WS No. 19 Mark III

P.W.–D.17.

Post Office Engineering Department

TECHNICAL PAMPHLETS FOR WORKMEN

Subject:

Internal Cabling and Wiring.

ENGINEER-IN-CHIEF'S OFFICE,
1919.

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INTERNAL CABLING AND WIRING.

(D.17.)

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TABLE OF CONTENTS.

INTERNAL CABLING AND WIRING.

GENERAL PRINCIPLES.

Classes of Installation.—Installations may be classed under three main heads :—

1. Trunk and Long Junctions.
2. Subscribers' and Short Junctions.
3. Telegraphs.

(1) *Trunk and Long Junctions.*—In this class the " speaking efficiency " is the most important consideration. The external paper-core cables, owing to their high insulation, low capacity, and good conductivity, have a high " speech efficiency." It is impracticable to maintain an equally high standard in the internal cabling, and for this reason it is essential that the internal cabling should be reduced to a minimum. A very high standard of internal wiring must be maintained and, except for short distance wiring in switchboards and to apparatus, all cables employed should be lead-covered types. The conductors forming a speaking pair must be twinned and, where external paper-core cables are designed for superimposed circuits, the multiple twin formation should be retained up to the transformer racks.

(2) *Subscribers' and Short Junctions.*—With this class the number of circuits involved is very large and the speech efficiency requirements are less stringent. In dry situations the less expensive types of braided cables may be used for internal wiring. As exchanges should always be " dry," switchboard cables are largely employed for internal wiring. The twin formation of wires forming a speaking pair must be maintained.

(3) *Telegraphs.*—A high insulation is necessary and the requirements are somewhat similar to trunk wiring, except that single conductor cables are employed in most cases.

Design of Installation.—The chief points to keep in mind with internal wiring are :—

(a) Speech efficiency of circuits.
(b) Security from damage.
(c) Accessibility for maintenance.
(d) Facilities for extension of plant.
(e) Economy of cost.
(f) Reduction of fire risk.
(g) Neatness and appearance.

The best lay-out, including such points as selection of runs, type of cable, and methods of supporting cables, will strike a sound balance between these somewhat conflicting requirements, their relative importance varying with the class of installation.

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Damage to be Guarded Against.—Damage may arise from mechanical injury, damp, and from direct or indirect contact with other plant carrying electric current. Wires or cables should be kept not only well clear of electric lighting or power circuits, but also of all metallic pipes, particularly compo. gas-pipes.

Protection Against Damp and Mechanical Injury.—Damp is the chief enemy. Main frames or other equipment on which cables are terminated should be in dry situations. Cable runs should be selected which avoid the dangers from damp or mechanical injury. Generally, lead-covered cables are used for trunk and telegraph wiring, as a high standard of insulation is necessary, and for subscribers' wiring in damp situations. Cheaper types of braided cables are used for subscriber and junction wiring in dry situations. Lead-covered cables should be used in under-floor runs where it is necessary to protect from mechanical injury, rats or fire danger.

Wood casing or iron troughing is used as a protection against mechanical damage.

Wires or cables passing through floors to a higher or lower level require special protection against floor sweeping and washing. The protective casing or covering used for this purpose should project above the floor level.

Unless properly constructed cable chutes are built, long under-floor runs should be avoided. Where such runs are unavoidable, sheet-iron floor troughing should be used unless the floors are of special fire and damp-proof construction.

Lift shafts are best avoided for important cable runs owing to the danger of mechanical injury and difficulty of access.

Fire Risk.—Lead-covered cables reduce the fire dangers. Braided cables must be made "flameproof" by impregnating the coverings with suitable chemical sizing material which is flameproof but does not absorb moisture.

The ends of vertical chutes should be closed by packing asbestos fibre tightly round the cables to prevent the chute acting as a chimney in the event of a fire. A similar precaution is necessary where a number of cables pass through a floor.

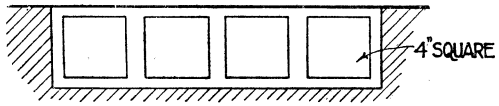
Uralite sheets placed between layers of jumpers on main frames and between layers of cables in switch sections reduce the fire dangers. There is a slight tendency for moisture to condense on the surface of the uralite. A small air space should therefore be left where practicable between the uralite and the wiring.

Economy of Cost.—Short runs are obviously desirable. For subscriber wiring, dry runs which enable braided cables to be used reduce the cost. Cheap construction on trunk wiring may be false economy. The lay-out of exchange plant is always planned with a view to economy in cabling. In a large sub-

scribers' exchange it is desirable to have the I.D.F. close to the switch sections, relays and meters, even if it is necessary to place it some distance from the M.D.F.

METHODS OF SUPPORTING CABLES.

In large exchanges, where many cables are involved, special supports are designed for cable runs. For lead-covered cables,

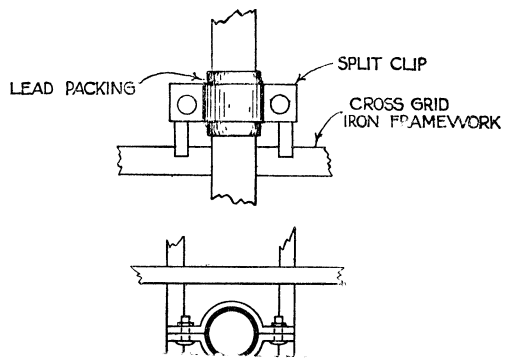


DOULTON DUCTS BUILT INTO WALLS FOR LEAD COVERED CABLES

Fig. 1.

conduits or cable chases are usually built into the wall. A common type of conduit is the square Doulton duct shown in Fig. 1. With this arrangement intermediate supports for the cables, even on vertical runs, are not necessary.

If lead-covered cables are run in large vertical chutes, the cables should be secured at six feet intervals by plumbers' tacks



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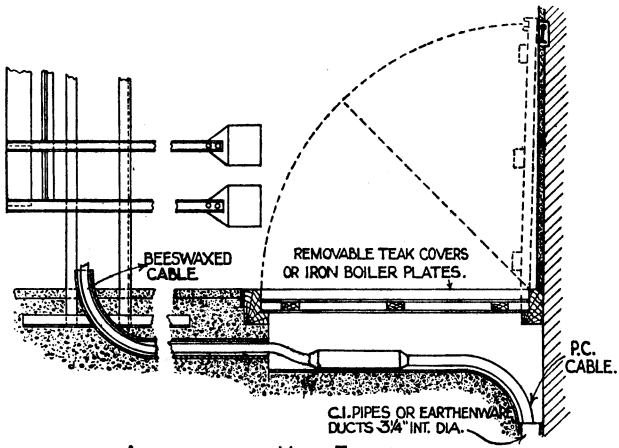
Page 3. Last paragraph. *Add at end :—*

Where the cable enters the pipe at the top of the run "Plugs, Hardwood," sawn through lengthwise and shaped to the size of the cable should be wedged between the cable and the pipe entering the cable trench.

The method of leading external cables to the main frame is shown in Fig. 3.

Switchboard cables are usually carried on cable racks made by a light flat iron framework supported from the ceiling or walls. Iron troughing suspended from the ceiling is sometimes employed.

It is undesirable to run switchboard cables in closed conduits where there is danger from damp. In vertical runs, where it is necessary to carry them in cable chases, the packing with asbestos fibre at each floor level should be designed to support the weight of the cables.



LEADING INTO MAIN FRAME.

Fig. 3.

In small offices, small cables, if few in number, should be cleated separately to the walls by means of zinc cleats or clips unless protection from mechanical injury is necessary. Wood casing or (where greater cable accommodation is required) iron troughing is used when several cables are run together or where it is necessary to protect from mechanical damage. In cases where it is necessary to carry the wiring externally, lead-covered cables in galvanised iron troughing are employed. Iron troughing used externally should be painted. Lead-covered cables of more than ½ in. diameter are supported every four to six feet by plumber's tacks. The lead strip or tack is secured to wood plugs driven into the wall.

CUTTING AND PLUGGING WALLS.

Cutting Walls.—Hole cutting and drilling should not be wholly carried out from one side. To prevent splintering woodwork or forcing off sections of plaster, indications of the cutting or drilling tool should be looked for upon the far side. When the breaking out point has been ascertained, the tool should be withdrawn and the cutting completed in the reverse direction. Careful measurement and level drilling will enable a cutting to be made from either side at will.

Plugging Walls.—Skill of hand rather than strength of arm is essential to neat wall plugging. The plugs supplied by the Department are $\frac{3}{4}$ in. square and from 2 in. to $2\frac{1}{2}$ in. long. To carry heavy cables larger plugs, about $2\frac{1}{2}$ in. long by 1 in. square, are required. They should be made of well seasoned

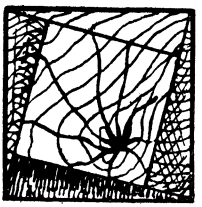


Fig. 4.

hardwood and cut as shown in Fig. 4. A solid fixing such as brickwork should be selected where possible. A cold chisel 9 in. × $\frac{5}{8}$ in., or a 10 in. × $\frac{5}{8}$ in. jumper, driven by a carpenter's hammer No. 6, is the most suitable tool for wall plugging.

TYPES OF CABLES AND COLOUR SCHEMES.

Switchboard Cables are employed for wiring subscribers' and junction circuits between the M.D.F., I.D.F., switch sections, and apparatus, and also for apparatus wiring in trunk switchboards. The cable, which usually has a $9\frac{1}{4}$ lb. tinned copper conductor, is provided in four sizes, 21, 42, 63, and 84 wires. It will be noticed that all these figures are multiples of 21, each cable being designed for the wiring of 20 subscriber or junction positions with one spare wire, or group of wires, for clearing faults; 21, 42, 63 or 84 wire cables are employed according to whether 1, 2, 3 or 4 wires per position are necessary.

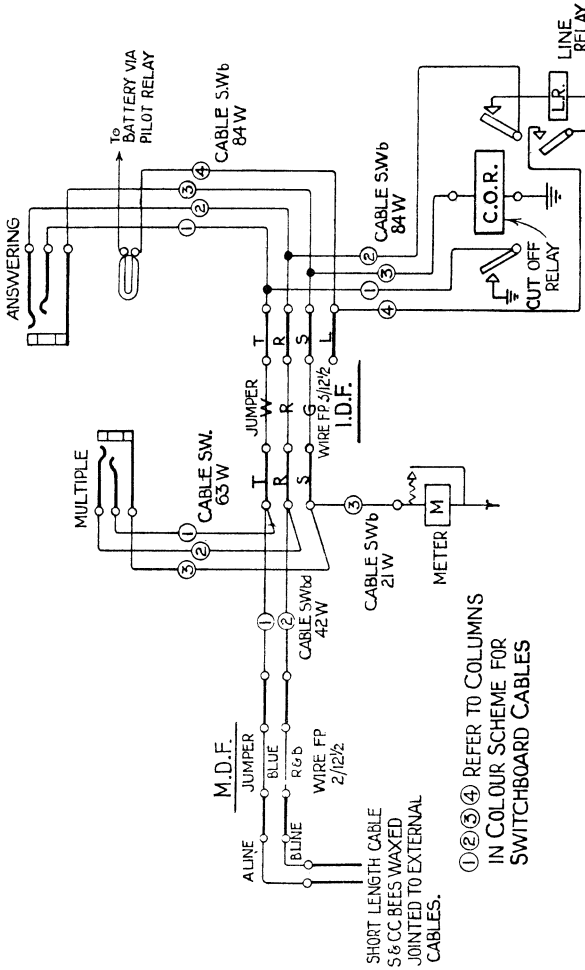


Fig. 5.

EXAMPLE OF USE OF SWITCHBOARD CABLES IN WIRING A C.B. EXCHANGE.

Fig. 5 illustrates part of the wiring of a C.B. exchange to show the use of switchboard cables. The cables are made flat, oval, or round to suit the various requirements. The conductors are insulated with layers of silk and wool, but earlier types were insulated with silk and cotton. The outer coverings consist of wool, paper tape, waxed paper, lead foil and flameproof braiding. A high insulation is, therefore, possible in dry situa-

Colour scheme for Switchboard Cables.

Pairs.		Pairs.	
Column 1	Column 2	Column 3	Column 4
1. Blue	White	22. Red, blue	Red
2. Orange	,,	23. Red, orange	,,
3. Green	,,	24. Red, green	,,
4. Brown	,,	25. Red, brown	,,
5. Slate	,,	26. Red, slate	,,
6. Blue, white	,,	27. Red, blue, white	,,
7. Blue, orange	,,	28. Red, blue, orange	,,
8. Blue, green	,,	29. Red, blue, green	,,
9. Blue, brown	,,	30. Red, blue, brown	,,
10. Blue, slate	,,	31. Red, blue, slate	,,
11. Orange, white	,,	32. Red, orange, white	,,
12. Orange, green	,,	33. Red, orange, green	,,
13. Orange, brown	,,	34. Red, orange, brown	,,
14. Orange, slate	,,	35. Red, orange, slate	,,
15. Green, white	,,	36. Red, green, white	,,
16. Green, brown	,,	37. Red, green, brown	,,
17. Green, slate	,,	38. Red, green, slate	,,
18. Brown, white	,,	39. Red, brown, white	,,
19. Brown, slate	,,	40. Red, brown, slate	,,
20. Slate, white	,,	41. Red, slate, white	,,
21. Red	,,	42. Red, white	,,

21 wire cables are made by cols. 1 or 3. 1913.
42 wire cables are made by cols. 1 and 2 twinned.
63 wire cables are made by cols. 1 and 2 twinned and col. 3.
84 wire cables are made by cols. 1 and 2 twinned with 3 and 4 twinned.
Wires coloured as col. 1 are used for tip or "A" wire.
Wires coloured as col. 2 are used for ring or "B" wire.
Wires coloured as col. 3 are used for sleeve or test wire.
Wires coloured as col. 4 are used for lamp.

Cable, E. and C. Core (lead covered), is used for battery lead power generator leads, wiring of supervisors' desks, and other cases in subscribers' exchanges where under-floor runs are necessary, or

where, for other reasons, protection from damp or injury is required It is made in various sizes with 10 lb. or 20 lb. conductors. The wires are coloured in a scheme similar to switchboard cables. The conductors are insulated with enamel and covered with two lappings of cotton impregnated with wax.

Cable, Silk and Cotton Core, single (lead covered), was used for trunk and telegraph wiring from main frames and protector cases to test boards and switch sections, and for subscriber exchange wiring in special cases when protection from damp was required. For the latter purpose it has been superseded by Cable E. and C.C., whilst for trunk wiring a higher grade cable—Cable E.S. and W. core, M.T.—has been introduced.

Cable, Silk and Cotton covered, beeswaxed (lead covered), is used in short lengths for terminating paper-core subscriber and junction cables, and also for short runs in internal trunk wiring. For very long runs it is more economical to use a paper-core cable terminated at each end by a short length of cable S. & C. core, beeswaxed. In terminating *external* cables, the red wire is used for the *A* line and the white wire for the *B* line.

TERMINATING CABLES.

Cable Waxing.—The ends of switchboard and S. & C.C cables must be waxed before connecting to tag strips. The outer covering and wrappings are first removed for a length equal to the length of required lacing *plus* two or three inches, care being taken that the wires are not damaged in the process. The stripped ends are then immersed in beeswax at boiling point and kept immersed until all air bubbles have ceased to appear on the surface of the wax. When taken out, the wires are carefully wiped with a clean cloth to remove superfluous wax. If the wax is absolutely at boiling point before immersion and reasonable care is exercised, not only will the silk and cotton coverings of the wires be saturated and coated, but the molten wax will have crept well up beneath the covered portion of the cable and have effectively sealed it against the entrance of damp.

The following three points to avoid fire risks are important :—

1. The proverb which says a watched pot never boils does not refer to a wax pot. The unwatched pot boils and also may cause a bad outbreak of fire.

2. A bucket filled with sand is a valuable stand-by.

3. Wire cuttings, cable strippings, or other inflammable material should not be allowed near a heating wax pot.

Cable "Forming" and "Lacing."—These are terms applied to the work of leading wires out of a cable at short spacings for the purpose of making them off upon soldering tags. The principles are explained below.

Cable Forming or Lacing Board.—This is illustrated in Fig. 6. It is a stout frame of wood used for the purpose of lacing cable wiring for switchboard jacks. *A* is a button or clamp holding the cable firmly in position while being formed. *B* is a row of ten pins spaced along the frame round which, as shown, one pair or one set of wires is bent at right-angles to the cable. *C* is a sliding section of the frame which can be adjusted to

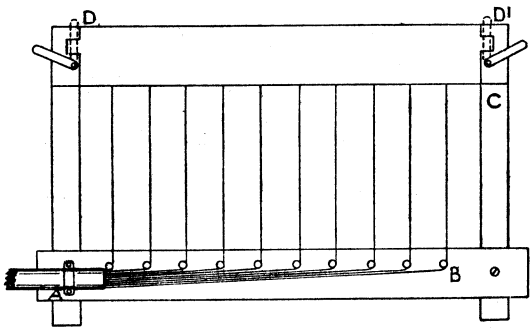


Fig. 6.

the length of lacing required. The jack to be wired lies between *D* and *D*1, which indicate the clamps holding it rigid when turned to the dotted position. The tags of the jack, of course, point in the direction of the pins. The board here described provides a means for forming out and lacing the cable wires and for soldering them to their respective tags on the jack.

The lacing of the cable, a very important part of the work, is carried out with lacing twine immersed before use in molten wax. The lacing should commence with a double turn at the butt of the cable and continue in single twine to the end, one tie being made at the point at which each pair or set of wires is turned out from the cable. It is essential that in every tie the knot be self-binding, or the lacing will run back to the butt and the cable lose its formation. The proper knot and the

Page 11, line 8. *Add at end* Wire V.I.R. 2 pr/20 M.T. is used for this purpose.

Page 11. Jumper Wires. Lines 10 and 11. *Amend to read:—*

Triple. Coloured White ; Red ; Green.

Quad. Coloured White ; Red ; Green ; Red-Green.

Page 11. Power Leads. *Delete paragraph and insert :—*

Lead covered cables should always be used for power distribution leads. Cable E. and C.C. 5pr/20 is the usual type for wiring Battery Racks or Power Distribution Boards to switch sections, for both signalling and speaking purposes. As far as possible cables for power leads should be run apart from other wiring. Cable E.L., Impregnated Paper Core, is used for secondary cell leads.

Page 11. Earth Connections, line 4. *Delete* soft, 7/16 *and insert* soft 19/16 and 37/16.

1/24

Page 12. *Delete first two lines and insert :—*

Wire, Copper, soft, 19/16 strand is sufficient at exchanges from 300 to 5,000 lines and 37/16 at larger exchanges. At exchanges with wall pattern switchboards the earth wires from the plates are continued to the protectors by means of Wire, Copper, soft, 3/20 or 7/18 strand, and at exchanges with floor pattern switchboards by means of Wire, Copper, soft, 7/16 strand.

1/24

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conductors are insulated with enamel, in addition to the silk and wool coverings. In terminating enamelled wire cables, care must be taken to remove the enamel before soldering to the tags.

Special arrangements are necessary for terminating long distance trunk cables which carry phantom circuits, so as to maintain a proper balance and a very high insulation up to the transformers. wire V.I.R. 2 p/20 mT is used for this purpose.

JUMPER WIRES.

When cables have been laced out on tag strips they should not be disturbed unless renewal or replacement of equipment or cables is necessary. Jumper fields are provided, *e.g.*, in M.D.F. and I.D.F., to enable cross-connections between cables to be made or altered without disturbing the cabling.

The types of wire used for jumpers are :—

Wire, Flameproof—

Single. Coloured White.
Twin. Coloured Blue ; Red and Blue.
Triple. Coloured ~~Red~~ White ; ~~White~~ Red ; Green.
Quad. Coloured ~~Red~~ White ; ~~White~~ Red ; Green ; Red-Green.

In damp situations *Wire, Enamelled and Flameproof,* should be used.

A consistent colour scheme should be used in jumpering so that one colour is always used for the same purpose. Any jumper wire made spare should at once be removed.

POWER LEADS.

Lead-covered cables should always be used for power distribution leads. Cable I.R. and C. 5-pair/20 is the usual type for wiring Battery Racks or Power Distribution Boards to switch sections for both signalling and speaking purposes. As far as possible cables for power leads should be run apart from other wiring. Cables E.L. 3/18, 7/18, or 7/16, which are lead-sheathed impregnated paper cables, are used for secondary cell leads.

EARTH CONNECTIONS.

A very low resistance earth is required at telephone exchanges and large telegraph offices. Several small earth plates in parallel are better than one large earth plate. *Wire, copper, soft,* 7/16, is employed for the main earth lead, which should be run as straight as possible, especially from lightning protectors.

Wire, copper, soft, 3/20, is sufficient for six switch sections, and 7/18 for a larger number of sections.

Wire, E. & F.P., 1/20, is used for connecting the common earth to switch spring tags.

All metal frame work should be earthed.

LABELLING AND RECORDS.

Great care is necessary to ensure that labelling and records are clear and kept up-to-date. Card records should be kept of all cross-connections on main frames and I.D.F's. For permanent work labels should be engraved.

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[*Continued on page iv. of Cover.*

LIST OF

Technical Pamphlets for Workmen.

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GROUP E.

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1. Subscribers' Apparatus C.B.
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