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Post Office Engineering Department

TECHNICAL PAMPHLETS FOR WORKMEN

Subject :

Open Line Construction.

PART II.

ENGINEER-IN-CHIEF'S OFFICE,
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OPEN LINE CONSTRUCTION

PART II.

(H.2.)

The following pamphlets in this series are of kindred interest:

H.1. Open Line Construction (Part I.).
H.3. Open Line Maintenance.
H.8. Power Circuit Guarding.

TABLE OF CONTENTS.

OPEN LINE CONSTRUCTION.

PART II.

1. WIRING.

The following types of line wire are in use:—

(1) **BRONZE.**

(a) **40 lbs. per mile.** This is the standard conductor for subscribers' circuits on routes already carrying bronze wires. It is also used for short junctions and telegraph circuits where transmission requirements admit of it.

(b) **70 lbs. per mile.** On routes already carrying bronze wires this is used for:—

(1) Subscribers' lines in exposed positions.

(2) Portions of trunk lines on overhouse standards where it is necessary to reduce the weight.

(3) Coastguard circuits in sheltered positions.

(4) Junction circuits.

(c) **150 lbs. per mile.** This is used for:—

(1) Coastguard circuits in exposed positions.

(2) Junction circuits in exposed positions.

(d) **300 lbs. per mile.** This is used for trunk circuits in special cases where abnormal interruptions are caused with copper wires by wind and snow accumulations.

The distinguishing characteristic of bronze wire is that the load necessary to put a permanent stretch on the wire (the elastic limit) is a greater proportion of the load required to break the wire than is the case with copper. This fact allows a lower factor of safety to be used, which means that bronze wires can be erected more tightly than copper wires, consequently there is less risk of contact between wires during wind storms. The resistance of bronze wire is slightly more than twice the resistance of the same length of copper wire of the same gauge. Its breaking weight is one and a half times as great as a copper wire of the same gauge and its elastic limit is practically twice the elastic limit of copper wire of the same gauge.

(2) **COPPER.**

100 lbs. per mile. For junction circuits.
150 lbs. per mile. For junction circuits, short trunks and important telegraph circuits.
200 lbs. per mile. Ditto.
300 lbs. per mile. For main trunk lines.
400 lbs. per mile. Ditto.
600 lbs. per mile. Ditto.

The chief characteristic of copper wire is its low resistance.

(3) IRON.

Iron wire of two gauges is in use for the less important telegraph lines:—

400 lbs. per mile *on* trunk lines.

200 lbs. per mile on junction lines.

Iron wire is galvanized to reduce corrosion, but in spite of this, in some manufacturing districts its life would be very short. In such localities copper and bronze wires are used for all purposes.

4) CADMIUM COPPER.

(a) **40 lbs. per mile.** This is the standard conductor for subscribers' circuits on all new routes.

(b) **70 lbs. per mile.** On new routes, this is used for:—

(i) Subscribers' lines in exposed positions.

(ii) Portions of trunk lines on over-house standards, where it is necessary to reduce the weight.

(iii) Coastguard circuits in sheltered positions.

(iv) Junction circuits.

The distinguishing characteristic of Cadmium Copper is that its electrical resistance being only 57% that of bronze, greater transmission efficiency approximating to a 50% improvement is obtained by its employment on those circuits formerly erected with bronze wire. In appearance and mechanical properties, however, it is identical with bronze wire, from which it can be distinguished only by chemical analysis; consequently care should be taken that a circuit composed of one material is not repaired with the other and that recovered wires of the two materials are kept separate. In order to facilitate this, cadmium copper wire should not be run on lines which carry bronze wires and *vice versa.* Pole lines carrying cadmium copper conductors should be identified by two " nails, letter, C " placed side by side one foot above the pole number. These nails should be fitted at the terminal pole, or the pole next to the junction pole in the case of a branch from an existing line which does not carry cadmium copper conductors and at quarter mile intervals thereafter if the route is more than a quarter of a mile in length.

If no bronze conductors are carried on the lines, cadmium copper will be erected in place of bronze wire in those cases enumerated in paras. (a) and (b). When this is done, subsequent 40 lbs. or 70 lbs. conductors required should also be of cadmium copper, and the routes should be marked with letter nails as detailed above, to indicate the presence of cadmium copper.

ERECTION OF LINE WIRES.

The stress which is put on line wires when they are erected is decided upon as a compromise between two mutually conflicting conditions. The tighter the wire, the smaller the sag, consequently there will be less risk of contact between adjacent wires if they are drawn very tight. On the other hand, a considerably increased stress is put on wires in position by the action of the wind and also by accumulations of snow and ice which occur at certain seasons. The tighter the wires, the less margin they have to resist these increased stresses, and on these grounds slack wires are preferable. As a result of experience, it has been decided that the greatest stress that shall be allowed on a line wire, apart from the stresses induced by weather conditions, shall be not more than one-third the breaking weight for bronze and cadmium copper, one-fourth the breaking weight for copper, and one-fourth the breaking weight for iron. This is usually expressed by saying that a factor of safety of 3 for bronze and cadmium and 4 for copper and iron is allowed.

Variation of temperature has also a very important effect on the sag and stress of a line wire. With an increase of temperature, metals expand. In the case of a line wire fixed at each pole, this means that the sag will increase and the stress decrease. The effect is partially compensated by the elastic properties of the wire. When a load is put on a wire, the wire stretches, but contracts to its original length when the load is removed, provided the elastic limit has not been passed. Consequently the decrease of stress resulting from the increase of temperature, as indicated above, causes a slight decrease in the length of the wire; but the effect of the increase of length owing to temperature expansion, and of the shortening of the wire owing to decrease of stress consequent upon the expansion, is a nett increase of length and a consequent increase of sag and decrease of stress in the line wire. For this reason it is necessary to take temperature into account in the erection of line wires. Tables are in use showing the stresses to be used in erection of various gauges of wires at different temperatures, and these have been drawn up so as to give the factors of safety mentioned above at a temperature of 10 deg. F. below freezing point, which is regarded as the lowest temperature likely to be experienced in this country. It will be understood from the above that the wires are at their tightest and have the least sag at this temperature. The following brief extract from these tables will give a sufficient idea of the different stresses to which wires are erected at various temperatures.

Temperature.	Stress on line wire (lbs.).			Sag on a 65 yard span (inches).		
	Bronze (40lb)	Copper (100lb)	Iron (200lb)	Bronze (40lb)	Copper (100lb)	Iron (200lb
Cold Winter Day (20° F.) ...	62	75	135	... 7	14½	16½
Temperate Day (65° F.) ...	50	55	90	... 8¾	20	24¼
Hot Summer Day (95° F.)	40	40	70	... 10¾	27	31

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For other gauges of wire of the same material, the stress is directly proportional to the weight per mile of the line wire. Thus the maximum stress to be placed on a 400 lb. copper wire is 75 × 4 = 300 lbs. As $\frac{92^2}{65^2} = 2$, other conditions being the same, the sag is proportional to the square of the length of the span; for example, for a 92 yard span the sags are twice as great as shown in the above tables for a 65 yard span.

When copper and cadmium copper or copper and bronze wires are run on the same line, the factor of safety should be 3 and 4.5, respectively, so that approximately the same dip is obtained for the two types of conductor at all temperatures. The risk of contact between wires is thus minimised.

2. WIRING TOOLS.

Bronze wire is paid out by hand from the coil, but for copper and iron wire a drum barrow, with a tapered galvanized iron drum, is necessary to support the coil during the paying-out process. The wires are placed in position and drawn up as tightly as possible by hand. Final regulation is done by ratchets and tongs for bronze and copper wire. No. 3 is used for 40 and 70-lb. bronze, No. 2 for 100 to 200-lb. wires, and No. 1 for heavier gauges. These tools were formerly used as separate tension-ratchets and draw-tongs connected, when in use, by a Keystone link, and many tools of this pattern are still in use. They are, however, combined as one tool in later issues. These tools are provided with spring tension indicators.

When regulating a bed of wires, it is not necessary that all the ratchets should be equipped with indicators. Ratchet and tongs No. 4 and 5 which correspond respectively with No. 2 and 3 are used in conjunction with these tools, the wires to which they are attached being pulled up by eye, to the same dip as the wires which are being regulated by indicator ratchets.

Draw-vices No. 2 are used for regulating iron wires, the appropriate ratchet and tongs being used to obtain the correct tension on one wire in the bank, the others being pulled up to the same sag by eye by means of draw-vices.

The use of draw-vices on copper and bronze wires is forbidden as there is much more risk of damaging the wire by gripping with a draw-vice than with tongs.

Draw-vices and tension ratchets when in use are attached to the arm by means of insulated tails. These consist of a globe strain insulator to one side of which is fixed a scissors-hook for attachment to an insulator spindle and, to the other side, a length of six-strand steel wire which may be wound round the drum of the ratchet or draw-vice as the line wire is drawn up. Two sizes of insulated tails known as small and large respectively are supplied. The smaller size is used with Ratchet and Tongs Nos. 2, 3, 4 and 5. The larger size is used with Ratchet and Tongs No. 1 and Draw Vices. New copper and bronze wires are always strained up slightly in excess of the tensions given in the tables and then slacked out to the correct tension in order to ensure that slight kinks are taken out of the wire.

3. CARE OF WIRE DURING ERECTION.

It is of vital importance that the greatest care should be taken in handling line wire during erection. It has been found that the strength of hard-drawn copper wire is very largely dependent on the surface being unscratched or unbroken. A very slight kink, which on casual observation may appear perfectly harmless, will reduce the strength of the wire considerably. During all wiring operations, therefore, line wire should be handled carefully.

4. METHODS OF AVOIDING INDUCTION.

It is very important that telephone lines should be free from interference from outside electrical circuits and also from other circuits on the same poles. It is a well known fact that a wire carrying a current can induce a current in a neighbouring wire. In the case of telephone circuits this means disturbing noises, humming from adjacent power circuits and cross talk from adjacent telephone circuits. Telegraph signals are also induced in a telephone circuit by an adjacent telegraph circuit. This trouble can be got over by arranging that the induction affects both wires of the telephone circuit to an equal extent. The condition necessary to produce this result is that the two wires of the telephone pair should be equidistant from the cause of disturbance throughout the length along which the disturbance takes place. On long and heavy lines disturbing conditions are very complicated; but it is possible to produce an approximation to the condition of equidistance laid down above by two methods which are in general use:—

(1) **Twist System.**—On this system, the wires are treated in squares, the wires at the ends of the diagonals of a square forming a telephonic pair. The wires of each square are revolved continuously in a right-handed corkscrew manner as shown in Fig. 1. The twist is complete in four spans and it will be seen that any wire of a square occupies in turn all four insulator positions of its square in these four spans.

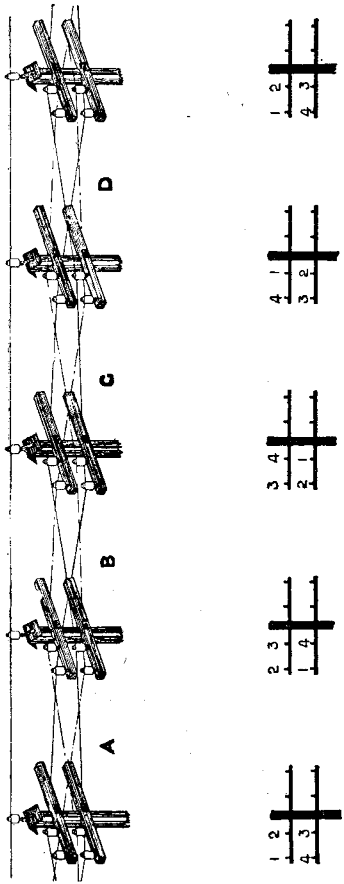
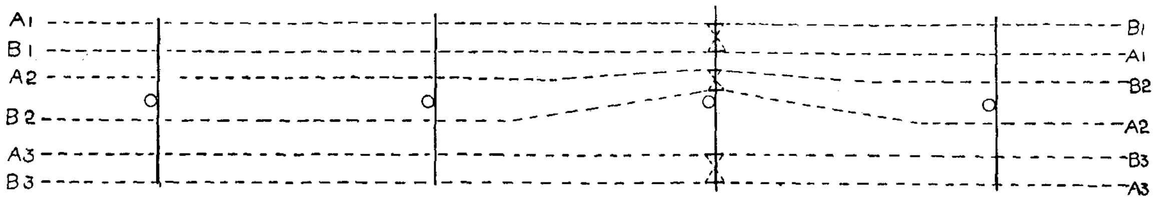


FIG. 1.

TRANSPOSITION SYSTEM. INSERTION OF CROSSES ON SIX WAY ARMS.

ARRANGEMENT OF INSULATOR SPINDLES.



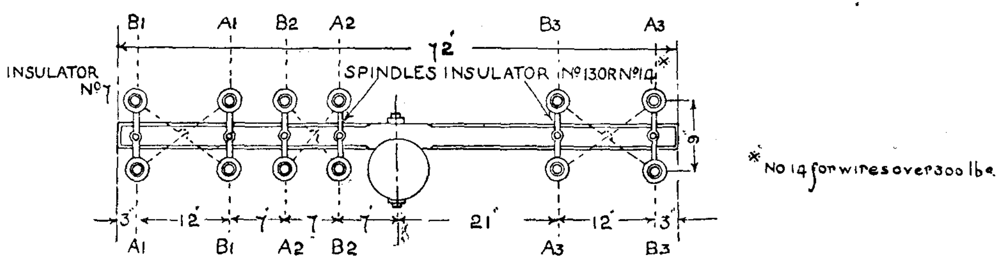


Fig. 3.

by the use of Spindles No. 13 for wires up to 300 lbs. and Spindles No. 14 for wires of larger gauge than 300 lbs., as shown in Fig. 3.

All new trunk and subscribers' lines are being built on the "transposition" system. Trunk lines which have been erected on the twist system and carry more than 8 arms devoted to trunk circuits are being completed to their full capacity on the twist system. Subscribers' lines which have been built on the twist system are being completed on the crossing system.

It is essential that the wires forming a telephone circuit should be of the same gauge and material.

5. BINDING-IN.

Bronze, cadmium copper and copper wires are bound in at the insulators in straight-through positions by means of tapes and binders as shown in Fig. 4. Tapes are thin flat strips of bronze, cadmium copper or copper. A tape is first wrapped round the line wire to prevent the wire being worn by friction where it rests against the neck of the insulator. The binder consists of a piece of line wire with the ends rolled flat, long enough to pass round the neck of the insulator, to wrap over the taped portion of the wire on each side of the insulator, and then to wrap over a portion of the line wire beyond each end of the taped

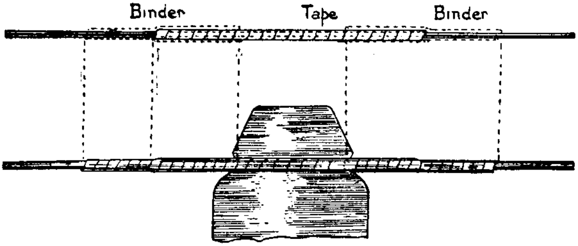


Fig. 4.

portion as shown in Fig. 4. This is done in order that the wire may not suddenly pass from a rigid to a free position; otherwise the wire would in course of time be liable to break at the insulator during severe wind storms.

The tape and binder are wrapped by hand, pliers only being used to press in the ends. Pliers should not be used to tighten the tape or binder as this would entail a risk of twisting the line wire under the tape, which would weaken the wire. It is necessary to use tapes and binders of the same material as the line wire; otherwise electrolytic action would take place between the two metals under continual exposure in damp and smoky atmospheres; and would result in corrosion and breakage of the line wire.

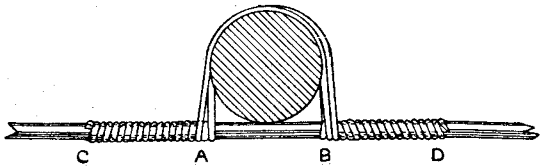


Fig. 5.

Two sizes of tapes and binders are used to suit the various gauges of bronze wire, one size for cadmium copper and four sizes for copper wires. Iron wire is bound in with 60 lb. G.I. binding wire as shown in Fig. 5. A piece of binding wire 36 in. long is required for 200-lb. wire and 48 in. long for 400-lb. wire. Two laps of the binding wire are taken round the line wire at A. The inner end is then taken round the neck of the insulator to the under side of the line wire at B, and after one complete lap, is taken back round the insulator to A, and lapped on the line wire for about a dozen turns to C. The other end of the binding wire is taken from the under side of the line wire at A, round the neck of the insulator to the upper side at B, and similarly lapped over the line wire to D.

6. TERMINATIONS.

Bronze, cadmium copper and copper wires of 150-lbs. per mile and under are terminated by means of bronze, cadmium copper

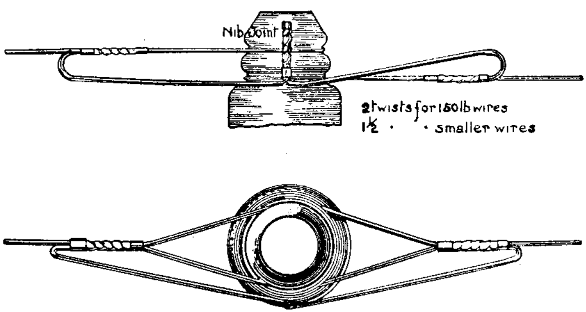


Fig. 6.

and copper jointing sleeves respectively as shown in Fig. 6, a loop being left large enough to allow the terminated wire to be slipped over the neck of the insulator when the strain is taken off, so that the insulator can be changed without interfering with the termination. When a double termination is required, a double-grooved insulator is used, and the tails of the two terminations are twisted together in a jointing sleeve. When wires of these gauges are to be terminated and led in, No. 16 insulators are used with I.R.V. core leading-in cables as shown in Fig. 7. Iron wires, and copper wires of 200-lbs. and over, are terminated by the use of wire, G.I., binding, and wire, copper, binding, 50-lbs. respectively, as shown in Fig. 8. Where double terminations are required, double grooved or terminal insulators are used, and the two tails bound together with binding wire and soldered. When these wires are required to be terminated and led in, No. 17 insulators are used with I.R.V. core leading-in cable, as shown in Fig. 9.

7. JOINTING.

For bronze, cadmium copper and copper wires of 150-lbs. per mile and under, bronze, cadmium copper and copper jointing

METHOD OF TERMINATING FOR 150-lb. BRONZE WIRES AND UNDER.

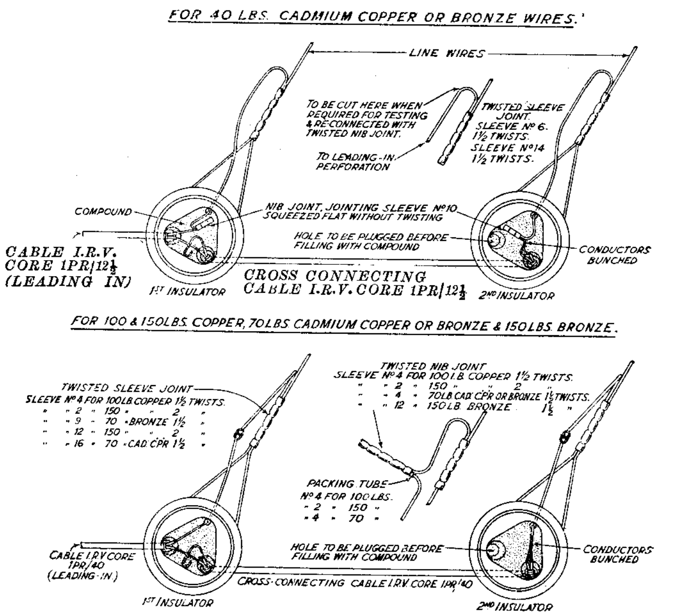


Fig. 7.

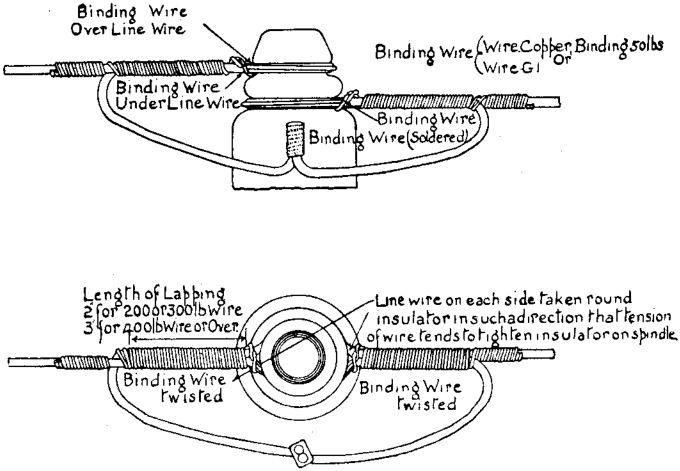


Fig. 8.

sleeves are used respectively. The ends of the wire are cleaned with emery cloth and placed side by side in a sleeve of the proper size with the ends of the wire just showing out of the ends of the sleeve. Both ends of the sleeve are gripped in the proper notches of two clamps, jointing No. 1, one of which is then revolved until the required number of twists has been given.

FOR COPPER WIRES 200 lbs. AND OVER.

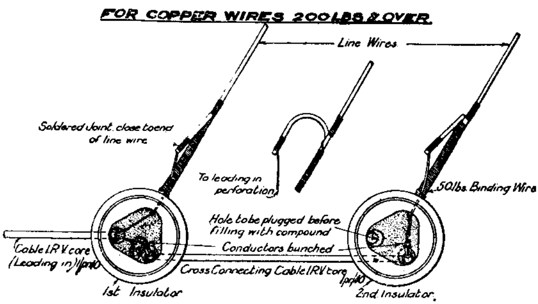


Fig. 9.

The various sizes of bronze and copper sleeves, and the number of complete twists required for each size are given in the following table:—

Size and Class of Line Wire		Length of sleeve.		Number of complete twists.
Bronze, 40 lbs.	...	$2\frac{1}{2}$ in.	...	4
Bronze, 70 lbs.	...	$2\frac{3}{4}$ in.	...	4
Bronze, 150 lbs.	...	5 in.	...	5
Copper, 100 lbs.	...	3 in.	...	4
Copper, 150 lbs.	...	$4\frac{1}{2}$ in.	...	5
Cadmium Copper, 40 lbs.	...	$2\frac{1}{2}$ in.	...	4
Cadmium Copper, 70 lbs.	...	$2\frac{3}{4}$ in.	...	4

When one of the wires to be jointed is short and its end is fixed, care should be taken not to revolve the clamp on the side of the joint as the effect of the twists in a short length of wire may be serious.

Electrolytic corrosion of the wires is liable to occur owing to moisture collecting in the cavities at the end of the sleeves, and in time breakage may take place at these points. To overcome this, sleeves of the same material as line wires should be used and the joint coated when dry with Black Varnish.

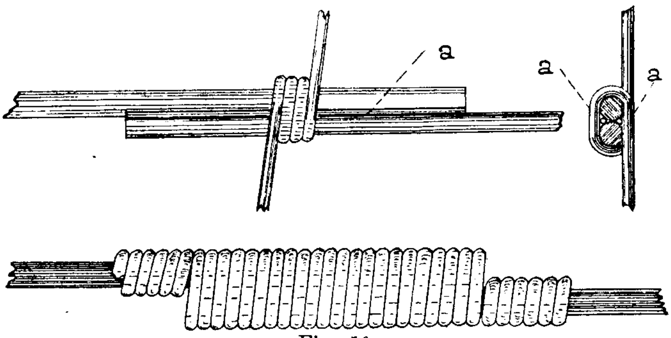


Fig. 10.

For iron wires and copper wires of 200 lbs. per mile and over, the Britannia joint is used. In making this joint, the ends of the two lengths of wire to be jointed are cleaned and laid side by side for the distance given for the overlap in the following table. The binding wire, being taken in the middle of its length, is applied first at the centre of the joint; the whipping is started as shown in Fig. 10 and carried along evenly until the right-hand portion is finished, then the left-hand portion is similarly dealt with. With wires of large gauge an appreciable space remains on each side of the joint between the point where the wires touch and the binding wire. It is difficult to fill this with solder, and not only do hollow joints result, but there is danger of overheating through fruitless attempts to resolder imperfect joints. To guard against this, and after the first few laps of binding wire have been laid on, pieces of binding wire the exact length of the overlap are pushed under the binding wire on each side of the joint, which is then completed.

50-lb. tinned copper wire is used for jointing copper conductors and 60 lb. G.I. for iron conductors. Soldering fluid is then applied and the joint rapidly soldered, surplus metal being wiped off and the joint allowed to cool naturally.

Size of Line Wire.		Length of overlap.		Length of jointing wire. (copper).		(iron).
800 lbs.	...	3 in.	...	74 in.	...	—
600 lbs.	...	$2\frac{3}{4}$ in.	...	64 in.	...	—
400 lbs.	...	$2\frac{1}{2}$ in.	...	48 in.	...	46 in.
300 lbs.	...	$2\frac{1}{2}$ in.	...	44 in.	...	—
200 lbs.	...	$2\frac{1}{4}$ in.	...	36 in.	...	$33\frac{1}{2}$ in.

Soldering.—The most important point to watch in soldering is absolute cleanliness of both the soldering bit and the surfaces to be soldered. It is impossible to solder an oxidized surface satisfactorily. Before commencing work the tip of the bit is tinned. This is done by heating the bit, cleaning with lump salammoniac and at the same time rubbing in solder. The solder should adhere to the tip of the bit and present a bright surface. During the whole of the operations the tip of the bit must be kept in this condition, frequent wiping with a rag after heating being necessary. If a film of oxide is allowed to form on the tinned tip, the bit is useless. Overheating the iron will burn off the tinning. The surfaces to be soldered should be carefully cleaned with fine emery paper, otherwise the solder will not run freely over and adhere to them. The presence of oil or grease is fatal to successful soldering.

Soldering should be carried out rapidly, or the solder will oxidize owing to frequent heating, and the presence of the oxide will prevent satisfactory amalgamation with the surfaces to be united.

Great care must be taken when soldering copper wire joints. Overheating of the wire will greatly reduce its breaking strength.

All soldered joints must be allowed to cool naturally, and the soldering fluid supplied by the Department must always be used. The use of spirits of salts is forbidden, as it tends to corrode the wire at the joint.

Joints in line wires are black varnished to prevent electrolytic action taking place between the solder and the material of the line wire.

8. GAME-GUARDS.

When lines run along roads across which game is driven, or in the neighbourhood of large pigeon lofts, it is often necessary to fit game-guards to the wires to make them conspicuous to flying birds.

Game-guards consist of cylindrical corks 3 in. long and $1\frac{1}{4}$ in. in diameter, cut half-way through longitudinally. They are bored with different sizes of slot for different gauges of wire. They are placed in position from a ladder supported on two trestle legs, and bound in tightly at each end with binding wire.

It is sometimes possible to drop the line wire so that the guards may be fitted on the ground and the use of a ladder avoided, but this is difficult to arrange on a working route.

The use of an endless sash-line has been tried with success for this purpose. The game-guards are placed in position near a pole and bound in. They are then dragged into the desired position by means of an endless line stretched between the two poles and loosely knotted to the line wire.

9. POLE TEST BOXES.

Pole test boxes are fitted at the junction of overhead and underground routes where it is desired to insert protectors, and also at maintenance boundaries where it is desired to provide testing facilities, and dummy fuses in fuse insulators will not meet the requirements.

Two types of box are now used for these purposes. They are known as Boxes, Pole, Test, E and G respectively, the former being used where the ultimate number of wires will not exceed 24 and the latter for lines of larger capacity. For test points only, a box known as Box, Pole, Test, D, which did not give protective facilities, was previously used, but this is now obsolete. Another type of box known as Box, Pole, Test, F is used where it is desired to accommodate a transformer for working a single wire circuit in conjunction with a metallic circuit. This box is also used on rifle ranges where it is required to plug in a telephone at various points along a circuit.

The boxes are fixed to the pole by means of fixing irons, which are supplied straight and may be bent to fit the pole.

The cables from the insulators are brought down the pole in wood casing.

10. EARTH-PLATES.

It is very important that good earth connections should be provided in connection with protective devices against lightning and power circuits. For this purpose earth-plates are provided, which consist of a G.I. or copper sheet fitted with a tail of stranded copper wire. They are buried vertically in the ground to a sufficient depth to ensure a moist situation, the top of the plate being in no case less than 2 feet from the surface. The tail is protected by being drawn into a lead pipe from its point of attachment to the plate, to a point well above the ground line.

Normally, G.I. plates 2 ft. 6 in. x 2 ft. 6 in. or 2 ft. 6 in. x 1 ft. 9 in. are used for exchanges. A copper earth-plate 4 ft. x 4 ft. is provided for use where the soil is impregnated with acid and where a G.I. plate would deteriorate rapidly. A small earth-plate of G.I. 1 ft. x 1 ft. is used for subscribers' premises where a water pipe is not available.

Earth Clips.—Earths in minor offices and subscribers' premises are normally obtained by connecting a 3/20 stranded copper wire to the water pipe system. Earth clips are used for this purpose. Two sizes known as No. 1 and No. 3 are in use. The former is for pipes up to 1 in. diameter and the latter for larger pipes. Care should be taken to ensure that the pipe to which connection is made is in metallic connection with the water mains and is not part of a local house system.

11. AERIAL CABLE.

The use of aerial cable as a permanent work is limited as much as possible, as, generally speaking, it is more difficult to maintain than open wires, and frequently underground work, which is immeasurably superior from that point of view, is found to be justified where an aerial cable would have advantages over an open line. Two types of cable are in use, viz. :—

(1) **I.R. Aerial.**—This is a rubber-sheathed cable, and although it has been largely used for permanent work in the past, its use is now practically limited to temporary works, such as the temporary putting through of circuits interrupted by storm breakdowns, or the cutting out of portions of a main route whilst extensive rebuilding or rearrangement is in progress. It is usually loosely called "interruption cable." For temporary work, any method of suspension which will safeguard the cable from accident for a short time, is used. For permanent work, it is slung on a steel suspending wire by means of suspenders made of marline, provided with a steel hook.

(2) **Cable P.C. Aerial.**—This cable is used when permanent work is required. It is a paper-insulated cable provided with a lead sheath consisting of an alloy of lead with 1 per cent. of antimony. This is used in place of the pure lead provided for underground cables to enable the aerial cable to withstand better the rougher treatment to which it is liable to be subjected. The smaller sizes of cable are suspended from two 190 lbs. steel wires by means of marline suspenders; for the suspension of the heavier cables, cable rings attached to a steel stranded wire are used.

Where it is to be connected to an open line it has been the practice to terminate the cable in a cable distribution plug. This is simply a sealed water-tight joint contained in a lead sleeve between the end of the cable and a number of single-pair lead-covered extensions for connection to the wires on the insulators.

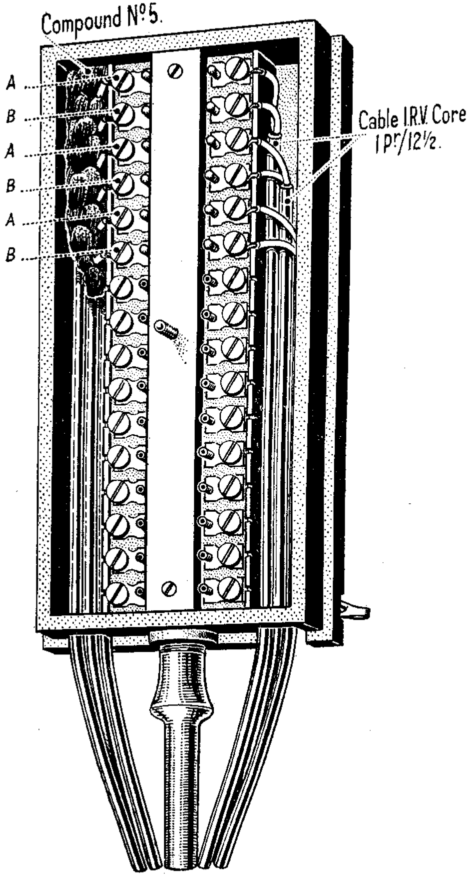


Fig. 11.
Front view shewing "Cable I.R.V. core 1 pair/12½" leads in position and shewing compounding on left hand side.

Blocks, Terminal have now replaced distribution plugs. The block is shown in Fig. 11. It consists of a black insulating material moulded to the shape shown. On the face are terminals fitted with screws and washers and with short tubes. At the back of the block is a central channel. A metal thimble is soldered to the cable sheath at a suitable distance from the end, the block screwed on to the thimble and the surplus sheathing cut away. The wires are then fanned out in the central back channel, the ends bared, cleaned and passed through small holes from the back of the block to the terminal tubes to which they are soldered. The terminals are connected to the insulators by means of single-pair lead-covered leads (Cable I.R.V. core 1 pr/12½) which are run as required. The leads from the terminals lie in the channels at the sides of the block and leave through the rectangular holes at the lower end. The channel at the back is filled with paraffin wax and an ebonite cover screwed on. The side channels on the front are filled with Compound No. 5 as the terminals are taken into use. Compound No. 7 is smeared over the uncovered terminals to guard against corrosion and the whole front and top of the block protected by a cover secured by a central wing nut.

Where the aerial cable is to be connected to an underground cable, a plain joint is used; and where it is led direct into a building for connection to a test frame, it is connected to a short length of enamel silk and wool covered cable impregnated with beeswax.

Erection of Suspending Wire.—For the smaller aerial cables up to approximately ⅞-in. in diameter two 190 lbs. steel wires are used for suspension. These are arranged to have a factor of safety of two, under the most adverse weather conditions, and when loaded with the maximum size cable which for 40 yd. spans has a weight per foot of 1·0 lbs. or for 60 yd. spans 0·8 lbs. The steel wires are first erected independently, being terminated at every 4th span and are clamped at intermediate poles by Brackets No. 12. The wires should not be twisted together and every termination should be made separately. The initial stresses to be put on the steel wires at various temperatures are shown below. The dip when the cable is in position is about 40 in. on a 60 yd. span.

Cable I.R. Aerial.	No. of steel suspending wires.	Cable P.C. Aerial.	No. of steel suspending wires.
8 pr/20	1	10 pr/10	2
12 pr/20	1	15 pr/10	2
19 pr/20	2	15 pr/20	3
		25 pr/10	2
		25 pr/20	4
		50 pr/10	4
		14 pr/40 M.T.	4

The steel wires are erected to the same stress for all types of cable.

Temperature.	Stress unloaded. 40 yds. span.	Stress unloaded. 60 yds. span.
Cold Winter's Day, 25° F.	410	240
Temperate Day, 65° F.	330	170
Hot Summer's Day, 95° F.	270	120

Erection of Cable.—Smaller types of cable are led from the drum to the first pole in a curve of each radius and suspenders are fitted at 20 in. intervals. When the cable reaches the first pole every fifth suspender is placed on the messenger wire. The cable is drawn along by a rope and winch, and a man up each pole unhooks the suspenders which are riding on the steel wires and replaces them on the opposite side of the pole as they come up to him. When the first end of the cable reaches the last pole but one, all suspenders are put on the suspending wire by the man at each pole.

With the heavier type of cable for which cable rings are employed, the rings are placed in a position at 20 in. intervals after the stranded suspension wire has been erected. The cable is then drawn through the rings using mechanical aids.

Care of Tools.—All possible care should be taken of tools as good work cannot be expected if they are allowed to get into bad condition. Defects should be reported at once, especially in the case of tools upon which a man's life may depend, such as ladders and safety belts, in order that repair or replacement may be arranged for.

Precaution against Accidents and Prevention of Faults.—Particular attention is directed to the official instructions as to "Precautions against Accidents" and "Prevention of Faults" which should be in the possession of all workmen.

Page 12. *Delete last sentence on page. Substitute:* One end of the sleeve is gripped in the proper notches of a Clamp, Jointing No. 1, and the other end in a Clamp, Jointing No. 3. These are then revolved until the required number of twists has been given.

Page 13. *Table. Amend last column to read as follows:—*

Number of complete twists.
3½
4
5
4
5
3½
4

Page 13. *3rd Paragraph. Delete* last line.

and the joint . . . Black Varnish

Substitute: and the ends of the sleeve thoroughly coated with Black Varnish. If the sleeve and wires are wet, they should be dried as much as possible before applying the varnish.

Page 18. *Delete* table at bottom of page. **11/33**

LIST OF

Technical Pamphlets for Workmen.

GROUP A.

1. Magnetism and Electricity.
2. Primary Batteries.
3. Technical Terms.
4. Test Boards.
5. Protective Fittings.
6. Measuring and Testing Instruments.
7. Sensitivity of Apparatus.
8. Terms and Definitions used in Telegraphy and Telephony.

GROUP B.

1. Elementary Principles of Telegraphy and Systems up to Morse Duplex.
2. Telegraph Concentrators.
3. Wheatstone. Morse Keyboard Perforators.
4. Quadruplex. Telegraph Repeaters, Sx., Dx., and Quad.
5. Hughes Type-printing Telegraph.
6. Baudot Multiplex.
7. Western Electric Multiplex. Murray Multiplex. Other Systems.
8. Fire Alarm Systems.

GROUP C.

1. Wireless Transmission and Reception.
2. Interference with Reception of Broadcasting.

GROUP D.

1. Elementary Principles of Telephony.
2. Telephone Transmission. "Loading." Telephone Repeaters and Thermionic Valves.
3. Principles of Telephone Exchange Signalling.
4. Magneto Exchanges—Non-Multiple Type.
5. Magneto Exchanges—Multiple Type.
6. C.B.S. No. 1 Exchanges—Non-Multiple Type.
7. C.B.S. Exchanges—Multiple Type.
8. C.B. Exchanges—No. 9 Type.
9. C.B. Exchanges—No. 10 Type.
10. C.B. Exchanges—No. 12 Type.
11. C.B. Exchanges—22 Volts.
12. C.B. Exchanges—40 Volts.
13. Trunk Telephone Exchanges.
14. Telephone Exchange Maintenance.
15. Telephone Testing Equipment.
16. Routine Testing for Manual Telephone Exchanges.
17. Internal Cabling and Wiring.
18. Distribution Cases, M.D.F. and I.D.F.
19. Cord Repairs.
20. Superposed Circuits, Transformers, etc.
21. Call Offices.

[Continued on page iv. of Cover.

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Technical Pamphlets for Workmen

(Continued)

GROUP E

1. Automatic Telephony: Step by Step Systems.
2. Automatic Telephony: Coder Call Indicator (C.C.I.) Working.
3. Automatic Telephony: Keysending " B " positions.

GROUP F

1. Subscribers' Apparatus. C.B.
2. Subscribers' Apparatus, C.B.S. Part I—C.B.S. No. 1 System.
3. Subscribers' Apparatus. Magneto.
4. Private Branch Exchanges—C.B.
5. Private Branch Exchange—C.B. Multiple No. 9.
6. Private Branch Exchanges—Magneto.
7. House Telephone.
8. Wiring of Subscribers' Premises.

GROUP G

1. Maintenance of Secondary Cells.
2. Power Plant for Telegraph and Telephone Purposes.
3. Maintenance of Power Plant for Telegraph and Telephone Purposes.
4. Telegraph Battery Power Distribution Boards.

GROUP H

1. Open Line Construction, Part I.
2. Open Line Construction, Part II.
3. Open Line Maintenance.
4. Underground Construction, Part I—Conduits
5. Underground Construction, Part II—Cables.
6. Underground Maintenance.
7. Cable Balancing.
8. Power Circuit Guarding.
9. Electrolytic Action on Cable Sheaths, etc.
10. Constants of Conductors used for Telegraph and Telephone Purposes.

GROUP I

1. Submarine Cables.

GROUP K

1. Electric Lighting.
2. Lifts.
3. Heating Systems.
4. Pneumatic Tube Systems.
5. Gas and Petrol Engines.