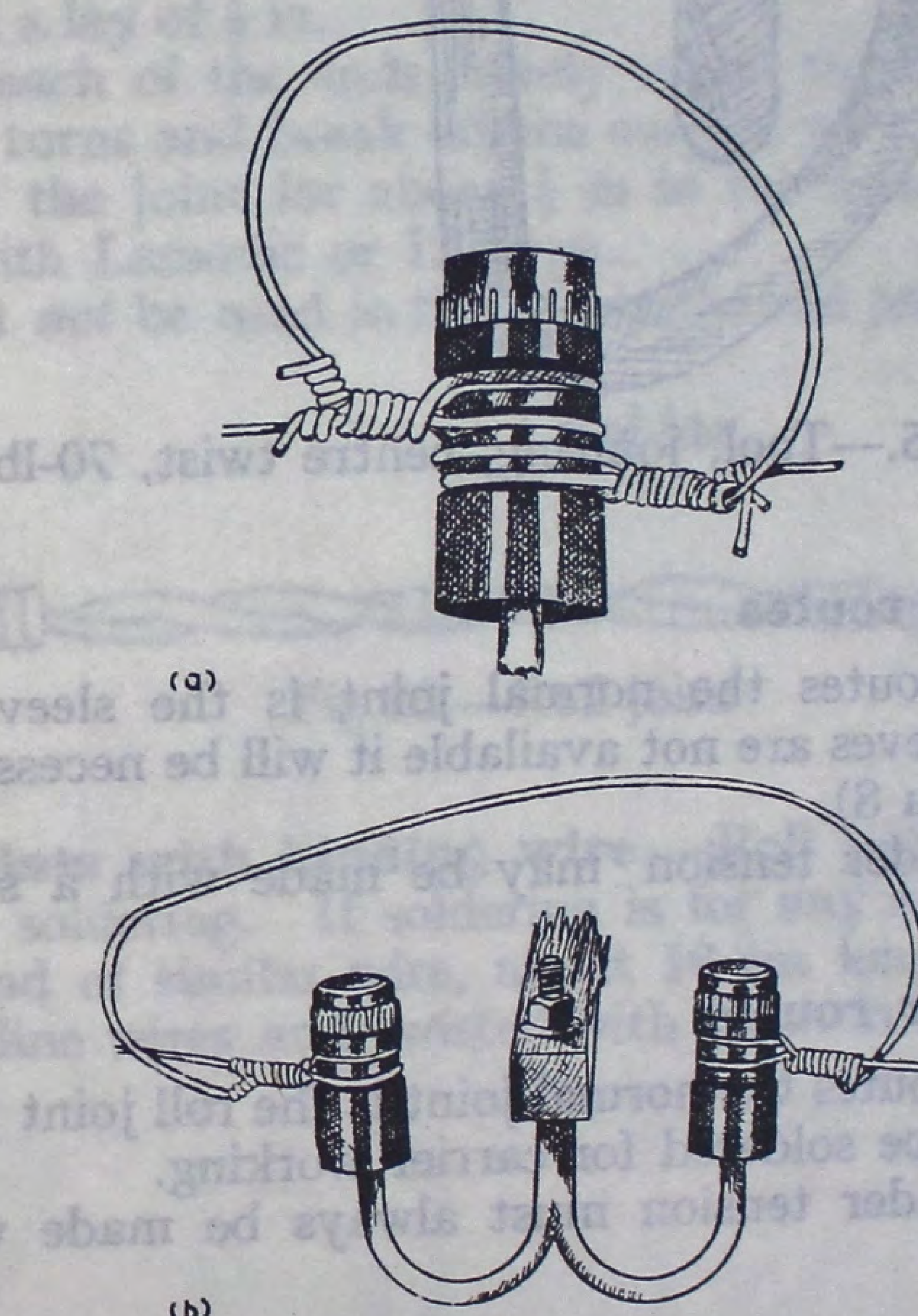

Fig 24.—Double terminations

SECTION 43.—JOINTING

1. **General.**—In multi-airline, as in all other types of aerial line, jointing should be kept to a minimum, and joints should seldom be necessary except at the ends of drums or coils of cable.

Standard joint

2. The standard joint for 70-lb cadmium copper PVC is the sleeve joint. There are two types :—

(*a*) The through joint, used when the joint s under tension.

(*b*) The joint made with a self-soldering sleeve, used when joints are *not* under tension.

3. Through joints and nib joints are made with *sleeves, jointing WD pattern, No.* 1 using a *tool, jointing, centre twist,* 70 lb (*see* Fig 25).

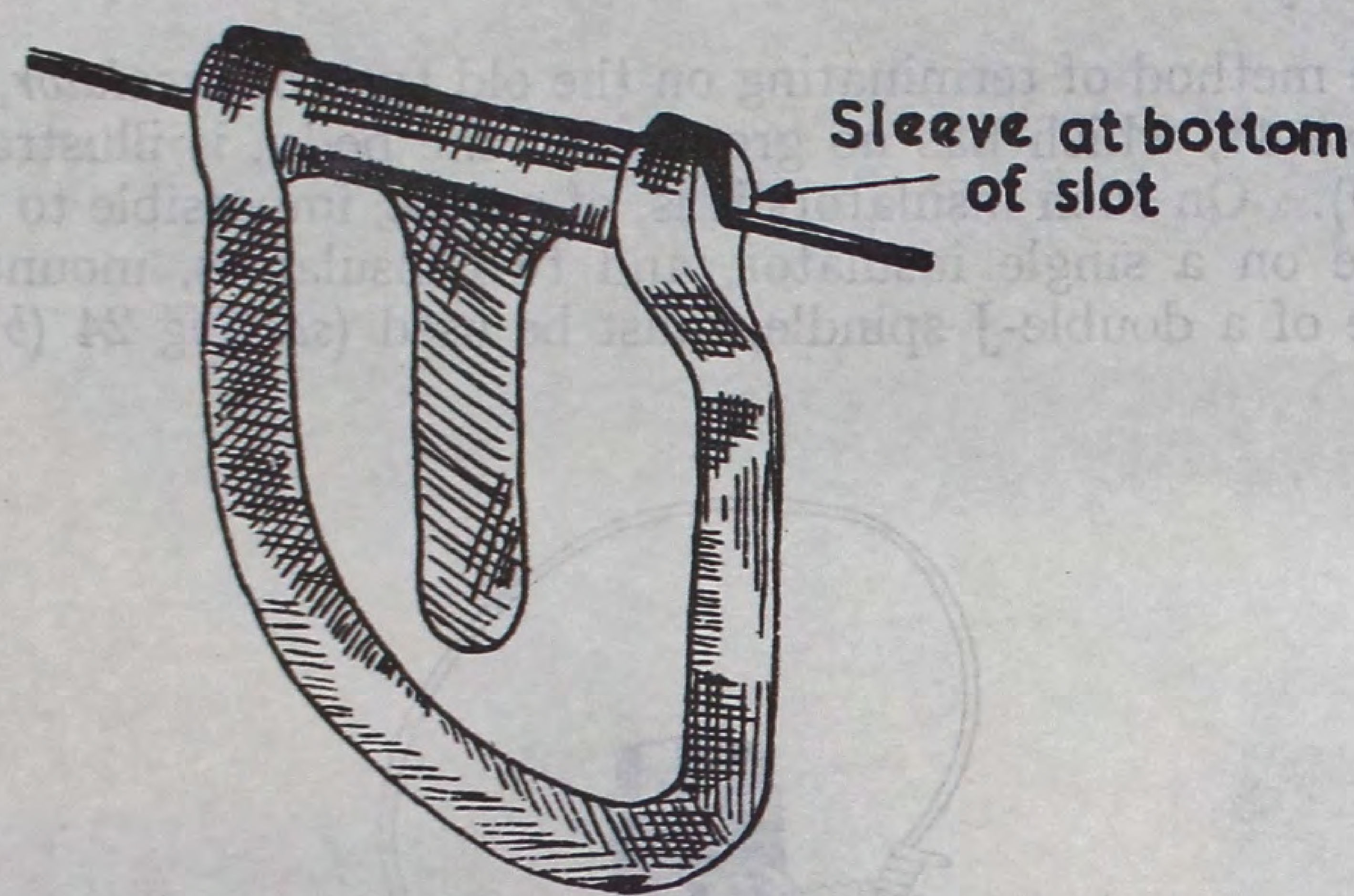

Fig 25.—Tool, jointing, centre twist, 70-lb

Joints in audio routes

4. For audio routes the normal joint is the sleeve joint (*see* para 6), but if sleeves are not available it will be necessary to use a roll joint (*see* para 8).

A joint not under tension may be made with a self-soldering sleeve.

Joints in carrier routes

5. For carrier routes the normal joint is the roll joint (*see* para 8). Roll joints must be soldered for carrier working.

A joint not under tension must always be made with a self-soldering sleeve.

6. **Sleeve joints** are made as follows :—

(*a*) Strip off 4 ins of insulation from the ends of the wires.
(*b*) Push the wires into a jointing sleeve from opposite ends, until each projects about ½ in beyond the end of the sleeve.
(*c*) Slip the sleeve into the slot of a *tool, jointing, centre twist,* 70 lb.
(*d*) Hold the tool firmly, with the sleeve in line with the wires, and give the centre tongue of the tool two complete twists.
(*e*) Disengage the twisted joint from the tool by giving the tongue a quarter-turn in the same direction as in (*d*), a half-turn in the reverse direction, and finally a quarter-turn in the original direction, bringing it parallel to the body of the tool.

The tongue must not be rotated beyond the limits laid down.

7. *The centre twist tool* produces equal and opposite twists in the two halves of the sleeve. It gives no appreciable twist to the wire and its design is such that it is practically impossible to destroy the sleeve.

8. **Roll Joints** are made as follows (*see* Fig 26):—

(*a*) Strip off 12 ins of insulation from the ends of the wires.
(*b*) Cross the wires, making an angle of about 45 degrees, 6 ins from the ends.
(*c*) Grasp the two wires on the left-hand side securely with the thumb and finger of the left hand, and twist the two wires on the right-hand side *round each other* for about 2 ins, with a lay of ½ in.
(*d*) Bind each of the ends closely round the standing part for five turns and break off the surplus wire by twisting.
(*e*) Solder the joint for about ½ in in the middle, and insulate it with Lassovic or IR tape.

Pliers must *not* be used in the making of roll joints.

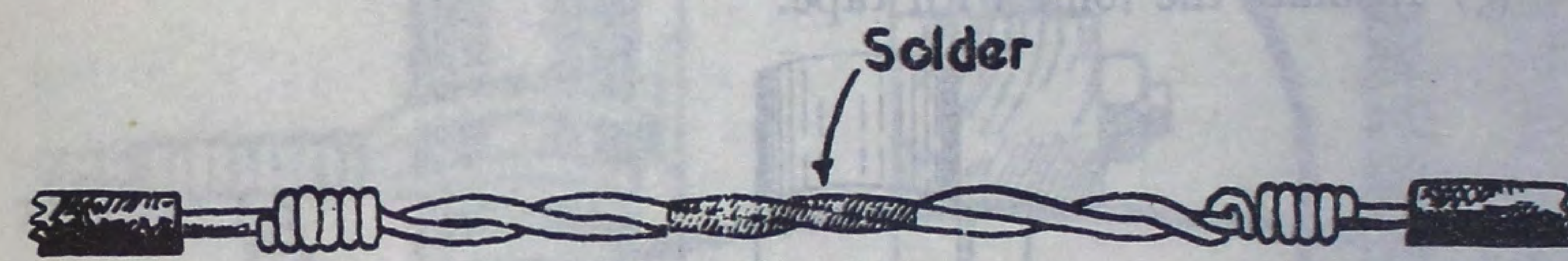

Fig 26.—Roll joint

9. **Roll joints with binding wire.**—Roll joints will not wear well without soldering. If soldering is for any reason impossible, another strand of similar wire, about 16 ins long, should be laid up with the line wires and twisted with them in making the joint (*see* Fig 27).

Fig 27.—Roll joint with binding wire

10. When a line is to be laid and reeled-in frequently, the roll joint is better than the sleeve joint since it is more flexible and less liable to break when the line is being reeled-in.

11. **Jointing to " D " class cable** (*see* Fig 28).—To joint 70-lb cadmium copper PVC to " D " class cable, proceed as follows :—

(*a*) Strip off 18 ins of insulation from the end of the " D " class cable and 1½ ins from the 70-lb cadmium copper PVC.
(*b*) Unwind the copper strand from the " D " class cable, and cut off the steel strands 1 in from the end of the insulation.
(*c*) Lay the bared portion of the " D " class cable along the 70-lb cadmium copper PVC.
(*d*) Bind the copper strand closely around the steel strands of the " D " class cable and the bared cadmium copper, starting from the edge of the insulation.
(*e*) Solder the joint.
(*f*) Leave the joint pointing downwards so that in wet weather water will not run into the insulation of the cables.
(*g*) Insulate the joint with tape.

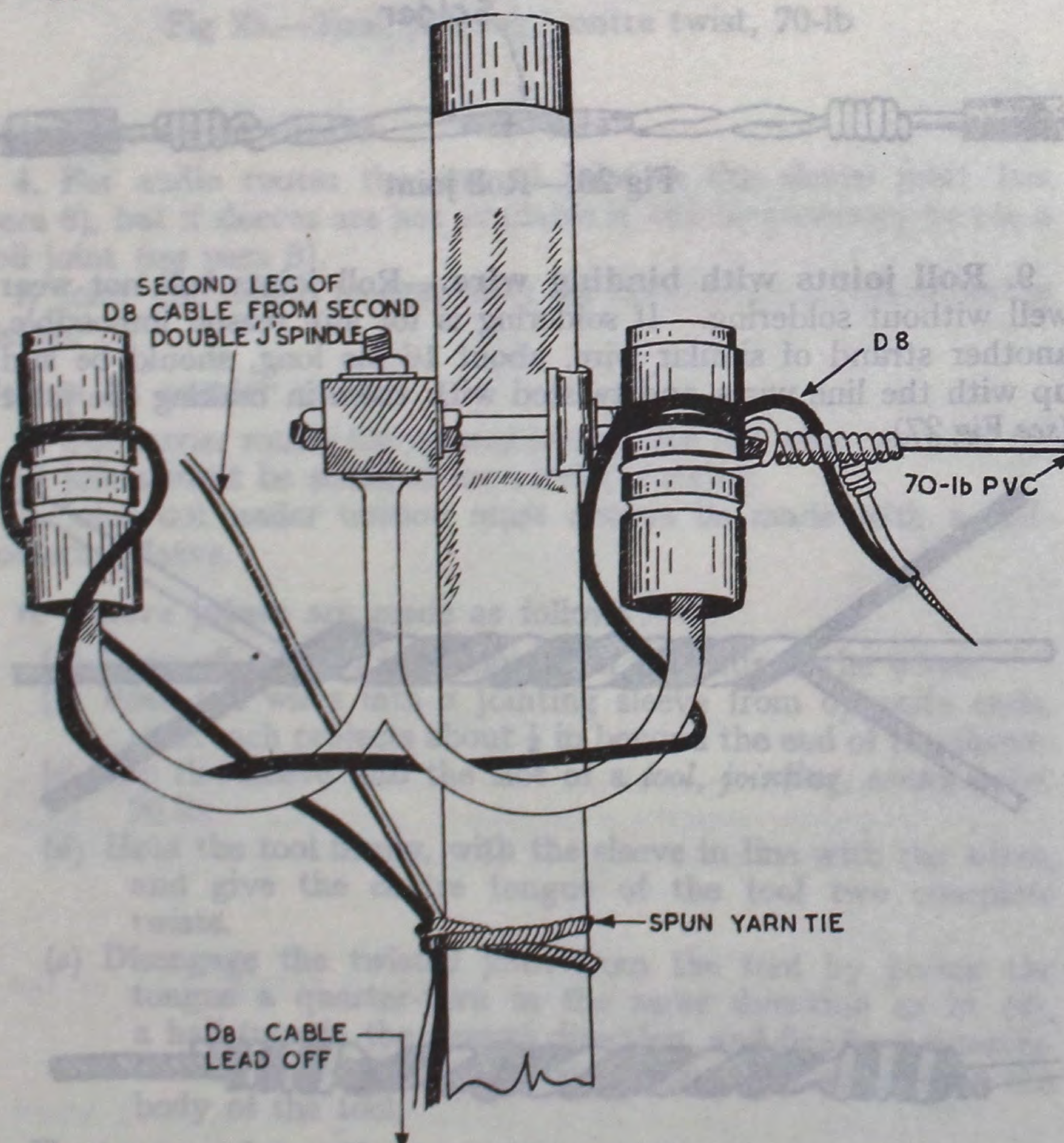

Fig 28.—Jointing 70-lb cadmium copper PVC to " D " class cables.

Jointing to quad cables

12. Jointing 70-lb cadmium copper PVC to quad cable is done the same way as jointing to " D " class cable, except that a tinned copper binding wire, 24 ins long, is required. The copper strand from a length of D8 cable is suitable. The insulated conductors of the quad are freed for about 3 ft by stripping the outer sheath (*see* Fig 29). The end of the sheath must be sealed with insulating tape.

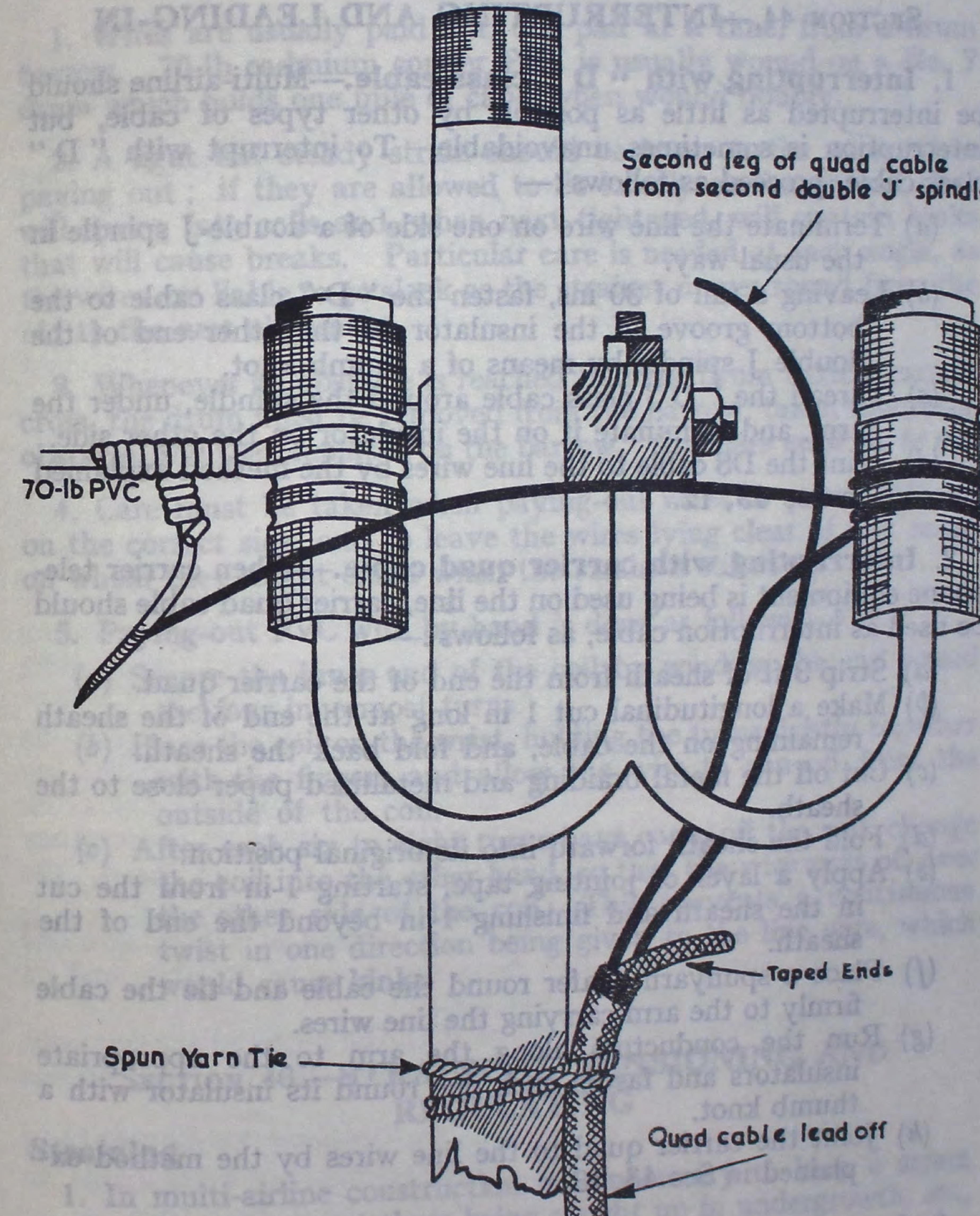

Fig 29.—Jointing 70-lb cadmium copper PVC to quad cable.

13. To join 70-lb cadmium copper PVC to carrier quad on carrier routes, one carrier quad is required for each pair of wires. The method is exactly the same as above, except that one pair of the carrier quad is cut at the same point as the sheath, and left unused.

It follows that two carrier quads will be required when jointing to the standard multi-airline route of four wires. By doing this the electrical quality of the line is increased.

14. All joints will be insulated with special plastic or Lassovic tape. If this is not available, IR tape or ordinary insulating tape should be used.

SECTION 44.—INTERRUPTING AND LEADING-IN

1. **Interrupting with " D " class cable.**—Multi-airline should be interrupted as little as possible by other types of cable, but interruption is sometimes unavoidable. To interrupt with " D " class cable, proceed as follows :—

(*a*) Terminate the line wire on one side of a double-J spindle in the usual way.
(*b*) Leaving a tail of 30 ins, fasten the " D " class cable to the bottom groove of the insulator on the other end of the double J spindle by means of a thumb knot.
(*c*) Thread the " D " class cable around the spindle, under the arm, and terminate it on the insulator on the other side.
(*d*) Joint the D8 cable to the line wires by the method explained in Sec **43, 12.**

2. **Interrupting with carrier quad cable.**—When carrier telephone equipment is being used on the line, carrier quad cable should be used as interruption cable, as follows :—

(*a*) Strip 3 ft of sheath from the end of the carrier quad.
(*b*) Make a longitudinal cut 1 in long at the end of the sheath remaining on the cable, and fold back the sheath.
(*c*) Cut off the metal braiding and metallized paper close to the sheath.
(*d*) Fold the sheath forward into its original position.
(*e*) Apply a layer of jointing tape, starting 1-in from the cut in the sheath and finishing 1-in beyond the end of the sheath.
(*f*) Place a spunyarn chafer round the cable and tie the cable firmly to the arm carrying the line wires.
(*g*) Run the conductors along the arm to the appropriate insulators and fasten each one round its insulator with a thumb knot.
(*h*) Joint the carrier quad to the line wires by the method explained in Sec **43**, 13.

3. **Interrupting with quad cable.**—Interruption with quad cable is carried out as follows :—

(*a*) Strip 3 ft of sheathing from the end of the quad cable.
(*b*) Apply a layer of jointing tape, starting an inch from the end of the sheath and finishing an inch beyond it.
(*c*) Proceed as in para 2 (*f*) to (*h*) above.

Leading-in

4. The principles of leading-in multi-airline are the same as those given in Sec **9**. Leading-in is exactly the same as interrupting, except, of course, that the cable joined to the line wire is usually led-off down the pole and buried from the pole to the signal office ; or it may be dropped off the pole and go straight into a building.

SECTION 45.—PAYING-OUT

1. Wires are usually paid out, one pair at a time, from a drum barrow. 70-lb cadmium copper PVC is usually wound on a No. 7 drum which holds one mile of cable when wound doubly.

2. A light but steady strain should be kept on the wires when paying out ; if they are allowed to lie loosely on the ground they will spring into coils and, when next tightened, will contain kinks that will cause breaks. Particular care is needed at each angle, as the wires are liable to go slack as the strainer moves round from the old to the new alignment.

3. Whenever an obstacle is reached that the drum barrow cannot cross, the drum must be removed from the barrow, taken round the obstacle, and then replaced on the barrow. *The wire must not be cut.*

4. Care must be taken when paying-out wires to pass obstacles on the correct side, and to leave the wires lying clear of any snags on which they might catch when the strain is taken up.

5. Paying-out PVC wire by hand is done as follows :—

(*a*) Secure the inner end of the coil by winding the end round the four innermost turns.
(*b*) Place the coil on the wrist, holding the turns lightly together with the fingers and allow the wire to run off from the outside of the coil.
(*c*) After each six to eight turns have come off the coil, change the coil into the other hand, so that the wire runs off over the other side of the coil. This prevents a continuous twist in one direction being given to the line wire, which would cause kinks.

SECTION 46.—STRAINING, TENSIONING AND REGULATING

Straining

1. In multi-airline construction it is necessary to keep a strain on the wires to prevent them being caught up in undergrowth, *etc.*, or coiling up and kinking.

2. The strain is kept by using straining bars which consist of wooden bars and *tongs, draw, light.* The tongs are attached to eye bolts at the ends of the bar and the wires inserted in the tongs. The apparatus is then attached to a safety belt, which the strainer wears

round his hips. Care must be taken not to strain too tightly otherwise the PVC insulation will split and run back.

3. When four wires are strained together, two normal straining bars are attached to the ends of a 30-in straining bar, which has special hooks for this purpose. The 30-in bar is then attached to a safety belt.

4. The strainer leans back on the straining bar so as to impose sufficient strain on the wires to keep them clear of the ground. The strain must be kept to a minimum to avoid the possibility of stretching the insulation.

Tensioning and regulating

5. Tensioning the wires consists of subjecting them to a certain tension to allow for the contraction of the wires when the temperature drops, so that they will then not be stressed beyond their breaking point.

Wires are tensioned at all terminations (*see* Sec **42**).

6. Tensioning is done by means of ratchets and tongs.

The insulated tail of the ratchet and tongs is pulled out for a distance of about 2 ft, and clipped to the spindle by means of a scissors hook. The wires are pulled up over the arm by hand.

Strip off the insulation, sufficiently to accommodate the jaws of the vice (N.B. The jaws must grip the copper and not the PVC). Strain up, and when the regulation is correct, terminate, remove the draw vice and tape the bare portion of line wire. If plastic tape is unavailable use india-rubber or ordinary insulating tape.

7. Two or four wires can be tensioned at the same time.

If only two of four wires are being tensioned at one time, two opposite wires (*eg*, the two outside ones) should be dealt with together.

When four wires are being tensioned, the procedure is to pull one wire up to the required tension with a ratchet and tongs that has a tension indicator known to be accurate, and regulate the other wires to it by sight. The ratchets and tongs used on these other wires need not have tension indicators and if they have, the readings should be ignored. The method is as follows :—

(*a*) An observer stands opposite the middle of a bay, and one bay away, as far back from the wires as possible, and on the highest ground available.

(*b*) The tensioner tightens one wire to the required tension with a tension indicator, and informs the observer when he has done so.

(*c*) The observer now indicates to the tensioner, by prearranged whistle signals, which of the remaining wires he is to tighten, and what tension is required in each wire.

Normally the two outside wires are done first, followed by the two inside wires. The wires are regulated until the observer can see a constant separation between the wires throughout two bays. When viewed in this way the wires appear very close together and it is quite easy to see when they are parallel.

8. The correct tension for 70-lb cadmium copper at various temperatures is shown below :—

	Degrees F	Tension
Arctic	0°	90 lb
Freezing	20°	75 lb
Mild	60°	55 lb
Hot	100°	35 lb
Tropical	120°	30 lb

SECTION 47.—ORGANIZATION AND DUTIES OF DETACHMENT

General

1. The most suitable working detachment comprises a commander and 19 men, but the duties are arranged in accordance with the basic organization, so that the numbers can be varied (*see* Appendix A). The stores required for one mile of route of four wires are given in Appendix B. Appendix C shows the standard span length, and dip.

2. *The whole essence of multi-airline construction is speed.* This can only be achieved by constant practice in laying and by the experience of the detachment commander, who must ensure that as a man finishes a specific operation in construction, another man is ready to follow him with another operation.

3. **Relative positions of numbers.**—Fig 30 shows the relative positions of the various numbers.

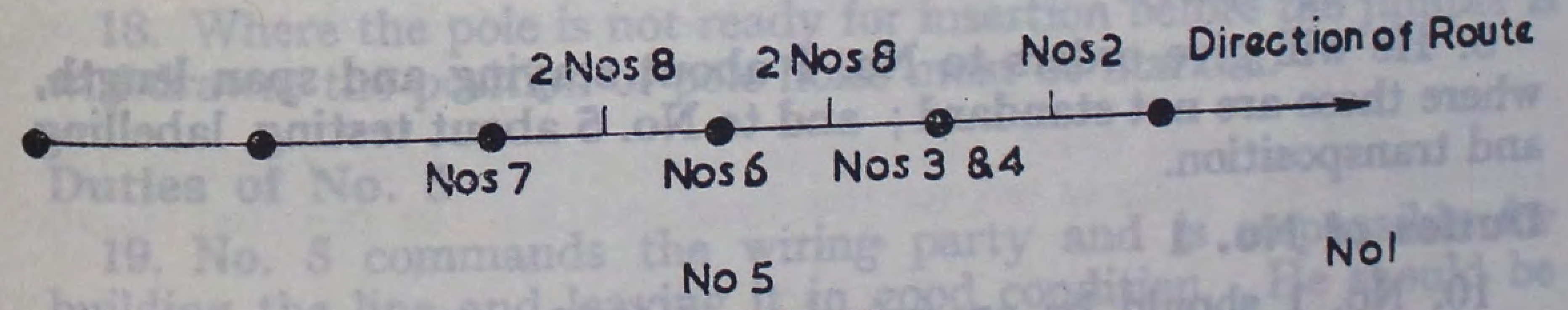

Fig 30

It should be noted that :—

(*a*) As the Nos. 7 start to lift a pole, two Nos. 8 pass the strain of the wires to the two other Nos. 8 who are one-and-a-half spans down the route. The Nos. 8 "leapfrog" each other in this way along the whole route.

(*b*) The Nos. 6 are normally one span ahead of the Nos. 7.

(*c*) Nos. 3 and 4 are normally one span ahead of the Nos. 6.

(*d*) The Nos. 2 are normally one span ahead of the nearest Nos. 8.

Duties of detachment commander

4. The detachment commander will carry out the general duties of a detachment commander as laid down in *Signal Training Pamphlet, No. 4, Part II*.

5. He will decide the exact path that the route is to take, and effect the best possible compromise between speed in construction, safety from traffic, ease of maintenance, and economy of stores. The more difficult the country the more does the success of the project depend on his energy and experience. He must be provided with a motor cycle or light car to enable him to move quickly up and down the route.

6. He will mark the general line of the route as follows :—

(*a*) By placing flags at intervals along the route at points from which it is possible to see the flag ahead, and the flag behind.

(*b*) When the line changes direction, by placing a flag at the appropriate point on the route where the angle will occur.

7. He must visualize the completed line in his mind as he plans it, taking care that he does not give his detachment unduly difficult tasks, such as carrying the wires over gorse patches or taking them unnecessarily through trees that would involve a lot of clearing. Particular care is necessary when choosing the best way through villages or other difficult places, though this may involve some delay. Generally speaking, more time will be lost eventually by giving the detachment a difficult route to build than by the delay due to a careful survey.

The commander should study carefully Secs **4, 5, 11** and **40.**

8. When time permits, he must go back along the route to see that work is progressing satisfactorily. He should, however, concentrate mainly on the design of the route, and trust Nos. 1 and 5 to build it properly.

9. He will give orders to No. 1 about staying and span length, where these are not standard ; and to No. 5 about testing, labelling and transposition.

Duties of No. 1

10. No. 1 should be an experienced NCO. He commands the construction party and is responsible for the preparations necessary to enable the wiring party to wire the line quickly.

11. He aligns the pole holes forward, standing at the last pole in the ground and lining Nos. 3 and 4 on the forward flag. He tells Nos. 3 and 4 the normal span length and he leaves them to work on this figure unless exceptional circumstances make it necessary to alter it.

12. He gives directions to No. 6 as to what stores to leave at each pole, and the positions of the stays at angles. He instructs No. 6 as to the number and position of stays to be provided.

13. He is responsible, with his party, for clearing the way for the wiring party, and must take special care that all branches of trees are removed that would prevent the clearance necessary for erecting the wires. He must ensure that each man in his party does his particular work without any loss of time, and that the whole party works as a team.

Duties of Nos. 2

14. Nos. 2, 2A, 2B and 2C pay out the wires from drum barrows. They examine the wires as they pull them out from the drums, to ensure that there are no dry joints, no kinks, and that all joints are insulated.

15. They must be careful that they do not delay the work when changing coils. If there is a lorry with the wiring party, the wire should be carried in this ; if not No. 5 must be informed when the coils are nearly finished, in order that he can arrange for a fresh supply from the stores lorry.

16. They help No. 7 and his assistants with the building of the line, when required.

Duties of Nos. 3, 3A and 4

17. These numbers make holes with hammers and jumpers for the erection of the poles. The alignment is given by No. 1 as explained in para 8. They are responsible for the correct spacing of the poles and for their most suitable local siting, which can be obtained by moving the position a yard or two forward or back on the same alignment so that the pole is :—

(*a*) On the highest ground available.

(*b*) Not on a footpath, nor too near a road.

(*c*) If possible, near a bush or stone that will give local protection.

18. Where the pole is not ready for insertion before the jumper is withdrawn, the position of pole holes must be marked.

Duties of No. 5

19. No. 5 commands the wiring party and is responsible for building the line and leaving it in good condition. He should be an experienced NCO. He must ensure that :—

(*a*) The Nos. 2 pay out the wires evenly, and keep the correct distance in front of the strainers.

(*b*) The Nos. 8 keep a steady strain.

(*c*) Each pole in the straight is left upright, and properly punned.

(*d*) All angle poles are set slightly against the strain.

(*e*) All stays are tight, and marked if dangerous to traffic.

(*f*) Each pole, as it is erected, carries the wires in rear of it clear of contacts, and high enough to be safe from traffic.

(*g*) The regulation of the wires is good.

20. No. 5 can personally assist the Nos. 7 at difficult places, but he must realize that he is not a working number but is in charge of the building party.

21. He should go back frequently along the line to see that any difficult portion has been successfully dealt with, and that angles are standing properly.

22. He must ensure that each member of his party does his particular work without any loss of time, and that the whole party works as a team.

Duties of Nos. 6

23. The Nos. 6 are the storemen. They should be under the NCO, who has charge of the front lorry with all its stores.

24. This NCO, assisted by the Nos. 6, prepares each pole with all necessary arms, insulators and stays ready for the builders, and places it near the hole prepared by Nos. 3 and 4. Whenever possible, the bulk of the stores should be prepared beforehand, but insulators should not be mounted until the pole is required for use, owing to the danger of breakages.

25. No. 1 tells him the type of stay required, and where to drive in the pickets. He should measure the stays to see that they are long enough, and when a natural holdfast is to be used he will leave the end of the stay lightly fastened to it, as a guide to No. 7.

Duties of Nos. 7

26. The Nos. 7 should be experienced men since they have the duty of actually building the line; they should include a NCO.

27. They place the wires in the insulators, erect the poles, make off the stays, ram down the earth round the poles, and generally complete the line. They carry ladders, mauls, a supply of tapes and binders, spare stays, punners and a few spare insulators in case of breakages.

28. When they reach an angle pole, they first observe the position of the pickets left by the front party; the position shows them :—

(*a*) The size of the angle.
(*b*) The correct position in which to place the pole over the hole, prior to its erection, so that the arm will truly bisect the angle of the line wires themselves.

Then they terminate, and bind-in the wires, where necessary.

Duties of Nos. 8

29. The Nos. 8 work in pairs, moving on the leap-frog principle and taking the strain alternatively, 1½ spans in front of the Nos. 7. Thus one pair is always " in the strain " while the other waits in the middle of the next span to take the strain.

30. When a pole has been erected, the first pair calls to the other " Take the strain." As they feel the wires behind them tighten, they slowly take their weight from the belt, unslip their strainers, and double forward to the strainers, who have taken over the strain. From there they will walk between the wires to their new positions, running the wires through their hands to detect kinks. If a strainer finds a kink, he will stop, cut it out, and make a joint, before taking the strain again. If sleeve joints are being used, the Nos. 8 will each carry a jointing tool, and a supply of sleeves.

31. At an angle pole the strain is first taken in line with the existing route. The strainer remains in this position until the angle pole has been erected and stayed. He then swings slowly round into alignment with the new route, and calls " Wind up the slack " to the payer-out.

32. **Dismantling the line.**—When dismantling the line, the duties are as follows :—

(*a*) No. 1 superintends.
(*b*) Nos. 7 begin to dismantle the poles.
(*c*) Nos. 8 strain the wires.
(*d*) Nos. 6 collect the stores on to transport.
(*e*) Nos. 2 reel in the wire.
(*f*) Nos. 3 and 4 assist Nos. 2 by guiding the wires on to the drums.
(*g*) No. 5 superintends the reeling-in of the wire and collection of stores.

APPENDIX A

BASIC ORGANIZATION OF LINE DETACHMENT

Basic Nos.	Basic organization	Multi-airline	Poled Quad	Poled " D " class	Poled " D " class using spiral eyes
1	NCO IC Front Party.	NCO IC Front Party.	NCO IC Front Party. Assists commander.	NCO IC Front Party.	NCO IC Main Party. Make holes and erect poles stays and find natural supports
2	Payers out.	2, 2A, 2B, 2C. Pay out wires, make joints.	2, 2A. Pull over cable.	2, 2A, 2B, 2C. Pays out cable.	2, 2A, 2B, 2C. Pay out cable (under No. 5).
3	Hammers and jumper, or augers and spoon.	3, 3A. Hammers and jumpers.	3, 3A. Augers, bars and spoons.	3, 3A. Augers, bars, etc.	3, 3A. Augers holes.
4	Hammers and jumper, or augers and spoon.	4, 4A. Knock in pickets.	4, 4A. Augers, bars and spoons.	4, 4A. Augers, bars, etc.	4, 4A. Fix pickets.
5	NCO IC Rear Party.	Responsible for wiring and erection of poles. Making off of stays, etc.	Supervise loading, straining, etc.	Supervise staying regulation and labelling.	Supervise laying and regulating.
6	Dress and carry poles and erect poles.	6, 6A, 6B. Supply stores, dressed as far as possible.	6, 6A, 6B. Dress and carry poles.	6, 6A, 6B. Dress and carry poles.	6, 6A, 6B. Work in front party. Depositing stores and poles under det/comds. instructions.
7	Erect poles.	7, 7A, 7B.. Erect poles, place wires in insulators. Make off stays	7, 7A, 7B, 7C, 7D. Erect poles.	Erect poles and pun.	7, 7A. Erect poles, stays and pun (work under No. 1).
8	Strainers and regulators.	8, 8A, 8B, 8C. Strain its wires and assists in regulating.	8, 8A, 8B, 8C. Lift off cable. Strain and regulate.	8, 8A. Carry up cable and regulate.	8, 8A. Carry up cable and regulate.
Probable No. in party.		Commander and 19 men.	Commander and 20 men.	Commander and 17 men.	Commander and 17 men.

NOTE.—Whenever an extra man is available he should be detailed to assist No. 5 and be responsible for the final safety of the line.

APPENDIX B

STORES REQUIRED FOR ONE MILE OF ROUTE

		Poled 7-pr VIR	Poled D8 twisted	Spaced D8 single 2-pr	Poled Quad	Poled carrier Quad	Tree slung cable	Multi-airline: 4 wires	Remarks
Cable, 7-pair VIR	miles	1⅛							
Cable, electric, D8 twisted	miles		2¼						
D8 single	miles			4½					
Quad	miles				1⅛				
Carrier Quad	miles					1⅛			
Wire, electric, cadmium-copper 70-lb PVC	miles							4½	
150-lb PVC single	miles						2½		
Poles, octagonal, 16-ft *or* light hop poles, 20-ft		60	36	40	60	60		46	
Arms, multi-airline 33-in								40	
Bolts								84	
Straps								42	
Insulators, field, cups, double groove								160	
Insulators, field, *bolts*, single								152	
Insulators, field, *bolts*, double								8	
Insulators, hanging No. 2							120		
Posts, picket, masts 70-ft steel				20					
Posts, picket, multi-airline, steel, 2 ft 3 ins			18		30	30		56	In hard ground, *pickets, angle, short, Mk* 3 may be used or in very soft ground, *posts, picket, multi-airline* 3⅛ *ft.*
Posts, picket, 2½-ft troughs, waterproof		160		45					
Staywire BB 11	ft	4,000	450	500	700	700		700	
Wire GI 60-lb	lb						6	20	
Nails, 4-inch	lb	60	80	180	60	60			
Nails, 6-inch	lb						11		
Sleeves, jointing, WD, pattern No. 1								16	
Sleeves, self-soldering No. 3								16	
Sleeves, jointing, No. 19							10		
Boxes, joint, quad cable No. 1					3				
Pots, loading, 2-coil, No. 2					1	4			
Pots, loading, 2-coil, No. 3					1				
Bobbins		60	80	180	60	60			Quantity, as required
Labels ; tape ; spunyarn									Quantity, as required

APPENDIX C

STANDARD LENGTH AND DIP

Type of construction	*Span length (feet)*	*Dip (feet)*
7 pair VIR	90	2½
Poled D8 twisted	150	3
Poled D8 spaced	132	2½
Poled quad	90	2½
Poled carrier quad	150–165	3
Tree slung cable	120–150	4
Multi-airline, PVC	132	1