PROVISION AND MAINTENANCE OF OVERHEAD WIRES

CONTENTS

INTRODUCTION

Overhead line construction is normally employed where the number of conductors required is small and overhead provision is therefore more economical than the use of underground cable. In general overhead construction is used nowadays for subscribers' distribution and for lightly loaded rural routes. The heavy pole line, carrying main routes, has almost disappeared.

Overhead spans may consist of bare copper or cadmium-copper conductors, termed open wires, or insulated cadmium-copper conductors termed covered wires. Open wires are fastened to insulators mounted on wooden arms fitted to poles. Covered wires, when used to provide added protection to a span, may be supported by similar fittings; or, for subscribers' distribution, may be supported by specially designed clamps.

OPEN WIRES

COPPER WIRE (hard-drawn)

The main characteristics of copper which favours its use for open wires is its low electrical resistance. The mechanical properties of copper are such, however, that the tension which may be applied to the wires is severely limited, consequently the dip in each span is considerable.

In the past, copper wires in sizes ranging from 100 to 800 lb/mile have been used but most of the sizes of conductor have been discontinued. Only two sizes are now available for use on telephone and telegraph circuits, these are:-

100 lb/mile, for use on junction circuits, and 150 lb/mile, for use on junction circuits, short trunks and important telegraph circuits.

150 lb/mile copper wire or 150 lb/mile cadmium copper wire may be used in maintaining existing routes of heavier gauge copper conductors, the choice of conductor depending on the circumstances of the repair or replacement.

Issue 5.2, 6/65

CADMIUM COPPER WIRE

This consists of an alloy of copper and cadmium. It has a higher tensile strength than copper wire of the same weight, also the proportion of the breaking load which will cause a permanent stretch in the wire is greater than for copper. This fact allows a lower factor of safety to be used, which means that cadmium copper wires can be erected more tightly than copper wires. The sizes of cadmium copper wires in general use are 40 lb. and 70 lb/mile.

Uses of cadmium copper wire are:-

40 lb/mile - Standard conductor for all subscribers' circuits.
70 lb. " - This is used for:-

(a) Subscribers' lines in exposed positions.
(b) Portions of copper conductor lines on over house standards, where it is necessary to reduce the weight.
(c) Coastguard circuits in sheltered positions.
(d) Junction circuits.

150 lb/mile conductors are available for use in exceptional circumstances e.g. long spans and important circuits in exposed situations, and for repairs as mentioned previously.

COVERED WIRES

P.V.C. INSULATED WIRE

This is a 70 lb. cadmium-copper conductor covered with a black polyvinyl-chloride insulation. It is used in the following circumstances:-

(a) For protection against corrosive fumes in the atmosphere.
(b) A small measure of protection against electrical leakage and momentary contacts:-

(i) for overhead power leads to private branch exchanges, and
(ii) for wires of a fire-alarm system using an earthed wire system.

(c) For reduction of fault liability due to fleeting contacts between overhead wires which are run through trees and where tree-cutting is not permitted.

P.V.C. insulated wire supersedes the jute insulated cadmium-copper conductor previously used for the above purposes.

HIGH VOLTAGE P.V.C. INSULATED WIRE

This wire, which has superseded paper-braided jute-insulated wire, has a 70 lb. cadmium-copper conductor insulated with blue, hard-grade polyvinyl chloride of thickness 0.065 inches. This wire is used on sections of line which:-

(a) Cross power circuits.
(b) Run with power circuits - joint construction.
(c) Cross d.c. electrified railways using third or fourth rail system.

V.I.R. INSULATED DROP-WIRE

When low, or medium-voltage power circuits have to be crossed, V.I.R. insulated drop-wire is used. This is a flat twin cable, consisting of two 31 lb. cadmium-copper conductors insulated with black V.I.R., and arranged in a "double D" formation. This formation is covered with a cotton braid, and finally sheathed with a black plastic material termed Neoprene (P.C.P.). The conductors are identified by their position relative to identification ribs see Fig. 1(b).

V.I.R. insulated drop-wire is also used, where the higher ohmic resistance of the latest type of P.V.C. drop-wire prevents the use of this type.

P.V.C. INSULATED DROP-WIRE

At present, there are two types of P.V.C. insulated drop-wire in use. One type is a flat twin cable having 20 lb. cadmium copper conductors, with a solid P.V.C. insulation formed in a "double D" cross section see Fig. 1(a). The conductors can be separated by tearing along the thin web of plastic material which joins them. One conductor of the pair is tinned to facilitate identification. The use of this type of cable will be discontinued, when existing orders have been met, and stocks are exhausted.

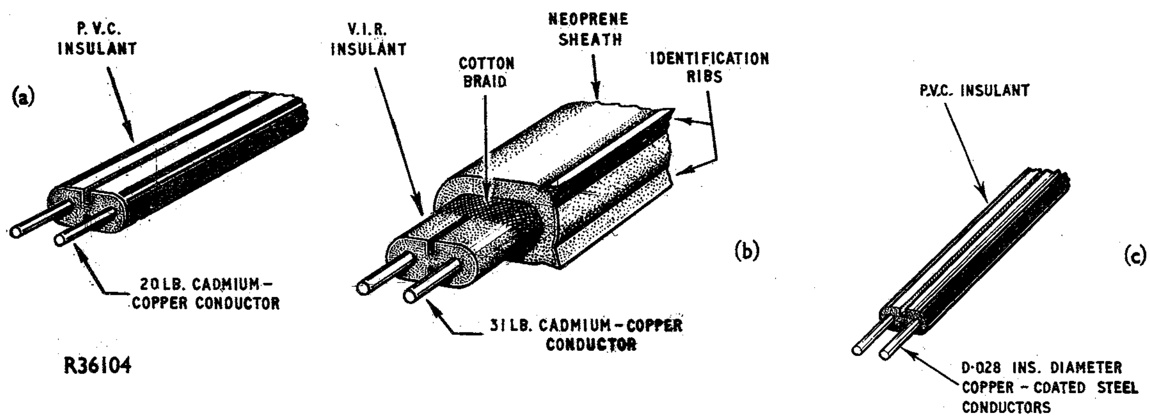


Fig. 1

The latest type of drop-wire has steel conductors of 0.028 inches in diameter, with a 0.0016 in. coating of copper. This gives each conductor a resistance of 235 ohms per mile, and a breaking load of 94 lb. The conductors are laid up as a flat pair, insulated with black, or grey P.V.C. in a "double D" formation of minimum radial thickness 0.015 in. see Fig. 1(c). No method of wire identification is provided. The cable has a cross-section area of half that of the earlier type, and with its more inconspicuous appearance, is now used as the standard method of distribution to subscribers premises.

ERECTION OF OPEN WIRES

To give adequate service, open wire routes must be erected in such a manner that breakdowns and contacts between wires, caused by the normal variations in weather conditions, are minimized. Circuits must also be positioned, in relation to each other, so that any fault or breakdown causes the minimum interference with the overall efficiency of the route. To achieve these ends, careful consideration is given to the tension, spacing, and the relative positions of circuits on the arms.

The value of stress which is put on line wires when they are erected is a compromise between two conflicting conditions. The tighter the wire the smaller the sag, and consequently the less the risk of contact between adjacent wires. On the other hand, the stress is considerably increased by the action of the wind and by accumulations of snow and ice which sometimes occur. The tighter the wires, the less margin remains for resisting these increased stresses, and on these grounds slack wires are, within limits, preferable. As a result of experience it has been decided that the greatest load that shall be allowed on a line wire, apart from those induced by weather conditions, must not be more than one third the breaking weight for cadmium-copper, and one fourth the breaking weight for copper. This is usually expressed by saying that a factor of safety is allowed.

The values are:-

for copper wire under normal conditions	4
" " " in exceptionally exposed situations	6
" cadmium-copper wire	3
" covered wires	5

The factors of safety assume a temperature of 20°F. At higher temperature the tension is less and the dip greater, and consequently the factor of safety is increased.

When copper and cadmium-copper wires are run on the same route, the factors of safety are modified to 3 and 4.5 respectively. This ensures that approximately the same dip is obtained for the two types of conductor at all temperatures.

When an open wire route is planned the positions of the various circuits are decided by applying the following principles.

(a) Circuits should occupy uniform positions throughout their length. This requirement simplifies identification when maintenance or restoration in the event of breakdowns is carried out. It also allows a standard transposition scheme to be applied. Transposition is a method of changing the relative positions of conductors in a route with the object of reducing inductive disturbance.

(b) The longest circuits should be on the uppermost arms and the remaining circuits should be arranged from the top downwards in order of length. When a route carries more than two circuits per arm the shortest circuits should be on the outer positions.

In conjunction with these principles it is also desirable that the more important circuits should be run in the upper positions to minimize the risk of serious faults due to broken wires. Also where the ultimate capacity of a route exceeds 20 circuits and 8-way arms are used, junction and subscribers circuits which extend furthest along the route should be run on the centre positions. This will allow the use of 4-way arms on parts of the line where development prospects are remote without changes in circuit positions.

The erection of open wires is commenced after the insulators have been fitted to the arms of the poles. The wires are terminated on the terminal pole insulators and paid out by hand or from drums mounted on the back of a gange vehicle. If the wire is paid out by hand the coil is reversed every 4 or 5 turns so as to pay out from the opposite side, this avoids the formation of kinks. To prevent entanglements only two wires are paid out at one time commencing with the inner positions of the top arms, then working outwards and so on down the pole.

As each intermediate pole is reached the wires are hoisted to the appropriate position on the arms using a length of sash line or pruning rods fitted with a socket and a wire stringing tool.

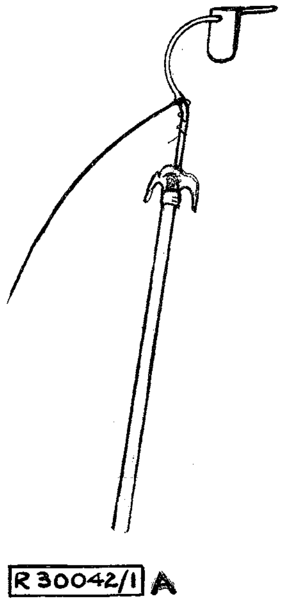


Fig. 2

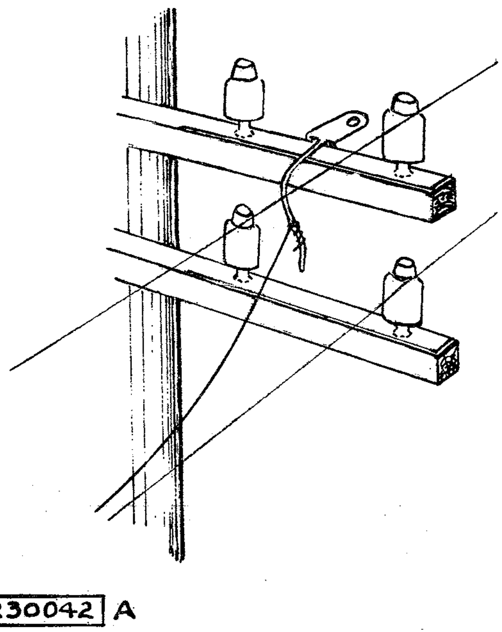


Fig. 3

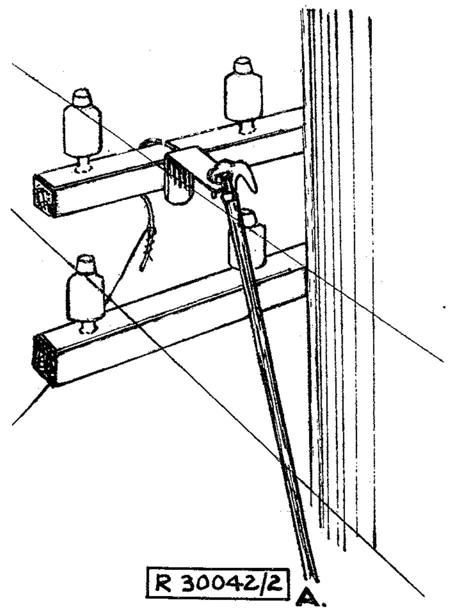
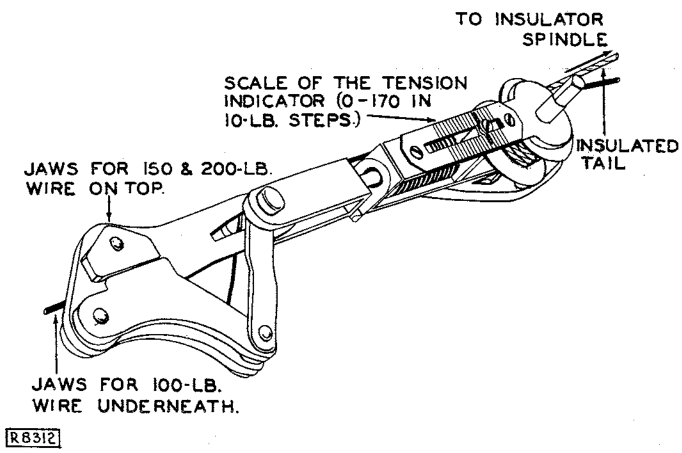


Fig. 4

The socket and wire stringing tool are illustrated in Fig. 2. The socket, which is fitted with two hooks, may be screwed to the pruning rod to accommodate the stringing tool as in Fig. 2, or may be inverted so that the hooks may be used to lift wires into position. The rods and attachments are useful on sections of line where there is no risk of contacts with circuits vertically below the wire being erected. For wires on the top arms or on outside positions the hook alone may be used. For inner positions on existing routes and where combiners and braces are fitted, the wire stringing tool is employed. To erect a wire by means of the stringing tool, the leading end of the wire is passed through the small hole in the stem of the tool, and twisted around the running end to prevent it running back. The tool is secured to the top of the rod by inserting the lower tapered end into the square hole in the socket. The rod is then raised until the top of the tool is just above the arm which is to carry the wire, and the tool is allowed to rest on the arm. A slight downward jerk is given to the rod, the socket is detached from the stringing tool, and the tool is left in position on the arm as shown in Fig. 3. The rod is then taken to the other side of the pole and the stringing tool is pulled over the arm, Fig. 4, bringing the wire with it, as the coil of wire is paid out on the other side of the pole. By repeating these operations at successive poles in the route the wire may be run in its correct position on the arms. The use of two stringing tools and two coils of wire makes it possible to run a pair of wires between terminal poles in a single journey.

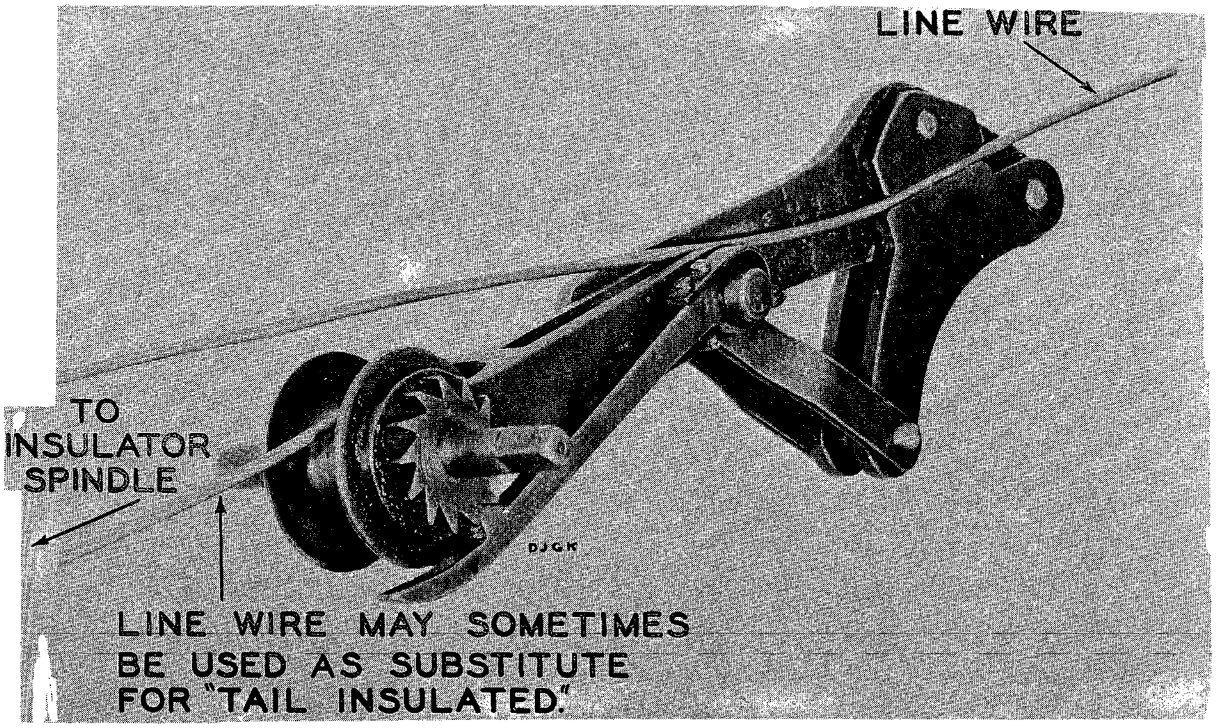
When the first pair of wires has been paid out to the terminal poles, they are "clipped in" to the grooves of insulators on any angle poles in the route, and pulled up hand tight. Ratchets and tongs are attached to the wires about 4 ft from the terminal arms and secured to the appropriate insulator spindle by means of insulated tails. The remaining wires for the route are paid out and secured in a similar manner.

Ratchets and tongs used for regulating 100 to 200 lb. wires are illustrated in Figs. 5 and 6, and those used for 40 and 70 lb. wires are illustrated in Figs. 7 and 8.



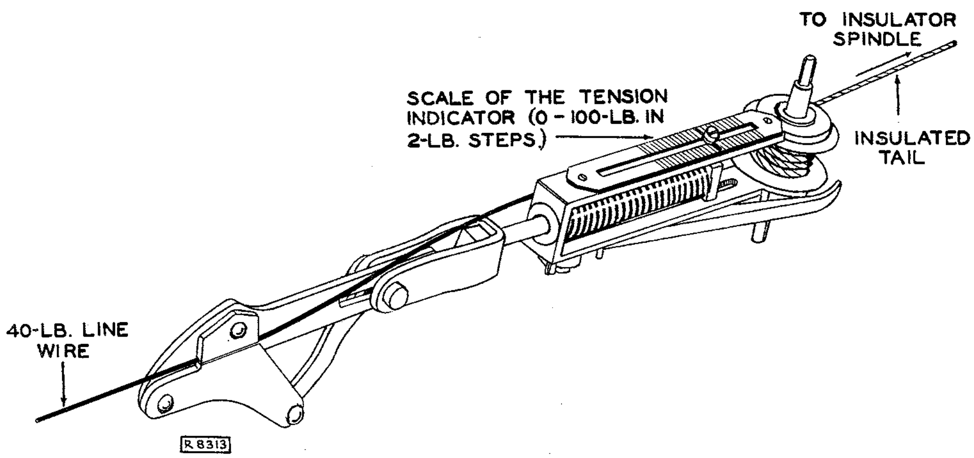
RATCHETS & TONGS FOR WIRE OF 100-200-LB. PER MILE.

Fig. 5



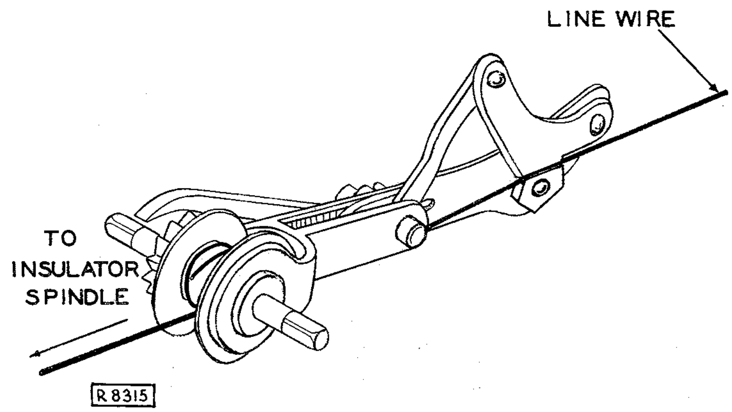
R34847.

Fig. 6



RATCHETS & TONGS FOR 40lb & 70lb WIRE.

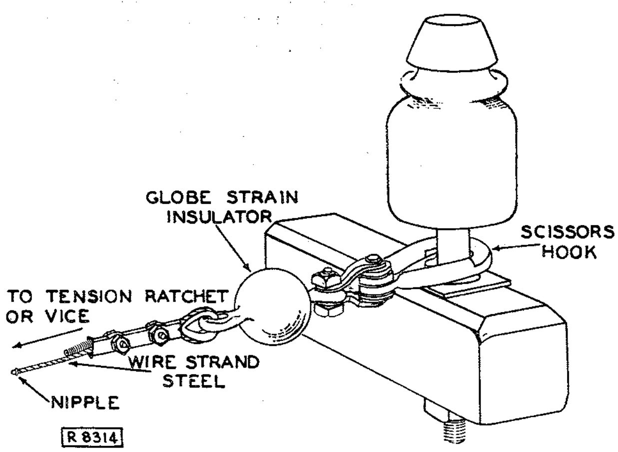
Fig. 7



RATCHETS & TONGS FOR 40 lb. & 70 lb. WIRE

Fig. 8

The ratchets and tongs illustrated in Figs. 5 and 7 are fitted with tension gauges. These are used to regulate the top arm wires. The remaining wires in the bed are tensioned with the ratchets and tongs having no tension gauges, illustrated in Figs. 6 and 8, to have the same dip as the wires on the top arm, the spacing between the wires being judged by eye.



AN INSULATED TAIL

Fig. 9

The insulated tail, illustrated in Fig. 9, consists of a length of 6-strand steel wire fixed to a globe insulator which is secured to a scissors hook. The insulated tail is used to secure the ratchet and tongs to the spindle of the appropriate insulator and the steel wire is passed through the hole in the ratchet drum and the scissors hook is clipped to the spindle. By turning the ratchet the wire is drawn on to the drum and the tension in the line wire is increased. The globe insulator maintains the insulation of the line and so prevents interference with working circuits on an existing route.

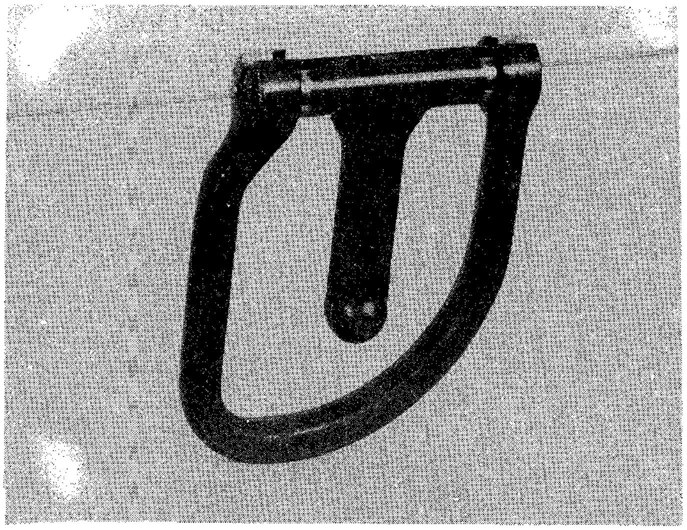
When all the wires are in position they are given an initial tension, momentarily, equal to the tension specified for 20°F. This is termed "pre-stretching" and it is carried out to remove any bends in the wire and to reduce internal stresses in the wire set up during manufacture. The tension is then reduced to the value appropriate to the working temperature. This value may be read directly from a thermometer which is specially calibrated to relate tension to working temperature for various types of overhead conductor. The thermometer should be placed in an open position at the beginning of operations. To avoid twisting the pole during tensioning, corresponding wires on each side of the pole on a particular arm should be tensioned together where practicable. If this procedure is not carried out the tension of the first wires regulated will be affected by any movement of the pole caused by tension being applied to other wires. When all the wires have been tensioned, the bed of wires can be terminated.

JOINTING

SLEEVE JOINTS

Open wires up to and including 150 lb. per mile are jointed by placing the two ends side by side in a copper or cadmium-copper jointing sleeve of oval cross-section and suitable size, and then twisting the sleeve.

The tool used for making joints in 40 lb. and 70 lb. wire at "through" positions is shown in Fig. 10 (by "through" positions is meant" in the span). Such joints should be made so that they can be reached from a pole. The tool grips the ends and centre of the sleeve, imparts equal and opposite twists to the two halves of the sleeve and does not twist the remainder of the wire. The necessary number of twists to obtain the maximum strength is indicated in the illustration (Fig. 13). For heavier wires, the large and small jointing clamps shown in Fig. 11 are used.



R31332

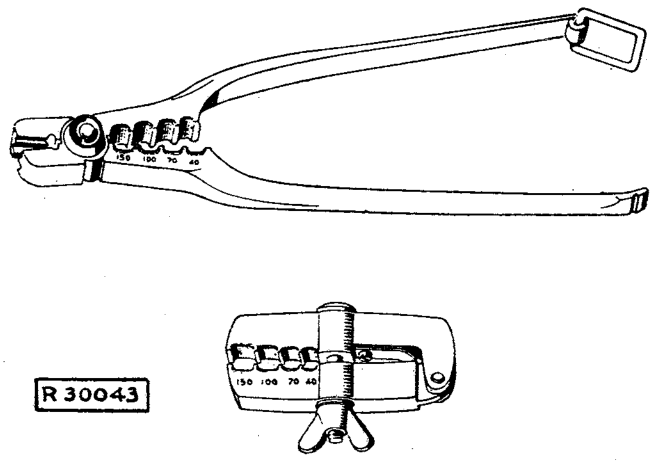
Fig. 10 - Centre-twist jointing tool

Corrosion is likely to occur on completed joints if moisture is allowed to collect in the cavities at the ends of the sleeve. To counteract this each joint is painted with black paint well worked in, except in those cases mentioned later when the joint is embedded in compound.

The choice of a large or a small clamp is governed by the size of the sleeve and the space available. The size of the wire governs the size of the sleeve, which must be a good fit. The clamps must always be kept at right-angles to the sleeve and at the ends of it (Fig. 12).

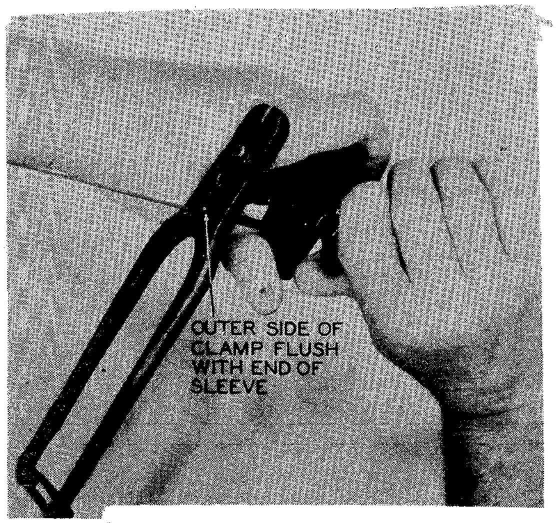
Joints in a span ("through joints") are always avoided if possible. A joint in a span is subjected to tension, which increases its fault liability. When it is necessary to join two lengths of line-wire near a terminating point, it is preferable that the joint should be in the bow or other connexion between the terminations, where it is not subjected to tension.

The large clamp is often used as a vice, and the twists made by turning the small clamp. Breakages are likely to occur if twists are made in short lengths of wire. When it is necessary to join a wire near a point where it is fixed



R 30043

Fig. 11 - Jointing clamps



R 31333

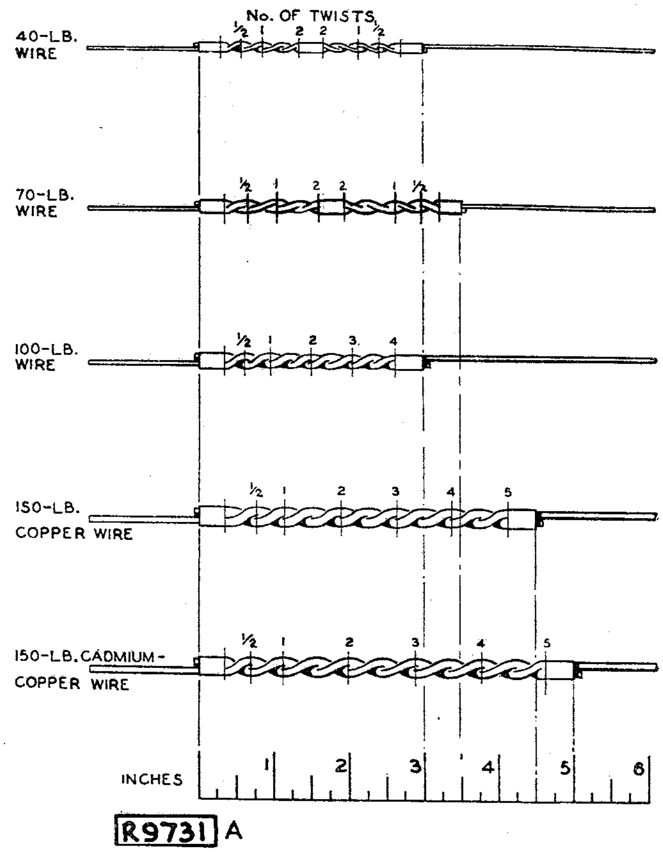


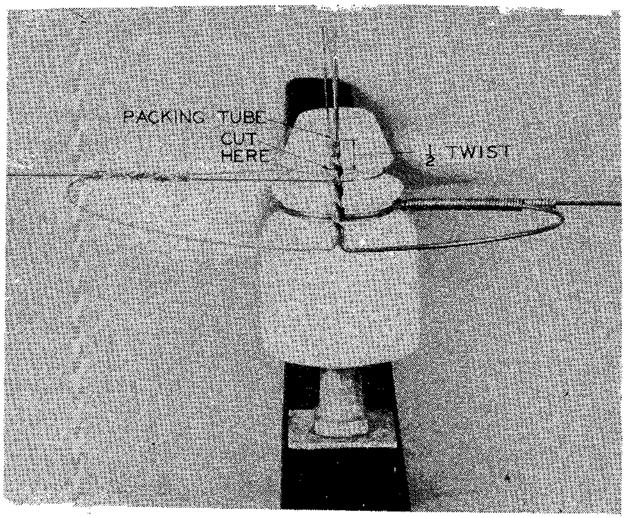
Fig. 12 - Fixing a clamp

Fig. 13 - "Through" twisted sleeve joints

in position (e.g., held in a regulating tool), the clamp nearer to the fixed point is held stationary and the other clamp turned. The twists are thus distributed through-out the longer length of wire. The application of the clamps is illustrated in Fig. 12.

Wire ends are always straightened, and cleaned with emery paper, before insertion in the sleeve. The correct number of twists in sleeve joints for 70, 100 and 150 lb/ml. conductors are indicated in Fig. 13.

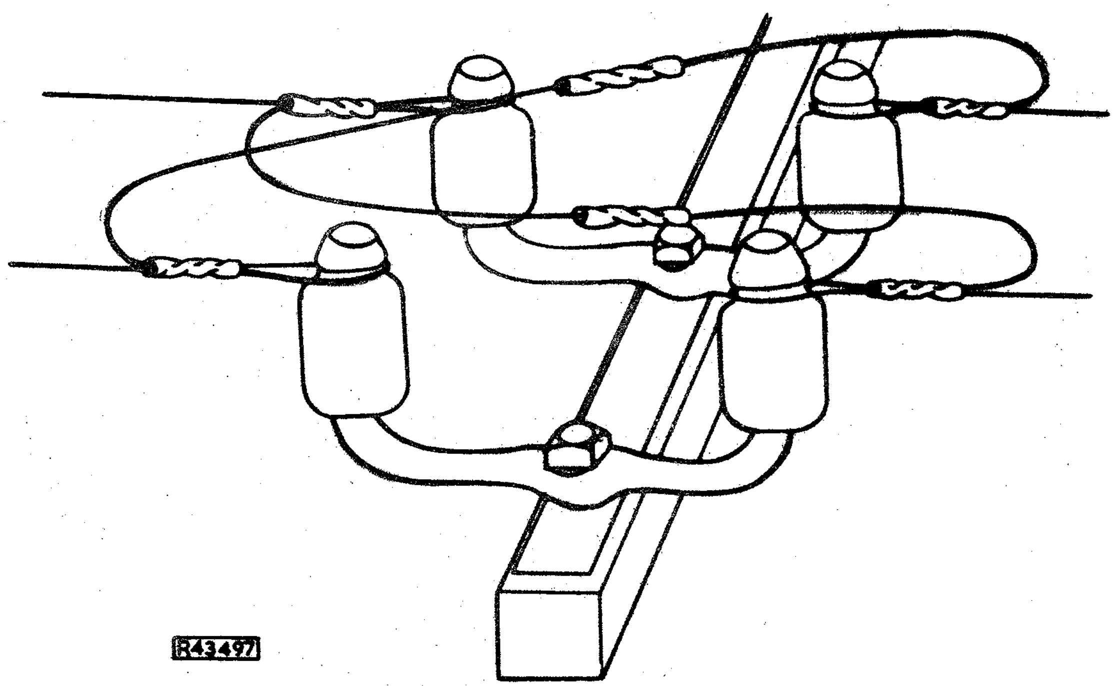
COMBINATION OF JOINTS



R31335

Fig. 14 - Nib joint

When conductors of different gauges are to be jointed, the joint is not made in the span. Both wires are terminated on an insulator, and the joint made in the bridge joining the two terminations, as shown in Fig. 14. The lighter wire has a copper tube fitted over it to bring its diameter up to that of the heavier wire. These packing tubes are provided for jointing 40 lb. wire to 100 lb. or 150 lb. wire, and are respectively $1\frac{3}{4}$" and 2" long. The method of making the joint can be followed from Fig. 14.



R43497

Fig. 15 - Connexions: joints in the direction of the wire

Fig. 15 shows a transposition cross.

JOINTING INSULATED WIRE

Through joints should not be made on insulated wire. Where a covered wire is to be jointed to an open wire, the open wire should be terminated on a through-position insulator and the covered wire terminated on a terminating insulator. The two conductors are then joined inside the cavity of the terminating insulator in the normal manner. Where two covered wires are to be joined, the wires are terminated on a terminating insulator (one groove per wire) and the conductor joined in the cavity of the insulator.

JOINTS AT TERMINAL POINTS

Fig. 16 - Crimping

Joints at terminal points between open wires and pole leads or drop-wires are made in the cavity of a leading-in insulator. Open wires of more than 40 lb. per mile are jointed to 40 lb. per mile copper or cadmium-copper wire to provide leading-in tails to the insulator. Terminal joints in open wires of less than 200 lb. per mile are in nib form and employ copper or cadmium-copper jointing sleeves. Where open wires of 200 lb. per mile or heavier are connected to leading-in cables or to pole-leads, all joints are soldered. Sleeve joints in the cavity of leading-in insulators are crimped; those outside the insulator are twisted. Both crimped and twisted joints are shortened, the unwanted portion being clipped off cleanly. Generally, crimped joints are shortened to a length of half an inch and twisted joints by clipping off approximately half an inch i.e. the portion of the free end containing half a twist. Crimping is effected by the use of a pair of large jointing clamps, and is illustrated in Fig. 16. The jaws are applied near the lower end of the sleeve to allow for shortening.

It has been general practice to bring both conductors of the pole-lead or drop wire into one insulator and to cross-connect one leg to the other insulator by means of a cross-connecting lead. This method, which is illustrated in Fig. 18, is now only used for V.I.R. insulated drop-wire. In the case of P.V.C. drop-wire and P.V.C. leading-in cable now in use, the two conductors are separated by tearing the two D-shaped sections apart and each conductor is led into its individual insulator. This method is illustrated in Figs. 17 and 19.

Where the ingress of moisture to insulators' cavities must be prevented, the cavities are fitted with a black compound. The holes are plugged with compound, and a layer of compound is placed over the bottom of the cavity. For effective sealing, the covering of each cable should project slightly into the compound. The joints or joints are then pressed into the layer and more compound added until the cavity is filled.

Where shared service is to be provided to subscribers, teed joints must be made at the junction between the two subscribers' lines and the exchange pair. These connexions are made by means of an insulator insert consisting of three screw terminals moulded into a block of insulating material, thus obviating the necessity for making crimped or soldered joints. Each inserts fit into the cavity of a specially designed insulator. No compound is required in the cavity.

The insert may also be used to make joints at terminal points on normal circuits where a cross connecting lead is used. The insert dispenses with the need for sleeve or soldered joints within the cavity. Where no cross-connecting lead is used, single connexions can be made within standard leading-in insulators by means of small rectangular brass inserts having two screw terminals. Figs. 17 to 19 illustrate the connexion of lead-in cables to various sizes of open wire using sleeve nib joints.

(Figs. 17 and 18 follows)

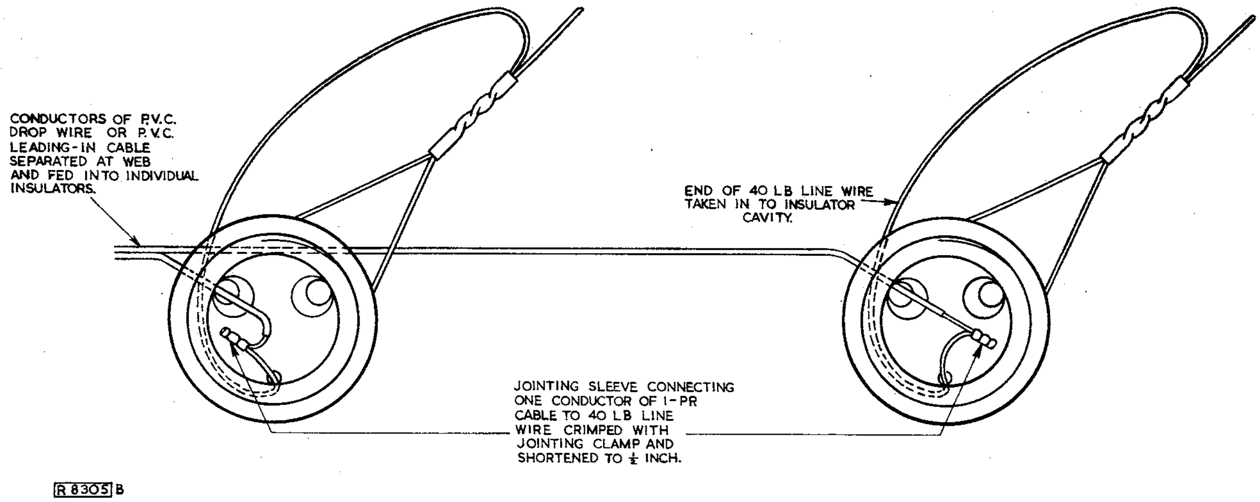


Fig. 17 - Connexion of leading-in cables to open wires of 40 lb. per mile

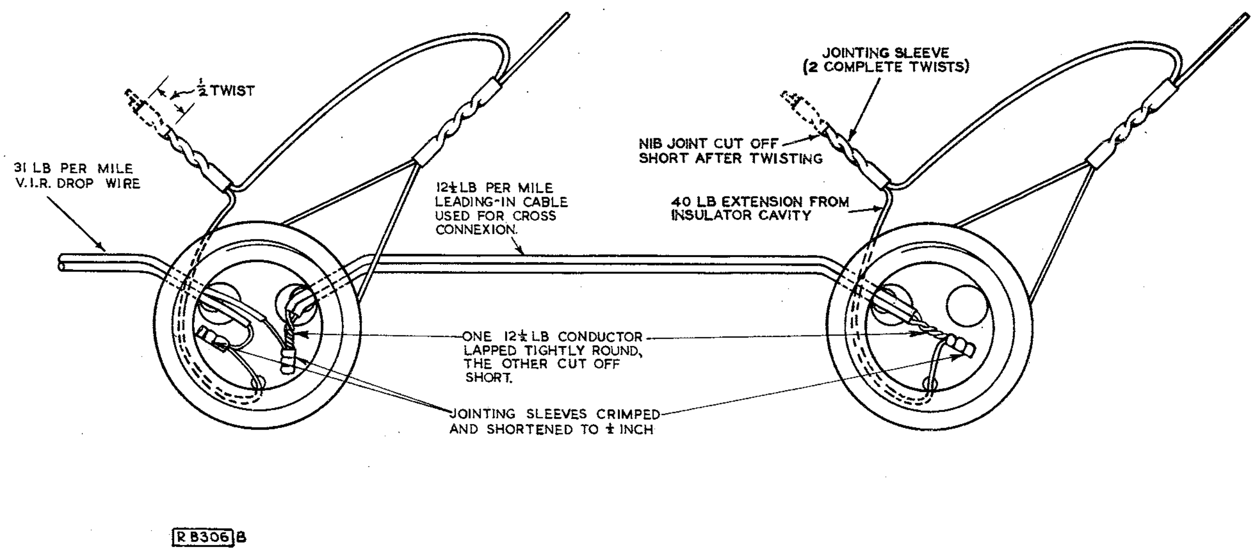


Fig. 18 - Connexion of leading-in cables to open wires of 70 lb. per mile.

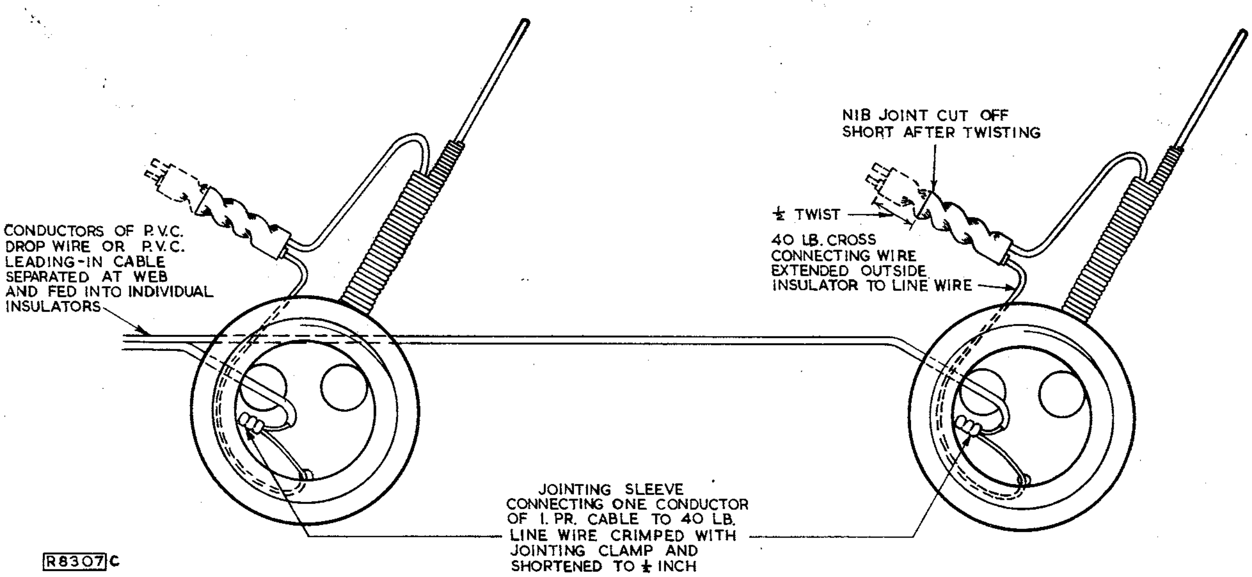


Fig. 19 - Connexion of leading-in cables to open wires of 100 and 150 lb. per mile.

TERMINATING OPEN WIRES

Terminating a line-wire consists of fixing it rigidly to an insulator so as to maintain the tension required.

Single termination is the term used when referring to the termination of a wire on one side only of an insulator. The term is applied to terminations at the ends of a wire and also to terminations at intermediate points where the wire is made-off once only to an insulator, e.g. at a transposition cross.

Double termination is the term generally used to denote the termination

(i) of a single wire in each groove of a double-groove insulator, with a jointless bridging loop or bow - a "through" termination,

or (ii) of two wires, one in each groove, on a double-groove insulator and connected by means of a bow formed by joining the two ends or "tails" together.

Terminations are essential at:-

(a) Terminal points, i.e. leading-in points, terminal and distribution poles.

(b) Test points where the circuits are not led into a building or pole test-box.

(c) Intermediate poles where an alteration in the position of a circuit is unavoidable, excepting points where such alteration is due to a difference in arm capacity - in which case "transition poles" are provided.

Line wires are terminated at both ends of the span at the following points:-

(a) Railway crossings.

(b) Road crossings.

(c) Crossings over power circuits, including the trolley wires of tramway or trolley-bus systems.

(d) Where an exceptionally long span, of 100 yds. or more, is unavoidable.

These terminations are required to obviate risk of the wire falling in the span in the event of a break occurring in adjacent spans.

Line-wires are terminated at other intermediate points, as follows:-

(a) At transposition poles. The longitudinal stays, provided at $\frac{1}{4}$ mile intervals, are also fitted at transposition poles wherever practicable.

(b) At least every $\frac{1}{4}$-mile in continuous sections of line, to limit the effect of breakdowns. The terminations are on longitudinally-stayed poles.

(c) At severe angles in the line, except where a pole is double-armed and the wires are carried on straight spindles.

(d) Where the erection of the wires is difficult; e.g. over rivers or trees, and over or on high buildings.

(e) At the next pole to the terminal (or distribution) pole, where it is required to divide the terminal stress between the first two poles on a line.

(f) At changes of conductor gauge or material.

(g) At junction poles, i.e., where the wires branch off, either to another pole-line or to a building.

All wires on the line are terminated at points (a), (b), (c), (d) and (e). Only the wires affected are terminated at points (f) and (g), and these terminations are cut out if, and when, the wire is extended by wire of identical gauge and material in the same relative insulator position.

METHODS OF TERMINATING

Line-wires of 40 lb. and 70 lb. per mile

The twisted sleeve termination is invariably used for these weights of wire, and an example can be seen in Fig. 14. The position of the sleeve relative to the insulator is such that the loop, when not in tension, can be readily detached from the insulator. The sleeve, when twisted with the wire, becomes virtually a joint and renders the loop practically inextensible. The number of twists given to the sleeve is $1\frac{1}{2}$ for both weights of wire.

To form the loop, the sleeve is pushed on to the standing part of the line-wire, and the free end of the wire passed round the insulator groove and brought back, through the sleeve, alongside the standing part. The sleeve is then moved into position and clamped; when terminating a regulated section, the free end is pulled at the same time so that the wire may be as tight as possible between the regulating tool and the insulator.

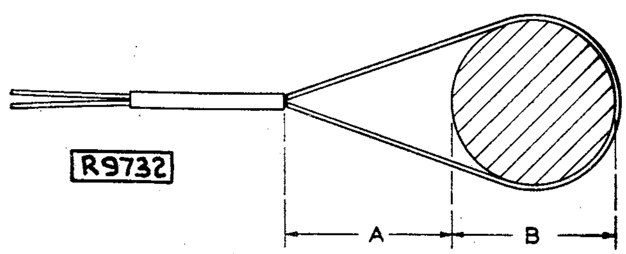


Fig. 20 - Position of sleeve relative to insulator

With reference to Fig. 20 the distance A is equal to or slightly greater than B. This is so that sharp bends at the sleeve are avoided, and the loop can be slipped off the insulator without altering the permanent sets in the wire.

When terminating a wire before it is pulled up, the loop may remain on the insulator if the clamp next to the insulator is held still and the other clamp rotated. The twists imparted to the wire of the span are taken out by turning the coil of wire, or by detaching the loop from the insulator after the clamps have been removed.

When terminating after regulating the clamp nearer the regulating tool is held stationary, the twists being made from the opposite end of the sleeve, with the loop detached from the insulator.

To remove the loop from the insulator, just ensure that the sleeve, with the clamps affixed, is in the correct position relative to the wire and the insulator. Then slacken the wire as required between regulating tool and insulator by turning the ratchet drum, and lift off the loop, one side at a time, taking care not to move the sleeve along the wire.

Line-wires of 100 lb. or more per mile

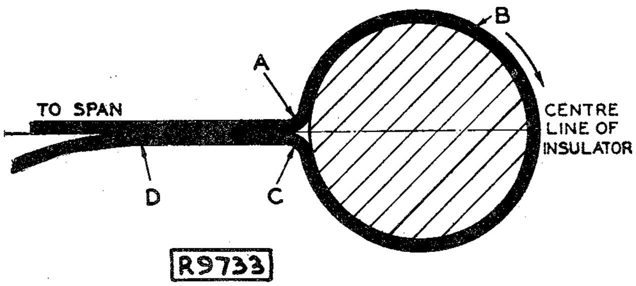


Fig. 21 - Looping line-wire around insulator

All open wires of 100 lb., or more, per mile are terminated by looping the wire closely around the insulator and making-off by means of a length of annealed binding wire, referred to as the "binder".

An advantage of the binder make-off is that, at intermediate points where the line-wire will itself form the connexion between the terminations, the wire can be terminated without destroying its continuity. During erection, therefore, wire is not cut at intermediate points as a matter of course for the purpose of terminating. Where termination (single or double) with jointless connexions can be made without inconvenience, line-wire is paid-out and erected without being cut. For a transposition cross, for example, the line-wire is taken direct from the first single termination to the second, one of the coils being passed under the other as paying-out proceeds.

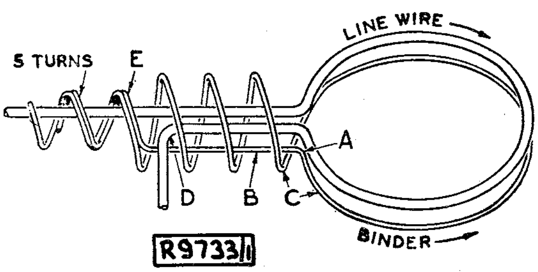


Fig. 22 - Making-off termination

Where the termination is at the end of a section which has just been regulated, the positions of the knees shown at A and C in Fig. 21 are carefully determined to ensure that the wire is taut between regulating tool and insulator, so maintaining correct regulation.

The following is the method of making-off, explained with reference to Fig. 22.

(a) Form a knee, A, in the binder and straighten the shorter portion B.

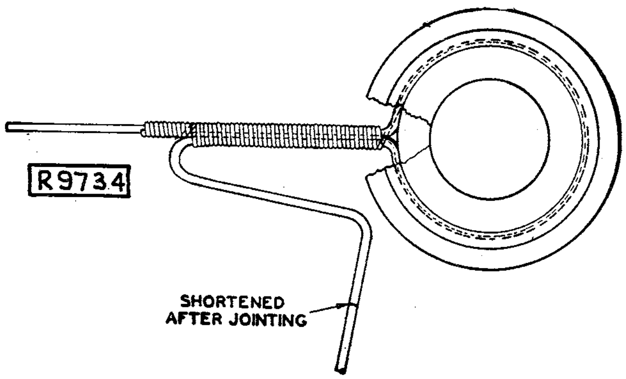


Fig. 23 - Termination for connexion to pole-lead: wires of 100 lb. or more per mile

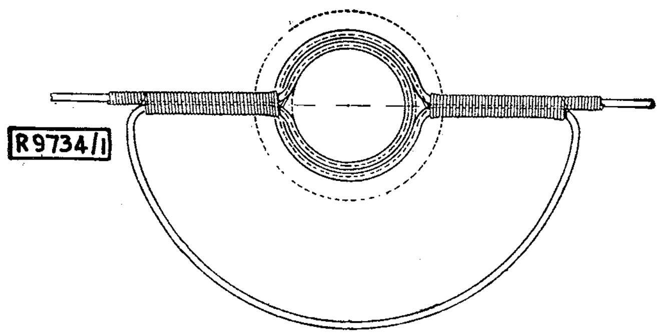


Fig. 24 - Jointless double termination

(b) With the longer portion towards that side of the insulator on which the bow or tail is to be formed, place B under, and central with, the standing part and the free portion of the line-wire and hold these together near the insulator.

(c) Take the free end C of the binder round the insulator, keeping it under the line-wire.

(d) Pull the binder tight, and pass it around both the free portion and standing part of the line-wire, embracing also the straight portion of the binder. Continue the lapping closely and tightly for from 2" to 3".

(e) Bend the free portion of the line-wire at D with an easy radius, at right angles to the standing part, and pull the straight portion of the binder up in the fork thus formed.

(f) Extend the lapping to this point and complete the binding by lapping both ends of the binder side by side around the main wire for five complete turns.

TERMINATING COVERED WIRES

Terminations are made in a similar manner to that for copper wire of 100 lb. and over, but insulated binding wire is used in place of the bare copper binding wire. The length of binding wire required for each termination is four feet, which allows about one inch beyond the point where the tail leaves the main line wire.

Fig. 25 illustrates the terminations employed at the junction between bare wire and covered wire.

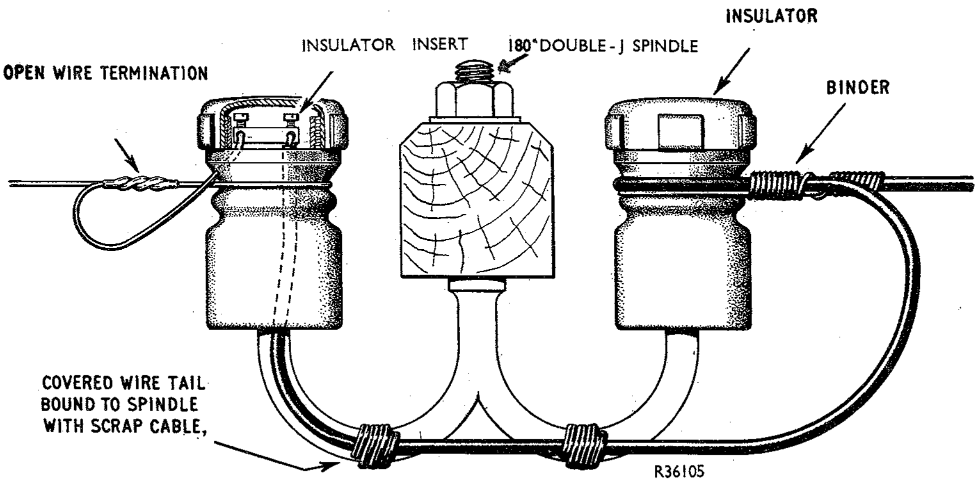


Fig. 25

The bare wire tail is led into the insulator via the wire hole in the side of the insulator. The tail from the covered wire termination is also led into this insulator via a cable entry hole. The two tails are connected by means of a brass insulator insert. The covered wire tails is bound to the insulator spindle with scrap leading-in cable.

The termination of two spans of covered wire is illustrated in Fig. 26.

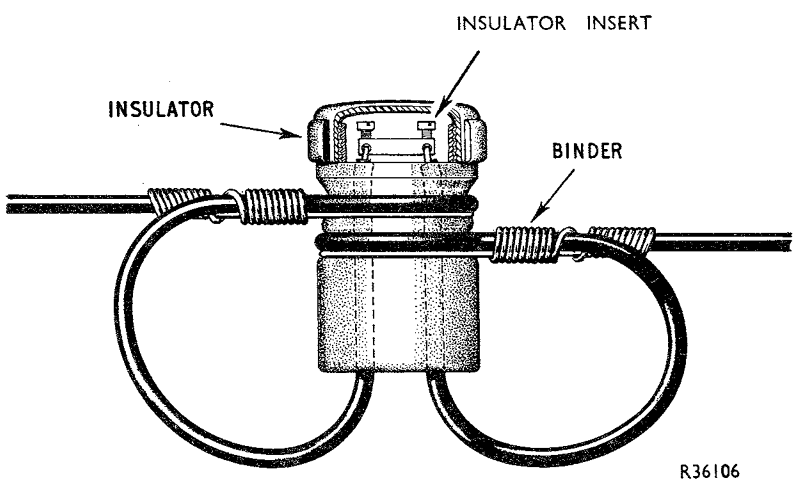


Fig. 26

BINDING-IN WIRES

Binding-in covered wires

Insulated wire is bound-in by means of insulated binding wire. The line wire is whipped with binding wire over a length equal to the diameter of the neck of the insulator. The whipped portion is then placed in the groove and the two free ends of the binder passed round the groove in opposite directions, given one and a half laps round the line wire and the ends of the binder again passed round the groove in opposite directions. The binding is then completed by making ten turns of the binding wire on the covered line wire at each side of the insulator. A binder 60 in. long is required. The binding is illustrated in Fig. 27.

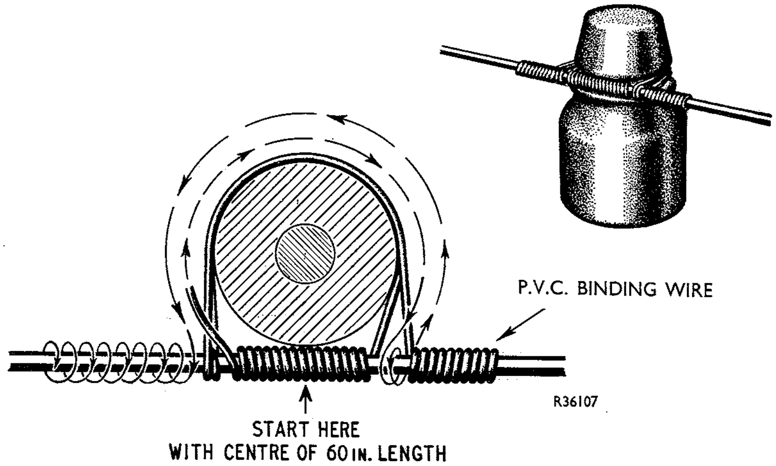


Fig. 27

Binding-in open wires

Open line-wires are bound-in at intermediate insulator positions where terminations are not required, tapes and binders being used for the purpose.

Exact detail and symmetrical construction are of great importance in ensuring freedom from inductive disturbance. Care is therefore taken to maintain the accurate separation of the line-wires as far as possible, by binding-in all the wires on any one pole to the same side of the insulators.

At angles in the line, bound-in wires are secured to that side of the insulator which ensures that the lateral stress is taken directly by the insulator and spindle and not by the binder.

Copper binders and tapes are used with copper wires, and cadmium-copper binders and tapes with cadmium-copper wires. If the materials are mixed, electrolytic action may ensue.

Tapes consisting of flat strips of annealed metal of uniform width and thickness throughout their length, are employed to safeguard the line wire against chafing where it rests against the insulator.

Binders consist of lengths of annealed line wire, the ends of which have been rolled flat. The length flattened at each end is such that at least one complete turn of the unrolled central portion of the binder is made at each side of the insulator, as shown in Fig. 28.

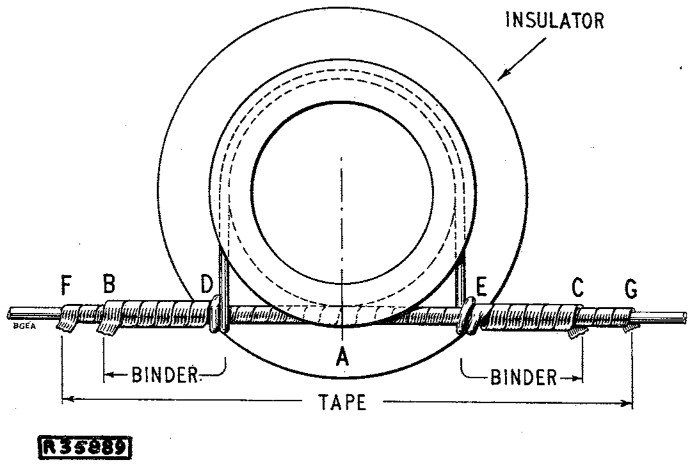


Fig. 28 - Method of binding-in copper and cadmium-copper wires

The overall length of the tape and binder are such that, when binding-in has been completed, the tape will extend beyond the binder. This arrangement reduces the risk of breakage due to vibration, by providing a gradual decrease in stiffness along the line-wire from the rigid point of fixing at the insulator.

In particularly exposed situations where breakage of binders is, or is likely to be, abnormal, the binding is reinforced by the use of a cross binder. This consists of a length of line wire identical with the conductor, except that, for conductors exceeding 150 lb. per mile, 150 lb. wire is used.

The normal binder lies on the insulator between the two parts of the reinforcement, which is secured by three complete twists from A upwards, as shown in Fig. 29.

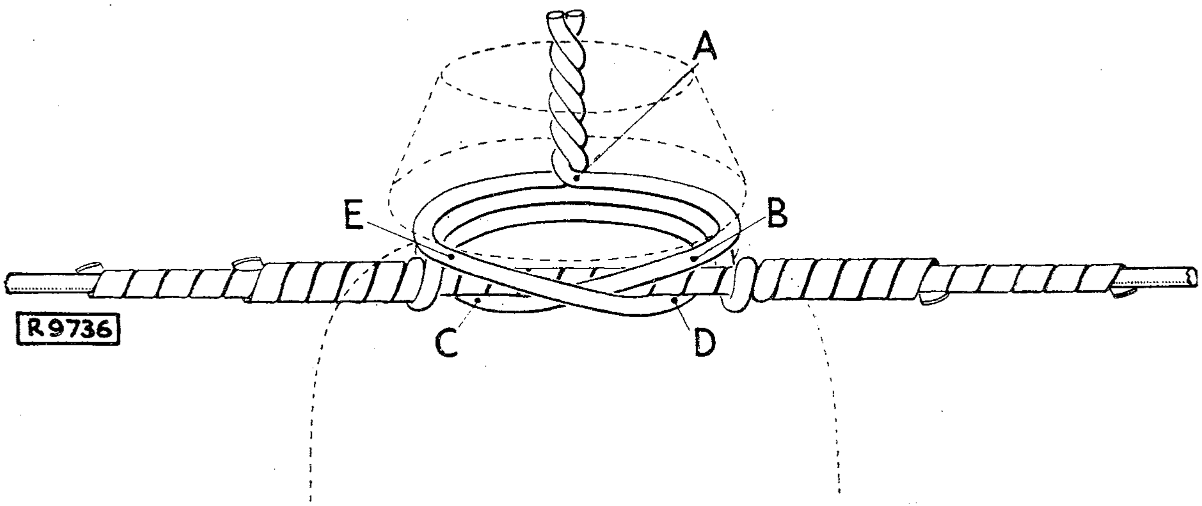


Fig. 29 - Reinforced binding

LEADING-IN AND TERMINAL CABLING

TERMINAL BLOCKS

Terminal blocks are normally used to facilitate the connexion of open wires, by means of individual cable leads, to the underground, aerial or leading-in cables.

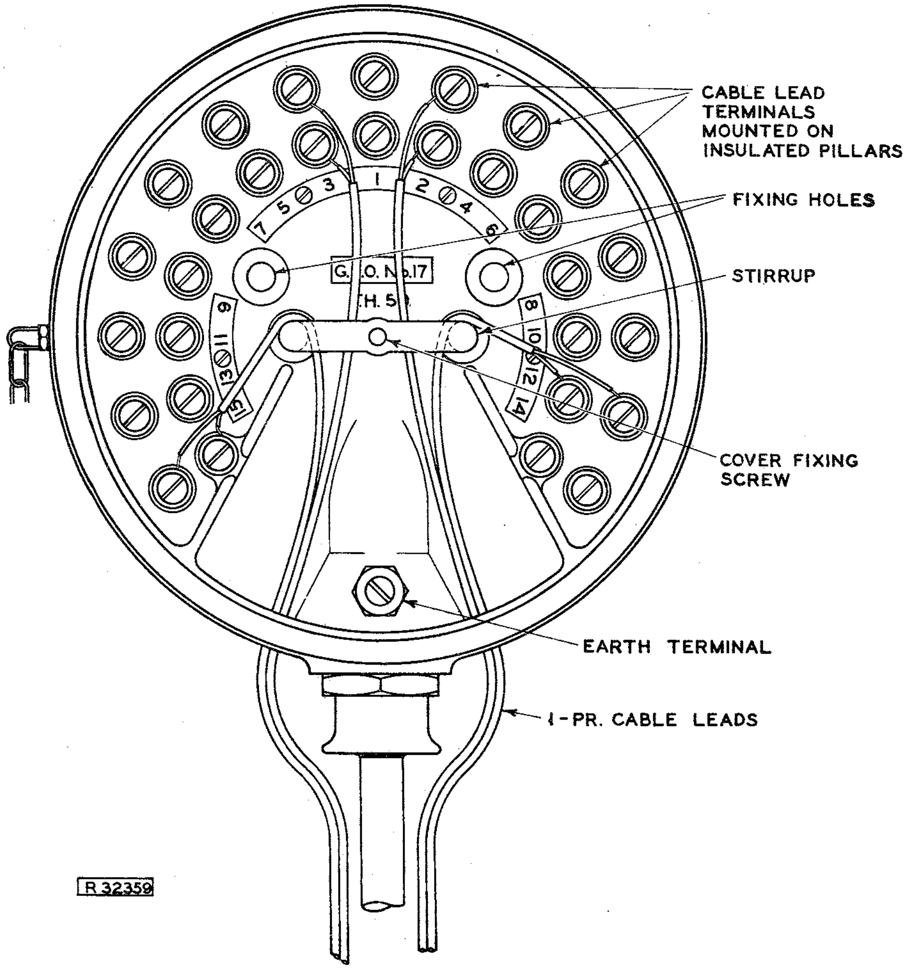


Fig. 30

Fig. 30 shows a front view (with the cover removed) of a terminal block. The block is circular and contains 15 pairs of terminals mounted on insulated pillars projecting above the face of the block. The pillars increase the length of the leakage path between adjacent terminals. The earth terminal is in contact with the thimble and provides an earth connexion when the lead covering of a cable is soldered to the thimble. The block cover is secured by a ridged knob which engages with the cover fixing screw mounted on top of a stirrup. In order to form an effective seal the cover seats on a rubber gasket of circular cross-section which is fixed in a groove around the outside of the upper surface of the body. When faults due to low insulation persistently occur at the terminal block, the front of the block is sprayed with a silicon compound.

Fig. 31 shows a rear view of the block with the back cover removed. The cover seats on a flat rubber gasket and is fixed by six screws. Two ridges on the outside of the back of the cover facilitate attachment of the block to a flat or curved surface. The 15 pairs of terminals project into the back of the block and have slots into which the cable wires are soldered. The cable is connected to the block in the following manner. The thimble is removed from the block and soldered to the sheath approximately a foot from the end of the cable. The sheath is removed to about one inch above the thimble and the wires are numbered. The front cover together with the back cover and its gasket are removed, and the wires inserted through the thimble hole into the back of the block. The block is screwed on to the thimble and the locknut tightened. The cable pairs are then formed out as shown in Fig. 31, the A-wires are connected to the inner terminals, the B-wires to the outer terminals and the connexions are soldered.

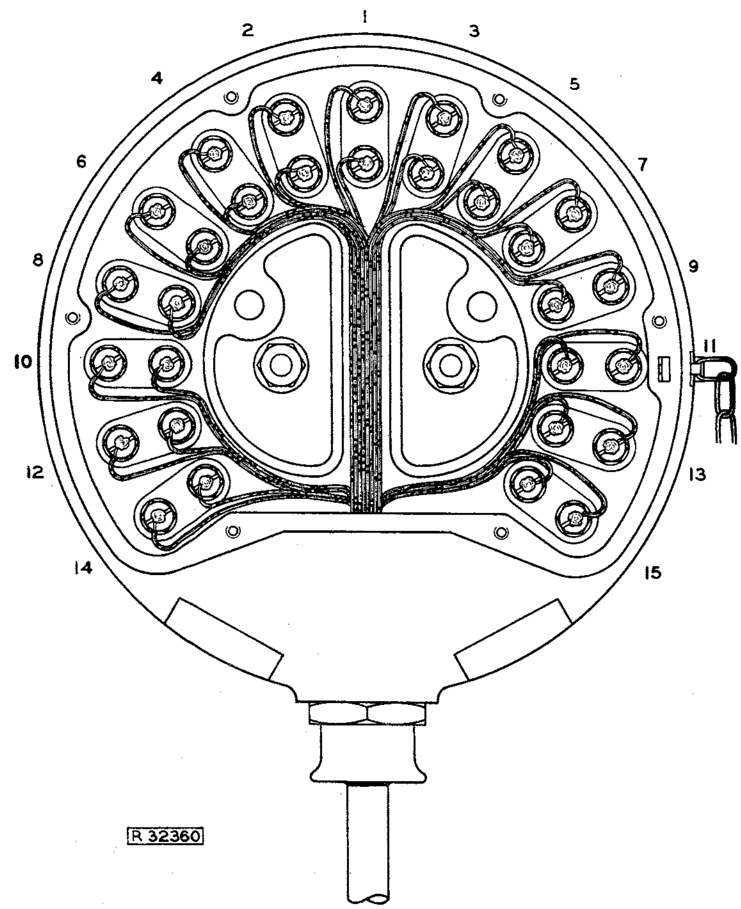


Fig. 31

The block is supported so that the back cavity surface is level, the fixing screws are placed in their inserts and the cavity is filled with hot paraffin wax. During the filling the cable is warmed to ensure a complete seal at the cable end. Additional wax is added whilst the block is cooling, to counteract the shrinkage which occurs. When all wax is solidified, the fixing screws are removed, the surface is scraped level and the rubber gasket and back cover are replaced.

Where the terminal block is fed by a polythene cable the thimble is secured to the polythene sheath by means of a packing of rubber adhesive tape. The paraffin wax is allowed to cool and tested with a scrap piece of polythene insulated wire before being poured into the cavity. The earth connexion is made by means of a length of tinned copper wire which is soldered to the pole earth-wire and terminated under the hexagonal nut of the terminal block.

The block is fixed in position by means of wood screws through the fixing holes shown in Fig. 30 and the cable sheath is bonded to the pole earth wire.

The one pair leads from the overhead wires are led into the block and taken through the stirrup. The lead covering is stripped about half an inch short of the inner terminals. Sufficient slack is left to allow for changing the position of the leads inside the block. The wires are terminated on the screw terminals and the cover is replaced.

Terminal blocks are not required for terminating leads:-

(a) in leading into a building where only a few circuits are ever likely to be required, or

(b) in connecting overhead wires to a pole test-box.

In such cases the leads are taken direct to the protective apparatus, or to the test-box connexion tags, as the case may be.

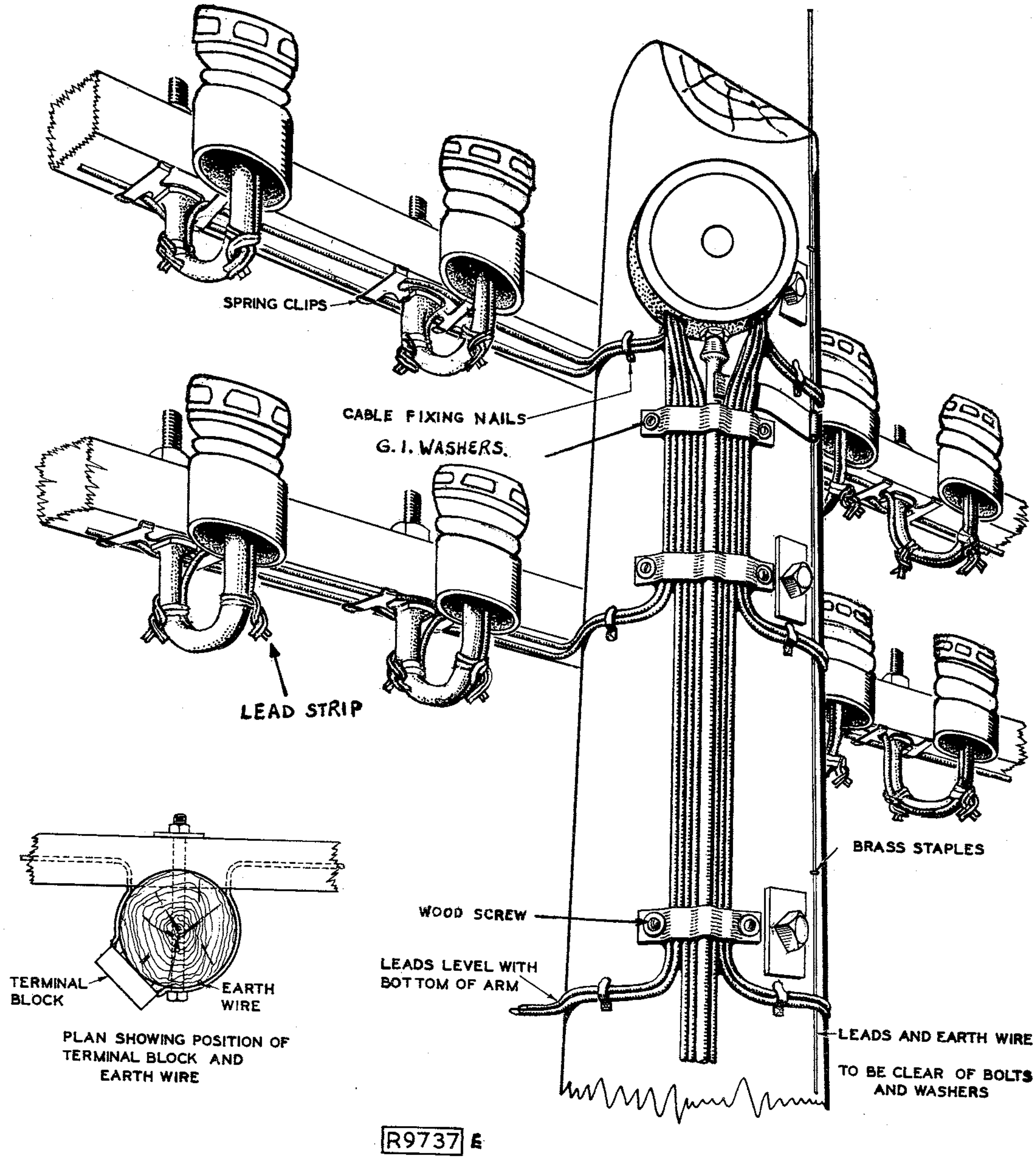
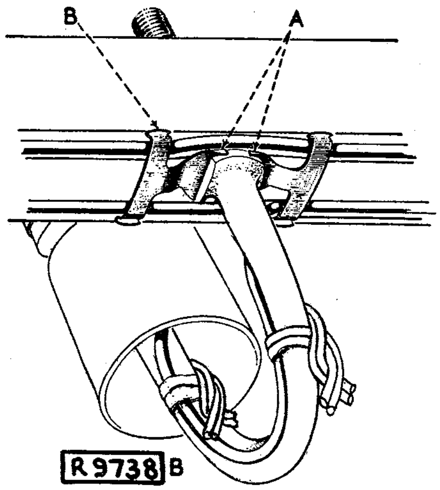


Fig. 32 - Terminal and distribution poles: general arrangement of cable, terminal block, and pole-leads

RUNNING AND FIXING POLE-LEADS

From the terminal block the pole-leads are run symmetrically alongside the main cable, thence round the pole at arm level, and along the underside of the arms, as shown in Fig. 32.

On the pole, the leads are fixed by means of cable fixing nails or lead strip and nails.



On the arms, the leads are fixed by means of sherardized spring steel clips. The general pattern and the method attachment to the arms are shown in Fig. 33. The down-turned nibs, marked A, ensure that, even if the spindle works loose on the arm, there will be little chance of the clip slipping out of position. The clip is sufficiently flexible to allow the pole-lead to be slipped into place from the side of the arm by depressing the tips of the fingers B.

The method of securing the pole-leads on spindles by use of scrap plastic cable is also illustrated in Fig. 33.

Fig. 33 - Method of attaching pole-lead clip to arms

LEADING UNDERGROUND CABLES TO POLES

The cabling arrangements at the foot of the pole will depend upon the type of cable and duct serving the D.P. One of the following methods should be used.

(i) Where buried polythene cable is employed, it is brought as close to the foot of the pole as possible - at normal depth - before bringing the cable to the surface. A bending radius of not less than 6 in. should be used.

(ii) For cable diameters of not more than 0.65 in. diameter, the cable may be fed to the pole by means of polythene duct. To avoid cabling difficulties, the distance between the joint and the D.P. should not exceed 25 yds. The cable fixed to the lower part of the pole is protected by a length of steel capping. The junction of the duct and capping is covered with a steel bend connector.

(iii) For cables of up to 0.75 in. diameter, asbestos-cement or cast-iron bends are used to feed the cable to the pole. Asbestos-cement bends are used with asbestos-cement duct and cast-iron bends with earthenware self-aligning duct. In both cases steel capping and bend connectors are used.

(iv) Cast-iron bends of suitable size are used for all cables greater than 0.75 in. diameter. The steel capping used in conjunction with these cables is too large to be accommodated in a bend connector, the connector is therefore not fitted and the capping is positioned as close as possible to the top of the bend.

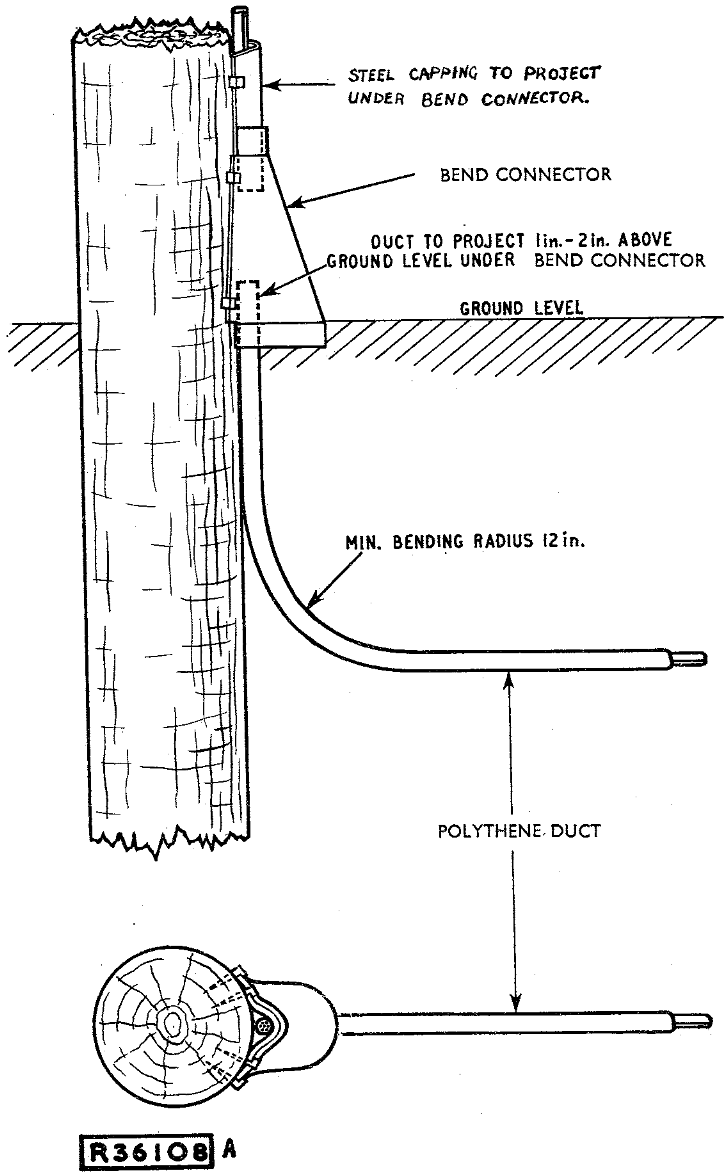


Fig. 34

Figs. 34 and 35 illustrate the general arrangement at the foot of a pole for cables in polythene and self-aligning duct respectively.

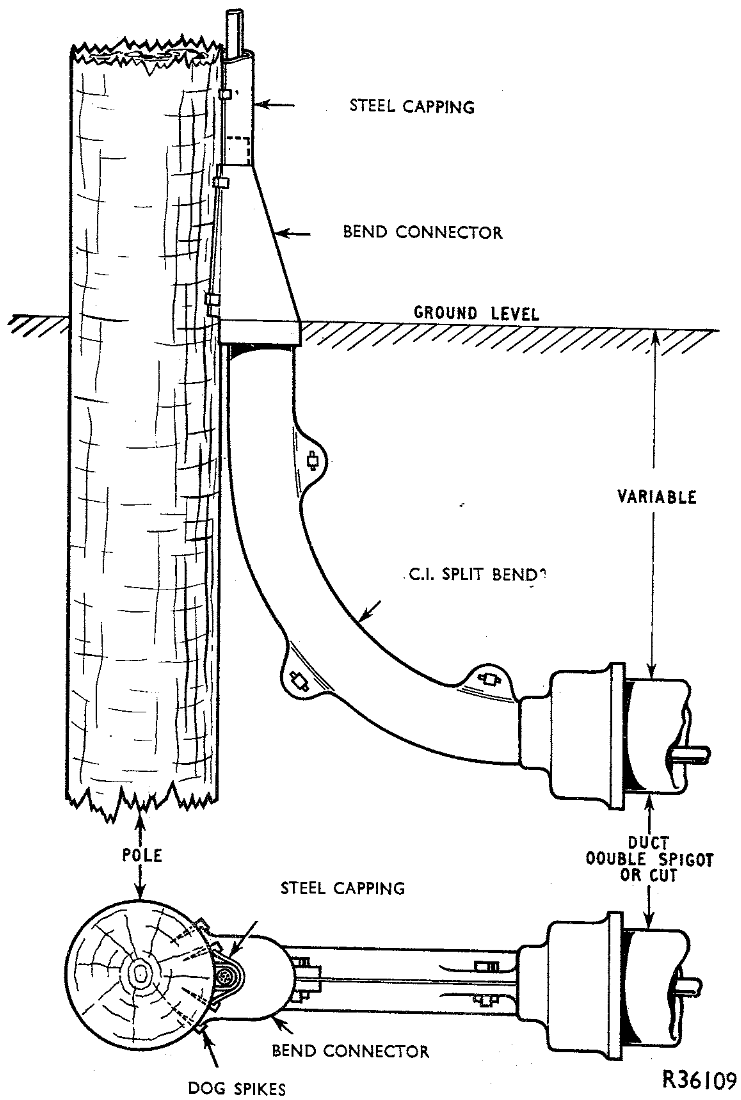


Fig. 35

OVERHEAD DISTRIBUTION TO SUBSCRIBERS

The following are the methods by which overhead distribution has been effected, with comments on their use and efficiency:-

(1) The erection of "through" open-wire lines from a distribution pole (D.P.) along a road, with services - open or drop-wire - to subscribers at intervals along the line.

This method is well adapted to the needs of an area with small development, but should not be used in suburban areas where reasonably good development is anticipated.

(2) Armed distribution poles with no "through" wires, serving subscribers radially from arm positions or fittings attached to the ends of the arms.

This frequently leads to unsightly D.P.'s, as well as to considerable technical inconvenience in arranging for the required spans to subscribers' premises. Arms were designed for through lines, and are ill-adapted for radial distribution.

(3) Cross-armed D.P.'s, with or without through wires.

This method is unsightly in suburban streets, requires taller poles, and provides for a much greater capacity than is either necessary or desirable under modern conditions.

(4) Open-wire distribution from pole-head D.P.'s.

(5) Drop-wire distribution from pole-head D.P.'s.

This was the method first used when pole-head D.P.'s were introduced. Whilst providing in many cases a sound and economic method of distribution, it frequently led to complaints due to the greater visibility of the covered wire in comparison with open wires. The use of a smaller drop-wire, however, has made this method more acceptable.

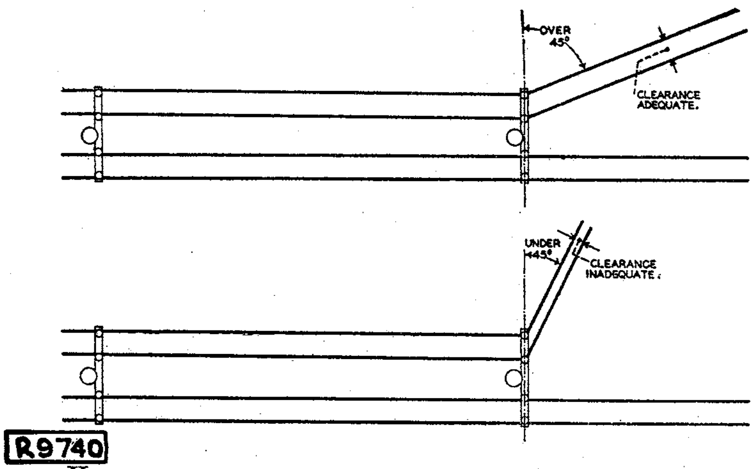
In order to meet present-day requirements and to render overhead distribution less liable to objection, the following general principles are observed in designing local distribution plant in residential areas:-

(a) Where scanty development is anticipated, method (1) above is employed.

(b) When the ultimate development is at least 7 circuits per 100 yards of road, distribution is effected by ring-type distribution poles (also called pole-head D.P.'s) erected at suitable intervals along the streets. A spacing of 80 to 120 yards will meet the average case. Each pole being served by cable, wires are not required between poles.

"THROUGH" DISTRIBUTION

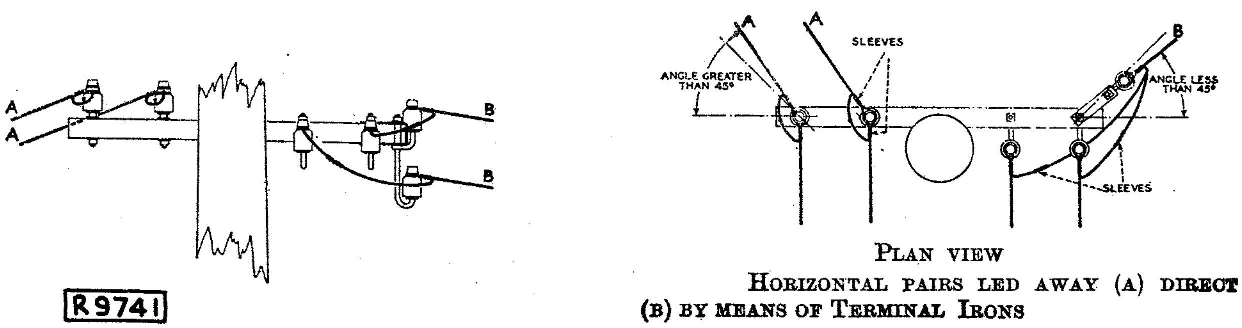
With this type of distribution the subscribers are served by wires led from an adjacent pole on a route which is fed from a common distribution pole. Figs. 36 and 37 illustrate methods of running the subscribers' lines from the junction pole.



—HORIZONTAL CLEARANCE, BETWEEN WIRES OF A SUBSCRIBER'S SPUR

Fig. 36

As the subscriber's spur leaves the junction pole at an angle to the through route, the clearance between wires secured to horizontally mounted fittings will be reduced. The spacing, normally between 8 and 9 inches, will be no more than $4\frac{1}{2}$ inches, if the angle between the spur and the line of arms is 30°. Therefore, where the spur leaves the junction pole on straight spindles at an angle of less than 45° with the line of the arm, the wires are run in vertical formation. This reduces the possibility of contact faults.



PLAN VIEW
HORIZONTAL PAIRS LED AWAY (A) DIRECT
(B) BY MEANS OF TERMINAL IRONS

Fig. 37

OPEN WIRE RING-TYPE DISTRIBUTION

The method of open-wire distribution for a ring-type distribution pole is illustrated in Fig. 38.

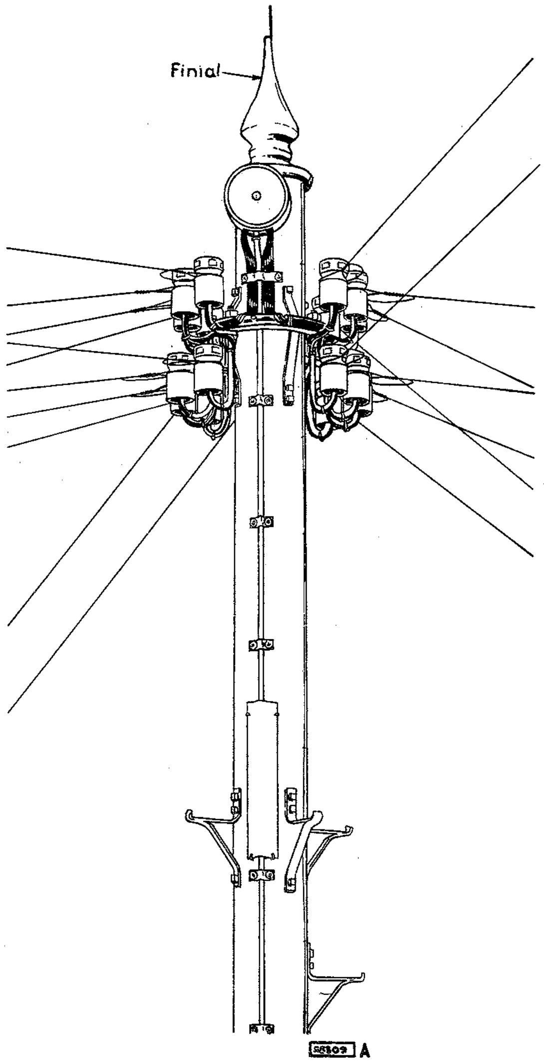


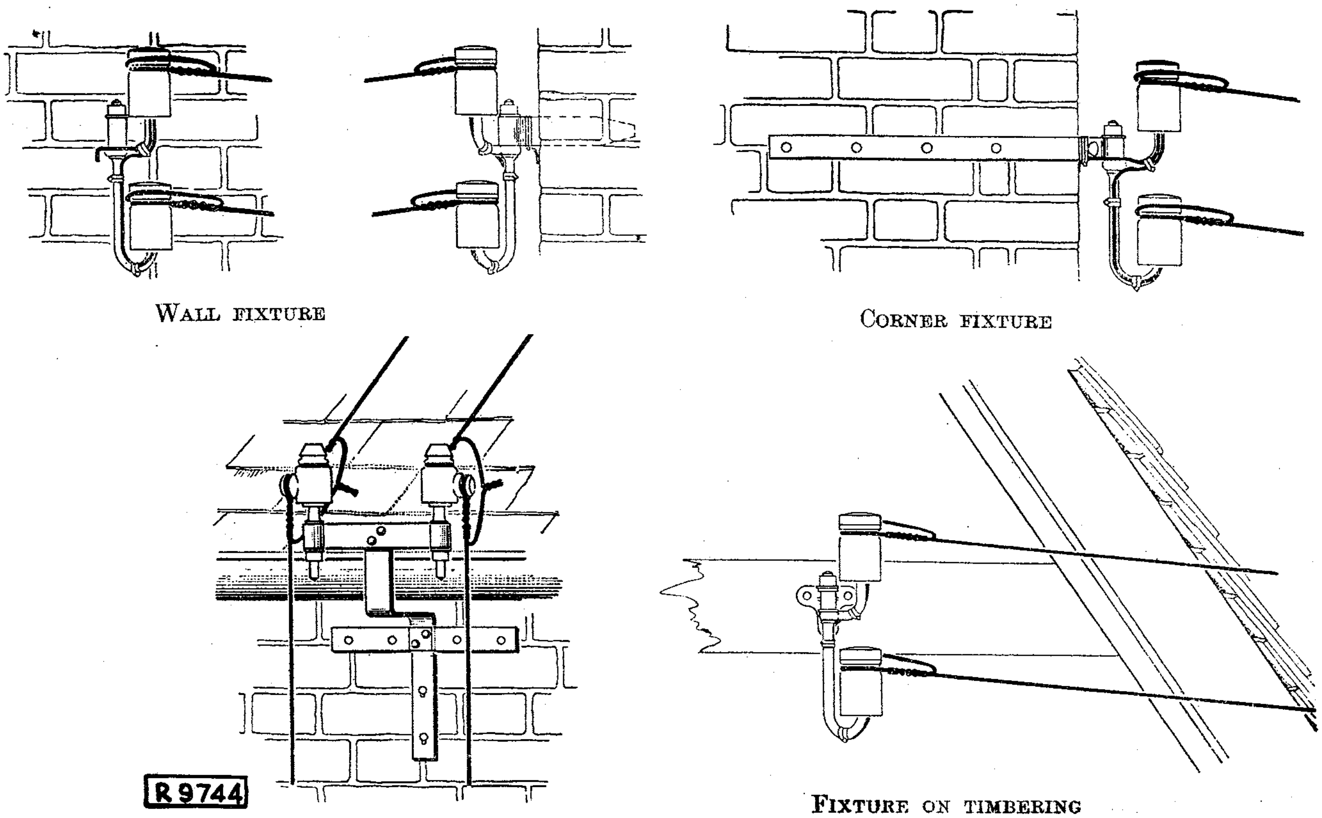
Fig. 38

The distribution pole is served by an underground cable terminated on a terminal block fitted to the pole. The individual circuits are connected to the open wire spans by means of pole leads.

The pole head consists of a channelled ring of steel or aluminium alloy fixed to the pole by means of brackets. A slot is provided in the upper flange of the steel ring, to enable the pole leads to pass into the channel without being chafed; on the alloy pole head, the pole leads are fed to the ring by means of channels in two of the brackets. Holes are provided in the ring to take a maximum of 15 Double-J spindles. The alloy ring is slightly larger than the steel ring and a quarter segment of the ring is without spindle holes; this provides a gap which gives easy access to the leads and terminal block.

If more than 15 circuits are required to be served from one pole two rings may be fitted, to provide a maximum of 20 circuits.

The span is terminated on the building so that there is sufficient clearance from obstructions and the lead-in cable is as short as possible. Attachments to chimneys are made only when it is found impracticable to obtain clearance in any other way. Some house fixtures are illustrated in Fig. 39. The eaves bracket illustrated is used where a change of direction is required from a chimney attachment.



WALL FIXTURE

CORNER FIXTURE

EAVES BRACKET

FIXTURE ON TIMBERING

Fig. 39

<u>Common defects in open-wire construction</u>

Most defects in open-wire construction arise either through the provision of incorrect components or materials for the job or through the omission of some factor for consideration in the original planning. Some common defects and their cause are as follows:

(a) Liability to contact between wires is increased by the use of double J spindles (horizontal formation) where double J (vertical formation) spindles should be used.

(b) The running of wires in horizontal formation at angles less than 45° with the arm results in small separation of wires and greatly increases the risk of contact.

(c) Untidiness of leads on a pole due to omission of cleats or clips often results in mechanical damage when tracing wires. The uncleating of leads in order that the ends may be extended to reach a new position in the terminal block is a practice to be strongly deprecated.

(d) The omission of sealing compound in the cavity of a pot-head insulator can cause damage to the termination through the ingress of moisture.

(e) A bad choice of fixture is often a cause of trouble. For example, a spike fixture (as in the second illustration of Fig. 39) should not be used if the angle between the wires and the wall face would exceed 60°. It is usually possible as an alternative to provide a corner fixture (as in the third illustration of Fig. 39).

COVERED DROP-WIRE DISTRIBUTION

The use of covered drop-wire for subscribers' distribution has the following advantages over open-wire distribution.

(1) The number of stores items used is considerably reduced.

(2) There are no joints between the pole terminal block and the terminating point at the subscribers' premises.

(3) Careful regulation to avoid contacts is unnecessary.

(4) Labour costs are lower.

(5) Improved maintenance conditions due to the elimination of regulation and the reduced liability of contact faults.

(6) The fittings at subscribers' premises are smaller, less unsightly and less liable to cause damage to brickwork etc. when fixed.

(7) There is a saving in the raw materials used particularly copper and steel.

The use of the copper coated steel P.V.C. insulated drop-wire, which has a small cross sectional area, has eliminated most of the complaints of unsightliness previously levelled at the wire in this form of distribution.

Covered drop-wire distribution

Covered wire distribution using P.V.C. covered drop-wire with a wedge-type clamp, and a plastic coated helical wire clamp is illustrated in Fig. 40.

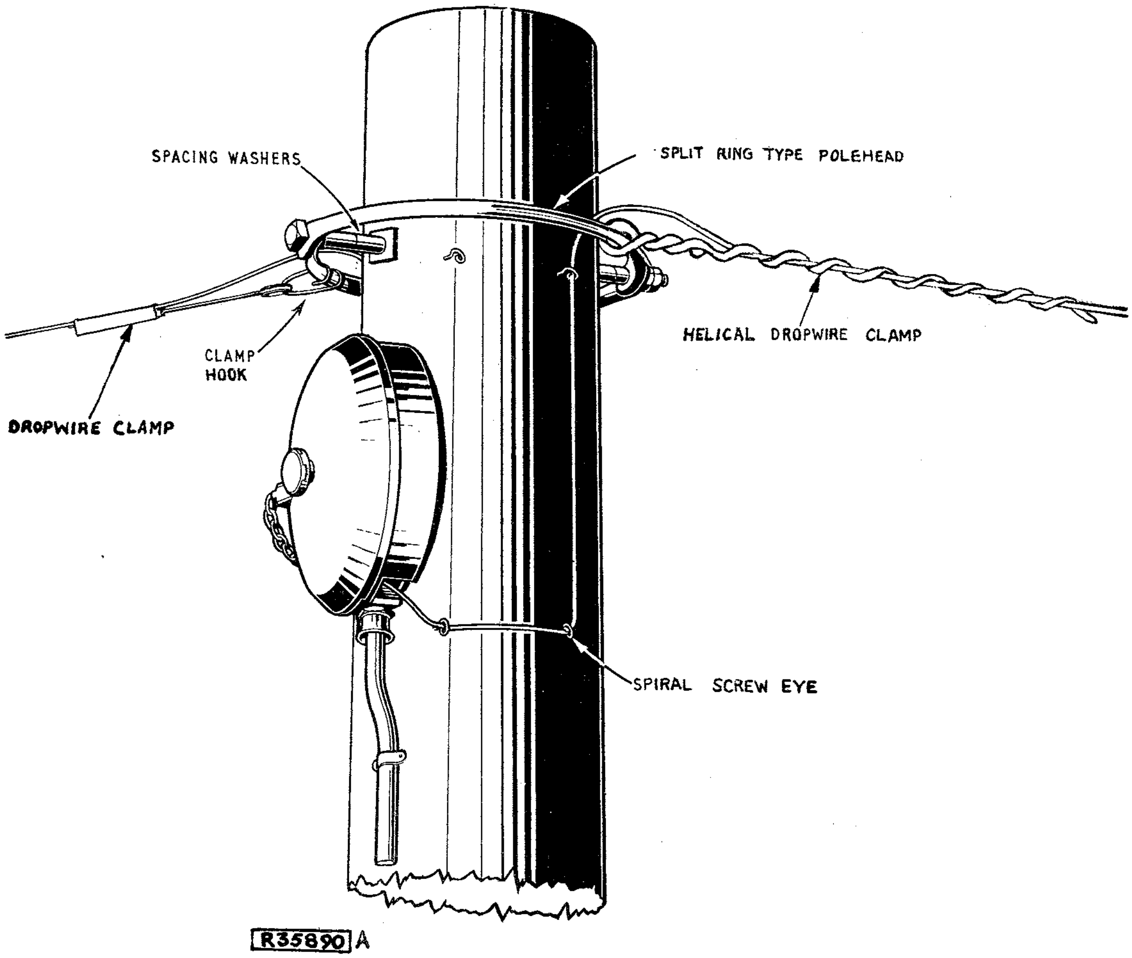


Fig. 40

The pole head consists of two half-rings of half-inch round galvanized mild steel, secured to the pole by an arm-bolt which carries spacing washers of suitable length to correctly position the pole head. The drop-wire is connected to the terminal block, which is fitted below the pole head, and positioned on the pole with spiral screw eyes. The span is supported, either by a wedge-type clamp held to the pole head by a steel clamp hook, or by an 18 in. long plastic coated helical steel wire with the end twisted back on itself.

The wedge-type clamp used with the larger P.V.C. drop-wire is shown in Fig. 41(a). The clamp consists of two main parts and a flat brass shim or pressure plate. A brass ring is attached to one end of the inner member by 70 lb. copper wire which is crimped to the clamp. To fix the wire in the clamp, the outer member is held horizontally with the slot uppermost and the wire is placed along the flat bottom surface. The brass shim is dropped into place over the wire. The shim is held in position by the extensions at each end whilst the inner member is drawn into position so that the drop-wire is firmly wedged between the shim and the outer member.

When V.I.R. covered drop-wire is used for subscribers' distribution, the wedge-type clamps illustrated in Fig. 41(b) is used. No shim is provided with the clamp but the bottom of the wedge slide is serrated to ensure a good grip on the cable.

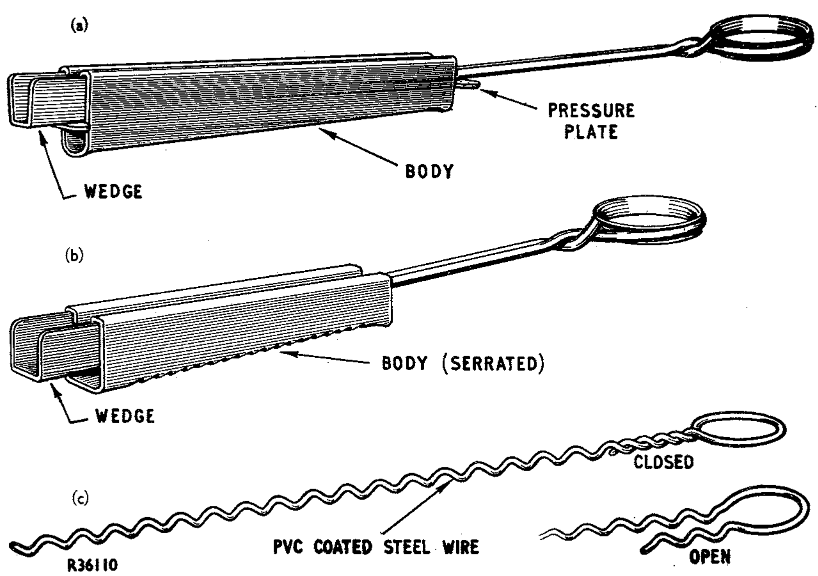


Fig. 41

The insulation of the later type of drop-wire is too thin to use a wedge-type of clamp; so an 18 in. stainless steel wire helex, coated with P.V.C. is used to grip the cable. There is a plain loop at one end of the wire with a short helical tail, which is twisted back on to the main helex, to form a closed eye for fixing to either a pole ring head, or a house bracket see Fig. 41(c). The eye of the clamp is first closed, and the cable is then fixed by winding it round the helex of the clamp.

The drop-wire is secured at the subscriber's premises by means of a second clamp as illustrated in Fig. 42. This is attached to the building by means of a bracket consisting of a small flat plate to which is welded a spiral eye. The drop-wire is run, without a break, to the terminating point in the subscriber's premises and is secured to the building by means of cable fixing nails on masonry and insulated staples on woodwork.

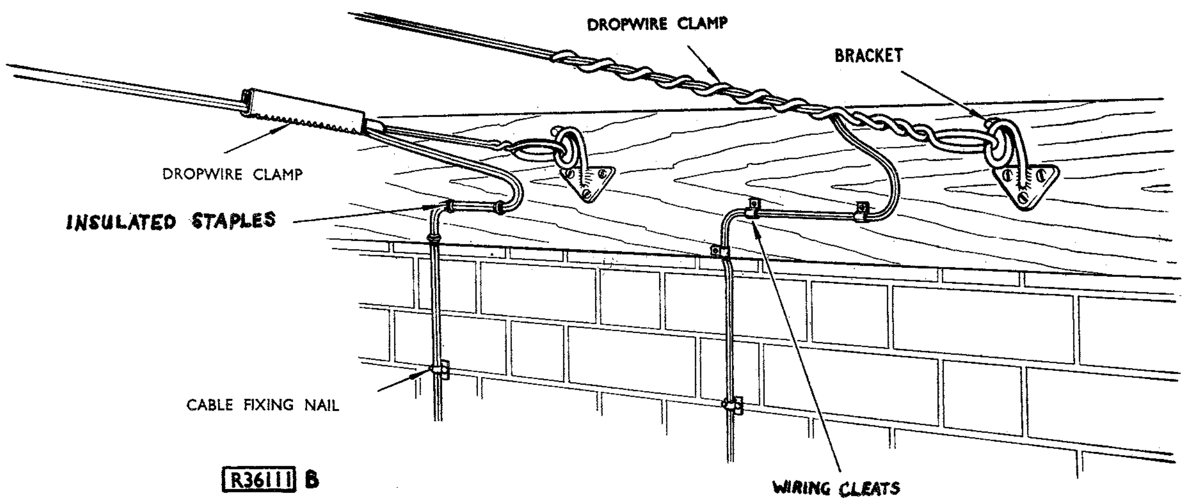


Fig. 42

Drop-wire distribution can also be provided, from existing ring type pole heads (designed for spindles). Then the clamp is attached to the pole head ring, using a small light shackle see Fig. 43.

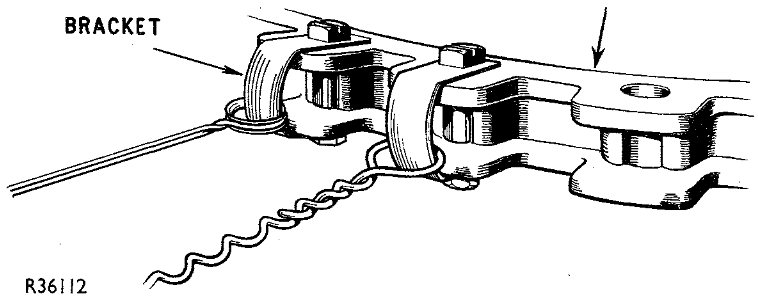


Fig. 43

When drop-wire distribution from an armed pole is required, the clamp may be fitted directly to a spindle.

When low or medium-voltage power crossings have to be made, the wedge-type clamps may be used in conjunction with P.C.P. covered wire.

Drop-wire may be run along the line of a route, provided that the span length does not exceed, 75 yards for the steel wire P.V.C. insulated type, or 60 yards for the V.I.R. insulated type, and provided the line is not in an exposed situation. At straight through positions, and at angle poles, where the pull-on-pole does not exceed 15 ft., the cable is supported by a plastic covered helical steel wire support (see Fig. 44) attached to the pole by a bracket (as shown in Fig. 42).

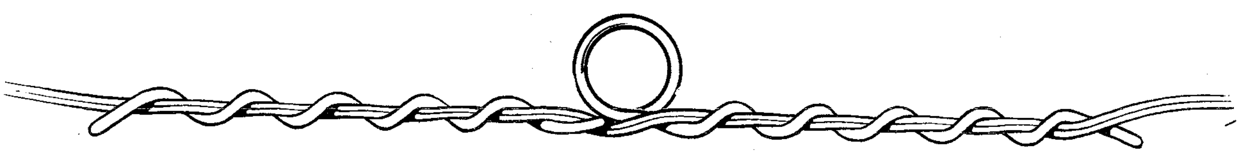


Fig. 44 - Drop-wire support

If, however, more than one pair is required along the route, an aerial cable of the appropriate size is erected.

For new housing estate developments, distribution by drop-wire from distribution poles is now standard practice; unless the estate developer makes a contribution towards providing individual underground feeds to each house.

With the latest type of drop-wire the "hairpin" type clamp (Fig. 41) has legs of equal length, whilst the conductor is copper-coated steel .045 in. diameter insulated with black P.V.C. 75 yard spans are possible at a tension of 50 lbs.

SILENCING OF WIRES

Annoyance is sometimes caused to subscribers by the humming of wires attached to a house, under certain conditions. If a complaint is received, one of the following two methods for preventing this nuisance is adopted. The methods are tried in rotation, i.e. if the first method fails, the second method is tried.

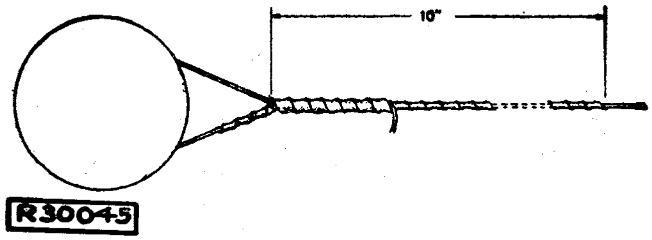


Fig. 45

Method 1. A strip of lead $\frac{1}{4}$ in. wide is spiralled round the wires at both ends of the spur for a length of about 10 in., as shown in Fig. 45. About 30 in. of lead strip is required at each termination.

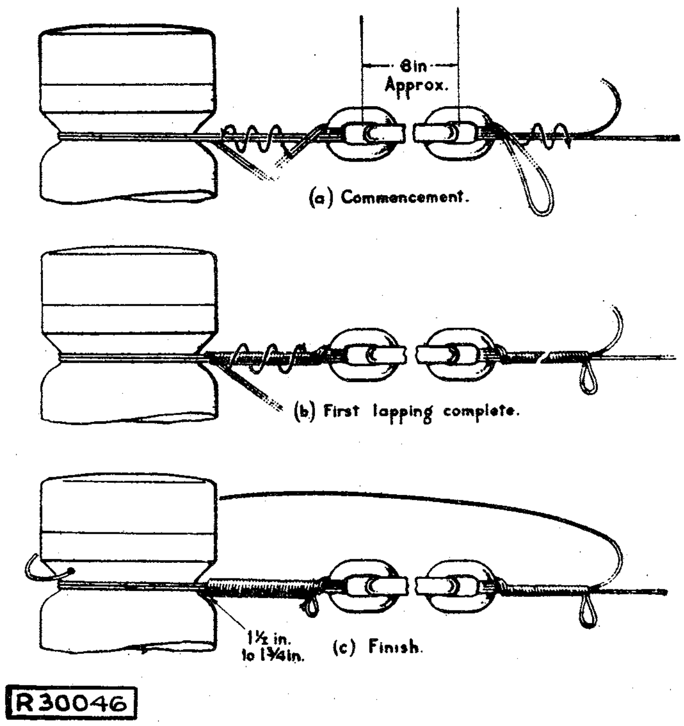


Fig. 46

Method 2. A short length of chain, between 6 in. and 12 in. long, is inserted in each wire, close to the house fixture. To avoid sharp bends in the wire the links are of material not less than $\frac{1}{4}$ in. in diameter. The chain is bound to the neck of the insulator by means of a double length of 40 lb. cadmium-copper wire, made off as shown in Fig. 46, the length of wire required being approximately 5 ft. The line wire is made off through the link at the other end of the chain, and the tail extended direct into the insulator cavity.

GAME GUARDS

The provision of game guards, to minimize the risk of birds flying into open wires, has to be considered from two aspects as follows:-

(a) The protection of game or other birds from injury by collision with open line wires by rendering the wires sufficiently conspicuous for the birds to avoid them in flight.

(b) The minimizing of fault liability in localities where there is a likelihood of game or other large birds flying into open line-wires, causing a contact between wires.

Generally, devices intended for the protection of birds from injury are only provided at the express request of the owner of the property or birds. They may, however, be provided where the erection of wires in a new locality (e.g. in the vicinity of a homing pigeon loft) is expected to give rise to a request for such provision, as the labour cost is less if guarding is provided when the wire is being erected than if provided subsequently. In localities where faults are likely to be caused by birds flying into the wires, appropriate action is taken, even if no request has been made for protection for birds.

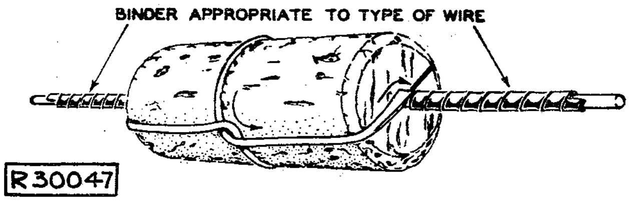
The use of guarding devices is generally confined to the protection of pheasants, partridges, grouse and homing pigeons. Guarding is of little or no use as protection for other large birds such as swans, wild-duck or geese. Furthermore, guarding is only provided in open situations where the birds are likely to fly, as guarding devices are only effective in silhouette, e.g. where wires cross open country or show against the sky line. A dark background, e.g. trees, greatly reduces their protective value.

Guarding wires under trees as a protection for pheasants (partridge and grouse keep to the open) is regarded as impracticable and unnecessary. Pheasants seldom fly up into trees, except as dusk to roost; they fly down again at early dawn, and at these times the light is barely sufficient to render any protective device visible against the dark background. Also, during these flights the speed of the birds is usually insufficient to cause injury by impact with a wire.

When guarding is required in the vicinity of pigeon lofts or game preserves, it is not provided from end to end of each span or section of line in the open indiscriminately. It may not be necessary to provide guards throughout the span or section of line and the points where guarding is required can usually be ascertained from the game-keeper or bird owner who generally knows the habits and likely lines of flight of the birds.

Game guards, which are cylindrical corks 3 in. long by $1\frac{1}{4}$ in. diameter, are fitted on 150 lb cadmium-copper wire.

In the case of other types of wire, however, consideration should be given to the use of covered wire, as the use of game guards would be likely to result in greatly increased fault liability. Covered wire is also used if game guards are asked for at such close spacing on the wires that replacement or substitution by covered drop wire is the cheaper alternative.

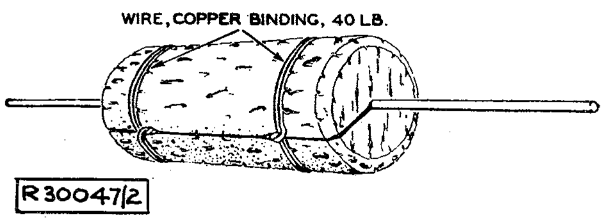


Method of fixing game guards at
accessible positions
Fig. 47

All guards are sawn half-way through longitudinally, to provide a slot into which the wire is passed to the central position.

Where the final position of the guard on the wire is accessible, i.e. on new lines before erection and on existing wires when a ladder derrick is available, the guards are secured to the wire as shown in Fig. 47.

Tight binding is essential, to reduce the risk of locking should the wires be forced into the contact. The direction of crossing of the binder in the middle of the guard relative to the direction of the wrapping round the wire can be seen in Fig. 47. This ensures that the guard will not slip along the wire.



Method of binding game guard where
final position on line wire is inaccessible
Fig. 48

Where the final position is inaccessible, the guards are fixed to the wire from the most convenient position near the end of the span, care being taken to see that there is not a joint in the line wire between the point of attachment and the final position of the guard. The guards are fixed in the manner shown in Fig. 48, two binders being required for each guard.

After binding, a length of sash line rather more than twice the length of the span is used to form an endless line, with a loose knot round the line wire behind the game guard, and the guard is thus drawn to its correct position in the span. Tight binding to keep the guard in place is therefore very important.

Game guards are distributed as evenly as is practicable over the whole bed of wires, and the following rules are observed:-

(a) Wherever possible, not more than one guard per span is fitted to any one wire.

(b) In spans where the number of guards required to obtain the desired guarding effect renders it necessary to fix more than one guard per wire, an approximately equal number is fitted to each wire, thus preserving the tendency of the wires to swing in unison when deflected by wind pressure.

(c) To minimize the risk of contact, the use of game guards on the outer wires (the wires most likely to be hit by the birds) is confined to positions near the ends of the span.

A scheme based on these principles and suitable for general use with 4-way, 6-way and 8-way arms is illustrated in Fig. 49.

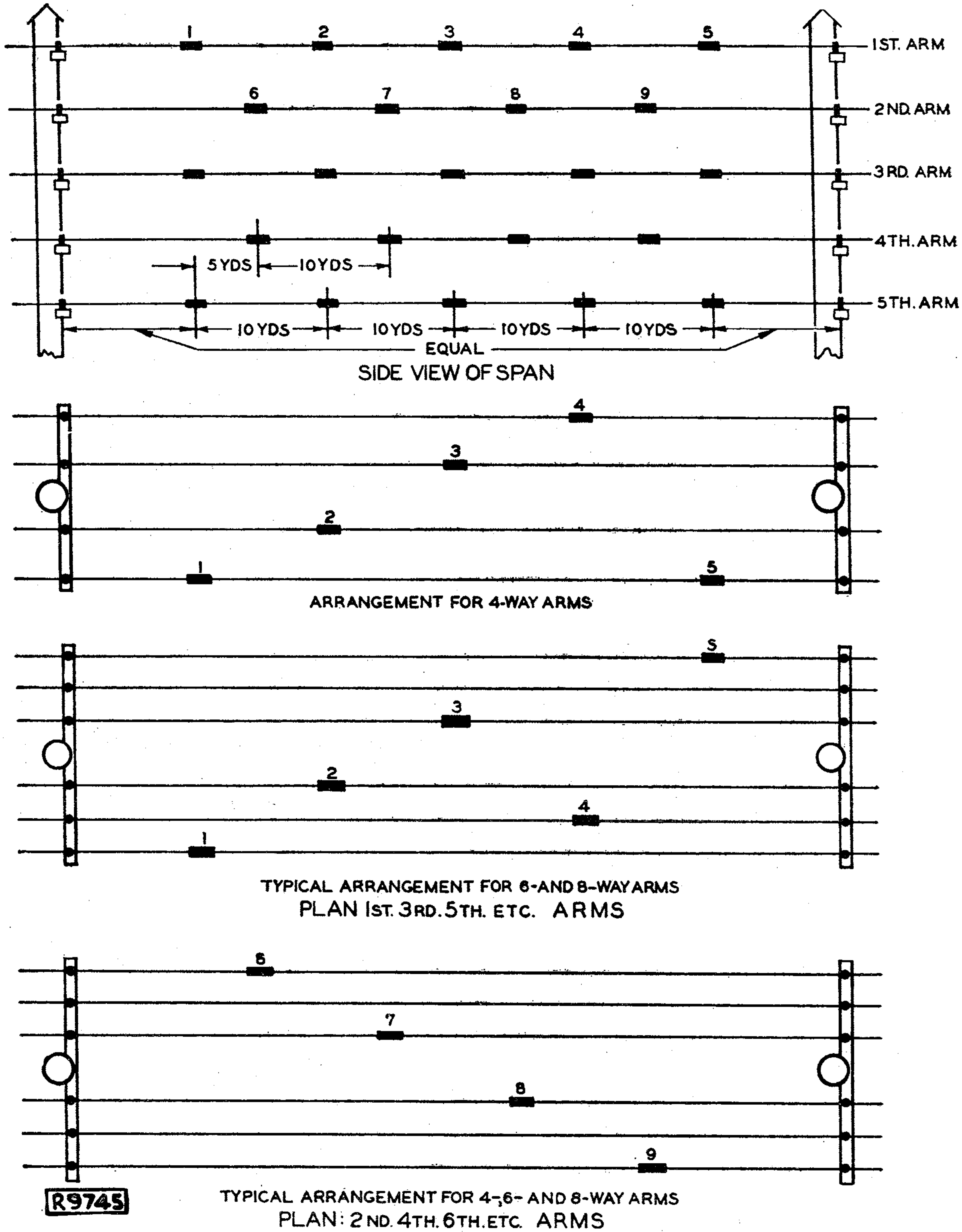
Where single pairs are concerned, half the total number of guards required is fixed to each wire. The guards are placed at equal intervals, those on one wire being fixed midway between those on the other. Closer spacing between the guards than is required for a bed of wires is generally deemed necessary on a single wire or a pair of wires, particularly for the protection of homing pigeons. In some circumstances it may be necessary to use covered wire as mentioned earlier.

When wires fitted with game guards are forced together by gusty winds or by birds, they are likely to become locked together by the guards and to remain so until separated. In the worst cases it may be necessary to cut and lower one or more of the wires to clear the fault. For this reason, whenever game guards are fitted special care is taken to prevent an increase in fault liability. Thus the tensions are maintained strictly in accordance with the values laid down for the particular wire in use. Increased spacing between wires may be adopted as an additional means of minimizing the number of faults. This may be done by one of three methods viz:-

(a) The use of arms providing 12 in. spacing on lines ordinarily carrying wires at 9 in. spacing, i.e. changing the arms.

(b) Fixing the wires in alternate positions and using 8-way arms to provide 4-way formation.

(c) Fitting longer arms than would otherwise be used and boring additional holes in non-standard positions for some of the spindles.



Arrangement of game guards in open suitable for general use
Fig. 49

MAINTENANCE AND REPAIR OF OVERHEAD LINES

To maintain efficient working of telephone systems it is essential to discover faults promptly, to remove them as quickly as possible and to give immediate attention to any minor defects in equipment that may be brought to notice through inspection. The latter is very important with regard to overhead line equipment since, if minor defects are allowed to accumulate, a breakdown of service almost inevitably results. Restoration of service is seriously delayed due to the difficulty of tracing the various contributory causes of the breakdown and of effecting the several repairs. To aid the prompt discovery of faults and minor defects, periodical testing is essential.

Many faults develop slowly and these can usually be detected from test results at an early stage before thay can seriously affect the service. The most common fault of this nature is low insulation resistance of the lines. In localizing these faults it is important first to prove the fault clear of the underground cable portion of the circuit. Convenient points for disconnexion in the line are at the terminal blocks and at pole test boxes. Probable causes of low insulation on overhead lines are:-

(a) Pole leads in bad condition (e.g. punctured lead sheaths, faulty termination, omission of sealing compound).

(b) Loose fitting covers on terminal blocks and pole test boxes.

(c) Bad condition of subscriber's lead-in.

(d) Leaky insulators (e.g. cracked or with deposit).

(e) Contact with foliage.

Where such faults cannot be cleared satisfactorily by cleaning or adjustment of the affected part of the line equipment, renewal is necessary.

REPAIR OF A WIRE BREAKAGE

It is desirable that the number of joints in a line wire should be kept to a minimum because they are a potential source of trouble. In view of this, when new joints are made in open wires existing joints should be cut out and the new joints made from the pole as close to the insulator as is possible. When an existing joint is out of reach from the pole the span should be renewed. Not more than one joint is permitted in each wire of a span between a pole and a fixture on a building and it must be made at the pole end of the span.

The method of repair to a broken span varies according to the way in which the wire is supported and the position of the breakage, as follows:-

(1) Break in spans terminated at both ends (e.g. at road crossings). New wire is erected and terminated at both ends.

(2) Break within reach from a pole where the wire is bound-in. A short length of new wire is pieced-in so as to extend about a foot beyond the insulator. This ensures that the binding-in is done on the new piece of wire and that both joints are accessible from the pole.

(3) Break within reach from a pole where the span is terminated (other end bound-in). A short length of new wire is pieced-in and the termination remade on the new wire.

(4) Break out of reach from a pole. The span is renewed. Where the span is bound-in at both ends the new span is made to extend one foot beyond the insulators at each end, so that the binding-in is done on the new wire.

(5) Breaks occurring near a house fixture. The span is renewed.

Six important points to be remembered

(i) No joint must be out of reach from a pole.

(ii) There must be no joints in spans which for safety precautions are terminated at both ends.

(iii) Not more than one joint is allowed in a spur wire from a pole to a building and the joint is to be at the pole end of the span.

(iv) In cases other than (ii) and (iii) two joints are permitted in each wire, one at each end of the span.

(v) When new wire is used for repairs, terminating and binding-in must be effected on the new wire.

(iv) Defective wire must not be used for repairs. (e.g. old wire, or wire damaged by kinking).

EXTENSION ARMS (for prevention of faults during renewal work)

Care should be taken not to cause faults on working lines when poles are being renewed. On important lines extension arms should be used to splay out the wires so as to leave adequate space between them for the erection of the new pole.

Extension arms consists of oak arms, in which are two insulated slots to receive the line wires. The axis of these slots is not at right-angles to the length of the arm, in order that the wires may be more easily retained in position during the progress of the work. They are also provided with two clamping hooks by means of which they may be fixed either to an arm or to the stiles of a ladder.

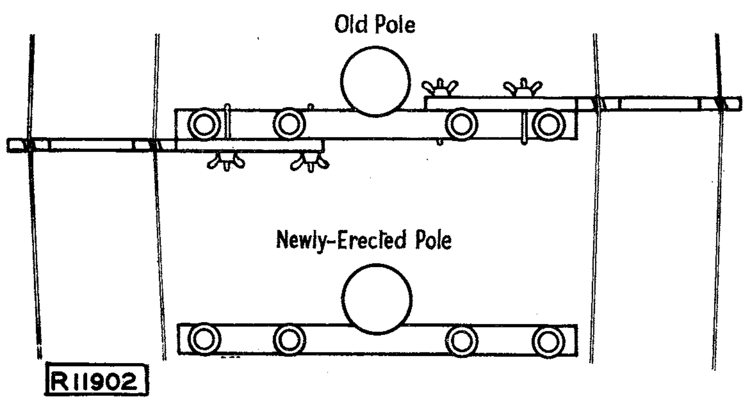


Fig. 50 Use of extension arms without ladders

When it is unnecessary to remove the existing pole before the erection of the new pole, the extension arms should be clamped to the arms of the existing pole as shown in Fig. 50. The wires should be unbound and placed in the insulated slots of the extension arms. It may be necessary to extend the wires in order to do this, e.g. at angle poles. The new pole should then be erected, the extension arms transferred to the arms of the new pole, and the old pole recovered.

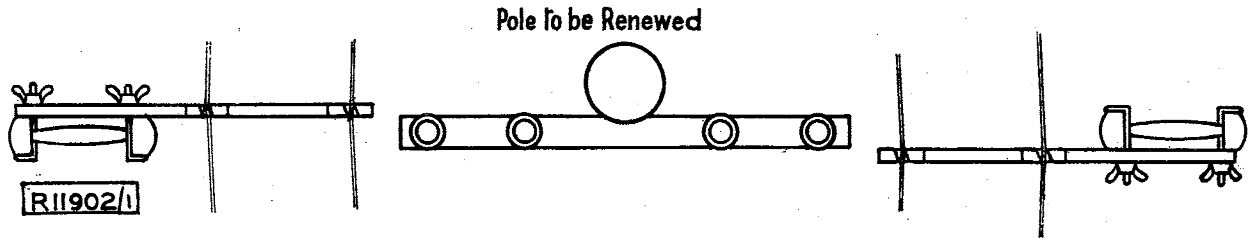


Fig. 51 Use of extension arms with ladders

If the existing pole is to be removed before the erection of the new pole, the extension arms may be fitted, as shown in Fig. 51, to ladders suitably supported outside the wires. The wires should then be transferred to the slots of the extension arms, and sufficient space between the wires thus provided to allow the renewal of the pole to be carried out.

Renewals on unimportant lines may occasionally be simplified by arming the new pole after erection, so avoiding the use of extension arms. A general practice should not, however, be made of the erection of unarmed poles.

STORM REPAIR PROCEDURE

Following a report of damage to overhead line plant due to a storm, the repair work should be organized in the following manner.

(a) Road clearance. Fallen plant which has become a source of danger to road users or property should be removed.

(b) Preliminary survey of lines. The survey is carried out to ascertain the extent of the damage so that the necessary gangs may be detailed for the permanent repair work.

(c) Diversion of important circuits. Whenever possible, arrangements should be made to provide alternative outlets for isolated exchanges.

(d) Speedy restoration of service. Generally, circuits must be dealt with in order of importance or in accordance with an authorized order of priority. In special cases diversion to an underground route may be possible.

(e) Visits to outlying exchanges. In certain cases some assistance may be necessary at outlying exchanges in disconnecting (pegging-out) faulty lines. This operation is important since breakdowns (especially those occurring at night) cause an abnormal drain upon the exchange battery.

(f) Detailed survey of damage. A detailed survey of all storm damage is made in order to prepare an estimate for cost of repair.

(g) Permanent repair. To restore the normal standard working, permanent repair should not be unduly deferred. When temporary repairs are left for long periods fault liability is greatly increased. The repair work is carried out in accordance with a works instruction prepared in conjunction with the storm repair estimate.

TREE CUTTING

Faults on overhead lines attributable to growth of trees and foliage occur mostly during the late spring and summer months. It is then usually impossible to cope with any other than the very urgent tree-cutting requirements. All necessary tree cutting should therefore be carried out during the period from the beginning of November to the end of February. Usually the operation can be performed by two men equipped with the necessary tools.

Tree-cutting tools. For the removal of twigs and small branches pruning rods are most useful. A shearing tool is attached at the end of a number of connected tubular rods, and is operated by pulling upon a cord which extends over the whole length of the pruning rods. The shears are used to remove the softer growth. For the removal of larger branches or harder wood, a saw can be attached to the rods in place of the shears. The saw has coarse teeth and cuts on the downward stroke. Branches which can be safely reached from ladders or from a ladder derrick can be cut with hand-saws. Bill hooks may be used for trimming tree trunks and removing tall shoots from hedgerows.

Method of cutting. Tree cutting should be carried out as far as practicable in compliance with the wishes of the owner. Where no special wishes are expressed, the operation must be carried out in a careful manner so as to avoid damage which would involve compensation. The following points should be observed:

(i) The leading shoots of young trees should be preserved.

(ii) Branches should be removed close to the trunk (i.e. without leaving a stump).

(iii) A portion of a branch (or branchlet) should be removed at the fork, the cut being made in line with the remaining portion.

(iv) When removing a branch a transverse cut should be made first from underneath and then from above. The first cut ensures that there is no tearing of the bark when the branch falls.

(v) Wounds made by the removal of limbs should be trimmed down flush with the surrounding surface of bark and coated with creosote and tar.

(vi) In the general clearance of branches and brushwood, special care should be taken to dispose of cuttings from poisonous trees, such as yew, laburnum and rhododendron, out of the reach of cattle.

Consent must be obtained from the owner of the trees before any tree-lopping or pruning is commenced. In the case of trees planted in public streets the Local Authority should first be consulted.

CLEANING OF LINE INSULATORS

In open country districts cleaning of insulators is seldom necessary. In industrial areas or near railways, soot and tarry deposits seriously lower line insulation.

Removal of dust, insects and cobwebs. This is best performed by use of a brush, the insulators remaining in position.

Removal of industrial grime. It is necessary to remove the insulators from the line, replacing them by new ones. The dirty insulators are then washed, usually at a convenient depot. Throughout the cleaning process they are conveyed in a wire basket or string bag.

The insulators are first dipped into hot rinsing water and then boiled for 5 to 15 minutes in the following solution:-

Quebracho extract	2 ounces
Caustic Soda	1 ounce
Water	1 gallon

Finally they are rinsed under hot running water. Vigorous or prolonged boiling tends to crack the glazed surface. Sudden changes of temperature also should be avoided. Insulators thus reconditioned are sorted and stacked for re-issue.

INSPECTIONS OF LINE PLANT

Overhead line plant inspection is part of the general maintenance procedure whenever work is being carried out on an overhead route. In addition to the day-to-day inspection by linemen and field supervisors of those parts of the route on which work is in progress, all poles and fittings are inspected at 6 yearly intervals.

END