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INSTRUCTION

IN

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VOL. II.—LINES.

1909.

Reprinted, with Corrections, 1914.

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WAR OFFICE,
26*th November*, 1914.

R. H. Brade

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Note.—The special light telephone equipment for Artillery and Infantry use in the field is not dealt with in this Book.

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Revised

INSTRUCTION IN ARMY TELEGRAPHY AND TELEPHONY.

VOL. II.

CHAPTER I.

LAYING FIELD CABLES.

Pace of Laying.

1. In open country the pace at which cable can be laid is limited only by the pace at which the wagon can move.

In close country, such as England, where provision must be made for the security of the cable at road-crossings, gates, and in villages, the normal cable detachment should work at an average rate of 3 miles per hour. If two detachments are available to lay one line, the pace may be increased to 5 miles per hour. At night, when the mounted men cannot work on their horses, progress is necessarily slower, and it will be seldom possible to lay cable faster than about 1½ miles per hour.

2. As a general rule, cable lines will be required under conditions when they must be laid quickly, and will be useless unless they can be depended upon for the transmission of messages.

Cable lines must be laid quickly.

To achieve this the detachment must be smart in drill, and every part of the equipment must be in perfect condition. The commander of a cable detachment should personally test the cable and instruments and thoroughly inspect the wagon and detachment to see that the equipment is complete and in thorough working order.

*Details of Laying.**

3. In laying cable lines the result to be aimed at is the safety of the cable. No rules as to where the cable should be laid can be given; this must be decided by the particular circumstances in every case. As a rule, the further it is from metalled roads where much traffic will pass, the better. Men and beasts will, especially at a check, move along the sides of the roads.

* For details of stores used see Chap. IV.

The paying out should be so regulated that the cable lies evenly on the ground everywhere. If it is stretched across a hollow in the ground, and is thereby not in contact with the ground, there is danger lest some one passing may trip in it, and break or drag it out of place.

It should be stretched out without any strain on it, but also without leaving it in loops or coils.

It should never be stretched off the ground across gates or gaps in hedges through which men or animals may pass or in any situation where it will interfere with traffic.

It should be laid out of sight if possible.

It should never be allowed to lie in water, or the current will leak to earth.

Over open ground.

4. If the cable is laid across an open space, care should be taken to lay it just stretched on the ground, and it should be pegged down every half mile.

Along tracks.

5. When the line follows a sandy track through bush or heather, it is generally best to lay the cable flat in the track where traffic passing over it will not injure it.

In front of dwelling-houses.

6. In laying cable in front of dwelling-houses it can be allowed to lie on the surface of the ground, but it should then be laid fairly tight, quite flat, and pegged down on each side so as not to trip up men or horses.

In villages or towns.

7. The only safe position for cable passing through large villages or towns is fastened high up on the buildings. This entails slow progress, and in peace the consent of the inhabitants is necessary. If it is absolutely necessary to pass quickly through a town, and consequently to take risks, the best place for the cable is the gutter by the side of the foot-path. The cable should be frequently tied down to the gratings of the surface drains, or to pegs.

Lines should not be laid parallel or close to each other.

8. Cable lines should be laid as far apart from each other as possible. If two lines lie alongside each other for any considerable distance, the signals on one line interrupt the signals on the other owing to electrical induction.

Road crossings.

9. When cable lines cross roads or tracks the cable should be raised at least 15 feet over the roadway or should be buried under the surface.

The cable should only be buried across soft and unmetalled tracks. Buried crossings are liable to cause earth faults in wet weather.

Twenty-four 17-foot jointed poles* are carried on each cable wagon, by means of which the cable can be raised over roads.

When a pole crossing is necessary, a hole 18 inches deep is made for each pole with a hammer and jumper. The tops of the poles are held over the holes, the cable is stretched between them and made fast to the tops of the poles by means of clove hitches taken in the cable. Sufficient slack should be left in the cable on each side of the crossing to admit of the poles

* "Poles, telegraph, wood, 17-ft."

being raised and of the cable being tied to their bases after erection. The poles are then simultaneously raised into their holes and are stayed back with one guy line each.

The guy lines are made fast to trees, fences, or any other available holdfast, or, if none are available, to pegs which will be driven into the ground.

If buildings or trees, to which the cable can be attached, are available, the line should cross by these.

A road may also be crossed by means of one pole and one house or tree attachment. In this case the pole will be erected first, and the cable will be drawn taut over the road from the top of the pole to the house or tree to which it will be attached.

10. When a cable line has to cross a railway it should be cut and passed under the rails. Care should be taken to keep it clear of all railway points. **Railway crossings.**

11. The best way of making cable fast to a projection on a building, tree, fence, the foot of a pole at a crossing or to any other holdfast is by making a barrel hitch with a piece of spunyarn through a loop or coil of the cable (*see* Fig. 1), and tying off the ends of the spunyarn to the holdfast. **Attachments.**

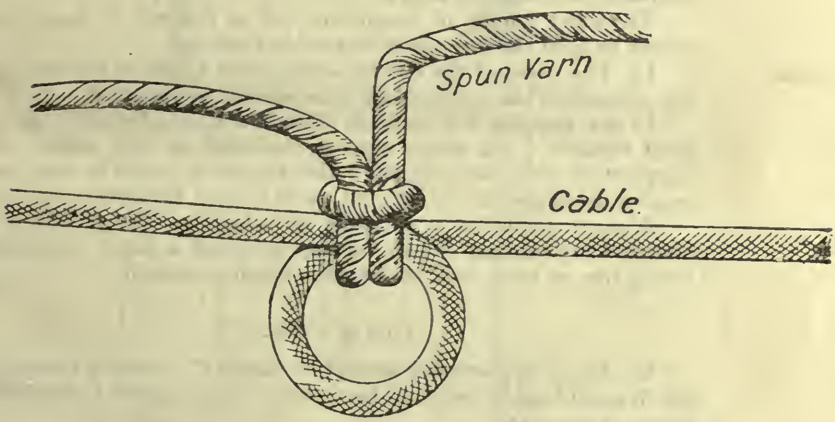


Fig. 1.

Occasionally it may be found more convenient to make a clove hitch with a bight of the cable round a stout holdfast, such as a large bough or a fencing post. If this is done, care must be taken to see that the end of the bight is secured so that the spring of the steel in the cable will not cause the clove hitch to become slack.

12. In many places it is necessary, and in any case it is advisable, frequently to tie the cable back to gates, hedges, and fences on the side of the road. **Tying back.**

Tying back is especially necessary when the cable follows the outside of a curve in the road, where it is liable to be dragged across the road if any strain comes on it.

The cable should be tied back as near to the ground as possible.

Temporary joints.

13. The outer end of the cable on each drum will always be kept prepared for jointing as follows (*see* Fig. 2).

The insulation should be stripped from a point 1 inch from the end of the cable for about 3 inches, and a piece of indiarubber tubing* from 5 to 6 inches long should be slipped on to the cable.

The inner end of the cable on each drum is similarly prepared, but has no tubing on it.

When a joint has to be made the ends of the cable will be tied together by a reef knot which will be formed on the uninsulated part of the cable (*see* Fig. 3).

This knot will be drawn as tight as possible to ensure good contact. The indiarubber tubing will then be drawn over the joint to insulate it.

Whenever it is necessary to make a temporary joint in cable the ends will be prepared, and the joint will be made and insulated as described above.

The short length of insulation left at the end of the cable serves to hold the strands of the cable together.

Earths.

14. The earth of the circuit on the cable wagon is formed by the contact of the tyres of the wheels with the ground.

In dry weather this earth is often found insufficient to give good signals. An earth pipe is provided on the wagon to supplement this, and whenever the wagon is halted to send or receive messages this additional earth should be used.

A good earth for a vibrator or telephone circuit can be obtained by driving a nail or the point of a knife into any living tree or bush, and leading the earth wire to it.

Care of Cable.

15. Every opportunity should be taken of running through the drums of cable, to repair the insulation, and make temporary joints permanent.

Repairing insulation.

16. Bared insulation is repaired by smearing the place with indiarubber solution, and binding round with indiarubber tape.

Making permanent joints.

17. To make a permanent joint, remove about 3 inches of insulation, and clean the ends, untwisting the strands so as to clean every part of each strand. Tie the bared ends together in a reef knot, pulling it up tight, and bind round closely with a piece of wire, and then solder in the usual way. Wash the joint well with water to remove all traces of the soldering fluid dry, and serve with indiarubber tape and solution, being

* "Pipe, hose, I.R., $\frac{1}{4}$ inch."

careful to make the tape overlap the original insulation by ½ inch on each side.

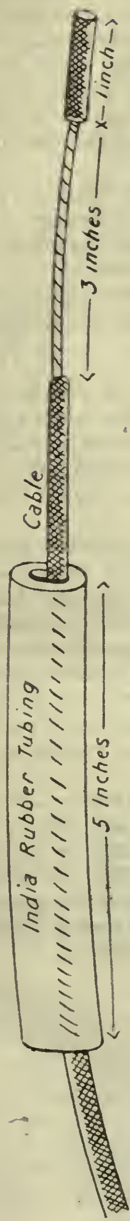


Fig. 2.

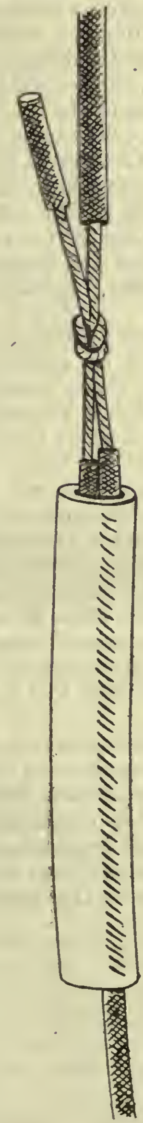


Fig. 3.

Telegraph Office.

17A. In Army cable units each section consists of two cable detachments, and is commanded by a subaltern. Each section should be allotted a distinguishing letter, taken from the first half of the alphabet, which should be changed as seldom as possible. The 1st detachment of each section is known by the section letter, the second by that letter preceded by S (a third would be preceded by T).

The three offices in each detachment retain permanent calls (*see* Vol. I., Chapter XXI, para. 9) consisting of the detachment letter or letters preceded by P for the office fixed to the cable wagon, Q for the office carried loose in the cable wagon (base office), and X for the office in the light spring wagon. Thus the call of the wagon office of the second detachment of a section lettered "L" would be PSL.

18. In field operations cable lines, in common with other message routes, are generally used for the internal communications of a unit of the Army. Several cables usually start from one point, which is known as the Telegraph Office, and should be situated as near as is possible to the Signal Office and the headquarters of the unit.

A superintendent will usually be appointed from the headquarters of the company to take charge of this office. He will be provided with a "tent telegraph," a table and a commutator.

On commencing work each cable detachment will terminate its cable on the commutator, and will connect the commutator to its third class office by means of a 15-yard length of cable, which will be carried, ready prepared with a U tab soldered to the end, in the canvas case of the vibrator. The Nos. 1 and 8 of the detachments will come under the orders of the superintendent.

If no office accommodation is available, a shelter tent will be pitched for each third class office. Each office will have its own "earth," and these should be separated as far as possible. Arrangements also should be made that the cables do not cross each other—a convenient arrangement is to bring the line cable to its own tent, and then the cable and 15-yard length together to a tent peg near the commutator (*see* Fig. 4).

DIAGRAM SHOWING ARRANGEMENT OF FIELD BASE TELEGRAPH OFFICE.

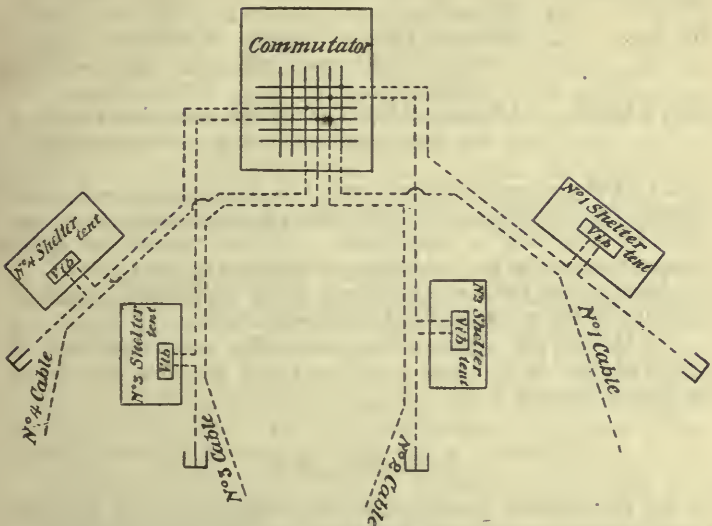


Fig. 4.

No. 8 is responsible that all cables of his detachment are left secure; the cables between tents should be trenched into the ground when possible.

Before the detachment starts, the commander must ascertain that his wagon office is working well to the office he has left.

Cable Drill.

19. The cable detachment is told off as follows:—

An N.C.O., mounted, as commander.
3 office telegraphists, dismounted, Nos. 1, 2, and 9.
3 sappers, dismounted, Nos. 3, 4, and 5.
3 linemen, mounted, Nos. 6, 7, and 8.

The cable wagon has a 6-horse team with 3 drivers, and is accompanied by a light spring wagon with pair and 1 driver. This wagon, in addition to spares, camp equipment and rations, contains 2 miles of cable and a third class office.

20. Before leaving quarters or camp it is the duty of the commander thoroughly to inspect the detachment, and the wagon, and its equipment. Inspection of detachment and equipment.

Every man of the detachment will carry a knife, pliers, and some lengths of spunyarn.

In addition the following will be carried :—

Commander ...	Crook-stick and whistle.
No. 4	Whistle.
No. 6	Whistle, 100-yard length of cable, two pieces tubing, two pegs, mattock in case, and crook-stick.
Nos. 7 and 8...	100-yard length of cable, two pieces tubing, two pegs, mattock in case, and crook-stick.

Orders and information. 21. Before commencing work the commander will make himself thoroughly acquainted with all orders regarding the duty he is about to undertake. He will obtain as much information as he can regarding the route to be followed by his detachment, the communication he is required to establish and all other communications to be established.

Office calls. 22. He will also obtain a diagram of the communications of which his line is to form a part, and will see that his detachment understands it.

Commencing Work.

23. On arriving at the place from which the cable line will start, the commander will give the order "Commence work."

Duties of No. 1. No. 1 takes his complete office equipment from the centre box of the limber, joins his instruments to the 15-yard lead to the commutator, or direct to the cable line if a commutator is not used, and to the "earth" lead, and establishes telegraphic and telephonic communication with No. 2 on the wagon. He remains at the base office.

He will give strict and constant attention to his instrument and will not leave it unless relieved. As soon as the office is established, he will begin a diary, recording the hour of opening; and the position of the wagon, as telegraphed to him by No. 2, noting the time against each entry.

Constant test of line. 24. In the event of five minutes elapsing between the signals from No. 2, which will consist while on the move in merely touching the key, he will at once report to the superintendent. If he be in charge himself he will at once send No. 8 along the line to remove the fault. He will expect to receive signals from No. 2 about every two minutes.

Messages. 25. If he has a message to send while the detachment is on the move he will offer it to No. 2, but will not insist on sending it until No. 2 is prepared to accept it. As a general rule a moving wagon will be stopped only for DS or SB messages.

If his office forms part of a telegraph office he will have no duties beyond sending and receiving messages, and keeping the diary referred to in para. 23. If he be in charge his further duties are dealt with in Vol. I, Chapter XXI.

26. No. 2 assists No. 1 to get his stores out, then takes his seat on the centre box, puts on his head-receiver, and exchanges calls with No. 1. As soon as the circuit is working satisfactorily, he calls out "through" to the commander. Duties of No. 2.

From this time on he will remain in his place, with his head-receiver on, giving strict and constant attention to his instrument, until properly relieved by order of the commander.

27. No. 3 unfastens the end of the cable from one of the rear drums and pays out cable as required. He hands the end of the cable to No. 8, then assists No. 4 to raise the flagstaff if one is required. He then gets the apron and glove* from the limber and takes his seat on the rear of the wagon ready to pay out the cable. Duties of No. 3.

28. No. 4 takes hammer and jumper from the foot-board of the limber, and a pole (for flagstaff), if required, from the wagon. He jumps holes for the earth pipe and flagstaff as directed by the commander. He receives the earth pipe from No. 5, fixes it firmly in the hole, and hands the end of the earth lead to No. 1. If required he takes the flag from No. 1, attaches it to the pole, and puts it up. He then returns the hammer and jumper and takes his seat on the perch of the wagon. Duties of No. 4.

29. No. 5 fetches a shelter tent complete, earth pipe, and mattock from off-side of limber. He lays out the tent and drives in front and rear pegs, he then inserts the front pole while No. 6 inserts the rear one, the two raise the tent together, No. 6 holding it up while No. 5 drives in the remaining pegs. He then returns the mattock and takes his seat on the off limber box. Duties of No. 5.

30. No. 6 dismounts, hands his horse to No. 7, and assists No. 5 to erect the tent as described above. He then mounts his horse and, taking a crook-stick in his hand, prepares to work behind the wagon. Duties of No. 6.

31. No. 7 dismounts, takes a crook-stick, and holds No. 6's and 8's horse. When the wagon is ready to move off he takes a turn of the cable round his foot and stands on it ready to take the strain. Duties of No. 7.

31A. No. 8 dismounts, hands his horse to No. 7, takes end of cable from No. 3 and end of 15-yard lead from No. 1 and fixes them to commutator under direction of superintendent. (If no commutator is used, he hands end of cable direct to No. 1.) Takes his horse from No. 7.

After the detachment has started he sees that everything is tidy, trenches in the cable if possible, sees to his horse, and remains ready to go out after a fault immediately he is called on.

31B. No. 9 obtains ground sheets, camp kettle, and rations for Nos. 1 and 8, and the latter's horse from the light spring wagon and places them where ordered. He then takes his seat on the light spring wagon.

* "Guard, hand, telegraph equipment."

Laying the Cable.

Empty drums to be dropped.

32. Each drum as it is emptied should be dropped on the ground and the cable passed through it to prevent the drum being removed. The drums should be placed as far as possible out of sight of passers-by.

Signals.

33. As the commander of a cable detachment will be usually in rear of his wagon the following signals are used to control the pace of the wagon :—

One blast on the whistle is the signal to go one pace slower or, when the team is walking, to halt.

Two blasts in quick succession is the signal for the halted team to move off at "the walk," or for a team moving at "the walk" to quicken its pace to "trot."

One long continuous blast is the signal to halt immediately.

Duties of commander.

34. The commander is responsible for the laying of the cable, the work of the office on the wagon, and the discipline of the detachment. His normal position while laying cable is close in rear of the wagon, on the opposite side of the road to that on which the cable is being laid. He controls the pace of the wagon.

Pace.

35. The pace at which the wagon is moved depends on circumstances. When speed is essential the horses may be kept trotting out well between crossings as they get rest while the crossings are being made. In working with troops the commander will endeavour to keep his wagon as near to the officer he is detailed to follow as possible, as it is important to deliver messages quickly. If it is evident that he will be unable to keep close up, he will ask the officer for a mounted orderly or a cyclist for delivery of messages.

The commander will watch the cable carefully as it is paid out, and direct No. 3 to pay out faster or slower according as more or less slack is required for it to lie well.

Tying back.

36. When the safety of the line makes it necessary that it shall be tied back at once, he will order No. 6 to tie back.

He must be prepared to take his crook-stick and work in rear of the wagon himself whenever No. 6 is occupied further in rear.

Crossings.

37. When it is necessary to carry the cable over a track or road, the commander must decide quickly how the crossing is to be made. The words of command are :—

"Pole Crossing," "Tree Crossing," "Pole and Tree," or "Bury."

He will receive the word "Through" from No. 2 every time the wagon halts, and will give him the position of the wagon to be telegraphed to the base office.

38. As soon as any interruption of communication occurs it is the duty of the commander of the cable detachment to take immediate action. He will first test his end of the circuit and ascertain that the fault is not in the wagon. Procedure when communication is interrupted.

The complete test of the wagon and its equipment is to join a telephone portable, D, to the cable just behind the wagon and to earth. If perfect signals are received in the telephone, the fault is beyond the wagon.

If this is the case, the commander will send back No. 7 (or No. 6 if No. 7 is not available) to act as lineman (*see* para. 75). He will take a " telephone portable, D " with him. The decision as to whether the detachment will remain halted or continue to lay cable while the line is unworkable lies with the commander: it depends on whether he has to keep up with a moving force; or if alone, how much time he has available to reach his rendezvous.

39. He will take care not to expose his detachment unnecessarily to the sight or fire of the enemy; to leave roads and approaches clear for traffic and to save his horses by dismounting the sappers and drivers whenever possible. He will be responsible for watering and feeding his horses at the prescribed times. Concealment from enemy.

40. He will make arrangements for the delivery of messages at the base when such arrangements are required, as No. 1 may on no account leave his instrument. When the detachment is paying out cable he will exercise a strict supervision over the messages sent, and will not allow unimportant messages to cause delay when speed is essential. He should read all messages sent or received by his office. When there is a press of work he will assist or detail a man to assist No. 2 in addressing and stamping messages for delivery. Control of office work.

41. While on the move, No. 2 will press his key at intervals of about two minutes, receiving the signals of the base office in return. If he fails to receive signals from the base he will at once so inform the commander. Duties of No. 2.

Whenever the wagon is halted for any purpose he will get into communication with the base office, and as soon as he is satisfied that the signals are good will call out " through " to the commander. He will then telegraph to the base office such information as he can give regarding the position of the wagon. Halts

41A. When the detachment arrives at its destination he will report to the officer i/c signals, and will take orders from him. If his office is to form part of a combined telegraph office it will come under the superintendent, and his responsibility as regards traffic ends. Arrival at destination

42. If he is offered a message by the base office while the detachment is on the move, he will inform the commander, stating what prefix is offered him, who will decide whether the wagon should be halted to receive the message or not. Messages.

His further duties, as to dealing with messages, &c., are given under the duties of telegraph-masters, in Vol. I.

Duties of No. 3.

43. No. 3 pays out the cable by pulling it off the drum with his hand and lets the cable run through his hand as it pays out, taking care that the slack does not catch on any projection of the wagon.

He commences running out from one of the rear drums and next pays out from the front drum on the same side of the wagon.

He will pay out very freely when the cable is being laid on the outside of a curve in the road.

Duties of No. 4.

44. No. 4 sits facing the rear and will watch the cable being laid; should the cable get caught up, he will stop the wagon by blowing his whistle. He applies the brakes as required.

Duties of No. 5.

45. No. 5 has no duties unless No. 6 and the Commander have both remained behind. In this case the wagon will move at the "walk" and No. 5 will take a crook-stick and lay the cable.

Duties of No. 6.

46. No. 6 rides about ten yards in rear of the wagon, laying the cable with his crook-stick in the position in which it is to remain. He should ride along the line in which the cable is to be laid, irrespective of where the wagon goes and should shout to No. 3 if the latter pays out so much slack that the cable sags between drum and crook-stick enough to catch on obstacles.

No. 6 should take his crook-stick in the hand on the side on which the cable is being laid, and over rough and bushy ground should hold it near the butt end, with the crook near the ground, guiding the cable to the exact spot where it will lie best.

When working round the outside of a curve in a road where a strain would pull the cable out in the road, he can save a great deal of tying back by looping the cable over bushes or stubs, or stones which will hold it in. He should loop it over something every 10 or 20 yards, choosing a definite bush or stub for the purpose and glancing behind him to make sure that the cable has been caught by it neatly. This requires considerable skill and practice to do well at a trot. On the command "Joint" he dismounts, takes the ends of the two cables, and stands on the new one with a turn round his foot to take any strain which may come from the wagon. He then makes the joint.

On the command "Tie Back" he at once dismounts, and ties back the cable to a natural holdfast, or to a peg driven by him.

Duties of No. 7.

47. No. 7 rides sufficiently far in rear of the detachment for the strain to be off the cable when he passes it. He should catch up at a crossing. The final responsibility for the safety of the line rests with him.

He should thoroughly understand what faults in laying a line are to be avoided. He will on his own responsibility correct any faults he finds, tying back and burying the cable where necessary. If the line has been laid too tight and has pulled across roads, he may have to put in an additional length of cable.

Pole Crossing.

48. On the command "Pole Crossing," the wagon halts beyond the place where the crossing is to be made. The commander superintends, and directs Nos. 4 and 5 where to jump holes and drive pegs* so as to get all the poles and pegs in line. If possible, he should direct them to use suitable natural holdfasts instead of pegs. He dresses the poles while Nos. 4 and 5 make off the stays.† He will frequently require to dismount to do all this properly. Duties of commander.

49. No. 2 reports if through. Duties of No. 2.

50. No. 3 pulls out 12 yards of slack, gets a pole,‡ a guy line,† a peg* and spunyarn. He works at the hole furthest from the wagon, puts the pole together, makes off the cable to the top of it with a clove hitch, allowing slack enough behind him to reach down the pole and leave a little slack at the bottom. He makes off the guy to the top of the pole, then holds the top of the pole over the hole that No. 4 has jumped and calls out "right" for No. 6 to measure the length of cable in the crossing. On No. 6's word "up," he raises the pole, places it in the hole, and presses it down firmly. He then ties the slack of the cable in a coil down to the foot of the pole and resumes his seat. Duties of No. 3.

51. No. 4 gets hammer and jumper from the near side of the limber, and jumps a hole for the pole furthest from wagon where directed by the commander. He leaves his jumper in the hole until No. 3 is ready to erect the pole, and drives the peg, which he receives from No. 3, 8 feet behind the crossing, and in line with the two jumpers (unless directed by the commander to use a natural holdfast instead). He removes the jumper as No. 3 puts in the pole, takes the guy line and makes it off to peg or natural holdfast, looking to the commander to get the proper strain on the pole. He then returns his hammer and jumper and takes his seat. Duties of No. 4.

52. No. 5 gets hammer and jumper from the off side of the limber, and jumps a hole for the pole nearest to the wagon, where directed by the commander. He leaves his jumper in the hole until No. 6 is ready to erect the pole, and drives the peg, which he receives from No. 6, 8 feet in front of the crossing, and in line with the two jumpers (unless directed by the commander to use a suitable natural holdfast). He removes the jumper as No. 5 puts in the pole, takes the guy Duties of No. 5.

* "Pickets, guy, telegraph, light."
† "Guys, telegraph pole."
‡ "Pole, telegraph, wood, 17-ft."

line, and makes it off to peg or natural holdfast, looking to the Commander to get the proper strain on the pole. He then returns his hammer and jumper and takes his seat.

Duties of No. 6. 53. No. 6 dismounts, hands his horse to the wheel-driver, and gets a pole, a guy line, a peg and spunyarn. He works at the hole nearest the wagon, puts the pole together, makes off the cable to the top of it with a clove hitch, holding the top of the pole over the jumper, and pulling the cable up tight from No. 3's pole when the latter calls "right." When he has done this, he gives the word "up" and raises his pole at the same time as No. 3, inserts it in the hole and presses it down firmly. He then gets his horse, ties the slack of the cable in a coil down to the foot of the pole, and stands on the cable with a turn round his foot until the strain is off it.

Tree Crossing.

54. On the command "tree crossing," the wagon halts beyond the place where the crossing is to be built. The commander superintends, and directs Nos. 4 and 5 which trees to use, and how far up to tie the cable.

Duties of No. 2. 55. No. 2 reports if through.

Duties of No. 3. 56. No. 3 pulls out about 12 yards of cable. Holds the ladder while No. 4 climbs the tree furthest from the wagon. Makes off the slack, if necessary, at the foot of the tree. Returns to his seat.

Duties of No. 4. 57. No. 4 gets the ladder or half of it from the wagon. Climbs the tree furthest from the wagon and makes the cable fast to it. When the crossing is completed, he returns the ladder and resumes his seat.

Duties of No. 5. 58. No. 5 gets the ladder or half of it from the wagon. Climbs the tree nearest to the wagon, and makes the cable fast to it. When the crossing is completed, he returns the ladder and resumes his seat.

Duties of No. 6. 59. No. 6 hands his horse to the wheel-driver. Holds the ladder while No. 5 climbs the tree nearest to the wagon. Makes off the slack, if necessary, at the foot of the tree. He gets his horse and stands on the cable with a turn round his foot until the strain is off it.

Bury Crossing.

Duties of commander. 60. On the command "bury crossing," the wagon halts beyond the place where the crossing is to be made. The commander superintends, and directs Nos. 4 and 5 in which direction to pick the trench; he should not dismount.

Duties of No. 2. 61. No. 2 reports if through.

Duties of No. 3. 62. No. 3 pulls out 3 or 4 yards of slack, fetches a spade from the off side of the foot-board of the limber, and digs out the trench that No. 4 has picked, starting from the centre of the crossing, and working to the rear. He then drops the spade, and covers the cable over with earth with his hands, after No. 4 has laid it in the trench, working again from the centre to the rear. He then returns his spade and takes his seat on the rear of the wagon.

63. No. 4 gets mattock from the near side of the limber, and picks a trench along the line of the crossing, starting from the centre and working to the rear. He then drops the mattock and, after No. 3 has dug out the trench, lays the cable in it, working from the centre again. He then returns his mattock and takes his seat on the front of the wagon. Duties of No. 4.

64. No. 5 gets a mattock from the off side of the limber and picks a trench along the line of the crossing, starting from the centre and working to the front. He then drops the mattock and after No. 6 has dug out the trench lays the cable in it, working from the centre again. He then returns his mattock, and takes his seat on the off limber box. Duties of No. 5.

65. No. 6 dismounts, hands his horse to the wheel-driver, gets a spade from the near side of the limber, and a peg, and digs out the trench that No. 5 has picked, starting from the centre of the crossing and working to the front. He then drops the spade, and covers the cable over with earth with his hands, after No. 5 has laid it in the trench, working again from the centre to the front. He then drives in a peg at the front end of the trench, making off cable to it with spunyarn. He returns his spade, gets his horse, and stands on the cable till the strain is off it. Duties of No. 6.

Reeling up.

66. The commander is responsible for the whole party. His position is close in rear of the wagon, where he can watch Nos. 3 and 6. He must be very quick to stop the wagon if the cable gets caught up anywhere. He will see that the lead driver follows the cable where possible, keeping it about 2 yards clear of his horses. Duties of commander.

67. The working of the line will invariably be continued exactly as in paying out unless distinct orders are given to the contrary. In the latter case, No. 2 has no duties while the wagon is on the move. Duties of No. 2.

68. No. 3 sits on the seat at the back of the wagon and lets the cable run through his hands as it is pulled in, distributing it evenly over the drum. Duties of No. 3.

69. No. 4 sits on the seat at the front of the wagon and attends to the wheel regulating the reeling up gear. The drum should be caused to revolve evenly and at such a pace as to keep No. 6 about 20 yards in rear of the wagon. It should be started and stopped gradually so as not to jerk No. 6. No. 4 should have his whistle constantly ready, and should be prepared to blow a long blast to stop the wagon if the cable gets caught up. Duties of No. 4.

Duties of No. 5.

70. No. 5 is spare while the wagon is on the move.

Duties of No. 6.

71. No. 6 rides in rear of the wagon, holding the loop of the cable (usually called the kink) in his crook-stick, and thus clears it off the ground while it is being wound on to the drum. He should hold his crook-stick in the hand on the side on which the cable has been laid, near the crook, pressing the butt forward and the crook back whenever a strain comes on the cable, to prevent it from jumping out of the crook. He should keep his horse in the line of the cable lying in front of him, irrespective of where the wagon goes, and should keep enough strain on the cable to pull out any slack in front of him. He should watch the cable on the ground about 10 yards in front of him, and clear it of obstacles at that distance, by pulling back and lifting his crook-stick, otherwise he will not have time. He should be prepared to pull back his horse and go slowly when there is slack in front of him to pull out, as at a crossing, and to go at a smart canter when all is clear if he has dropped far in rear of the wagon. He should use every endeavour to prevent the kink from getting behind him; if it does, and it catches in his horse's legs, he should at once ride forward until it is clear. In reeling up round a corner, he should ride well away towards the opposite direction to that in which the wagon is turning, pulling the kink of the cable with him, to prevent the cable from catching in the wheels of the wagon. If, by mischance, he drops the cable, he should gallop forward to the wagon and pick it up again close to the drum.

Duties of No. 7.

72. No. 7 rides on ahead of the wagon and clears the cable, so that it can be reeled up without delay. He will clear it away from all bushes, &c., on which it may be caught, leaving it lying clear of the road. Wherever the cable has been tied back he will remove the spunyarn.

He will clear the cable from all buried crossings.

At the end of each length of cable he will dismount and undo the joint. If the line is still being worked, he will hold the ends of the cable together until the wagon comes up.

72A. On arrival at a crossing the wagon passes it and halts. Nos. 3 and 4 take down and dismantle the pole or attachment furthest from the wagon, No. 4 fetching and returning the ladder and climbing the tree if required. No. 5 takes down and dismantles the pole or attachment nearest the wagon by himself, unless communication has been dispensed with, in which case No. 2 will assist him. No. 5 will fetch and return the ladder and climb the tree if required, No. 2, if available, returning the stores.

Each number on completion of the work will resume his seat on the wagon.

Fast Cable.

73. When it is required to lay cable as fast as possible and two cable detachments are available for work, one detachment

will lay the cable while the other detachment will follow, erecting the crossings and making the line safe.

No. 5 of the leading detachment and Nos. 1 and 2 of the rear detachment have no duties.

No. 3 of the leading wagon will be careful to see that sufficient cable is left at road crossings to enable the line to cross overhead.

No. 7, leading detachment, and No. 6, rear detachment, will be employed by the Commander of the leading detachment to watch the cable at road crossings until the rear detachment comes up and to tie back where necessary.

No. 7 of the rear detachment will follow both detachments.

Slow Cable.

74. If cable must be laid at night and it is too dark for ordinary working, Nos. 6 and 7 must dismount and give their horses to the drivers to lead. Particular care must be taken to leave plenty of slack, and linemen must be sent through from both ends at earliest dawn.

If lights are allowed, one lamp should be placed on the limber to throw a light on the drum and one hung on the rear of the wagon to throw a light behind.

Linemen.

75. When a fault occurs on a cable, a lineman shoulb be as once sent out from each end. He will be equipped with telephone portable D, crookstick, mattock, and a 100-yard length of cable.

If the line is less than 4 miles long, he will run the cable through his crookstick until he finds the fault or meets the other lineman. If the line is longer, he will proceed at 6 miles an hour to the first drum, where he will tee in with his telephone, repeating this until he has located the fault within a 2-mile length. He will then run through this length with his crookstick until he has found the fault.

When an interruption occurs, the base operator will at once commence sending dashes and calling "base" into his hand telephone; the wagon operator will similarly send dots and call "wagon." It will then be unnecessary for the lineman to speak at all. Intermediate offices should act as "base" to "wagon" and as "wagon" to "base."

The lineman must not return until he has satisfied himself that the line is right by listening for more signals with his telephone.

76. Cable lines which remain out for more than a few hours will be patrolled by a lineman at least once a day, or oftener if ordered. The lineman will act generally as laid down in Chapter III, para. 3, (1) to (9). Particular attention will be

paid to the safety of the line, especially at crossings. The cable should not be run through the crookstick unless it is desirable to place it in a different position.

Use of Third Office.

77. The third office carried in the light spring wagon, and No. 9, can be used in various ways, of which the following are the more common :—

(*a*) On a cable line over 10 miles long to act as a testing point midway. If possible, one or two linemen should be left here.

(*b*) To serve a Unit lying on the route of the cable. In this case special arrangements must be made for orderlies for delivery of messages.

(*c*) To alternate with the base office when the latter is to be moved further along the line, owing to tactical requirements.

Long cable lines

78. If long cable lines are required, it is frequently impossibie to pick them up with the same detachment. In such cases the detachments should be worked in pairs, one running out, while the other remains behind to reel up when the line is no longer required. Cable and stores to the amount probably required are handed over to the leading detachment from that remaining behind. No. 9 and the third office of the reeling-up detachment should be taken on and dropped to form a testing point, where should also be sent the Nos. 8 of both detachments. The reeling-up detachment should supply the base office, No. 7 acting as base lineman.

CHAPTER II.

ERECTION OF AIR LINE.

Introduction.

1. The air line equipment is designed for field telegraph lines, it can easily be carried in wagons and can be erected quickly. **Speed of laying.**

Light field telegraph lines will frequently lose much of their use unless they can be erected quickly. In average English country, air line should be erected at a pace of not less than 1 mile per hour. In open country it can be erected much faster. A detachment should be able to erect at least 5 miles of line and do an average day's march. Three or four such detachments should, provided material is available, be able to place the headquarters of a force, which includes infantry, in communication with the base, by means of air line, at the end of every day's march.

An air line section consists of two air line detachments, under a subaltern, and includes a cable wagon without a detachment. When a line of any considerable length is to be run, the senior officer marches the detachment along the route to be followed, dropping them to commence work at suitable distances. The section officers will, as a rule, accompany him until their leading detachments are dropped, and then return to the rear detachment; but the cable wagons should remain with the rear detachments of each section, until required. Each section officer is responsible for the work of his two detachments, and that the line built by them is in good condition throughout.

When a Commander (the subaltern and his cable wagon being with the other detachment) finds that he must use cable instead of air line, he sends a mounted man to inform the subaltern of the length required and locality: the subaltern will use his discretion as to whether he sends the cable wagon at once or carries out the work when the rear detachment arrives at the locality.

Each detachment, after it has finished its portion, is responsible for correcting any faults or repairing breakdowns in the line built by the other detachments as it passes along it; or for building more line in case a detachment has got delayed from any cause.

To accomplish this, detachments must be thoroughly trained in rapid construction of air line, and every individual should have his special duties allotted to him.

The principles, details, and drill here laid down are the the result of many years' experience. Variations in detail may, in exceptional circumstances, be necessary. As, however, the officer or N.C.O. in command of a working detachment will usually have some experience, it is not necessary to teach variations.

Principles of Air Line Construction.

2. In erecting air line there should be as few angles as possible, because every angle is a source of delay, owing to the necessity of staying or strutting the pole at the angle, and also frequently a source of weakness in the line.

Attachments to trees, buildings, or permanent poles are very useful to strengthen the line, especially at sharp angles and road crossings, but as they require additional time and stores to make, they should not be resorted to too freely.

Stayed poles are more quickly erected than strutted poles, they take less material and are stronger. Strutted poles should only be used where there is not sufficient space clear of traffic to stay an angle back properly.

Avoid traffic.

3. The poles should be erected beyond reach of any traffic; but if the line runs far from a track which the wagon can follow, much time will be spent in carrying poles and stores across country, and linemen patrolling the line will have difficulty in following it. If the wire barrow cannot follow the line, additional time will be spent in erection, as the wire will have to be cut and pulled by hand.

It is of the utmost importance that poles and stays should be placed clear of traffic. On high roads, when troops are moving, and especially in the neighbourhood of camps, there is frequently a block, causing the traffic to extend from hedge to hedge; in such cases the only safe position for the pole is in or over the hedge. In open countries, on active service, convoys frequently guide themselves from camp to camp by the line, with disastrous results. It is worth while choosing a somewhat less direct route for the line in such places, and taking it over natural obstacles, to discourage troops from following it. If a pole has to be erected near traffic, it should at once be protected by a mound of earth or stones.

Protect poles in dangerous places.

4. No matter what precautions are taken, or how stringent the orders published on the subject, light poles will inevitably be overturned if placed where men and animals congregate. Should it be impossible to avoid erecting poles in such positions, extra strong ones should be selected, and they should be banked up, fenced with stones, and surrounded with prickly bushes, if such can be found, as early as possible. Great trouble

was experienced in South Africa with mules out grazing. The best remedy was to dig a ditch round the pole about 3 feet away from it, piling the earth up into a bank outside the ditch, or round the pole inside the ditch.

Crossings. 5. The line should cross roads as seldom as possible, as there is always a danger lest a break in the line may lower the wire and make it a source of danger to traffic. Drivers' whips are also liable to become entangled in the wire and pull it down.

Fifteen feet in the clear in the centre of the span will be found sufficient for all probable requirements. Without the aid of natural supports, double poles are required to give this height; and as double pole angles are inadvisable, it becomes necessary to obtain a straight run of at least three bays, which, in many cases, requires a great deal of skill. A high bank will often give a safe position for a single angle pole of the required height, but a tree or other solid attachment is the best for an angle at a crossing. A hanging insulator on a long tail can very often be used with advantage. Crossings are also required over the gates of fields in the hay and harvest seasons, but these generally present no difficulties.

Occasionally it is necessary to cross a road where no natural supports are available, and where it is impossible to obtain a straight run of 3 bays. The line should then be terminated on each side of the road, and a slack bay of wire run across on double poles between the terminal poles. The terminal poles should be completed in the ordinary way, and the double poles and slack bay erected like a cable crossing (see Chapter I, paras. 50 to 53), the ends being left long enough to joint on to the line wires with the aid of a half ladder.

Localise breakdowns. 6. It is necessary at intervals along a line to arrange that, if the wire breaks, the effect of the break shall be localised, and that the wire shall not hang in a position where it is dangerous to traffic, especially at roads.

In order to do this, the wire is bound in to the insulators at intervals—in a straight run, usually to every fourth insulator: on both sides of a road crossing; at every angle or stayed pole.

Approximately every eighth pole should be stayed fore and aft, *i.e.*, in the direction of the line. If time admits, fore and aft stays should also be placed at each end of a bay exceeding 120 yards, or important road crossing.

Spacing poles. 7. Twenty-two poles per mile are provided, and consequently poles will be spaced about 80 yards apart. The distances between poles will, however, vary according to the nature of the country.

When the line passes over spurs, poles must be placed closer together to ensure a clearance of 10 feet throughout the span; when the line crosses valleys, the poles may be placed further apart.

Woods. 8. Even under the most favourable circumstances, air line through woods is tedious and troublesome. Frequent tree attachments cause great delay, and it is difficult to clear intermediate trees and branches without a great deal of clipping. In rough weather, boughs will fall and break the line, and in wet weather, boughs which cleared it above when dry will sag down on to it. It will often be found best to run a cable through woods, tying it up securely to the trees; and every air line section is provided with a cable wagon for this purpose among others. A cable lying on the ground, and connected to air line, is very liable to damage by lightning.

Contacts. 9. Contacts with thick boughs or buildings must be avoided at all costs, as they constitute bad earth faults. It is desirable also to avoid foliage, though it is frequently impracticable, from want of time, to completely prevent contacts with the outer twigs. Many of them on a long line will cause a considerable loss of current in wet weather.

It will frequently be necessary to insert a short length of cable to avoid contacts, and two 88-yard lengths are carried on the air line wagon for this purpose

Swamps. 10. In wet or swampy ground poles are very apt to sink and stay pegs to draw. It has also been found that poles standing in water or in very damp ground are specially liable to be struck by lightning.

Entering camp. 11. Angles should be avoided in a camp; the line should be taken to such a position that a straight run can be arranged to the terminal pole, and then run in on double poles.

*Details of Air Line Construction.**

Jumping holes. 12. The holes for air line poles are usually made by two men with a "jumper" and two "hammers, R.E. telegraph sledge."

The jumper is placed vertically in the ground, and held there by one of the men while the other hits it a few blows with the hammer till it stands of itself. Both men then strike the jumper alternately, until it is 18 inches deep in the ground, taking care to keep it absolutely upright. It is then loosened by a few blows on each side, but is not withdrawn until the pole is ready to be placed in the hole, otherwise it is difficult to find the hole, which may also get filled up. In very sandy ground it is necessary to pour in a little water before withdrawing the jumper.

Some skill is required to strike fair blows on the jumper, as an inexperienced man, by missing the jumper, may break the hammer handle, or by bringing the edge of the hammer down on the jumper may chip the latter. The hammer should be firmly grasped with both hands, and swung round a complete circle with the full length of the arm. The hands must not be

* For details of stores used, see Chap. IV.

allowed to slide up and down the handle. At the moment when the hammer head strikes the jumper the handle of the hammer should be horizontal. Thus as the jumper goes further into the ground the hands must be lowered nearer the ground at the end of the swing.

13. Dry joints are made in the following manner:—The ends of the wires are well scraped with a knife from 6 inches from the end to 12 inches from the end, care being taken not to unstrand the wire. The cleaned ends are then placed across each other at right angles, at 10 inches from the end, and each in turn is twisted tightly round the standing end of the other, the turns being made as tight as possible, and close up to each other, until the ends are only 6 inches long. Each side is then pinched up tight with the pliers, the greatest care being taken to avoid touching the wire with the cutters. The ends are cut off short, and pinched in with the pliers, to prevent them from cutting the hand when the wire is handled. *See* Fig. 1. Jointing the wire.

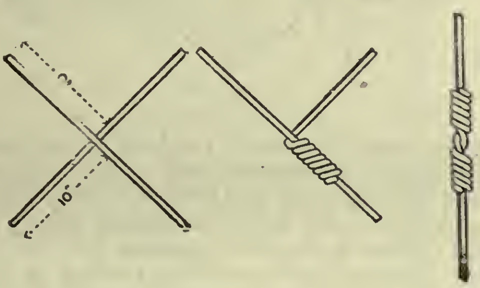


Fig. 1.

14. Binding in is performed as follows:—The line wire is placed in the slot of the insulator, and the pole given a quarter turn, so that the wire engages under the corners of the slot. The insulator is held nearly horizontal, and the pole twisted so that the upper portion revolves from left to right, and that the wire is engaged under the lower left and upper right corners of the insulator. The binder (a piece of wire, similar to the line wire, 12 inches long) is then placed with its centre in the slot, on the top of the line wire, and so as to engage with the upper left and lower right corners, lying across the line wire nearly at right angles. Each end of the binder is then bent round the outside of the insulator, to the opposite side, and twisted three or four times round the line wire, always starting underneath the line wire. The turns are made tightly, and close up to the insulator, and are pinched up with the pliers, leaving the ends standing up vertically to assist in unbinding and to make the fact that the pole i, Binding in to straight insulator.

s

bound in clearly visible. The ends are cut off to 1½ inches long. If a binder is properly put on, the line wire cannot slip through the insulator, whatever the strain. *See* Fig. 2.

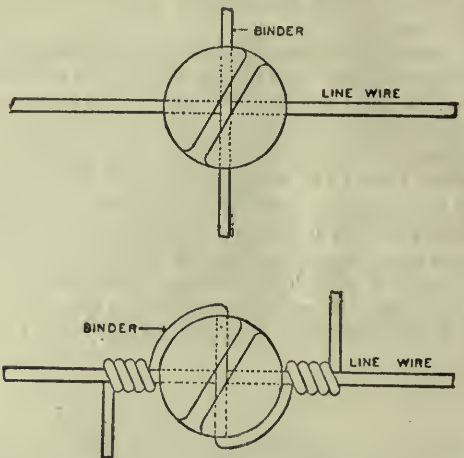


Fig 2.

Binding in to hanging insulator.

15. The line wire is placed in the hook of the insulator, and a binder placed also in the hook, with its centre across the line wire and at right angles to it. Each end of the binder is then passed tightly round the hook, and wound tightly four or five times round the line wire on the opposite side, as in the case of a straight insulator, the turns being pinched up tightly with the pliers, and 1½-inch ends left projecting (*see* Fig. 3).

Fastening off wire.

16. A wire is made off as follows:—Take two turns with the wire, at about a foot from its end, round the insulator shank or holdfast to which the wire is to be fastened off; then take two sharp turns round the wire itself, close to the shank or holdfast. The end should be cut off to 1½ inches long, and left standing out at right angles, to facilitate unbinding. As, however, it is inadvisable to shorten stays which will be required for use again, the bottom end should not be cut off, but the spare end should be run lightly but neatly along the wire.

Paying out wire.

17. The line wire is payed out from a drum carried on a barrow. Two men are required to pay it out.

At all times a light but steady strain should be kept on the wire, as, if it is allowed to lie loosely about, it will spring into coils; these coils will not pull out when a strain comes again, but will form kinks, which will have to be cut out. The most careful attention is necessary at each angle, as, while the strainer is moving round into the straight, the wire is necessarily slacked. On the caution "Wind up the slack" from the strainer, the wire must be carefully wound up by hand. If by mischance the wire behind does fly into coils, they must be treated very carefully; one man should wind up the drum slowly, while the other goes back and puts them straight before they have had time to form kinks.

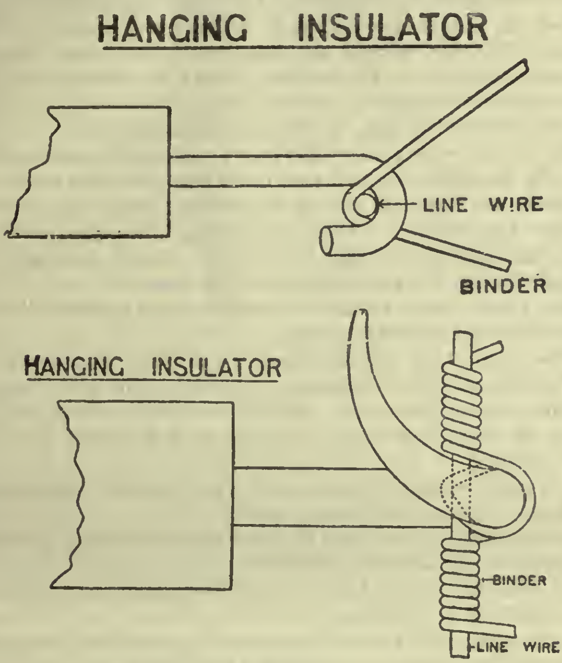


Fig. 3.

18. The normal position of the barrow is $1\frac{1}{2}$ bays in front of the front strainer, and this should not be exceeded unless the wire is to be cut and pulled back, in which case the barrow should be taken at once to the point where the line is again accessible, and the end pulled back by one man, the other steadying the drum as it revolves. It is sometimes also desirable to increase this distance of $1\frac{1}{2}$ bays at the very end of the drum, to avoid checking the strainers while the drum is changed. In crossing traffic, the barrow should be kept on the near side of the traffic till the front strainer is up to it, to obviate stopping the traffic longer than necessary. Position of barrow.

19. The barrow follows the line of poles put up by the front party. Care must be taken to go to the proper side of permanent attachments, such as trees, and to go in a direct line from attachment to attachment. If hedges or bushes intervene, the wire must be lifted into the proper line as far as possible, help being obtained if necessary. Route of barrow.

Care must be taken to cross ditches at right angles, so that both the wheels of the barrow take the weight equally, otherwise the axle is likely to be bent.

Straining wire.

20. In erecting air line the line wire is strained as follows:—

The wire is held by means of "apparatus, repairing, wire," attached to a belt worn round the hips of a man called the strainer. Two strainers are required; they take the strain alternately, standing 1½ bays in front of the builder when working in the straight, and as far as possible, but not more than 20 yards from him, in the case of an angle.

The strainer nearest to the party which is erecting the pole will keep the strain on the wire until that pole has been erected, and until he has told the next strainer, one bay further on, to "take the strain." Then on feeling the wire behind him tauten, he will gradually let go the strain and will double forward to take the strain again in his turn.

The strain will always be taken in the direct line of the poles which are already erected.

When an angle pole is being erected, the strainer will take care that there are no obstacles to prevent him swinging round into the new alignment. He will do this when the pole is erected, at the same time shouting to the barrowman "Wind up the slack."

It is unnecessary to lean heavily on the wire; the main point is to have an even and steady strain.

Before taking the strain the feet should be firmly planted in the ground, and should not afterwards be moved.

Commencement of line.

21. The line should when possible start from a permanent pole, a tree, or a building.

If no convenient tree, permanent pole or building is available, it will be necessary to erect a terminal pole.

When working in the manner described in para. 1 each portion of the line, except the first, should be commenced by making fast the line wire to a natural holdfast: there is no need to start from a hanging insulator.

Hanging insulator with tail.

22. A hanging insulator is fastened to a building or tree by a tail. A tail is made by taking a piece of wire of suitable length, doubling it, and making off one end of it to the hook at the end of the hanging insulator furthest from the cup in the usual manner, viz.: two turns round the hook and then two turns round the wire. The other end is then available to make off to a "bent shank," or round a pole or tree. The ends of the tail should be left projecting 1½ inches to facilitate dismantling.

If it is desired to keep the hanging insulator close to the holdfast it may be made off as follows:—Place the hook of the insulator in the centre of a piece of wire, and twist the ends together twice close to the insulator. Then pass the ends round the holdfast, and back again, and twist them together close to the insulator, leaving the ends projecting 1½ inches.

23. A "link, pole" is screwed into the top of a stout pole, and a hanging insulator hooked into the eye of it, cup away from the pole. If a link is not available an ordinary insulator shank can be used, and a hanging insulator with tail used. Three double stays are made off round the neck of the "link, pole," each stay being made off separately. Terminal pole.

24. A double stay is made by taking 10 yards of wire, doubling it at the centre and twisting the parts together. Double stay.

25. The ends of the stays will be made off to pegs or other holdfasts, which should be in one line at a distance of 7 feet from the foot of the pole. Holdfasts.

The centre holdfast should be in the alignment of the terminal pole and the next pole to be erected, the outer holdfasts about 3 feet on each side.

If pegs ("pins, tent, wood, large," or "pegs, stay, telegraph") are used, they will be driven in flat side towards the pole, and sloping against the strain of the stays.

26. Before the terminal pole is erected the end of the line wire will be made off to the hook of the hanging insulator at the cup end, and the "lead" to the terminal office will be connected to the line wire as follows: Remove the insulation for about 4 inches, and scrape the conductor clean with a knife, leaving 2 inches of insulation at the end to prevent it from unstranding. Scrape also 3 or 4 inches of the line, just clear of the hanging insulator if the line is terminated. Fasten the lead with a clove hitch round the top of the pole, about 14 inches from the end of the insulation, and twist the end round the hanging insulator until the cleaned portion of the lead will just reach the cleaned portion of the wire. Lay the cleaned portion of the lead along the cleaned portion of the overhead wire and bind it securely there with a binder, the ends being left projecting $1\frac{1}{2}$ inches. Connect "lead" to line.

The terminal pole can now be erected. It will be firmly planted in the hole which has been jumped for it.

The centre stay will be made off first sufficiently tight to give the pole a slight set against the strain of the line wire.

The outer stays will then be made off, care being taken that the pole does not lean to either side, and that the stays are all taut.

27. Every stay which might, through its invisibility in the dusk, be a source of danger to men or animals, should be marked so as to attract attention. Marking stays.

To mark a stay, a piece of wood or a branch should be tied to it at a suitable height, to attract attention.

If nothing else suitable is available, a 13-foot pole should be used.

When marking a single stay, the marking pole should be bound to the stay and the upright pole in such a position that its base rests on the ground about 1 foot outside the stay peg or holdfast, and that it crosses the upright pole at a height of about 6 feet.

When marking two or more stays, the base of the pole should rest on the ground beyond one of the outer stay pegs; the pole should be bound to each stay in such a position that the top of the pole is about 8 feet above the ground.

To bind a marking pole to a stay or pole, take a turn round the stay or upright pole with the centre of a piece of wire and twist the ends together twice, pinching the turns up tight with pliers, so that the wire will not slip. Then pass the ends round the marking pole in opposite directions, and twist the ends together again tightly, leaving the ends projecting 1½ inches to facilitate dismantling.

Tightening stay peg.

28. No stayed pole should be left until it has been ascertained that the holdfasts for the stays are thoroughly secure. If it is necessary to drive a stay peg in further, after the stay has been made off to it, the strain of the stay wire will be taken off the peg by pulling on the stay with pliers before driving in the peg, care being taken to turn the cutters away from the wire.

13-foot light pole.

29. The normal support for the line wire is a light 13-foot pole, with an insulator on a shank screwed well home into the pole.

To erect this pole it is held between the knees with the insulator near the hole, but 2 inches on the side towards the finished portion of the line when working on the level. If the last pole erected stands on higher ground, this distance must be increased, and *vice versâ* if the last pole is on lower ground. The wire is then placed in the slot of the insulator, and the pole is given a half turn to fix it there; the pole is then planted in the hole, pressed down firmly, and packed at the base with small stones, &c., care being taking that it is truly vertical.

Double pole.

30. Double poles are required at road crossings, and where additional height is necessary. A double pole is made by fixing an 8-foot pole, with an insulator, on to a stout (octagonal) 13-foot pole, by means of two clips placed at 3 inches from the ends of the overlap and nutted up tight with a spanner. The overlap should be at least 3 feet.

In preparing a double pole, care should be taken to keep the two poles truly parallel.

The line wire should always be bound in at a double pole, and judgment must be exercised in the distance from the hole at which the insulator is held for this purpose. Care must be taken that a double pole is left standing truly vertical. The two poles forming its parts should be in the same plane as the line wire, and the base should be well rammed with stones.

Angle pole with stays.

31. At angles a stout pole should be chosen, and for angles with a deviation of less than 30° from the straight an ordinary insulator and one stay will be required.

For angles of from 30° up to 60° from the straight (A to B, Fig. 4) two single stays and a hanging insulator should be used. For 60° up to 90° (B to C) three single or two double stays and a hanging insulator. For 90° (C) three double stays and two hanging insulators on tails, the wire being terminated and bridged over. The bridge is made by leaving enough wire when the ends are cut off to joint together: the bridge should stand out clear of contacts.

A stay wire should be made off to the shank of the ordinary insulator with one turn above and one turn below the nut.

Angle poles with hanging insulators are prepared in the same way as a terminal pole.

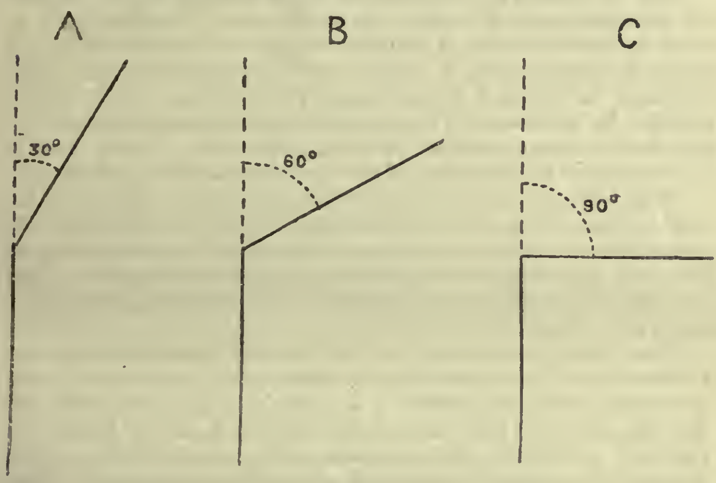


Fig. 4.

32. The greatest care will be exercised in the selection of proper holdfasts for the stays; they should, as far as possible, be trees, stout bushes, or fencing posts, and the stays will be run as nearly as possible horizontal. When stay pegs are used they should be driven firmly into the ground at least 5 feet from the base of the pole. Iron stay pegs are provided for use when the ground is too hard for wooden pegs. Selection of holdfasts.

33. When one stay is used, the holdfast should be in the line which bisects the angle made by the line wire of the bays on either side of the angle pole. Position of holdfasts.

When two stays are used, their holdfasts should be about 4 feet apart on opposite sides of the bisecting line.

When three stays are used, the centre stay will be in the line which bisects the angle and the other stays equidistant on either side.

Some practice is required to judge the position of the bisecting line correctly. In teaching men to do this, it will be found useful to lay poles on the ground at the angle with their ends touching the angle pole and their lengths in prolongation of the two bays.

Making off stays.

34. In making off the stays of a two- or three-stayed angle, the stay nearest the strainer should be passed round its holdfast, and held there by one man while the strainer moves halfway into the new alignment; another man should then dress the pole, and order the stay to be tightened or loosened as required. It is then made off, and the next stay held round its holdfast until the strainer is in the new alignment, when the pole should be dressed again, and the stay made off.

Angle pole strutted.

35. A strutted pole is essentially a stayed pole with the pole on the slant, and the stay nearly vertical. Another pole is used to erect it, and is left in the ground to stiffen it. To make a strutted pole a stout pole is required with a straight insulator in it, and an ordinary pole with a "link, pole" screwed in, the shank of the insulator being passed through the link before being screwed into the stout pole. A stay wire is then made off to the shank of the insulator as described above.

If a "link, pole" is not available an insulator shank can be used instead. The shanks should be withdrawn sufficiently to allow of two turns of a binder being taken below the nuts in the form of a figure of 8, and the ends twisted together. The poles should be laid close together. The usual stay should be made off to the strut.

The most usual place for this form of pole to be required is where the line runs along a hedge on a convex curve, and it is frequently very difficult to erect neatly. The poles are laid together on the ground, or held in a nearly horizontal position, with the tops over the hole, and the butts in the direction in which the strut is to stand when finished. The wire is then bound in in the usual way, and the two poles raised together as one; one man then holds the pole with the link in it erect, while another man places the strut (with the insulator in it) in position, so that it has a firm place to butt against, when the upright pole is in the hole and leaning 3 inches against the strain. Sometimes the strut pole can best be fixed by lashing it to a tree with wire; sometimes it will have to be lifted right over a hedge. When both poles are quite firm, and pushed well home, the stay is made off to a holdfast at the foot of the upright pole, to prevent the whole construction from turning over when the strain comes on it. When the ground falls away behind the pole it will frequently be necessary to use a double pole for the strut.

Fore and aft stays.

36. Fore and aft stays are stays in the direction of the line, one on each side of the pole, to localise the effects of a breakdown. A stout pole is used, and two stays are made off to it in the usual way. The pegs are driven each side of

the hole, in the line, and 7 feet from the hole. A stay-guard should be left. Particular care should be taken that the stays are left taut and that the binding in is firm, otherwise the pole is comparatively useless in case of a breakdown.

Rocking stays. 37. Rocking stays are similar to the above, but the pegs are placed at right angles to the line instead of in it. They are more usually added afterwards by a strengthening party or the lineman.

Rocking stays are required to steady the line in exposed places where the wind would cause it to rock dangerously.

Attachment to trees, buildings, &c. 38. A hanging insulator fastened to a natural holdfast is the best form of support for a sharp angle. A tail is passed round the holdfast, and then several times round the standing part. A bent shank can also be used if necessary for securing a "tail."

Unless the tail is so long that the insulator stands more than 2 feet clear of the natural holdfast a guard wire should be provided, made from a stay, made off above and below the insulator, and standing out stiffly in a bow round the line wire.

Bent shank. 39. A bent shank can be used for attaching a straight insulator, or for securing a tail for a hanging insulator. It can be either driven direct into a tree or brickwork, or nailed up with two $2\frac{1}{2}$-inch clout nails. When used for securing a tail it should be driven in at right angles to the strain, and if into brickwork care should be taken to choose a joint several bricks from the edge, or there is danger of loosening the last brick.

On permanent poles. 40. For attachments to permanent wood poles a bent shank should be used, nailed on. A wire should be bound round pole and bent shank as well; at the top of the lower half of the bent shank if the strain is outwards, at the bottom if it is inwards.

Terminating. 41. A terminal pole is slow to erect, and not over strong; advantage should always be taken of suitable natural supports, such as trees, in commencing and finishing a line.

To terminate a wire on a hanging insulator on a tree or other natural holdfast, the slack wire is passed through the hook of the insulator, and then strained beyond it. A strainer is then buckled round the bough, in the "longest" hole, and clipped on to the wire as far out as it will reach. The strain is then pulled up hole by hole until a little more than the requisite strain is attained, and the wire cut and made off to the insulator in the usual way. The strap should be arranged so that the buckle is close to the strainer before pulling up.

When a double termination and bridge is necessary on a natural holdfast, the wire, as soon as it is cut, should be joined to the second hanging insulator. Enough wire should be left at both insulators for the ends to be jointed together into a bridge standing well clear of any contacts. The ends of the joint should be left standing up $1\frac{1}{2}$ inches.

To terminate the line on a pole with hanging insulator, the strain is taken 5 yards short of the pole, and the end of the line wire made off to the insulator, the length of line wire required being measured by holding the top of the pole to which the insulator is attached over the hole, but 2 inches towards the finished line. The pole should have three double stays, and, after the line has been made off to the insulator, the other strainer takes the strain at the extreme end of the centre stay while the pole is being erected, the first strainer taking his instrument off. The outside stays should be made off first.

41A. At intervals on the line, depending on circumstances, but perhaps 3 miles apart, arrangements should be made for the lineman to disconnect for test. A joint without a strain on it is required: if a bridge at a double termination which is accessible without a ladder occurs, no further arrangement is necessary. If not, a hanging insulator should be inserted in the line close to an ordinary pole, which can easily be taken down. This insulator should be bridged over, the joint being in the middle of the bridge and having the ends left projecting 1½ inches.

Air Line Drill.

42. A detachment for the erection of air line consists of—

1 officer or N.C.O. mounted as commander.
10 dismounted men of whom two should, if possible, be N.C.Os.
1 mounted man.

It is divided into two parties: The front party commanded by No. 1 is responsible for laying out the line, making holes for poles, preparing poles, and fixing insulators. The rear party commanded by No. 5 lays out the wire, strains it, fixes it to the insulators, and erects the poles.

Duties of the commander.

43. The commander, besides being responsible for the work of the detachment, selects the route which the line is to take. Considerable practice is required to do this properly: he must always have a clear idea in his head as to how the next half-dozen bays are to be constructed. For this purpose he must constantly ride ahead, leaving directions with No. 1 as to how to proceed in his absence.

When a length of line in the straight appears possible he should go on to the far end, and give a signal for No. 1 to align on. If the straight run is not more than 4 or 5 bays, he can choose, and mark the exact site for the next angle, selecting a spot which will be convenient for the next portion of line.

It is convenient for him to carry a couple of small flags, to show the line distinctly, and to leave to mark the point he has chosen for the next angle.

In designing the line he must bear in mind speed in construction, security from damage by traffic, ease of maintenance, good insulation, and economy of stores.

Whenever possible he will ride back and see that the rear party is carrying out its work properly and keeping up.

He is also responsible for seeing that the horses are watered and fed at the prescribed periods.

44. No. 1 should, if possible, be a N.C.O.; if not, an experienced sapper. He commands the front party, consisting of Nos. 2, 3, and 4, and is responsible that the orders of the commander as to the design of the line are properly carried out. He superintends the jumping of the holes, taking care that the line of direction is properly kept and that each pole is in the best possible local position, *i.e.* :— Duties of No. 1.

(1) That the pole is on the highest ground available.
(2) That it is not on a footpath or too near a road.
(3) That it is not exactly opposite a gap in a hedge.
(4) That if the ground is sandy, the chosen spot is moist, or has grass growing on it.
(5) That, if possible, it is near a bush, or stone, or piece of rough ground, which would deter traffic.
(6) That if it is to be an angle pole there must be room for the stay, and if possible a natural holdfast, such as a railing, tree, or bush, to fasten it to.

During any temporary absence of the commander he carries on with the line according to his last instructions. He will take an early opportunity of warning No. 6 of a point where the line becomes inaccessible for the barrow, in order that he may lose no time in cutting the wire, taking on the barrow, and pulling back the end of the wire.

45. Nos. 2 and 3 each carry a "hammer, telegraph sledge," and one jumper between them. Duties of Nos. 2 and 3.

They jump the holes for poles, pace the distance between poles, which will usually be about 80 yards; in the absence of No. 1, select the exact spot for the pole, as follows:—

The line is taken by standing with the heels together facing the line of poles, holding the jumper, point upwards, in front of the face. The position of the hole is found by moving right or left to get in line with the poles already erected, and backwards or forwards to get the best place. In the case of a fresh alignment the man holding the jumper as above should face No. 1 and move as he directs for the line. When the spot is obtained, the jumper is placed in the ground in the angle between the heels.

They will also fix all insulators to trees, buildings, and permanent poles as directed by No. 1.

46. No. 4 should be an experienced sapper, as he is wagon man, and has charge of the wagon and all its stores. He is responsible that the wagon is properly loaded before starting, that the cask is filled with water, and that the wheels are greased. Duties of No. 4.

His position in working is in rear of the wagon, where he prepares the pole required for each support, as ordered by No. 1; he leaves poles, insulators, and all other stores that are required by the builder for the complete pole or attachment.

He must use his discretion as to the amount of work he does on each pole, according to whether the front or rear party are working the faster, but should always screw in insulators and "links, pole," and drive in stay pegs.

He will arrange his stores for work as follows:—

Straight insulators, preferably screwed into the poles beforehand; if not, in a tool basket slung on the chain of the tailboard.

Hanging insulators, links, pole, bent shanks, and nails, in a tool basket slung on the chain of the tailboard.

Stay pegs, on the deck of the wagon, behind the rear box.

Stay wires, coiled up, and hung on horns on each side of the tail of the wagon.

Maul, on the deck of the wagon, behind the rear box.

24-oz. hammer, and spanner, in tool basket.

He will be especially careful that no stores fall off the wagon and are lost, and is held responsible that this does not occur.

He will arrange to have a double pole and a strutted pole always ready in case they are called for.

Duties of No. 5.

47. No. 5 is the N.C.O. in charge of the rear party, consisting of Nos. 6 to 11, and is responsible for the building of the line, and that it is left in a safe condition. He assists No. 10 when not otherwise engaged, but must exercise a strict supervision over all the rear party.

The following points call for particular attention from him:—

(1) That 6 and 7 pay out the wire evenly, and do not allow slack to lie about; and that they keep $1\frac{1}{2}$ bays in front of the front strainer.
(2) That 8 and 9 keep an even steady strain on the wire.
(3) That each support is built strongly, and strictly in accordance with the authorised methods.
(4) That all poles in the straight are left truly upright.
(5) That all angle poles are set slightly against the strain.
(6) That every angle pole, double pole, fore and aft stayed pole, fourth pole in the straight, is bound in.
(7) That all holdfasts are firm, and in the right place, and all stays tight.
(8) That all stays dangerous to traffic are marked.
(9) That the wire is everywhere of the authorised minimum height, 10 feet in ordinary bays and 15 feet at crossings.
(10) That the wire is left free from contact.

Duties of No. 6.

48. No. 6 pulls the barrow, working in the front shafts. He assists No. 7 in all his duties. If the wire has to be cut, he pulls the end back, and makes the joint.

Duties of No. 7.

49. No. 7 pushes the barrow, running the wire through his hand as it pays out, to detect bad places. He wears an apron

and glove* to protect himself from being cut by it. If a bad place is detected, he must at once halt the barrow and cut it out, and make a fresh joint.

50. Nos. 8 and 9 both carry "apparatus repairing wire" attached to their hips by belts. They alternately take the strain on the line wire in front of No. 10 at a distance of $1\frac{1}{2}$ bays in a straight run. They are responsible that all bad joints and weak places in the wire are cut out and that there are no kinks. When going forward to take the strain a strainer will always pass the wire through his pliers as he goes forward and inspect it. **Duties of Nos. 8 and 9.**

51. No. 10 has a very responsible position and should be an experienced man. He carries a mallet, a supply of binders and a spare stay. He binds in, erects poles, makes off stays, rams in the holes and generally completes the line. **Duties of No. 10.**

52. No. 11 (mounted man) is at the disposal of No. 5 for work where required. His chief duties are as follows:— **Duties of No. 11.**

(1) To clear the line of small contacts, working with a crook-stick in rear of No. 10.
(2) To fetch any stores that may be required from the wagon.
(3) To assist in carrying poles when the line is being built along a route which the wagon cannot follow.
(4) By continually riding back for 5 or 6 bays to ensure that the line is standing satisfactorily behind, and that all holdfasts are secure.
(5) To assist No. 10 when the country is so easy that he is not required for other duties.

Dismantling.

53. The commander is in charge of the party, exercises a general control, and assists at any point where help may be required. **Commander.**

54. No. 1 is in charge of the front party, consisting of Nos. 8, 9, and 10. Nos. 1 and 10 each take one of the spare strainers from the wagon, and the party works in front, taking out the poles, unbinding them, and laying them down by the roadside, butts to the front. Stay pegs also are pulled up and placed carefully by the poles, the greatest care being exercised that all the stores left behind are placed where No. 5 will see them, and are not lost in long grass. If a stay peg cannot be got out without the use of the maul, the pole should be replaced in the hole to call No. 5's attention to it. The four numbers walk along the line, the front man always halting at the first pole to be taken down, while the others pass on. **Work of the front party dismantling the line.**

The first number to come up takes the strain, while the second to arrive dismantles the pole.

* "Guard, hand, telegraph equipment."

Tree attachments that cannot be reached without a ladder should be left for the rear party.

Work of No. 11, clearing the wire.

55. No. 11 works next, mounted, and with a crook-stick. He clears the wire of all obstacles, so that it lies ready to be picked up by the barrow party.

Work of Nos. 4 and 5, picking up stores.

56. No. 5 works with No. 4 in rear of the wagon, picking up the stores, unbinding and coiling up stay wires, and putting them on the wagon, and is responsible that nothing is left behind. If the front party do their work properly, and there are no tree attachments, No. 5 ought not to need to halt the wagon at all. Poles can be picked up and put straight into the wagon, and dismantled on the move.

Work of rear party, reeling up wire.

57. Nos. 2, 3, 6, and 7 form the wire party, and wind it up. No. 7 wears apron and glove and guides the wire on to the drum. No. 2 walks behind, holding the bight in a hanging insulator; No. 6 pulls the barrow, or steadies it if it is lashed on to a wagon, and No. 3 winds the handle. This last is very heavy work, and Nos. 6 and 3 should often change rounds.

Use of second wagon.

58. A great saving of time is effected if a second vehicle, such as another air line wagon, or, better still, a cable wagon, is available to wind up the wire, as Nos. 5 and 7 are apt to delay each other by wishing to stop the wagon at different times. If more mounted men are available, they may be advantageously employed in taking down tree attachments with the front party, each carrying a half ladder on his horse.

CHAPTER III.

MAINTENANCE OF AIR LINES.

Linemen.

1. The maintenance of lines is carried out by linemen, who should, as a rule, be mounted on horses, mules, or bicycles, and have charge of a definite piece of line, the length varying with the difficulty of the country, and the means of locomotion. As a rough rule a lineman mounted on a horse or mule can maintain 8 to 10 miles of line, on a bicycle if the line is along good roads 12 to 15 miles of line, and on foot 4 to 6 miles.

Lineman stations.

2. On a long line it is necessary to have a small telegraph office at every lineman station. To economize these offices the linemen should be stationed in pairs, at double their length of maintenance apart, and the linemen at each station should work outwards to meet the linemen from the next station on each side.

Standing orders for linemen.

3. Standing orders for linemen should be issued in writing to each man on the following pattern :—

(1) You are in charge of the line from............to............
(2) You will start daily on your maintenance inspection of the line at......a.m.
(3) Before starting you will ascertain from the telegraph master the state of the line from the morning test, in order that you may know what faults to look for especially.
(4) You will proceed through the line at a pace of 6 miles an hour if on a horse, 10 miles an hour if on a bicycle, and 4 miles an hour if on foot, until you meet the next lineman or reach the next office, stopping only to repair serious faults or breakdowns.
(5) On meeting the next lineman you will tee in with telephone, and report to the offices on each side of you, taking instructions as to any faults which have appeared since you left the office.
(6) You will then proceed at the same pace to the end of your maintenance section.
(7) You will then return slowly through your line, testing every stay by hand, clearing contacts, and strengthening the line where necessary.
(8) On return to your station you will report to the telegraph master, and see to the comfort of your horse.

(9) During the remainder of the day or night you will be ready to turn out quickly in case of a breakdown.

(10) If turned out for a breakdown you will proceed through the line at the pace laid down in para. (4), teeing in with telephone every half hour until you reach the breakdown, or receive orders by telephone that it has been repaired.

(11) After repairing a break, and receiving a telephone message that the line is right, or after receiving telephone message at one of your halts that the line is right, you will return to your station at a steady pace.

(12) You will render a daily or weekly report to the............ This report is to be kept written up to date, and sent in to the...........punctually by the method ordered by him.

Tools for lineman; air line.

4. A lineman employed on air line should be provided with a set of lineman's tools, consisting of the following :—

Mallets, heel peg	1	
Baskets, tool, leather handled	1	
Hammers, claw, 24-oz.	1	
Irons, soldering, tinman's, small ...	1	
Screwdrivers, G.S., 9 in.	1	
Spanners, McMahon, 9 in.	1	
Cells, electric, inert S	2	(in Tel. Port. D).
,, ,, ,, spare	2	(war only).
Galvanometers, Q & 1	1	
,, ,, cases	1	
Apparatus, repairing wire	2	
Mattocks, telegraph equipment ...	1	
,, ,, ,, cases ...	1	
Rods, clearing, obstacles	1	
Telephone sets, portable D	1	

In addition, he should have the following :—

Knives, clasp	1
Pliers, side cutting, 8 in., pairs ...	1
Belts, lineman's	1

A set of tools, electrician's, is available at each second class office.

Stores for linemen; air line.

5. And in addition he should be provided with the following stores; their expenditure is to be shown on the report, and more are to be applied for as required :—

Pins, tent, wood, large	10
Sal ammoniac, in lumps, lbs.	$\frac{1}{4}$
*Soldering solution or paste.	
Cotton waste, white, lbs.	$\frac{1}{2}$

* Zinc chloride solution is used.

Insulators, ebonite, hanging	2
" " with shank ...	3
Brackets, insulator, bent shank ...	3
Cable D 5, yards...	100
Clips, pole, sets	8
Links, pole	3
Pegs, stay, telegraph	10
Pipe, hose, I.R., ¼ in., yards	1
Poles, telegraph, wood, 13 ft., light ...	2
" " " 13 ft., octagonal	2
" " " 8 ft.	8
Wire, electric, Z9, yards	200
Cordage, spunyarn, hemp, 1 thread, tarred, lbs.	2
Solder, tinman's, soft, lbs.	1

Duties of Lineman.

6. The duties of a lineman are not confined to the removal of faults, there is always some work to be done on an air line—strengthening it, protecting poles from traffic, &c., and the condition of a line should improve every day. The principal points to attend to in order to keep the line in good working order are given below.

7. The line should be cleared of all contacts. Clearing contacts.

Leaves and twigs within a foot above the line should be cut away with a clearing rod. In peace manœuvres and training it will often be found that the owners of trees object to this clipping and it cannot be carried out thoroughly. Sometimes a slight readjustment of the poles can be made which will clear the wire from such contacts.

Contacts with large boughs, tree trunks or buildings are best cleared by fixing an insulator to the point of contact by a bent shank bracket or by altering the line slightly at an adjacent angle, or by raising or lowering the nearest insulator.

Rubber tubing is also provided for use as a temporary insulation at points of contact. If it is used the tube is split and placed round the wire, split away from the point of contact. The tubing should be bound to the object (bough, &c.) with which the line is in contact with spun yarn, otherwise it will probably not keep its place. In any case this is an unsatisfactory means of insulating the line and should only be resorted to as a very temporary means of clearing the faults.

Strutted poles should be carefully inspected to see that there is no contact between the link on the upright pole and the insulator. This contact is a frequent cause of earth faults.

8. All poles in the straight should be kept truly vertical and should be firmly fixed in that position. They will, if necessary, Straightening poles.

be taken down and bound in again if the binding in wire is in the wrong position. Stones will be rammed into the ground round them.

Strengthening angles.

9. A weak angle is a constant source of danger to the line. All stays and their holdfasts will be tested by hand to see that they are secure. If a stay-peg is drawing, even slightly, it is not safe. If it is driven in again it will probably give again during wet weather. A new holdfast should be sought or another stay-peg should be driven in in firmer ground, or an additional stay should be fixed. No stay should be shifted until its new holdfast is quite secure.

Raising the line.

10. The line should be carefully watched to see that it has sufficient height at road crossings and at the gates of fields to clear traffic and that in the open it is high enough to clear all mounted men. If it has not sufficient height it should be raised. This can be done (*a*) by shifting the position of insulators attached to trees or buildings; (*b*) by adding double poles; (*c*) if due to slack wire, by cutting out a piece of wire; (*d*) by adding poles or by shifting the position of poles on undulating ground.

Adding stays.

11. Wherever there is a long straight run of line over open country, rocking stays, if not already provided, should be added.

If fore and aft stays have been omitted they will be added at—

(*a*) Every eighth pole or nearest ordinary pole.
(*b*) At each side of a bay over 120 yards long.
(*c*) At each side of an important road crossing.

Rocking and fore and aft stays may sometimes be advantageously fixed to one and the same pole in a straight run over open ground.

Marking stays.

12. All stays which are even in the least degree likely to be a danger to traffic should be clearly marked.

Protection of poles.

13. Any poles liable to be interfered with by traffic or animals should be sufficiently protected. A small ditch, a large stone, or a few bushes, will often be sufficient to divert traffic.

Sometimes it will be found necessary to expend a great deal of labour in guarding a pole efficiently.

Replacing broken insulators.

14. All broken insulators will be replaced.

Binding in.

Soldering joints.

15. If the line is to remain standing for any considerable period, the wire should gradually be bound in at every pole, and all temporary joints be cut out; new ones being made and soldered.

Repair of Air Line.

Line wire broken.

16. If the line wire is broken the first thing to be done is to make a temporary connection with cable, so that the line may be workable while it is being mended. The ends should be

brought as close together as they will lie, and cleaned for a length of 3 or 4 inches about 4 feet from the ends. A piece of cable should then be bound on to the cleaned portions.

Two or three poles should then be unbound, and taken off the wire on each side of the break. If the break is a very bad one, such as is sometimes made when a vehicle has caught the wire, and pulled it very tight before breaking it, there will possibly be four or five broken poles on each side. These should all be removed, except the stumps, which should be left to mark the holes, and the lineman should satisfy himself that he has seen the whole of the damage.

One of the strainers is then put round the waist, and attached to the line wire 18 inches from one of the broken ends. A strain is taken, and a stay-peg driven in the ground at the point reached, and the strap of the strainer is then transferred to this stay-peg. It is important that the strap should be in the longest hole, and that the peg should be driven as near the other broken end as the wire will reach.

The other end is then taken on the other strainer, and pulled up in a similar way, and the strap of this second strainer slipped through that of the first. If the straps will not reach, a piece of wire must be jointed on to the broken end, and the strainer moved up on to it.

The peg is then taken out, and the wire strained up, joint made in the ordinary way, and the cable removed. The broken poles must be replaced by spare ones taken from marking stays. If there are not enough of these available, the longest bits can be lashed together with wire and used as a temporary pole until another can be brought out.

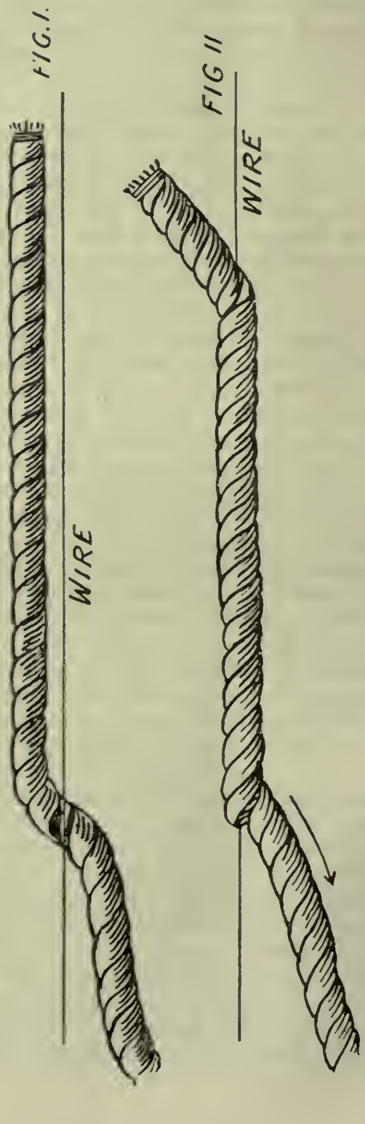
Another method is, the line having been put through temporarily with cable, the lineman may join the end of his coil of air line to one of the ends of the line wire and so extend it sufficiently to reach the other end of the line wire. He will then pull up the ends as tight as possible by hand and make a temporary joint. He will next by means of his strainers, joined together by a strap, tighten up the wire as much as is necessary, cut out the temporary joint and make a new joint.

Repairs without strainers.

17. It may sometimes happen that a line has to be mended when no strainers are available. To do this take two poles, with insulators in them, and bind the line wire 12 inches from each broken end, firmly into the insulators. Then drag them towards each other as near as the strain on the wire will admit—if a stay-peg is available to drive in behind one insulator while the other is being pulled up, they should very nearly meet. Then make off a piece of wire, cable, or spun yarn to the shank of one insulator, pass it round the shank of the other, and pull up on it until the ends of the wire have crossed enough to make the joint, next make fast the lashing and joint the wire.

Another means of straining wire without "strainers" is to attach a piece of rope (a horse's head rope is very suitable) to the wire as follows :—

Lay the wire across the rope at about a foot from its end, slightly untwist the rope and insert the wire between the strands as shown in Fig. I, then take six turns with the rope round



the wire, untwisting the rope at the same time so as to open the stranding, Fig. II.

The wire will now lie inside the rope as a core and will not pull through the rope. The same piece of rope cannot be used often for this purpose, as gradually the strands will lose their power of gripping the wire.

Broken angle pole.

18. If an angle pole is broken and has to be replaced, take down three poles on each side of the broken one. Pull the wire by hand towards the hole as far as it will come. Lay the new pole on the ground inside the angle, in the line, bisecting it, bind the wire into the insulator, put on the stay wires, and coil them down the pole. Take a stay-peg, and walk away from the hole, in the direction in which the pole points, for about 20 yards, outside the angle, and drive in the peg. Bind one end of a coil of air line on to the shank of the insulator, uncoil the wire and pass it round the peg, pull up on this wire until the insulator is within 1 foot of the hole, and make off. Raise the pole, keeping the foot against the butt until vertical, then pull in again on the long stay until the head of the pole is a little beyond the hole, and make off again. Place the butt in the hole, drive in the proper stay-pegs, uncoil and make off the proper stays.

The long stay should be used as an additional stay to strengthen the angle.

Another method; in confined situations it may not be possible to get more than a couple of yards from the pole, so that a long wire could not be used. In such cases fix an insulator and stay on to a new pole, and bind the line wire into the insulator; pass the strap of the strainers round the holdfast of the stay, and fix the strainer on the stay. Push the pole up from the butt, and raise it till about 6 feet from the ground; slack out or pull in the strainers, whichever may be required, push the butt in again towards the hole, and attend to the stay as before. Repeat these operations until gradually the butt can be brought up to and placed in the hole. Make off, and remove the strainer.

Tree attachments giving way.

19. The repair of a broken tree attachment presents no difficulties if the tree can be climbed. In the case of an angle the wire will be pulled into position by a long stay before it can be made off.

Testing for Faults.

20. It sometimes happens that a lineman sent out to remove an earth fault fails to detect it by sight.

If, when the linemen tee in at their meeting place as ordered in para. 3 of this chapter, the telegraph master at the head office reports the earth still on, the linemen must be prepared to disconnect the line for testing from the office. This is done first at the meeting place, and then, when it is decided on which side the fault lies, by the lineman concerned at first at intervals of about a mile, and afterwards shorter ones, till the fault is located.

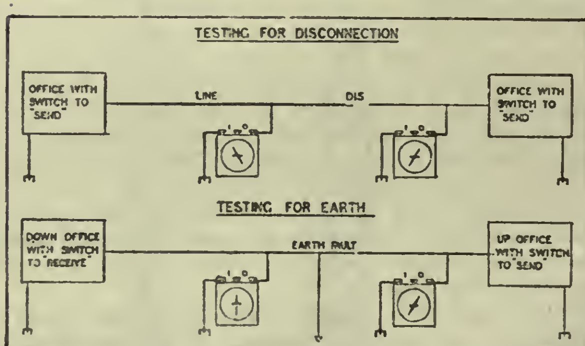
Upon telephonic instructions being received to "dis" the line for test, the lineman clips on his strainers, with the straps looped together, and makes all ready to cut. He then reports on the telephone "I am quite ready—are you ready—now," and at the word "now" cuts the line between the strainers and disconnects his telephone. It is important that the telegraph master shall know the exact moment when the line is cut.

After the period for which a "dis" has been requested (generally two minutes) is over, the lineman tees in with his telephone, and receives instructions as to whether to disconnect again there, or move on to another point.

Use of detector.

21. As it may happen at times that a lineman's telephone is out of order, the following methods of testing for a fault with a detector will be practised:—

(*a*) *A Disconnection.*—Before starting out the lineman will see that the telegraph master has placed a current on the line. The lineman will then test his detector immediately outside the office, joining Q terminal to line, and I to earth, and noting which way the needle throws.



As he passes along the line he tees in with his detector in an exactly similar manner, at intervals, and so long as he gets the same deflection he knows that he is getting a current from his own office, and that the fault is still in front of him. A deflection in the opposite direction would mean a current from the next office, and that he has passed the disconnection. If the fault has been repaired by the other lineman, and the line is again working, the Morse signals will be easily seen in the detector.

(*b*) *An Earth.*—In this case the up station puts a current on the line, and the down station does not.

The lineman from the up station will get a deflection from his own station, until he passes the fault, when he will get no deflection or a very slight one. The lineman from the down station will get no deflection, or a very slight one, until he passes the fault, when he will get the current from the up station.

To get any satisfactory results from testing with a detector, it is essential to get a good earth.

CHAPTER IV.

SPECIAL FIELD TELEGRAPH STORES AND MISCELLANEOUS STORES.

Field Stores.

Apparatus, repairing wire, Mark III.

1. "Apparatus, repairing wire, Mark III," commonly known as a "Strainer," is used for straining field telegraph wires when building or repairing a line. It consists of a draw vice, to which is attached a pulley and cord. A ring is also provided, attached to the loop of the draw vice.

The main portion of the draw vice is of $1\frac{1}{8}$-inch steel. The jaws are formed between the pivoted block and the gripping lever, which are mounted on the main portion, and are $\frac{3}{16}$ inch thick and $1\frac{1}{8}$ inch long, grooved and case hardened. When fully opened they are $\frac{3}{16}$ inch apart. The gripping lever works in a slot $1\frac{3}{4}$ inch long.

The pulley has a $1\frac{1}{2}$-inch brass sheave mounted in $\frac{1}{16}$-inch steel cheeks, 3 inches long by 2 inches wide, and is attached to the draw vice by a swivel eye. The cord is 12 feet long, of $\frac{5}{8}$-inch 3-ply white cotton cord, and is spliced to the eye of the pulley. The ring is triangular, with $2\frac{1}{2}$-inch side, and is made of round wrought iron or steel of $\frac{1}{4}$-inch diameter.

The weight of the complete apparatus is specified not to exceed 19 ozs.

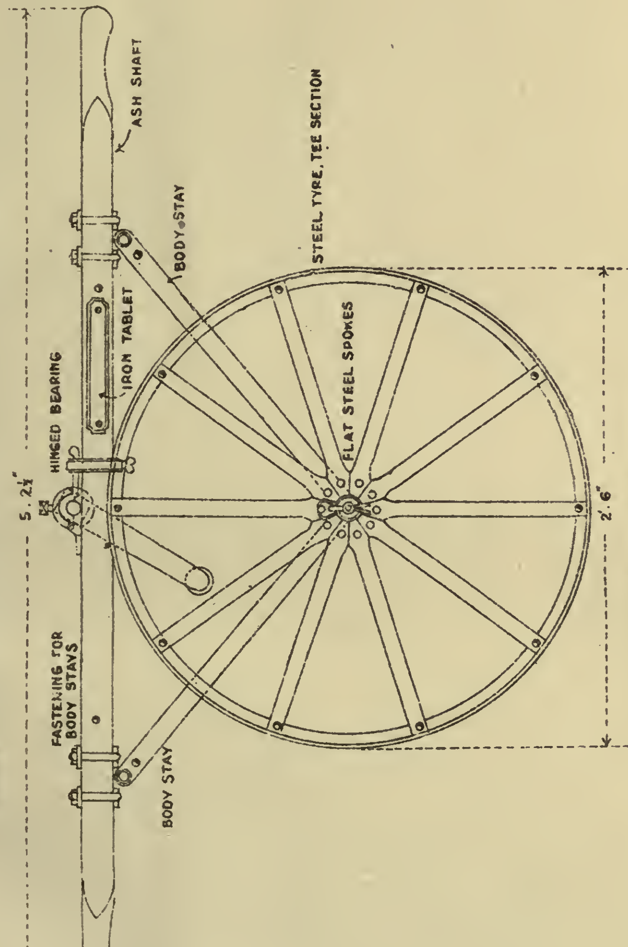
Aprons, basil, brown.

2. "Aprons, basil, brown" are used to protect the clothes when handling wire or cable. They are 38 inches long by 32 inches wide, and are made of the best English basil. They are held in position by a strap round the shoulders and one round the waist. Weight 1 lb. 8 ozs. (approximately).

Barrow, drum, universal, Mark I.

3. The "Barrow, drum, universal, Mark I" (Fig. 1), is a double hand barrow, mounted on wheels, and is used for carrying drums of air line or cable when paying out or reeling up by hand. For readier transport it is detachable into five portions —the shafts with shaft stays, the body with cross stays and axle, and the wheels. A spindle for carrying the drum and a detachable crank handle for turning the handle also form part of the barrow. The shafts are of $1\frac{7}{8}$-inch by $1\frac{1}{8}$-inch ash, 5 feet $2\frac{1}{2}$ inches long, and are spaced 1 foot $1\frac{5}{8}$ inch apart in the clear by two $1\frac{1}{2}$-inch by $\frac{3}{8}$-inch shaft stays fixed between them 1 foot $2\frac{1}{4}$ inches from their centres. Outside these shaft stays four mild steel clip brackets are fixed to the under side of the shafts to take the ends of the body stays. Outside the clip brackets the shafts bend outwards, giving a space of 1 foot $3\frac{3}{4}$ inches in the clear between the handles. Bearings of mild steel to take the spindle, fitted with caps hinged and secured by a sliding ring, are screwed to the top of the shafts at the centre.

BARROWS, DRUM, UNIVERSAL, MARK I.



SIDE ELEVATION.

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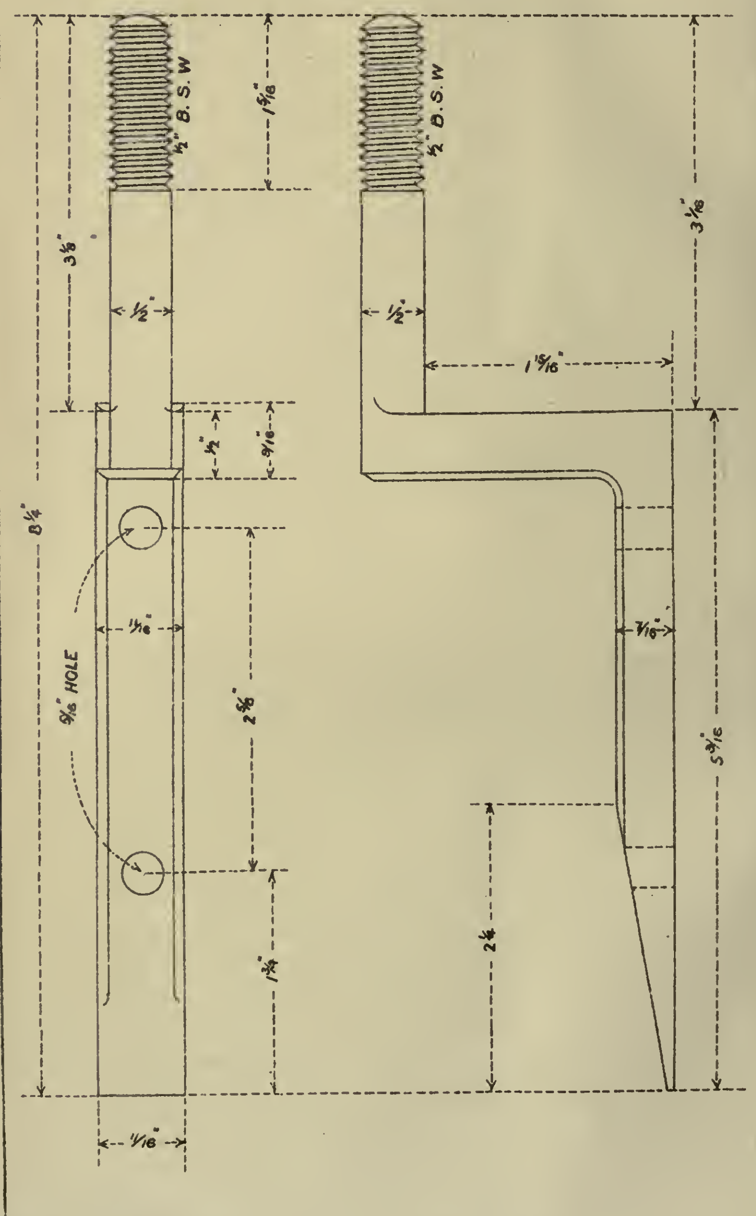
Malby & Sons, Lith.

BRACKET INSULATOR, BENT SHANK MARK III

2/3 FULL SIZE



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3296

Malby & Sons, Lith.

The four body stays are rigidly fixed into pairs by means of four cross stays; all of these are of 1-inch by $\frac{1}{4}$-inch mild steel. The body stays are 1 foot 10 inches long, and are fastened at the top to the clip plates by means of a removable pin and butterfly nut. At the lower end they terminate in eyes, which carry the axle. The axle is 2 feet $1\frac{3}{4}$ inches long, and of 1-inch square medium carbon steel, fitted with a swinging eye at the centre for a drag rope, and terminating in conical-shaped arms to carry the body stays and wheels.

The wheels are of 2 feet 6 inches diameter, of mild steel, with flat tyres and a gunmetal hub, and are held in place by split linch pins.

The drum spindle is of square section, with 1-inch side and 1 foot $7\frac{1}{2}$ inches long over all. One end has a shoulder 2 inches wide formed on it, $4\frac{1}{2}$ inches from the end, the part beyond being of round section to fit the bearing, and finished square to take the handle. The other end is finished round in section for the other bearing. Two loose collars with screw pins are provided to admit of different sized drums being held steady on the spindle.

The crank handle is 9 inches long, fitted at one end with a socket to take the end of the spindle, where it is fixed with a screw pin, and at the other with a revolving wooden handle mounted on a 6-inch pin.

The parts are all carefully gauged and interchangeable. The weight of the complete barrow is 110 lbs.

Belt, lineman, Mark I.

4. The "Belt, lineman, Mark I," is 3 feet $8\frac{1}{2}$ inches long by $1\frac{3}{4}$ inches wide by $\frac{1}{8}$ inch thick, of bridle leather, and is fitted with a frog for carrying pliers, and a runner with a swivel hook for carrying a clasp knife. Its width is governed by the dimensions of the strainer, for use with which it is intended.

Bracket, insulator, bent shank, Mark III.

5. The "Bracket, insulator, bent shank, Mark III," is made of wrought iron, galvanized, of the shape and dimensions shown in Fig. 2. It is screwed to take the cup of an insulator, ebonite. The bracket is suitable for either driving into a wall or tree, or nailing on to a post. Its weight is 10 ozs. When nailed to a post it is secured by two $2\frac{1}{2}$-inch clout nails.

The older patterns are not so strong or so suitable for driving into a wall.

Cable, electric, D 5, Mark IV.

6. "Cable, electric D 5, Mark IV," is the latest pattern cable for field telegraph equipment; it is supplied in two-mile lengths, ready wound on "Drum, cart, cable."

The conductor consists of 19 strands of No. 30 S.W.G. wire (·012-inch), five being of tinned copper, and 14 of galvanized steel. They are laid up as follows: one centre strand of the copper wire is run straight, the next six (four copper and two steel) are laid up round it with a right-handed lay of ·437 inch, the next 12 (steel) are laid up outside them with a left-handed lay of ·875-inch. The conductivity resistance is 63 ohms per mile.

The conductor is coated with rubber to a diameter of ·125 inch, and braided with 48 threads of flax hemp. It is then vulcanized, and finally thoroughly impregnated with ozokerite compound. The insulation resistance should be not less than 6000 ohms per mile when new and tested after 24 hours' immersion in water, with one minute's electrification at 150 volts.

The object of vulcanizing after braiding, instead of before, as is more usual, is to make the braiding adhere firmly to the cable.

The diameter of the completed cable is not greater than ·145 inch, its breaking strain not less than 390 lbs., and its weight not more than 85 lbs. per mile.

For instructions for the care of field cable *see* Chap. I, paras. 15 *et seq.*

Cable, electric, D 5, Mark II.

7. "Cable, electric, D 5, Mark II," is very similar to the Mark IV, except that the strands are all of galvanized steel. The diameter of the completed cable is not greater than ·137 inch, its breaking strain not less than 550 lbs., and its weight not less than 80 lbs. per mile. Its conductivity resistance is 200 ohms.

Cable, electric, D 5, Mark III.

8. "Cable, electric, D 5, Mark III," is similar to the Mark IV, except that it is vulcanized before, instead of after, braiding; as a result the insulation resistance is 620 megohms per mile, but the braiding strips so easily from the cable that it has not been found satisfactory, and will not be issued for use on service. The diameter of the completed cable is not greater than ·137 inch, and its weight not more than 80 lbs. per mile.

Climbers, pole, Mark IV.

9. "Climbers, pole," are steel spurs which can be fixed to the inside of the ankles, to enable a man to climb a permanent wooden telegraph pole.

They consist of a stem, 16 inches long, with a tread projecting from it at the lower end, whose width is 2½ inches. On the opposite side of the tread a spur $\frac{13}{16}$ inch long is riveted to the stem. The whole of this portion is of double shear steel, without welds.

A pad of basil, stuffed with horsehair, is held on the stem between the stem and the ankle by leather loops.

The climber is fastened to the leg by a 21-inch leather strap, ⅞ inch wide. The weight of a climber without straps or pads is 1 lb. 7 ozs.

Clips, pole, Mark I.

10. "Clips, pole," are used for fastening together two field telegraph poles when a longer pole is required. A set consists of two complete clips (one large and one small), and weighs about 1 lb.

Each clip consists of two galvanized malleable iron straps, and a bolt and nut to hold them together. The straps are of two sizes, large and small. The width is ⅞ inch in each case; the large ones are 4⅛ inches long, the small 3⅞ inches. In the small clips the hole for the bolt is in the middle, in the large ones $1\frac{7}{8}$ inch from one end and $2\frac{1}{4}$ inches from the other. The straps are shaped on each side of the bolt to grip the poles.

The bolts are square headed, and square shouldered for $\frac{3}{4}$ inch, are $3\frac{1}{8}$ inches long under the head, and are threaded $\frac{5}{8}$-inch British Standard Whitworth thread for $1\frac{1}{2}$ inch. They are made of wrought iron, and galvanized.

11. "Drum, cable, No. 1," is for use in mountain equipment, with "Barrow, drum, universal." It is made of sheet iron or steel. The cheeks are $21\frac{1}{4}$ inches external diameter, spaced $5\frac{3}{4}$ inches apart at the core and 8 inches apart at the outer edge. The edges are stiffened by bending them over a ring of $\frac{3}{16}$-inch iron. **Drum, cable, No. 1.**

The core is of sheet iron, hollow, dovetailed and brazed to the cheeks. A lead hole of brass is found about 2 inches from one cheek.

The spindle for this drum is of wrought iron. One end is fitted with a squared taper end to take the handle. A bearing with two shoulders is also formed near this end to fit the barrow and prevent side play. The bearing at the other end is plain.

The spindle is also fitted with two collars to take the discs which secure the drum. The collar at the squared end of the spindle is shouldered. Both collars are fitted with feathers fitting keyways on the discs. A hexagonal nut clamps the discs to the drum.

The two discs are $7\frac{1}{4}$ inches in diameter with a projecting rim $5\frac{1}{2}$ inches in diameter fitting into the hollow core of the drum. They are bored $1\frac{17}{32}$ inch and slotted to fit over the feathered collars of the spindle.

Weight of drum	..	11 lbs. 6 ozs.
Weight of spindle	..	5 lbs.
Weight of two discs	..	5 lbs.

12. The "Drum, cable, No. 4," is intended for use with the "Barrow, drum, universal," when the wire used is supplied in coils and not on drums. Each drum consists of two cheeks and two inner removable cones. The one cheek carries a tube of steam piping which is fitted with gunmetal bushes to take the spindle, and threaded on the outside to take a nut, a handle is cast on the nut to enable it to be turned by hand. The inner removable cones fit inside the cheeks. By loosening the nut, cross arms on the tube can be turned so as to pass between projections attached to the other cheek, and the cheeks can be pulled apart. A coil of wire can thus be inserted on, or withdrawn from the drum. The drums are made of sheet iron No. 16 S.W.G., the overall dimensions are 22·5 inches by 9·3 inches and the weight is 46 lbs. **Drum, cable, No. 4.**

13. The "Drum, cart, cable, Mark III," is the drum which forms part of a cable wagon. Cable issued to field telegraph units is supplied on this drum in two-mile lengths. **Drum, cart, cable, Mark III.**

The core consists of two cheeks of elm 1·25 inch thick and 9 inches in diameter, held together by 12 yellow deal battens 10 inches long, which are driven into recesses cut in the core cheeks and secured there by $1\frac{1}{4}$-inch wire nails. The core is strengthened by four forged steel binding strips wound diagonally round the battens, and screwed to them. The straps are $\frac{1}{2}$ inch wide, ·028 inch thick, and 18·9 inches long.

To the outside of the core cheeks are fastened by screws and rivets the drum cheeks, each composed of two thicknesses of yellow deal with the grain in contrary directions. The drum cheeks are 1 inch thick, and 24 inches in diameter. The cheeks have hand holes for carrying. The edges are protected by steel bands shrunk on as rims and secured with 1-inch screws.

To the outside of each drum cheek is screwed a boss plate, pierced by a 1·062-inch square hole at the centre to take the spindle, and provided with four straps in the shape of a cross extending to the rim of the drum cheek to strengthen it. One of the boss plates is extended near the centre into a recess cut in the cheek and carries a brass terminal screw, to which the inner end of the cable is led through a hole in the drum cheek, and made off.

The drum weighs 39 lbs.

Drum, wood, packing, No. 2.

14. The "Drum, wood, packing No. 2," is the working drum for air line. The wire is supplied ready wound, 1 mile on each drum. It is composed of a core, consisting of cheeks and battens, and of drum cheeks.

The core cheeks are 14 inches in diameter, and $1\frac{1}{4}$ inch thick, of English elm. Fourteen core battens, of yellow deal or American spruce, 6 inches by $1\frac{1}{2}$ inch by $\frac{1}{2}$ inch, are let in flush with the outer edges of the core cheeks, and nailed to them.

The drum cheeks are 1 foot $9\frac{1}{2}$ inches in diameter, and 1 inch thick, of yellow deal or American spruce, each made in two thicknesses, with the grain in the opposite directions, glued and nailed together. The drum cheeks are secured to the core cheeks by six wood screws, 2 inches long, No. 21 gauge. Hand holes for carrying are cut in the cheeks.

In the centre of each drum cheek is fixed, by three 2-inch screws, a triangular wrought iron plate, with a $1\frac{1}{16}$-inch square hole in the centre to take the spindle. Corresponding holes are cut through the drum and core cheeks.

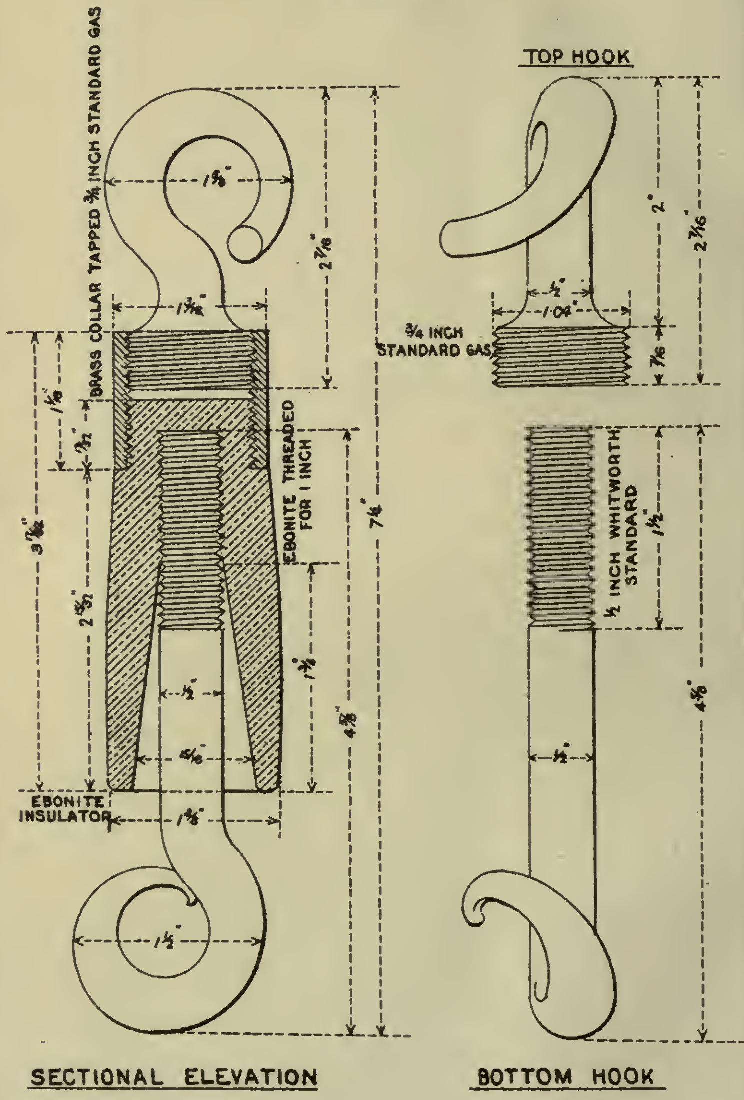
For transport purposes the edges of the drum cheeks are held together by 12 $8\frac{1}{4}$-inch wooden battens nailed to the edges.

The weight with battens is 27 lbs.

Flags, distinguishing, telegraph, Mark III.

15. The "Flag, distinguishing, telegraph, office, Mark III,' is the distinguishing flag for a telegraph office. It is of bunting, 3 feet by 2 feet, top half white, bottom half blue, and is fitted with a toggle and line for hoisting on a flag pole.

INSULATOR, EBONITE, HANGING. WITH TOP & BOTTOM HOOK. 2/3 FULL SIZE.



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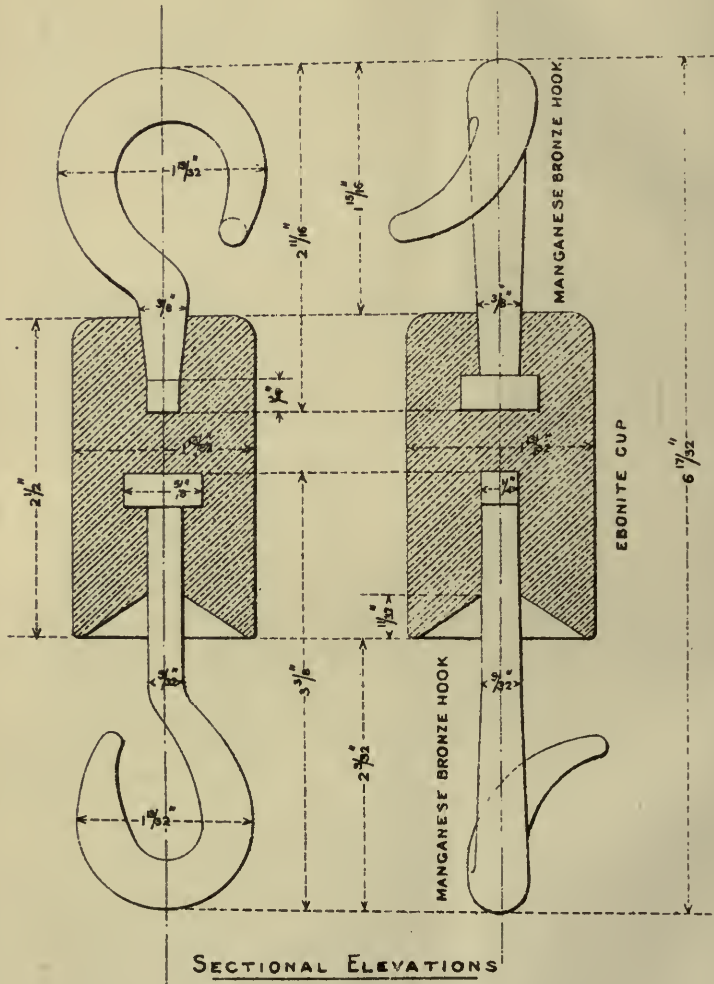
INSULATOR, EBONITE, HANGING, MARK II. WITH FIXED TOP & BOTTOM HOOKS.



SECTIONAL ELEVATIONS

2/3 FULL SIZE

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16. "Guards, hand, telegraph equipment, Mark III," are leather guards used to protect the hands when cable or wire is being run through them, either in paying out or reeling up. Guards, hand, telegraph equipment, Mark III.

17. "Guys, telegraph pole" are used as stays for the 17-foot wood pole for making a cable crossing. They are 21 feet 6 inches long, of 3-strand, 6-thread, white Italian hemp. Each guy is finished with a 2-inch eye splice at each end. The breaking strain is not less than 375 lbs. when new. Guys, telegraph pole, Mark II.

18. The "Hammer, R.E., telegraph, sledge, Mark II," is used for driving the "jumper" into the ground for making a hole for a field telegraph pole. Hammers, R.E., telegraph, sledge, Mark II.

The head weighs 16 lbs., and is of the best cast (crucible) steel, its length is 9 inches and width $2\frac{7}{8}$ inches. The faces are rounded. The hole for the shaft is in the centre, and is $1\frac{3}{4}$ inch by $1\frac{1}{4}$ inch.

The shaft is of best quality well-seasoned prime white straight-grained hickory, and is 2 feet 8 inches long clear of the head. It is fitted to, and wedged into, the head. Its weight is 1 lb. 2 ozs. It is shaped oval in section 1 inch by $1\frac{5}{16}$ inch, and swells slightly at the handle end.

19. The "Insulator, ebonite, hanging, Mark I," has now been superseded by Mark II, but as many still exist it is here described. Insulators, ebonite, hanging, Mark I.

It consists of an ebonite cup, to one end of which is screwed a brass collar carrying the top hook, to the other is screwed the bottom hook. The insulator is shaped and dimensioned as shown in Fig. 3. The cup is of the best quality ebonite, the brass collar is of solid drawn brass, and the hooks of galvanized wrought iron.

The insulator has an insulation resistance of 5,000 megohms when measured with 450 volts after 24 hours' immersion in water, and weighs 14 ozs.

Owing to the weakening of the ebonite by the screw threads being turned on it, it is very liable to break with a cross strain.

20. The Mark II hanging insulator differs from the Mark I in that it is all in one piece, the ebonite cup being moulded to the base of the hooks; in this manner the weakness caused by cutting screw threads in the ebonite is avoided. Insulator, ebonite, hanging, Mark II.

The insulator is shaped and dimensioned as shown in Fig. 4. The hooks are of manganese bronze, and the base of each has a T-head to hold it into the ebonite.

The insulation resistance should be 5,000 megohms between the hooks with 450 volts, and the insulator should stand a longitudinal pull of 750 lbs. The weight is 8 ozs. The insulators are packed 100 in a case for storage and transport.

21. The "Insulator, ebonite, with shank," is used for screwing into the top of a field telegraph pole to support the wire; it is also used with "Brackets, insulator, tubular, iron pole, semi-permanent," and can be used with "Arms, telegraph pole, tubular, A or B," though the shank fits rather loosely Insulator, ebonite, with shank, Mark II.

into the hole in this type of arm. The complete insulator consists of an ebonite cup and a galvanized wrought iron shank. The cup is also used with "Brackets, insulator, bent shank." This insulator is intended for use with the 3-strand field wire (Wire, electric, Z 9, or Z 31), but can be used for other wires up to 100 lbs. per mile in weight.

The Mark II pattern is now obsolescent, but a large number are still in use. The cup of this pattern is provided with a cast brass cap screwed on to the top. The top of the cap is slotted $\frac{3}{16}$ inch wide, and undercut, to take the wire. The shank, or bolt, is threaded $\frac{1}{2}$-inch Whitworth Standard thread, and provided with a fixed hexagonal collar and a movable hexagonal nut.

The insulator is shaped and dimensioned as shown in Fig. 5; it has an insulation resistance of not less than 5,000 megohms when measured with 450 volts after 24 hours' immersion in water. It weighs 12 ozs., and is supplied packed in cases containing 100.

Insulator, ebonite, with shank, Mark III.

22. The Mark III pattern differs from the Mark II in that the slot for the wire is formed in the ebonite of the cup, and not in a separate brass cap. It is shaped and dimensioned as shown in Fig. 6; the insulation resistance is the same as that of the Mark II, and the weight is 8 ozs. It is packed in cases containing 100 complete insulators.

Jumper.

23. The "Jumper," which would be more properly described as a boring bar, is used for making holes in the ground for the erection of field telegraph poles, being driven in by the "Hammer, telegraph, sledge." It is made of the best cast (crucible) steel, and has a hardened point. It is 2 feet 9 inches long, and 2 inches diameter, with an octagonal section. It weighs 27 lbs. 10 ozs.

Ladder, field telegraph, Mark II.

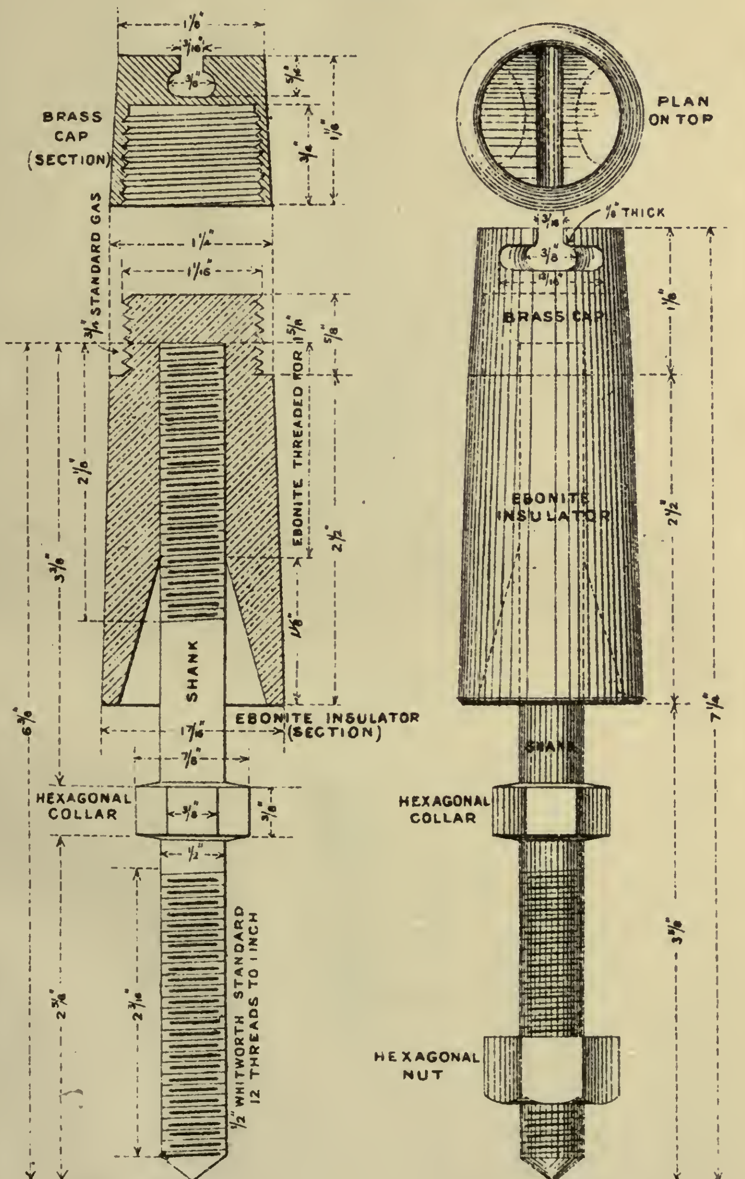
24. The "Ladder, field telegraph, Mark II," is now obsolescent, being succeeded by the Marks III and IV. Many are, however, still in use. It is in two lengths, each 9 feet long, arranged to fit one to the other with an overlap, producing a ladder 17 feet long. Each length consists of two stiles and ten rounds. The stiles are held together by two $\frac{3}{8}$-inch rivets. The ends of the stiles are shod with malleable cast iron shoes. Securing bands are fixed inside the stiles of the lower length, and outside the stiles of the upper length, $11\frac{1}{4}$ inches from the end, to hold the overlap when the ends are fitted together.

The stiles are of English ash, $2\frac{3}{16}$ inches deep, the width being $1\frac{1}{8}$ inch for the lower length, and $1\frac{1}{16}$ inch for the upper. They are $10\frac{3}{4}$ inches apart in the clear for the lower length, and $8\frac{1}{2}$ inches for the upper length. The rounds are of split English oak, $1\frac{1}{8}$ inch diameter at the centre, and $\frac{3}{4}$ inch wide at the stiles. They are spaced $9\frac{1}{2}$ inches from centre to centre. The ladder weighs 40 lbs.

Ladder, field telegraph, Mark III.

25. Ladder, field telegraph, Mark III, now obsolescent, is also composed of two lengths, each 9 feet long, but differs from

INSULATOR, EBONITE. WITH SHANK. MARK II.



DETAIL OF PARTS

ELEVATION

2/3 FULL SIZE

To face page 52.

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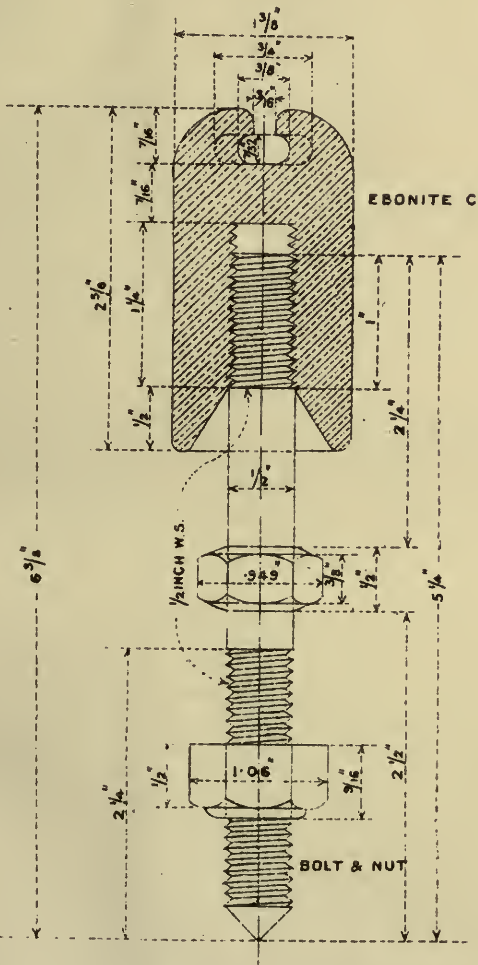
INSULATOR, EBONITE. WITH SHANK, MARK III.

EBONITE CUP, WITH BOLT & NUT



SECTIONAL ELEVATION

2/3 FULL SIZE

To face page 52.

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Mark II in that the top of the lower length is fitted with socket brackets of wrought or malleable cast iron under which the upper length slides. The bottom of the upper length is fitted with swinging locking hooks of steel which engage with the rounds of the lower length at any desired point. The ladder can thus be extended to any length from 9 feet to about 17 feet 3 inches.

The stiles are of yellow deal, the rounds of beech wedged into the stiles, alternate rounds being secured by hard wood pins.

The top of the lower length is fitted with a $\frac{1}{4}$-inch rivet, on which a length of $\frac{1}{2}$-inch iron pipe is mounted to act as a roller for the upper length.

The butt of the upper length is fitted with a $\frac{1}{4}$-inch rivet, and the tip is provided with a curved iron bar pivoted into iron plates screwed to the outside of each stile. Weight, 37 lbs.

Ladder, field telegraph Mark IV.

26. Ladder, field telegraph, Mark IV, is generally similar to Mark III. The locking hooks are, however, of wrought iron or forged steel, and fixed instead of swinging; the rounds are of split English oak secured to the stiles by headless wire nails; and each length is fitted with two wrought iron rivets. Weight, 36 lbs.

Links, pole.

27. "Links, pole," are used for making a strutted pole. Each consists of a threaded shank to screw into the upright pole, terminating in an eye, which carries a loose link through which the insulator shank of the sloping pole passes.

The shank is $4\frac{5}{8}$ inches long overall, made of the best tough fibrous chain iron, and is $\frac{1}{2}$ inch in diameter. They are threaded $\frac{1}{2}$ inch B.S.W. for 3 inches from the bottom. The eye has an internal diameter of $\frac{5}{8}$ inch.

The loose link is $2\frac{3}{8}$ inches long and $1\frac{1}{4}$ inch wide, made of round chain iron, $\frac{3}{8}$ inch in diameter.

The links are galvanized, and are capable of standing a breaking stress of $3\frac{1}{4}$ tons. They weigh $6\frac{1}{2}$ ozs.

Mattock, telegraph equipment.

28. The "Mattock, telegraph equipment," is a small pick with a chisel shoe on the end of the wooden helve, and is supplied with, and carried in, a leather case.

The head and shoe are of the best wrought iron or mild steel with steel ends welded on.

The head is $11\frac{1}{2}$ inches long over all. One end is fashioned as a pick, $6\frac{3}{8}$ inches long from the centre of the helve, the other as a blunt edge, $2\frac{11}{16}$ inches wide at the cutting edge.

The shoe is $5\frac{1}{2}$ inches long, with a chisel point $1\frac{1}{4}$ inches wide, and is riveted to the helve.

The helve is of English ash, and the length over all with shoe fitted is 2 feet $2\frac{1}{2}$ inches.

The leather case consists of a back, fitted to the shape of the mattock and $12\frac{1}{2}$ inches wide, carrying a pocket into which the helve fits, and a cover to buckle over the mattock. It is fitted with straps to secure it to saddle and girth.

The weight is 3 lbs. 10 ozs. without case, and 5 lbs. 5½ ozs. complete.

Pegs, stay, telegraph, Mark II.

29. "Pegs, stay, telegraph, Mark II," are cast steel pegs, for use as holdfasts for air line in hard ground.

They are 13 inches long and 2¼ inches wide, terminating at the bottom in a point 3¼ inches long, and at the top in a head formed by an external thickening of the steel to a width of 3 inches. In section they form a segment of a circle, ¼ inch thick, distance between the sector and the circumference being ⅝ inch internally.

They weigh 2½ lbs. each.

Pickets, guy, telegraph, light.

30. "Pickets, guy, telegraph, light," are wrought iron pickets for use as holdfasts for the guys of the 17-foot cable pole.

They are 12 inches long, ⅜ inch thick at the head, and ⅛ inch thick at the point. The width at the point is ½ inch, and just under the head 1⅛ inch.

The point is chisel shaped. The head is 2$\frac{5}{16}$ inches wide, rounded at the top, and has an undercut shoulder on each side.

The weight is 15¼ ozs.

Pins, wood, tent, large.

31. "Pins, tent, wood, large," are used for holdfasts for air line stays in soft ground.

They are made of beech, ash, or oak, and are 20 inches long by 1 inch thick. The heads are 2½ inches wide, with a notch on one side 3 inches from the top.

They weigh 1 lb. 2 ozs.

Pipes, earth, Mark II.

32. "Pipes, earth," are made of solid drawn iron or steel tubing, 1·309 inch in external and 1 inch in internal diameter. They are 3 feet long over all, and are pierced with 22 holes $\frac{5}{32}$ inch in diameter to allow water to percolate. The lower ends for a length of 2½ inches are finished off to a tapered point, the tip being solid for ¾ inch. The upper ends are threaded 1-inch British standard pipe thread for 1⅝ inch, and fitted with a wrought iron collar 1⅝ inch long and 1⅝ inch in external diameter to strengthen the pipe against the blows of a hammer when driving it in.

¾ inch below this collar two brass bushes $\frac{11}{16}$ inch diameter are brazed into the pipe, each with a square hole, 0·27 inch side, to take a square-shouldered steel terminal screw with hexagon nut and washer.

A rectangular hole ⅞ inch by $\frac{5}{16}$ inch is cut through the pipe, with its bottom 2⅜ inches below the bottom of the collar. This enables the pipe to be revolved when withdrawing by the insertion of a chisel or bar.

The earth pipe weighs 6 lbs.

Poles, telegraph, wood, 17 feet.

33. The "Pole, telegraph, wood, 17 feet," is used with the field cable equipment, for carrying the cable clear of road crossings, &c. It is made of Oregon pine, and is in two portions.

The top portion is 1⅜ inch in diameter at the top, and

$1\frac{9}{16}$ inch at the base. The top is ferruled with iron and bored out from $\frac{11}{16}$ inch to $\frac{5}{8}$ inch diameter for $3\frac{1}{2}$ inches. Into the hole is fitted an elm peg $4\frac{13}{16}$ inches long, with a mushroom top $1\frac{5}{8}$ inch in diameter. It is held with a screw so as to give a space of $\frac{1}{2}$ inch between the top of the pole and the bottom of the mushroom. In the Mark II pattern the "peg" is formed in one piece with the pole. The base of the top portion is scarfed for $6\frac{1}{2}$ inches, and fitted with a 10-inch solid drawn steel tube to take the scarfed end of the lower portion.

The lower portion is $1\frac{3}{4}$ inch diameter at the butt and $1\frac{17}{32}$ inch at the tip. The tip is scarfed $6\frac{1}{2}$ inches and the butt is pointed.

The complete pole is painted in bands 12 inches wide, alternately black and white. The weight is 8 lbs. Each complete pole should sustain a 56-lb. weight at the centre, when supported at points 6 inches from each end.

Poles, telegraph, wood, 13 feet, light, Mark IV.

34. The light 13-foot pole is used for air line construction where no angle is required. It is made of Oregon pine, and is 13 feet long, circular in section, of 1·83 inch diameter at the butt and 1·35 inch at the tip.

The butt is pointed, and the tip ferruled and bored out to take the insulator bolt. It is painted in bands 12 inches wide, alternately black and white.

Each pole will bear without fracture a weight of 130 lbs. at the centre when placed on supports 11 feet apart.

The weight is 8 lbs.

Poles, telegraph, wood, 13 feet, octagonal, Mark III.

35. The stout pole is used at angles. It is generally similar to the light pole, but is octagonal in section, 2 inches between sides at the butt, and $1\frac{1}{2}$ inch at the tip.

It will bear a weight of 160 lbs. at the centre when placed on supports 11 feet apart, and weighs $9\frac{1}{2}$ lbs.

Poles, telegraph, wood, 8 feet.

36. The "Pole, telegraph, wood, 8 feet," is similar to the light 13-foot pole except that it is 8 feet long and $1\frac{1}{2}$ inch diameter throughout. It is bored and ferruled at both ends. It is used together with a stout pole and pair of "Clips, pole," for obtaining extra height at crossings, &c. It weighs 3 lbs. 13 ozs.

Pots, fire, telegraph mechanics.

37. A "Pot, fire, telegraph mechanics," consists of a cylindrical body mounted on three legs and provided with a handle, the whole being made of wrought iron. The body is 11 inches high and $6\frac{3}{4}$ inches in diameter, open at the top and fitted with a grate at the bottom. On one side, 2 inches above the grate, is an opening $3\frac{3}{4}$ inches wide and $2\frac{3}{4}$ inches high. Level with the bottom of the opening is a flat tray, projecting $4\frac{1}{4}$ inches, to carry the irons. Two ventilating holes are formed in the sides of the body. The handle is so fitted that it cannot fall foul of the irons.

This stove is a convenient portable brazier for heating soldering irons. Weight about 11 lbs.

Rods, clearing obstacles.

38. A set of "Rods, clearing obstacles," consists of 4

contact rods, hook, saw, shears, line and thong, and leather caps and straps.

The contact rods are of bamboo, graduating in diameter from $1\frac{1}{2}$ inch at the butt of the complete rod to $1\frac{1}{8}$ inch at the top. Each length is 5 feet long. The ends are plugged with cane and glued. The lower end of the first length is fitted with a brass ferrule, those of the other lengths with gunmetal sockets $3\frac{1}{2}$ inches long, threaded $\frac{3}{4}$-inch British standard pipe thread to a depth of $\frac{5}{8}$ inch. All the upper ends are fitted with gunmetal caps $3\frac{7}{8}$ inches long, terminating in a $\frac{3}{4}$-inch British standard pipe thread $\frac{5}{8}$ inch long. The ferrules, caps, and sockets are riveted to the rods. On the fourth or top rod an iron strap and eye is wired to the side, 9 inches from the end. Weight of the four rods $8\frac{1}{2}$ lbs.

The hook is of wrought iron, $9\frac{1}{2}$ inches long, to screw on to the top rod. Weight 15 ozs.

The saw has teeth 5 to the inch. It is fitted to a socket which screws on to the top length. Weight 14 ozs.

The shears also screw on to the top rod, and are fitted with a spring to open the jaws when the strain on the line is released. Weight $2\frac{3}{4}$ lbs.

The line is 18 feet long, of 1-inch plaited sash cord. It has an eye at each end. To one of these is secured the thong, of raw hide, 5 feet long, and $\frac{1}{4}$ inch wide. The thong tapers in thickness from $\frac{3}{16}$ inch to $\frac{1}{16}$ inch.

Two leather caps, joined by straps and buckles, are provided to hold the ends of the bundle of rods.

Sticks, crook, long, Mark II.

39. The "Stick, crook, long," is used in erecting air line for lifting the wire clear of branches or other impediments.

It consists of a pole of English ash, to one end of which is fixed a U-shaped head. The pole is ferruled, and the head has a shank $4\frac{5}{8}$ inches long which is inserted in the pole and riveted through the ferrule.

The head is of best cast steel, forged to shape, $\frac{3}{8}$ inch in diameter. One arm is slightly turned outwards and pointed, the other bent over outwards into a small hook.

The total length is 7 feet $6\frac{1}{2}$ inches, and the weight is 3 lbs.

Sticks, crook, short, Mark II.

40. The "Stick, crook, short," is used for laying cable. It is generally similar in construction to the long one, but is 3 feet $1\frac{1}{2}$ inch long over all. The head is shaped like a ring, of radius $1\frac{3}{8}$ inch, with one of the upper quarters omitted.

The weight is 1 lb. 2 ozs.

Table, telegraph, Mark I.

41. The "Table, telegraph," is a small collapsible table for use in telegraph offices in the field.

The top is $41\frac{1}{2}$ inches long by $24\frac{1}{2}$ inches wide, ploughed, tongued, and glued together at the joints, and fitted on the under side at each end with an oak cleat.

The 2-inch by $1\frac{1}{16}$-inch legs are in pairs, each pair tenoned into a 2-inch rail, which is hinged to the underside of the top. A steel strap holds each pair of legs 6 inches from the feet. The pairs of legs fold flat to the underside of the top, one pair inside the other.

The inner face of each leg is fitted with a socket plate, to which is fitted an iron stay rod. When the table is open these stay rods fit into socket plates underneath the top.

With the exception of the cleats the table is all made of yellow deal.

The weight is 35 lbs.

Tents, complete, shelter.

42. "Tents, shelter," are small shelter tents used with, and forming part of, 3rd class telegraph offices. They were formerly known as *tents d'abri*.

The tents are made of linen duck. Each tent consists of two sheets and two weather lines. The sheets are 6 feet long and 5 feet 4 inches wide, overlapping and buttoning together along the ridge. Each sheet has a triangular flap at one end, so as to close one end of the tent when it is pitched with a 7-foot splay.

The weather lines are 8 feet 6 inches long. There are three loops along the edge of the sheets to peg down.

With the tent are used two 4-foot ash poles, and seven $10\frac{1}{2}$-inch pins. A mallet is also supplied. The complete tent weighs 14 lbs.

Tents, complete, telegraph.

43. The telegraph tent is used for a 1st or 2nd class telegraph office. It consists of an inner and an outer roof, pin bag, two mallets, six large and 44 small wood pins, one ridge and two upright poles, a valise, two vases, two weather lines, and a tying-up cord.

The ridge poles are 7 feet 6 inches long, and the uprights 8 feet $4\frac{1}{2}$ inches long, each in two pieces.

The roofs are of linen duck. The outer one is 7 feet 6 inches long at the ridge and 8 feet 6 inches at the lower edge, and each side is 11 feet wide. It is stretched over the ridge pole, and held out by five bracing lines on each side. The inner one hangs from the ridge pole by five loops; the sides are 7 feet 5 inches long, and the walls at the sides 3 feet 6 inches high. Walls also close both ends, with an overlap.

The internal floor space is 10 feet by 7 feet 6 inches, and the weight complete 120 lbs.

Tools, electricians, sets.

44. "Tools, electricians, sets," are provided for the use of linemen to enable small repairs and adjustments to instruments, &c., to be carried out. One set is provided in the equipment of each 1st or 2nd class office. The set is contained in an enamelled cowhide holdall, size 9 inches long, and about 4 inches in diameter when rolled up. Each set consists of:—

Bottle, zinc, oil	1
Brush, watchmaker's	1
Case, boxwood, files	1

Case, tools, telegraph instrument	1
Cleaner, contact, telegraph instrument ...	1
File, Lancashire, smooth, 4-inch, round ...	1
„ smooth, half-round, 4-inch	1
Gimlet, spike, $\frac{1}{4}$-inch	1
Hammer, telegraph instrument	1
Handle, file, flat tang	1
Holdall, tools, electricians'	1
Mandril, telegraph instrument	1
Pins, adjusting, 4-inch	1
„ „ $2\frac{1}{2}$-inch, stout	1
„ „ „ fine	1
Pliers, round nose, 4-inch	1
„ sidecutting, 5-inch	1
Screwdrivers, forked, $3\frac{1}{2}$-inch	1
„ „ $2\frac{5}{8}$-inch	1
„ telegraph instrument	1
„ watchmaker's, $\frac{1}{4}$-inch	1
„ „ $\frac{1}{8}$-inch	1
Spanner, telegraph instrument...	1
Tweezers, large	1
„ small	1

Miscellaneous Stores.

Brackets, insulator, tubular, iron pole, semi-permanent.

45. "Brackets, insulator, tubular, iron pole, semi-permanent," are for use with "Insulators, ebonite, with shank," and "Poles, telegraph, iron, semi-permanent."

The brackets can be used singly or in pairs; in the former case one "saddle" and two bolts are required for each bracket, in the latter case no saddles are required, but two bolts are wanted for each pair of brackets.

Each bracket is $4\frac{1}{2}$ inches over all, and made of best malleable cast iron, galvanized. The tube for the insulator shank is $1\frac{3}{4}$ inch long by $\frac{9}{16}$ inch internal diameter. It will, therefore, not take the bolt of the porcelain insulators (para. 37, Chap. V). The brackets are suitable for poles up to $1\frac{3}{4}$ inch diameter. The bolts for securing the brackets are $2\frac{5}{8}$ inches long, of wrought iron, square headed, and threaded $\frac{3}{8}$-inch British Standard Whitworth; each bolt is provided with one hexagonal nut.

Weight of bracket, $10\frac{1}{2}$ ozs.; saddle, 2 ozs. each; and bolts, 3 ozs. per pair. Complete, $15\frac{1}{2}$ ozs.

Connectors, $\frac{3}{16}$-inch.

46. "Connectors, $\frac{3}{16}$-inch," are brass tubes $1\frac{3}{8}$ inch long by $\frac{3}{16}$ inch internal diameter, provided with two screws ($\frac{9}{16}$ inch long under head, and threaded No. 2 B.A.), one near either end, screwing through a hole in the side of the tube. They are used for temporary connections of wires, and for connecting up to the zinc pole of batteries composed of such cells as the

"Leclanché J," where the zinc rod of the cell terminates in a copper wire.

47. "Connectors, wing nut," are provided for connecting up to the zinc pole of batteries composed of cells such as the "Leclanché G," where the zinc plate of the cell terminates in a copper strap. The connector consists of a screwed brass rod provided with two wing nuts, one being soldered to the rod. The rod is $\frac{11}{16}$ inch long, and threaded No. 2 B.A. Connectors, wing nut.

48. "Counters, bone," are used for labelling circuits, &c. They are $\frac{15}{16}$ inch in diameter. Counters, bone.

49. "Gloves, indiarubber," are provided for the use of linemen and others when working on lines, &c., where there is danger from shock due to contact between the telegraph lines and power circuits. Gloves, indiarubber.

They are supplied in four sizes, viz.:—

Width.	Length.
$4\frac{3}{4}$ inches	7 inches
5 ,,	8 ,,
$5\frac{1}{4}$,,	9 ,,
$5\frac{1}{2}$,,	10 ,,

50. "Plates, earth, telegraph, Mark II," are for providing an earth connection at a permanent telegraph or telephone office. They are of galvanized wrought iron, 2 feet square by $\frac{1}{8}$ inch thick. A conductor, consisting of 12 feet of seven strands of No. 16 S.W.G. tinned copper wire, is passed through a $\frac{1}{4}$-inch hole in the corner of the plate (2 inches from either edge), brought round the standing part and soldered; the wire is also soldered to the plate on each side, and the whole joint varnished. Plates, earth, telegraph.

The weight of the plate complete with conductor, when new, is specified as not less than 24 lbs.

51. "Poles, telegraph, iron, semi-permanent," are intended to carry three 100-lb. wires, such as the field telegraph wire. One wire is carried as a "cap" wire and the others on "Brackets, insulator, tubular, iron pole, semi-permanent." Poles, telegraph, iron, semi-permanent, Mark II.

The Mark II pattern (often known as the "Mannesman") is in one piece 16 feet 6 inches long over all, of best quality mild steel. The lower 10 feet is 2·35 inches in external diameter, and pointed at the bottom. The upper 6 feet 6 inches is 1·6 inch in diameter. The tip of the pole is fitted with a cap, bored and threaded $\frac{1}{2}$-inch B.S.W. to take the shank of an ebonite insulator. When a cap wire is not required the hole is filled with a "point" which is a pointed plug $2\frac{1}{4}$ inches over all, the lower $\frac{15}{16}$ inch being threaded $\frac{1}{2}$ inch B.S.W.; the point is hexagonal for $\frac{5}{16}$ inch above the threaded portion, to take a spanner.

The pole weighs 40 lbs., and should be capable of standing a strain of 170 lbs. applied to the tip at right angles to the butt, the pole being blocked for 3 feet from the butt. This test mnst cause no permanent set, the deflection under the strain mnst not exceed 25 inches, measured from the position of the tip when deflected to the position assumed by the tip when released.

Poles, telegraph, iron, semi-permanent, Mark III.

52. The Mark III pattern pole has a uniform taper from $1\frac{1}{4}$ inch diameter at the tip to $2\frac{7}{8}$ inches diameter 3 feet from the bntt, the remaining 3 feet has a uniform diameter of $2\frac{7}{8}$ inches except the last $3\frac{1}{2}$ inches which is solid and pointed. The weight is not to exceed 45 lbs., and the testing strain is 130 lbs. In other respects the pole is similar to the Mark II pattern.

Poles, telegraph, iron, semi-permanent, Mark IV.

53. The Mark IV pattern consists of 1 base, 4 tapered sections, and 1 cap. The sections are joined by a socket joint, each section fitting over the one below it. The maximum length of any section is 4 feet $11\frac{3}{4}$ inches. Each section is made of sheet steel, riveted, and is strengthened at the lower end by an extra band of sheet steel. The ends of each section are made to gange to ensure fit and interchangeability. The total length of the pole when put together is between 20 feet 6 inches and 21 feet 6 inches.

The weights of the sections are: Base, $26\frac{3}{4}$ lbs.; bottom section, $15\frac{3}{4}$ lbs.; second section, 10 lbs.; third section, $8\frac{1}{4}$ lbs.; top section, 5 lbs.; cap, $7\frac{1}{2}$ ozs. The diameter is $1\frac{3}{8}$ inch at the top and $4\frac{1}{4}$ inches at the base.

Each pole is tested by being gripped in its base for 18 inches from its lower end. A pull of 50 lbs. is applied to the tip at right angles to the pole to take up the joints. The pnll is then increased to 100 lbs., when the pole must not fail or buckle, or take up a permanent set of more than 6 inches, excluding the take up of the joints. A proportion of the poles are also tested in a similar manner with a pnll of 200 lbs., under which they must not buckle or fail in any way.

Poles, telegraph, wood, 15 feet.

54. "Poles, telegraph, wood, 15 feet," are made of fir, and are in two pieces, jointed in the same way as the 17-foot pole; they are $2\frac{3}{4}$ inches diameter for 2 feet 6 inches from the butt, which is pointed, and $2\frac{1}{4}$ inches at the tip which is ferruled and bored to take the shank of an ebonite insulator. The weight is $13\frac{1}{4}$ lbs. They are useful where two wires are required temporarily, and where transport difficulties make them preferable to the semi-permanent iron pole.

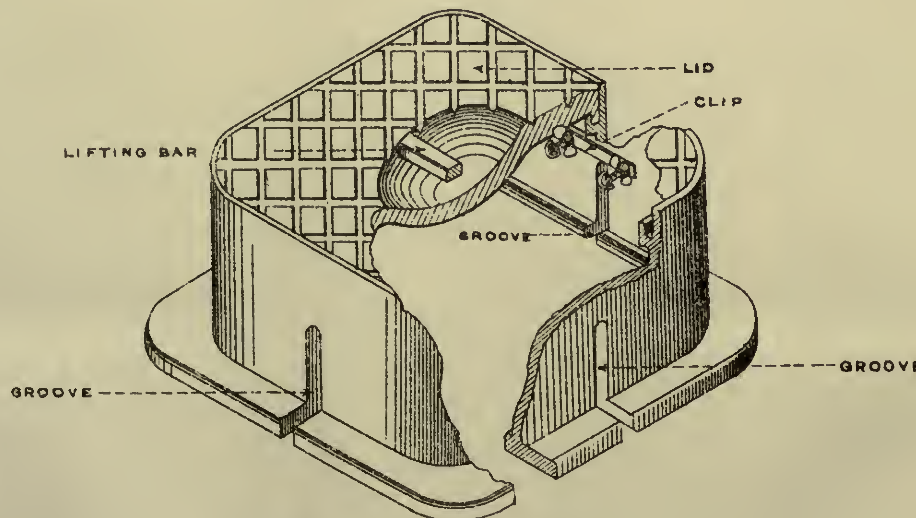
Staples.

55. The following patterns of staples are supplied as Ordnance Stores:—

"Staples, bellhangers'."—These are flat-crowned staples of tinned steel, $\frac{3}{8}$ inch long from the under side of the crown, $\frac{1}{4}$ inch wide between the legs, made of wire not less than No. 12 S.W.G. wide or No. 16 S.W.G. thick.

Weight, about 400 to 1 lb.

BOX, CABLE, RIFLE RANGE.



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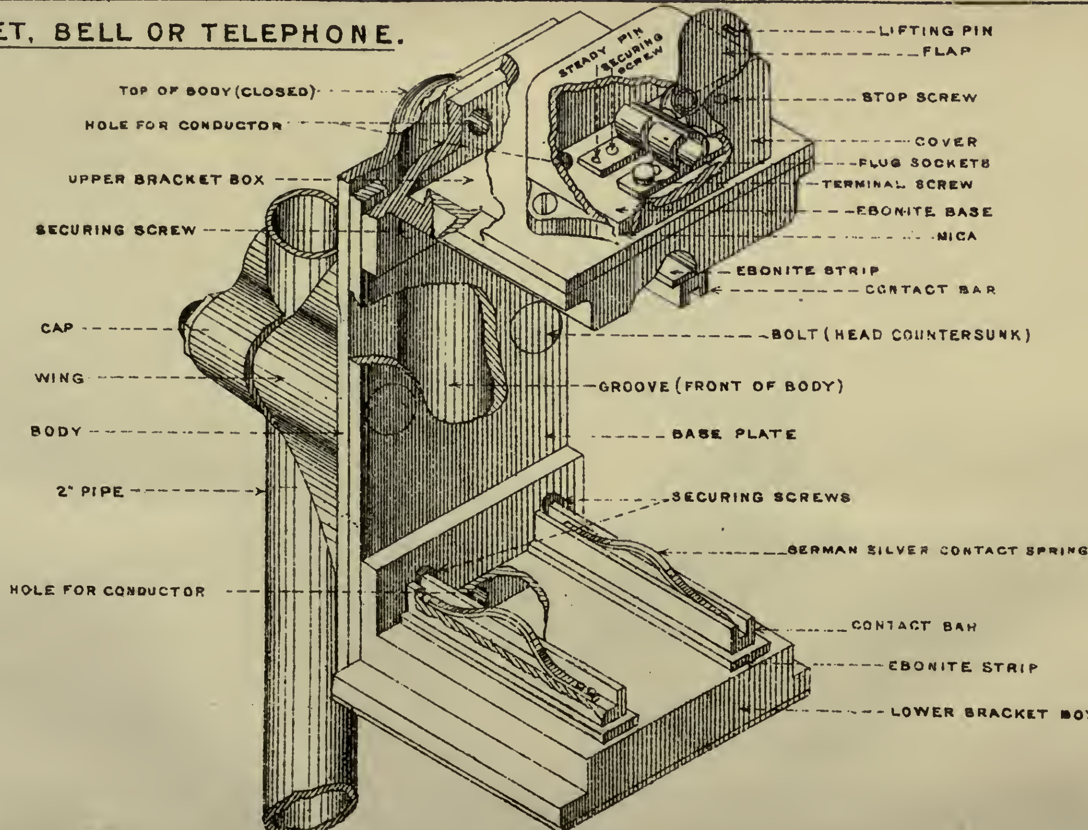
BRACKET, BELL OR TELEPHONE.



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"Staples, iron," are made in three sizes, as under:—

	Length over all.	Space between legs.	Weight.
No. 4 S.W.G. ...	$2\frac{1}{2}$ inches	$\frac{7}{8}$ inch	17 to 1 lb.
No. 8 " ...	$1\frac{3}{4}$ "	$\frac{3}{8}$ "	51 to 1 lb.
No. 11 " ...	$1\frac{1}{2}$ "	$\frac{1}{4}$ " (full)	125 to 1 lb.

They are made of galvanized wrought iron or mild steel.

For running insulated wires, "Staples, insulated saddle," should be used.

They are made of tough steel of flat section, and in two sizes:—

Length.	Section of wire.	Space between insulated sides of saddle.
$\frac{7}{8}$ inch	·1 inch × ·08 inch	$\frac{3}{16}$ inch
"	"	$\frac{1}{4}$ "

The inner side of the staple is insulated with a fibre saddle, $\frac{1}{16}$ inch thick, $\frac{5}{16}$ inch wide.

56. "Trays, battery plate," are ebonite trays 12 inches by 10 inches by 3 inches deep, and are supplied for use when amalgamating the zinc plates of batteries. The weight of the trays is not less than 2 lbs. **Trays, battery plate.**

Special Stores for Field Firing Ranges.

57. The "Box, cable, rifle range" (Fig. 7), is intended to protect the joints in C 1 cable when used on field firing ranges. It is a cast iron box without a bottom and with a removable lid. The cable is inserted through a groove in the side of the box, and the armouring wires are splayed out and clamped in the clips provided. Care should be taken that the armouring wires are clamped, so as to make a sound mechanical and electrical joint. The cables are jointed in the usual manner, and insulated with rubber tape and primed tape. **Box, cable, rifle range.**

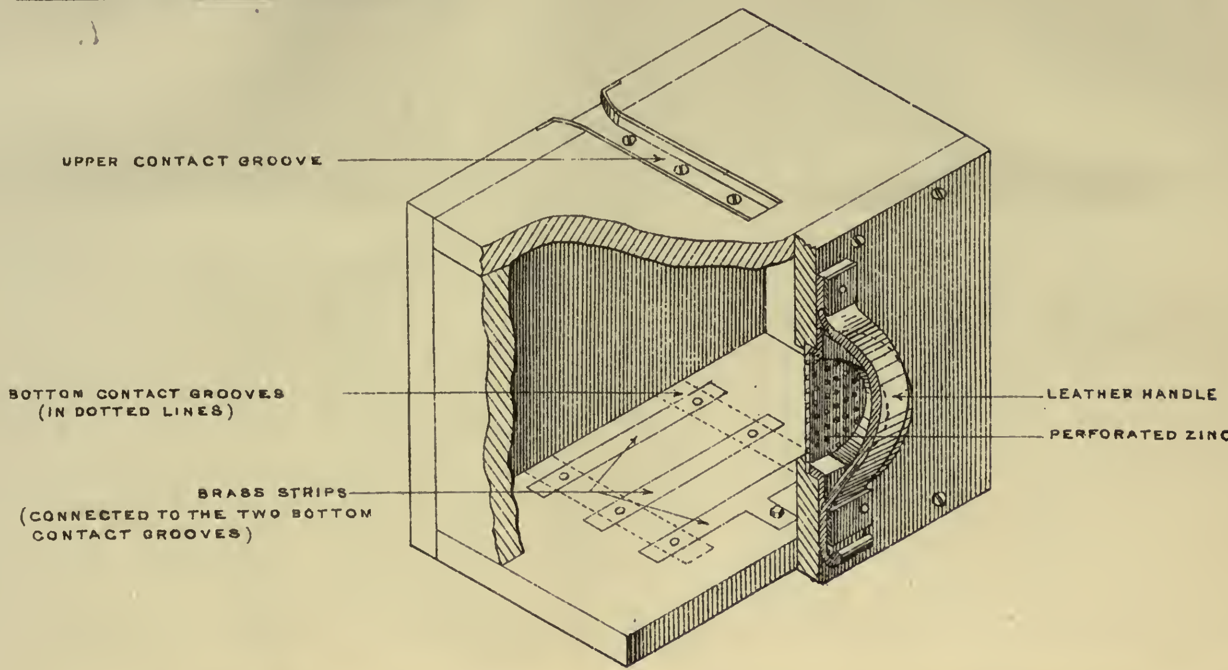
58. The "Bracket, bell, or telephone" (Fig. 8), is intended for use on field firing ranges for the purpose of connecting a bell at the target pits. The bracket consists of a body which is clamped to a 2-inch pipe fixed in the pit. A cover plate is bolted to the body, and carries two bracket boxes with contact bars. The cores (or core and armouring) of the cable are connected to the contact bars by means of terminal screws in the bracket-boxes. The bracket boxes are so arranged that a "Case, bell bracket," containing a "Bell, electric, magneto, R," can be slipped in, the bell being then connected to the cable through the contact bars in the brackets. Plug sockets, similar to those of the "Box, plug, single," are also mounted on the upper bracket, the sockets being connected electrically **Bracket, bell or telephone.**

to the contact bars. By means of these sockets and a "Plug, jack, W.D.," a portable telephone can, if required, be connected to the cable in lieu of the bell.

Case, bell, bracket.

59. The "Case, bell, bracket" (Fig. 9), is a wooden case made to contain a "Bell, electric, magneto, R" when used in the pits of field firing ranges. The box is of teak, and is provided with three contact grooves to fit the contact bars of the "Bracket, bell, or telephone"; terminals are provided inside the box for connecting the bell to the brass lining of the contact grooves. The front of the box is pierced with a circular opening covered by a piece of perforated zinc to allow of the escape of sound.

CASE, BELL, BRACKET.



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CHAPTER V.

CONSTRUCTION OF PERMANENT LINES (AERIAL).

Surveying.

1. The time available for the construction of a permanent line usually admits of careful consideration as to the best route to be followed and the preparation of a detailed estimate as to the stores required and the amount of money necessary for labour, cartage, and other incidental expenses.

If the line is a long one, or one of any importance, it will be necessary to make an examination of the various routes which can be followed in order to select that which is most suitable.

In doing this the following points should be borne in mind:—

(i) The route should be as direct and short as possible.
(ii) A straight road is preferable to a winding road on account of the number of stays and struts which can be saved thereby.
(iii) The route should be as free from trees as possible.
(iv) A road with a sufficient width of roadside waste in which to place the poles is desirable.
(v) Villages and towns should be avoided if possible.

Selection of route.

2. It must be recollected, when selecting routes in England in peace time, that the War Department has none of the rights possessed by the Postmaster-General for the erection of poles on public highways. It may therefore be preferable in some cases to go on private property instead of the road, as considerable saving in distance may be effected thereby, but as a rule the maintenance of a line running along a road is easier and the cost of construction less.

Detailed survey.

3. Having selected the route to be followed, a detailed survey of the road should be made, and the more care and attention devoted to this survey the easier and cheaper will the construction be.

The points to be decided when making this detailed survey are:—

(i) The side of the road to be followed.
(ii) The size and position of each pole, its description (whether A, H or single), length, size, &c.
(iii) The particulars as to stays and struts required, giving length, size, and any other details.
(iv) The details of the consents for which it will be necessary to apply.

(v) The consideration of the best means for the conveyance of the material to the spot and its distribution when there.

(vi) The fittings required for each pole, such as description of insulators, arms, bolts, hook guards, &c.

To carry out this survey, the officer or N.C.O. making it should be accompanied by two or three men with surveying rods.* The spans should be carefully paced and the surveying rods held up in the proposed positions for the poles. The best alignment can then be made and the position of struts and stays decided on. The position of each pole should be carefully entered in the survey book. This position should be identified as clearly as possible by its distance from some fixed object, such as a gateway, wall, hedge, tree or some other object which will not shift, so that the foreman who has to carry out the work may be readily able to identify the spot without being shown.

It is advisable to have a book specially ruled, in which the various details can be entered, and the following is a suitable type:—

No. of pole.	Span in yds.	Side of road, R. or L.	Position of pole.	Length of pole.	Details of stays.	Details of struts.	Arms.	Insulators.	Other pole fittings.	Consent required.	Remarks.

The various columns must, of course, be of sufficient width to allow of the details being clearly entered.

Too much care cannot be given to recording these details, and a survey should be so complete that any other man can readily follow the proposed route and the details of construction intended. Much subsequent trouble, time and expense may be saved by a carefully prepared survey.

Experience will alone enable a good survey to be made, as it is impossible to lay down rules to meet all cases, but the appearance and eventual cost of construction depends to a large extent on the experience and foresight of the individual making the survey.

In selecting the side of the road to be followed, consideration must be given to the facilities offered for staying and strutting,

* Any light rod is suitable for the purpose.

for avoiding trees and the danger of wires falling into the roadway.

Wires should not cross the road more often than is absolutely necessary.

On hilly roads the length of consecutive poles should be such as to prevent abrupt differences of level in the wires, and this can be arranged by selecting suitable positions for the poles and varying their lengths.

4. Tree attachments should never be used if they can be avoided, as the swaying of trees in the wind is liable to cause contacts and wear through the wires at the insulators. Tree attachments.

5. The distance apart of poles depends upon the character of the line. For a line for a small number of wires, say up to five, spans may run up to 80 yards, but for heavier lines they should not exceed 70, and for lines with 16 wires or more, 60 yards, but the length of span must much depend on the character of the road. In exposed places and on sharply curving roads the supports must necessarily be closer together, and it is only experience which can decide the best distance in each case. Distance apart of poles.

On routes carrying revolving telephone wires, *see* para. 69, the supports should be as nearly as possible 60 yards apart, whatever the number of wires and nature of the road.

6. Before any portion of the line can be constructed it will be necessary to obtain the consent of the road authorities and private individuals on whose land it is desired to erect the poles. It should be possible to make the necessary applications from the details recorded in the survey book, though the refusal of consent in some cases may cause an alteration to be made to the line as originally proposed. All consents should be obtained in writing and retained for future reference. Wayleaves.

7. Before the working parties proceed to carry out the work, all the stores required for the sections on which it is proposed to start should be on the spot, so that time and expense is not wasted by going over the same ground twice. Careful consideration should be given as to the most convenient points to which the various stores should be sent. The facilities available for cartage to the spot required, and for storage until required, must be borne in mind. It may frequently be necessary to hire a piece of ground or a shed in which to place the stores until the working party reaches the spot. Valuable stores such as copper wire are liable to theft, so that a lock-up store should, if possible, be obtained for them. Distributing stores.

Poles.

Poles are of two kinds, viz.:—

(i) Wooden.
(ii) Iron.

The nature of the country will generally decide which is the most economical kind to use. At home wooden poles are generally used, as, when well creosoted, they last very many years, are cheaper than iron, and do not offer the same opportunities for causing faults. Abroad, however, in many places wooden poles would last but a short time owing to attacks of insects and other causes, so that iron poles there become necessary. Iron poles may also be of advantage in some places, as they are less conspicuous than wood.

Wooden poles.

9. When the use of wooden poles is decided upon, creosoted poles should be used if possible; in some cases landowners in giving consent may stipulate for poles to be painted, and it is then necessary to use burnettised or plain poles, but this should not be done if it can be avoided as the life of such poles does not average more than eight or nine years, whereas a pole creosoted under the conditions prevailing at the present day will last 30 or more years.

Classes of wooden poles.

Wooden poles are issued in three classes, viz., light, medium and stout, and can be obtained in lengths from 22 to 80 feet, the most useful sizes being 28, 30, and 32 feet.

The class of pole to be used depends on the number of wires which the line is ultimately to carry, and the following is the general rule to be followed:—

Light poles should be used on lines carrying 1 to 5 wires.
Medium poles should be used on lines carrying 6 to 10 wires.
Stout poles should be used on lines carrying more than 10 wires.

The wires in these cases are considered as 400 lbs. to the mile. A corresponding increase may be made when lighter wires are used, but it should be borne in mind that in a wet snowstorm as great an accumulation of snow will take place upon a light wire as on a heavy one, so that it may be taken that the safe limit for wires weighing 100 lbs. to the mile would be for light poles 10 wires, medium poles 20, stout poles being utilized for any number over 20.

If a line is likely to be required for an exceptional number of wires, it is advisable to use A or H poles (paras. 12 and 13).

Height of poles.

10. Poles should be of such a height that the lowest wire should never be less than 12 feet from the ground at the lowest point in the span, and when crossing roads or railways there should always be a clear headway of 20 feet.

11. Pole holes should be dug in the direction of the wires and not crossways, so as to get the solid earth against the strain of the pole. This is shown at A in Fig. 1, the improper method being shown at B. The section to which pole holes should be dug is shown at C. Pole holes.

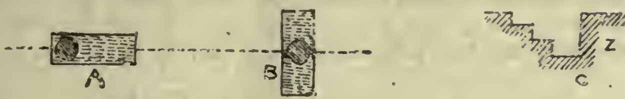


FIG. 1.

The general rule for the depth to which poles are to be buried is one-fifth of their length, but in no case less than 4 feet, nor need it be more than 6 feet, except in the case of very long poles such as 50-foot poles and over, when the depth of the pole may advantageously be increased to a reasonable extent. In rock the hole may be 1 foot less in depth. In swampy ground it will be well to bolt a timber block to the butt of the pole.

When erecting poles it is desirable to set them so as to bear slightly against the stress of the wires to allow for the settling of the disturbed soil, but this setting should only be sufficient to allow the pole to resume a vertical position when all settling has ceased. Care must be taken when filling in the holes that the earth is well rammed all round the pole as its stability is much affected thereby.

Special attention must be given to see that holes are never left open at night or even during the men's temporary absence at meals or other times, without being guarded.

12. A poles are used in cases where an exceptionally large number of wires has to be provided for, or on slight curves where there is not room to stay or strut, or on long straight lengths of ordinary line where double staying is not possible. They are, however, open to certain objections as they are expensive in material and costly to erect; they are inconvenient on telephone lines where the symmetrical position of the wires with regard to one another is essential, and when erected they are unsightly and do not offer the same support to a line as a well stayed or strutted pole. In their construction two medium poles should be used of as nearly as possible similar dimensions and appearance. Each leg is scarfed at the upper end so that when fitted together they will form an isosceles triangle, as shown in Fig. 2. They must not be too much tapered at the joint, nor should each pole be reduced by more than one-third of its diameter. The distance apart of the legs at the ground line will depend on the amount of space available, and, if possible, this distance should not be less than 3 feet in the clear, but it may be necessary at times to reduce it to 1 foot. If reduced below this the advantage gained by the use of an A pole is so slight as not to justify its expense, and the scarf "A" poles.

joint becomes too long. This joint should not exceed 5 or 6 feet. At the scarf the poles are fastened by two $\frac{5}{8}$-inch bolts. The arms are secured by a bolt through each pole. A tie bolt (para. 30), is fixed about half-way down the triangle, and at the bottom the legs are notched and a wooden tie 7 inches or 8 inches square is fitted and secured with $\frac{3}{4}$-inch bolts. The whole structure is thus a very rigid one. It will probably be necessary to use two pole roofs (para. 32), to cover the whole

Fig. 2.

Fig. 3.

top of the pole. If saddles (para. 33) are required a trenail (or hardwood cylindrical pin) about 1 inch in diameter should be driven through both poles parallel with the arms and below the apex of the roof. The coach screws which hold this saddle should then enter this trenail.

Great care must be exercised in erecting an A pole. The hole may have to be deepened, and it should be arranged that the necessary set is given with both legs resting on solid ground.

The earth should be made as solid as possible by ramming all round the legs, and it may be desirable to fit an additional block crossways at the foot of one leg. The erection of an A pole requires considerable skill and experience on the part of the foreman in charge, but when well put together it will stand considerable strain.

13. H poles are also used where an exceptionally large number of wires has to be carried and are more suitable than A poles, when the wires to be provided for are telephone wires whose positions on the poles must be kept symmetrical. "H" pole.

As the arms used on H poles are longer than those on A poles, the same height of pole enables a larger number of wires to be carried.

They are more sightly than A poles and do not take up more room at the ground line, but do not afford the same support at angles.

Medium poles are used unless the number of wires is very large, when stout poles are necessary. The poles are placed at a uniform distance of 18 inches apart in the clear. They are united at the top by the arms which are usually 72 inches long when medium poles are used, and 76 inches long when stout poles are used, and are bored for six insulators.

Near the butt is fixed a timber brace which should be notched not less than 6 inches in, and attached by two brace bolts. This brace should be 8 inches by 8 inches and of a length suitable to the size of the poles. In order to make the two supports into one solid structure a system of trussing is necessary. No special stores are provided for such trussing, and any system must be adopted which can be produced on the spot. As a guide, the system adopted in the G.P.O. may be described. In this system the poles are connected by tie bolts (para. 30), the lowest being fixed 6 inches above the ground line. These tie bolts are connected by truss rods (*see* Fig. 3), which are themselves connected together by steel truss rings which afford the necessary means of tightening them. Four special iron blocks are used with each truss ring, which fit into the channel of the ring and afford a good bearing surface for the truss rod nuts. The lower tie bolt is attached to the bottom brace by two brace rods 6 feet in length carried down just inside the poles. The trussing should be carried upwards to a point just below the position which will be occupied by the bottom arms when the line is full. The truss rods used by the Post Office are issued in two lengths, viz., 3 feet and 4 feet, so that a combination can be arranged which will admit of the trussing being carried to the required height. The top tie bolt is provided with special washers 8 inches by $2\frac{1}{2}$ inches by $\frac{1}{4}$ inch, fitted on the inside of the pole and secured by coach screws, to prevent the tie bolt from crushing into the fibre of the poles.

14. There is no service pattern of iron pole, and demands will be met as required. The patterns of iron poles obtainable Iron poles.

in the market are so numerous that only a general description of such poles can be given. In most cases they consist of a cast iron base which is fixed into the ground, and to which the pole is then fitted. These bases vary in length and size according to the length of pole required. In some cases, a rectangular or circular base-plate is provided, on which the base can rest to prevent it sinking into the ground. This base-plate is sometimes bolted and sometimes screwed to the base. In other cases the base is made with a point, so that it can be driven into the ground similarly to a pile. In the case of the heavier poles, iron pieces 6 to 8 feet long are sometimes provided, and these pass horizontally through the base at right angles to one another. One objection to this arrangement, however, is that is necessary to excavate such a large hole before the pole can be erected. In other cases, again, the base is intended to rest on a concrete bed without any plate or cross-pieces, and a further layer of concrete is placed round the base near the surface of the ground, but such a course is only desirable when poles are likely to carry heavy routes.

The poles themselves are usually formed of one or more tapering wrought iron tubes, or parallel lower tubes with tapering top tube, according to the length of pole required. The greatest length which it is desirable to have in one tube is from 25 to 30 feet. If a greater height than this is required, it will be necessary to build up the pole with other lengths of tube.

The methods of attaching the tube to the base, or the different lengths of tube to one another, vary in different cases, but generally the upper portion fits into the lower, being secured by driving or screwing a taper ring between them. In other cases, the upper portion of the base, or lower tube, is reduced in diameter for a foot or so and the tube, or upper length, fits over it, no ring being then necessary.

The thickness of metal of which the tubes are constructed will vary according to the lengths and the number of wires intended to be carried.

The top of the pole should be filled up by a lightning rod being fitted into it, or else by an ornamental wooden finial.

Iron poles should be periodically painted to preserve them.

When demanding iron poles, care should be taken to specify the height of pole required (*i.e.*, height above the ground line plus $\frac{1}{5}$), and the ultimate capacity, in number and weights, of wires for which the line in question is being constructed.

Arms.

Wooden arms. 15. Wooden arms are used with wooden poles only, and are cut from well-seasoned cak. The service patterns are:—

Arms, telegraph pole, ordinary, 24-inch.
" " " 48-inch.
" " terminal, 24-inch.
" " " 48-inch.

The ordinary arms are $2\frac{1}{2}$ inches by $2\frac{1}{2}$ inches in section, and the terminal 3 inches by 3 inches. The latter are for use when terminal or fuze insulators are used, and are bored for $\frac{3}{4}$-inch insulator bolts; they would only be used in other cases when wires heavier than 400 lbs. to the mile are being run.

The 24-inch arms carry two insulators spaced 18 inches apart, and may be used for telegraph lines carrying not more than eight wires. They should not be used for revolved telephone circuits.

The 48-inch arms are those generally used, and should always be used when more than four telephone wires are required. They are bored for four insulators, spaced 12 inches, 18 inches, 12 inches.

For A and H poles longer arms are required; these are not service patterns, and, if required, must be specially demanded, and the number of insulators and their spacing must be stated in demands.

For routes carrying a large number of telephone circuits of 70 or 40 lb. wire (say more than 24 wires) it is generally desirable to use 78-inch arms bored for eight insulators spaced 9 inches apart. When these are used, "arm combiners" should be bolted to the ends of the arms to brace them together; each combiner is about 14 inches long, and should, as a rule, be provided locally.

16. All arms should be attached to the same side of the pole, which should be, for the sake of uniformity, the "up" side, *i.e.*, that of the most important terminal office. Where it is necessary to terminate the wires, the arms should be on the side of the pole which will cause the pull of the wires to draw the arms into the slots. Fixing arms.

The arms should be spaced 12 inches apart, the top arm being 9 inches from the top of the pole. Slots for wooden arms should be cut to a depth not greater than $1\frac{1}{2}$ inches and should be such a width that the arms may have to be driven into position. They should be coated with a mixture of tar and creosote, in the proportion of one part (by measure) of coal tar to two parts of creosote, before the arms are finally fastened. All arms must be fitted square with each other, so that the whole structure may be symmetrical. This is specially necessary when revolving telephone circuits are concerned. The arms should be so placed on the poles that when in position they are at right angles to the line of the wires, except at angle poles, where they should bisect the angle formed by the line of the wires. If this angle is very acute it may be desirable to double-arm the pole with one arm on each side so that each wire passes round two insulators, and in that case the two arms are bolted together midway between the insulators.

When the change of direction is a right angle or nearly so, the pole should be crossed-armed, *i.e.*, a second set of arms should be fixed between those of the first, one set being at right angles to each of the directions of the wires. The wires are then terminated and joined by cross connections, which should, if possible, be bare wires, as covered wires are liable to cause faults which are difficult to trace.

Arms are fixed to the poles by means of bolts of the proper length. "Bolts, telegraph pole, $\frac{1}{2}$-inch," and "Bolts, telegraph pole, $\frac{5}{8}$-inch," are supplied for the purpose, the length required must be stated in demands; the former are for use with ordinary arms and the latter with terminal arms. Each bolt is supplied complete with neck washer, nut washer, and nut. The neck washer of the $\frac{1}{2}$-inch bolt is 2 inches by 2 inches by $\frac{1}{8}$ inch thick, and the nut washer 3 inches by 2 inches by $\frac{1}{4}$ inch thick. For the $\frac{5}{8}$-inch bolt both washers are of the latter dimensions. The bolts and washers are galvanised. The nut end of the bolt, together with the nut washer, should be on the same side of the pole as the arm, the neck washer bearing against the pole. The head of the bolt and the washer should be placed symmetrically, and the nut tightly screwed up.

Iron arms

17. Iron arms are also used in certain cases. There are two patterns issued in the service, viz., A for use with wooden poles, and B for iron poles, and they are supplied in two lengths, viz., 20 inches for two insulators, and 44 inches for four insulators, known as "Arms, telegraph pole, tubular, A 20 inches," etc. A proposal to reduce the length of the 4-wire arms for iron poles to 38 inches is under consideration.

Arms of pattern A are fitted into the pole similarly to wooden arms, but those of pattern B have special fittings for gripping the pole. With both patterns wooden sleeves are used which fit on the top of the arms and give a flat bearing for the insulator bolts, and prevent a wire which comes off an insulator touching the iron arm and so causing a fault. Iron arms should not be used for wooden poles if wooden arms can be obtained.

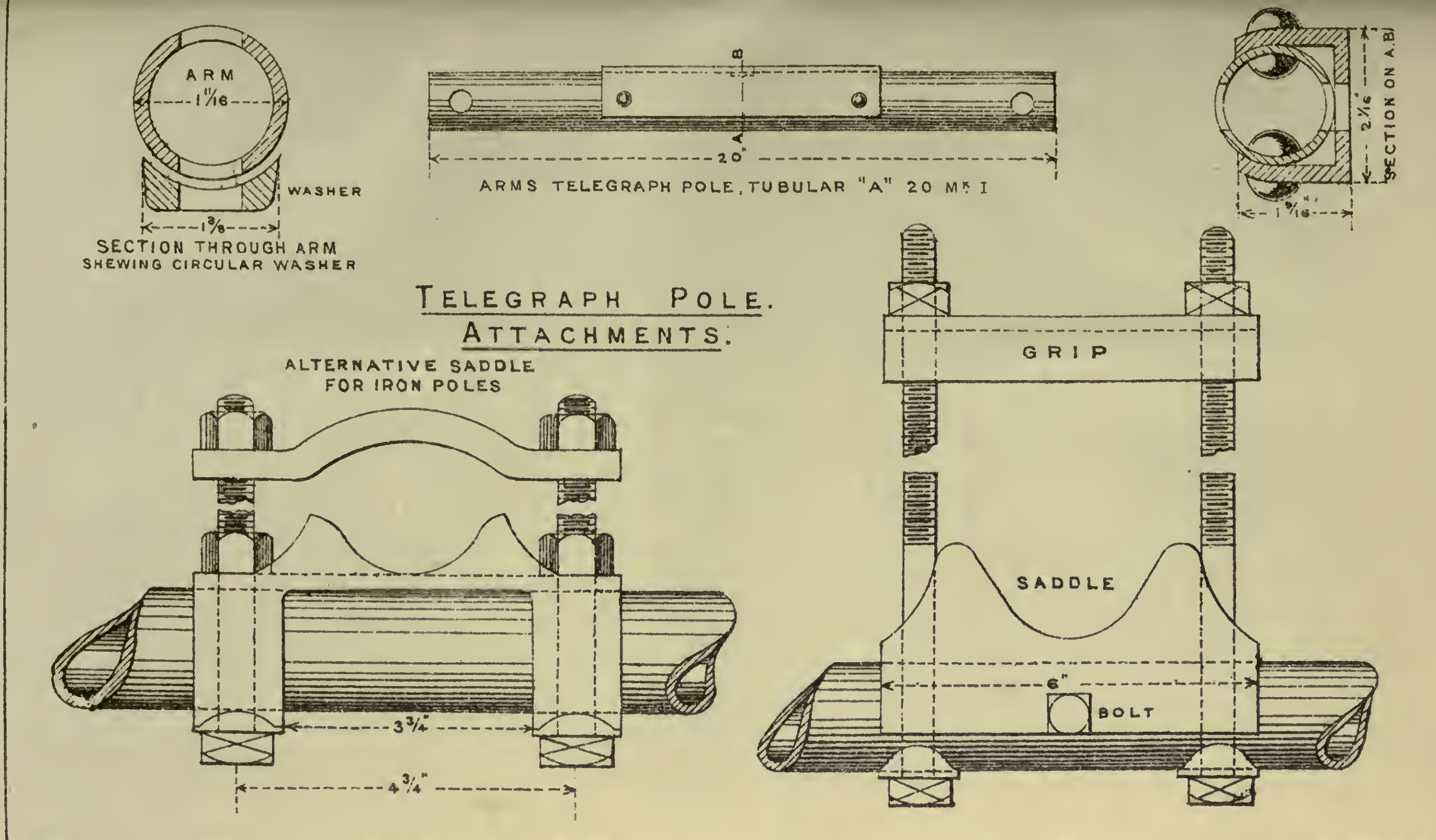
The arms are illustrated in Fig. 4, and are provided with a curved washer for each insulator hole, to give a flat bearing for the lower end of the bolt.

The "B" arms are supplied to fit poles from $2\frac{1}{4}$ inches to $3\frac{1}{4}$ inches, or from $3\frac{1}{4}$ inches to $4\frac{1}{4}$ inches diameter respectively, as demanded. If other sizes are required, the diameter of the pole or standard at the point where the arms are to be attached must be stated in demands.

Stays and Struts.

18. When the poles are not strong enough of themselves to withstand the stress placed upon them by the strain of the wires by wind, snow, or other causes, it is necessary to support them. This may be done in two ways, by means of stays or struts.

A stay is the term applied to the support which is required to resist tensile stresses, and consists of a wire attached at its



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upper end to the pole which has to be supported and fixed at its lower end firmly into the ground (Fig. 7).

A strut is the term applied to the support which is secured to resist compression stresses, and is formed by a wooden pole placed with its upper end against the pole to be supported and its lower end fixed to a block buried in the ground (Fig. 12).

Stays. 19. A stay should be used, whenever possible, in preference to a strut as the latter is more expensive, requires more skill to fit and is difficult to shift should the addition of wires necessitate an alteration.

In order to secure the full efficiency of a stay, the following conditions should be observed:—

(*a*) Its upper end should be attached as nearly as possible at the resultant point of the strain of the wires, which may be taken to be the middle point between the upper and lower arms.

(*b*) A means of tightening it at any time must be provided.

(*c*) It should be so attached to the pole as not to weaken it.

(*d*) It should be so fixed as to make as large an angle as possible with the pole.

Where stays are used. 20. In addition to the stays which are required at angles they should be fixed at the following points in the line:—

(i) At terminal poles.

(ii) At each road-crossing on a heavy line, where double longitudinal stays (*i.e.*, stays in the direction of the wires) should be fixed, one on each side of the road, to hold up the wires across the road should a breakdown occur.

(iii) Where such road crossings are infrequent longitudinal stays should be placed on heavy lines about every quarter of a mile.

(iv) On heavy lines wherever heavy gauge wires stop and are continued by lighter wires.

(v) On long straight runs, rocking stays (*i.e.*, stays in a direction perpendicular to the wires) should be inserted at intervals, especially on heavy lines.

Position of stays. 21. The position of the stay should be such that it will best withstand the stresses it has to meet.

Wherever a single stay is sufficient it should be placed, if at a terminal pole, in the direction of the line of the wires or, if at an angle, in the prolongation of the line bisecting the angle formed by the line wires. Where two stays are required to give the necessary support they should make equal angles with this line or with the line of the wires.

In some cases, however, the ground available may not permit of this being done, and then a V stay may be used or a second stay fixed in the same line as the first.

When using a V stay the two branches should be fixed at equal distances from the resultant point, thus A B should equal

B C (*see* Fig. 5), and the stay where it loops round the stay tightener should be lapped round with " Wire, electric, Z 21."

The direction of the stay rod should be towards the resultant point.

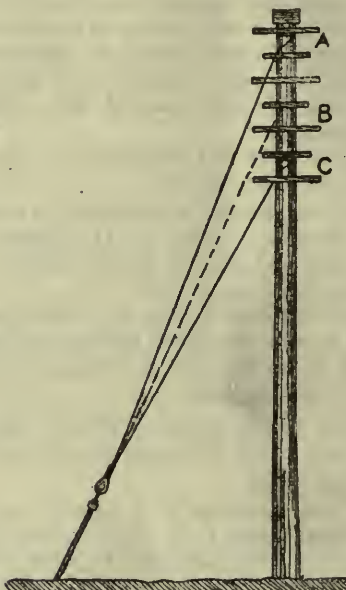


FIG. 5.

Where a second stay is required in line with the first, care must be taken that the two are parallel (*see* Fig. 6), as stays at varying angles are unsightly.

The most efficient position in which a stay can be fixed is at right angles with the pole, but this is obviously in most cases impossible. Generally speaking, however, for stays at angles the base should not exceed half the height of the resultant point above the ground and for stays on terminal poles it should equal that height.

Stay wires. 22. The service patterns of stay wires are composed of several strands of galvanised iron wire, the descriptions being as shown :—

Designation.	Description.	Breaking Weight.
Wires, stay—		lbs.
BB 1	7 strands, No. 14, S.W.G. ..	2,450
BB 3	3 " " 8, " ..	4,200
BB 4	4 " " 8, " ..	5,600
BB 5	5 " " 8, " ..	7,000
BB 7	7 " " 8, " ..	9,800

BB 1 is intended for use with roof standards, &c., but may be used on light lines. BB 3 and BB 5 are obsolescent, and no more will be provided. If no proper stay wire is available, it may be improvised by twisting up the necessary number of strands of any galvanised iron wire obtainable.

The size to be used depends on the amount of strain to be borne, and is usually decided by experience, as the strain varies in every case.

Fig. 6.

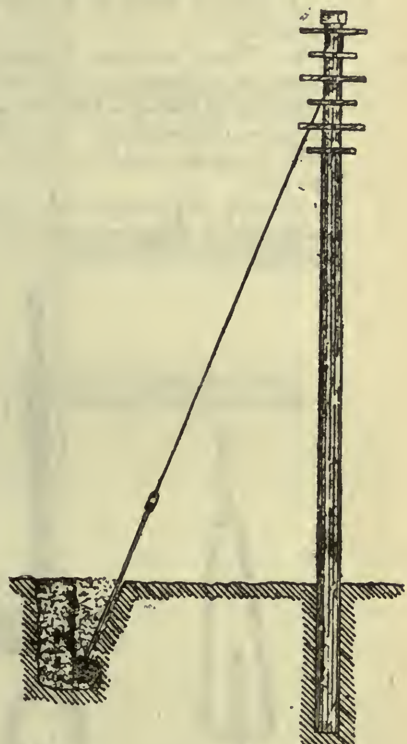


Fig. 7.

The lower end of the stay is made off to a stay rod, terminating in a stay tightener, and the rod is secured in the ground, usually by means of a stay block.

23. The stay block should be buried to a depth varying from 3 feet 6 inches to 6 feet, according to the nature of the soil and the stress to which the stay will be exposed. The hole in which it is buried should be undercut so that it may have the firm earth to resist the upward pull. (*See* Fig. 7.) **Stay blocks.**

Where hard rock exists it may be necessary to drill a hole and fix the stay rod therein with melted lead.

A stay block should be about 10 inches by 5 inches in section and 2 to 4 feet long, according to the strain on the stay. Wooden railway sleepers, cut in halves, make serviceable stay blocks. Stay plates, "Rods, stay, plates," 2 feet square, for $\frac{5}{8}$-inch or $\frac{3}{4}$-inch rods, have been sealed as service stores, but are inconvenient for general use, and should only be used when wooden blocks are not obtainable, or are liable to damage by insects or other causes.

A hole is bored in the stay block, through which the stay rod passes.

Stay rods. 24. There are two sizes of stay rods used in the service, known as "Rods, stay, 6 feet by $\frac{5}{8}$ inch," and "Rods, stay, 8 feet by $\frac{3}{4}$ inch." The breaking strains are 95 cwts. and 142 cwts. respectively. The end which goes through the stay block is square, and a steadying plate with a square hole is provided.

The top of the stay rod is threaded and passes through the lower end of the stay tightener and is there secured by a nut. (*See* Fig. 8.)

Fig. 8.

Fig. 9.

This thread should be coated with white lead and tallow to protect it from rust.

On the top end of the stay tightener is placed a galvanised iron thimble, round which the lower end of the stay wire is made off.

Fixing stays. 25. To attach the stay wire to the thimble of the stay tightener a special tool, shown in Fig. 9, and known as "Tools stay," is used, and the method of attachment is as follows:—Bend the stay wire to form two knees from 4 inches to 6 inches apart, according to the size of the thimble, the first of these knees being from 13 inches to 22 inches from the end of the wire, according to the number of wires in the stay.

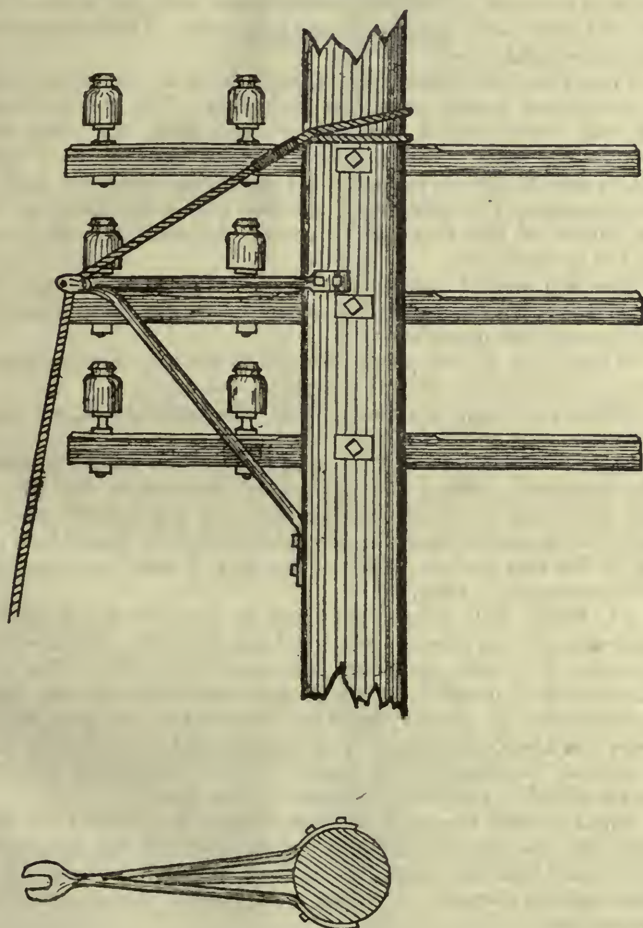


FIG. 10.—Stay Crutch.

Then bend the wire between the two knees round the thimble, using the tool to draw it close into the groove. Unstrand the free end and straighten out the wires, pick out one end for the first lap, loosen the tool while this wire is placed underneath it. Again grasp the remaining wires with the tool and place them symmetrically parallel with and around the main strand, so that they will bind into it without spoiling its circular shape. Grip with the tool and revolve the latter with the free wire under the hook on the thimble side of the tool. This wire should make eight laps. Then loosen the tool and take a second of the loose wires, place it in the hook of the tool and twist as in the case of the first wire. This wire should also make eight laps.

Then treat the third and similar ends in the same way until all are evenly bound round the main stay. The third, fourth, and fifth wires should make seven laps each, the sixth and seventh six laps. The projecting short ends of each wire (which should not be more than ½ inch long) must be worked in by grasping the splice with the tool (the ends being within the hollow of the tool) and turning the tool over each end until it is worked in.

The top end of the stay wire is attached to the pole by being lapped twice round it, secured by staples and spliced in the manner just described.

When fixed to iron poles, the end of the stay wire is lapped twice round the pole just above one of the arms.

When two stays are made off at the same point, one turn round the pole will be sufficient for each.

Stay crutch. 26. No stay should be fixed so as to approach within 3 inches of a line wire. When the position of the stay on the pole is such that this is otherwise impossible, a stay crutch may be used, and in such a case the stay wire should be bound into the end of the stay crutch. "Crutches, stay, ¾ inch," are provided for this purpose. (Fig. 10.)

Pole spur. 27. When only a small base can be obtained for a stay, it may frequently be advantageous to truss the pole. This is done by means of a pole spur and stay wire (Fig. 11). The pole spur should, if possible, be fixed equidistant between the point of attachment of the stay wire and the butt of the pole, where a stay rod should be fixed. A groove should be cut in the pole to receive the stay rod, as shown in the figure, and the stay washer should be nailed to the end of the butt.

Poles trussed in this way must always be blocked on both sides, and the stay wire should not be bound to the pole above the ground line, as, when this is done, the pole is less able to stand sudden stresses. "Spurs, pole, ¾-inch," are provided for the purpose.

Stay guards. 28. Stays should be so fixed, if possible, as to obviate the danger of horsemen or foot passengers running against them, and if this is impossible, they should be protected by stay guards.

Such guards should stand 6 feet out of the ground and may be formed of old poles cut to suitable lengths, or of casing attached to the stay, or any other means available on the spot.

These guards should, of course, be made as visible as possible by painting or other means.

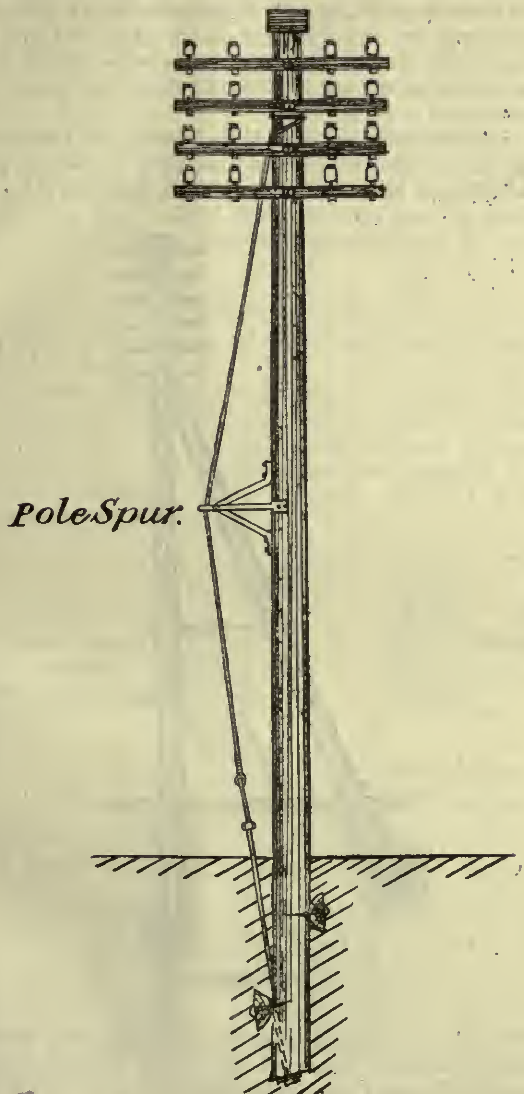


FIG. 11.

29. A strut should be so fixed as to act also as a stay so that in whichever direction storms may act, the strut will be able to bear the increased stresses. Struts.

Struts should be fixed at the resultant point wherever possible, but it should be remembered that struts cannot easily be shifted after erection, so that it is better to fix them at that point which will be the resultant point when the line is full. Where four-wire arms are in use, the struts should be fixed under the wires as shown in Fig. 12, but then poles of considerable stiffness must be used.

The angle which a strut should make with the pole is usually decided by the amount of ground available, but, when possible, they should follow the same principles as laid down for stays.

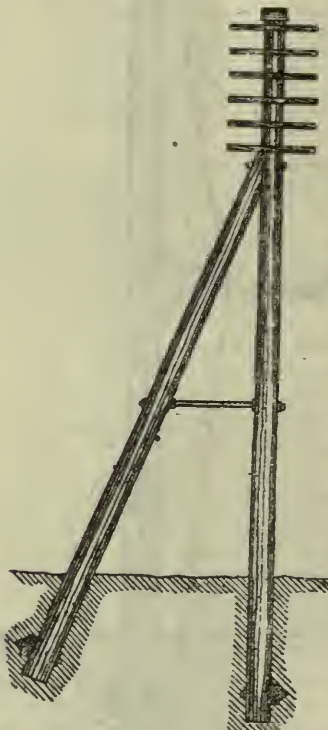


FIG. 12.

In fixing the strut the pole must not in any way be cut into or weakened, but the head of the strut must be carefully scarfed to fit the pole, the surface of the joint being covered with a mixture of tar and creosote.

The head of the strut is fixed to the pole by a $\frac{1}{2}$-inch or $\frac{5}{8}$-inch bolt as shown in Fig. 12. About half-way down the strut a tie-bar of suitable length is placed to connect it with the pole.

Near the bottom of both the pole and the strut notches are cut and strong blocks 3 or 4 feet long are bolted securely to each. The strut should extend at least 4 feet into the ground.

Care must be taken that where there is danger of a horseman passing between the strut and the pole the space below the tie-bar be at least 12 feet.

When a strut is required with an iron pole a special arrangement will have to be made locally for securing it to the pole. No recognized method of making such an attachment exists, and the method most suitable must be devised in each case. An iron strut should, however, never be used if it can be avoided.

Miscellaneous Fittings.

30. In describing A and H poles and struts, mention has been made of tie-bolts. **Tie-bolts.**

These tie-bolts consist of a tube, a bolt and certain washers.

The bolt passes through the two poles, to be connected together, and is secured on the outside of each by means of washers and a nut. No special bolts are supplied for this purpose, and suitable bolts of the size required must be specially obtained in each case.

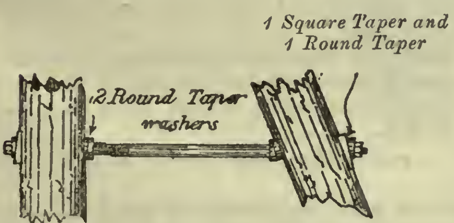


FIG. 13.

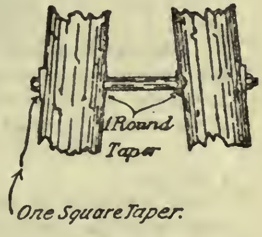


FIG. 14.

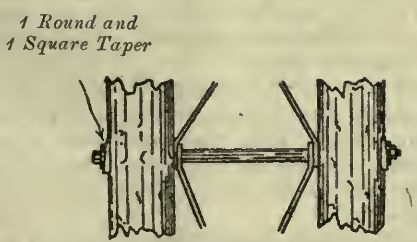


FIG. 15.

The tube is used between the poles to be connected and the bolt passes through it. This tube should be of galvanized wrought iron 1 inch (internal) diameter. It must be carefully cut to the required length. The washers required are

"*Washers, taper, round," and "*Washers, taper, square," the latter having one face hollowed out to fit the roundness of the pole. These washers must be so combined as to afford the nuts and end of the tube a level bearing, and the way in which this should be done is shown in the accompanying figures, Fig. 13 showing a strut, Fig. 14 an A pole, and Fig. 15 an H pole. The special washers referred to under the heading of H pole are a special pattern, and must be separately obtained if required.

Earth wires. 31. All wooden poles must be earth-wired, that is to say, must have a wire running down them and connected to earth.

The object of this is to cut off contacts between contiguous wires and also to act as a lightning conductor.

Iron poles need, of course, not be earth-wired. Earth wires should be of 400-lb. galvanized-iron wire, "wire electric Z 23," and should be fixed beneath the washers placed between the pole and the head of the arm bolt, and after being carried down well below the point where subsequent arms will be fixed they should be taken a quarter of a turn at right angles and then be taken down on the least exposed side to the bottom of the pole, where they should be formed into flat spirals and stapled. They should be stapled down the pole, the staples being at a distance of 9 inches apart for a length of 8 feet from the ground, but beyond that they may be 2 feet apart.

The earth wires must not touch the galvanized iron roof, but should project about 3 inches above the side of the roof. A single earth wire will be sufficient for A poles, but two wires should be used with H poles.

It is not advisable to earth-wire poles planted in rock or on a viaduct.

In the case of 48-inch and longer wooden arms, the arms must also be earth-wired to cut off contact between wires on the same side of the pole. This is done by running a wire along the arms (which can be connected to the earth wire of the pole by means of the arm bolt) with a turn round the arm between each insulator bolt hole.

In some cases iron earth wires may be unsuitable, owing to the acid fumes in the neighbourhood and the consequent short life of iron wires. It is then advisable to use copper wire, in which case copper staples must also be used. Old copper or bronze wire would be suitable wire to use under these circumstances.

When copper or bronze wire is used for this purpose the poles should be grooved to receive the wire for at least 6 feet upwards from the ground line, so that the wire cannot readily be removed by dishonest persons.

Pole roofs. 32. The tops of all wooden poles must be covered to prevent wet soaking into the pole.

* Not vocabulary stores.

For this purpose galvanized iron roofs known as "roofs, telegraph pole," are used. These are issued in two patterns, viz., cut and uncut, the former being intended for use when a cap wire is to be run, and the latter for poles with no cap wire. Roofs must be fixed transversely with the pole. The top of the pole is cut to fit the roof and is coated with a mixture of tar and creosote (one part by measure coal tar to two parts creosote). The uncut roof is fixed by means of "nails, rosehead, 2-inch," and the cut roof by the coach screws of the saddles.

33. When a cap wire is to be erected, galvanized iron saddles known as "saddles, insulator," are used of the shape shown in Fig. 16. The insulator bolt passes through the saddle and is secured by its nut, for which purpose a recess is left in the underside of the saddle. The saddle is fixed to the pole by means of 3-inch coach screws.* **Saddles.**

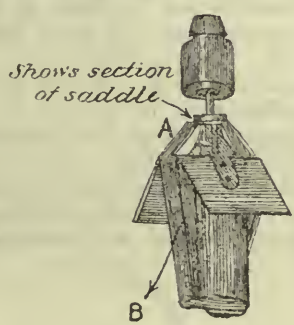


FIG. 16.

At angles the strain on these saddles is considerable, and they should be strengthened by means of saddle stays as shown in fig. 16. A is a piece of galvanized hoop iron, fixed to the pole by means of 3-inch coach screws, but as it is undesirable to bend the pole roof, hardwood wedges, as shown at B, are used to fill up the space between the pole and the edge of the roof. They are fixed to the pole by wire nails independently of the stay.

"Saddles, insulator, stays" and "saddles, insulator, wedges," are provided for the purpose, the latter being issued in three sizes, "thick," "medium," and "thin," for light, medium, and stout poles respectively.

34. In some cases it may be considered preferable to fix brackets on poles instead of arms. For this purpose galvanized iron brackets known as "brackets, insulator, wood pole," are supplied. They should not be fixed opposite one another, but alternately on each side of the pole, the first one 8 inches from the top, the next 6 inches lower down on the opposite side. **Brackets.**

* The length of the screw is measured exclusive of the head.

Brackets should, however, never be used where arms are possible. They are fixed by means of two coach screws at the top and one 3-inch rose-headed galvanized iron nail below (known as "nails, rosehead, 3 inches").

"Brackets, insulator, angle," and "Brackets, insulator, wall," single and double, are also issued for fixing to masonry or brickwork. Care must be taken that the brackets obtain a good hold, walls being plugged if necessary or the brackets embedded in cement. If fixed to a chimney stack and the pull is away from it, it is better, if possible, to carry a band right round the stack.

There is no service pattern of bracket suitable for use with ordinary iron poles.

Pole steps. 35. "Steps, telegraph pole," may be fixed on tall poles to avoid the use of long ladders. They should be fixed alternately on either side of the pole 18 inches apart by means of 3-inch coach screws, and should not be fitted at a less height than 12 feet from the ground, so that they may not be used by unauthorized persons.

It may also be advisable to use two pole steps on poles carrying only a saddle wire for the use of linemen renewing insulators, &c. They should be fixed opposite to each other about 3 feet 6 inches from the top.

Hook guards. 36. "Guards, insulator, hook," may be used at points where there is a danger of wires which may break away from the insulator falling into the road and causing an accident (*see*

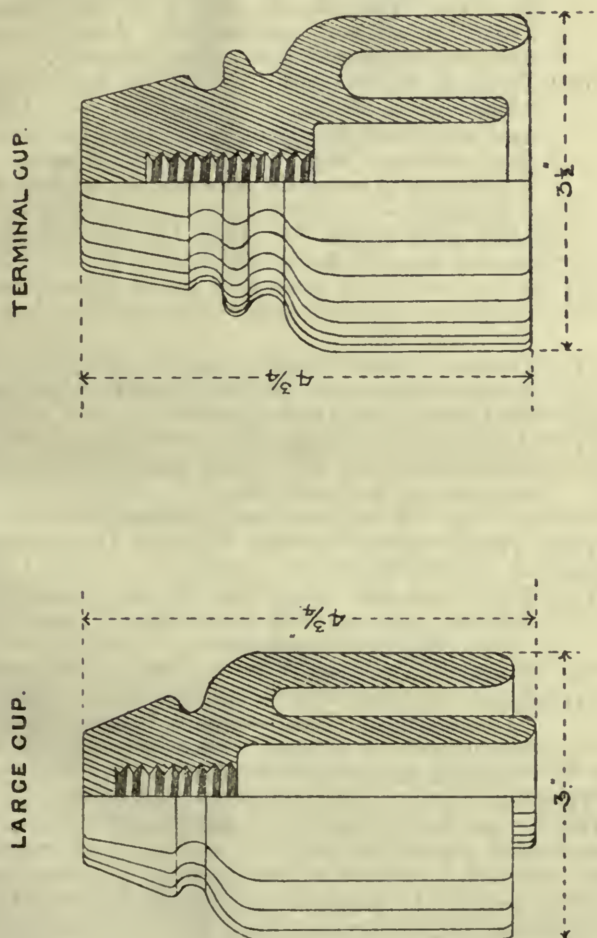
FIG. 17.

Fig. 17). They must be so secured that there is no danger of their slipping round and coming in contact with the line wires.

Insulators.

37. The insulators used in the service are made of glazed porcelain. They were formerly white, but brown are now provided as being less conspicuous. They were also formerly issued in two patterns, single and double shed; the former are now obsolete. In the latter there is a second cup within the first, the object of this being that the inner cup is protected from wet by the outer one, and consequently there is always a more or less dry surface to prevent leakage between the wire and the bolt.

The porcelain cup is secured to a bolt, or spindle, either by cement or by screwing. The former method has the disadvantage of necessitating replacing the bolt as well as the cup if the latter is broken. Service insulators (*see* Fig. 18) are now all of the screw pattern, and consist of three parts, viz., the porcelain cup, the bolt, and an indiarubber ring,



INSULATORS.

Fig. 18.

which is fixed between the cup and the shoulder of the bolt. This ring both increases the insulation and allows for the unequal expansion and contraction of the cup and bolt under changes of temperature.

Cups. 38. There are six types of cups in the service, viz.:—

(*a*) "Large double shed," which is the most useful size, and is used in conjunction with $\frac{5}{8}$-inch straight bolts for all wires except as stated below, and with $\frac{5}{8}$-inch "J" bolts for all wires over 70 lbs.

(*b*) "Small double shed," which are for use with wires up to 70 lbs., especially on poles carrying a large number of wires. They can be used with the "long" or "short" $\frac{5}{8}$-inch bolt, but the latter should be used if available, the former being rather unsightly.

(*c*) "Terminal double shed," which are larger than the "large" cups, and have two grooves; they should be used with $\frac{3}{4}$-inch straight bolts at poles where the gauge of wire changes, or at road and railway crossings where it is desired to terminate the wires, and at sharp angles with heavy wires. They should be used at terminal poles with $\frac{3}{4}$-inch "J" bolts for terminating wires heavier than 150 lbs. to the mile.

(*d*) "Fuze," which are used with $\frac{3}{4}$-inch bolts where it is desired to insert a "fuze tube, 2-inch," in the line (*see* Chap. VII).

(*e*) "Leading in and Terminal, large" single shed, with a screwed cover are for use with wires over 150 lbs. and are threaded for $\frac{3}{4}$-inch bolts.

(*f*) "Leading in and Terminal, small" single shed, with a screwed cover are for use with wires up to 150 lbs. and are threaded for $\frac{5}{8}$-inch bolts.

Bolts. 39. The bolts are made of steel, galvanized, and are each provided with a nut and washer. There are three patterns of straight bolts in the service, viz.:—

(*a*) "$\frac{5}{8}$-inch, straight, long," for use with "large" cups, and can also be used with "small" cups, but are rather long for this purpose.

(*b*) "$\frac{5}{8}$-inch, straight, small," for use with small cups only.

(*c*) "$\frac{3}{4}$-inch, straight," for "terminal" and "fuze" and "Leading in and Terminal, large" cups. These must be used with "terminal" arms, and will not fit the "arms, telegraph pole, tubular."

There are also five patterns of "J" bolts (Fig. 19) in the service for use at terminal poles, and should be used in most cases instead of shackles (para. 42), as they give better insulation. The shape of the "J" bolts ensures that the stress on the wire acts in the plane of the arm bolt, and thus obviates the tendency of the arm to cant, as would be the case if straight spindles were used.

The patterns are known as—

(*a*) Insulators, porcelain, bolts, $\frac{5}{8}$-inch "J," large, single.
(*b*) ,, ,, ,, "J," small ,,
(*c*) ,, ,, ,, "J," large, double.
(*d*) ,, ,, ,, "J," small ,,
(*e*) ,, ,, $\frac{3}{4}$-inch "J," single.

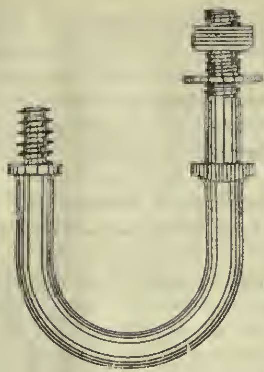


FIG. 19.

The "⅝-inch 'J,' single," is used with "ordinary" and "tubular" arms and "large" cups for terminating wires over 70 lbs.

The ¾-inch are used with terminal arms for terminating heavier wires.

The "⅝-inch 'J,' double," large and small are used on light lines when the wires have to be led in and out, or in conjunction with single terminating irons (para. 44) for leading off wires from a main line. When heavy lines are terminated for leading in, it is often better to double-arm the poles, and use single "J" bolts.

40. The indiarubber rings are issued in two sizes, viz., large and small, for ¾-inch and ⅝-inch bolts respectively. Rings.

41. Complete insulators are demanded as "insulators, porcelain," with the designation of the required cups and bolts added, *e.g.*, "insulators, porcelain, large, straight bolt," or "insulators, porcelain, terminal, 'J' bolt," &c. Complete insulators.

When fixing insulator bolts to arms the nut that secures them must always be screwed up tightly with a spanner and not merely by hand pressure.

42. Shackle insulators, "insulators, shackles," are still a service store, but their use should be avoided whenever possible on account of the inferior insulation they offer. They can be used either singly or in pairs, and are secured to the arm or other support by means of galvanized iron straps and pins. A strap is secured both above and below the shackle by a pin passed through the centre of it, the other ends of these straps being secured by a pin passing through the arm or other attachment (*see* Fig. 20). Shackles.

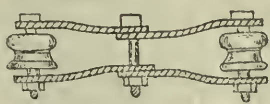


FIG. 20.

Leading-in cups.

43. "Insulators, leading in," are a form of insulator provided for the purpose of bringing the lead from a terminated line wire into casing, and yet at the same time exclude the entrance of moisture. They consist of a porcelain tube bent at right angles and fixed in a galvanized iron hood, by means of which it is attached to the casing. Fig. 21 shows the section of such a cup.

This insulator has been superseded by "Insulators, leading in and Terminal," of which there are two sizes, large and small, for $\frac{3}{4}$-inch and $\frac{5}{8}$-inch bolts respectively.

The small size will be used for wires of 150 lbs. and under.

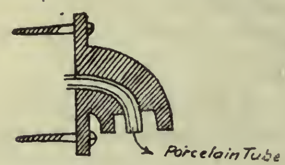


FIG. 21.

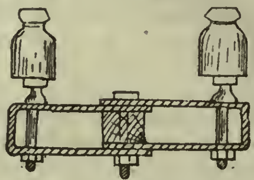


FIG. 22.

Terminating irons.

44. "Irons, terminating," are shown in Fig. 22. They are supplied in two forms, "double" and "single." The terminating iron should be secured to the arm with bolts $4\frac{1}{2}$ inches by $\frac{1}{2}$ inch, and the insulators should be fixed in the end holes.

Irons, terminating, double, should be used for introducing crosses in telephone lines (para. 82), or where it is required to terminate two wires for leading in, or for other reasons.

Irons, terminating, single, are fitted with holes to receive an insulator at one end and a bolt at the other. They are used principally for leading off wires from the end of an arm, and it will, therefore, be found most convenient to attach the terminating iron to the arm by means of the outer insulator bolt. Where a single wire has to be led off, a single J-bolt should be used instead; where two wires are to be led off a double J-bolt may be used; or, with revolving wires, two single terminating irons may be fitted to the ends of two adjacent arms and two single J-bolts used.

Roof Poles.

45. In many cases it is impossible to use wooden poles to carry wires over houses, and it is then sometimes necessary to place a standard on a roof. In this case it is desirable, if possible, to place it on one of the partition walls, but if such is not available the most substantial part of the roof must be selected. The ridge is sometimes convenient. A cast iron chair having a socket for the standard is first placed on the roof, and the standard which consists of a wrought iron tube is then placed on it. The standard must be most carefully

stayed in all directions and not only against the strain of the wires. The stays are formed of the ordinary stay wires made off to a special stay tightener (known as "stay tighteners, ⅝-inch"). This is a tightener similar to that on the ordinary stay rod, but instead of a long rod it has a short rod with a hook at the end of it. This hook fastens into an eye bolt which is cemented into the wall of the building or otherwise securely fixed. The hook should be moused.

Iron arms of the pattern used for iron poles are issued with standards.

No service pattern of roof pole exists, and when putting forward demands, care should be taken to state the position on the roof the pole will occupy (such as ridge, partition wall, &c.), in order that a suitable chair may be provided, also the total number of wires for which the route is being constructed, and the least height from the base of the pole at which the lowest arm can be fixed.

Wire.

46. The wire used in the service for conductors is of three different kinds—iron, copper, and silicium bronze. The conductor resistance of iron wire is approximately six times greater than that of copper of the same size, and for the same resistance the electro-static capacity and self-induction of iron wire is higher than that of copper, at the same time its cost is very much less.

No definite rules can be laid down as to what wire is to be used. In general, iron wire is used for telegraph work, 400 lbs. to the mile galvanized iron wire (Z 23) for main telegraph lines, and 200-lb. galvanized iron wire (Z 21) for minor telegraph lines.

For long quadruplex and high-speed Wheatstone circuits, and also on very heavy sections of main telegraph routes, it is sometimes advisable to use 150-lb. or 200-lb. copper wire. In manufacturing districts, or where exposed to sea air, iron wire does not last, and copper or bronze wire may advantageously be used.

For telephone work copper or bronze wire should always be used, except where it is too liable to be stolen in out of the way places. For main telephone trunk lines the Post Office use from 150 to 600-lb. copper wires; for junction lines, &c., 100-lb. copper; and for subscribers' lines 70-lb. and 40-lb. bronze. For service purposes 70-lb. bronze wire will usually be sufficient for the longer telephone wires, and 40-lb. bronze for short exchange connections, especially when heavy routes have to be run.

Bronze wire has the same advantages as copper, but higher tensile strength and slightly higher resistance.

Certain details of wire are given in the following table:—

TABLE OF LINE WIRES.

(*See* also Appendix I.)

Designation.	Material.	Nearest S.W.G.	Conductor resistance per mile.	Approximate weight per mile.	Breaking strain.
Wire, electric—					
Z 3	Silicium bronze..	18	45·5	40	200
Z 5	" " ..	16	27	70	345
Z 7	" " ..	14	12·27	100	390
Z 9	" " ..	3/18	12	100	375
Z 17	Copper	14	8·78	100	330
Z 21	Galvanized iron..	10½	26·64	200	620
Z 23	" " ..	7½	13·32	400	1,240
Z 31 ..	" steel	3/18	50	100	450
Not service stores	Copper	11½	4·39	200	650
Not service stores	"	9½	2·928	300	950
Not service stores	"	8	2·195	400	1,250
Not service stores	"	6	1·464	600	1,800
Not service stores	"	4½	1·098	800	2,400

Erection.

Working party.

47. Permanent lines are, as a rule, erected by a party specially organized for the purpose, and the strength of the party will depend on the nature of the work to be done.

For the erection of a light line of only one wire, only a small party with a considerable proportion of labourers is required, whereas for the erection or renewal of a line of heavy poles carrying a large number of wires a much stronger party is necessary, and the proportion of wiremen may conveniently be increased. For general work a party of one foreman, three wiremen, and three labourers is a convenient size and readily admits of additional wiremen or labourers being added as required.

Foreman.

48. The foreman's duty is to take charge of all the details of the work and see that they are properly executed. He should be responsible for the care of and proper use of all stores which are handed over to him for the work. He will be provided with a copy of the survey book which should give full particulars of the work which it is intended shall be done. The details given in this book should be such as to admit of his carrying out any ordinary work without further instructions, but if the work is of an important nature it is advisable that he should be taken over the route by the officer or N.C.O. under whom it is being carried out. As a rule the foreman should not be expected to work himself, as his time will be fully occupied laying out work, checking stores, seeing to the work of the party, &c., but when

time and opportunity permits he should be ready to work himself. He may be required to obtain some of the minor consents necessary, though these should have been, as far as possible, obtained by the officer or N.C.O. in charge.

In war time it may have been impossible to make a preliminary survey, and in that case the foreman may be required to do everything himself. He will then have occasionally to go on ahead of his party and select the route to be followed. He is, however, not likely to be troubled by the question of consents in such a case.

Wiremen and labourers.

49. The wiremen are employed "dressing" poles* and carrying out all the skilled work connected with the wires, such as jointing, pulling up, binding in, etc.

The labourers do all the unskilled labour, such as digging holes, attending on the wiremen when up poles, pulling out the wire, &c.

Safety belts.

50. "Belts, lineman, safety," are provided for the use of men working in windy weather on tall poles, steep roofs, &c. Great care should be taken of these belts, any defects should immediately be brought to notice. If they come in contact with acid special attention should be called to the matter, as latent defects may be caused which may only become evident when the belt breaks.

Tools.

51. The tools required by a party vary according to the strength of the party and the work on which they are to be employed, but the following is a list of tools usually allowed for a party of one foreman, three wiremen, and three labourers, working with wooden poles:—

Augers, screw, 1"	3
„ „ ¾"	3
„ „ ½"	3
„ handles, 16"	6
„ „ 13½"	6
„ „ 12"	6
Awls, blade, brad	2
„ handles, brad, small ..	2
Axes, felling, curved helve ..	2
„ „ helves (spare) ..	4
„ hand, 3 lbs.	3
„ „ helves, 21"	6
„ pick, heads, 4½ lbs. ..	4
„ „ helves, 36"	8
Baskets, tool, leather-handled ..	3
Barrows, wire, hand	2
Blocks, tackle, G.S., 1½" cordage, double	1
Blocks, tackle, G.S., 1½" cordage, snatch	1
Braces, carpenters', rachet, with 24 bits	2
Brushes, paint, oval	2
„ „ sash tool, No. 6	1
Brushes, tar, short	2
Cans, oil, lubricating, G.S. ..	1
„ „ 5½ pints	1
Cases, saw, hand	3
Crowbars, 5′ 6"	2
„ 3′ 6"	2
Chisels, firmer, 2"	3
„ „ 1"	3
„ hand, cold, 1" × 8½" ..	1
„ „ „ ½" × 4½" ..	1
Climbers, pole, pairs	3
Cordage, hemp, hawser, 3-strand, white, 1½" .. fathoms	30
Cord, sash .. .. .. yards	144
Files, coarse cut, ½ round, 10" ..	3
„ „ ½ „ 12" ..	3
„ saw, gulleting, for pit and frame, 8"	1
Files, saw, gulleting, for pit and frame, 6"	1
Gimlets, spike, ⅜"	3
„ twist, No. 2	3
Gouges, handled, firmer, 1" ..	3
„ „ „ 2" ..	3

* See para. 53.

Hammers, R.E., telegraph, sledge	1
Hammers, R.E., telegraph, sledge handles	2
Hammers, claw, 32 oz.	3
,, handles, 14″.. ..	6
Handles, file, middling	6
Holders, file, with handle, ½ round, 10″	3
Holders, file, with handle, ½ round, 12″	3
Hooks, bill	2
,, ,, handles (spare) ..	2
,, reaping, large	2
Irons, soldering, tinman's, large	3
Knives, clasp	6
Ladders, field telegraph	3
Oil, olive, lubricating .. pts.	2
Oilstones, carpenters'	1
Pliers, side cutting, 8″	6
,, ,, 8″, cutters..	12
Pots, fire, telegraph mechanics'..	2
Ratchets, telegraph, small (or spring)	6
Rammers, earth	2
Rods, clearing, obstacles ..	1
Rules, carpenters' common ..	3
Saws, hand, 26″	3
,, crosscut, blade, 5′, Mark II	1
,, ,, handles, ,, pair	1
Screwdrivers, G.S., 12″	2
,, ,, 6″	2
Shovels, R.E.	4
,, ,, helves, 32¾″ ..	4
Spanners, adjustable, 15″ ..	3
Squares, carpenters', 9″.. ..	3
Tapes, measuring, linen, 100-feet	1
Tongs, draw, heavy (or light) ..	6
Tools, grafting, clay	3
,, stay	2
Vices, draw, Mark II	12
,, hand, 16-oz.	1

The party must, of course, be provided with some kind of cart in which their tools can be kept and carried along the route as the work advances. No special pattern of cart is provided in the service for this purpose, so that the best arrangement possible must be made for each occasion.

Laying out stores. 52. The first duty of the party on reaching the starting point will be the laying out of the stores along the route. These will have been sent beforehand to various depôts along the route, from which they will have to be distributed. This must be done by means of hired timber tugs or military transport if available.

When ready to commence work the foreman will tell off each man to his own particular job. If poles are to be erected, the holes will be dug by the labourers in the spot pointed out by the foreman, and the pole to be erected will be "dressed" on the ground by a wireman in a convenient position as near as possible to the hole. The top of the pole should be raised on a trestle formed by two arms fixed by an arm bolt at the centre and secured at the bottom by a few strands of wire.

Dressing poles. 53. "Dressing" a pole consists in fixing the roof, arms, brackets (if required), earth wire, and any other necessary fittings, and, if possible, the stay should be fixed to the pole. It should be borne in mind that all fittings can be put on much more accurately and quickly when on the ground than after the pole is up. Great care must be taken when fixing the arms to see that they are exactly square and the same distance apart at each end. This should be carefully checked by the foreman.

Raising poles. 54. When the hole is dug and the pole ready for erection, the party should be called together to put up the pole. If the party is provided with a pole cart, or a pair of wheels on which the pole can be carried, the pole is lifted on this and run up to the hole so that the butt rests against the side of the hole marked Z in the section shown in Fig. 1. Against this side is placed a piece of timber (preferably wetted) or two crowbars which will assist the butt to slide down as the pole is raised. The pole is then raised on the shoulders of the men and then by means of ladders until in an upright position.. A light pole can be easily handled in this way, but a heavy pole requires considerable care, particularly as it approaches an upright position.

With each pole, except in the case of short light ones, two or more guys should have been fixed to the top to assist in its erection and to steady it until the hole is filled up. Tall poles, *i.e.*, 45-feet poles and over, must be raised by means of a derrick previously erected and well stayed. When the pole is in an upright position it will be twisted, if necessary, so that the arms face in the right direction and will be given any required set. This will be done by the foreman by eye. When properly set the hole will be filled in, care being taken that the earth is well rammed, particularly close round the pole. Any surplus earth will be scattered about and the surface of the ground restored as nearly as possible to its original condition. As soon as the poles are up the necessary stays and struts should be fixed. A considerable length of pole line should be erected before the wiring is proceeded with, and it is desirable if the poles are erected in soft ground or during wet weather to delay the wiring as long as it can conveniently be done. In this case, however, consideration must be given to the circumstances in which the men have to reside, as much time is wasted if they have to go a long distance to and from their work, but on the other hand, time is also wasted if they have to go twice over the same section of the route. The shifting of the tool cart along the route involves considerable labour, and it is therefore better, if possible, to completely finish a section of the line before moving on.

55. When the wiring is to be done the coil of wire is Wiring. placed on a "Barrow, wire, hand." This is a barrow on which is a revolving drum on which the coil is placed. The end is then taken away by one or more men, the drum revolving as it is drawn out. One man must always remain at the barrow for the purpose of checking it when required. The length of the coils varies according to the gauge of the wire, as coils are generally made up to about the same weight, viz., about 100 lbs.

Drums are not required for paying out light bronze wire. After removing the canvas wrapper and wire binders, the inner end should be secured by taking the last four inner turns and wrapping the extreme end of the coil round them. A loop should then be made at the outer end, and the coil is ready for paying out. It will usually be desirable to divide the coil into two portions. The unwinding must be done from the outer end. The half coil should be placed on the wrist, the fingers clasping it to prevent the coil from springing out, and the wire should be allowed to run off corkscrew fashion. *The coils should be changed from hand to hand as each eight or ten convolutions pass out from the wireman's hand, thus avoiding kinks in the wire.*

As the wire is pulled out it is placed in its proper position on the arms. When the whole coil is run out the end at the drum is jointed on to the end of the piece already run, and the other end is strained up by hand as far as possible by two or three men pulling on it, and a tension ratchet, or similar device, is then placed on the last pole by which it is pulled up to its approximate strain.

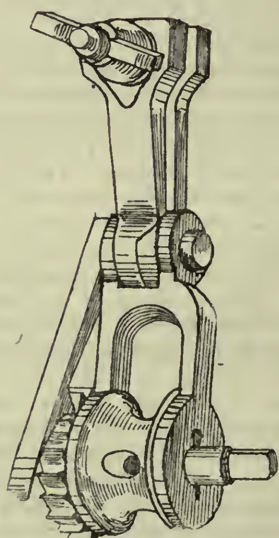


Fig. 23.—Vices, Draw, Mark II.

Fig. 24.—Key for Vice, Telegraph, Draw.

"Vices, draw, Mark II" (Fig. 23), are used for iron wires; "Tongs, draw, heavy" (Fig. 25), are used for heavy copper wires, in conjunction with "Vices, draw," or block or tackle; "Tongs, draw, light" (Fig. 26), with "Ratchets, telegraph, small" (Fig. 27), or "spring" (Fig. 28), for wires under 150 lbs. per mile.

"Vices, draw," and "Ratchets, telegraph," are issued complete with keys (Fig. 24). The keys for "Ratchets, telegraph, small," and "spring" are interchangeable. "Ratchets, telegraph, spring," are provided with a dynamometer spring and scale graduated up to 170 lbs.

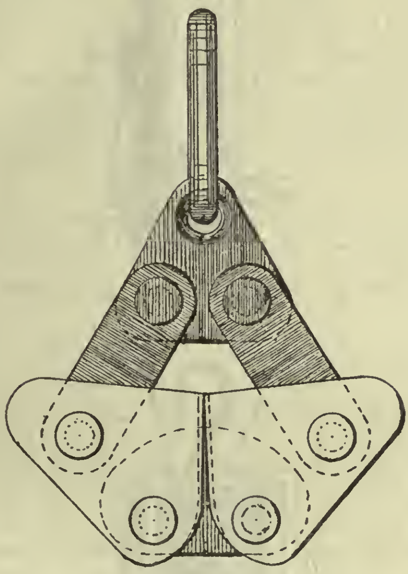


FIG. 25.—Tongs, Draw, Heavy, Mark I.

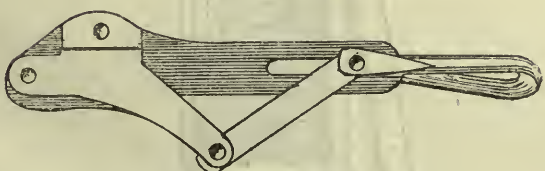


FIG. 26.—Tongs, Draw, Light, Mark I.

Great care must be exercised in pulling out the wire to prevent accidents at the points where it crosses roads and gateways, and a man should always be placed to warn passers by.

56. When all the wires have been run over a certain section, they are loosely bound in to the insulators by means of a binding wire, and the whole are then properly regulated. The number of bays which can be regulated at one time will vary **Regulating.**

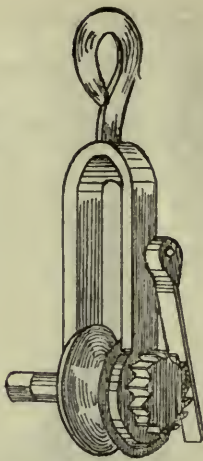


FIG. 27.—Ratchet, Telegraph, Small, Mark I.

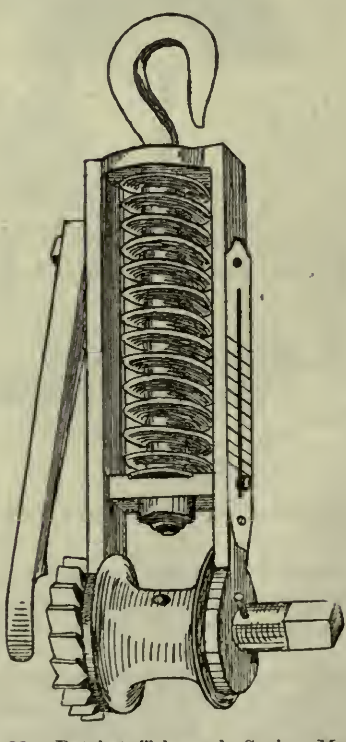


FIG. 28.—Ratchet, Telegraph, Spring, Mark I.

somewhat according to the gauge of the wire, as with the heavier wires not more than four bays can be regulated at a time, whereas the lighter wires may run to six or even eight. Ratchets must be fixed at the points between which the regulating is to be carried out. The tension to which a wire should be pulled up depends on the temperature at the time, and it should never exceed one quarter of its breaking strain under conditions of low temperature. The following table gives the tension to which the different wires commonly in use should be pulled up. The fact that in practice the spans vary somewhat in length need not be taken into consideration. It will be sufficient if the general average of the length of bays is taken, and the stresses will adjust themselves in the spans of different length.

TABLE OF STRESSES IN LBS. FOR SPANS IN YARDS.

Temperature Degrees F.	200 lbs. G. 1 (Z 21).				150 lbs. Copper.				100 lbs. Copper (Z 17).			
	60 yds.	70 yds.	80 yds.	90 yds.	60 yds.	70 yds.	80 yds.	90 yds.	60 yds.	70 yds.	80 yds.	90 yds.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
30	110	115	119	122	84	91	96	99	56	60	64	66
40	92	99	105	110	66	73	79	84	44	48	53	56
50	81	89	95	101	56	63	69	75	37	42	46	50
60	73	81	88	94	50	56	62	67	33	37	41	45
70	67	75	82	88	45	51	57	62	30	34	38	41
80	62	70	77	83	41	47	53	58	27	31	35	38
90	58	66	73	79	39	44	49	54	26	29	33	36

Temperature Degrees F.	70-lb. Bronze (Z 5).							40-lb. Bronze (Z 3).						
	60 yds.	70 yds.	80 yds.	90 yds.	100 yds.	120 yds.	140 yds.	60 yds.	70 yds.	80 yds.	90 yds.	100 yds.	120 yds.	140 yds.
30	46¼	52½	58¼	63½	68¼	76	82¼	26½	30¼	33¼	36½	39¼	43½	47¼
40	32½	37¼	42	46½	50¾	58¼	65	18½	21½	24	26¾	29	33½	37¼
50	26½	30½	34½	38½	42	49	55¼	15	17½	20¼	22	24¼	28	31¾
60	22¾	26½	30	33½	36¾	43	49	13	15¼	17¼	19¼	21¼	24¾	28
70	20½	23¾	26¾	30	33	38¾	44½	11¾	13½	15½	17¼	19	22¼	25½
80	18½	21½	24½	27½	30¼	35¾	41	10¾	12½	14	15¾	17½	20½	23½
90	17¼	20	22¾	25½	28¼	33¼	38¼	10	11½	13	14¾	16¼	19	22

From these figures the stress for other wires can easily be obtained. The stresses for 100-lb. wire are half those for 200-lb. and those for 400-lb. double those for 200-lb. For the intermediate temperatures a proportion between the stresses given may be taken.

The following table gives the sag which the above stresses may be expected to give, and the information given therein may be useful in determining the length of pole required in certain cases.

TABLE OF SAGS FOR THE SPANS GIVEN IN THE PREVIOUS TABLE.

Temperature Degrees F.	Iron Wires.				Copper Wires.			
	60 yds.	70 yds.	80 yds.	90 yds.	60 yds.	70 yds.	80 yds.	90 yds.
	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.
30	1 5	1 10	2 3½	2 10	1 4	1 8½	2 1½	2 7
40	1 8	2 1	2 7	3 2	1 9	2 1½	2 7	3 0½
50	1 11	2 4	2 10½	3 5	2 1	2 6	2 11½	3 5½
60	2 1	2 7	3 1½	3 8	2 3½	2 9	3 3	3 10
70	2 3½	2 9½	3 4	3 11	2 6½	3 0½	3 7	4 2
80	2 5½	3 0	3 6½	4 2	2 9	3 3½	3 10	4 5½
90	2 7½	3 2	3 9	4 4½	2 11½	3 6	4 1½	4 9

Temperature Degrees F.	Bronze Wires.						
	60 yds.	70 yds.	80 yds.	90 yds.	100 yds.	120 yds.	140 yds.
	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.
30	1 2	1 4⅝	1 7⅝	1 10⅞	2 2¼	2 9¾	3 6½
40	1 7⅞	1 11½	2 3¼	2 7¼	2 11¼	3 8	4 5⅝
50	2 0⅜	2 4⅝	2 9⅛	3 1¾	3 6½	4 4½	5 3½
60	2 4¼	2 9⅛	3 2¼	3 7⅜	4 0½	4 11⅜	5 11¼
70	2 7½	3 1	3 6⅝	4 0¼	4 6	5 6	6 6½
80	2 10⅜	3 4½	3 10⅞	4 4¾	4 11	5 11⅞	7 1¼
90	3 1⅜	3 7⅞	4 2½	4 9	5 3½	6 5¼	7 7½

The sag varies with the material but not with the gauge.

In practice, when regulating, after the wires have been pulled up to the correct tension, it will be found that some final adjustment must be given by eye, particularly when running revolving telephone wires when the symmetry with other wires on the same poles will be a matter of great importance. The skill and care of a foreman is well shown by the regulation of the wires he erects. Special care should be exercised when running new wires on the same poles as wires which have been up some time, as the latter will have stretched considerably, and the new wires must consequently not be pulled up so tight as to run any risk of contact.

57. When it is necessary to renew wires without interrupting the circuits, re-wiring hooks* are sometimes used. Re-wiring.

* Not a service store.

These are iron bars with a socket at one end which slips over the end of the arm on which is the wire to be replaced, and a hook at the other in which the new wire is run. This new wire is strained up to its approximate tension when in the hook, and then connected at each end to the line wire. The old wire is then cut down and the new one moved from the renewing hook on to the insulators and finally regulated.

Interruption cable.

58. This method, however, cannot be adopted when renewing revolving telephone wires, and there is no alternative then but the use of interruption cables (Cable, electric, C 4). This cable consists of four insulated wires, and is laid temporarily along the route, the wires to be replaced being crossed on to it. The old wires are then cut down, the new ones run and regulated. The cable can then be cut out. The use of such a cable may also be necessary where extensive alterations are being made to a line which will render it impossible otherwise to avoid interruption.

If C 4 cable is not available, any other suitable insulated wire or cable can be used.

When using interruption cable the necessity of terminating the line wires on the side of the pole where the cable is cut in, and of disconnecting them on the side of the pole where construction work is in progress, is frequently overlooked. Unless this is done, interruption cable is useless.

Work on existing lines.

59. The carrying out of work on existing lines without causing interruptions demands the greatest care and supervision. Much annoyance and dislocation of business may be saved by notifying those concerned of the dates and hours between which wires will be subject to interruptions. In any case, when working on existing lines, foremen should try to arrange their work so that operations likely to cause interruptions to working wires, such as transferring or regulating wires, &c., are carried out during slack hours of business. Operations which can, with care, be carried out without interrupting working wires, such as digging pole holes, dressing poles, cutting in additional arms, and running new wires on the bottom arms, permanently binding in wires, &c., should be carried out during the busiest hours of the day.

Jointing.

Iron and copper wires.

60. The jointing of line wires is a most important point in construction, as badly made joints are a source of endless trouble.

The Britannia joint is the joint which should be used for both iron and copper wire.

When making these joints the ends of the wires to be joined together must be scraped thoroughly clean so that the wires present a bright metallic surface. The ends of the two wires must be cut off square and laid side by side for a distance varying according to the size of the wire. This distance is shown in the table given below. The two are then bound together by means of a binding wire. The binding wire used for jointing iron wire is known as "wire, jointing and binding, AA 21," and that for copper wire as "wire, jointing and binding, AA 17."

The length of binding wire required for each joint depends upon the size of the line wire to be jointed, and is given in the table below, which also gives the weight of jointing wire which should be allowed per mile of line wire in framing estimates. To make the joint the binding wire is taken in the middle of its length which is applied first at the centre of the joint. The whipping is started as shown in Fig. 29 and carried along evenly until the right-hand portion is finished, then the left-hand half is similarly dealt with. The whole of the overlap is covered with

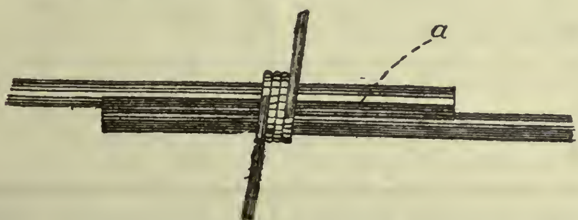


FIG. 29.

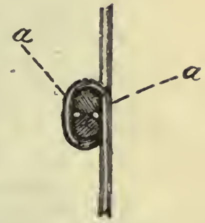


FIG. 30.

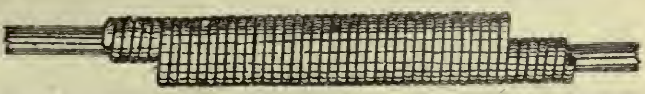


FIG. 31.

the binding wire and about half a dozen turns carried along the line wire and each side of the overlap as shown in Fig. 31. In the case of heavy wires, such as those weighing 600 and 800 lbs. to the mile, a considerable space will exist 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 to enable this to be done, pieces of binding wire of the exact length of the overlap are pushed under the binding wire after the first few laps are laid on as shown at "*a*" in Fig. 30.

61. The joint is then completed by being soldered. The flux which should be used is resin or "zinc chloride solution." Soldering.

Spirits of salts must *not* be used as a flux.

The surface of the soldering iron should be well tinned so that the solder may run freely over it, and the iron should be sufficiently hot to admit of the rapid soldering of the joint without annealing the wire, and by a single application of heat. The superfluous metal is then wiped off and the joint allowed to cool slowly.

No strain must be put on until it is cold. Great care must be exercised in soldering copper wires not to anneal the wire by the improper application of heat, as the breaking strain is then reduced by nearly 50 per cent.

TABLE OF JOINTS.

Size of Line Wire in lbs. per mile.	Length of Joint in inches.	Length of Jointing Wire per joint.		Weight in ozs. of Jointing Wire required per mile of Line Wire.
		Iron.	Copper.	
		ins.	ins.	ozs.
400	2½	46	48	4
200	2¼	33½	36	3
150	2	—	30	2
100	1¾	—	26	1

Bronze wire. 62. When jointing bronze wires, the following method should be adopted in lieu of the Britannia joint (*see* Fig. 32).

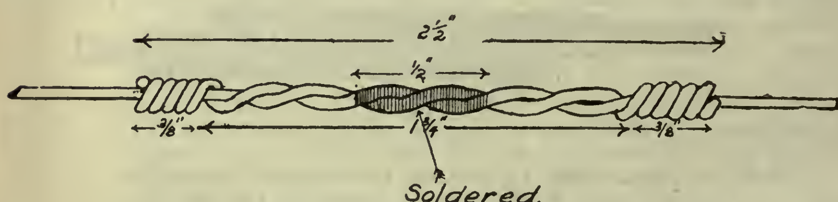


FIG. 32.—Bronze Wire Joint.

Thoroughly clean the ends to be jointed. Lay them side by side overlapping for a length of 8 inches, and twisted together in the central portion for a distance of 1¾ inch, the twist having a lay of about ½ inch. Each end should then be tightly wrapped round the other wire for a length of ⅜ inch, making the completed joint 2½ inches long. The joint should be carefully soldered for about ½ inch in the middle. It should then be cleaned from any of the soldering fluid which may remain upon it, and afterwards painted with "varnish, black tar," if necessary diluted with a little naphtha. In order to avoid nicking the wire, the joint should be made without pliers, except for cutting off the ends.

Jointing wires of different sizes. 63. When it is necessary to join together wires of two sizes, or an iron and copper wire, they should be terminated on different grooves of a terminal insulator, or on two separate insulators, and the tails joined.

Terminating.

64. Terminating iron and copper wires is done by taking the end of the line wire once round the insulator and bringing it back along the standing part for 2 inches or so, and binding the two parallel parts with binding wire (as when making a joint) and soldering them. A "tail" of 6 or 7 inches is left which is bent round away from the standing end so as to make connection with the leading in or other required wire. In the case of copper wire, a copper tape should be bound round the part passing round the insulator in the same manner as when binding in (*see* para. 67). As it is impossible to strain heavy wires and to make this turn round the insulator without their slipping back, it is desirable to make off this portion round the insulator separately from the line wire, but leaving a sufficient length of the standing part to admit of the line wire being jointed to it when properly strained up. **Iron and copper wire.**

65. The method of terminating bronze wires is as follows:— After regulating, and while the tongs are still on, the wire should be cut, leaving a length of 30 inches beyond the centre of the insulator. At a point 10 inches beyond the centre of the insulator the wire is doubled back on itself, the loop thus **Bronze wire.**

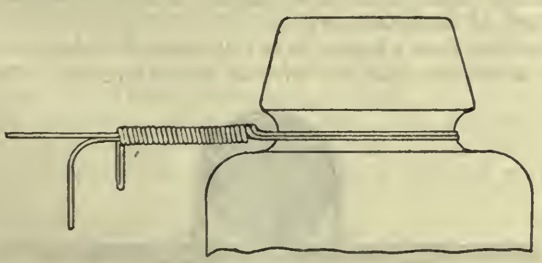


FIG. 33.

formed being passed round the insulator, and then wrapped closely for $1\frac{1}{2}$ inches round the line wire and the end which has been doubled back. The loop should not be cut at the end of the wrapping. The end which has been doubled back should be turned outwards and cut to about $1\frac{1}{2}$ inches in length, so that the leading-in wire may readily be soldered to it (Fig. 33).

Where a double termination is required (on a two-groove insulator), each wire should be terminated as above described, except that it is necessary to leave a length of 40 inches beyond the centre of the insulator. After the wrapping has been done, the loose ends should take one turn round the bottom groove of the insulator in reverse directions. They should then be twisted together for about half an inch and soldered (Fig. 34).

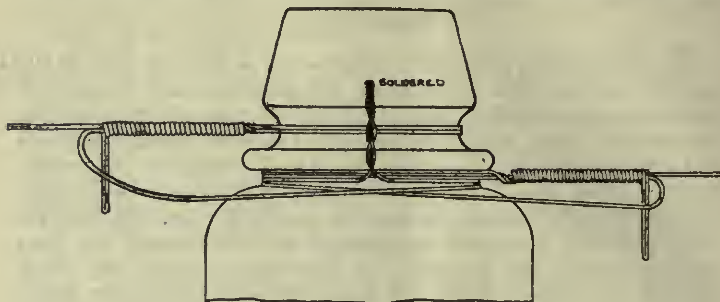


FIG. 34.

Binding.

Binding iron wires.

66. The line wire has to be securely bound to each insulator and it should be placed on that side of the insulator which will bring the strain on the insulator and not on the binder. In straight lengths the line wire should be bound in on the side of the insulator next the pole. The wire used for binding in iron wires is "wire, jointing and binding, AA 21," weighing 60 lbs. to the mile. This is cut into lengths of 36 inches for binding 200-lb. and 48 for 400-lb. wire.

The method then adopted is as follows:—Two laps of binding wire are taken over the line wire at A (*see* Fig. 35). The inner

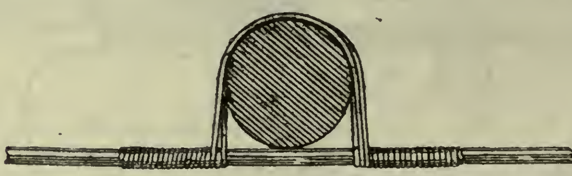


FIG. 35.—Binding Iron Wire.

end is then taken round the neck of the insulator to the underside 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 underside 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.

Binding copper wires.

67. Copper wires are treated in a different manner, as, though the method adopted for iron wire can of course be followed, it is liable to cause the line wire to be rapidly worn

away. In this case the line wire is first served from A to D (*see* Fig. 36) with a sheath of copper tape, the length and width of which varies with the size of wire to be bound on. "Tapes, telegraph, Mark II," are used for wires 100 to 150 lbs. to the mile. The "binder, 17-inch," is then placed round the neck of

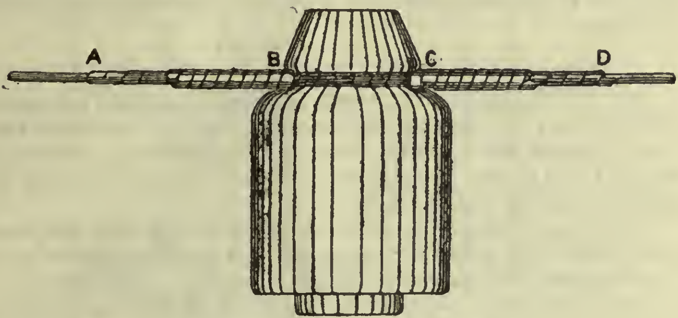


FIG. 36.—Binding Copper Wire.

the insulator and the ends (brought over the conductor at B and under it at C) closely wrapped around the served portion of the conductor as shown, by means of two pairs of pliers. The tape serving is in all cases to extend a short distance beyond the binder to protect the wire during removal of the latter.

New binders should invariably be used, and old binders recovered during alterations should be returned to store, and disposed of as old copper.

If copper wire heavier than 150 lbs. to the mile is used, special tapes and binders must be demanded.

68. In binding in 40-lb. bronze wire (Z 3) copper binding wire No. 18 S.W.G. ("wire, binding, AA 3") is used. The binding wire should be neatly and tightly whipped round the Binding bronze wire.

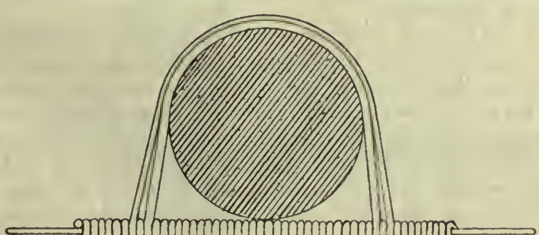


FIG. 37.—Binding Bronze Wire.

line wire for a distance equal to the diameter of the insulator groove. The ends should then be passed round the insulator in reverse directions, one over, and one under the line wire, round which they should again be wrapped for two turns. The ends should be once more passed round the insulator in opposite directions, and finely whipped round the line wire for a further seven or eight turns. The ends of the binding wire should then be cut off close (Fig. 37).

The length of the binding wire is 36 inches.

70-lb. bronze wire (Z 5) is bound in the same way, only No. 17 S.W.G. wire (AA 5) is used, and the length required is 42 inches.

Elimination of Inductive Disturbance on Telephone Lines.

Elimination of disturbance.

69. The objects of the twist system of erecting telephone wires are—(1) the prevention of inductive disturbance in telephone circuits, arising from currents in neighbouring telegraph wires; and (2) the prevention of "overhearing" between one telephone circuit and another.

The former object is attained by revolving the telephone wires, and by equality of insulation, and careful regulation of the wires and of adjacent telegraph circuits.

Importance of symmetry.

70. Exactitude of detail and symmetry of construction form very important elements in securing immunity from inductive disturbance. With this object in view it is important that all the wires on a pole should be bound on the same side of the insulators.

"Symmetrical Twist" System. Principle and application.

71. The standard method of revolving telephone wires which provides for the twist being carried out in a right-hand direction is shown in Fig. 38. It will be observed that the wires make a complete revolution in four spans of the line, so that they are brought to the same average distance from all external disturbing influences (such, for instance, as a working telegraph circuit which is run straight, as shown in the figure). Thus the disturbing influence of the telegraph wire upon the spans A, B, C, and D of one wire of one of the two telephone circuits is exactly counteracted by the same disturbing influence upon the return wire. The full lines represent one circuit, and the dotted lines the other.

Insertion of additional supports.

72. If additional supports are subsequently inserted, the symmetry of the twist must be maintained as far as possible. When *one* support is added (thus forming two spans out of one) the shorter of the two should run straight, so that the minimum length may be exposed to external inductive interference. It will be evident that if the twist were continued in both spans, the effect would be the insertion of a cross on the circuits throughout, and this, as a general rule, would be very undesirable.

When two supports are inserted, forming two additional spans, the wires should be twisted in the usual manner. This will have the effect of reversing the A and B wires of all the loops supported on the poles. Care should be taken to carry out the work, and introduce correcting crosses at the nearest terminal poles, at such a time as is least likely to interfere with the working of the circuits.

Where, however, *three* extra supports are necessary, it would generally be advantageous to insert *four*, by which means the twist will not be interfered with.

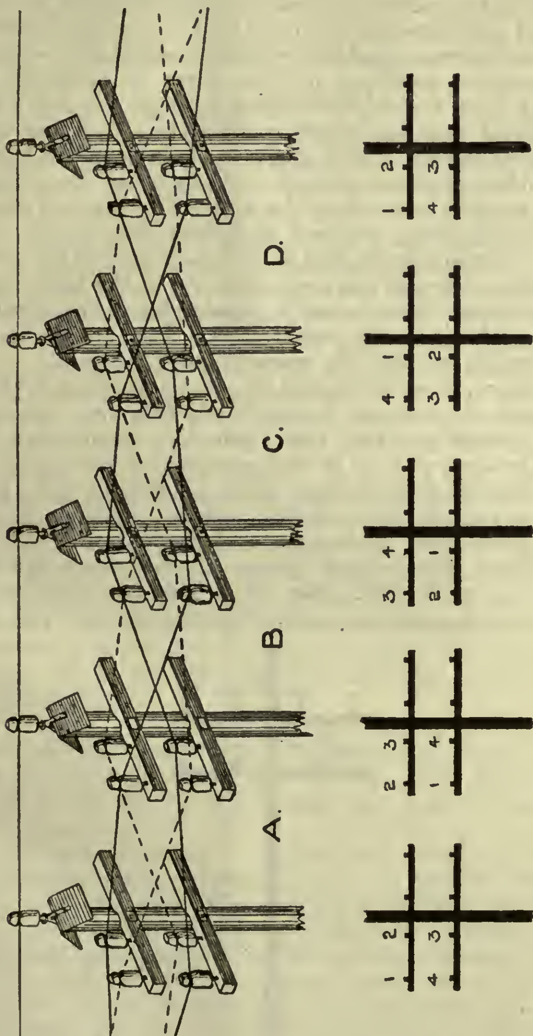


FIG. 38.

If additional poles are inserted in several consecutive miles of existing telephone line, the sections so dealt with must be so rearranged as to avoid straight spans. The permissive paragraphs above refer only to isolated cases and not to continuous lengths where the resulting disturbance may be cumulative.

Causes of overhearing.

73. *Overhearing* between one telephone circuit and another arises either from want of symmetry of position or want of uniformity of electrical conditions. If the case of four wires constituting two metallic circuits be considered, it will be recognised that each wire of one circuit forms a source of disturbance to the other circuit; and the point to be decided is—what shall be the relative positions of the wires in order to secure immunity from mutual disturbance between the two circuits? It is evident that the requirement is to secure that the individual wires of each circuit shall be maintained at a uniform average distance from each wire of any other circuit, and this can best be done by erecting the wires as a square, of which the two wires diagonally situated shall form one circuit. If this condition be maintained, that is, if at each pole on the route the four wires in diagonal pairs are virtually at the four corners of a square, mutual disturbance is equalised, and there will be no overhearing between the two circuits. This is true in regard to the circuits, whether the wires be twisted or not.

Relative positions of conductors.

Group of four wires twisted in square.

74. Hence, if two telephonic circuits be erected as a "square" and twisted, they should be absolutely free from overhearing between themselves and from inductive disturbance due to external sources, so long as each such source maintains a mean average distance from the two wires of each circuit; and this is true as regards two circuits twisted together occupying uniform rectangular positions upon the poles.

Overhearing between pairs in adjacent groups.

75. When two or more groups of four wires are erected adjacent to each other, the conditions are more complex. Assuming each group to be symmetrically twisted (as must be

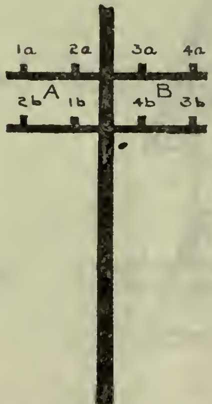


FIG. 39.

the case in order to avoid disturbance from other external sources), then throughout their course certain of the wires are *not equidistant* from the two wires of a pair in an adjacent group, with the result that overhearing occurs. For instance (Fig. 39), it will be found by calculation that 3a is not at an average equidistance in each revolution from the two wires 1a and 1b in the No. 1 circuit; nor is 3b; consequently, 3a and 3b each constitutes a source of disturbance to the No. 1 pair. The effect of 3b tends to neutralise the effect of 3a, and *vice versâ*, but the two wires not being equidistant from each of the wires of the No. 1 pair, the disturbing effects are not completely neutralised, and overhearing results. Similar effects occur in connection with circuits 2 and 4, but there is no overhearing between circuits 1 and 4, or circuits 2 and 3, as the wires in these cases are the same mean distances apart in every four spans.

It should be specially noted that the overhearing takes place between the circuits which are parallel, the a and b wires of the respective pairs occupying the same relative positions upon the arms. The overhearing is not due to this, however, but arises from the fact that each wire of one pair is not equidistant in each revolution from both wires of the other pair.

76. It should be remarked that, although overhearing exists on all circuits situated as described, it is less on circuits composed of small gauge wire, than upon circuits where heavy conductors are employed. On wires 400 lbs. and upwards it is apt to become very pronounced. There are other modifying conditions, as, for instance, it is partially masked by the effect of underground wire at the extremities of the circuits. Modifying conditions.

77. The elimination of this interference between circuits in different groups is effected by the device of crossing the two wires of each circuit of a group at certain definite points. Elimination by "crossing."

In effect, the "cross-over" reverses the relative positions of the two wires of a circuit in alternate sections, and the inductive effect of other circuits upon them is equalised, and, therefore, neutralised thereby.

The "cross-over" points in each group are arranged symmetrically relatively to those in adjoining groups, but the number of such points in each group must be varied as indicated by Fig. 40. Fig. 41 shows the order of the groups upon the poles.

78. If overhearing upon a route be general, one group of four wires may revolve continuously, and "crosses" should be inserted in the others. Where wires of different weights are employed for the different circuits, the continuously revolved group should preferably be that upon which the heaviest conductor is employed, for the reason that, the circuit being generally of greater length, it is desirable that the highest possible insulation per mile be maintained, and, therefore, the insertion of additional insulators is to be avoided. Selection of circuits to be crossed.

79. Figs. 40 and 42 illustrate the method of arranging the "cross-over" points, the former showing a route upon which the continuously revolved group of wires is carried on the two upper arms, and the latter illustrating the case where the same group is on arms lower down the pole. Principle of crossing.

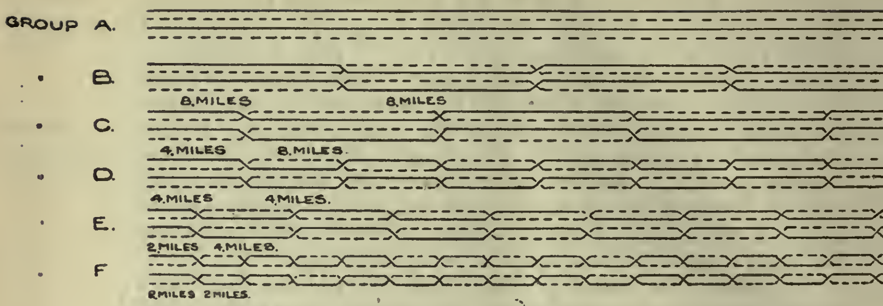


FIG. 40.

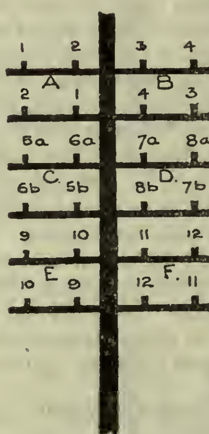


FIG. 41.

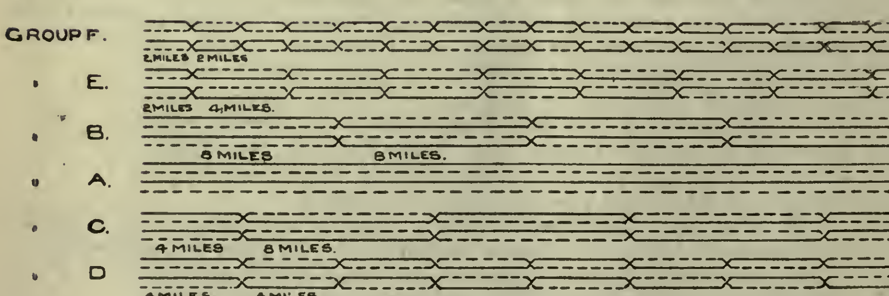


FIG. 42.

80. The distance apart at which "cross-over" points should be inserted in circuits is a matter which depends upon so many varying conditions that it can only be determined by experiment. In some instances 8 miles has been found the maximum distance possible between crossing pionts, while in others, disturbance has been perfectly eliminated by three crosses in a hundred miles. *Distance between crossing points.*

Each "cross-over" should be effected at the end of a complete revolution of the group of four wires.

81. The diagrams (Fig. 42), which have been marked on the basis of an 8-mile maximum, show the relative arrangement of the "crosses" in the different groups, and the following explanation will probably make the matter clear. *Explanation by example.*

Group A is revolved continuously.

The crosses in group B are inserted 8 miles apart, the first cross being made 8 miles from the terminal pole. The crosses in group C are also 8 miles apart, but the first cross is made 4 miles from the terminal pole, so that each cross is effected midway between those in the preceding group.

The crosses in group D are inserted 4 miles apart, the first cross being made 4 miles from the terminal pole. It will be seen that the first and third crosses in this group coincide with the first and second crosses in group C, but overhearing between these two groups is overcome by the effect of the second and succeeding alternate crosses in group D, which are inserted midway relatively to the successive crosses in group C, and this arrangement applies throughout the entire length of the circuits. The crosses in group E are also inserted 4 miles apart, the first cross being placed 2 miles from the terminal pole, so that the crosses in groups B, C, and D, are effected midway between those in group E.

As already explained, the whole question is one of average equidistance, and the general principle can be well illustrated in connection with the two groups C and D. Considering one (the upper) circuit of group C in relation to one wire (7a, Fig. 41) of the upper circuit of group D, it will be found by calculation that in four spans on 48-inch arms 5a is at a mean distance of 30 inches from 7a, while 5b is 32·5 inches from the same wire, this condition being maintained for a distance of 4 miles. The first cross-over being made on *both* groups, the same relative distances are retained for a further 4 miles. Then a cross-over on D *only*, secures a reversal of these relative positions, which reversal is still maintained at the next crossing, which takes place on *both* groups. Thus, at the end of 16 miles, 5a and 5b have each been at an average distance of 30 inches from 7a for 8 miles, and of 32·5 inches for a similar distance, and the disturbing influence of 7a upon the whole circuit 5 is therefore *nil*. The same applies to the next 16 miles, and equally also to the effect of the wire 7b upon the same circuit.

In Group F the crosses are effected two miles apart, and are arranged relatively to the other groups in a manner similar to that described above. Crosses inserted two miles apart should only be resorted to in the case of the shorter circuits on a route.

The diagram illustrates a line of 12 circuits, but it will be evident that, by repeating the crosses shown (working backward), the arrangement as it stands is capable of application to a 34-circuit line without increasing the number of crosses. On such a route the distance between the extreme upper and lower circuits will probably in itself prevent overhearing, and the principal difficulties will be found between adjacent groups of wires.

Method of effecting crossings.

82. The "cross-over" should be done as illustrated in Fig. 43.

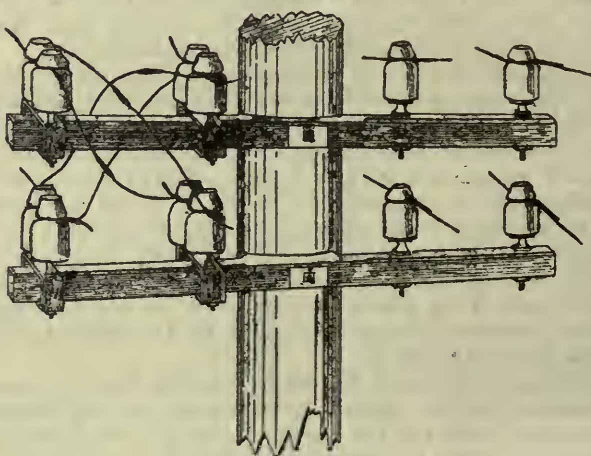


FIG. 43.

It will be seen that the left-hand group of wires is terminated on each side of the pole on separate insulators, the arms being fitted with terminal irons and terminal insulators. The crossing over is secured by rigid connections formed by tail pieces left to the line wires beyond the binding, the ends being lapped together and soldered like an ordinary joint. If the crossing wires be arranged as shown, there should be no risk of contact at the points of crossing, but workmen must exercise great care when engaged on these poles.

Points for special consideration.

83. The following considerations are to be borne in mind in connection with the elimination of disturbance from telephone circuits.

Disturbance may, as already stated, be due to bad regulation or to defective or unequal insulation of the two wires of a circuit or of adjacent circuits (telegraph or telephone). *The insertion of crosses will not eliminate these faults, and before crossings are made it should be ascertained, by tests and examination of the line, that the defective route does not contain such faults.*

According to the foregoing instructions, crosses should only be introduced for the purpose of eliminating "cross-talk," and it will, of course, be understood that cross-talk which is common to several circuits may become evident upon any given circuit as "noise" rather than as articulate speech.

On very heavily laden routes it may be found that slight overhearing, which would be objectionable if observable as articulate sound, is so toned down to an inarticulate murmur that it is scarcely observable. Advantage may in some cases be taken of this condition to more or less avoid the need of crossing.

Again, although Figs. 40 and 42 show all but one group as being crossed at one or more points, it is not intended that the crossing points shall be inserted upon a circuit unless experience shows that overhearing actually takes place.

Further, due attention must be given to the route of the wires. Overhearing upon a circuit does not necessarily mean that crossing points are required throughout its whole length. The source or sources of disturbance may often be localised to certain sections, and the fault dealt with accordingly. Indeed, it is important that the whole question of crossing-over points be dealt with on this principle. If, for instance, on a certain route of, say, eight circuits, that number be increased to 16 circuits for a distance of 18 miles, then the first of any necessary crossing points should be situated 9, $4\frac{1}{2}$, and $2\frac{1}{4}$ miles from the terminal poles of the section in question.

Aerial Cable.

84. Aerial cables are used where for any reason there is not sufficient clearance for open wires, *e.g.*, under bridges, or through trees where it is not possible to cut them sufficiently to clear the lines. The use of such cables should be avoided if possible. The service pattern is known as "Cable, electric, C 16," and has 16 cores of 40 lbs. to the mile conductors. The conductors are laid up in four quads of four wires each, and when used for metallic telephone circuits the two wires forming one circuit should be those forming a diagonal of a quad. "Cable, electric, C 4," can also be used for this purpose.

The suspending wire should be 400-lb. galvanized-iron wire (Z 23), and the cable is suspended from this by "Suspenders, raw hide," spaced 3 feet apart. If one suspending wire is insufficiently strong, two or more must be used, and in this case the clips of the suspenders should enclose all the suspending wires, which should not be twisted. The suspending wire is first erected, and the raw hide suspenders attached to the cable. In fixing the suspenders, not only the hook, but a portion of the raw hide should be passed through the slit. A proportion of the hooks are passed over the wire and the cable drawn along by a rope. Wiremen must be stationed at each support to shift the hooks, and to attach the remainder as the cable passes.

Joints in aerial cables should be avoided if possible.

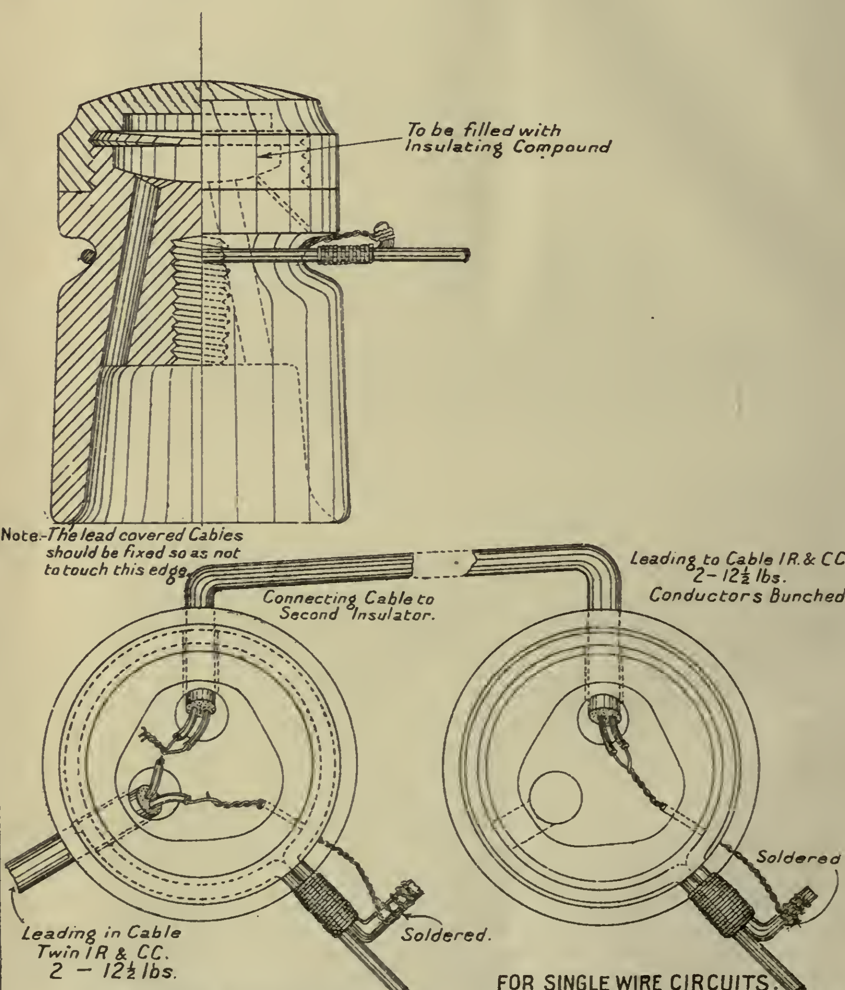
Leading In.

85. Arrangements must be made for bringing the leading-in wires down the poles, and this should, as a rule, be done by means of wooden casing. A groove should never be cut in the pole itself for this purpose. The size of the casing, which should be made locally, will depend on the number of wires to be led in. With a creosoted pole a casing of box section must be used, as creosote has a most destructive effect on india-rubber or gutta-percha, and must not be allowed to come in contact with the wires. When square uncreosoted timber is used for the terminal poles it will be sufficient if two strips of timber about 1 inch thick are firmly secured to the pole, and a faceboard of suitable width provided as a covering. All casing must be painted.

If the wires are to be led into a building by a length of underground pipe, the pipe should be brought up the pole to a point a little above the ground line, and the wooden casing should overlap the pipe by a few inches, to exclude moisture. If the pole is sufficiently close to the building the wooden casing can be taken from the pole to the wall, and along the wall to the point of entry, the casing should then be taken through the wall, which should be made good round it. When only one or two wires have to be led in they can be run in composition piping instead of casing.

Wire used. 86. The leading-in cable will, as a rule, be "Cable, I. R. and C. core, $2/12\frac{1}{2}''$." The cable will be threaded through one of the holes under the shed of the insulator terminal and leading in. The lead will be stripped from the end of the cable to a point about $\frac{1}{8}''$ beyond where it enters the top cavity of the insulator. When I. R. and C. core cable, $2/12\frac{1}{2}''$, is used for a single wire circuit the two conductors will be bared of insulation, up to a point about $\frac{1}{2}''$ from the lead covering, twisted together and led to the open wire tailpiece through the hole between the cavity and the groove of the insulator. The twisted conductor will be soldered to the tailpiece. When the operation is completed the whole of the cavity will be filled with "Sealing Compound," carefully poured in, the unoccupied

METHOD OF FITTING "INSULATOR, TERMINAL & LEADING IN SMALL" (⅝" THREAD). AND "INSULATOR, TERMINAL & LEADING IN, LARGE" (¾" THREAD).



FOR DOUBLE WIRE CIRCUIT.

FOR SINGLE WIRE CIRCUITS. OR SECOND WIRE OF 2 12½ CABLE.

Fig. 43ª

Malby & Sons, Lith

hole in the insulator being plugged to prevent the compound from leaking.

The compound will be melted in a copper pot, and its temperature will not be allowed to rise much above that of boiling water. It must be continuously stirred during heating in order to prevent burning.

For double-wire circuits two terminal and leading-in insulators will be used, one to terminate each open wire. The leading-in cable will be taken through the insulator nearer to the casing or pole. One of the conductors will be connected to the tailpiece of the wire terminating on that insulator, and, as the single conductor is weak where exposed to the atmosphere, it will be bent back on itself and twisted, the twist coming well within the cavity, or a separate short length of wire will be twisted up with it. The other conductor of the cable will be soldered to the bunched conductors of a piece of similar cable, 2/12½", which will be led into the cavity through the second hole. The other end of this short piece of cable will be taken to the second insulator, through which it will be threaded and its conductors connected to the tailpiece of the open wire, terminating on that insulator as in the case of a single-wire circuit. The cavity of each insulator will be filled with "Sealing Compound" (*see* Fig. 43 A).

The leading-in cables will be neatly secured to the under sides of the arms, and will be so fixed that the lead covering will not touch the shed of the insulator. With iron arms or brackets the cables may be clipped in position by "wires, jointing and binding, AA 21." Leading-in cups are not required on the casing, the cables will pass into the casing through small holes slanting upwards from the outside in order to exclude rain.

For double-wire circuits in diagonal positions the short cables inter-connecting two insulators will be protected between the arms by means of a strip of wood fixed vertically on each side of the pole close to the arms. The strip is not to cover the cable but to protect it from accidental injury by the feet of men working on the pole.

The same method will be used where the wires terminate on "brackets, insulator," for leading in to an office or other building, except no external casing will be required.

The internal end of the cables will be connected direct to the instruments or frame without special treatment of the ends and only a minimum length of sheathing will be removed, except that when they are taken into a "Box test pole E," these ends will be protected by a dressing of Chatterton's Compound well worked into and around the ends of the lead sheathing.

If cable I. R. and C. core 2/12½" is not available, wires electric S 1 or S 11 or cable electric A 2, A 4, A 10, or A 20 may be used, the method of procedure being similar to that above described.

If the building is some way from the terminal pole it may be more convenient to use armoured cable. If the length of underground work is more than about 50 yards, a "Box, test, pole, E," should, as a rule, be provided, and lightning dischargers fitted. (*See* Chap. VII.)

It may in some cases be necessary to lead in with aerial cable (*see* para. 84).

Inside buildings.

87. The wire inside buildings should be led carefully round all corners, and stapled down, if only one or two wires are being dealt with, or they may be protected in casing or pipes if necessary. When a considerable number of wires are required single groove casing of a suitable size must be provided. When running wires under floors they should be placed in shallow wooden troughs run in the same direction as the floor boards, and the boards under which they run should be screwed down and not nailed.

CHAPTER VI.

CONSTRUCTION OF UNDERGROUND LINES.

1. The advantages of underground, as compared with overhead, wires are as follows:— Advantages.

(i) They are less liable to damage, either by storms, &c., or maliciously by being cut, or by shell fire.
(ii) The absence of poles is an advantage where concealment is desirable.
(iii) Where a very large number of wires is required, *e.g.*, for telephone systems in large towns, the wires are out of the way, and take up much less room than ordinary overhead construction.
(iv) They are out of the way of open circuits carrying heavy currents, such as tramway trolley wires, or open wires used for transmitting electrical power.
(v) They are safe from the effects of lightning (*i.e.* if the whole circuit is underground).

2. The disadvantages are:— Disadvantages.

(i) More expensive to construct, both in money and time (except in exceptional cases).
(ii) More difficult to repair if faulty or damaged in any way.
(iii) They have a greater capacity than open wires, and are consequently not so good for telephone work over long distances, and the speed of sending in long-distance telegraph work is less than with aerial construction.

3. In civil practice, underground work is used for telegraph circuits for some of the wires between important towns, to ensure that communication shall not be entirely interrupted during bad storms; also in towns where overhead work would be difficult or unsightly, and where telegraph circuits cross open conductors carrying heavy electric currents for power or traction purposes. When used in civil practice.

4. For telephone work it is only used in towns, or where absolutely necessary. Long-distance telephone trunk lines must always, if possible, be overhead, owing to the better speaking thus obtained.

5. In the field, underground wires would never be used, owing to the time taken in construction. Military uses.

In fortresses, underground work is used to a considerable extent for telephone purposes, and for use with range-finding instruments, &c. In these cases safety from shell fire, &c., and in some cases concealment, are of such paramount importance that overhead work is often impossible.

It does not follow that all lines in fortresses should be underground. Wherever a route can be selected that is reasonably safe from shell fire, and where concealment is not of great importance, the ease of inspection and repair of overhead wires makes this method of construction the better one. In many cases it will suffice if the portion of the route in the neighbourhood of batteries, &c., is underground, the rest of the route being overhead.

Underground work.

6. In underground work the conductor has to be insulated over its entire length, and the insulating covering has to be protected. There are two main types of underground construction :—

(*a*) Armoured cables laid direct in the ground (this is the method usually adopted in the service).
(*b*) Insulated wires, or cables made up of several wires, drawn into pipes.

Insulation of underground wires.

7. The insulation of underground wires may be :—

(*a*) Indiarubber.
(*b*) Gutta-percha.
(*c*) Paper, or other porous and fibrous material.

In the service, indiarubber is used.

Gutta-percha.

8. The Post Office formerly used gutta-percha and do so still in some cases. The wires (laid in pipes) in fortresses at home are largely of this type. Gutta-percha is, however, unsuitable for use in hot climates, or where large changes in temperature are met with.

Paper cables.

9. Paper insulation is now almost universally used in civil practice, as the capacity of cables thus insulated is comparatively small, and the size of cables containing a given number of wires is much reduced. This insulation to be effective *must be dry*, and to ensure this the cables must be entirely lead sheathed ; this sheathing must be air tight, and the cables must be periodically dried out by pumping dry air through them. Special apparatus is required for this, and special precautions are necessary when laying and jointing. For these reasons they are unsuited for general military uses, military cables being mostly scattered in isolated localities.

Paper cables are made up in various sizes, those in use in the Post Office varying from 6 to 600 conductors, the latter cable being slightly over 3 inches in diameter. They are unarmoured, and consequently have to be laid in pipes or conduits.

Paper cables will not be further considered here.

Rubber insulation.

10. Pure rubber forms a good insulation, but will absorb considerable moisture, has no great strength, and becomes

"tacky" when warmed, it also absorbs oxygen very readily, and thus deteriorates. To prevent the rubber from taking up oxygen from the copper wire, it is necessary for the latter to be well tinned, or separated from the rubber by a layer of cotton; another reason why rubber should not be in contact with copper is given in para. 52. "Vulcanising" the rubber, *i.e.*, adding sulphur, increases the strength and prevents to a large extent the absorption of water and oxygen, *i.e.*, it improves the rubber for insulating purposes. It has, however, the disadvantage that the sulphur acts on the conductor and corrodes it.

Rubber insulated wires are consequently formed as follows:—The wire is first tinned, then coated with pure rubber, then with a "separating" layer of vulcanised rubber containing a small percentage of sulphur, and an outer layer, or jacket, containing more sulphur, this layer being the thickest.

Special care necessary.

11. The efficiency and durability of an underground line depend almost entirely on the care bestowed on every single operation; hence, in order that the best results may be obtained, it is imperative that particular attention be given to the most minute details. If the line is properly constructed there will be little or no necessity for repairs, but if the laying and jointing, &c., are badly done, endless trouble will be caused in the future.

The actual digging of trenches, laying of the pipes or cables, will, as a rule, be done by contract labour. In such cases it is imperative that the work should be supervised by a thoroughly competent foreman. No trenches should be filled up until the work has been inspected by an officer, and, if armoured cable is being laid, until the cable in the section of trench concerned has been tested.

Records.

12. Very careful records must be kept of all underground work. If this is not done, great trouble and delay is caused if faults occur, or if alterations are necessary. Details of the method of keeping these records are given in Chap. VIII.

Service Patterns of Cables.

13. The cables used in the service for underground work are of two main types, known as "Cables, electric, A," and "Cables, electric, B." Details of the different cables are given in Appendix I.

"A" type cables.

14. The "A" type cables consist of one or more cores; each core is made up of three strands of No. 20 S.W.G. tinned copper wire, with a conductivity resistance of 8·27 ohms per 1,000 yards, and an insulation resistance of 8,800 megohms per 1,000 yards. The insulation is indiarubber, as described in para. 10, the rubber being covered with a layer of primed tape. One, two, or four such cores are then enclosed in a lead tube, the scores being filled with tanned jute. The cores

are twisted so as to avoid induction when used for telephone work.

These cables require additional protection, and if laid underground should be drawn into pipes.

"B" type cables.

15. The "B" type cables are similar to the "A" type, but are armoured in addition to the lead covering, and are therefore suitable for laying direct in the ground.

Cable, electric, C 21.

16. In addition to these cables, "Cable, electric, C 21," may be used where a large number of wires are required for telephone work. This cable consists of 20 cores, each of three strands of No. 22 S.W.G., suitably twisted for telephone work. It is lead covered but not armoured, and cannot therefore be laid direct in the ground. The insulation resistance is 1,500 megohms per 1,000 yards.

Cable, electric, C 20.

"Cable, electric, C 20," is similar to "C 21," but without the lead covering; it is intended primarily for indoor use.

Choice of cables.

17. It is more economical to run a few large cables than the same number of cores distributed in smaller cables, but it is not generally advisable to join several small cables to one large one, except at a test box. Two 2-core cables may, however, be joined to one 4-core in a "Box, joint, cables, lead covered." It should be noted that the cores of "Cable, electric, B 7," and seven out of the nine cores of "B 9, Mark I," are not revolved for telephone work, and should not be used for such work if it can be avoided, except for short lengths, say under 440 yards. The two cores used for a telephone circuit should always compose a "pair" in a cable, or the two diagonally opposite cores of a "quad," when the cores are laid up in fours. The ninth core in the "B 9, Mark II," cable is run straight down the centre of the cable, and is intended for P.F. work only.

Armoured cable is, as a rule, cheaper to lay than cable in pipes, but if there is a probability that extra cores will be required along any given route, it may be better to run pipes, as alterations and additions can then be easier made.

Issue, Storing, and Testing of Cables.

Issue.

18. The above mentioned cables are supplied on drums, the maximum length of each pattern that can be supplied in one piece is shown in Appendix I. To avoid unnecessary cutting or jointing of cables, demands should state, where possible, the exact lengths required.

The dimensions of the drums vary somewhat, but do not exceed the following:—

Diameter of cheek..	6 feet.
Diameter of cheek over battens ..	6 feet 3 inches.
Width of drum	3 feet 9 inches.

A circular hole, 3 inches in diameter, is provided in the centre of each cheek to take a spindle for unwinding the cable.

With every issue of cables, a statement giving the previous history of each cable is forwarded to the station, and a distinguishing, or identification mark, called the Woolwich mark, is affixed to the cable.

Storing.

19. Electric cables are very costly, and are liable to rapid deterioration if not properly stored and handled. Their care is, therefore, most important. It must be borne in mind that it is impossible to tell, by visual inspection alone, whether a cable is serviceable or not. This can only be ascertained by electrical tests. To ensure that cables are properly looked after, a careful record of their condition and distribution should be kept (*see* Chap. VIII, para. 24).

Cables, unless buried or fixed in position, should be stored in a cool place, sheltered from the sun and rain. The ends of the conductors should be kept sealed.

Sealing ends of cables.

20. To seal the ends of the conductors, proceed as follows:—

Cut the conducting wires off close to the insulating material.

Remove the tape carefully from the insulating material for not less than 2 inches.

Pull the insulating material just over the ends of the conducting wires.

Make perfectly sure that the end is perfectly dry and free from grease by warming with a spirit lamp or wiping with a cloth steeped in naphtha.

Rub a little indiarubber solution well into the insulating material where the tape has been removed. Take a piece of indiarubber tape of suitable length, commence serving (*see* para. 60), using solution, at a point $\frac{1}{2}$ inch from the end of the cable; after serving two turns round the cable, pass the tape over the end of it, bring the tape back and serve another turn in the usual way, next to the first turns; pass the tape again over the end in such a way that it crosses the previous turn at right angles; serve back, working away from the end of the cable to the point where the tape has been removed; serve forward again, getting two more turns as before over the end, and continue as above until the end is properly covered with tape.

Apply more indiarubber solution over the serving, and slip over it a piece of vulcanised rubber tubing, if available, with its ends turned up, until half the tubing is on the cable core. When it is in position apply more solution at its ends, thus filling up the empty half of the tubing, and turn down the ends. Turn the projecting half of the tubing back on to the other half, and tie tightly with twine. A temporary seal may be made with paraffin wax as described in para. 22 (below).

Testing cables.

21. The cables should always be tested before they are taken out to the site for laying.

The test for conductivity resistance should be taken with a Wheatstone's bridge in the usual manner (*see* Vol. I.

Chap. XX). The test for insulation should be taken with a "Megger" when this instrument is available, or by the deflection method, as described in "Military Electric Lighting" (1908), Vol. II, p. 126. For accurate results the cable should be entirely immersed in water, except a few inches at each end; the wires from the testing instrument should be connected to the core under test, and to a copper plate laid in the cable tank.

Although the insulation resistance of the cables when first made is very high—over 8,000 megohms per 1,000 yards—yet if the insulating material is exposed to the weather, it soon deteriorates; so that the insulation of the ends of the cables and cores which have been left exposed for purposes of identification and test is always less than that of the rest of the cable. To obtain reliable results it is therefore necessary to cut a short length off each end, and to specially prepare both ends to prevent, as far as possible, surface leakage.

Preparing ends for test.

22. The ends should be prepared as for an ordinary joint (paras. 52 *et seq.*) with a 1½-inch length of bare wire, and ½ inch of insulation tapered off. The outer surface of the insulating material for about 3 inches below the taper should then be carefully cleaned of any trace of tape, felt, or similar material, and the surface of the rubber scraped with a knife, care being taken to handle this cleaned portion as little as possible. The whole of the end of each core should then be dried and warmed by a spirit lamp, or in some other way, and dipped in molten white paraffin. The wire at one end of each core must then be cleaned ready to connect to the testing instruments, care being taken to hold the core by the wire and not to handle the paraffined portion. Both ends of the wire connecting the cable to the instrument should be similarly treated, and the connection between the wire and cable made by a brass connector.

Unless these preparations are very carefully made, the tests will be merely of the insulation of the ends of each core and not real tests of the cables themselves.

It is useless to attempt to take a careful test for insulation on a wet day, or even in damp or foggy weather.

All cores except that under test should be connected together and to earth, the lead covering and armouring should also be connected to earth.

Tests after the cables are laid should be carried out in a similar manner, as far as the circumstances allow.

Results of all tests should be carefully recorded.

Preliminary Survey.

23. As in the case of aerial work, a preliminary survey should be carried out in order to:—

(i) Select the most suitable route.
(ii) Estimate the cost of the work.
(iii) Obtain all necessary information regarding way-leaves, &c.

When the route to be followed has been selected, the actual positions of the cables or pipes, joint boxes, &c., must be determined. All available information relating to the position of gas, sewer, water, electric light, and other mains should be obtained, and the existence of vaults and other underground structures crossing the line of route should be noted. Positions should be selected which, while affording the most suitable route for the trenching, provide also the best facilities for the subsequent maintenance of the wires with the minimum amount of interference from road traffic or other causes. Generally speaking, in towns, &c., the footpath is, where practicable, to be preferred in most cases. On country roads where there is a margin of land at the side of the road, this should as a rule be selected, the line being marked out at a reasonable distance from the metalled portion of the road. Any unnecessary crossing of a road is to be avoided.

In selecting routes through towns and in the country, the comparative cost of reinstating the various surfaces should be taken into consideration. When there is any doubt as to the available depth of a roadway or footway, *e.g.*, in crossing a bridge, and there is any difficulty in obtaining reliable information, arrangements should be made to dig trial holes to ascertain the depth available. Care should, of course, be taken to see that the holes are dug in places where the least depth is anticipated, *e.g.*, with arched bridges, at the crown of the arch, in the middle of the roadway, &c. Trial holes are also useful in places where reliable information is not forthcoming as to obstructions likely to be met with.

In laying out trench work, trial holes should be dug in advance of a length of trench before the trench is actually excavated, and every precaution taken to avoid the necessity of having to abandon lengths of trench work.

24. While the work is in progress the portions of the road that are disturbed should be duly fenced, lighted, and watched by night. After the completion of the work the road or street must be restored to as good a condition as it was before it was broken up. Fencing, &c.

Laying Armoured Cable.

25. All cables following the same route should be laid in the same trench. As a general rule, the depth of the trench Trenches.

in ordinary soil should not be less than 3 feet, except on rifle ranges or where there is no risk of injury by vehicles or shell fire, when the depth may be reduced to 2 feet or even 18 inches.

The bottom of the trench should be as level as possible, and the cables should be laid neatly along it, crossing being avoided as far as possible. In filling in the trench the cables should be covered first of all with 3 or 4 inches of fine soil, and care should be taken that no sharp stones are in contact with them. If the trench bottom lies in soil containing refuse or ashes, at least 4 inches of clean soil must be packed all round the cable to minimise chemical action on the armour and lead sheathing.

In some cases it may be desirable to place above the cables, before completing the filling in of the trench, a layer of flat stones, slates, tiles, or tarred planking, to give further protection from accidental injury.

When opening trenches containing cables, the use of picks should be prohibited except where absolutely unavoidable.

Position of joints.

26. The B type cables are made in lengths of 4 yards over a quarter or half a mile, in the intention that the distance apart of the joint boxes should be multiples of a quarter of a mile; there will then be 4 yards spare cable at each joint. It is very desirable that these joints should be arranged, as far as possible, at uniform intervals, and that, when several cables are laid together, the whole of the joints on each section should be grouped at one point.

Protection of joints.

27. The joints must be protected by one of the following methods:—

(*a*) By means of special joint boxes, *see* para. 45; this method should, as a rule, be adopted.

(*b*) By means of brick or masonry joint boxes built in the ground (para. 42).

(*c*) When no other means is practicable, by splicing (para. 51).

Transport of cables.

28. When an extended system of lead-covered cables is to be laid, a special drum carriage should be obtained or improvised. The diameter of the wheels should be about 18 inches greater than that of the largest drum, and the axle should be arranged so that it can be passed through the centre of the drum, and secured to the cheeks. The axle should be 3 inches in diameter for the largest drums, and provided with linch pins, washers, and drag ropes, and with shafts for animal draught, if the nature of the ground is such as to make this form of transport practicable. Where the ground is difficult it is generally more convenient to move the drum by manual labour, but shafts of some description will still be required for steering.

In order to mount the drums, a wooden ramp should be made upon which they can be run up. The axle should be passed through and the wheels attached. The drums can then be transported to the trench in which the cable is to be laid.

For handling the drums four hand-spikes and two large scotches should also be provided.

When rolling drums on the ground it is important that they should be rolled one way only; this is marked on the drum by an arrow.

29. If the trench is in open ground, the cable can be laid by wheeling the drum carriage parallel to it, and unwinding the cable at the same time. In wooded country, or where obstacles prevent the passage of the drum close to the trench, it will be necessary to leave it at one end of the section, and carry out the cable by hand. For this purpose fair-leads are useless with heavy cables. The quickest and most satisfactory method is to carry it bodily on men's shoulders, it should not be dragged along the ground. Laying cables.

If the ground is not suitable for this method of transporting the drums, it will generally be possible to roll them into position, where they can be jacked up, so as to revolve on a spindle, and allow the cable to be paid out. The drum should be turned so that the cable is paid out from the top of the drum. Care must be taken not to bruise the cable when rolling the drum. *On no account whatever should the drum be taken to pieces and the cable paid out in coils, nor should any attempt be made to pay out the cable by rolling the drum along the ground.* If the cable is taken off the side of the drum it will lie in loops, and cannot be properly laid—if these loops are pulled out straight the cable is "kinked" and the insulation and lead covering are damaged, leading to troublesome faults, and sooner or later making the cable useless.

30. When necessary to pass obstacles such as water mains, drain pipes, &c., the cables should, if possible, be laid above them, and, where necessary, specially protected by pipes, iron troughing, or in other ways. When necessary to pass below such obstacles, the cables must be threaded through. In many cases it will be advantageous to pass them through pipes at such points. Obstacles.

31. When two or more cables are laid in the same trench, care should be taken to preserve their relative positions, so long as they continue in the same trench, *i.e.*, they should not be laid across each other. Changes in direction, by crossing of cables, should, if possible, only take place immediately outside a joint box, or where the joint giving rise to the change of direction occurs. Much subsequent trouble will be saved if this is strictly adhered to, and the relative positions of the various cables accurately recorded in the route plan kept at the station. Position of cables in trenches.

32. Complete records and plans should be made at the time, showing the exact position of each trench, and joint box. These plans should preferably be prepared before the trenches are filled in, and at the time the test is taken preparatory to filling in. Special marks to show the position of the joints, Identification marks.

&c., should not be necessary if the records are properly kept, and are to be avoided, except inside W.D. enclosures.

In batteries, &c., where there is any likelihood of holdfasts being driven into the ground, the position of the cables should be carefully marked on the gronnd.

Filling in trenches.

33. Trenches when first made are liable to damage by heavy rain as the subsidence of the newly filled soil turns them into watercourses. This can often be avoided by the careful selection of routes, but where necessary the surface must be protected by rough concrete, or flat stones. Trenches should be perambulated periodically.

Before filling in the trenches a rough test must be taken and recorded. After such test the ends of the cores must be properly identified and sealed.

Laying Cables in Pipes.

34. Where it is decided to use pipes, cast-iron spigot and socket pipes should be used. The pipes used should have been dipped when thoroughly clean and suitably heated in a hot (300° to 400° Fahrenheit) bath, containing the following mixtures :—

Coal tar	1 cwt.
Tallow	7 lbs.
Quicklime, slaked ..	10 lbs.
Fine resin..	4 lbs.
Coal naptha	Sufficient to thin the composition to a degree suitable for proper coating.

Size of pipes.

35. The sizes of pipes generally used are 2, 3 and 4 inches diameter. The following table shows the maximum number of cables that can be drawn into these pipes for very short lengths :—

Cable.		Capacity of pipes.		
Nomenclature.	External diameter, inches.	2-inch.	3-inch.	4-inch.
A 1, Mark II	·236	45	96	180
A 2, Mark II	·488	11	24	44
A 4, Mark II	·543	8	18	32
B 2, Mark II	·85	4	9	16
B 4, Mark II	·95	3	6	12
B 9, Mark II	1·65	1	1	4
C 21, Mark I	1·5	1	1	4

For practical purposes it may be assumed that—

			Cables.
A 2″ pipe will hold	28 cores	made up as	7—A 4
3″ ,,	60	,,	1—C 21 and 10—A 4
4″ ,,	120	,,	4—C 21

If several cables have to be drawn into the same pipe, it is better to draw them simultaneously, taking care to prevent undue twisting; where additional cables have to be drawn in, great care is necessary to avoid damage to both old and new during the process.

The pipes should be carefully gauged for internal diameter, and the exterior examined to see that it is smooth and free from all defects. The inner edge of the spigot end, and the inside shoulder of the socket end, should be examined to see that they are properly rounded off and smooth.

A bell-mouthed pipe is of service where a line terminates in a manhole or vault, or where it enters a building.

36. Pipes should be laid at a minimum depth of 2 feet below the surface, measured from the top of the pipe. **Laying pipes.**

The pipes should be laid with a slight fall for drainage purposes, and suitable arrangements must be made for draining the manhole, &c. Abrupt alterations in direction or level must be avoided. If the direction varies gradually the pipes should be laid in a curve of large radius. At sharp angles joint boxes or split bends should be inserted, and the pipes run thence as straight as possible in each direction.

37. The bottom of the trench should be hard, smooth, and level, and small hollows should be excavated at the points where the sockets rest, so that the whole of the pipe will be well bedded on the soil. In cases where the ground is exceptionally loose, or has been recently disturbed, the bottom of the trench should be well punned. **Trenching.**

38. The joints in the pipes are more readily made above ground than in the trench, and it is therefore usual to join pipes in batches of three before laying. For this purpose the pipes are placed on blocks of wood about 6 inches high, provided with a suitable slot, and the spigot of the one pipe is closely fitted into the socket of the next. A packing of spun yarn is then inserted into the annular space, and tightly driven in by means of a caulking iron, sufficient yarn being used to fill the space to within 1 to $1\frac{1}{2}$ inch of the socket end, according to the size of the pipe. This should be done with much care, so as to prevent the possible entry of molten lead into the interior of the pipe during the next operation. A layer of plastic clay, rolled into a cylindrical form, is then laid round the mouth of and bedded against the socket, and a small orifice is provided on the upper side. Molten lead is then poured in through this orifice, until the remainder of the **Jointing pipes.**

annular space is filled. When the lead has cooled, it is tightly caulked with a "lead set," so as to render the joint both gas and water-tight. These lengths are then carefully placed in the trench and levelled, the spigot end being inserted and jointed in the end socket of the completed section, and the operation completed for the next length.

Each length of three pipes, before being laid in the ground, must be thoroughly cleaned out by means of a mop of white yarn attached to the centre of a piece of galvanized iron wire, which should be drawn backwards and forwards.

The insertion of a wet ladle into molten lead has given rise to serious accidents, owing to the explosive force of the steam generated. To avoid this the ladle should be kept inverted over the melting pot, mouth downwards, so as to keep it perfectly dry and warm. The scum should be removed from the surface of the lead before pouring.

The following quantities of yarn and lead are required for making the joints :—

MATERIALS FOR SOCKET JOINTS.

Size of pipe.	Weight of yarn per joint.	Weight of lead per joint.	Depth of lead.
inches.	ozs.	lbs.	inches.
2	1½	1¼	1
3	2	1¾	1¼
4	3¼	2¾	1½

Pulling-in wire.

39. As the work proceeds, an iron wire should be threaded through the pipe, to be used for the subsequent operation of pulling in. When the wire is to be used for drawing in the cable, it should be "Z 23" (400 lbs. to the mile), but "Z 21" (200 lbs.) will suffice if a rope is to be used for the latter operation. As the cable is drawn in, it should be coated with petroleum jelly, or a mixture of tallow and graphite.

Plugs for pipes.

40. The open ends of the pipes should always be plugged, to prevent the ingress of stones and grit.

Earthenware ducts.

41. Where a considerable number of heavy cables are required, it will generally be found preferable to use earthenware ducts instead of iron pipes, the ducts being laid in concrete, a separate duct for each cable. The Post Office use ducts having an octagonal shape externally. The ducts are laid on a 6-inch bed of concrete, if necessary reinforced by T-irons; each duct is bedded in about ½ inch of cement mortar, and the interstices filled in with cement. The ducts are jointed by wrapping round the joints a piece of calico, made adhesive by being soaked in ozokerite preparation, a wooden mandril

being inserted in the duct to ensure perfect alignment, and being left in until the cement has set. The spaces between the ducts and the sides of the trench are filled in with concrete as each layer of ducts is laid, and the whole covered with a 5 to 7-inch layer of concrete, according to circumstances. It is, of course, desirable to lay sufficient ducts, to allow for all probable extensions. It was found by the Post Office that when six or more ways were required, this method of laying was more economical than iron pipes; up to five ways the latter are used.

42. Joint pits, or drawing-in boxes, must be provided at all sharp angles, and at intervals of not more than 220 yards in the straight; the distance apart in the straight depends on the class of cable to be drawn in. Joints in lead-covered cables should never be drawn into pipes. Joint pits.

The pits may be built of brick or concrete, and should be of a minimum size of 2 feet square in plan, and 1 foot 6 inches deep. Deep pits should be larger in plan. The pit should be covered with a cast iron frame, or a stone set in a cast iron or concrete frame; suitable means must be provided for lifting the covers. The covers may be either flush with the ground or buried. An eye-bolt should be built into the bottom of the pit, for attaching the tackle required for drawing in the cables.

In many cases it is desirable to bury an earth plate below the foundations of the pit (lead, sheet, 4 or 5 lbs. to the foot, is suitable) and carry a 1-inch lead strip from this to the joint pit, the lead sheathing of the cables being eventually soldered to this strip (*see* para. 52).

As the work proceeds, an accurate site plan must be prepared, showing the positions of pipes, joint boxes and pits, &c., and all important measurements must be filled in.

Stores and Materials for Laying and Jointing Cables.

43. The tools and special stores required for laying and jointing cables and covered wires are given in the following tables:—

Vocabulary designation.	Remarks.
Bottles, glass, stoppered, narrow-mouthed, 16 oz.	For naphtha, coal tar.
Bottles, tin, methylated spirits, 1½ pints.	
Bowls, hand	½ gallon iron, tinned, wood handle.
Boxes, connecting buried cable	For rifle ranges (para 48).
„ joint, cables, lead covered.	With flanges to suit the nature of cables to be laid for "A" and "B" class cables (para. 45).
Box for tallow.	
Files—	
Coarse cut, flat, 12-inch.	
„ half-round, 10-in.	
„ „ 8 „	
Smooth, „ 8 „	
Hammers, fitters, 24-oz.	
Handles, file, middling.	
Holders, file, with handle.	
Irons, soldering	(Para. 53).
3-lb., ½-inch groove	For jointing electric wires.
9-oz.	For small work.
4-oz., hatchet head	For soldering lead sleeves.
Tinmans, large	
Knives, clasp	
Ladles, pouring, 1 quart .	For pouring melted glue, &c. (para. 46).
Lamps, blow, spirit, Mark II ..	(Para. 46).
Mallets, serving.	
Pliers—	
Gas, 9-inch.	
Side cutting, 8-inch, Mark III.	
„ 5-inch.	
Pots, fire, telegraph mechanics	For heating soldering irons.
„ melting, 3 pints	For melting glue, &c. (para. 46).
Rule, G.S., 4-fold.	
Saws—	
Cutting metal, 6-inch.	
„ „ blades, 6-inch.	
Dovetail, iron back.	
Scissors, trimming, Mark II.	
Screwdrivers, G.S., 9-inch.	
Spanners, McMahon, 9-inch.	
Towels, hand, hospital.	
Vices, jointers	(Para. 50).

44. The materials required for jointing cable are given below. The estimated quantities for jointing cores similar to the "A" and "B" class cables are also given. Each core jointed in a multiple core cable is reckoned as one joint.

Vocabulary designation.	Remarks.	Quantity per 25 joints.
Cloth, emery, No. F ..	.. ..	¼ quire.
Cordage, spunyarn—		
Hemp, 3-thread, tarred	.. ..	5 lbs.
„ „ white.		
Cotton waste, coloured ..	.. ..	2 lbs.
Glue, marine.		
Methylated spirits ..	.. ..	2 quarts.
Naphtha, coal tar ..	.. ..	¾ pint.
Rosin, black	.. ..	½ lb.
Sleeves, lead	For covering joints in lead-covered cables, diameters measured internally.	As required.
$\frac{5}{16}''$ × 12″	For A 1 Mark II, and inner core of B 9 Mark II	
$\frac{7}{16}''$ × 12″	For A 1 Mark I, B 4 Mark I, B 7, and outer cores of B 9 Mark I.	
$\frac{9}{16}''$ × 12″	For A 2 Mark II, A 2 Mark III, B 2 Mark II, centre cores of B 9 Mark I, and outer cores of B 9 Mark II	
$\frac{11}{16}''$ × 12″	For A 2 Mark I, B 2 Mark I, A 4 Mark I, B 4 Mark II.	
Solder, tinman's, soft ..	.. ..	1 lb.
Solution, rubber, 3-oz. tubes	.. ..	3 tubes.
Tallow, Russian.. ..	.. ..	½ lb.
Tape, rubber, pure ..	.. ..	1 lb.
„ double primed, 1-inch	Primed with rubber on both sides. Not used with lead sleeves.	2 lbs.
Tubing, rubber	Not used with lead sleeves.. ..	6½ feet.
½-inch.		
⅝-inch.		
Tubing, lead	Issued with boxes, as required.	
Wire, jointing and binding, AA 11	(Para. 55).	1 lb.
Varnish, shellac.. ..	For coating primed tape used for protecting joints without lead sleeves	½ pint.

No special chests or boxes are provided for carrying tools and materials, but such boxes should be provided locally.

45. The "Box, joint, cables, lead covered," is illustrated in Fig. 1, and consists of a cast iron trough of rectangular section, with cover secured by 12 bolts. A special spanner is issued with the boxes. The under side of the cover is formed with a rib fitting into a corresponding groove in the body. A piece of soft lead tubing is inserted to form a water-tight joint between the body and the cover, the tubing being carefully laid in the groove, and pressed in by the rib on the cover. Each end of the box contains two chambers. The cables pass through these and are sealed water-tight. Box, joint, cables, lead covered.

The same pattern box is used with all descriptions of lead-covered armoured cables, except on rifle ranges; the inner and

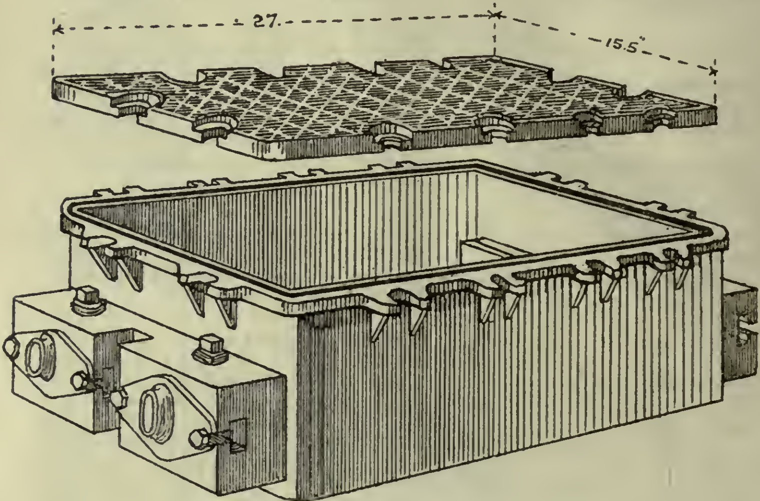


FIG. 1.—Box, Joint, Cables, Lead covered.

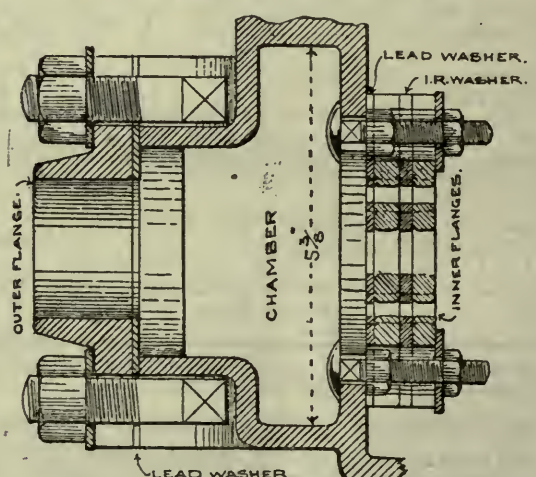


FIG. 2.—Sealing Chamber and Flanges for B 9 Mark I Cable.

outer flanges, which close the sealing chambers, being changed to suit the particular description of cable employed. In demanding these boxes, the patterns of cable for which they are to be used must be stated in order that the correct flanges may be supplied.

Each outer flange consists of an iron flange with a lead washer, and is secured by two galvanized iron bolts and one washer per bolt.

Each inner flange consists of two iron plates, one lead and one rubber washer, secured by two galvanized iron bolts, 2 inches by $\frac{5}{16}$ inch. Each bolt has two hexagon nuts and one washer.

A section of the sealing chamber is given in Fig. 2.

When only one cable enters or leaves the box, the spare openings should be closed by " blank " flanges.

46. The cables should be carefully marked at the exact points where they enter the box, and the outer flanges and lead washers should then be slipped over them. The outer covering should then be stripped back to the points marked on the cables, and the armouring wires turned back at right angles at the same point and cut off, allowing the ends to project about $\frac{3}{8}$ inch, so as to prevent any strain coming on the core when the outer flanges have been bolted on to the box. A tight joint should be made between the cable and the flange by suitable packing of tarred yarn or wood wedges. **Insertion of cables.**

Both inner and outer flanges are then fixed by screwing up the nuts of the side bolts, and the joint is made water-tight by pouring marine glue, or other suitable sealing compound, through the hole in the top of the chamber. The following is a suitable compound :—

	Per cent.
Soft coal tar pitch	80
Ground brick	15
Paraffin wax	5

Care must be taken to completely fill this chamber by pouring in more from time to time as the hot compound cools and settles down. When set, the plug should be re-inserted in the filling hole. The spanners issued with the " Vice, jointers," will fit the plug in the boxes of the latest manufacture.

In heating the glue, the fire used should not be more than sufficient to melt it, so that all risk of overheating may be avoided. It is essential that the chambers should be warmed before pouring in the compound. " Lamps, blow, spirit, Mark II," are provided for heating the chamber ; " Ladles, pouring, 1 quart," for pouring ; and " Pots, melting, 3 pints," for melting the glue

The slack of the lead-covered cores should be coiled neatly inside the box. Chambers not used should have the blank flanges screwed down, but should not be filled with compound.

In order to facilitate the jointing of the cores, and to allow for the reduction in length, should it at any time be necessary to remake a joint, sufficient slack should be left on each cable in each box. In cases where sufficient slack is not available, suitable " A " type cable may be inserted, but this necessitates replacing a single joint by two joints.

Depth of boxes.

47. The boxes are intended to be laid flush with the ground where wheeled traffic is not anticipated and protection from shell fire is not required, or to be buried at such a depth as may be necessary. Brick pits are not required with these boxes except in very wet ground.

Box, connecting buried cables.

48. The "Box, connecting buried cables,"* is provided for connecting successive lengths of "B 2" cable on rifle ranges, and for providing a means of connecting an instrument to the wires. The box is illustrated in Fig. 3, and consists of a cast iron trough with cover. The cover is raised in the centre and provided with a hinged flap. The box is intended to be set in the ground, with its longer axis parallel to the range, and the hinge of the flap away from the butts. Inside the raised cover is placed a plug socket, covered by a metal dome and screwed cap. The joint at the base of the dome is made watertight with a rubber washer. The plug socket takes the "Plug, jack, W.D." (*see* Vol. I, Chap. XIV, para. 3).

The cable is inserted into the box in the same way as into "Box, joint, cables, lead covered." Sealing chambers not required should be closed with wooden plugs and sealed with marine glue, or compound. The lead-sheathed cores of each cable are then passed through the glands in the cover, and watertight joints made by means of the gland nuts and rubber washers. Inside the dome the lead sheath is removed, and one core of each cable permanently soldered together and inserted into one terminal of the connecting socket, the other cores of the two cables being similarly connected and inserted into the other terminal; the connecting sockets thus being joined in parallel across the cable.

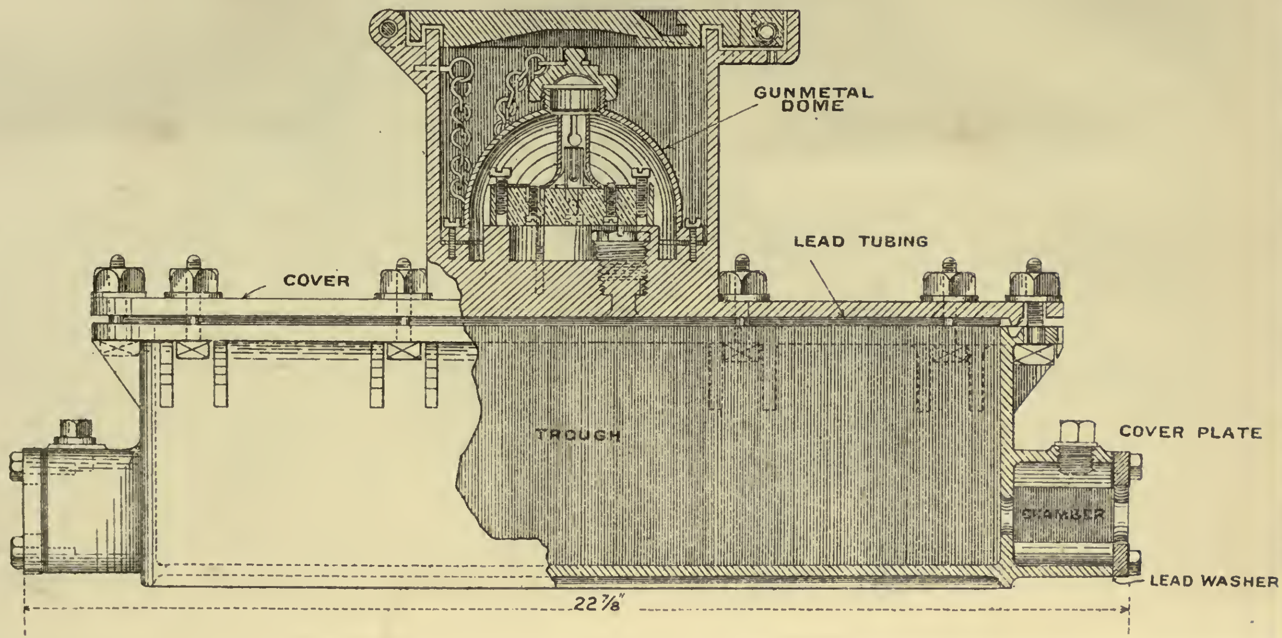
The cover of the box is then put on, the joint made with soft lead tubing, or wire, so as to be watertight, and the lid screwed tightly down. Care should be taken to leave spare core inside the box. No more of the lead sheathing should be removed from the rubber than is found necessary. No joint in the dielectric will be required inside the box, as the bare conductors will be clamped on to the terminal pillars. Between the boxes the cable should be run in continuous lengths without joints.

Box, junction, classification range.

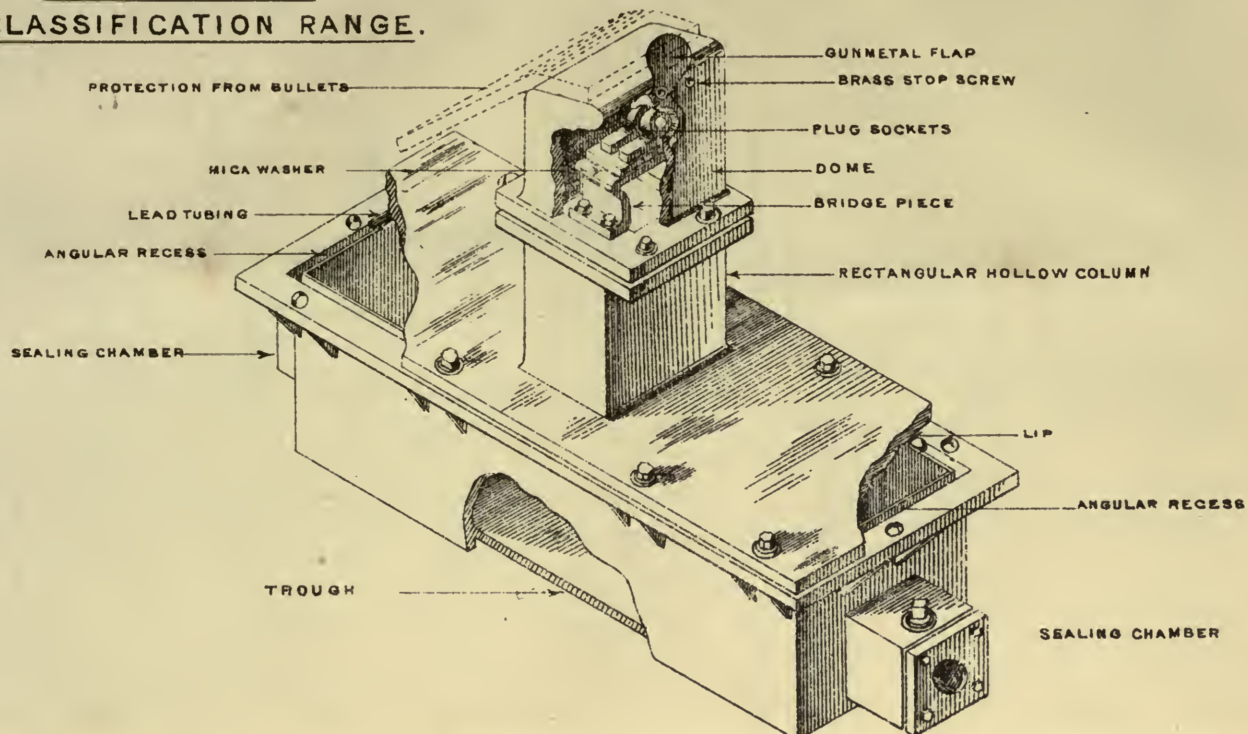
49. The "Box, junction, classification range," is a later pattern of the "Box, connecting buried cables," and is illustrated in Fig. 4. It consists of a cast iron trough with two sealing chambers for the cables, generally similar to the Box, connecting buried cables. A rectangular hollow column is cast on the cover, and on to this is bolted a dome; the latter should project about 4 inches above the ground line. The joint between dome and column is made with lead wire. The dome contains sockets similar to those in the "Box, plug, single."

* Now obsolescent and superseded by Boxes, joint, cable, armoured grip, large and small.—*See* Instructions for jointing solid impregnated paper insulated lead covered W.D. Cables, 1913.

BOX CONNECTING BURIED CABLES.



BOX, JUNCTION,
CLASSIFICATION RANGE.



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which take the "Plug, jack, W.D." for connecting the telephone leads. The sockets are placed so that the plug is inserted horizontally, and the hole for the plug is covered with a pivoted brass flap.

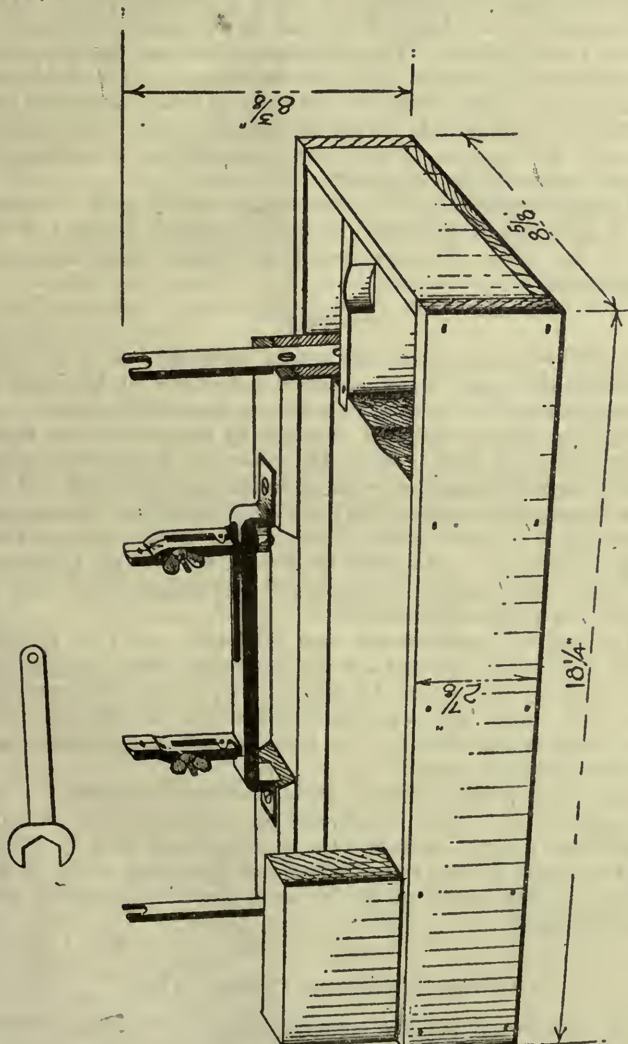


FIG. 5.

The box should be placed in the ground so that the hole for the plug faces the targets, and the side of the dome away from the targets should be protected from injury from bullets by a sheet of iron provided locally or some rough concrete.

The cables are led in and sealed in the usual manner, and the cores led up and connected to the terminal screws on the plug sockets.

Vice, jointer's.

50. The "Vice, jointer's," is illustrated in Fig. 5, and consists of two small vices mounted on a gunmetal bridge. One vice is fixed to the bridge, the other is adjustable, sliding in a slot cut in the bridge. The adjustable vice can be clamped in any position by means of a nut underneath. The bridge is mounted on a deal block, at the ends of which are fixed two wrought iron guide rods slotted at their tops, the slots being in line with the centres of the vice jaws. These rods serve to support the cables to be jointed.

A small wooden anvil is provided on which ends of cables can be prepared for jointing. A box extension is fitted to one end of the block, to carry a coil of binding wire and other small stores.

Splicing.

51. When joint boxes cannot be obtained, or it is found impracticable to use them, a splice may have to be made in an armoured cable. A splice is made as described below.

The iron wire armouring is carefully taken back for about 3 or 4 feet from each end of the cable for future recovering after the splice is made, care being taken that the "lay" of the wires is preserved as much as possible, to facilitate subsequent "marrying"; 1 foot length of the whole of the cores is then cut clean away, so as to allow sufficient armouring to protect the splice when made. Jointing and insulating should then be carried out as described below.

The centre lead-covered core (if such exist) is spirally coated with white spunyarn to the necessary size to receive the outer lead-covered cores; the scores between the outer cores are filled with white spunyarn, and the whole of the cores are bound tightly together by two layers of white spunyarn, laid on reverse to each other.

The armouring is now replaced and "married." The marriage of the wires is effected by cutting off a suitable length from every alternate wire at either end, and by fitting each long wire of one end in between two long wires of the other end. The whole of the splice is then firmly served with tarred spunyarn.

Jointing Cables and Covered Wires.

Precautions.

52. Before commencing jointing a cable, the cores must be properly identified and labelled (Chap. IX, para. 16).

The hands and the insulated conductor must be perfectly clean and dry before commencing to make a joint.

The dielectric should be carefully removed from the wire by a diagonal cut with a jointer's scissors ("Scissors, trimming, Mark II "), leaving the dielectric neatly tapered, carefully avoiding nicking the wires.

The very greatest care must be taken that the tinned surface of the copper conductor is not scratched or damaged in any way; experience has shown that when rubber comes in contact with pure copper, the free sulphur that is always to be found in small quantities in the innermost lapping of rubber, attacks the copper conductor, sulphide of copper is formed, and this renders the conductor brittle and useless. The copper also, in its turn, attacks the innermost layer of rubber, on which the insulation depends, *see* also para. 10.

Consequently, in handling joints with a file or pliers, the utmost care should be taken not to leave any copper untinned.

The wires are to be cleaned with naphtha or benzole; the former is supplied for the purpose.

In addition it is of the utmost importance that no rubber solution comes in contact with the bare wires; solution should be used sparingly.

It is also desirable, especially in the neighbourhood of electric light or power circuits, to ensure that the armouring and lead covering are electrically connected together, and to earth; the object being to prevent electrolytic action, *see* para. 42.

53. The soldering irons provided are detailed on p. 124, and illustrated in Figs. 6, 7 and 8. Soldering irons should never Soldering.

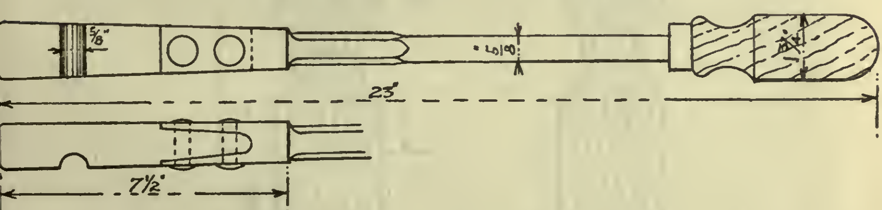


FIG. 6.—Iron, Soldering, 3 lbs.

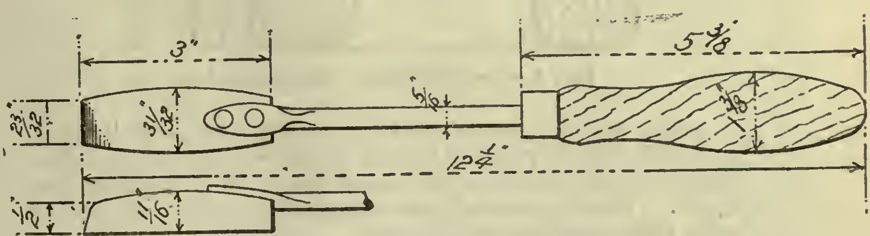


FIG. 7.—Iron, Soldering, Jointer's, 9 oz.

be allowed to get too hot and "burn." This always gives rise to an excessive lurid green flame, and is not only injurious to the "copper bit," but burns all the tinning off, thereby giving extra labour, and wasting time in re-tinning.

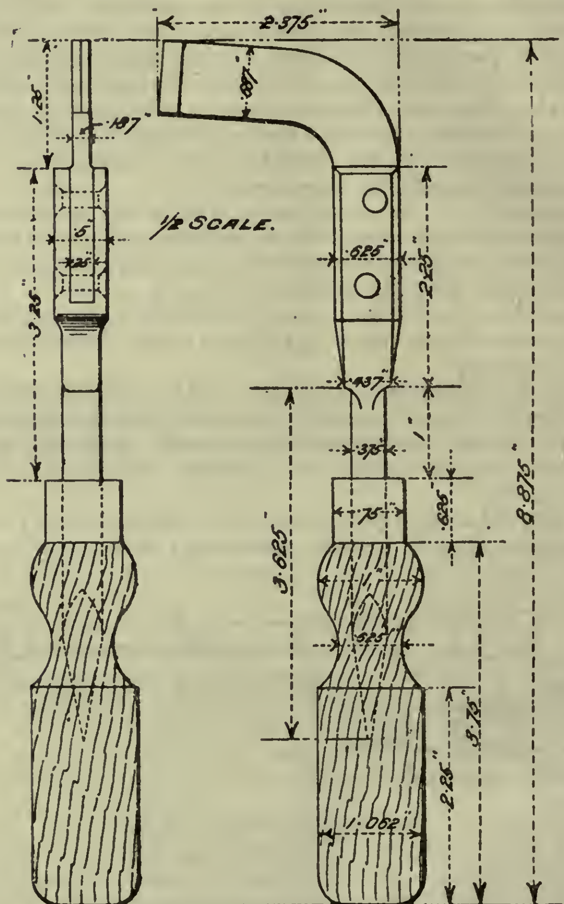


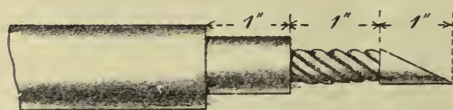
FIG. 8.—Iron, Soldering. 4-oz. hatchet head.

Irons may be cleaned with emery cloth, or carefully with a suitable file, they should be *well tinned*, and hot enough when used to be unbearable when placed about 1½ inches from the cheek. The irons should be wiped when taken out of the stove before applying to the joint.

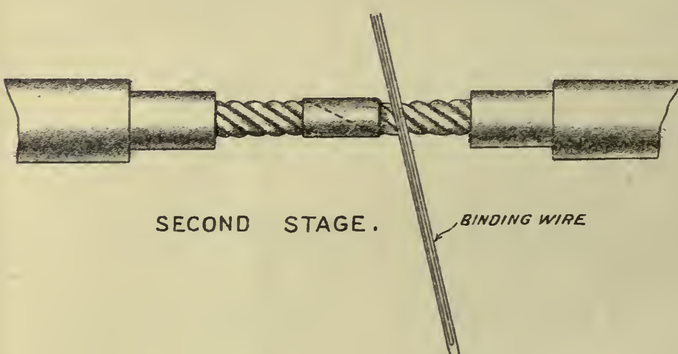
Quick soldering is essential, as continued application of heat seriously weakens copper wire and makes it brittle, as well as giving heat time to run back along the wire and damage the insulation. Too great a heat causes solder to "rot" and

STRAIGHT JOINT { SINGLE WIRE, 16 W.G AND LARGER. / 3 STRAND, 7 STRAND } SMALL WIRES.

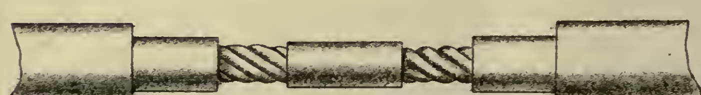
SCARFED JOINT.



FIRST STAGE.



SECOND STAGE.



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become useless. Too much attention cannot be paid to the soldering irons, as it is perfectly hopeless to attempt to solder a joint with a dirty iron, a badly tinned iron, or an iron that is not hot enough.

Rosin only must be used as a flux.

54. Joints in lead-covered cables should be covered with a lead sleeve after insulating (for sizes supplied *see* p. 125). If a sleeve is not available, lead sheet (4 lbs. per square foot) should be substituted, and indiarubber tubing should be used for any joints in rubber-insulated conductors that are not lead covered. The sleeve or tube (paras. 62 and 63) must be slipped over one of the conductors before starting jointing. **Lead sleeves.**

The hands should be carefully washed after dealing with lead-covered cables.

Details of Jointing.

55. Single wire 16 S.W.G. and larger. Strip off the armouring, jute, lead, and taping, if any exist, for a length of about 3 inches—if necessary secure the ends by serving. **Single wire, 16 S.W.G. and larger.**

Remove about 2 inches of the insulating material and carefully clean the wire with naphtha.

Scarf the ends of the wire with a suitable file till the two ends fit.

Adjust the jointer's vice and grip the conductors close to the insulation, the scarfed faces being opposed to each other in a vertical plane.

Secure one end of a piece of binding wire (AA 11) to one clamping screw of the vice, and take a few open turns tightly round the joint from one end to the other to keep the scarfs in position for soldering. With a very little solder on the bit, sweat the scarfed faces together. Remove the binding wire and smooth the joint with a file, taking great care not to remove the tinning, or to cut into the wires on either side.

Take a piece of binding wire (AA 11), 4 to 6 feet long, bent in four, and place the double bight on the left-hand clamping screw of the vice. Cut through the single bight so as to have four free ends. This will prevent the wires from over-riding during the binding.

With the four wires side by side, bind over the wires from a point ¼ inch to the left side of the scarf, to a corresponding point on the right side, pressing the turns close up together with the thumb nail and pulling them tight. Secure the free ends round the right-hand clamping screw of the vice.

Sweat through the joint and binding wire, cut away the loose ends, and smooth the joint over as before (*see* Fig. 9).

56. *Single Wire or 3-Strand under* 16 *S.W.G.*—Strip and clean the wires as in para. 55, place the two wires across each other, the crossing point being the middle of the bared part. **Single wire under 16 S.W.G.**

Grip the crossing point with pliers, and twist one of the free ends round the standing part of the other wire. Do the same with the other, straighten the joint and trim up the ends, taking care that no projecting end is left (*see* Fig. 10).

Sweat up and clean the joint as before.

Stranded conductors.

57. *Seven- (or more) Stranded Conductors.*—Remove covering, &c., for about 3 inches, and insulation for about 2 inches, as above.

Unlay, clean and lay up again the ends of the wires, sweat them up solid for about an inch from the tip.

Scarf the soldered ends with a suitable file, and proceed as in para. 55 (*see* Fig. 9).

Insulating Joints.

58. The insulation of joints is usually effected with indiarubber tape and solution. Indiarubber tape is issued in tins containing 2 ozs. Solution is issued in collapsible tubes of 3 ozs. Tins or tubes of solution should never be left open, and great care should be taken to prevent water getting into them.

Indiarubber tubing is only provided of $\frac{1}{2}$ inch and $\frac{3}{8}$ inch inside diameter; where these sizes are not suitable or not available, primed tape and shellac should be used for outside covering. The indiarubber tubing, if used, should be quite dry and clean, inside and out.

Indiarubber tape.

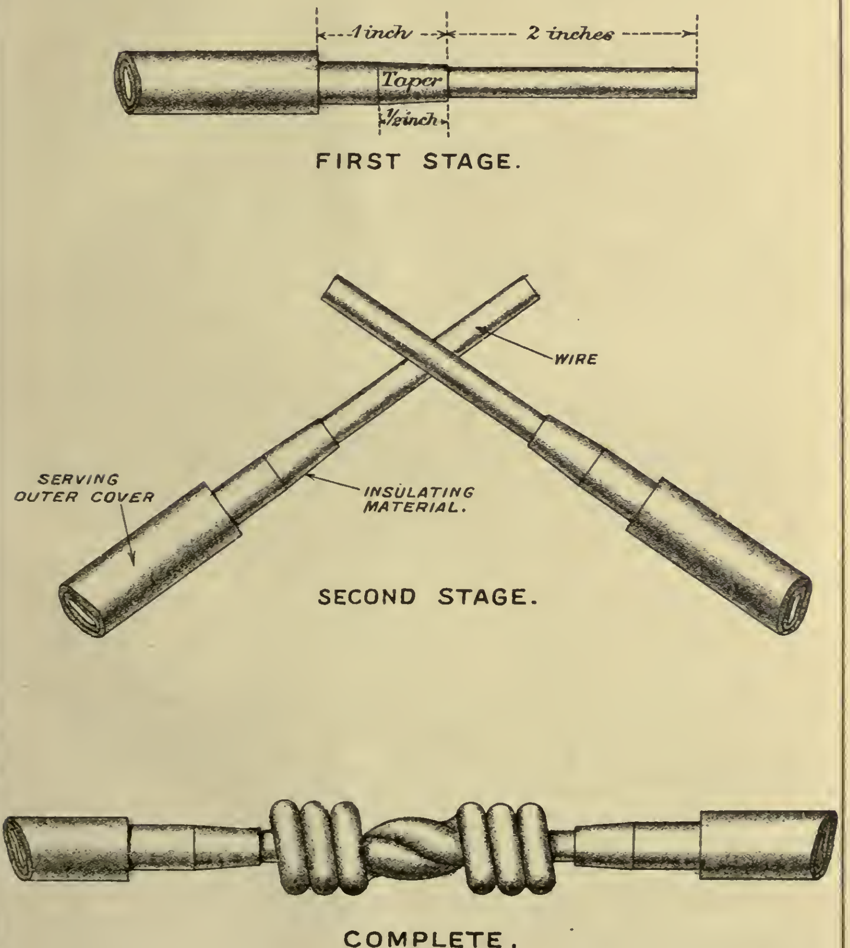
59. Indiarubber tape should be stretched gradually and perfectly evenly; if the tape is very old, it is well to warm it slightly before stretching it, say, by keeping it in the pocket, or by passing it through warm water, as described below. Care must be taken not to overdo the stretching, so as to cause the tape to lose its elasticity. Should this result be inadvertently produced, the tape can be restored to its normal condition by warming it slightly.

A good way of warming tape is by unrolling it and passing it through a bath of hot water at a temperature of about 150° F., and then through cold water, before recoiling. This prevents the sticking which takes place if the roll of tape is placed bodily into hot water.

The tape must be perfectly dry before use. Tape which is too old to stretch evenly, or which presents a hard cracked surface, or is soft and inelastic, should not be used.

The most important part in making an insulated joint is to lay the tape serving over the insulating material of the core in such a manner as to cause it to unite perfectly with the core, both on the tapered portion and beyond the taper. Care must be taken that the serving is commenced on the bare wires, and not on the tapered portion of the insulation, and that the serving is not carried, even ever so little, over any part of the insulating material before commencing to use indiarubber solution; at the same time, the solution must not come into contact with the bare wire.

STRAIGHT JOINT, SINGLE WIRE UNDER 16 W.G.



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60. Serving with indiarubber tape, whether with or without indiarubber solution, should always be done in the following manner:—Cut the ends of the piece of tape to a point, and stretch it till there are no dark spots in it. Wind it tightly round the object to be served, stretching the tape in doing so till it is only half its normal width, and making each turn overlap the preceding turn by half its stretched width, the tape being consequently laid on helically. **Serving with indiarubber tape.**

It is well to use the third finger of the right hand for smearing the solution, thus leaving the thumb, fore, and second fingers free for serving with. Care must be taken not to allow the hands or fingers to become covered with solution, as it is then very difficult to produce good work. On completing the serving, the end of the tape should be held in position with the fingers until it adheres. Rubber solution should be very sparingly used.

61. Joints should be insulated as follows:—

Cut away any of the insulation damaged during the soldering operation. Bare the insulation for about 2 inches on each side of the joint by removing the tape or other protective covering. Scrape the rubber lightly and remove all threads and dirt, taking great care not to cut the rubber. Trim the ends of the rubber to a taper about $\frac{1}{2}$ inch long (but the length of the taper will vary with the thickness of the insulation), the pure rubber, if possible, being just exposed at the bottom of the taper. The tapers must on no account be exposed to the air for a longer time than is necessary, and must be kept scrupulously clean and dry; if by any means they become in the least dirty, they must be wiped over with a piece of clean rag, free from fluff, damped with naphtha. **Details of insulation.**

Commence serving with indiarubber tape on the bare wire just beyond the point of the tapered point of the insulation, and wind first over the bared wires, *using no solution.* As soon as bared wires are covered, apply a little indiarubber solution to both sides of the tape, and also to the insulating material, and continue the serving up the tapered part, and along for a further distance of $\frac{1}{2}$ inch. Then serve back over the joint, continuing to use a little indiarubber solution; carry the serving along the tapered portion of the insulating material, and along for a further distance of $\frac{1}{2}$ inch on the other side of the joint. Then serve again over the joint, now carrying the serving to the top of the taper on the other side of the joint On reaching this point serve back again over the joint to the top of the other taper.

After this continue the serving forwards and backwards, always using solution, until the tape is served up nearly to the diameter of the lead covering of the conductor.

62. The lead sleeve (para. 54), where such is used, is now drawn back over the joint, and its ends carefully soldered to the lead core. This is a difficult operation requiring considerable skill. The temperature of the soldering iron requires very **Lead sleeve.**

careful attention; if too hot it will burn through the lead, if too cold the solder will not adhere properly.

Before the lead sleeve is slipped over the core the ends should be scraped clean, the cleaned surface extending about 1 inch down the inside of the tube. The ends should also be slightly opened out. The lead covering of the cores should be cleaned in the same way where the ends of the sleeve are to be soldered.

A little tallow is then smeared on the cleaned surfaces of the lead, and a little finely powdered rosin sprinkled over it. A few drops of solder are then dropped into the end of the sleeve, and the soldering iron passed round to complete the joint, a small hatchet bolt being used. This operation should be done quickly, or the lead covering of the core will burn, only sufficient heat should be applied to make the solder adhere thoroughly to the surfaces of the lead.

Indiarubber tubing.

63. When indiarubber tubing is used (*see* paras. 54 and 58) the joints must be finished over the rubber tape with a covering of double primed tape and shellac varnish. More indiarubber solution should then be applied over the serving, and the indiarubber tubing then drawn down, with its ends turned up, over the joint. When it is in position immediately over the joint, apply more solution at its ends, and turn them down.

Tie the ends of the tubing tightly with twine, about ½ inch from the ends. Pass the twine round the tubing, and tie with a thumb-knot; then bring the ends round to the other side, and secure them with a reef-knot, thus making two complete turns of twine round each end of the tubing.

Terminating Cables.

"A" type cables.

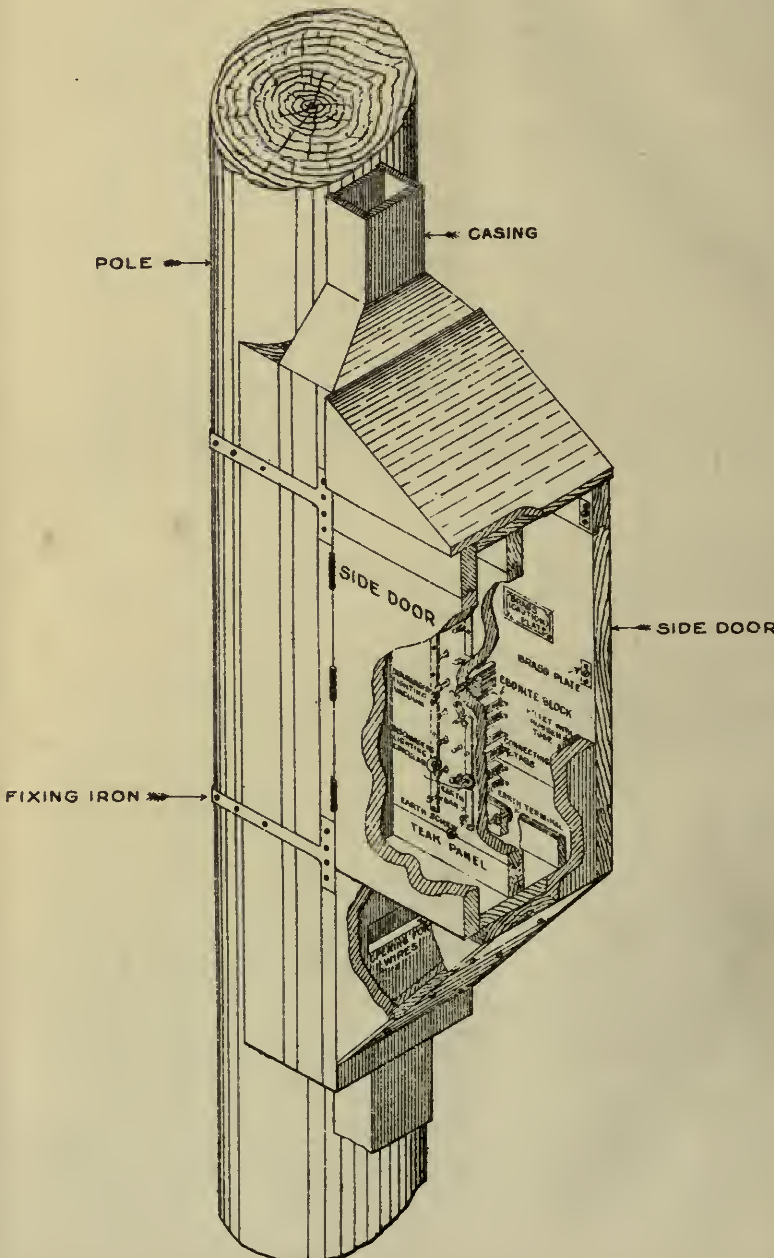
64. When "A" type cables enter a building the pipes containing them should be led to a small pit inside the building, close to the wall, and if possible immediately underneath the spot where it is intended to fix the terminal battens or strips (Chap. VII, paras. 10 *et seq.*). This pit should have a suitable iron or wooden cover. The cables should then be brought up the wall to the terminal strip, the lead tube being cut off about 2 feet from the strip, and the cores fanned out on a wooden batten plugged to the wall. It is generally convenient to carry this batten right down to the floor. Wooden cleats, or suitable clips with screws, should be used for attaching the cable and cores to the batten; staples must not be used.

If desired, the whole of the work may be enclosed in wood casing, and this should always be done when the lead-covered cable is liable to be damaged by being kicked, or by furniture being knocked against it.

"B" type cables.

65. "B" type cables may be treated in the same way, except that a pit is not necessary. The armouring wires should be cut off an inch or two below the point where the lead tube is cut, and the ends of the armoured portion whipped with iron binding wire (AA 21) or spunyarn.

Box, Test, Pole, E.



CHAPTER VII.

LINE TEST BOXES, TERMINAL STRIPS, JUNCTIONS OF MAINTENANCE, AND PROTECTION FROM POWER CIRCUITS.

Box, Test, Pole, E.

1. The "Box, Test, Pole, E," is the same as the Post Office store known as "Pole Test Box, E," and can be used for the following purposes:— **Use.**

(*a*) To provide a convenient test point on aerial lines, especially at junctions of maintenance.
(*b*) For inserting fuzes to protect aerial wires from power circuits.
(*c*) For testing, and inserting lightning dischargers, or dischargers and fuzes, at junctions between aerial and underground lines.

When lightning dischargers are not required the Post Office use a slightly simpler type of box, known as "Pole test box, D," but this is not a service store, and the E boxes can be used in all cases.

2. The box is illustrated in Fig. 1. It should be fixed to the pole as shown, and the wires brought down the casing to the opening provided in the lower portion of the box. On square terminal poles the use of a back board is, of course, unnecessary. **Description.**

The box is divided into two parts by a partition. The wires are brought in on the "front" of this partition, and (when used at junctions between aerial and underground routes) the wires from the aerial lines are soldered to the upper pair of tabs of each set of four sockets, and those from the underground lines to the lower tabs. The wires are connected through by U-links. Each telephone circuit should be connected to one set of four tags. The U-links are normally inserted vertically, and the lines are then "through," if the links are removed the lines are "disconnected," and, if inserted horizontally, the lines are "looped." Special plugs and cords are provided for test purposes, or for temporary cross connections.

The two upper sockets of each set of four are extended through the partition to the back of the box, for the purpose of connecting the lines to the lightning dischargers.

The doors are secured by screws which can only be turned by one of the special type of screwdrivers issued with the boxes.

The normal size of the box is for 16 wires (*i.e.*, eight metallic circuits), but any multiple of eight wires can be supplied as required. When these boxes are demanded, provision should be made for the maximum number of wires the pole is likely to carry, links and dischargers being provided for the lines actually erected.

Accessories. 3. Each box is issued with one special screwdriver and one test cord with two pegs. Links, fuzes, and dischargers must be demanded separately as required.

Lightning dischargers. 4. On the back of the partition in the box are two vertical earth bars for fitting lightning dischargers, and these are provided with one terminal screw each for the earth connection. Either *" Dischargers, lightning, circular, Mark II," or *" Dischargers, lightning, vacuum," can be fitted. When the former are used, one unmounted discharger must be demanded for each wire to be protected. The one plate of the discharger screws direct into the earth bar, and the screw holding the clip screws into the extension from the line socket. In this case the earth wires are connected to the bottom of the earth bars.

When vacuum dischargers are used they are fixed as shown in Fig. 1, one long screw and one short screw must be demanded for each discharger to be fixed. In this case the earth wire is connected at the upper ends of the earth bars.

Links, cut-out. 5. When it is desired to insert *" Fuzes, tube, 2-inch," in the lines, " Links, cut-out," are substituted for " Links, U." These links are illustrated in Fig. 2, and are fitted to take *" Fuzes, tube, 2-inch."

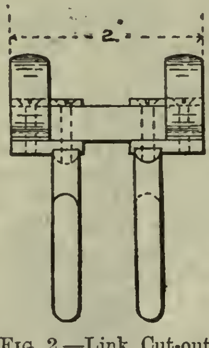


FIG. 2.—Link, Cut-out.

Earths. 6. The provision of a good earth at all test boxes fitted with lightning dischargers is very important. The ordinary pole earth wire is not sufficient. An earth plate is, as a rule, necessary, and if iron pipes are used for the underground

* Described in Vol. I, Chap. XVII.

wires, these should be connected as well, care being taken to make a good electrical connection. The earth wire should be rnn as straight as possible, and sharp bends should be avoided. The earth wire shonld be of copper, 7/18-strand copper wire is suitable. The pole should be grooved to receive the wire as in the case of ordinary copper earth wires (Chap. V, para. 31).

Insulators, Porcelain, Fuze.

7. "Insulators, porcelain, Fnze" are provided to enable a "Fuze, tube, 2-inch," to be inserted in a line without the necessity of providing a special test box. **Use.**

8. The Mark I pattern is illnstrated in Fig. 3. The insulator is provided with two grooves, as in the case of the terminal insulator (Chap. V, para. 38) on which the wires are terminated. **Mark I.**

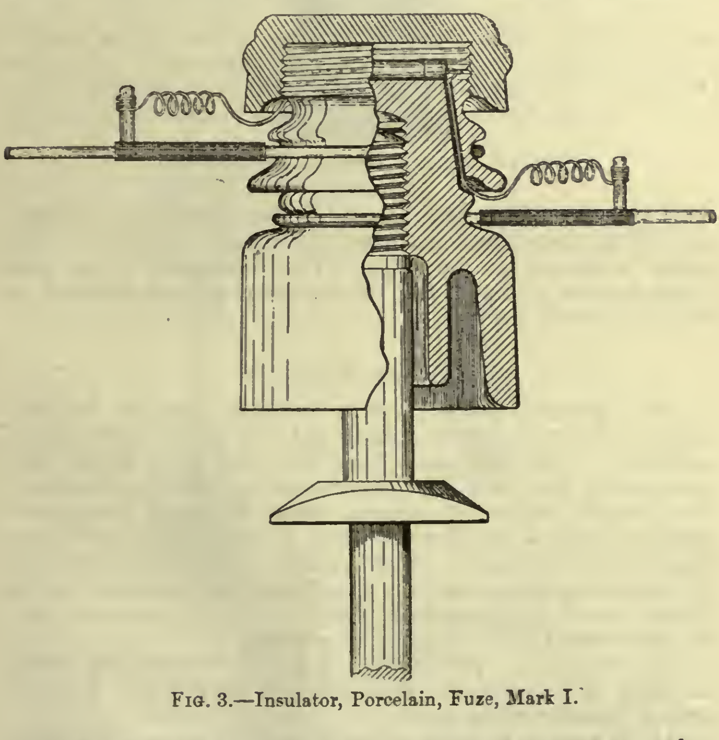


FIG. 3.—Insulator, Porcelain, Fuze, Mark I.

The connection between the wires is made by a "Fuze, tube, 2-inch, with wire extension" (Vol. I, p. 237). The terminated line wire should have a tail-piece projecting horizontally to provide for the fuze connection (in the figure the tail-pieces are shown vertically for the sake of clearness). The fuze rests in a groove in the top of the insulator, and is protected by a screwed porcelain cover. The extension wire connected to that portion of the line terminated on the lower groove of the insulator is to be passed through the hole in the crown of the insulator, so as to keep it clear of the other section of the line. No more of this pattern insulator will be provided.

Mark II. 9. The Mark II pattern is shown in Fig. 4. The wires are terminated in the same way as for the Mark I. The cover of the insulator is of "Ambroin" instead of porcelain, and an ordinary "Fuze, tube, 2-inch," is used, the clips for which are

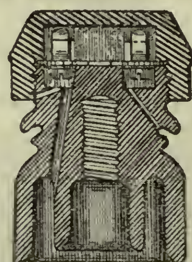


FIG. 4.—Insulator, Porcelain, Fuze, Mark II.

fixed on a loose fibre base, secured by the cover being screwed on. The connections are made by wires connected to the screw terminals on the clips. The connecting wires pass through holes in the body of the insulator, and are soldered to the line wires as before.

Battens, Ebonite.

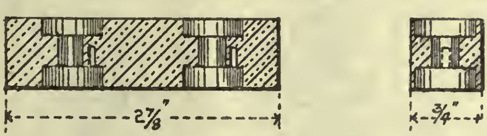
10. "Battens, ebonite," were formerly supplied for test boxes on Fortress command lines, and P.F. cables, especially at junctions of maintenance. They have not been found very satisfactory, and have been superseded by "Strips, terminal." The battens consist of ebonite strips 3 inches wide, with sockets mounted on them to take U-links. The wires are connected to binding screws at the back of the batten, and the through connections made by the U-links in the same way as in the case of the "Box, test, pole, E." "Links, cut-out," can be used instead of the U-links, if required.

The battens are provided for 2, 4, 7, or 9 wires, and either mounted or unmounted. The mounted battens are fixed on a wood base for indoor use.

Box, ebonite batten. 11. When the batten is exposed to the weather, is liable to be tampered with, or injuriously affected by the climate, it can be enclosed in a "Box, ebonite batten." This box is provided with chambers at each end by means of which the openings, at which the conductors enter, can be sealed in the manner described in Chap. VI, para. 46, for joint boxes. "Dischargers, lightning, vacuum," can be fitted in this box if required.

Strips, Terminal.

12. " Strips, terminal " (Fig. 5), are ebonite strips arranged for mounting terminals. They are used for terminating P.F. or telephone lines, &c., especially those used in connection with

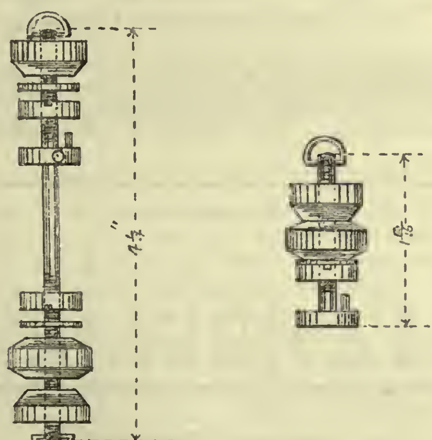


Longitudinal section. Cross section.

Fig. 5.—Strips, Terminal, 2 wires.

defence works, and for making up test boards for use on such lines. They are supplied for 2, 4, 7, or 9 terminals.

Two types of terminals are supplied for use with these strips, viz., " Long shank " and " Short shank," Fig. 6.



Long shank. Short shank.

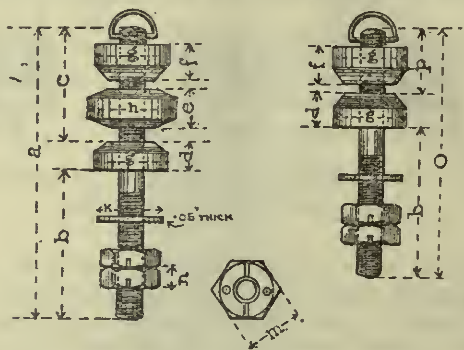
Fig. 6.—Terminals, Strip.

The long-shank terminals are intended to be used with two ebonite strips, one fixed on either side of a partition in the test box, the shank passing right through the partition. Care must be taken in fixing these that no portion of the terminal or shank touches the woodwork of the partition.

The short-shank terminals are for use with one ebonite strip where there is no partition in the test box.

Terminals, Electrical Instruments.

13. "Terminals, electrical instruments," are provided in four sizes, and either "double" or "single" in each size. They are the standard terminals used in all service pattern



Double. Hexagonal nut. Single.

FIG. 7.—Terminals, Electrical Instruments.

electrical instruments, and can be used for many purposes. The shanks are threaded B.A. standard threads sizes 0, 2, 4, and 6 respectively. The principal dimensions are (see Fig. 7) :—

Size—B.A.	Dimensions in inches.												
	a.	b.	c.	d.	e.	f.	g.	h.	k.	m.	n.	o.	p.
0	$2\frac{15}{16}$	$1\frac{1}{2}$	$1\frac{1}{8}$	$\frac{5}{16}$	$\frac{13}{32}$	$\frac{3}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	$\frac{5}{8}$	·54	·2	$2\frac{15}{32}$	$\frac{21}{32}$
2	$2\frac{13}{16}$	$1\frac{1}{2}$	1	$\frac{5}{16}$	$\frac{11}{32}$	$\frac{3}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{9}{16}$	·5	·2	$2\frac{7}{16}$	$\frac{5}{8}$
4	$2\frac{23}{64}$	$1\frac{1}{4}$	$\frac{27}{32}$	$\frac{17}{64}$	$\frac{5}{16}$	$\frac{5}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{1}{2}$	·4	·15	$2\frac{1}{64}$	$\frac{1}{2}$
6	$1\frac{57}{64}$	1	$\frac{23}{32}$	$\frac{11}{64}$	$\frac{9}{32}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{3}{8}$	·3	·15	$1\frac{57}{64}$	$\frac{13}{32}$

Junctions of Maintenance.

14. In all cases where lines maintained by one authority are joined to lines or instruments maintained by another authority, some method of testing and disconnecting the lines must be provided at the junction of maintenance.

Aerial. 15. Where the lines on one side of the junction are aerial a "Box, test, pole, E," usually forms the most convenient method of arranging this.

Underground. 16. Where the lines on both sides are either underground or submarine a test box, pit, or hut must be provided. In this case "strips, terminal," are convenient for arranging the testing facilities required.

The junction can be arranged in any of the following ways:—

(i) By simple double terminals.

(ii) By two sets of double terminals fixed side by side, the wires from one side of the junction being connected to the lower nuts of one set of double terminals, and those from the other side to the other set. The two sets of terminals are then connected together by brass straps, or short pieces of stout bare copper wire, using the upper portions of the double terminals.

(iii) By dividing the test box into two distinct parts by a partition, and terminating all the wires maintained by one authority in each portion. The connections are then made by "strips, terminal," and "terminals, long shank," the shanks of the terminals passing through the partition.

When this last mentioned arrangement is adopted, and it is not possible to use the long-shank terminals, separate sets of double terminals should be used in the two portions of the box, and the connections made by short pieces of stout insulated copper wire soldered to the lower portion of the terminals to be connected.

If the junction of maintenance is also a junction between aerial and underground wires the necessary protecting devices must also be provided, as directed below.

Junctions between Aerial and Underground Wires.

17. Where aerial wires join underground or submarine wires (except short lengths of underground wires, say under 50 yards, for leading in to an office) it is necessary to protect the underground wires or cables from the effects of lightning, and, in addition to this, arrangements should be made at such points for testing, to facilitate the localisation of faults.

As an additional protection against lightning it is a good plan to twist the ends of the leads from the cables in the pole test box into a spiral or helix before soldering to the tabs, so as to form a rough choking coil (*see* Vol. I, p. 233).

18. Either "Dischargers, lightning, circular," or "Dischargers, lightning, vacuum," should be fitted; the former are preferable except in damp situations, where they are liable to cause faults (*see* Vol. I, Chap. XVII). Lightning dischargers.

If the circuits are also liable to leakage currents from power or lighting circuits, "Fuzes, tube, 2-inch," should also be inserted.

Where one or two wires only are concerned the dischargers may be fitted in a box made locally and fixed to the pole, and fuzes may be inserted in fuze insulators. In some cases it may be advisable to provide a special test hut, or to lead the wires into an adjacent building if such exists, but in most cases a "Box, test, pole, E," should be used.

In all cases care must be taken to provide a good earth for the dischargers (*see* para. 6).

Special cases. 19. In exceptional cases, where aerial lines are connected to submarine cables, and where there is exceptional liability to damage by lightning, owing to the prevalence of severe thunderstorms, it may be desirable to provide special protective devices. If such devices are required they must be specially demanded. These devices consist of more or less elaborate forms of inductive resistances or choking coils inserted in the circuit between the air gap of the ordinary discharger and the instrument or cable to be protected.

The device used by the Post Office in such cases is known as the "Tablet" protector, and consists of a coil of fine platinum-silver covered wire wound on a metal bobbin connected to earth. This coil provides the necessary inductive resistance, and also acts as a bobbin protector. A large plate discharger and a "Fuze, tube, 2-inch," are also included in the protector.

Test Points on Lines.

20. In addition to the test points required at junctions of maintenance, and junctions between aerial and underground work, points should be provided at intervals where it is possible to disconnect the wires for test, or to alter the connections. The provision of such points at suitable places greatly facilitates making any alterations to the circuits necessitated by altered requirements, and, in the event of an important line failing, not only facilitates the localisation of the fault, but will often enable the line to be made good by the utilization of a spare wire, or one appropriated for a less important circuit, pending the removal of the fault.

Telegraph lines. 21. On telegraph lines it is usual to lead all the wires into the test box of any office that is on, or close to, the main route, even though only a small proportion of the wires are actually connected to instruments at that office. This is usually sufficient in the case of aerial wires.

Where such offices do not provide sufficient test points, others should be provided. The distance apart of such points must depend on circumstances, and no rule can be given. It should, however, be noted that faults on underground lines cannot be located by inspection, and that opening joints for test purposes is laborious and unsatisfactory; test points on underground lines should, therefore, be liberally provided. They are constructed in the same way as those for junctions of maintenance.

Aerial lines. 22. If extra test points are required on aerial lines it will usually be sufficient to terminate the wires on the two grooves of a terminal insulator, or on two separate insulators, as described in Chap. V, para. 82, and bridge over with a piece of bare wire. In such cases the bridging piece should be soldered. Fuze insulators, with dummy fuzes, also form a ready and convenient means of testing where overhead conductors are concerned, and save the necessity of cutting and resoldering bridging pieces. It may in some cases be desirable to use a pole test box, in which case "Box, test, pole, E" (without lightning dischargers), is suitable.

It must be borne in mind, however, that, especially where aerial telephone lines are concerned, every testing point creates an additional point of weakness. The leads necessary for leading wires into buildings or pole test boxes reduce the insulation, and are a frequent source of "loss of insulation" or "difference of insulation" faults. A badly made or unsoldered joint at a bridging piece is a frequent and most difficult fault to trace.

In some cases testing points actually tend to delay the clearance of faults and to encourage bad maintenance. The time taken in obtaining a reliable test is frequently more than a lineman would have taken in clearing a fault if he had carefully patrolled the line, instead of proceeding to various points to test. An increase in the number of tests also increases the possibility of wrong and misleading tests.

The necessity of each testing point should, therefore, receive careful consideration, and the number of testing points on aerial lines should be reduced to a minimum.

Underground work in fortresses.

23. In underground work in fortresses advantage should be taken of the presence of any War Department buildings in suitable positions to lead in the wires to a test board, or in some cases a special test hut or pit may be required. All wires must be carefully labelled at such points.

Submarine cables.

24. Testing facilities should always be provided at the landing places of submarine cables, even if no special protection from lightning is required.

Protection from Power Circuits.

25. The method of protecting instruments from leakage currents from power and lighting circuits, by the provision of heat coils and fuzes, has been dealt with in Vol. I, Chap. XVII. This protection is not, however, sufficient in all cases.

If any considerable leakage occurs due to a contact with a power line it may be dangerous to anyone coming in contact with the wire concerned. It is, therefore, desirable not only to take the precautions mentioned below, but also to insert fuzes in the line at either end of any portion liable to such faults, especially when aerial telegraph and power lines cross. The fuzes may be inserted either by means of the "Box, test, pole, E," fitted with "Links, cut-out," by "Insulators, porcelain, fuze," or by "Dischargers, lightning, D."

Under-ground lines.

26. Where underground wires cross, or run parallel with, underground power mains, they should be kept at a reasonable distance apart, and in no case should the cables, pipes, ducts, or troughs, &c., containing them be laid in actual contact.

If the two sets of plant have to be laid very close together, say within a few inches of each other, a bed of concrete should be laid between them.

Tramway trolley wires.

27. The commonest case affecting aerial wires is when they cross tramway trolley wires. The Board of Trade regulations dealing with the guard wires that are required in such cases are given in Appendix II. The object of the guard wires is to prevent, if possible, a broken telegraph* wire coming into contact with the trolley wire, or, at any rate, to ensure that before touching the trolley wire it is connected to earth by contact with the earthed guard wire. If the wire is earthed in this manner, it not only to a large extent prevents leakage currents passing along the telegraph line, but should also cause the circuit breaker protecting that portion of the trolley wire to open, and thus disconnect it from the power supply.

Power lines, 650 volts and under.

28. Where telegraph lines cross aerial power lines working at a pressure not exceeding 650 volts, it is generally preferable for the telegraph lines to cross below the power lines; the latter being, as a rule, of stouter wire than the telegraph wires, they are less liable to break.

Where the power lines cross below the telegraph wires, guard wires should be erected, as in the case of trolley wires. When the telegraph lines are below the power circuits, it is necessary either to erect cradle guards on the power circuit supports or to place guard wires on the telegraph poles. The latter is generally the preferable arrangement. Care should be taken in all cases to secure an efficient earth; the ordinary pole earth wires should not be used for this purpose.

Covered conductors.

29. When the aerial power circuit consists of covered conductors, and these pass below the telegraph lines, earthed suspension wires may be accepted in lieu of guard wires.

It may be desirable in some cases to run the telegraph wires past the power circuits in cables instead of open wires.

Power circuits over 650 volts.

30. In the case of power circuits working at "High tension" (650 to 3,000 volts) or "Extra high tension" (over 3,000 volts), the above-mentioned precautions are insufficient, and it is necessary to ensure that accidental contact *cannot* take place. To ensure this, one of the following methods must be adopted:—

(*a*) Terminate the telegraph wires at either side of the crossing and connect by underground lines. This method is often objectionable from the telegraph point of view, especially on telephone trunk circuits.

* The term telegraph wire in this connection includes telephone wires, &c.

(*b*) Provide a cradle between the power and telegraph lines, with a sufficiently close mesh and of sufficient strength, to prevent the possibility of a broken wire curling in and making contact with the wires below. This method is not very satisfactory, as it is difficult to construct a really satisfactory cradle, and in any case such cradles are liable to damage from an accumulation of snow in a climate where snowstorms occur.

(*c*) Carry the power line over the telegraph lines on two tall poles with a short span between them, so that a broken wire will hang down clear of the telegraph wires. This method is rather undesirable from the power transmission point of view, as it involves unevenly balanced spans.

(*d*) Provide a structure for the joint support of both the telegraph and power circuits at the point of crossing, the angle of crossing being as near as possible a right angle. The structure should consist of two or four poles, either wood or iron, and should be so braced or stayed that under no circumstances can it be torn down by the failure of either the telegraph or power lines. The power lines to be attached to the upper portion of the structure above the telegraph lines, and screened from the latter by an iron grid or lattice platform, efficiently earthed, so as to absolutely prevent the possibility of contact between the two sets of wires. The earth wires should be insulated and protected by being enclosed in an iron pipe. This method is, in most cases, the best.

Work in the Vicinity of Power Circuits.

31. When work is being carried out in the neighbourhood of power circuits, great care should be exercised with a view to the prevention of contact between the telegraph and power circuits. Workmen should always use indiarubber gloves (Chap. IV, para. 49) when working on lines which cross power circuits, or which are so close to them that there is the slightest risk of contact occurring in the event of a wire breaking.

32. In running wires over or under aerial power circuits, the endless sash-line system should be adopted. A double line should be passed over, or under, the power circuits and strung fairly taut between the two telegraph supports, being passed round an insulator spindle at each side. The wire to be erected should be fastened to one side of the endless line, and drawn across with a sufficient strain upon it to prevent contact with the power circuit.

Running wires over power circuits.

Fallen wires. 33. In the event of a telegraph line falling and making contact with the overhead power line, or in the event of the power line or its guard wires falling, all traffic in the close vicinity should be stopped.

Notice should be given as early as possible to the nearest official of the power or tramway company, who should take steps to cut off the current, and to deal with any fallen power or guard wires.

If the fallen wire is in contact with any person and it is necessary to remove it at once in order to save life or prevent injury, the following points should be remembered :—

(*a*) Never touch the wire with bare hands or damp gloves.
(*b*) Never touch the person in contact with it, except as mentioned in (*c*).
(*c*) Use a *dry* stick, *dry* rope, *dry* paper, or article of *dry* clothing, or indiarubber gloves if available, to drag the wire away or to drag the person away from the wire. It is important that any article used for this purpose should be *dry*.
(*d*) If it is impossible to get the wire away from the person, the wire should be dragged to the nearest tramway rail, and held down to it, or otherwise "earthed" in the best method available. A considerable amount of flashing may be caused by this, but will not cause injury.

Persons rendered unconscious by electric shock should be treated in the same way as the apparently drowned.

CHAPTER VIII.

RECORDS.

1. Careful records of lines and instruments must be kept in all telegraph and telephone systems. The importance of such records being correct and up to date can hardly be over-rated.

The exact method of keeping these records, and the exact amount of information required, must vary according to circumstances. In all cases, however, the records should include a diagram of the circuits, and a plan showing the routes of the wires.

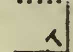
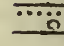
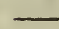
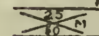
Pole diagrams, showing the position on the pole of the wires composing the various circuits, should be kept for the various sections of all aerial routes, and especially for junction and terminal poles.

2. There are no telegraph systems of any size normally controlled by the army in peace. It is, however, quite possible that such a system would have to be taken over as the result of military operations. In such cases there will seldom be time to prepare elaborate plans, and the circuits will be varying with great frequency. The records to be kept should be as complete as circumstances allow, and the method of keeping them will naturally be based on any records of existing lines, &c., that may be available. Telegraph systems.

3. Circuit diagrams should show all the lines working, with the instruments normally used, all existing wires that are spare, and all points at which the lines are led in for testing. Circuit diagrams.

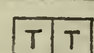
The conventional signs used to represent the various instruments are given below. These signs should invariably be adhered to as far as they are applicable. In all cases a key to the signs used should be inserted on the diagrams. The lines representing the wires should be joined up to the symbols representing the instruments in use.

TELEPHONE SETS.

Concentrator, or switch telephone, 5 line	
" " " 10 "	
Office set, connected to civil exchange, magneto call	
" " " battery call or central battery working ...	
Office set, with battery call	
" magneto call ... ... (*e.g.*, telephone sets, office or wall.)	
Phonopore (or similar)	
Portable, with magneto call ... ... (*e.g.*, telephone set, portable, A, B, or C.)	
Portable, with vibrating call ... ... (*e.g.*, telephone set, portable, D.)	
Switch, telephone, intermediate (or similar)	
Switchboard, telephone exchange, metallic	
" " " single wire	

Note.—Switchboards should be marked "S" or "M," according as they are suitable for single or metallic circuits.

The number of indicators fitted and the ultimate capacity of the board should be shown by a fraction, thus $\frac{25}{50}$ means a board for 50 circuits, but which has only 25 indicators fitted.

Speaking tubes (when used in lieu of a telephone circuit) ...	
Several telephone offices in one building...	

TELEGRAPH INSTRUMENTS.

A.B.C. instruments... ... ...

Morse Recorders, Simplex ... ...

„ „ Duplex ... ...

Single Needle ... ...

Sounder, Simplex ... ...

„ Duplex ... ...

„ Quadruplex ... ...

Vibrator ... ...

„ with separator ... ...

Wheatstone, Simplex ... ...

„ Duplex ... ...

Translating stations should be shown by two sets of the apparatus used, connected together by a X

e.g., Sounder, Simplex, translating station ... ...

Wheatstone, Duplex, „ „ ... ...

or ... ...

MISCELLANEOUS APPARATUS.

Bells, electric battery .. ..

„ „ magneto ... ...

Bell push, electric ... ...

Box connecting buried cable ... ...
(For rifle ranges, &c., or similar)

Box plug, single ... ...

„ „ with portable telephone ... ...

„ double ... ...

„ „ with portable telephone ... ...

Generators, magneto ... ...

Position finder ... ...

Relay, magneto, for local bell or gong ... ...

	Trans-mitting.	Receiv-ing.
Dials, electric, range and training (P.F.)		
„ mechanical and electrical (D.R.F.)		
„ order...		
Water level indicator		

It is also often convenient to distinguish between the different classes of wires, or their use, by means of differently coloured lines or by broken lines. In diagrams of field systems the following conventions should be adhered to :—

Permanent wires—continuous lines.
Field air line—chain dotted.
Field cable—plain dotted.

In such cases the use of the lines will usually be sufficiently indicated by the symbols for the apparatus used.

Telegraph circuits should be known by the call signals of the terminal offices they connect, and should be labelled accordingly on all test boxes and diagrams. Where there is more than one circuit between two offices, each circuit should be given a number as well.

Records of Permanent Military Telephone and Command Systems.

4. The permanent military systems in fortresses, garrisons, &c., are all on more or less similar lines, and the records should all be kept in the same way. Certain records of these systems are required annually by the War Office, these records consist of :—

(*a*) Route Plans.
(*b*) Circuit Diagrams.
(*c*) Returns of Lines.
(*d*) Returns of Offices and Instruments.

These records should be prepared in conformity with the following instructions :—

Names of offices.

5. Names of offices or places at which apparatus is fixed, or lines terminated or led in, should be given on plan, diagram, and returns, *identically the same wording being used in each case*, and in correspondence relating thereto. Each separate room in which apparatus is fixed constitutes an office, and the name shown on plans, &c., should be that under which it appears in the Construction Returns. When any room or building is allotted on mobilisation a special title, such as "Section Commander's Post," this name should be given in the documents as well as its normal appropriation in the Construction Returns.

Junctions.

6. Points or junctions (*a*) at which the number of conductors is varied, or (*b*) at which the condition of circuits is changed, *i.e.*, from aerial to buried or submarine, from cable to separate wires, &c., or (*c*) where the maintenance of the wires alters, should be indicated by a distinguishing letter in block capitals on route plan, diagram, and return of lines. Where a certain number of wires branch off from a main route at, say junction H, the sub-junctions on this branch may be lettered H_1, H_2, H_3, &c. When the alphabet is exhausted the lettering should be continued as AA, BB, &c.

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d.

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ns.

ROUTE PLAN.

Plate I.

3296 78064/765. 7500. 12 14

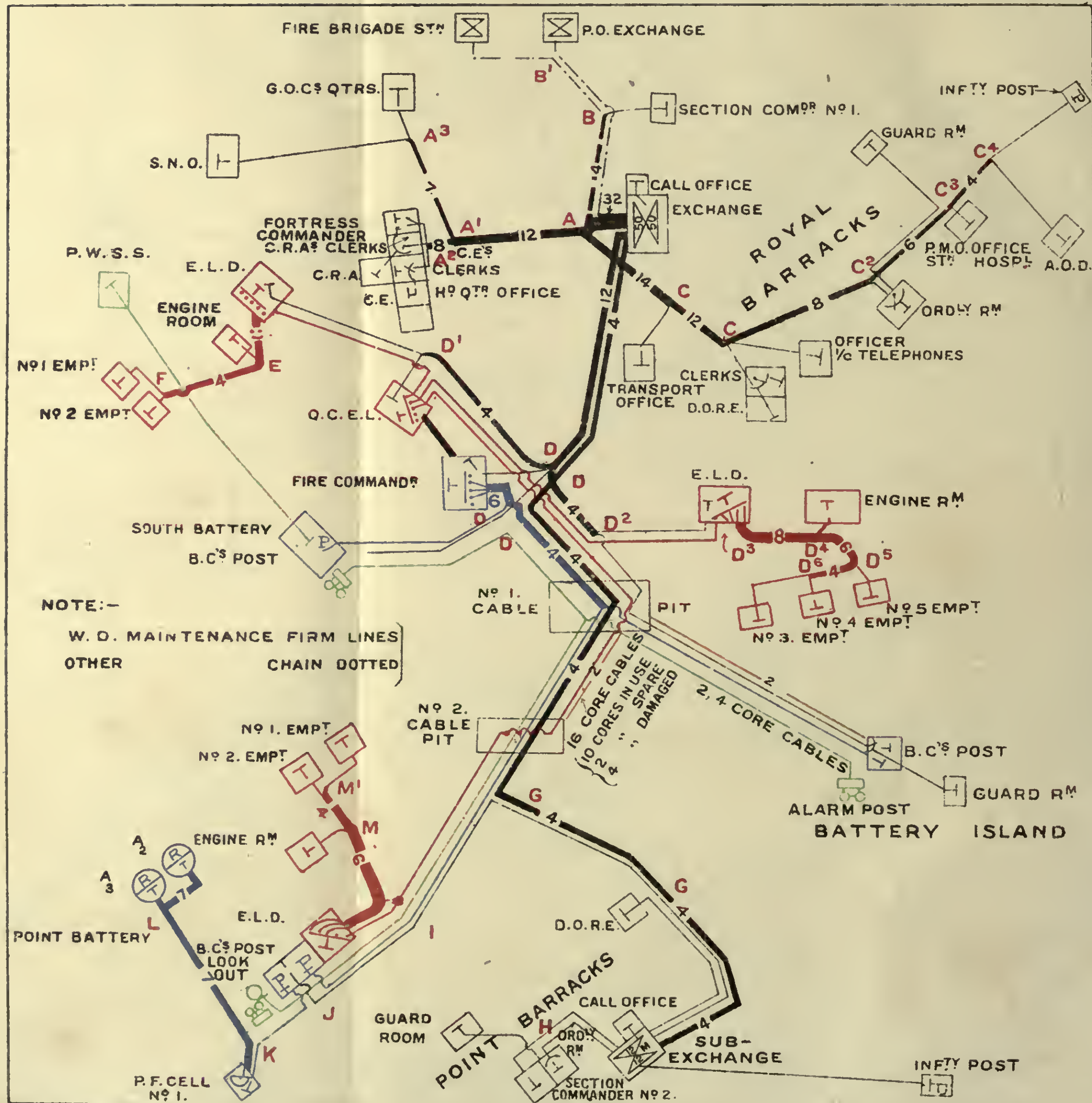
Malby & Sons, Lith.

Note:- *This plan is only prepared to illustrate the method of showing the circuit routes for Record purposes, and it should not be taken as showing what circuits are required. Plans should as a rule be prepared on a larger scale than above.*

To face page 159.

DIAGRAM.

Plate II.



3296. 28064/265. 7500. 12. 14.

Malby & Sons, Lith.

Note:— *This Diagram is only to illustrate the method of showing the circuits for Record purposes, and it should not be taken as showing what circuits are required.*

To face page 159.

7. The records should show all existing lines. When any lines are not in use they should be shown as spare, and, if faulty and not worth repair or recovery, a note to that effect should be made. All lines to be shown.

8. Approved lines, not yet constructed, should be shown on the diagram by broken lines, and similarly on the route plan if the lines go over a route not before followed; they should not be entered in the return of lines until the construction work has been commenced. Approved lines not yet constructed.

9. Lines connecting offices to Civil Exchanges need not be shown except where the lines are maintained by the War Department, but the instruments must be shown on the diagrams and included in the returns of instruments, and the offices should be marked on the route plans. Junction lines between the Civil and Military Exchanges should be shown on the diagram. The position of the Civil Exchange should be shown on the route plan. Lines to Civil Exchanges.

10. The route plan should be prepared when possible on a local map or chart, on a convenient scale, sufficiently large to admit of its being read with ease without being inconveniently bulky. It should show the precise route of the different lines, and the exact positions of the various offices, junctions, test boxes, &c., including all places at which apparatus is fixed, or intended to be fixed for use, should be shown. Where the scale of the general plan is too small on account of the concentration of offices in certain parts, plans of these parts, drawn to a larger scale, should be attached. Route plans.

Routes will be indicated by single lines, no matter how many wires there may be. Underground and submarine lines should be coloured blue, and aerial red. Offices should be shown by black or red rings, and the name of each clearly written against it.

A typical route plan is given in Plate I.

11. The circuit diagram is intended to show clearly how the different offices are connected together, and what apparatus is fixed at each, and also by whom the different lines are maintained. Circuit diagrams.

A typical diagram is given in Plate II.

In order that the different circuits may be readily traced, and the various classes of lines distinguished from each other and from spare wires, certain conventional colours will be applied to the diagrams sent to the War Office. These colours are as follows:—

Exchange circuits, and direct connections for purely administrative purposes	Black.
R.A. command lines	Blue.
R.E. ,, ,, ...	Red.
Alarm, and other special direct circuits for command purposes	Green.
Spare wires	Brown.

When colouring lines, especially on sun prints, care must be taken to use distinctive colours. Sun prints of diagrams for local use need not be coloured unless desired.

Maintenance of lines.

12. The maintenance of the lines should be shown by their character; where the bulk of the lines are maintained by the W.D. these will be shown in firm lines, while lines maintained by other authorities will be shown chain dotted. Where the bulk of the lines are maintained by the G.P.O. or other civil authority, these will be shown by firm lines. A key to the types of lines used should be given on the diagrams.

Offices.

13. Offices and test boxes (as described in Chap. VII, paras. 14 to 24) will be shown on the diagram by rectangles, and where there are two or more offices in a single building they will be shown by separate but contiguous rectangles.

Apparatus.

14. Apparatus will be represented by the correct symbols (para. 3) drawn within the rectangles, and the circuits will be shown joined up to the apparatus to which they are connected. The symbols will be coloured similarly to the lines to which they are connected.

Arrangement of diagram.

15. The diagram should follow the general routes of the lines, each work or barrack should be shown distinct. Care should be taken in the arrangement of the diagram to avoid circuits crossing each other unnecessarily. The route plan should be taken as a guide upon which to build up the diagram, and care must be taken to locate the various junctions so that no difficulty will be experienced in comparing them with the route plans and the return of lines. It is, however, useless to make any attempt to keep the diagram to scale, as this will lead to either cramping the circuits in some places, or to producing a diagram of unwieldy size, which is difficult to follow. Where necessary, the diagram may be on several sheets, but in this case care must be taken to ensure that the circuits can be easily traced from one sheet to the next.

"Bunching" circuit.

16. When more than two wires are used to work any instrument, *e.g.*, P.F. circuits, and these wires all run along the same route without any branching off between offices, they should be shown on the diagram by a single *thick* line of appropriate colour, and the number of wires should be indicated by a figure written across it at intervals.

Where a number of circuits emanate from one piece of apparatus such as an exchange switch board, or concentrator, they should be "bunched" and shown by one thick line as long as they follow the same route; the number of wires should be indicated by a figure as above. Any branch leaving such a "bunch" should be shown leaving it with a slight curve, so as to indicate which way the wires run after they have joined the bunch. No circuit having once left such a bunch is to be shown as again entering it, and if the circuit rejoins the same route later, it must be shown by a separate line.

Junction lines between two exchanges should not be shown "bunched" with other lines.

Main routes where many lines are shown bunched should be shown with very bold lines, and where fewer lines are bunched the lines should be thinner, but all lines representing more than two wires should be drawn decidedly thicker than those representing one or two wires only.

In all other cases wires in use should be shown by a single fine line for each metallic circuit, and a single fine line with "S" across it at intervals for each earthed circuit.

17. Spare wires will always be shown by a single brown line, the number being written across it at intervals. Spare wires.

18. Where submarine cables exist, a note should be made of the number of separate cables, and the number of cores in each. If any cores are unserviceable this should be stated. Submarine cables.

19. Where blue sun prints are used for reproducing the diagrams, the lines, &c., normally shown black, should be left white, but the other lines coloured over. Blue prints.

20. Speaking tubes should be shown on the diagrams where they exist for command purposes. Speaking tubes.

21. The return of lines should be on Army Form K 1297. Each separate route should be shown with its branches by a series of consecutive entries, commencing from the principal office, and working outwards. Each entry should embrace all the wires contained in the section referred to, a section being the length of line between one office and an adjacent junction, or test box, or between two adjacent junctions or offices. The sections should be numbered consecutively on the return to facilitate reference. Return of lines.

22. The return of offices and apparatus should be on Army Form K 1299. The names of the offices should be entered in the same order as they appear in the return of lines, and have identically the same wording as appears on the route plan and diagram. Return of offices and apparatus.

The whole of the apparatus fixed in any office must appear in one place.

Apparatus provided and maintained by the Royal Garrison Artillery should be shown in the return in red ink.

Apparatus fixed in military offices, or in other places where the W.D. is responsible for the use or care of them, but provided and maintained by a civil authority, must be included in the return. All apparatus the property of the W.D. and on R.E. charge must be included in the return wherever fixed. The return should show by whom the apparatus is maintained in each case.

Other Records.

23. In addition to the above-mentioned records a special route plan of all cable routes should be kept to show the exact position of all cables, pipe lines, junctions, joint boxes, &c., Cable route plans.

and should enable any point to be located on the ground without unnecessary digging, or the provision of special marks on walls, &c., to indicate the position of the joints or cables.

Inside batteries, &c., where the position of the cables is marked on the ground (*see* Chap. VI, para. 32), this plan need not be so accurately kept.

A convenient method, to avoid a map of unwieldy size, is to have the route plan on a not very large scale, say 6 inches to the mile, and to insert carefully dimensioned sketches of all ruling points, with a reference to the point on the map to which they refer.

Cable records. 24. Records of all cables received at the station and tests made of such cables must be kept in Army Book 18, in accordance with the instructions contained therein.

Test records. 25. All circuits, except exchange circuits, should be carefully tested for conductivity and insulation resistance at least twice a year, and the tests recorded in a book kept for the purpose.

Rough insulation and conductivity tests of exchange circuits should be made from the switchboard or exchange test board daily, in the manner described in Chap. XIX, paras. 27—29, Vol. I, and as accurately as the arrangements at the exchange permit of rapid tests being made. Accurate tests should also be made at fixed intervals, and always after any work has been done on the lines.

The results of all tests should be systematically recorded, and if the condition of any line appears to be deteriorating, this should be attended to at once. This will ensure the removal of many faults before they develop sufficiently to interrupt the working.

Command telephone lines should be tested by speaking on them at least once a week, if more accurate tests are not feasible, and a record of such tests kept on a card at the points concerned, showing date of test, result of test, and the name of the individual who made the test.

CHAPTER IX.

MISCELLANEOUS.

Storing and Testing Material.

1. Telegraph material in store should be carefully examined from time to time by an officer or properly qualified non-commissioned officer, and all material issued from store should be carefully examined before being sent out.

2. All bare wire issued from Woolwich may be taken as complying with the specification, and a visual inspection to judge of its general condition will be sufficient. It will as a rule be impracticable to test bare wire electrically. Any kinks or unsoldered joints should be cut out and proper soldered joints made. If the wire has been used before, and the coils are untidy, they should be uncoiled, stretched, and recoiled. Rusty wire should be rejected. **Bare wire.**

Coils of copper or bronze wire should be stored wrapped in sacking, as issued, and should not be kept in contact with the ground, or another metal.

3. Cable and covered wire is liable to deterioration, which may not be evident on visual inspection ; the conductor may even be broken without any external evidence. They should, therefore, be tested for continuity and insulation before issue. **Cable and covered wires.**

To localise a fault in the insulation, one end of the cable should be connected through a sensitive galvanometer to the negative pole of a battery, the other pole of the battery being connected to a metal plate in a vessel of water, the far end of the cable should be disconnected, and both ends kept dry. If the cable be then passed through the water, a deflection will be obtained on the galvanometer when the fault is under water.

Field cable must be carefully run through and examined after use, and all temporary joints properly made and insulated, as described in Chap. I.

4. Poles must be examined by eye as to general condition. Field air-line poles should be rejected if they are cracked or if the insulator holes are enlarged. Doubtful holes should be gauged with an insulator bolt. **Poles.**

5. Old arms recovered during alterations or renewals should not be re-issued until they have undergone the following tests :— **Wood arms.**

(*a*) They should be carefully examined to detect any appearance of rot, splits, or serious shakes.

(*b*) They should be supported near the ends upon two other arms, and their soundness tested by striking them with an 8-lb. sledge hammer.

Those found satisfactory should be repainted before issue, and the others rejected.

Insulators.

6. Broken insulators should be rejected, though in dry climates slightly broken ones may be used on short lines. Insulators need not be tested electrically.

All insulators should be carefully cleaned before use; dust, straw, and dirt adhere to them, and, if not removed, the insulation of the line is much impaired. The following method is a good one for cleaning porcelain insulator cups:—The insulators should be steeped in a bucket of hot water in which $3\frac{1}{2}$ lbs. of soda has been placed. After immersion for some time they should be taken out of the bucket and rubbed inside and out with a diluted solution of hydrochloric acid (one of acid to four of water), applied by means of a woollen or worsted mop. The insulators should then be rinsed in a bucket of cold water, and any dirt should be rubbed off with waste. A bent wire should be used for holding the insulators whilst the acid is applied.

Other line stores.

7. Stay rods, iron arms, bolts, &c., shonld be examined by eye, special attention being paid to the fit of nuts, and to the absence of rust, and cleanliness of screw threads.

Batteries.

8. Daniell, bichromate, and open-type Leclanché cells are not issued or stored ready made up. They should be examined visually for defects, and any received into store from use should be washed out and dried. The points to be looked for are given in Vol. I, Chap. II. Cracked porous pots, crumbling agglomerate blocks, bad carbon rods, worn out zincs, &c., should be rejected.

Sealed Leclanché cells should be tested and, if necessary, refreshed, or dismantled and again made up. Each cell should be tested separately.

Dry cells should always be tested before taking over or issue, and at intervals when in store. Dry cells whose E.M.F. has fallen to 1 volt should be rejected.

Testing and Storing Apparatus.

9. All apparatus should be examined mechanically and electrically when received into store before re-issue.

Mechanical examination.

10. The mechanical examination should ascertain that:—

(i) The apparatus is complete.
(ii) The adjustments are correct.
(iii) There is no apparent friction between moving parts.
(iv) The springs are in proper condition.
(v) The screws fit well and run smoothly, and that any subject to vibration, or to any force tending to shift them, are secured by the proper lock nuts or set screws. The screws in all service pattern instruments are specified to be B.A. standard threads, even numbers only.

(vi) The moving parts are properly oiled at the points of friction.

(vii) Contact points, studs, &c., are clean and in proper condition.

11. The electrical examination should ascertain that:— **Electrical examination.**

(i) There is continuity in every lead and connection, and that there is no appreciable resistance whatever in the electrical circuit, except that of the coils, which should be correct.

(ii) The insulation of parts not electrically connected is correct. The insulation resistance should be at least one megohm.

(iii) The electrical connections and joints are well and securely made. When screws are used for making the connections, there should be no lacquer on the surfaces on which contact depends.

(iv) The instruments work with the proper currents.

(v) The direction of the deflection of galvanometers is correct.

12. The correct resistance, sensitiveness, &c., of the various instruments are given where the instrnments are described. **Resistance of instruments.**

In measuring resistances in cases where accuracy is of importance, it may be taken that the resistance increases with the temperature for each degree Fahrenheit, as follows:—

Copper	·238 per cent.
German silver	·015 ,,
Platinum silver	·017 ,,
Platinoid	·017 ,,

If the resistance of a coil tests low, it probably means that the insulation is impaired, and if it tests high it probably means a partial disconnection.

13. Instruments mounted in sets on baseboards should be tested separately, as well as in the complete set, and the connections between them verified. **Baseboards.**

14. Instruments tested and ready for issue should be stored separately from those waiting test or repair. **Storing.**

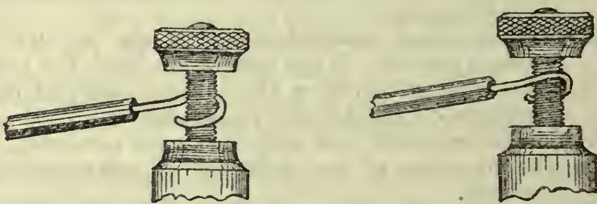
It is a good plan to wrap all instruments that are ready for issue in brown paper, to keep them from dust, &c., and to mark on the paper the date of the examination, and the initials of the examiner.

Connecting up Instruments, &c.

15. In connecting up instruments, &c., there are a few points that should be remembered, if the work is to be satisfactory.

If the connecting wires are taken through holes in backboards or baseboards, &c., before connecting to a terminal, care should be taken that the insulation is not damaged. The rubber insulation should be intact almost up to the terminal itself, and the conductor should be bared for such distance only as is necessary to connect it to the terminal. The braiding or tape used to protect the rubber should be removed for a short distance further than the rubber itself is removed. The end of the braiding should be bound with waxed thread to prevent unravelling.

In connecting a wire to a terminal, it should be bent round the terminal in the form of a hook or loop, and placed round the shank of the terminal in such a manner that tightening the latter will tend to draw in the wire to the shank and not to loosen it (*see* Fig. 1).



Correct. Incorrect.

Fig. 1.—Method of Connecting a Wire to a Terminal.

Care should be taken that the wire and terminal are both clean and bright where the contact is made, and that no portion of the insulation is gripped in the terminal. It should be noted that tin is less liable to make bad contact owing to oxidation, &c., than copper, it is a good plan, therefore, to see that the wire (and even the terminal) is well tinned at the points of contact.

When stranded conductors are used, care should be taken that the strands are well twisted together before being placed round the terminal, and that no loose strands are sticking out to cause contacts with other conductors or terminals. In permanent work it is desirable to sweat the strands together at the end before placing round the terminal, or to form an eye at the end of the conductor, to fit round the shank of the terminal.

When leading a wire to a terminal, it is generally desirable to leave a little slack, and this may conveniently be formed into a neat coil. Such coils should, however, not be formed in wire forming part of the earth connections of lightning dischargers.

Identification of Wires.

16. It is frequently necessary to identify wires in a cable, &c., such as those leading from an office to a terminal pole, &c. If the ends of the wires are available this is easily done with a battery and detector. One wire is used as a return, this wire may be any one in the cable, or an earth connection, or the lead sheathing or armouring may be used

instead. A detector is joined in series with this wire at each end, and a two-cell battery is included at one end. The lead from the battery is then connected to the wire it is desired to label No. 1, and the lead from the detector at the other end is tapped round all the wires in turn till a deflection is obtained. The man at this end then makes three beats on the detectors by breaking and making the connection three times, and then holds the wire on till the man at the other end has replied by making three beats. Both then label the wire No. 1, and the process is repeated with No. 2, and so on till all the wires have been identified and numbered.

A convenient way of labelling the cores of cables is to stamp the number of the core on a short piece of lead tubing, and slip this over the end of the core before it is jointed or terminated.

17. If the ends of the cores are not available, and it is not desirable to cut the cable, the cores can be identified by means of a "wire finder," this is constructed as follows. A piece of sheet iron about 3 inches by 3 inches by $\frac{5}{16}$ inch is bent so as nearly to form a cylinder, leaving a gap about $\frac{5}{8}$ inch wide between the adjacent edges. Strips of ordinary "tin plate" may be used instead of sheet iron. Round this are wound a few hundred turns of fine insulated wire, the turns being parallel to the axis; 900 turns of No. 38 S.W.G. ("Wire, electric, W 14") have given good results. The turns of wire are protected by a binding of primed tape. The finder is used as explained below. **Wire finder.**

At the end of the cable send a "call" from either (*a*) a "Telephone Set, portable, D," or (*b*) a "Vibrator, telegraph," or (*c*) a chattering bell, battery, and push, to earth and any one wire, say No. 1, and earth all wires at the other end of the cable. At the point where the wires are to be identified connect a telephone receiver to the ends of the wire-finder coil. Then, while listening in the receiver, slip the wire finder over the cores or wires, one at a time. As soon as the right one has been selected a buzz will be heard in the receiver.

For rapid work, using this method, a telephone set should be joined up on one of the wires, so that the man with the wire finder, having identified a wire, can call up the other man and ascertain its number.

If a telephone is not available a convenient method for using the wire finder is for the operator at the end of the cable to tap each wire in turn, using the Morse code signal for the number of the wire he is tapping, preceded by an extra long contact on that wire; the assistant using the finder leaves it on any wire till he has received a signal on it, and then labels the wire accordingly.

APPENDIX I.

LIST OF SERVICE PATTERN CABLES AND WIRES USED FOR TELEGRAPH AND TELEPHONE PURPOSES.

Nomenclature. Designation. 1.	Nomenclature. Detail. 2.	General Description. 3.	External Diameter in inches. 4.	Weight. 5.	Breaking Weight, lbs. 6.	Number of Strands per Conductor, and S.W.G. 7.	Conductivity Resistance at 60° F. per Conductor (Ohms). 8.	Insulation Resistance at 60° F. (Megohms). 9.	Maximum Length supplied. 10.	Approximate Weight of Full Drum. 11.
Cables, electric—	For telegraphs, telephones, and position finding; also power up to 6 amperes; lead-covered; for drawing into pipes.			lbs. per 1,000 yards.			per 1,000 yards.	per 1,000 yards.	yards.	cwts.
A 1, Mark I ...	*Single*	*Tinned copper, vulcanized rubber, primed tape, coated ozokerite, lead tube*	·363	844	...	3/20	8·27	12,900	110	coil
A 1, Mark II ...	"	Tinned copper, vulcanized rubber, primed tape, coated ozokerite, lead tube	·228	360	...	7/23	7·95	8,800	1,324	7
A 2, Mark I ...	*2-core*	*Tinned copper, vulcanized rubber, primed tape, coated ozokerite, 2 cores twisted, filled tanned jute, prepared tape, lead tube*	·628	1,780	...	3/20	8·27	12,900	60	coil
A 2, Mark II ...	"	*Tinned copper, vulcanized rubber, primed tape, coated ozokerite, 2 cores twisted, filled tanned jute, prepared tape, lead tube*	·5	1,254	...	3/20	8·27	9,000	45	coil

A 2, Mark III	2 ,, ...	Tinned copper, vulcanized rubber, primed tape, coated ozokerite, 2 cores twisted, filled tanned jute, prepared tape, lead tube	·444	1,050	...	7/23	7·95	8,800	1,324	16
A 4, Mark I ...	4 ,, ...	Tinned copper, vulcanized rubber, primed tape, coated ozokerite, 4 cores twisted round centre core of tanned jute, filled tanned jute, prepared tape, lead tube	·536	1,250	...	7/23	7·95	8,800	884	14
A 10	10 ,, ...	Tinned copper, vulcanized rubber, red and black primed tape, coated ozokerite, 2 cores twisted, filled tanned jute, 4 pairs laid up round centre pair, filled tanned jute, prepared tape, lead tube	1·124	3,000	...	7/23	7·95	8,800	...	...
A 20	20 ,, ...	Tinned copper, vulcanized rubber, red and black primed tape, coated ozokerite, 2 cores twisted, 2 pairs laid up together, filled tanned jute, 8 pairs laid up round 2 pairs, filled tanned jute, prepared tape, lead tube	1·15	4,000	...	7/23	7·95	8,800	...	...
Cables, electric—	FOR TELEGRAPHS, TELEPHONES, AND POSITION FINDING; ALSO POWER UP TO 6 AMPERES; LEAD-COVERED AND ARMOURED; FOR LAYING DIRECT IN THE GROUND.									
B 2, Mark I ..	*2-core*	*Tinned copper, vulcanized rubber, primed tape, coated ozokerite, 2 cores twisted, filled tanned jute, prepared tape, lead tube, served jute, armoured 26/13 iron wire, compounded, tarred jute, coated preservative compound*	1·06	4,300	8,400	3/20	8·27	11,750	1,324	55
B 2, Mark II ...	2 ,, ...	A2, Mark III, served tanned jute, armoured galvanized iron wire, compounded, served jute, coated preservative compound	·90	*2,300	*11,850	7/23	7·95	8,800	1,324	35

* Figures are approximate.

Nomenclature. Designation. 1.	Nomenclature. Detail. 2.	General Description. 3.	External Diameter in inches. 4.	Weight. 5.	Breaking Weight, lbs. 6.	Number of Strands, per Conductor, and S.W.G. 7.	Conductivity Resistance at 60° F., per Conductor (Ohms). 8.	Insulation Resistance at 60° F. (Megohms). 9.	Maximum Length supplied. 10.	Approximate Weight of Full Drum. 11.
Cables, electric—*continued.*	For telegraphs, telephones, and position finding; also power up to 6 amperes; lead-covered and armoured; for laying direct in the ground.			lbs. per 1,000 yards.			per 1,000 yards.	per 1,000 yards.	yards.	cwts.
B 4, Mark I ...	*4-core*	*Tinned copper, vulcanized rubber, primed tape, coated ozokerite, lead tube, 4 cores twisted round jute filled and served jute, armoured 35/13 iron wire, compounded, tarred jute, coated preservative compound*	1·353	7,000	12,320	3/20	8·27	11,750	884	60
B 4, Mark II ...	4 ,, ...	A 4, Mark I, served tanned jute, armoured galvanized iron wire, compounded, jute, coated preservative compound	1·02	3,200	9,000	7/23	7·95	8,800	884	36
B 7	7 ,, ...	*Tinned copper, vulcanized rubber, primed tape, coated ozokerite, lead tube, 7 cores twisted together, filled and served jute, armoured 36/11 iron wire, compounded, tarred jute, coated preservative compound*	1·67	11,300	19,600	3/20	8·27	12,900	444	53

B 9, Mark I ...	9 ,, ...	*Tinned copper, vulcanized rubber, primed tape, coated ozokerite, lead tube, 7 single cores twisted round 1 double core, filled and served jute, armoured 39/11 iron wire, compounded, tarred jute, coated preservative compound.*	1·81	13,360	21,450	3/20	8·27	12,900	444	62
B 9, Mark II ...	9 ,, ...	4 A 2, Mark III, twisted round 1 A 1, Mark II, filled and twice served jute, armoured 39/11 iron wire, compounded, tarred jute, coated preservative compound	1·85	10,700	*21,450	3/20	8·27	8,800	444	51
B 10	10 ,, ...	A10, Mark I, served tanned jute, armoured galvanized iron wire, compounded, served jute, coated preservative compound	1·66	7,100	19,800	7/23	7·95	8,800	...	...
B 20	20 ,, ...	A20, Mark I, served tanned jute, armoured galvanized iron wire, compounded, served jute, coated preservative compound	1·70	8,200	20,350	7/23	7·95	8,800	...	...
Cables, electric—	FOR TELEGRAPHS, TELEPHONES, AND POSITION FINDING; MISCELLANEOUS.									
C 1	Single core, river crossings	Tinned copper, vulcanized rubber, primed tape, armoured 18/20 galvanized steel wire, braided jute, coated ozokerite	·35	334	3,000	3/22	13·67	1,500	1,000	3¾
C 4	4-core, interruption cable	Tinned copper, vulcanized rubber, primed tape, braided cotton, 4 cores laid up round 7 steel wires	·7	567	700	7/24	9·47	1,500	444	4
C 16	16 ,, aerial use ...	Tinned copper, vulcanized rubber, red or black primed tape, 4 cores twisted round jute, filled jute worming, prepared tape, 4 quads twisted, filled jute, prepared tape, braided hemp, coated ozokerite	1·1	1,600	...	3/22	13·67	1,500	1,000	17

* Figures are approximate.

Nomenclature. Designation. 1.	Detail. 2.	General Description. 3.	External Diameter in inches. 4.	Weight. 5.	Breaking Weight, lbs. 6.	Number of Strands, per Conductor, and S.W.G. 7.	Conductivity Resistance at 60° F., per Conductor (Ohms). 8.	Insulation Resistance at 60° F. (Megohms). 9.	Maximum Length supplied. 10.	Approximate Weight of Full Drum. 11.
Cables, electric—*continued.*	For telegraphs, telephones, and position finding; miscellaneous.			lbs. per 1,000 yards.			per 1,000 yards.	per 1,000 yards.	yards.	cwts.
C 20	20-core internal use ...	Tinned copper, vulcanized rubber, red and black primed tape, 2 cores twisted together, 3 pairs twisted together, 7 twisted pairs laid up outside, prepared tape, braided hemp, coated ozokerite	1·1	*1,850	...	3/22	13·67	1,500	1,000	23
C 21	20 ,, lead-covered ...	Tinned copper, vulcanized rubber, red and black primed tape, 2 cores twisted together, 2 pairs twisted together, 8 twisted pairs laid up outside, prepared tape, lead tube	1·1	4,500	...	3/22	13·67	1,500	444	23
C 6	6 cores, *i.e.*, 4 cores, currents up to 20 ampères, 2 cores for telephones	Tinned copper, layer cotton threads, vulcanized rubber, primed tape, 2 cores twisted, filled tanned jute, 4 cores laid up round centre pair, filled tanned jute, prepared tape, double braided, ozokerite compound	1·0	1,200	...	4 cores 61/28 2 cores 7/28	2·34 20·53	5,000 7,000	... ...	... ...

Cables with the same conductors as the "A" & "B" classes but paper insulated instead of rubber insulated are also in use in the service.

* Figures are approximate.

Nomenclature. Designation. 1.	Nomenclature. Detail. 2.	General Description. 3.	External Diameter in inches. 4.	Weight. 5.	Breaking Weight, lbs. 6.	Number of Strands per Conductor, and S.W.G. 7.	Conductivity Resistance at 60° F. per Conductor (Ohms). 8.	Specified Insulation Resistance at 60° F. (Megohms). 9.	Normal Length supplied in Coil or on Drum. 10.	Weight of Coil or Full Drum. 11.
Cables, electric—	FIELD TELEGRAPHS AND TELEPHONES.			lbs. per mile.			per mile.	per mile.	miles.	lbs.
D 1	Single, 22·5 lb. per mile	Tinned steel, insulating paper, impregnated ozokerite, cotton tape, braided black cotton, coated ozokerite	·09	22·5	140	7/34	~~1·065~~ 1065	...	½	coil. 11¼
D 3	Single, 40 lb. per mile	Tinned steel, insulating paper, vulcanized rubber, braided red, coated ozokerite	·1	40	240	12/33	500	...	1	40
D 5, Mark II	Single, 80 lb. per mile	*19 tinned steel, vulcanized rubber, braided hemp, coated ozokerite compound*	·137	80	550	19/30	200	...	2	drum. 200
D 5, Mark III	Single, 80 lb. per mile	*5 tinned copper, 14 galvanized steel, vulcanized rubber, braided flax, dyed red, coated ozokerite compound*	·137	80	350	19/30	63	620	2	200
D 5, Mark IV	Single, 80 lb. per mile	5 tinned copper, 14 steel galvanized, vulcanized rubber, braided hemp, coated ozokerite	·145	84	390	19/30	63	·006*	2	220

* An insulation of 1,000 megohms is often obtained on test.

Nomenclature.		General Description.
Designation.	Detail.	
1.	2.	3.
Cables, electric—	For telegraphs, telephones, and position finding; submarine.	
G 3	*3-core ... ...*	*Tinned copper, vulcanized rubber, primed tape, 3 cores twisted, filled tanned jute, primed tape, armoured 30/16 iron wire, braided hemp, coated ozokerite compound*
G 4, Mark I... ...	*4 ,, ...*	*Tinned copper, vulcanized rubber, primed tape, 4 cores twisted, filled tanned jute, primed tape, armoured 16/12 iron wire, braided hemp, coated ozokerite compound*
G 4, Mark II ...	*4 ,, ...*	*Tinned copper, vulcanized rubber, primed tape, 4 coloured cores twisted, filled tanned jute, primed tape, armoured 16/12 iron wire, two servings jute, coated preservative compound*
G 4, Mark III ...	*4 ,, ...*	*Same as G 4, Mark II, 1 red and 3 ordinary coloured cores*
G 4, Mark IV...	4 ,, ...	Tinned copper, vulcanized rubber primed tape, brass tape (if required), 4 cores twisted, filled jute, primed tape, armoured galvanized iron wire, two servings jute, coated preservative compound, extra armouring covered with 2 servings jute yarn for shore end if required
G 7, Mark I... ...	*7 ,, ...*	*Tinned copper, vulcanized rubber, primed tape, 7 cores twisted, filled tanned jute, primed tape, armoured 16/9 iron wire, two servings jute, coated preservative compound*
G 7, Mark II ...	*7 ,, ...*	*Same as G 7, Mark I, 7 coloured cores ... ...*
G 7, Mark III ...	*7 ,, ...*	*Same as G 7, Mark I, 1 red and 6 ordinary coloured cores*
G 9	9 ,, ...	Tinned copper, vulcanized rubber, primed tape, brass tape (if required), 1 core surrounded by 4 pairs, filled jute, primed tape, armoured galvanized iron wire, 2 servings jute, coated preservative compound, extra armouring covered with 2 servings jute yarn for shore end if required

External Diameter, in inches.	Weight.	Breaking Weight, lbs.	Number of Strands per Conductor, and S.W.G.	Conductivity Resistance at 60° F. per Conductor (Ohms).	Insulation Resistance at 60° F. (Megohms).	Remarks.
4.	5.	6.	7.	8.	9.	10.
	lbs. per 1,000 yards.			per 1,000 yards.	per 1,000 yards.	
·87	2,150	6,160	7/22	5·84	14,700	Submarine mining cable
1·1875	3,250	8,400	7/22	5·84	14,700	
1·1875	3,250	8,400	7/22	5·84	14,700	
1·1875	3,250	8,400	7/22	5·84	14,700	
1·1 1·75	3,000 without, 9,000 with extra armouring.	8,400 without, 42,000 with extra armouring.	3/20	8·27	9,000	In demanding, the total length required and lengths of shore armouring, must be stated.
1·375	5,170	15,000	7/22	5·84	14,700	Submarine mining cable
1·5	5,170	15,000	7/22	5·84	14,700	
1·5	5,170	15,000	7/22	5·84	14,700	
1·5 2·35	5,020 without, 17,100 with extra-armouring	*13,200 without, *56,000 with extra armouring	3/20	8·27	9,000	In demanding, the total length required and lengths of shore armouring, must be stated.

* Figures are approximate.

Nomenclature. Designation. 1.	Detail. 2.	General Description. 3.
Wires, electric—	For telegraphs, telephones, and power up to 10 amperes; internal use; covered; single-core	
S 1	Single-strand, currents to 4·2 amperes	Tinned copper, vulcanized rubber, primed tape, braided hemp compounded
S 3, Mark I ...	*Single-strand, currents up to 6·8 amperes*	*Tinned copper, vulcanized rubber, primed tape, braided cotton, coated ozokerite compound*
S 3, Mark II ...	Single-strand, currents up to 6·8 amperes	Same as S 1 ... ...
S 11, Mark I ...	*Three-strand, currents up to 4·2 amperes*	*Tinned copper, vulcanized rubber, primed tape, coated ozokerite*
S 11, Mark II ...	*Three-strand, currents up to 4·2 amperes*	*Tinned copper, vulcanized rubber, braided red and white cotton, saturated paraffin wax*
S 11, Mark III	Three-strand, currents up to 4·2 amperes	Same as S 1 ... ...
S 13...	Three-strand, currents up to 6·4 amperes	Same as S 1 ... ...
S 15...	Three-strand, currents up to 10·3 amperes	Same as S 1 ... ...
Wires, electric—	For telegraphs, telephones, and bells; internal use; cotton-covered.	
T 3	Single, for bell circuits, and instructional purposes	Tinned copper, double cotton-covered, paraffin wax
T 5	Single, for bell circuits, rubber-covered	Tinned copper, pure rubber, double cotton-covered, paraffin wax
T 11...	Twin, for bell circuits	Tinned copper, double cotton-covered, 2 cores, twisted. paraffin wax
T 13	Twin, for bell circuits, and telephones, rubber-covered	Tinned copper, pure rubber, double cotton-covered, 2 cores, twisted, paraffin wax *Note.*—Normal colour of cotton, green. Others can be supplied if specially demanded

External Diameter, in inches. 4.	Weight. 5.	Number of Strands per Conductor, and S.W.G. 6.	Conductivity Resistance at 60° F. per Conductor (Ohms). 7.	Insulation Resistance at 60° F. (Megohms). 8.	Remarks. 9.
	lbs. per 1,000 yards.		per 1,000 yards.	per 1,000 yards.	
·180	66	1/18	13·68	8,800	
·204	85	1/16	7·7	528	Not normally used for telegraph or telephone purposes.
·215	85	1/16	7·7	8,800	
·175	71	3/22	13·67	2,000	
·19	60	3/22	13·67	2,000	
·210	74	3/22	13·67	8,800	
·230	95	3/20	8·27	8,800	Ditto ditto
·260	135	3/18	4·65	8,800	
·080	16	1/22	39·82	...	Not for permanent telegraph or telephone purposes.
·090	20	1/20	24·09	...	For internal wiring of exchange boards, &c.
·160	32	1/22	39·82	...	Not for permanent telegraph or telephone purposes.
·180	40	1/20	24·09	...	For use on cross connecting frames, exchanges, &c.

Nomenclature. Designation. 1.	Nomenclature. Detail. 2.	General Description. 3.	External Diameter in inches. 4.	Weight. 5.	Number of Strands per Conductor, and S.W.G. 6.	Conductivity Resistance at 60° F. per Conductor (Ohms). 7.	Remarks. 8.
Wires, electric—	For instruments; silk-covered.			lbs. per 1,000 yards.		per 1,000 yards.	
W 22	Single silk-covered	Copper ...	·030	6·977	1/22	39·82	
W 24	,, ,,	,, ...	·0235	4·307	1/24	64·51	
W 26	,, ,,	,, ...	·0195	2·883	1/26	96·36	
W 27	,, ,,	,, ...	·0179	2·394	1/27	116·1	
W 28	,, ,,	,, ...	·0163	1·949	1/28	142·5	
W 30	,, ,,	,, ...	·0139	·68	1/30	203·1	
W 31	,, ,,	,, ...	·0131	1·198	1/31	232·0	
W 32	,, ,,	,, ...	·0123	1·038	1/32	267·7	
W 34	,, ,,	,, ...	·0107	·7533	1/34	368·9	
W 35	,, ,,	,, ...	·0099	·6280	1/35	442·5	
W 36	,, ,,	,, ...	·0091	·5140	1/36	540·5	
W 37	,, ,,	,, ...	·0083	·4115	1/37	675·2	
W 38	,, ,,	,, ...	·0075	·3204	1/38	867·3	
W 39	,, ,,	,, ...	·0067	·2406	1/39	1155·0	
W 40	,, ,,	,, ...	·0060	·2050	1/40	1355·0	
W 41	,, ,,	,, ...	·0056	·1723	1/41	1613·0	

W 42	,, ,,	,, ...	·0052	·1424	1/42	1951·0	
W 43	,, ,,	,, ...	·0048	·1153	1/43	2409·0	
W 44	,, ,,	,, ...	·0044	·0911	1/44	3409·0	
W W 18	Double ,,	,, ...	·051	20·50	1/18	13·55	
W W 26	,, ,,	,, ...	·0205	2·883	1/26	96·36	
W W 32	,, ,,	,, ...	·0133	1·038	1/32	267·7	
W W 33	,, ,,	,, ...	·0125	·8900	1/33	312·2	
W W 35	,, ,,	,, ...	·0109	·6280	1/35	442·5	
W W 38	,, ,,	,, ...	·0085	·3204	1/38	367·3	
Wires, electric—	FOR INSTRUMENTS; UNCOVERED.			grs. per yard.			
X 1	German silver ...	... ...	·0124	1·35	1/30	...	Instrument repairer's use.
X 3	,, ,, ...	... ...	·022	4·2	1/24	...	
X 5	,, ,, ...	... ...	·036	11·2	1/20	...	
X 31...	Platinum for contacts	... ...	·065	...	1/16	...	
X 41...	For resistances ...	... ...	State in demand	...	State in demand	State in demand	

Nomenclature.		External Diameter in inches.	Weight.	Breaking Weight, lbs.	Number of Strands per Conductor and S.W.G.	Conductivity, Resistance at 60° F. per Conductor (Ohms).	Remarks.
Designation.	Detail.						
1.	2.	3.	4.	5	6.	7.	8.
Wires, electric—	For aerial lines; uncovered.		lbs. per mile			per mile	
Z 3	Bronze, 40 lbs. per mile	·050	40	200	...	45·5	Supplied in coils.
Z 5	,, 70 ,, ,, ...	·066	70	345	...	27·0	
Z 7	,, *100* ,, ,, ...	·079	100	390	1/14	12·27	
Z 9	Silicium bronze, 3-strand, 100 lbs. per mile, field equipment	·045	100	150	3/18	12·00	Supplied on "Drums, wood, packing No. 2," 1 mile per drum, total weight, 127 lbs.
Z 17	Copper, 100 lbs. per mile	·08	100	330	1/14	8·78	Supplied in coils.
Z 21	Galvanized iron, 200 lbs. per mile ...	·121	200	640	1/10½	26·64	
Z 23	,, ,, 400 lbs. ,, ...	·171	400	1,260	1/7½	13·32	
Z 31	Steel, 3-strand, field equipment, stays and instructional purposes	·045	100	425	3/18	50·0	Supplied on "Drums, wood, packing No. 2," 1 mile per drum, total weight 127 lbs.
Wires, jointing and binding	Uncovered.						
AA 3	Copper, for binding Z 3	·05	40	68	1/18	...	
AA 5	,, ,, ,, Z 5	·056	50	85	1/17	...	
AA 11	Copper, tinned, for jointing cables	·0124	2·5	...	1/30	...	
AA 13	,, ,, ,, ,,	·018	5·0	...	1/26	...	
AA 17	,, ,, ,, Z 17 ...	·056	50	...	1/17	...	
AA 21	Galvanized iron, soft, for binding and jointing Z 21 and Z 23	·065	62	156	1/16	...	

Nomenclature.		Weight.	Breaking Weight, lbs.	Number of Strands per Conductor and S.W.G.
Designation.	Detail.			
1.	2.	3.	4.	5.
Wires, stay—	For Permanent telegraph and telephone lines; galvanized iron stranded.	lbs. per 1,000 yards.		
BB 1	7-strand, No. 14 S.W.G....	625	2,450	7/14
BB 3	3 ,, *No. 8*	*1,054*	*4,200*	*3/8*
BB 4...	4 ,, No. 8	1,400	5,600	4/8
BB 5	5 ,, *No. 8*	*1,750*	*7,000*	*5/8*
BB 7...	7 ,, No. 8	2,450	9,800	7/8

APPENDIX II.

BOARD OF TRADE REGULATIONS AS TO GUARD WIRES ON ELECTRIC TRAMWAYS.

Regulation.

If and whenever telegraph or telephone wires, unprotected with a permanent insulating covering, cross above, or are liable to fall upon, or to be blown on to, the overhead conductors of the tramways, efficient guard wires shall be erected and maintained at all such places.

EXPLANATORY MEMORANDUM.

NOTE.—The expression "telegraph wire" includes all telegraph and telephone wires.

For the purpose of this memorandum, telegraph wires are divided into two classes, namely:—

(*a*) Wires weighing less than 100 lbs. per mile (No. 14, S.W.G.).

(*b*) Wires weighing 100 lbs. per mile (No. 14, S.W.G.) or more.

Each guard wire should be well earthed at one point at least, and at intervals of not more than five spans. The resistance to earth should be sufficiently low to insure that a telegraph or telephone wire falling on and making contact with the guard wire and the trolley wire at any time will cause the circuit breaker protecting that section to open.

The earth connection should be made by connecting the wire through the support to the rails by means of a copper bond. When first erected, the resistance to earth of the guard wires should be tested, and periodical tests should be made to prove that the earth connection is efficient.

Guard wires should be, in general, of galvanized steel, but in manufacturing districts in which such wires are liable to corrosion bronze or hard drawn copper wires should be used.

The gauge of the guard wire should not be less than seven strands of No. 16 or one of No. 8 wire.

The supports for the guard wires should be rigid and of sufficient strength for their purpose, and at each support each guard wire should be securely bound in or terminated.

The rise of the trolley boom should be so limited that if the trolley leaves the wire it will not foul the guard wires.

TELEGRAPH WIRES CROSSING TROLLEY WIRES.

Class (a).—Wires weighing less than 100 *lbs. per mile.*

The guard wires may be of the cradle or hammock type, attached to the arm of telegraph poles. It is necessary that the spans should be short; and, if required, an additional pole or poles should be set.

1. Where there is one trolley wire, two guard wires should be erected (Fig. 1).

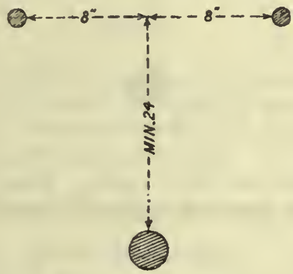


FIG. 1.

2. Where there are two trolley wires at a distance not exceeding 12 feet apart, two guard wires should be erected (Fig. 2).

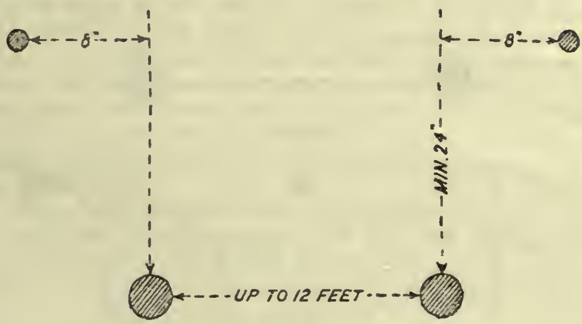


FIG. 2.

3. In special cases, at junctions or curves, where parallel guard wiring should be complicated, two guard wires only will generally suffice if so erected that a falling wire must fall on them before it can fall on the trolley wire.

Class (b).—Wires weighing 100 *lbs. or more per mile.*

4. Where there is only one trolley wire, two guard wires should be erected (Fig. 3).

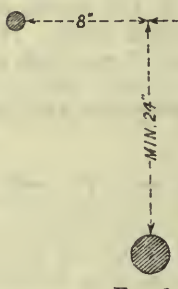


FIG. 3.

5. Where there are two trolley wires not more than 15 inches apart, two guard wires should be erected (Fig. 4).

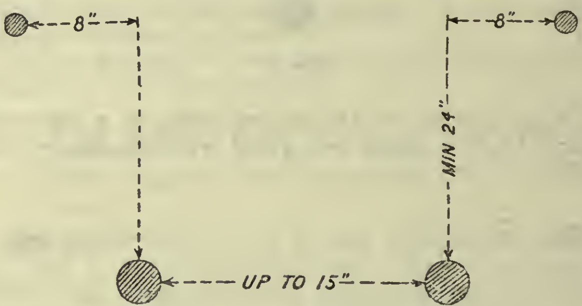


FIG. 4.

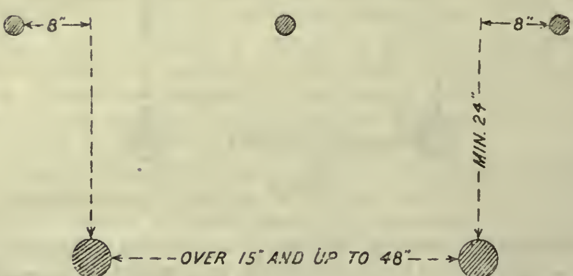


FIG. 5.

6. Where there are two trolley wires and the distance between them exceeds 15 inches, but does not exceed48 inches, three guard wires should be erected (Fig. 5).

7. Where the distance between the two trolley wires exceeds 48 inches, each trolley wire should be separately guarded (Fig. 6).

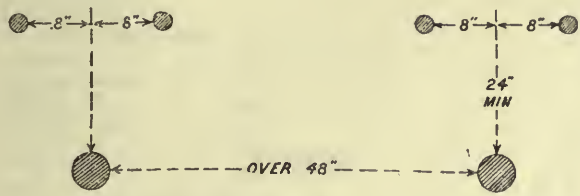


FIG. 6.

8. It is desirable, where possible, to divert telegraph wires from above trolley junctions and trolley wire crossings, and undertakers should endeavour to make arrangements to that effect with the owners of telegraph wires.

TELEGRAPH WIRES PARALLEL TO TROLLEY WIRES.

Classes (a) and (b).

9. Where telegraph wires not crossing a trolley wire are liable to fall upon or to be blown on to a trolley wire, a guard wire should be so erected that a falling wire must fall on the guard wire before it can fall on the trolley wire.

If the trolley wire is enclosed within a triangle formed by the vertical plane of a telegraph wire, and an imaginary line drawn at an angle of 45° from the uppermost telegraph wire on the side nearest to the trolley wire, a guard wire should be erected on span wires or on the brackets. This indicates the minimum requirements. In very exposed situations or for heavy routes of wires more than one guard wire may be needed.

10. When guard wires are attached to other supports than the trolley poles they should be connected with the rails at one point at least.

11. When it is possible that a telegraph wire may fall on an arm or a stay, or a span wire, and so slide down on to a trolley wire, guard hooks should be provided.

GENERAL.

12. Minimum guarding requirements for Classes (*a*) and (*b*) are provided for in this Memorandum, but in exceptional cases, such as in very exposed positions, or for unusually heavy telegraph wires, special precautions should be taken.

Board of Trade,
7, Whitehall Gardens, London, S.W.,
May, 1905.

INDEX.

The Entries in heavy type are the Vocabulary Nomenclature of Service pattern Stores.

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* See also Volume I.

* See also Volume I.

* See also Volume I.

* See also Volume I.

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