WS No. 19 Mark III

PW—11

I.1

Post Office Engineering Department

TECHNICAL PAMPHLETS FOR WORKMEN

Subject

SUBMARINE CABLES

ENGINEER-IN-CHIEF'S OFFICE
1919

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 Communications. (*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 Systems.

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GROUP C.

1. Wireless Transmission and Reception.

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GROUP D.

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18. Distribution Cases, M.D.F. and I.D.F.

[*Continued on page iii of Cover.*

† Out of print.

FOR OFFICIAL USE

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.

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CORRECTION SLIP TABLE (*cont.*)

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SUBMARINE CABLES

(I 1)

The following Post Office Technical Instruction is of kindred interest :

T.I.XV. Cordage and Tackle.

SUBMARINE CABLES

TABLE OF CONTENTS.

SUBMARINE CABLES

Submarine cables are generally laid and maintained by the Submarine District. It is not, however, proposed to deal in this short pamphlet with cable-ship work, but to present some description of the cables used across rivers and docks and occasionally in shallow sea water, and of the nature of the work involved in laying and repairing them.

1. DESCRIPTION OF TYPES AND THEIR USE.

Submarine Cables differ in type from those used on underground Land Lines. Where it is possible to select a river or dock crossing in a position free from the interference of steamers and small vessels, and where there is not likely to be much movement of the cable, paper core, lead-covered cables similar to those used on Land Lines are provided, but with the addition of a single iron wire armouring, or double steel-tape and iron-wire armouring. For other positions, cables with a core of stranded copper insulated with Gutta Percha and protected by armouring wires are used. The lead-covered cables known as "armoured cables" usually carry a varying number of conductors weighing 10 to 20 lbs. per mile which are built up as required. The completed lead-covered cable is covered with a layer of tanned jute yarn, and then served, in the case of single armouring with galvanised iron wires. The sheathed cable receives two coatings of compound and two servings of tanned jute yarn laid on in contrary directions. Where heavier armouring is necessary the lead sheathing receives, as in the case of the single wire armoured cable, a layer of jute yarn and then two steel tapes, jute servings, and a sheathing of galvanised iron wire, with two servings of jute yarn over all.

The Gutta Percha core cables known as "Submarine" cables and containing 1 to 28 wires are built up as follows :—

Each conductor is formed of a strand of 7 copper wires

This formation possesses greater flexibility than a solid conductor, allowing for the coiling and handling to which the cable is subjected. The stranded conductor is covered to a specific thickness with layers of Chatterton's Compound and Gutta Percha. For sea use, the cores are wound with a pliable brass tape as a protection against the Teredo worm, which experience has shown to have been the cause of faults on cables not so protected. The cores prepared for 1 to 28 wire cables are wormed and served with jute yarn, to make up a cylindrical form, and receive the sheathing wires. Cables containing from 1 to 8 cores are made up of stranded copper conductors, each weighing 107 lbs. to the nautical mile, and covered with Gutta Percha insulation weighing 150 lbs. to the nautical mile (2,029 yards). Above 8 wires each copper conductor weighs 42¼ lbs.; and the Gutta Percha 55 lbs. to the nautical mile. During the late war, however, a reduction of the weight of copper to 42¼ lbs. and of the Gutta Percha to 55 lbs. in the 2 to 8 core types has been much resorted to, and these cables will frequently be met with, and will continue to be used very largely in the future for short distances. The core made up as above is sheathed with galvanised iron wires, varying in number and gauge, as the size of cable and its position require. Fig. 1 shows the successive layers and coverings in a 1-core cable, and is typical of the remaining types. Fig. 2 shows a cross section of a 2-core cable, approximately full size.

A sheathing of 280-mil. wire is provided for cables which may be subject to interference, or where they are laid over a rocky sea or river-bottom. A lighter sheathing of 108-mils. is provided where the position is more favourable. Table 1, page 19, will be found useful in the identification of the cables generally in use.

2. CABLE LAYING.

As already stated, the work of cable laying is usually carried out by the Submarine District staff, and with the aid of properly equipped ships; but in shallow waters vessels of shallow draft have to be used, and improvised methods adopted in fitting up the craft for the cable service. The craft, usually a motor lighter, or a tug and barge, with a large rowing boat, is selected having regard to suitable coiling space for the cable (see Table 2, page 20) and a clear run for paying out the cable over the stern. Sheaves are suspended along the docks, or, alternatively, spars are lashed in position to serve as runners and guides. A brake is provided near the stern by means of hand-worked lever spars, which are made to bear on the cable as required during the paying-out operation. As every case of cable laying presents its own special difficulties in the kind and depth of water, sand and mud banks, rate of tide, etc., the actual method of cable laying cannot be laid down as a definite and invariable procedure. In tidal river, as well as in sea-work, high water slack tide usually presents the opportunity for landing the shore end, and

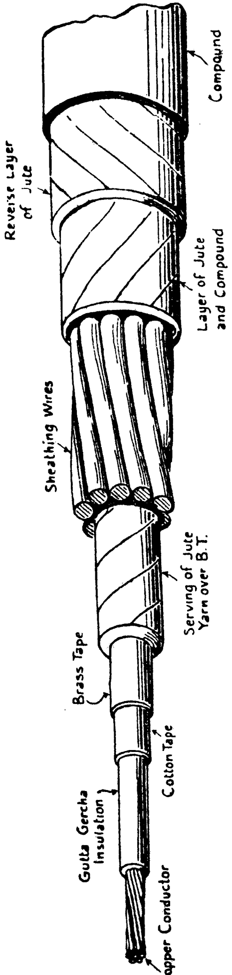


Fig. 1.

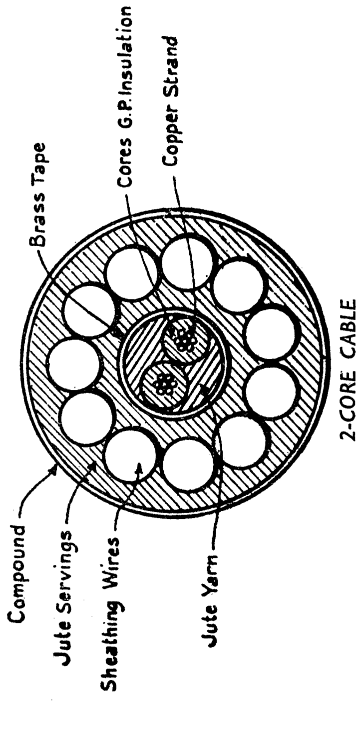


Fig. 2.

the craft would anchor as close in-shore as possible at such a time; would send its boat ashore with a light line made fast to a rope on the craft, and the land party would haul first on the line, then on the rope, and finally on the cable, until sufficient cable had been drawn ashore to reach to the terminal point, —a cable hut or pole test box. The cable should be secured by rope or chain attachments to suitable posts on shore, before the craft weighs anchor. This is a necessary precaution, since in the initial stages of paying out it occasionally happens that sufficient weight is put on the cable to pull it from its termination. When all is secure on shore, the craft steams away at slow speed, paying out the cable as it proceeds, and taking compass bearings throughout of objects on land to ensure that the line routed is followed. The cable is paid out, and the slack regulated by means of rope or wire stoppers on the cable, or by means of the brake referred to previously.

After the cable has thus been laid out, and when the craft is within a safe distance of land (having regard to depth of water and tide conditions), the anchor is let go, and a rope taken ashore. The cable is then turned over to bring the test box end, which is undermost in the coil on board, uppermost, and the rope having been made fast on the cable, the hauling ashore proceeds. In providing for the securing of the shore end it should be borne in mind :—

(*a*) **that the Gutta Percha insulation perishes with exposure to sun and heat ;**

(*b*) **that the fouling of the cable by a vessel's anchor may result in the cable being torn from its termination, with some damage to the pole test box or cable hut.**

Steps should therefore be taken to bury the shore end of the cable to a good depth, where possible, and to secure it by fixing hooked bars well driven into the ground, or by rag bolts, chain attachments, etc. Very little can be done to bury a cable laid over rocks or up the face of a cliff, and where such a landing cannot be avoided, the utmost should be done to observe the precautions indicated above as far as possible.

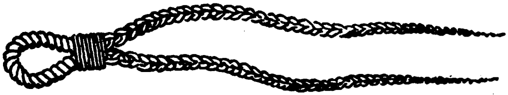
In dock work cable chutes are often constructed which allow of the cable being readily laid and secured. The services of a diver are of course necessary for cleating the cable in position. Where chutes do not exist, a position across the dock free from berthing interference is selected, and this is usually near the lock gate entrance. The cable is laid out above and from one side of the dock to the other, and a " bight " formed sufficient to allow for the distance down the two dock walls and across. After making secure on each side, a double rope is passed round the cable on each side of the bight, and the cable is pulled out and fully extended. One end of each of the double ropes is then slipped, so that the cable falls into position. The cable is then made secure up to the point of entering the water. For very short river and canal crossings, other methods are adopted, such as drawing across from a drum or from a wagon by a working party or by a team of horses.

3. REPAIR WORK.

When a short cable across a dock or a river becomes faulty it is generally more economical to replace it than to attempt to repair it.

When a cable lies in comparatively shallow water, repairs in the case of the longer river crossings are often successfully undertaken by " under-running," with the aid of a tug and barge or other suitable craft. In these cases a rope attached to a float is fastened to the cable at low-water mark, and this is picked up when there is sufficient water for the boat to come in shore. The cable is then raised with blocks and ropes until it can be carried over the boat and placed in sheaves fixed fore and aft of the vessel. It is then hand-hauled and (assisted by tackle if necessary) passed over the boat until the fault is reached, blocks and ropes being used if necessary. If the cable is broken, the end is buoyed, and the cable under-run from the other side until the second end is secured. If sufficient slack is not obtained to overlap the first (buoyed) end, a sufficient length of new cable is inserted between the broken ends. The method of jointing and splicing is described later.

In other cases of river crossings where heavy cables are concerned, or where strong tides have to be contended with, and also in sea work, more powerful means of dealing with the work become necessary. The craft is selected with reference to the conditions to be dealt with. The first essential is that the vessel should possess good lifting appliances. It is usual to select one having a powerful winch—if possible one with double barrels and independent action, and to fit the vessel out with bow sheaves and other running sheave tackle. The vessel should provide good hold space for cable, and have a reasonably clear fore-deck for grappling, hauling-in, jointing, splicing and paying-out operations. A sufficient supply of grapnels (Fig. 4), buoys (Fig. 5), sheaves (Fig. 6), " mushroom " anchors (Fig. 7), and brake gear are placed on board, together with hemp and wire

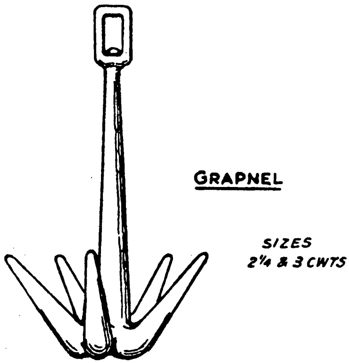


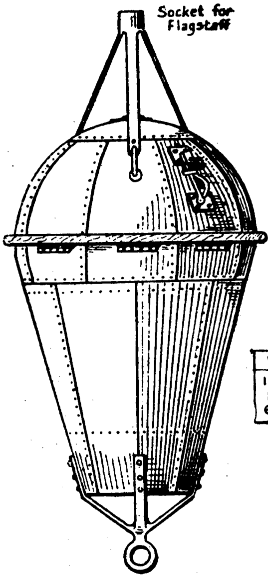
ROPE STOPPER

Fig. 3.

ropes, stoppers (Fig. 3), chains, swivels, shackles, jointing, and splicing tools, and a length of new cable.

Fig. 4.

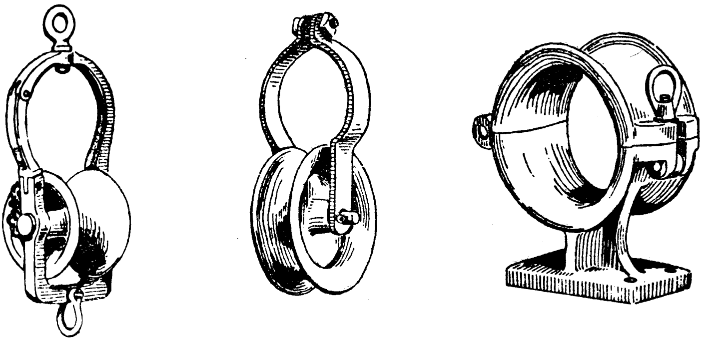




WEIGHTS	SAFELOADS
1QR 18LBS	3 CWT
1½ CWT	6½ CWT
6¾ CWT	12½ CWT

Fig. 5.

The following description of a repair on one of the heavier-type cables will also serve to indicate the procedure with a light sheathed cable; except that in the latter case the winch



SHEAVES & BELL MOUTHED LEAD

Fig. 6.

may generally be dispensed with, and the cable hauled inboard by hand or by blocks and ropes.

The vessel proceeds to the scene of the fault as located by tests from the shore and marked on a chart. This position is found by compass bearings of shore objects, or by taking angles with a sextant. A buoy, secured to a mushroom anchor (Fig. 7) with a suitable length of rope, is dropped overboard as a mark.

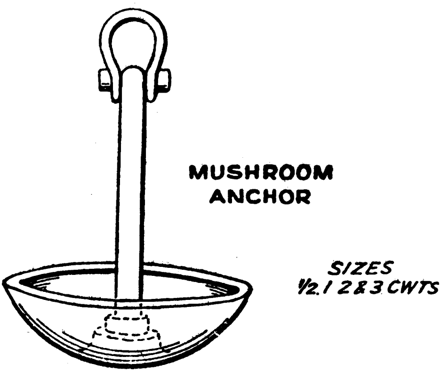


Fig. 7.

A grapnel (attached usually to a wire rope connected with the winch barrel) is then paid out over the bow sheave; and the vessel steams at slow speed, or, if the tide is suitable, is allowed to drift across the cable line. The cable may not be picked up at the first attempt, and the grappling drives are repeated as frequently as are found necessary. The grappling rope is watched (or generally sat upon) during this operation, and the strain on the rope when the cable is hooked is readily detected. If the vessel is grappling astern, as is often found expedient, it is given a touch ahead as soon as the cable is hooked, to prevent any heavy strain being put on the cable. The tension of the grappling rope is, however, steadily maintained in order to prevent the cable slipping off the grapnel, and as the vessel comes over the line of the cable the hauling in by winch commences. If there is evidence of a heavy strain it is wise to cease hauling, ease a little, then maintain the strain and let the vessel ride to the cable. Frequently the cable is embedded in sand, and by so "nursing" it, is lifted out of the sand, and the hauling may again proceed. This process may have to be repeated many times before the cable finally reaches the bows. Two chains are laid over the bow sheaves for "stoppering" on the cable, one on each side of the bight caught by the grapnel. The chain on the side on which the cable is believed to be good, is shackled to a rope, and taken to the second barrel of the winch, and the chain on the other side of the cable may be made off on a bollard. The making off of the ropes or chains on the cable is usually done from a chair slung over the bows. As soon as the cable is secured, it is cut through with a hack saw close to the grapnel. The side which is made fast to the bollard is paid away and the first end is then hauled inboard for testing, and stoppered off at the bows. If this side proves good the other end may then either be abandoned by being slipped overboard, or, if storage space permits, it may be hauled inboard and coiled. The core of the good length is then sealed to keep the water out, and is served with yarn, and laid back within the sheathing wires. A buoy prepared for the cable is next placed in position on one side of the vessel, secured by a suitable length of rope and chain to a mushroom anchor placed near the bow sheaves, and the buoy rope made fast along the side of the vessel by yarn strands. The size of the buoy used is determined by the depth of water, the weight of chain and rope it will have to support, and by the strength of tides. The cable is next paid away and lowered, streamed out, and finally the mushroom is let go, its weight carrying away the yarn strand holding the buoy rope, and the buoy is slipped overboard, as the rope runs out. The vessel is manœuvred throughout the operation to maintain its position, and also to prevent any strain coming on the cable, and, with the slipping of the buoy, goes astern to prevent the fouling of her propeller by the riding buoy. The other end of the cable is now grappled for in the same way as before, with the same procedure of hauling in, etc. Two good ends having been obtained, preparations are made for jointing and splicing to the new cable on board. The sheathing wires on the new cable are opened out for a distance

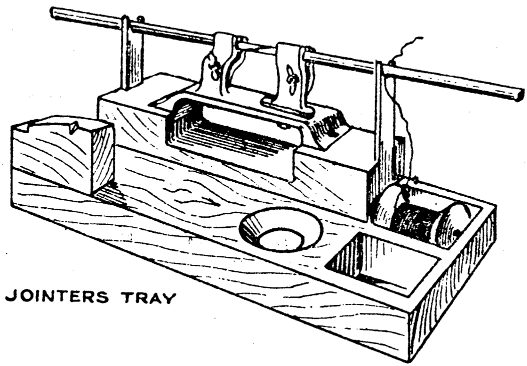
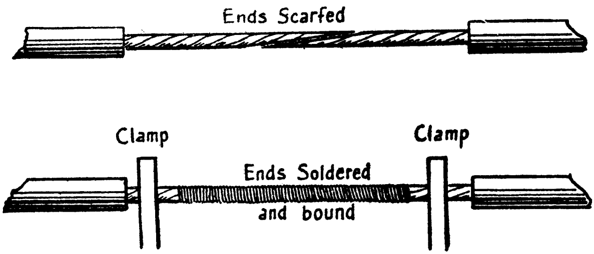


Fig. 8.

of about 10 yards, and the exposed core is cut away with the exception of 4 feet required for jointing. The sheathing wires are cut away on the old cable for 3 feet and bound so as to keep them in place (see Fig. 10). The conductor joint is next made. The insulation on each core is removed for 1½ in., the copper strand is opened out, each of the seven wires is scraped and cleaned bright with glass paper and then twisted up again to form a strand as before. Each end is soldered and trimmed and is then filed down obliquely on one side. The rough corners left by the solder are filed off and smoothed with glass paper. The ends are now clamped in the jointers' tray (Fig. 8) and brought close together fitting truly and presenting a bright silvery appearance.

The joint is now bound with fine copper binding wire to within ¼ in. of the clamps on each side, the binding being of open spacing to allow of removal after the solder has been run in. A neat solid joint is thus made, and the binding wire is removed. A further close binding is laid on in the middle part of the joint and soldered. A second wrapping is then laid on to near the clamps on each side. This is soldered at each end only, and close to the clamps. The joint is smoothed off and is now ready to receive the insulation (Fig. 9).

The soldering fluid is first cleaned off the joint by rubbing with a clean rag soaked in naphtha, and the joint given a coating of Chatterton's Compound worked over to cover every part, smoothed with the smoothing iron, and worked over with the finger and thumb to ensure that there are no air bubbles in the covering. The Gutta Percha of each core is now warmed up and drawn down until within about ½ in. apart. One end is then drawn down to a point and the other end worked over it, completely covering the copper joint. After being warmed



CONDUCTOR JOINT
Fig. 9.

up and well smoothed down, a second serving of compound is given to the Gutta Percha. A strip of Gutta Percha sheet 3 in. × 1½ in. is next warmed up and one end laid under the joint and worked from one end to the other, in one direction only, with an upward pressure. It is again warmed up and worked round the core until every part is completely covered. The overlap of Gutta Percha above the joint is nipped together and cropped by scissors close to the core. It is again warmed up, worked, and smoothed over. A second strip of Gutta Percha about 6 in. × 1½ in. is next laid on and worked in the same way, so as to taper on to the core on either side. It is given an additional coating of Chatterton's Compound, again smoothed over by rubbing with the hands well moistened. The completed joint with the copper conductor well centred and with a complete fusion of the layers, measures from 6 in. to 9 in. long and is very little larger in diameter than the core.

In jointing multiple core cables the cores should be cut so that the joints can be "staggered" or separated to avoid damage by compression when the core is re-covered by the sheathing in a splicing. In cables up to 8 cores the distance apart is generally about 6 inches, but in the lighter types and greater number of cores, 4 inches is sufficient. Great care is required to cut the wires to the correct length, otherwise, when the set of joints has been completed, there may be a slack or tight wire. A good and convenient method is to cut the cores

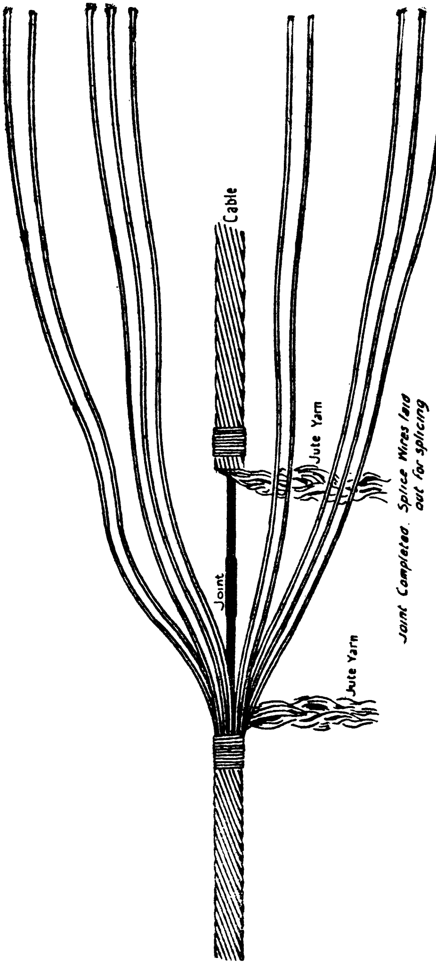


Fig. 10.

SHEWING WIRE LAPPINGS

Fig. 11.

with the help of a 6 or 4 inch measure, say, a wooden stick ¼ in. square.

Considerable practice is required to produce a really good

Gutta Percha joint. Cleanliness in the operation is essential; air bubbles must be excluded, as they would, sooner or later, result in the breakdown of the insulation owing to the pressure to which the joint is subjected at the sea bottom. Beginners practise on short lengths of core, and on completion slice up the joint insulation with a sharp knife to prove the centring of the conductor and the fusion of the layers. The layering should not be visible in a well-made joint. When the joint has been cooled the co.e is first covered with cotton tape, then with brass tape, and finally with jute yarn, and the sheathing splice is then commenced. The sheathing wires from the new cable are laid out in twos and threes as shown in Fig. 10 and are in turn wound round the yarn-covered core and over the sheathing wires of the old cable. With iron sheathing there is little difficulty in laying-in the wires in the proper position by hand. As the wires are carried round into position, they are bound with soft iron lapping wire at intervals to prevent any springing out of position. Fig. 11.

The sheathing is then served with tarred yarn by means of the serving mallet, illustrated in Fig. 12. This splice, known as the "overlap splice," has now almost entirely superseded the old "butt" splice in cables of light type.

The "Butt" or "laid in" splice is perhaps more difficult to make, but it is far neater and will stand more handling. The ends should be prepared in the same manner as for the "overlap." The cable end from which the core has been removed is called the "long end," and the other end the "short end."

When the joints have been covered in, half the wires on the "long end" should be laid in as far as the sheathing wires of the "short end," and then unlaid in pairs. One pair should be selected and laid in on the "short end" after a corresponding pair has been removed. The first pair should be carried to the full length, cut off and trimmed so that the butted wires are on the top; they are easily trimmed off with bolt clippers and should be butted" so as nearly to touch the ends of the pair cut out on the "short end." A piece of tarred tape is then served over the "butted" ends, three inches on either side of the "butt," and completed with a lapping of G.I. wire No. 14. The next pair is then taken and laid in in the same way and "butted" a yard and a half from the first pair and so on until the last pair, which are "butted" just clear of the joints. In this way the joints are clear from the "butts" as those "butts" are all on the "short end." The splice is then served with spun yarn.

The distance apart of the "butts" depends on the length of the splice and the number of sheathing wires and, in the case of short splices made in boats, three or four wires may be "butted" instead of two and the splice will still be extremely strong provided that the lappings have been tightly served on with a mallet.

Although the "laid in" splice seems a more lengthy proceeding than the overlap, with an experienced gang of men it can be made almost as quickly.

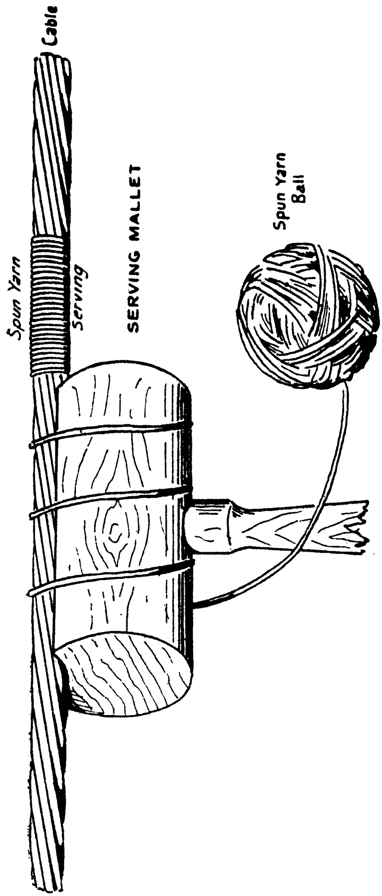


Fig. 12.

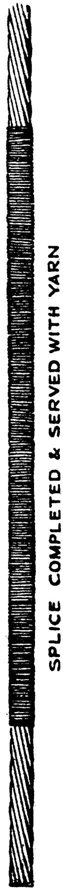


Fig. 13.

When all is ready the paying-out of the new length proceeds. The cable is allowed to run out, and is checked by means of the brake and stoppers as the vessel makes her way to the buoyed end, which was left on page 12. The buoy is picked up, the buoy rope taken to the winch, and the end hauled inboard. Two ends are now over the bow sheaves, the cable paid out is stoppered, and the recovered end is brought well inboard, stoppered, and formed in preparation for the joint and

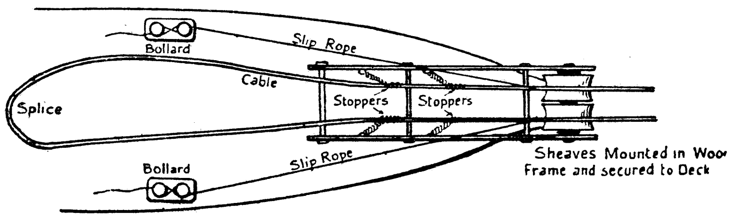


Fig. 14.

splicing operations. These having been carried out as already described, the repaired cable remains inboard in the form of a bend or " bight." Slip ropes are fastened to each side of the cable near the bows, and taken round bollards on either side of the vessel. The stoppers at the bows are next removed, and the slip ropes are eased away carefully to allow the cable to pass out-board. There is a considerable pulling force on the ropes, but the turns round the bollards easily hold the cable. The bight is guided clear along the decks and over the bow sheaves, still held by the ropes which also pass out over the sheaves. As the cable reaches the water, it is suitably streamed out, and at the word of " cut " the ropes are simultaneously severed. The ends fly overboard and the cable sinks to its position. Fig. 14 shows the deck plan of the preparations made for the paying out of the final splice.

The following alternative method of slipping the bight is sometimes adopted. A double tailed stopper is put on to the cable and the end of a slip rope of Manilla is put through the loop of the stopper and made fast to a bollard ; the standing part of the rope is taken to the winch end. The weight is taken by the winch, the stoppers removed and the bight eased over the bow sheave and, when suitably streamed, the short end of the slip rope is slipped and the rope hove on board. The only loss in this case is the stopper which, of course, remains on the cable.

The repair operation is completed with the picking up of the mark buoy laid at the commencement of the operations.

TABLE I.

CABLES, SUBMARINE.

Cable. Description. (*See Note.*)	Weight of each core Copper Gutta Percha per n.m.	No. of sheathing wires.	Dia. of sheathing wires in mils.	Approx. dia. of cable. inches.	Approx. weight of cable per n.m. tons.
*1 core LS BT	107/150	17	96	0·8″	2
1 ,, HS BT	107/150	10	280	1·5″	7·25
2 ,, LS NBT	42¼/55	17	108	0·9″	2
2 ,, HS NBT	42¼/55	10	280	1·5″	7·5
2 ,, HS BT	107/150	11	280	1·6″	7·75
*3 ,, HS BT	107/150	11	280	1·6″	8
4 ,, LS NBT	42¼/55	19	108	1·1″	2·5
4 ,, HS NBT	42¼/55	10	280	1·6″	7·75
4 ,, HS BT	107/150	12	280	1·7″	8·6
*6 ,, HS BT	107/150	14	280	1·85″	10·5
*7 ,, HS BT	107/150	14	280	1·9″	10·5
8 ,, LS NBT	42¼/55	30	108	1·5″	4·5
8 ,, HS NBT	42¼/55	13	280	1·9″	10
8 ,, HS BT	107/150	20	280	2·4″	15·5
*12 ,, HS NBT	42¼/55	14	280	2·0″	12
16 ,, HS NBT	42¼/55	16	280	2·2″	12·5
28 ,, HS NBT	42¼/55	19	280	2·4″	15·5

* Obsolescent types.

NOTE.—3-, 6- and 7-core cables are not twinned and are, therefore, unsuitable for telephone working.

Nautical mile = 2,029 yards.

Mil .. .. = $\frac{1}{1,000}$ inch.

Maximum C.R. per nautical mile—
107 lbs. copper 11·26 ohms at 75° Fahr.
42¼ ,, ,, 28·52 ,, ,,

NOTE.—LS = Light sheathed.
HS = Heavy sheathed.
BT = Brass taped.
NBT = Not brass taped.

TABLE II.

TO FIND LENGTH OF CABLE WHICH CAN BE ACCOMMODATED IN VESSEL'S HOLD OR OTHER SPACE AVAILABLE FOR RECEPTION OF CABLE.

$$\text{Length of cable in yards} = \frac{136\ (h-5)\ (R^2-9)}{d}$$

where h = height in feet to under-deck beams from bottom of hold.
d = diameter of cable in inches.
R = outer radius of coil in feet.

NOTE.—The above formula allows for all deductions in respect of irregularities in coiling, eye or cone space, and working head-room in hold.

TABLE III.

MANILLA ROPE.

Breaking Strains and Safe Loads.
(According to Admiralty requirements.)

Size of rope (circumference).	Approx. weight per 120 fathoms.	Approx. breaking strain.	Factor of safety.
Inches.	lbs.	tons.	
6	826	11·5	6
5½	672	9·75	6
5	567	7·75	6
4½	462	6·5	6
4	380	5	6
3½	287	3·75	6
3	210	3	6
2½	150	2	6
2	91	1·35	6

TABLE IV.

FLEXIBLE STEEL WIRE ROPE.

Breaking Strains and Safe Loads.
(According to Admiralty requirements.)

Size of rope (circumference).	Approx. weight per 20 fathoms.	Approx. breaking strain.	Factor of safety.
Inches.	lbs.	tons.	
6	620	96·6	6 (for 6 to 2½)
5½	560	81·6	
5	460	67·8	
4½	300	44·8	
4	240	35·6	
3½	180	27·6	
3	140	19·5	
2½	90	13·5	
2	55	8	

TABLE V.

CHAIN.

Breaking Strains and Safe Loads.
(According to Admiralty requirements.)

Size of Chain (diameter of iron of link).	Approx. weight per 20 fathoms.			Approx. proof load.	Factor of Safety on proof load.
Inches.	cwt.	qrs.	lbs.	tons.	
1	10	2	6	18	2½ (for 1 to shackles)
$\frac{7}{8}$	8	0	9	13.75	
$\frac{3}{4}$	5	3	16	10.125	
$\frac{11}{16}$	4	3	26	8.5	
$\frac{5}{8}$	4	0	10	7	
$\frac{9}{16}$	3	1	10	5.5	
$\frac{1}{2}$	2	2	10	4.5	
$\frac{7}{16}$	2	0	0	3.5	
$\frac{3}{8}$	1	1	25	2.531	
Shackles and shackle pins				$6{\cdot}75d^2$	

d = diameter

TABLE VI.

LIST OF GEAR GENERALLY REQUIRED FOR WORK IN A TUG AND BOATS FOR SHALLOW WATER WORK.

The gear taken, however, will generally be arranged according to the nature of the repair it is required to make.

3 Small buoys and moorings.
2 Bladder buoys.
2 Grapnels.
1 Grapnel rope.
1 Brake set.
1 Bow baulks for tug.
1 Bow baulks, small, for boats.
2 Cable sheaves.
4 Stoppers.
2 Manilla lines, 2½ in., 20 fms.
2 Manilla lines, 2 in., 20 fms.
2 Manilla lines, 2 in., 10 fms.
12 Lashings, 1½ in. manilla, 5 fms., and
*1 Coil 1 in. wire rope in two lengths of 100 fms. each.
2 Heaving lines, hemp, 1½ in.
12 pairs leather gloves.
1 Handspike.
2 Cable horses.
2 Tackles.
1 Jointer's tent.
1 Cable grip.

* This will be required should the cable be broken in a narrow channel, so that the rope may be secured to the cable and then buoyed away from the traffic.

One jointer's box, complete, with supply of G.P. sheet, Chatterton's compound and wood naphtha.

One box of cable tools, containing :—

4 Serving mallets.
1 Cable pricker.
2 Hammers.
1 pair easy bolt clippers.
1 pair large pliers.
1 Hacksaw and spare blades.
4 Cable knives.
½ cwt. spun yarn, 3 yarn.
1 Roll prepared tape.
1 Small roll brass tape.
14 lb. G.I. wire, No. 14.
4 lb. G.I. wire, No. 18 (if for lightship work).
2 lb. petroleum jelly.

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LIST OF
Technical Pamphlets for Workmen
(Continued)

GROUP D—*continued.*

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 Exchanges—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.

GROUP L.

1. " Safety First " for P.O. Engineering Workers.

† Out of Print.