H 5



PW—H 5

# Post Office Engineering Department

# TECHNICAL PAMPHLETS FOR WORKMEN

*Subject*

## Underground Construction Part II.—Cables

***ENGINEER-IN-CHIEF'S OFFICE***
*1919*
*Revised and re-issued March, 1924*
**Previous Issues Cancelled**

(Reprinted March, 1929, including Correction Slips to date.)
( .. April, 1931, ,, ,, ,, ,, ,, .)
( ,, April, 1933, ,, ,, ,, ,, ,, .)

LONDON
PRINTED AND PUBLISHED BY HIS MAJESTY'S STATIONERY OFFICE
To be purchased directly from H.M. STATIONERY OFFICE at the following addresses:
Adastral House, Kingsway, London, W.C.2; 120 George Street, Edinburgh 2;
York Street, Manchester 1; 1 St. Andrew's Crescent, Cardiff;
80 Chichester Street, Belfast;
or through any Bookseller

1936

Price 6*d.* Net

## LIST OF

# Technical Pamphlets for Workmen

**GROUP A**

1. Magnetism and Electricity.
2. Primary Batteries.
3. Technical Terms.
4. Test Boards.
5. Protective Fittings.
6. Measuring and Testing Instruments.
7. Sensitivity of Apparatus.
8. Standard List of Terms and Definitions used in Telegraphy and Telephony. (*Not on sale.*)
9. Standard Graphical Symbols for Telegraphy, Telephony and Radio Communication. (*Not on sale.*)

**GROUP B**

1. Elementary Principles of Telegraphy and Systems up to Morse Duplex.
2. Telegraph Concentrators.
3. Wheatstone System. Morse Keyboard Perforators.
4. Quadruplex, Quadruplex Repeated Circuits and Telegraph Repeaters, Simplex and Duplex.
5. Hughes Type-printing Telegraph.
6. Baudot Multiplex Type-printing System.
7. Western Electric Duplex Multiplex. Murray Duplex Multiplex. Siemens and Halske Automatic Type-printing System.
8. Fire Alarm Systems.

**GROUP C**

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

**GROUP D**

1. Elementary Principles of Telephony.
2. Telephone Transmission. "Loading." Telephone Repeaters and Thermionic Valves.
3. Principles of Telephone Exchange Signalling.
4. Magneto Exchanges—Non-Multiple Type.
5. Magneto Exchanges—Multiple Type.
6. C.B.S. No. 1 Exchanges—Non-Multiple Type.
7. C.B.S. Exchanges—Multiple Type.
8. C.B. Exchanges—No. 9 Type.
9. C.B. Exchanges—No. 10 Type.
10. C.B. Exchanges—No. 12 Type.
11. C.B. Exchanges—22 Volts.
12. C.B. Exchanges—40 Volts.
13. Trunk Telephone Exchanges.
14. Maintenance of Manual Telephone Exchanges.
15. Telephone Testing Equipment.
16. Routine Testing for Manual Telephone Exchanges.
17. Internal Cabling and Wiring.

[*Continued on page iii of Cover.*

## CORRECTION SLIP TABLE

The month and year of issue is printed at the end of each amendment in the Correction Slips, and the number of the slip in which any particular amendment is issued can, therefore, be traced from the date. In the case of short corrections made in manuscript, the date of issue of the slip should be noted against the correction.

The Summary portions of the Correction Slips should be completed and affixed below in numerical order.

# UNDERGROUND CONSTRUCTION

## PART II.—CABLES

(H. 5.)

*The following pamphlets in this series are of kindred interest :*

H. 4. Underground Construction, Part I.—Conduits.

H. 6. Underground Maintenance.

*See also*

P.O Technical Instruction XIV.

# UNDERGROUND CONSTRUCTION

## PART II.—CABLES

TABLE OF CONTENTS

# UNDERGROUND CONSTRUCTION

## PART II.—CABLES AND CABLING

### 1. TYPES OF CABLES

**Lead-covered Paper Core Cables** are invariably used by the Department in connection with underground networks. The cables are conveniently divided into two sections, viz. :—

(i) Main.
(ii) Local.

In **Main Cables,** Trunk Circuits, Long Distance Junctions and Telegraph Circuits are carried, and the cables may be made up in the form of Multiple Twin, Quadruple Pair, or Single Screened types. **Local Cables** are usually of the Twin Pair type and are utilised for local distribution and short distance junction circuits.

Each conductor consists of a solid, annealed copper wire of standard diameter, weight and resistance. The separate wires are covered with a wrapping of paper of uniform thickness, and a definite colour scheme is adopted in the wrapping of the conductors. By this means, different wires in the cable can be distinguished.

The paper-covered conductors are enclosed in a sheath of lead and coiled on drums. After being subjected to a series of stringent tests to prove the Insulation Resistance, the Electrostatic Capacity, and the condition of the Lead Sheathing, the wooden drums are lagged, ready for transit or storage.

In **Twin Cables,** not exceeding 15 pairs, each conductor is wrapped with paper of different colour and the two separate conductors making a pair are uniformly twisted together and wrapped with coloured thread. In the case of Twin Cables containing more than 15 pairs, two conductors, each wrapped with paper of the same colour, are twisted together to form a pair.

In making up **Composite Cables,** the conductors of different gauge are arranged in separate layers.

**Multiple Twin Cables** are made up of a series of cores of four wires, formed by successive twinning operations.

Two wires separately insulated with similarly coloured paper, one with a red string and the other with a white string, are twisted together to form a pair. Two pairs of wires of different colours, which may be made red, white, blue or green, are twisted together to form a two-pair core.

There are a number of multiple twin cables in use, formed of 8-wire cores, but in the standard specification this type has been replaced by the 4-wire core cable referred to above. This

method of cable construction provides for super-imposing upon pairs in the same core, and also allows of " bunching " two pairs of wires to form one circuit.

**Quadruple Pair Cables.**—This type of cable has been superseded by the Multiple Twin type, but there is a large amount of Quadruple Pair Cables still in use. It consists of one or more cores, each containing 4 twisted pairs, laid up round a centre to form a " Quadruple Pair " core. The two wires in each pair are insulated with the same coloured paper, but the paper is lapped with differently coloured threads. The four pairs forming the quadruple pair are also covered with paper of distinctive colours. For super-imposing purposes in quadruple pair cables, diagonal pairs in the same core are used.

**Single Screened Cables.**—Although there is a considerable amount in use for telegraph circuits, this type of cable will not be supplied in future. Each conductor is covered with wrappings of paper and finally by a winding of screening tape, made of soft copper, and it is arranged that all the screening tapes are in contact with the lead sheath. This type of cable permits single wires to be used for Telegraph purposes without interfering with Telephone circuits in the same cable.

## 2. DRAWING IN CABLES

Before the drawing-in operations are started, it is necessary to prove that the conduit is in good order. If the cabling immediately follows the laying of the conduit, a draw wire will be in position, but where the wire is not available, sweep's rods are passed through. The rods are issued in two sizes, " Thick," in 5 ft. lengths, and " Thin " in 6 ft. lengths. Rods pushed into an empty conduit are fitted with a " guide wheel " on the leading rod, but where the conduit already contains a cable a " Leader for sweep's rods " is fitted. A 1½ in. rope is attached to a " follower " on the last rod, and by this means a brush is drawn through the conduit. If there is any doubt as to the condition of the conduit, it is tested by drawing through a 4 ft. length of test cable, having a diameter ¼ in. less than the internal diameter of the conduit. The sheath of the test cable is examined after drawing through, and it can be decided from the appearance of the sheathing whether the internal surface of the conduit is in good condition.

When drawing in cables, it is desirable, wherever possible, to pull down hill and also towards the spigots of the conduits.

When drawing cables into Jointing Chambers, the cable drum is placed over the conduit into which the cable is to be drawn, and the cable paid out from the top of the drum with a large radius curve (Fig. 1). Where jointing chambers are not provided, the cable drum may be placed over the forward

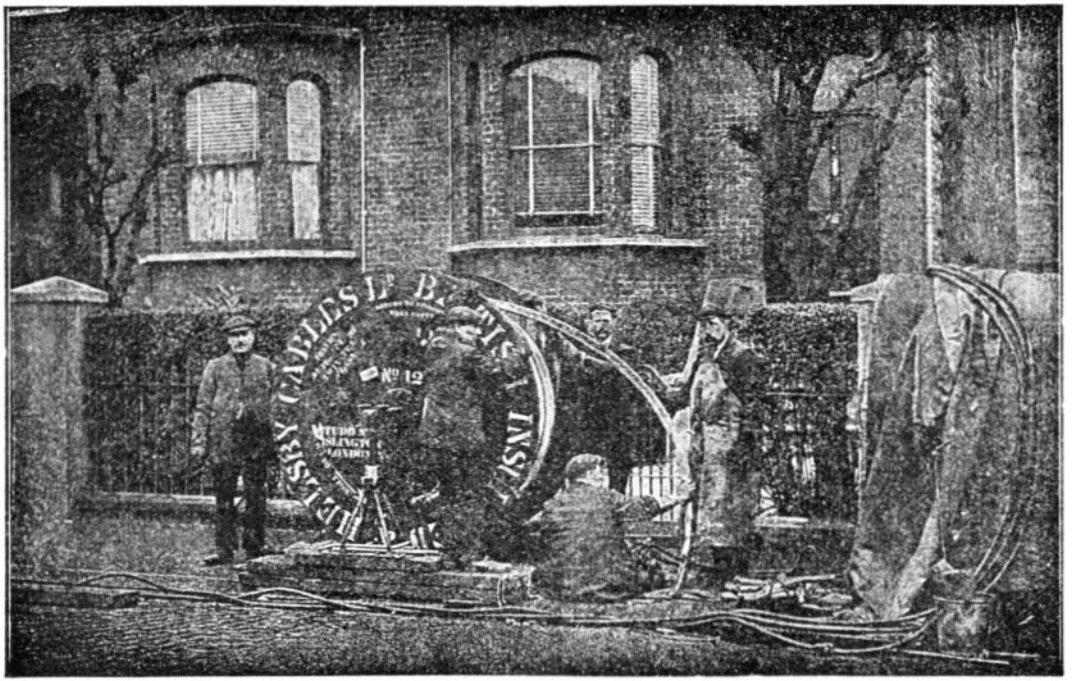



Fig. 1.
*DRAWING IN CABLES THROUGH JOINTING CHAMBER.*

conduit and the cable fed from the under side of the drum. The lead sheath must not be allowed to touch the ground, or damaged in any way, by coming into contact with the edge of the conduit where the cable enters.

Spindles are supplied for use in connection with the revolving of the cable drums, and shoes, consisting of iron shod wooden wedges, fitted with a handle are provided for slewing the drums into position (Fig. 2).

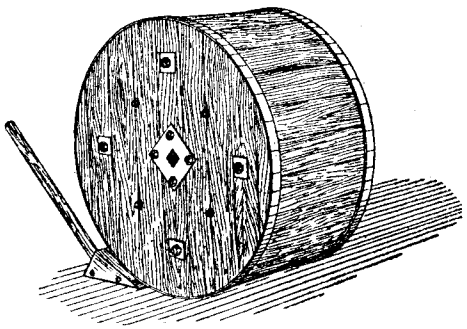


Fig. 2.

*LAGGED CABLE DRUM AND CABLE SHOE.*

Lifting Jacks are placed under each end of the Spindle, and the drum raised to a sufficient height to admit of free revolution on the spindle.

**Cables up to ¾-inch diameter are drawn in by hand.** The end of the cable is doubled back upon itself for about 4 inches and securely bound with prepared tape, to form an eye to which the pulling rope is attached. In the case of **heavy cables,** the end of the cable is uncoiled from the drum and the sealing

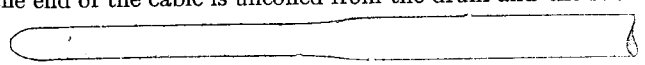


Fig. 3.

*DRESSED CABLE END.*

disc sawn off, care being taken to prevent the entry of moisture into the cable. The conductors are next punched back inside the sheath for ¾ in., and the lead sheathing at the end dressed down into the opening, until this is reduced to rather less than half the original internal diameter of the sheath. A lead disc, cut to size, is then forced into the reduced end, or cup, of the sheath, on to the ends of the conductors.

The **dressing of the cable** is an important part of the work. Starting from the end of the cable, the lead is dressed down

evenly on to the conductors round the sheath by means of a Boxwood Dresser, over the length to be occupied by the cable grip (Fig. 3). The object of dealing with the cable in this way is to ensure that both the lead sheath and also the cable conductors are evenly reduced, and consolidated, to form a strong mass of metal, prepared to take the stress later on. The end of the cable is then dressed off and the small cup carefully filled with solder, to produce a round sealed termination.

**Cable Grips.** (Fig. 4.)—To place the steel wire Cable Grip in position, it is first compressed lengthwise, and in this way the diameter is increased. It is then held firmly and placed over the cable until the nose of the grip presses hard on to the sealed end of the cable. The mouth of the grip is then pulled over the cable, the lattice gripping the cable tightly throughout the

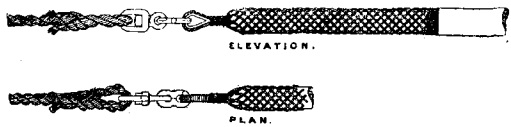



Fig. 4.

*CABLE GRIP, ORDINARY.*

enclosed length. The mouth of the grip is securely bound to the lead sheath with a few turns of strong string, or prepared tape, to prevent the grip from slipping. A Keystone Connecting Link of suitable size is used to attach the eye of the cable grip to the swivel at the end of the pulling-in rope.

The Crab Winch is placed in position at the pulling end. Where Ring Bolts or Anchor Irons are available, Snatchblocks and tackle are fitted in the jointing chamber, so that the pull can be taken vertically to the winch. When ring bolts or anchor irons are not available, a temporary anchorage is made with timber. If the jointing chamber is small and the conduit shallow, blocks and tackle may be dispensed with, whilst on country roads the winch is securely anchored to crowbars driven into the ground. Neither the cable sheath nor the pulling-in rope must be allowed to come into contact with the conduit or the earth.

Before putting any stress on the pulling-in tackle, the foreman should see that everything is in good order and securely fixed. At the cable end, three men are required to handle the drum; one man to lead the cable into the jointing chamber, whilst a man is also stationed in the manhole to guide the cable into the conduit. The two last-named men carefully examine the cable sheath as it passes through their hands, to ensure that the sheath is in perfect order. A man will be employed to

lubricate the cable thoroughly with **Petroleum Jelly.** The coating of the cable sheath with jelly should be continuous and even, as, in addition to acting as a lubricant, the jelly tends to protect the cable from chemical action.

When the section of cable has been drawn through, the lashing of the cable grip is removed, and the mouth of the lattice drawn towards the nose of the grip, which will then release its hold.

The cable end is carefully examined in order to ensure that no accident has occurred to it during the drawing-in operations. If there is any sign of damage, the end is cut off and a new sealed termination made. Should a cable be subjected to exceptional stress during pulling-in, an air pressure test as described on page 15 is made at once.

Where it is necessary to draw a large cable into a conduit which already contains one or more cables, it may be advisable

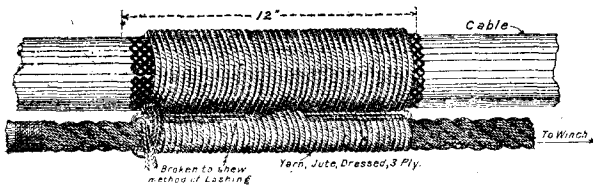



Fig. 5.

*CABLE GRIP, SPLIT.*

to withdraw temporarily the smaller cables and to pull the larger cable into the empty conduit, finally restoring the smaller cables. This course is adopted whenever there is any fear of damage to existing small cables.

Where jointing chambers are not provided, and cable jointing is not put in hand at once, the cable ends are protected by timber placed at each side of the cable and on the top. If the size of the cables permit, Couplings will be placed in position over the two cable ends, as a temporary protection. The ends of the conduits will be filled with Cotton Waste, or Yarn, to prevent the entry of soil when the ground is temporarily filled in.

### 3. DRAWING OUT CABLES

A Split Cable Grip (Fig. 5) is of value when it is desired to withdraw a cable from a conduit, or to apply a pulling stress at an intermediate point. The Split Grip is made up of a curved piece of Steel Wire mesh, 12 in. long, issued in $1\frac{1}{2}$ in. and $2\frac{1}{2}$ in. sizes. The $1\frac{1}{2}$ in. size is used on cables from 1 in. to $1\frac{3}{4}$ in. diameter and the $2\frac{1}{2}$ in. size on cables from 2 in. to 3 in. diameter.

The grip is fixed on to the cable and the pulling rope laid alongside and securely lashed with yarn to the cable. Careful adjustment of the lashing is required, to prevent any slipping

of the grip when stress is applied, but not too tightly to prevent the slipping of the grip along the cable when the stress is removed from the pulling rope. If careful attention be paid to the lashings at the outset, only one attachment of the rope to the grip should be required.

When it is desired to withdraw small cables from a conduit, in which they have become "bound," the cables may be loosened by first rodding the conduit, then by passing a loop of well lubricated rope round the bound cables and drawing the looped rope through the conduit. A tail rope is attached to the loop, as a safeguard in case of stoppage.

**General.**—All Jointing Chambers should be cleaned out and dried before jointing work is started. Fire baskets or braziers may be used for the drying of chambers, but great care should be taken to see that the cable sheaths are not damaged by heat. Workmen should never work in a jointing chamber in which an open fire is burning, and, when the fire has been removed from the chamber, a few minutes time should elapse to allow for free ventilation before the workmen enter.

**Jointer's Tents** and suitable guards are used round jointing chambers. The jointer's assistant should keep a careful watch upon the Department's plant and tools.

In the case of carriageway manhole frames, a **wrought iron fender** is fitted round the entrance, whilst jointing is in progress, to prevent surface water from entering the manhole.

Where there is no jointing chamber, the hole is made large enough to enable the jointer to work in comfort. Two planks, each 10 ft. x 9 in. x 3 in., are placed along the side of the hole, to make a platform for two jointers' tents, mounted end to end. The flap of the windward side of the tent is kept closed to prevent currents of air, always more or less damp, from passing over the joint. To keep out surface water, a banking of earth or clay is made round the hole. If water is present in the hole, a sump is sunk in a suitable place outside the tent and the water removed by means of a contractor's pump. If the soil is very loose it may be necessary to "timber" the hole. The bottom and sides of the hole are covered with ungalvanized iron sheets, 3 ft. x 2 ft., to protect the exposed cable from moisture. The whole of the interior is then covered with canvas sheets.

The cable ends are placed in position (Fig. 6) and the lead sleeve passed over one end. Any bending or straightening of the cable is effected before the jointing is commenced and the handling of the cable should be done with the greatest care, in order to avoid damage to the sheath or to the cable conductors. The ends of the cable are supported whilst the jointing is in progress. The sheathing is removed from each end (Fig. 7),

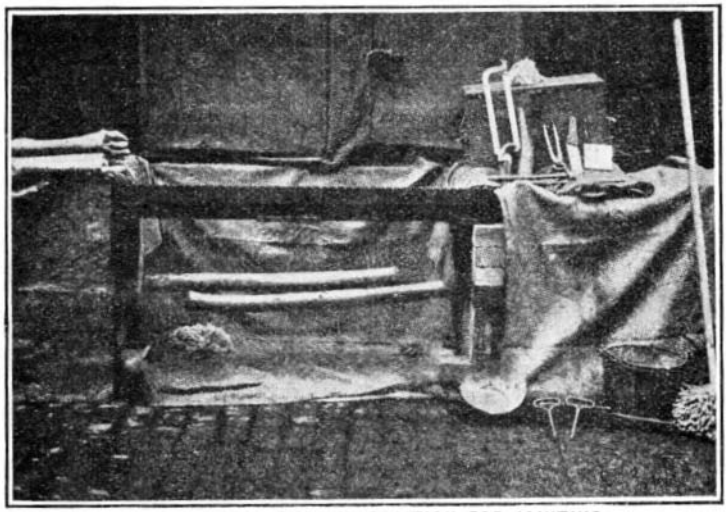


Fig. 6.—*CABLE ENDS IN POSITION FOR JOINTING.*

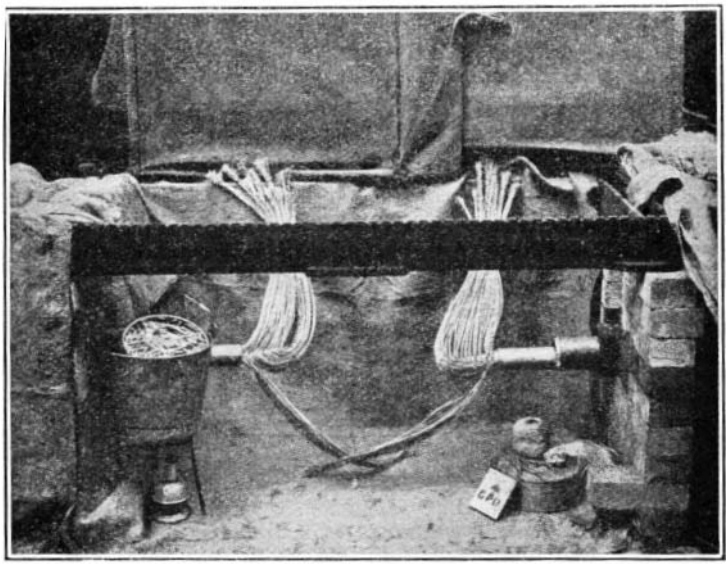


Fig. 7.—*CABLE ENDS CUT IN READINESS FOR JOINTING.*

taking care that the straight distance between the two cuts is about four inches less than the length of the lead sleeve. All rough edges are removed from the metal and a wrapping of insulating paper tied at the point where the sheath has been cut.

The conductors in the outer layer of each cable are separated into two portions, tied and bent back at right angles. Each layer is dealt with in similar manner until the whole of the cable has been carefully separated.

## 4. JOINTING

**Subscribers' Twin Cables.**—Before the lead sheath is slipped over the cable, care must be taken to ensure that the portion of the sheathing of the cable upon which the lead sleeve will rest during the jointing operations is thoroughly clean.

To joint wires in 6½, 10, 20 and 40 lb. twin pairs, the joints in the bottom half of the outer layer should be made first, followed by the next half layer, until the whole of the joints are made. The pairs of wires in one layer should be jointed to pairs of wires in the same layer, but the relative positions of individual pairs in the same layer need not be maintained, i.e., any pair in a given layer may be jointed to any other pair approximately in the same position in the same layer. This method of jointing is sometimes referred to as "Random Pair Jointing" or "Non-Sequence Jointing."

It has been the practice hitherto to endeavour to obtain a very compact joint by joining the wires as straight across the joint as possible in order to leave the minimum amount of slack. A disadvantage of this practice is that it is difficult to gain access to the inner layers of the joint when re-arrangements are required and consequently piecing is frequently necessary.

In future, the wires should not be drawn so tightly across the jointing gap before being given the two twists including the paper wrapping. This will result in a looser joint and enable it to be opened out more readily.

The method of jointing known as the seven movement method will be followed for jointing 6½, 10, 20 and 40 lb. cables. The seven operations required for jointing each wire are illustrated by Figs. 8 to 14 respectively and are as follows:—

(1) The two wires are brought together - -
(2) The unstripped wires are given two complete twists - - - - - - - - } (Fig. 8)

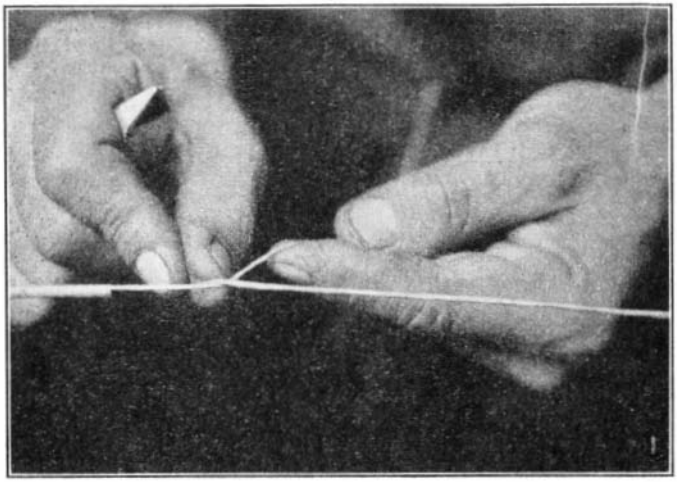


Fig. 8.

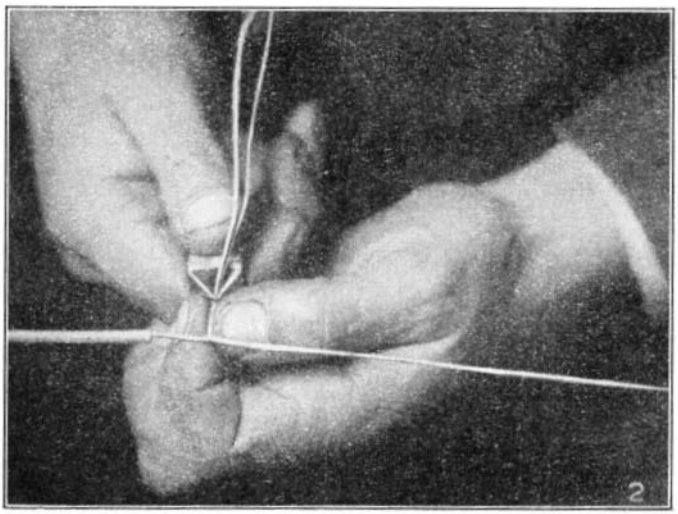


Fig. 9.

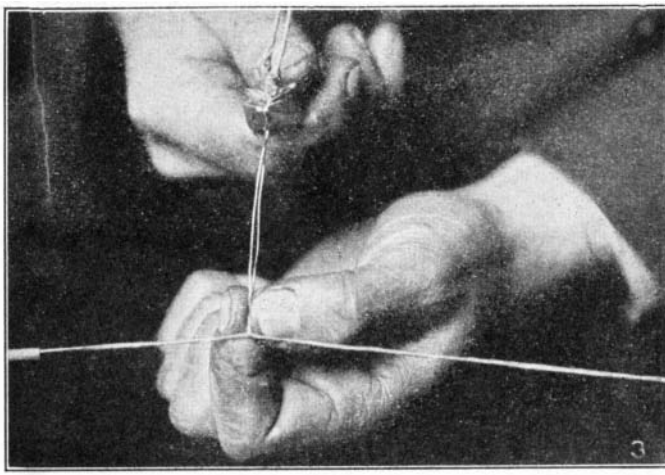



Fig. 10.

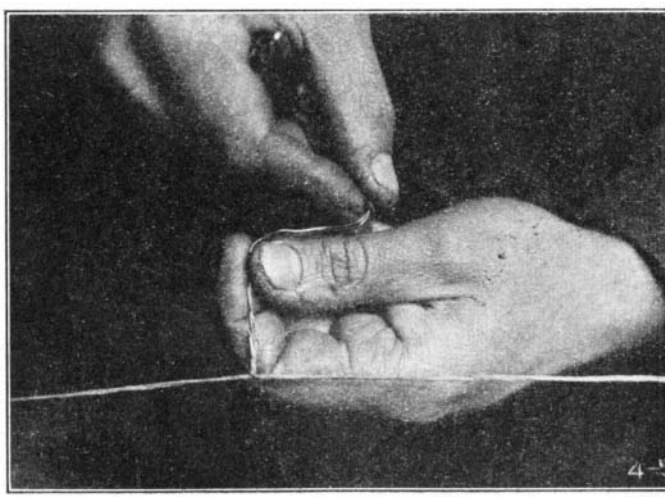



Fig. 11.

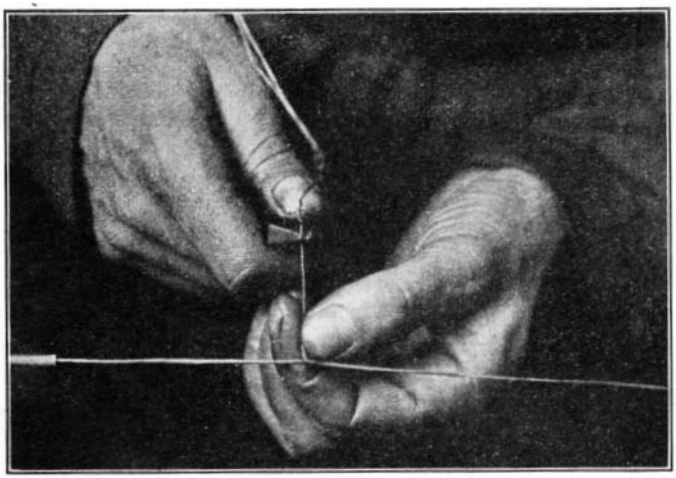


Fig. 12.

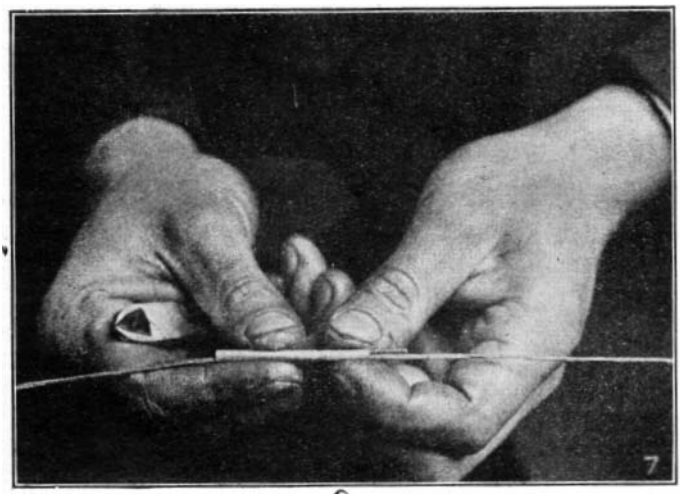


Fig. 13.

(3) The two wires are then stripped in one movement, the Tool, Instrument, No. 103 being held in the reverse position to avoid damage to the wires - - - - - - - - (Fig. 9)

(4) The thumb and finger of the left hand are then shifted to hold the paired wires 2-in. from the paper twist - - - - - - - - - (Fig. 10)

(5) The first finger and thumb of the right hand are then used to twist the stripped wires ten times - - - - - - - - - - (Fig. 11)

(6) The Tool, Instrument, No. 103 is given a turn from 180° before the spare ends of the wires are finally severed. Joints in cables other than 40 lb. cables will not be soldered - - (Fig. 12)

(7) The twisted wires are then folded down and a paper sleeve is drawn over them - - - (Fig. 13)

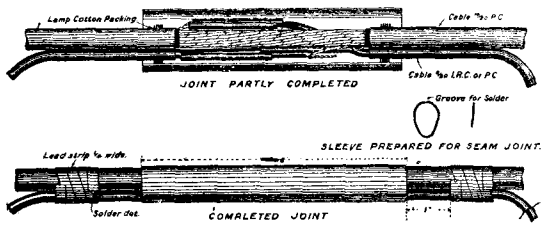



Fig. 14.

*METHOD OF MAKING PARALLEL JOINTS.*

In making joints on cables up to 8 pairs, the conductors covered with similarly coloured threads are jointed together throughout, for identification purposes. For this reason, no two pairs in a small cable are similarly coloured.

When the joint has been completed, it is wrapped with $\frac{7}{8}$ in. Insulating Paper, bound with thread, and the lead sleeve drawn over. The space between the sleeve and the sheathing is caulked with cotton waste, or lamp cotton, to prevent solder from running into the joint. Lineman's thin solder is used for soldering the sleeve.

**Parallel Joints.**—These are made on small distribution cables up to 8 pairs, when it is desired to lead off from 1 to 4 pairs (Fig. 14). A split sleeve is used to enclose the parallel joint,

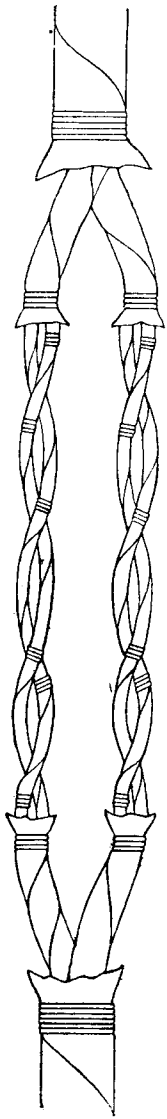


Fig. 15.

MULTIPLE TWIN CABLE JOINT.

which is made either on the up or down side, as required. The wires are taken off by a separate small cable, and both the main and small cables are enclosed in the seamed sleeve. A V-shaped groove is made at the top of the seam and solder run in carefully at the ends of the sleeve, and also along the seam, to complete the joint. Lead strip ¼ in. wide is bound round the cables, 1 in. from the lead sleeve, to prevent the bending of the soldered joint.

**70, 100, 150 and 200 lb. Twin Conductors.**—The binding thread on each of the two wires selected for jointing is unwrapped for 2 in. from the point where the conductors will be cut, and the thread tied over the paper. The loose thread on one side is cut away, but the other thread, about 12 in. long, is allowed to remain. The paper is unwrapped to the point where the thread is fastened, and the paper cut to allow an overlap of 1½ in. on each side, which will cover the joint later on. The conductors are cut and cleaned so as to butt closely when drawn out straight. A tinned copper jointing tube is placed over the butted ends and the joint soldered. One wrapping of the loose end of insulating paper is placed over the joint and the second

spare wrapping placed over this and tied securely by the spare thread left for the purpose.

**Multiple Twin Cables.**—No definite rules are laid down for crossing colours in 2-pair core cables, but the principle of jointing different coloured pairs is maintained (Fig. 15). In the case of cables made up of 8-pair cores, a complete core is first selected from each side of the joint and the cores divided into 4-pair cores. The ends are prepared for jointing as set forth above, two similarly constructed cores selected and separated into two 2-pair cores which are still further divided into two pairs.

Care is taken not to remove more of the coloured paper wrappings than is absolutely necessary, as the colours serve to identify the wires. The coloured pairs must be joined up as shown below, the colour mentioned first being taken from the side from which jointing is proceeding.

Join Red Pair to Blue.
Join White Pair to Green.
Join Blue Pair to White.
Join Green Pair to Red.

With the adoption of these colour changes, a pair of wires on one side is jointed to a pair on the other, then the second pair dealt with in like manner, to form a through 2-pair core under one wrapping of paper. The adjoining 2-pair core is jointed similarly to make a 4-pair core.

**Quadruple Pair Cables.**—A core on one side is always connected to a differently-coloured core on the other side and the diagonal position of pairs maintained. In every quadruple core the red pair is diagonally opposite the white, and the green pair opposite the blue. If red is jointed to green, then white must be jointed to blue.

**Screened Wires.**—The copper tape is removed for 3 in. on one side and 1 in. on the other, the ends of the tape being tied down with thread. The outer layer of paper insulation is unwrapped for the same distance on each side, and the conductors exposed for ¾ in. on each side, by removing the inner wrappings of insulating paper. A paper sleeve is pushed over the side from which the greater length of tape has been removed, and the butted joint enclosed in a copper jointing tube and the joint made in the usual way. The paper sleeve is then drawn over the joint, so as to enclose the under wrappings of paper. The outer wrappings on each side are replaced and tied down with thread. Joints in screened wires are distributed, or "staggered," evenly over the length of the gap, and are never made opposite each other in adjacent wires.

Paper sleeves are only used on screened conductors, or on joints exceeding 40 lb. gauge, where it is desired, for any special reason, to make a numbered joint.

**Completion of Joint.**—When the complete joint has been made and before the final wrapping of paper is put on, such joints as are made in pits, open boxes, or at couplings are thoroughly dried by means of charcoal braziers (Fig. 16). In manholes Torch Lamps are used instead of braziers. The brazier or lamp is moved slowly backwards and forwards near the joint and the ends of the sheath, until it is judged that all signs of moisture have been removed. Care is necessary in the operation, to avoid overheating the paper and making it brittle. The time required for brazing depends upon the condition of

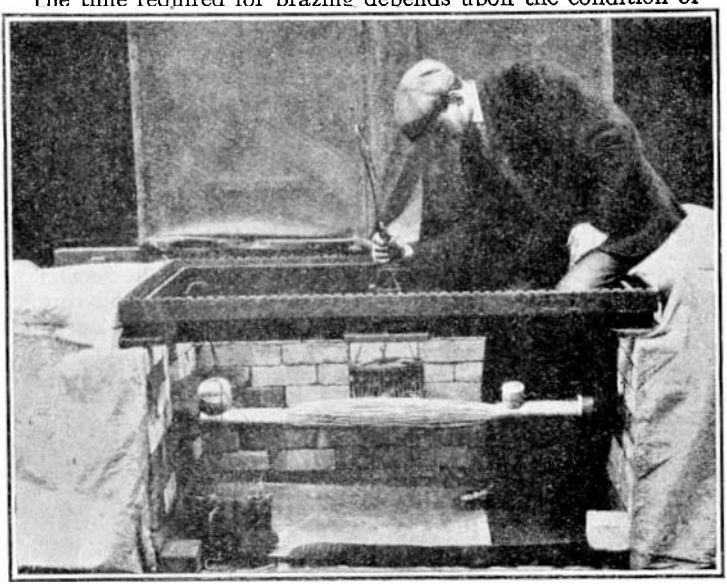


Fig. **16.**

*DRYING OUT COMPLETED JOINT.*

the atmosphere and also on the size of the cable, but for a 2¾ in. diameter cable at least two hours brazing is necessary.

On completion of the drying process, a spiral wrapping of 2 in. Insulating Paper, on which the Jointer's name has been written, is wound over the joint. If for any reason the plumber is unable to take over the joint for "wiping" immediately after completion, the lead sleeve is drawn over the joint and securely wrapped with Adhesive Insulating Tape.

**Plumber's Wipe.**—The lead sleeve is drawn over the joint and dressed down at the ends. A wiped joint is made with Plumber's Solder. Plumber's Black, mixed with water, to

make a thin paste, is painted on the cable to limit the flow of the Solder. The heat used in making the joint tends to expel moisture through a small hole made in the sleeve, or through the air nozzle, and the heating of the joint is continued until there is no sign of condensation on a small mirror held over the hole. When the joint is perfectly dry, the hole is sealed by means of a carefully made " patch wipe " (Fig. 17). **Wiped**

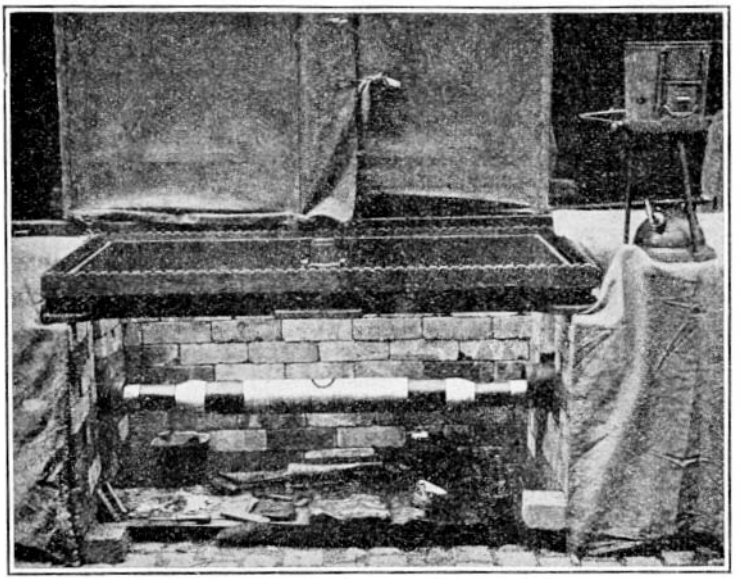


Fig. 17.

*"WIPED" JOINT SHOWING "PATCH WIPE."*

**joints** are made on sleeves which exceed 1 in. in diameter. **Blow Pipe joints** are made on sleeves up to 1 in. diameter. Cable wipes are marked with the name of the plumber or jointer and also the date.

**Pressure Test.**—The jointed cable is tested in half mile sections to prove both the perfect condition of the Lead Sheath and also the Plumber's work. The cable ends are sealed with Lead Caps fitted with Air Nozzles. A Pressure Gauge, range 0-60 lbs., 4 in. dial, is connected to one nozzle and a similar gauge, also a 3-way cock, attached at the Desiccator end (Fig. 18) The pressure is then applied to the cable and, when the gauge at the distant end registers 20 lbs., the plumber's work is tested by smearing soapsuds over the wipes in turn.

Flaws in plumbing will show up by the appearance of " bubbles." If any defect is revealed, the wipe is broken down and re-made.

As an alternative to the foregoing, Gauges, Pressure, 15 lb. to 22 lb., or other similar type may be used and the soapsuds test dispensed with.

The Cable Sheath in the section under test is proved by closing the 3-way cock. When the gauge at the distant end indicates a pressure of 20 lbs., the pressure is allowed to equalise throughout the cable. A record is made at the time when both gauges read alike and a second reading taken 24 hours later.

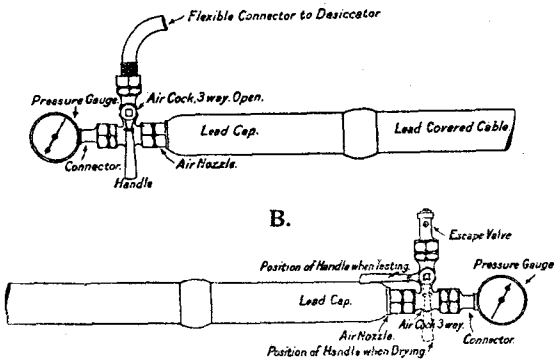



Fig. 18.

*PRESSURE TESTING APPARATUS.*

During this period there should be no observable fall of pressure, but if the test reveals any defects, the cable must be regarded as faulty and instructions sought.

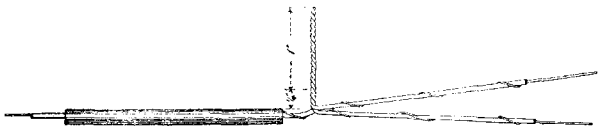
When two half mile sections are jointed together, the desiccator is attached to the connecting joint itself and a pressure of 15 lbs. maintained, whilst the soapsuds test is applied to the joint. After proving the plumber's work, the air nozzle is removed and a lead patch carefully wiped over the hole.

**Y Joints.**—In order to divide a main cable into two smaller branches, a " Y " joint is made (Fig. 19). A special " Y " sleeve is prepared from short lengths of sleeves, of slightly greater internal diameter than the external diameter of the cables to be dealt with. The sheath is removed from the ends of the branch cables, the wires threaded through the " Y " sleeve, and a straight lead sleeve passed over the main cable. The through conductor joints are made and afterwards any teed jointing done. The exposed conductors are dried with

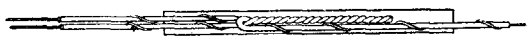
braziers, the main sleeve drawn forward and wiped to the main cable, and also to the " Y " piece. The junction of the " Y " piece to each branch cable is also wiped.

**Divided Sleeves.**—If it is necessary to divide a main cable into several branch cables, a Dividing Sleeve is used (Fig. 20).

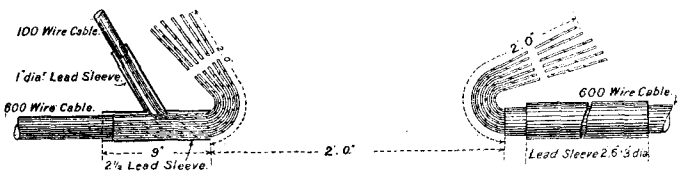
*TEE JOINTS IN 10 lbs. CONDUCTOR CABLES.*



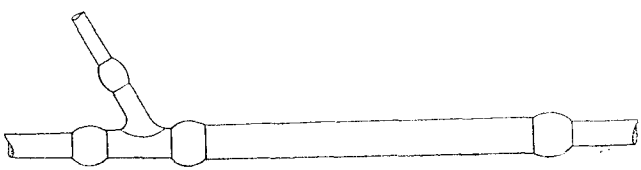
*A.—Teed Conductors (Showing Triple Twist).*



*B.—Teed Conductors Sleeve Over.*




*C. Arrangements for Teed or Y Joint.*



*D.—Completed Teed or Y Joint.*

Fig. 19.

*"TEED" OR "Y" JOINTS.*

The main sleeve is first passed over the cable, the branch cables taken through the tubes of the dividing sleeve and the conductors jointed to the main cable in the usual way. The main sleeve is then drawn back and wiped on to the main cable and also to the heavy end of the dividing sleeve.

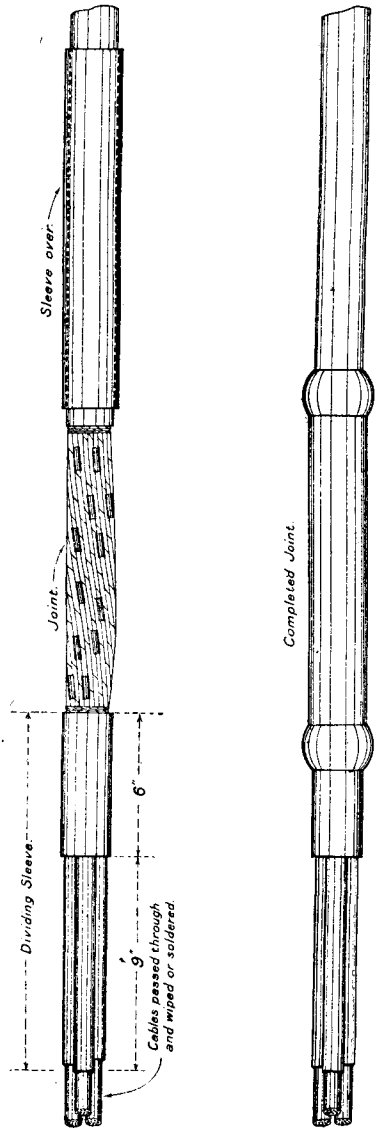



Fig. 20.

METHOD OF USING DIVIDING SLEEVES.

**A Cable Distribution Head** is used in order to connect main cables to a number of branching cables. It consists of a cast iron box with holes bored in its sides to take gun-metal linings. The Head is fixed to the wall of a Jointing Chamber by means of Lewis Bolts. An Indiarubber Washer is placed between the flanges and the cover to improve air-tightness. Wiped joints are generally made between the lead-covered cable and the gun-metal lining, before the latter is placed in position on the Cable Distribution Head. The plumber's wipe should never be made

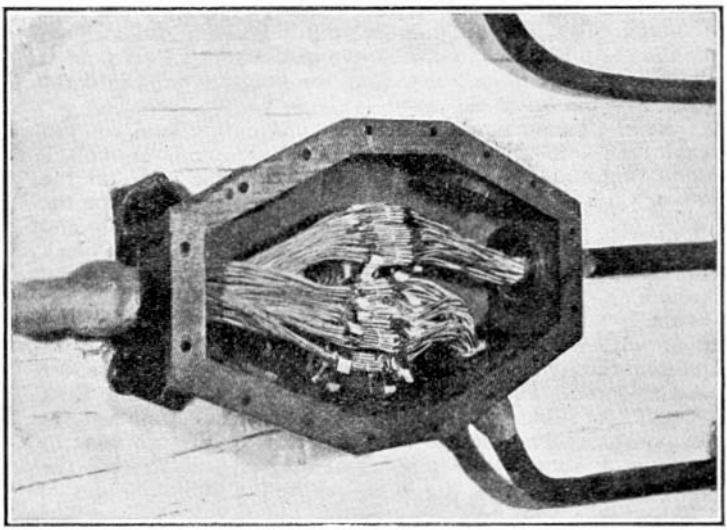


Fig. 21.

*CABLE DISTRIBUTION HEAD. COVER REMOVED TO SHOW LAY OUT AND LABELLING OF CONDUCTOR.*

with the Indiarubber Washer in position, as the heat applied may damage the washer and make it impossible to keep out moisture. The Conductor joints are made in the ordinary way and pairs are numbered and tagged with distinctive labels for identification purposes (Fig. 21).

The screwing up of the cover should be done carefully. The nuts are first screwed up by hand and pressure evenly applied; finally the tightening is done by means of a special spanner. Every care is taken to keep the conductors thoroughly dry and, when the cover has been screwed up, or restored, after removal for circuit rearrangements, the Head is subjected to an air pressure test—soapsuds are smeared over the Wiped Cable joints, also over the junction between box and cover, to detect

leakage. The careful use of Torch Blow Lamps is recommended in warming and drying the casting and cable ends.

**Solid Plugs** (Fig. 22) are used to take a number of separate pairs from a small cable where a parallel joint would be unsuitable. The fitting consists of a lead plug, cast round a series of separate short lengths of lead-covered cable. In special cases the plugs are fitted with G.P. tails.

The solid plug is jointed to the cable in the following way :— A thimble is slipped over the main cable, the lead sheath stripped back from the cables and the conductor joints made and soldered. The lead sleeve is drawn into position and soldered to the cable and plug. The sleeve is afterwards heated by a spirit lamp and melted insulating compound poured into the joint and the screw cap fixed.

**Blocks, terminal,** are issued for terminating lead covered cables at Distribution Poles, etc. The blocks are made of black insulating material fitted with a trough at the back for the Paper Core Cable, and Terminal Plates on the front for the leads. The front is protected by a close fitting cover. The end of the cable is lead through a thimble at the base of the block to which it is soldered. The cable pairs are passed into the trough and fanned out to correspond to the small holes leading to the terminals on the front of the block. The trough is then filled with melted paraffin wax. The individual wires after passing through the holes in the terminals are turned over and soldered. From the terminal plates Cable I.R.V. Core 1 pr./12½ for subscribers' circuits and Cable I.R.V. Core 1 pr./40 for trunk circuits is led to the insulators. (It is proposed to incorporate in T.I. XIV a series of diagrams illustrating the block, with full particulars of the method of fitting.)

## 5. PROTECTED CABLE

This type of cable is laid direct in the ground, in situations where there is no prospect of development of the Service, nor disturbance of the subsoil. The cable is of the Lead-covered Paper Core type, and the sheath is usually made up of a heavier weight of lead.

The cable is covered with wrappings of Hessian Tape, dipped in a mixture of Pitch and Tar compound and afterwards covered with whitewash. It is supplied in convenient sizes for distribution up to 25 pairs. The cable is laid under Carriageway and Footway in narrow trenches at depths below the surface to the top of the cable as shown below :—

| | Inches. |
|---|---|
| *Carriageway .. .. .. .. | 24 |
| ,, paving across Footway .. | 12 |
| Footway, all descriptions of pavings .. | 9 |

*NOTE.—At roadway crossings protected cable will be laid in a conduit.

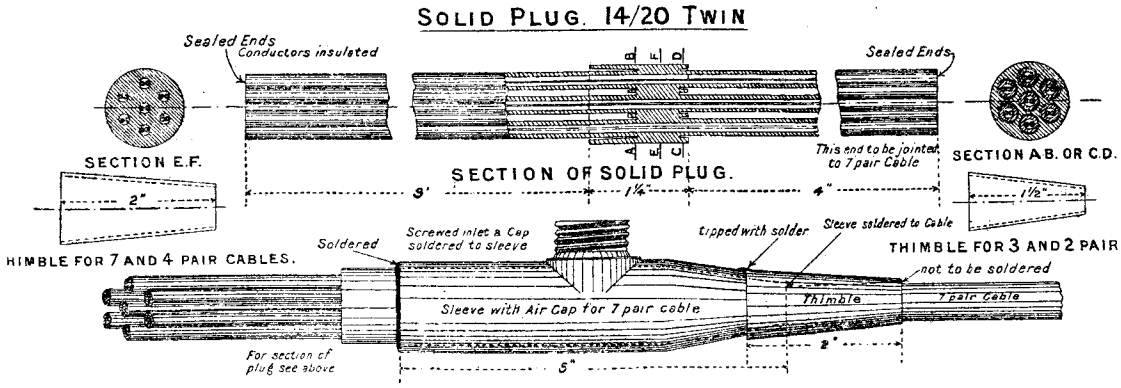



Fig. 22.

*SOLID JOINT COMPLETE (WITH THIMBLE) FOR 7 PAIR CABLE.*

The bottom of every trench is carefully levelled and rammed and a cover of 2 to 3 inches of fine soil, free from stones, placed over the cable.

Joints are made in the usual way, care being taken to restore the Hessian Tape when the joint is completed. The cable joint is protected from injury by placing a piece of "Wood" Troughing 18 in. long, over it.

## 6. TERMINATING CABLES AT DISTRIBUTING POLES, ETC.

The connection is secured by the use of Blocks, Terminal. The block should be fixed on the pole below the top arm on the side of the pole opposite to that on which the arm is fixed.

If the underground conduit is a Duct No. 11, it is arranged to terminate about 14 in. from the pole (the last duct will be a No. 11 double spigot or an ordinary No. 11 cut to appropriate length by removing the socket end). A C.I. Split Bend No. 25 is fixed to the end of the duct to protect the cable below the ground line. The upper flange of this bend is arranged to be about 4 inches below the ground line, and a piece of 400 lb. G.I. Wire passed round the pole and below the upper flange of the bend is used to fix the bend rigidly in position against the pole.

If Wood Troughing is used for the underground conduit it is brought right up against the surface of the pole and a hole cut in the cover to allow the cable to emerge and be taken up the pole.

Sufficient cable is drawn through the conduit to provide a lead up to the pole to the Block, Terminal. The joint between the cable and the Block, Terminal, is made on the ground. The cable is fixed to the pole by lead cleats which are nailed to the pole at intervals of 2 feet, starting 10 feet above the ground level. The portion of the cable that is to be covered by protective capping, as described below, is fixed to the pole by suitable pieces of lead strip. The Block, Terminal is fixed in position by means of screws. Care should be taken that the Block is not strained during the fixing operations, and that there is no stress on it in its final position.

A ten foot length of Rolled Steel Capping is used to protect the cable on the lower part of the pole. This capping is approximately D shape in section and accommodates a cable up to one inch in diameter, or two cables 11/16 in. in diameter. The capping is allowed to rest on the upper flange of the split bend or on the cover of the Wood Troughing when troughing

is used and is fixed to the pole by Galvanized Dog Spikes, at intervals of 2 feet. A little Compound No. 6 is applied to the joint between the capping and the bend, and between the pole and the bend, if the joints are not sufficiently close to exclude soil. Similarly, some simple method of packing the junction between the capping and the wood troughing and the troughing and the pole is adopted.

The capping is galvanized, but additional protection from the atmosphere should be afforded by painting on both sides with Black Paint for Ironwork.

The capping can be readily removed for repainting or to allow access to the cable when desired.

Should it be required to lead a cable of greater diameter than 1 in. up a pole, a C.I. Split Bend No. 24, associated with an appropriate size of W.I. Pipe, is used to protect the cable.

Should it be required to connect the underground route to the open line through a pole test box, the Block, Terminal is fixed immediately below the pole test box and protected by a suitable wooden casing made locally. The twin leads from the Block, Terminal are Cable I.R.V. Core, 1 pr/40, for connection to the pole test box terminals. The leads from the open wire side of the test box are of Cable I.R.V. Core, 1 wire/40, and are protected by a wooden casing until they reach the level of the arms.

The termination of underground Balanced Trunk Cables carrying phantom circuits on Main Distributing Frames is effected by joining the Paper Core Cable to Wire V.I.R. 2 pr/20 M.T. Lengths of wire are cut off and the taping removed from each wire for the length required for jointing *plus* the length of the solid joint. The V.I.R. wires are then passed through a suitable piece of lead sleeve 8 in. to 12 in. long, the length varying with the number of wires in the cable. The end of this sleeve, which is to be joined to the Paper Core Cable, will be packed with cotton wool and dressed down tightly over the V.I.R. wires. The sleeve is then held upright, and Compound No. 2 which has been raised to melting point poured into the cavity until it is full, care being taken whilst the compound is being run in to keep the sleeve warm, thereby ensuring a solid mass of compound when the liquid cools. A lead cap fitted with an air-nozzle is then soldered on the dressed side of the sleeve, and a pressure test applied to prove that the sleeve is airtight.

The open end of the sleeve is bound with Insulated Adhesive Tape 2 in., both sleeve and leads being covered for a distance of 4 in. After testing and numbering, the V.I.R.

leads are jointed to the Paper Core Cable in the usual way. The wire joints are soldered. The lead sleeve is then wiped on between the Paper Core Cable and the newly formed solid joint.

Cable, Enamelled Silk and Wool Core, Multiple Twin, is used for terminating trunk and balanced junction cables which do not carry phantom circuits.

Silk and Cotton Core Beeswaxed Twin Cable has been used for terminations in the past, and this type of cable will still be utilised for ordinary junction and subscribers' cables up to 200 pairs.

An ordinary straight joint is made between the Paper Core and the E.S. and W. and the S. and C.C. cables.

Wire, Enamel and Cotton Lapped, 1 pr/10, where convenient and economical, is used for terminating subscribers' and non-balanced junction cables above 200 pairs. The wire is stranded and bound together to form a cable of sufficient length for jointing to the paper core cable at one end and formed out and laced for termination on the main distribution frame at the other end. This operation is greatly facilitated by the use of a Forming Board. When the cable has been formed, the individual wires or groups of wires are held firmly in position by means of lacing twine which has been soaked in beeswax at a temperature of 300°–350° F. The free end of the cable is then passed through a length of lead sleeve long enough to reach from the paper core cable to a point a few inches above the floor level under the main distribution frame. Before jointing the termination to the paper core cables small pieces of cotton wool are forced in between the insulated conductors at each end of the joint where they enter the lead sheath, starting from the centre of the wires and working outwards so that each layer is thoroughly dealt with. The wires are then jointed, using soldered joints and paper sleeves. A lead sleeve placed in position previously on the paper core cable side is drawn over the joint and wiped. The joint is then tested with air pressure at not less than 20 lb. per square inch. The joint is finally made solid with Compound No. 2, using a portable oil blast furnace.

The street cables converge in an External Chamber of suitable size and the Paper Core Cables are led by the most direct route to the Engineering Test Room, where they are connected to one of the terminating cables described above. The length of the terminating cable is kept as short as possible.

All cables are properly arranged and supported. In vertical runs, where cables are exposed, lead strips are sweated on to the cables, from 4 to 6 feet apart, and the strips secured to plugs in the wall. In horizontal runs, the cables are supported

on the wall by means of wall hooks, spaced about 3 feet apart. A packing of lead strip is placed between the cable and the wall hook.

**Tapping Out.**—Before the joint at the terminating point is made, the wires working inwards to the Main Distribution Frame and outwards to the Paper Core Cable are carefully tapped out and numbered by means of Detectors.

The cables to and from the Main Distribution Frame are usually led from the bottom, laced out carefully, secured with lacing twine and tagged to the Frame. The cable forms, made up, from the junction of the Paper Core Cable to the frame, are not taped, but where the cable forms run alongside ironwork, the ironwork, at points of contact, is covered with Adhesive Tape. Where the horizontal bars of the M.D.F. are made of channel iron, the channel is fitted with hard wood strips to carry the cable, both the hardwood strip and the cable being secured to the ironwork by lacing twine.

(31862) Wt. 1258/8299 1500 5/36 Hw. G.344 (T.S. 8)

# LIST OF
# Technical Pamphlets for Workmen

*(Continued)*

**GROUP D**—*continued*

18. Distribution Cases, M.D.F. and I.D.F.
19. Cord Repairs.
20. Superposed Circuits, Transformers, Bridging Coils and Retardation Coils.
21. Call Offices.
22. Units, Amplifying. (*Not on sale.*)

**GROUP E**

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

**GROUP F**

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

**GROUP G**

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

**GROUP H**

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

**GROUP I**

1. Submarine Cables.

**GROUP K**

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

S.O. Code No. 43-9999