WS No. 19 Mark III

P.W.—H.2.

POST OFFICE ENGINEERING DEPARTMENT

TECHNICAL PAMPHLETS FOR WORKMEN

Subject:

Open Line Construction

PART II.

ENGINEER-IN-CHIEF'S OFFICE
1919

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.

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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.

(b) **70 lbs. per mile.** 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.

8143. Wt.18198/1104. 5,500. 9/19. S.O.,F.Rd.
353. Wt.4154/525. 750. 5/20. S.O.,F.Rd.

(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.

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, one-fourth the breaking weight for copper, and one-fourth the breaking weight for iron. This is usually expressed by saying that we allow a factor of safety of 3 for bronze and 4 for copper and iron.

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 increase 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 (25° F.)	62	75	130	...	7	14½	16½
Temperate Day (65° F.) ...	50	55	90	...	8¾	20	24¼
Hot Summer Day (95° F.)	40	40	70	...	10¾	27	31

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 x 4 = 300 lbs. For the same length of span, 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.

2. WIRING TOOLS.

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PAGE 3. *Delete all below* " 2. WIRING TOOLS " *and insert the following :—*

Bronze wire is paid out by hand from the coil, but for copper and iron wire a drum barrow, with a tapered galvanised 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. 3 and 4 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 scissorshook 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, are supplied, the former being intended for use with Ratchet and Tongs No. 3 and Draw-Vices [redacted], the latter with the remaining sizes of ratchets 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.

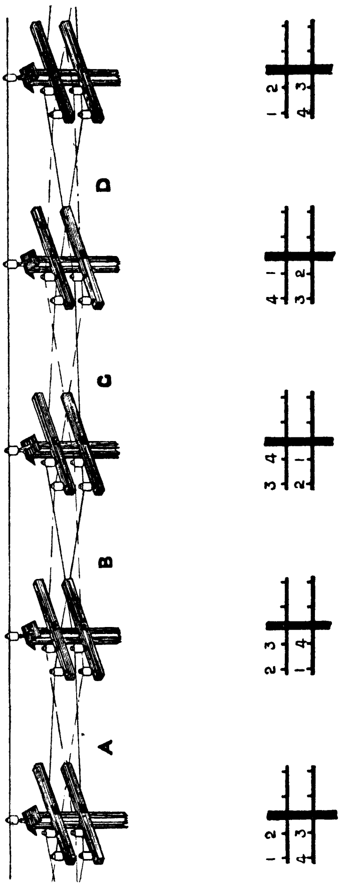

FIG.1.

The system will not fulfil its object unless the wires occupy symmetrical positions throughout their whole course. Thus it is necessary for the insulator positions at all poles to be identical, and also for the four wires of a square to remain equidistant from each other along a span. A slack wire would throw this out, consequently the importance of good regulation, that is, ensuring that the wires are all equally tight, will be readily seen.

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PAGE 6. *Delete* paras. 2 & 3, *also* Fig. 2, *and insert the following:*

A simple twist of this kind does not entirely get rid of interference between the various squares on a heavy route. Final adjustment is made by crossing over the two wires of a pair by means of Spindles No. 13 as shown in Fig. 2. Crosses are inserted in the various squares on a pole line at different points.

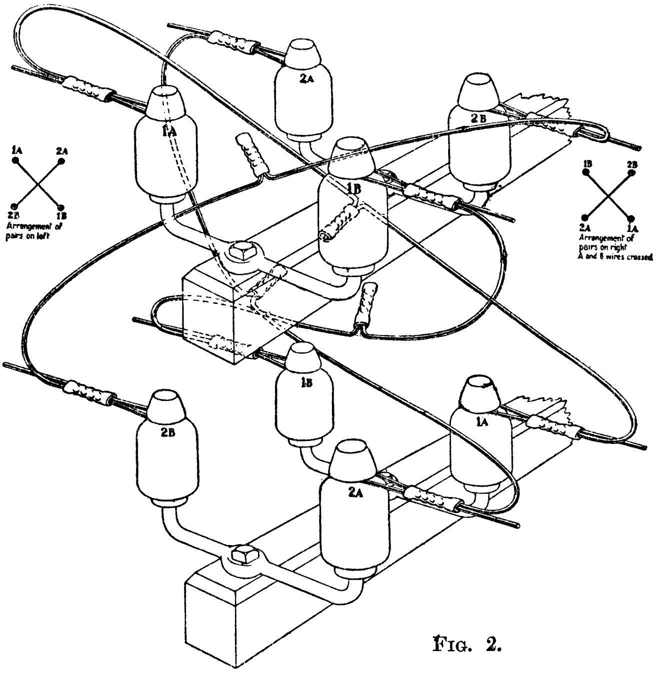


FIG. 2.

(2) **The Crossing System.**—This system aims at the same results, but renders the construction easier than in the case of twisted wires. The wires are run on the straight with flat pairs, *i.e.* two adjacent wires on the same arm form a telephone pair. The two wires of a pair are transposed at pre-arranged intervals by the use of Spindles No. 13 for wires up to 300 lb. and Spindles No. 14 for wires of larger gauge than 300 lb. as shown in Fig. 3.

All new trunk and subscribers' lines are being built on the "crossing" 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.

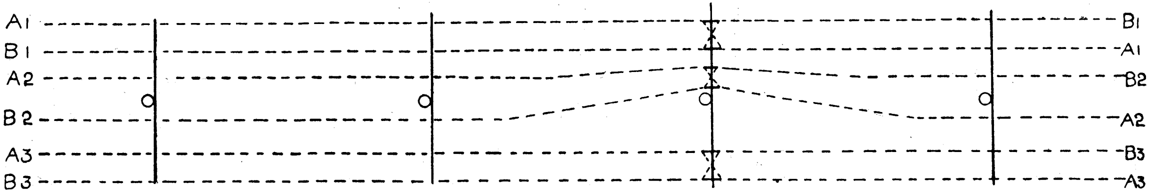
It is essential that the wires forming a telephone circuit should be of the same gauge and material.

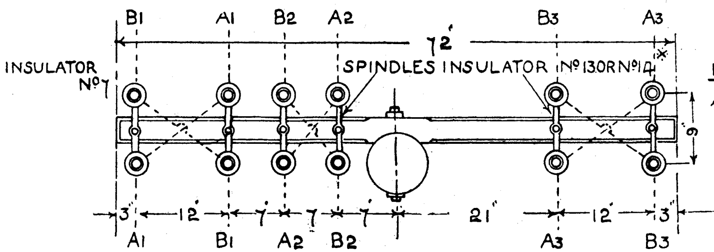
5. BINDING-IN.

Bronze and copper wires are bound in at the insulators in straight-through positions by means of tapes and binders as

TRANSPOSITION SYSTEM. INSERTION OF CROSSES ON SIX WAY ARMS.

ARRANGEMENT OF INSULATOR SPINDLES.





NOTE. PAIR A2 B2 TO BE CROSSED ON RIGHT AND LEFT SIDE OF POLE ALTERNATELY.

* No 14 for wires over 300 lbs.

Fig. 3.

shown in Fig 4. Tapes are thin flat strips of bronze 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 portion as shown in

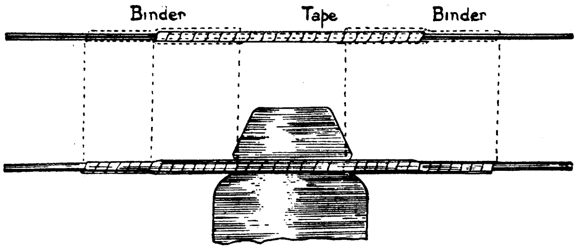


Fig. 4.

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 onlv 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.

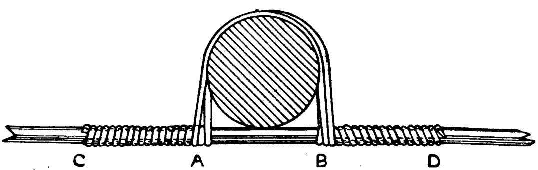


Fig. 5

Two sizes of tapes and binders are used to suit the various gauges of bronze wire, 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 wires and copper wires of 150-lbs. per mile and under are terminated by means of bronze and copper jointing sleeves

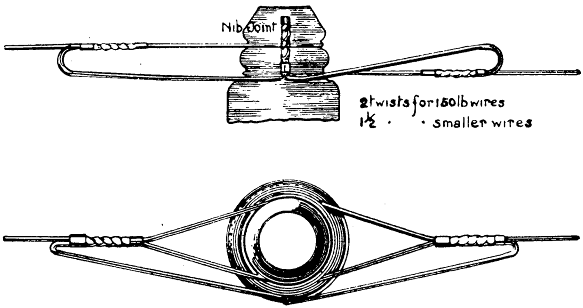


Fig. 6.

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 E. and C.C. 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, 60-lbs., 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 and copper wires of 150-lbs. per mile and under, bronze and copper jointing sleeves are used respectively. The

METHOD OF TERMINATING FOR 40lb. BRONZE WIRES.

P.W.-H.2.

PAGES 10 and 11. *Delete* Figs. 7 and 9 *and insert the following.*

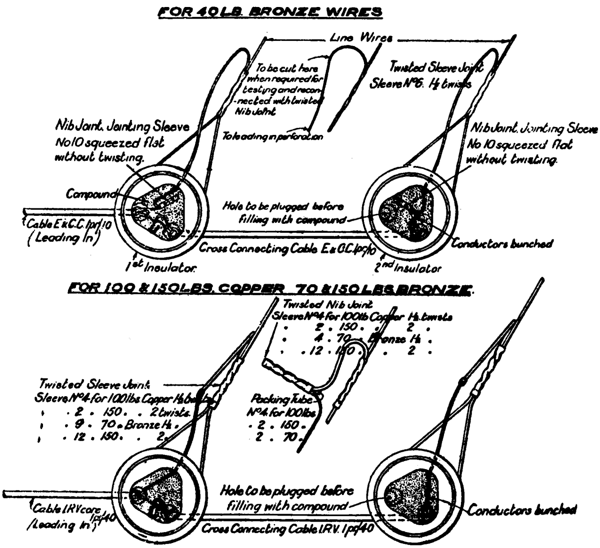


FIG. 7.

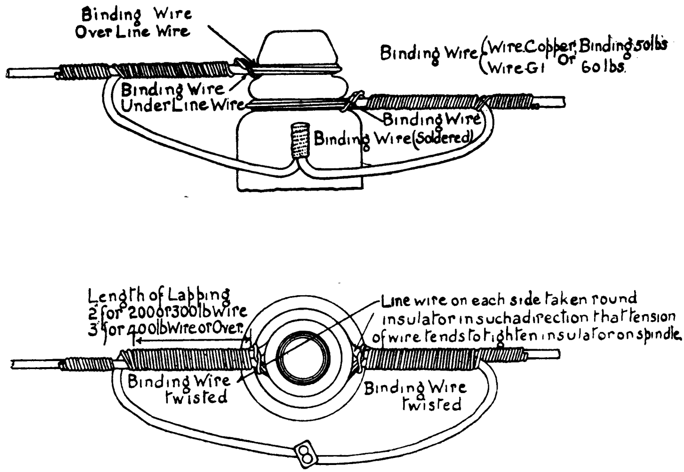


Fig. 8.

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. One end of the sleeve is gripped in the proper notches of a clamp, jointing, No. 1

FOR COPPER WIRES 200lbs. AND OVER.

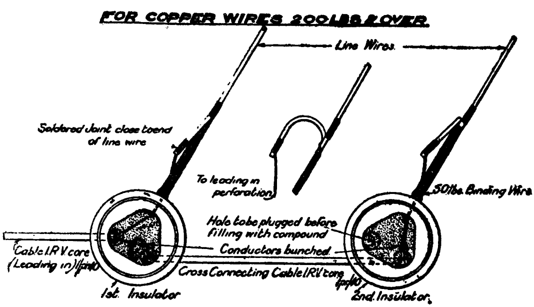


FIG. 9.

and the other end in a clamp, jointing, No. 3. The latter is then revolved until the required number of twists has been given.

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. ...	2½ in.	4
Bronze, 70 lbs. ...	2¾ in.	4
Bronze, 150 lbs. ...	5 in.	5
Copper, 100 lbs. ...	3 in.	4
Copper, 150 lbs. ...	[redacted] 4½"	5

When one side of the wire to be jointed is short, care should be taken to hold the end of the sleeve adjoining that side by the No 1 clamp so as to avoid twisting it when revolving the No. 3 clamp.

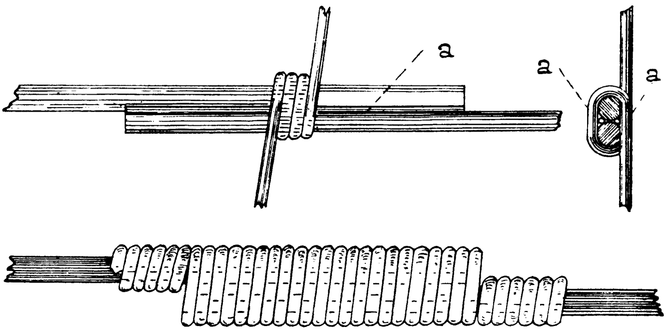


Fig. 10.

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 1¼ 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.

P.W.-H.2.

PAGE 14. *Delete* para. 3 *and insert the following :—*

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.

testing facilities, and dummy fuses or fuse [illegible] 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 raw hide or 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 slightly thicker and of a harder metal than is used for underground cables, in order to withstand the rougher treatment to which a suspended cable is liable. It is suspended from 190-lb. steel wires, by means of raw hide or marline suspenders.

Where it is to be connected to an open line the cable is terminated 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. Where the 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 silk and cotton-covered cable impregnated with beeswax.

Erection of Suspending Wire.—190-lb. steel wire is used for suspending aerial cables, different numbers of suspending wires being used for various types of cable as shown below. The steel wires are first erected independently, being terminated every five spans, and clamped at intermediate poles by Bracket No. 12. When more than one steel wire is used, the wires must not be twisted together, and every termination must be made separately. The initial stresses to be put on the steel wires at various temperatures are shown below. These are arranged so that when loaded with the weight of the cable, a factor of safety of ~~three~~ about is allowed on the coldest day likely to be experienced, neglecting the effect of wind pressure. The dip when the cable is in position is about feet on ~~a 60~~ yard span.

PAGE 16. *Delete from* Cable I.R. aerial *to* 385 lbs. *and insert the following* :—

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

All suspending wires are erected to the same stress for all types of cable.

Temperature.		*Stress unloaded.*
Cold winter's day,	25° F.	390 lb.
Temperate day,	65° F.	315 ,,
Hot summer's day,	95° F.	260 ,,

1/22

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... 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 "Precaution against Accidents" and "Prevention of Faults" which should be in the possession of all workmen.

Printed by HIS MAJESTY'S STATIONERY OFFICE.

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.

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. General Principles of Wireless Transmission and Reception.

GROUP D.

1. Elementary Principles of Telephony.
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3. Principles of Telephone Exchange Signalling.
4. Magneto Exchanges—Non-Multiple Type.
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6. C.B.S. 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 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.
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3. Maintenance of Power Plant for Telegraph and Telephone Purposes.
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8. Power Circuit Guarding.
9. Electrolytic Action on Cable Sheaths, etc.
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