

Crown Copyright Reserved

PW—A5

# Post Office Engineering Department

## TECHNICAL PAMPHLETS FOR WORKMEN

*Subject*

### Protective Fittings

ENGINEER-IN-CHIEF'S OFFICE

1919

*(Reprinted March, 1927, incorporating amendments to date)*

(	,	March, 1929,	„	„	„	)
(	„	April, 1930,	„	„	„	)
(	„	Dec., 1931,	„	„	„	)
(	„	June, 1933,	„	„	„	)
(	„	Sept., 1935,	„	„	„	)

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

1935

Price 6d. 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.

# PROTECTIVE FITTINGS

(A. 5)

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

- A.1 Magnetism and Electricity.
- D.1. Elementary Principles of Telephony.
- D.14. Maintenance of Manual Telephone Exchanges.
- D.18. Distribution Cases, M.D.F. & I.D.F.
- F.8. Wiring of Subscribers' Premises.

## TABLE OF CONTENTS.

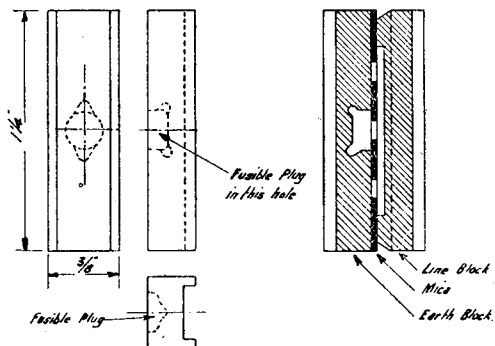
	PAGE
PROTECTORS ... ..	5
HEAT COILS ... ..	9
(a) EARTHING TYPE ... ..	9
(b) BREAK TYPE ... ..	13
FUSES ... ..	13
HOW PROTECTIVE DEVICES OPERATE ... ..	14
MOUNTINGS ... ..	16
(a) EXCHANGE EQUIPMENT ... ..	16
(b) SUBSCRIBERS' EQUIPMENT ... ..	24

# CORRECTION SLIP TABLE

Serial No. of Slip :	Date of Issue :	Corrections carried in	
		on date :	by (initials) :

INNER (EARTH) CARBON  
WITH FUSIBLE PLUG

SECTION OF INNER AND OUTER  
CARBONS AND MICA



OUTER (LINE) CARBON  
CHAMFERED AND RECESSED

MICA FOR PROTECTORS D

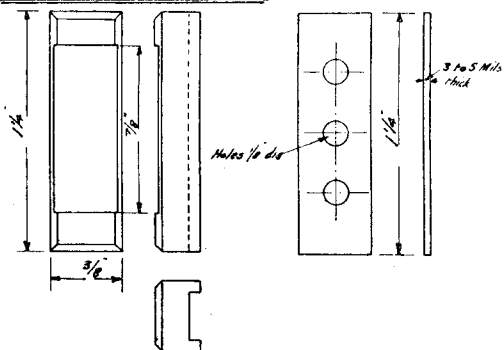
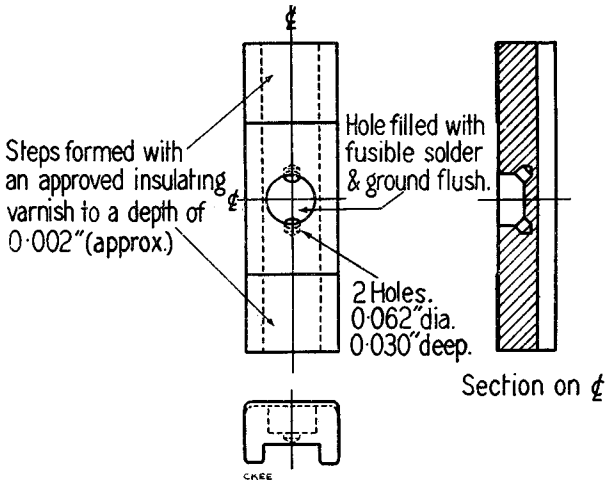
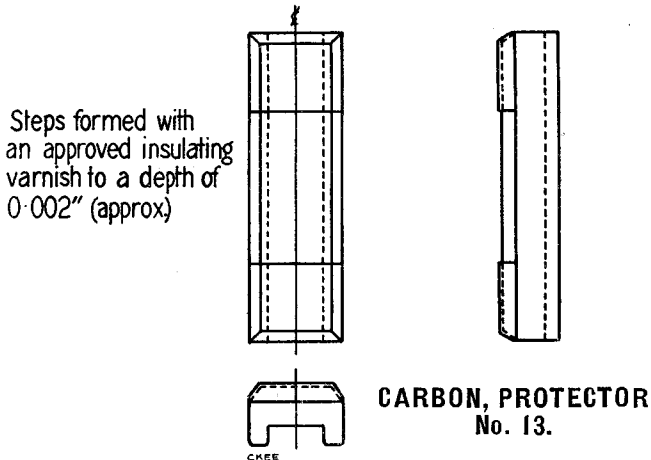


Fig. 1.

CARBONS, PROTECTOR, Nos. 10 and 11.



CARBON, PROTECTOR  
No. 12.



CARBON, PROTECTOR  
No. 13.

Fig. 2.

CARBONS, PROTECTOR, Nos. 12 and 13.

## PROTECTIVE FITTINGS.

**Telephone and Telegraph apparatus is safeguarded** against damage from lightning discharges, or heavy currents resulting from contacts with power or lighting circuits, **by means of protectors, fuses and heat coils.** These devices are so designed and constructed as to remain unaffected by the normal speech and signalling currents, but they act automatically whenever a current passes of sufficient magnitude or pressure to harm the apparatus. By their action the line is either disconnected and the foreign current isolated, or a direct earth connection is applied to the line providing a path for the current without passing through the apparatus.

### PROTECTORS.

The name "Protector" is usually applied to that portion of the protective apparatus which is operated by lightning or high voltage discharges. Lightning Protectors usually consist of two electrodes—one connected to *line* and the other to *earth*, the electrodes being separated by a small spark gap which breaks down at comparatively low voltage. The spark gap protectors used by the Post Office are of two classes:—

- (1) Open or air gap ;
- (2) Vacuum (air or other gas at very low pressure).

A satisfactory lightning protector should possess the following properties:—

- (a) It should efficiently earth the line when the voltage exceeds approximately 500 volts.
- (b) It should carry heavy discharges without undue heating or arcing.
- (c) It should provide high insulation up to the point of breakdown.
- (d) It should restore the insulation when the potential of the conductor becomes normal.
- (e) It should be capable of easy examination, removal or replacement.

The carbon type of protector is now adopted almost universally for telephone and telegraph work.

The type in general use is Protector "D," but other types "C," "G," and "H" are in use for special purposes. The protector "C" is illustrated in Fig. 3. The electrodes are circular carbon discs  $1\frac{3}{8}$ " in diameter. The line carbon is mounted on a metal back plate with a projecting pin which fits into a hole in a connection plate or bar. The other electrode is held in position by a spring clamp which is connected to

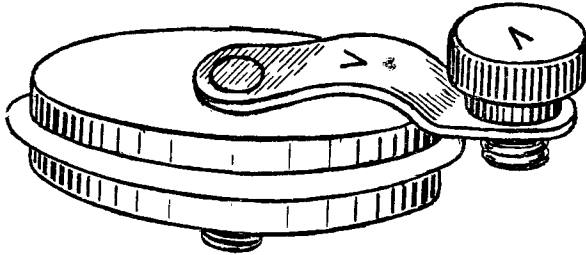


Fig. 3.

### PROTECTOR "C."

earth. The separator is a mica sheet with holes to form the spark gap. The separator is slightly larger in diameter than the electrodes in order to minimise leakage over the edges.

Protectors "C" are used for the protection of submarine or under-river cables. They are also used in pole test boxes "E" for the protection of underground cables connected to open wires, but in this case the carbon with metal back plate is made the earth electrode. It is an efficient lightning arrestor but should be fitted only in a dry situation.

As an office protector, it has been superseded by Protector "D." This consists of two carbon blocks of the shape and dimensions shown in Fig. 1. The inner or earth electrode has a recess in the centre into which is cast a fusible plug composed of an alloy containing bismuth, tin and lead. The melting point of this alloy is between  $200^{\circ}$  and  $212^{\circ}$  F. The plug is finished off flush with the surface of the carbon block. The outer faces of the carbon blocks are slotted and the slots engage with springs and guides on the mountings in which the protector is fitted. The face of the line carbon is recessed and the edges chamfered to reduce the risk of leakage between the two blocks due to dust bridging the gap. Between the carbons is placed a strip of mica three to five mils thick containing  $\frac{1}{8}$ " holes as spark gaps. In the latest design of Carbons, Protector Nos. 12 and 13 the line carbon is not recessed (see Fig. 2). Both active surfaces of the carbons are first treated with a film of insulating varnish to seal in carbon dust produced in manufacture and to prevent low voltage leakage due to atmospheric



dust without appreciably affecting the breakdown voltage. The spark gap is formed by steps of high grade insulating varnish applied to the ends of the active faces of the carbons to a thickness of approximately 2 mils each, the mica separator then being unnecessary.

The **external line** is always connected to the spring which engages the slot on the *outer carbon*, and the spring which engages the slot on the *inner carbon* is connected to *earth*. A pressure of 500 volts or more between the two carbon blocks (i.e., between the line and earth) is sufficient to spark across the air gap, and in cases where the pressure is maintained the resulting arc generates sufficient heat to melt the fusible plug on the inner carbon. The molten metal runs, making permanent contact between the two carbons and thereby earthing the line.

Protectors "D" are efficient and cheap, take up little space, but must be fitted in dry situations.

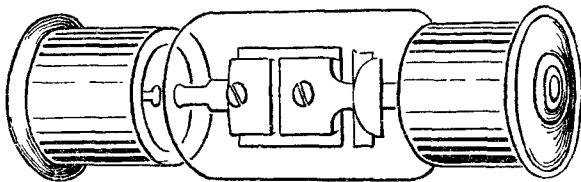


Fig. 4.

#### PROTECTOR "G."

Protector "G" is illustrated in Fig. 1 (b). The electrodes are metal blocks enclosed in a gas-filled vacuum tube; overall length  $2\frac{1}{2}$  inches and diameter  $\frac{3}{4}$  inch. The protectors can be fitted in Pole Test Box "E" by means of clips G 1 and G 2, whilst wire extensions can be fitted locally when it is necessary to fit this type in Pole Test Boxes "A" or "B." The protector is used in test huts and old pattern Pole Test Boxes where, owing to dampness, a protector with open spark gap cannot be employed.

Protector "H" is similar to "G" but is provided with special end clips for attachment to the terminals of transformers fitted in pole boxes. A protector is connected between the terminals of each winding of a transformer in order that lightning discharges may be diverted from the coils. "G" and "H" protectors do not require to be tested periodically, but some become faulty with age. If trouble is experienced on a circuit and the efficiency of the protector is suspected, a new one should be fitted and the old protector returned for test.

For testing purposes "Boards, Vacuum Protector Test," consisting of a Coil, Induction No. 5, a cylindrical condenser

and a press key, are employed. The spark gap across the secondary winding of the induction coil should be adjusted to  $\frac{1}{8}$  inch. If the contact breaker on the primary side is properly adjusted the coil should work with one Leclanché cell. When the coil is adjusted to give a good spark across the  $\frac{1}{8}$  inch gap, a single protector connected between the secondary terminals should glow when the key is depressed. If no glow or if sparking is observed between the protector electrodes, the protector is faulty.

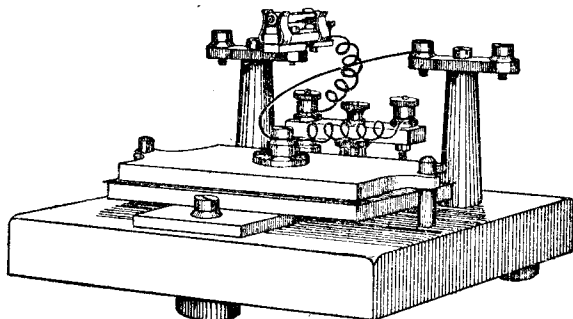


Fig. 5.

### PROTECTOR TABLET.

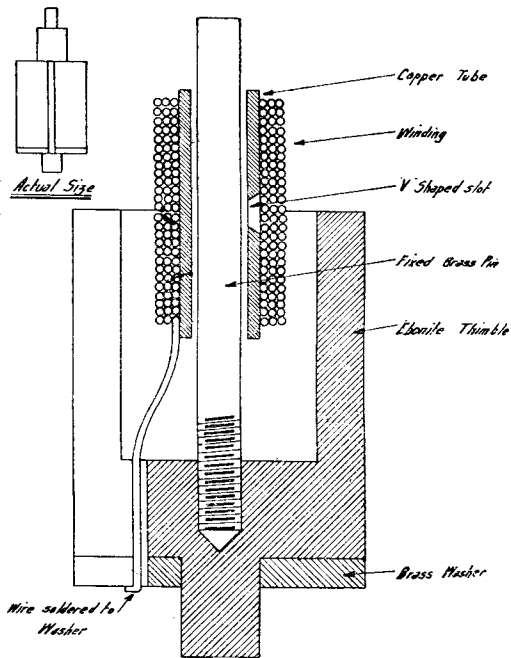
Protector Tablet (Fig. 5) consists of a plate protector, a bobbin protector and a one-ampere fuse, and is used for the protection of main submarine cables at the junction of the cables and land lines. The electrodes of the plate protector are large brass plates separated by a large perforated mica disc. The bobbin consists of a coil of fine silk insulated wire wound on a brass bobbin. The silk-covered wire forms part of the line circuit and the bobbin is connected to earth. The silk insulation forms the spark gap and lightning surges break down this insulation and discharge to earth. The fuse is fitted as a final protection against heavy discharges. The open wire is connected to the line electrode of the plate protector and the submarine cable is connected to the fuse with the bobbin protector intermediate. The bobbin protector also acts as an inductance, but the external wire connections from the bobbin protector should also be spiralled to introduce additional inductance. An independent earth connection should be made to each tablet protector where two or more are fitted together so that alterations to one protector will not affect the others.

Spare bobbin protectors should be kept in the hut to provide for prompt renewal as the insulation of the silk wire is easily broken down by a heavy discharge.

## HEAT COILS.

The heat coil is a device designed to protect apparatus against damage from external currents whose pressure is insufficient to spark across the carbon protector, i.e., currents at a lower pressure than 500 volts. Two types of heat coil are in general use—the earthing heat coil, which, as its name indicates, connects the line to earth when it operates, and the break heat coil, which disconnects the line. As a general rule break heat coils are fitted in subscribers' premises and earthing heat coils at exchanges, although break heat coils will be found in most exchanges of the magneto type.

The earthing heat coil, known in the Engineering Department as the "B" type, is illustrated in Fig. 6. It consists of a fibre or ebonite split thimble, in the centre of which is a rigidly fixed



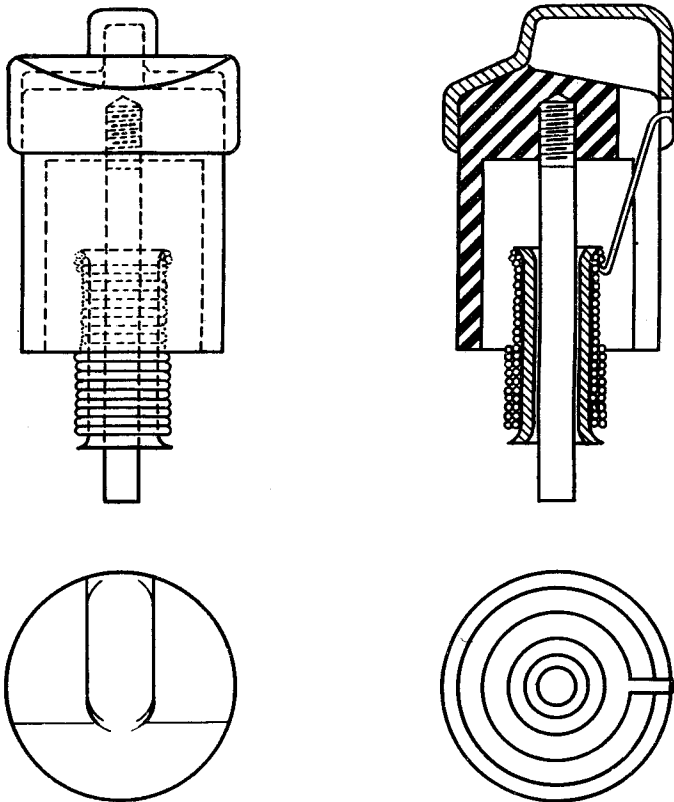
4 Times actual size.

Fig. 6.  
EARTHING HEAT COIL.  
"B" TYPE.

brass pin. Over this pin is slipped a small copper tube with a "V" shaped slot cut centrally on one side. The coil is wound over the tube as shown in the figure. One end of the winding lies in the "V" slot, and the wire, copper tube and brass pin are soldered together, a special solder with a low melting point being used. The other end of the winding passes through the ebonite thimble and is soldered on to a brass washer fixed on its outer face.

When mounted in the heat coil fitting (see Fig. 16) the external end of the copper tube rests on a fixed spring through which the brass pin passes and engages a lighter travelling spring. The ebonite thimble is pressed in the direction of the fixed spring by the outside spring, which bears against the metal washer. It will be seen that a circuit from the outside spring (which carries the internal line) to the fixed spring (which carries the external line) is completed through the winding of the coil. When a sufficiently heavy current traverses the winding the heat generated melts the solder in the "V" slot. The ebonite thimble then moves forward, carrying with it the brass pin, which slides through the copper tube. The end of the brass pin pushes the light travelling spring forward into contact with the earthed centre plate of the mounting, thereby earthing the line.

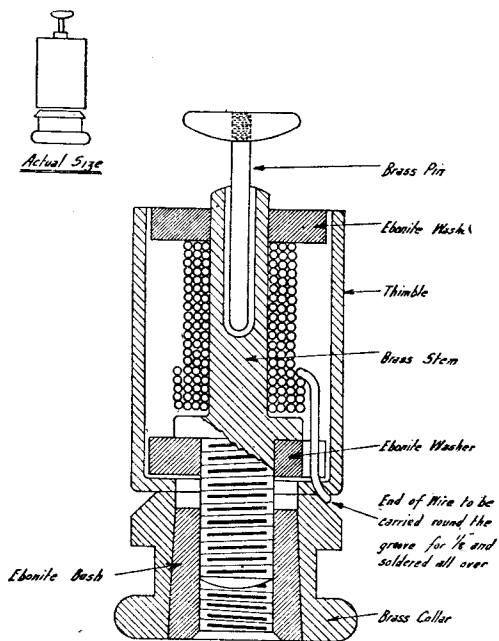
Referring to Fig. 16 it will be seen that the heat coil is connected in series with the line, the outer spring resting on the brass washer of the heat coil and the inner spring upon the copper tube. Providing all these contact points are clean a good connection is maintained, but as the exposed parts of these contacts tend to become dirty, and as the heat coil is free to revolve, the contact resistance varies considerably. For certain circuits, such as those used for picture transmission, such variations cannot be tolerated, and it is necessary for such circuits to use Heat Coil BB, Fig. 2A. In this heat coil the brass washer is replaced by a brass cap, which fits rigidly within the slot of the outer protector spring to maintain definitely the position of contact. The belled ends of the copper tube provide a knife-edge contact, free from superfluous solder, with the inner springs and also prevent the wire, forming the coil, from slipping off the copper tube.



CKEF

Fig. 7.

COIL, HEAT "B B" ASSEMBLY.



4 Times actual size.

Fig. 8.  
BREAK HEAT COIL.  
"A" TYPE.

The coil in general use is wound with double silk covered German silver wire to a resistance of approximately 4 ohms, and is specified to carry 0.35 ampère for 3 hours without operating, but to actuate with 0.5 ampère within 210 seconds.

The break heat coil, known in the Department as the "A" type, is illustrated in Fig. 8. The coil is wound over a central brass stem fixed inside a brass thimble. The stem is insulated from the thimble by means of ebonite washers fitted at either end. Immediately below the brass thimble is a brass collar fitted with a tapped and tapered ebonite bush. The brass stem passes through the lower end of the brass thimble and is screwed into the ebonite bush, thereby clamping the brass collar and brass thimble tightly together. The coil in general use is wound with double silk covered German silver wire to a resistance of approximately 5 ohms, and is specified to carry 0.3 ampère for three hours without operating, but to actuate with 0.5 ampère within 60 seconds. The inner end of the winding is electrically connected to the central brass stem and the outer end is brought out through the brass thimble, the end bared and laid in a groove between the thimble and the brass collar. The thimble, collar and wire are then all soldered together. The upper end of the central brass stem, as shown in the figure, is drilled to receive a brass pin. This pin is of such a diameter as to slide freely in and out of the hole in the stem, but is soldered to the stem by means of a special solder with a low melting point.

When mounted in the heat coil fitting (see Fig. 17) the heat coil is held in tension between two springs which engage respectively with the slot in the brass collar and the knob on the end of the brass pin. It will be seen that the circuit is completed from the one spring to the other *via* the convolutions of the coil. When a sufficiently heavy current traverses the windings, the heat generated melts the solder which is holding the brass pin in the hole in the central brass stem, and the tension on the springs pulls out the pin, thus disconnecting the circuit. The outer springs are usually provided with additional contacts which are arranged to complete a local bell circuit and give an audible alarm when a coil operates.

#### FUSES.

The function of the fuse is to disconnect the external line from the internal equipment after the operation of one or other of the earthing protective devices, viz., the carbon protector or the earthing heat coil.

The standard type of fuse now in use is illustrated in Fig. 9. It consists of a short unglazed porcelain tube of small bore with a metal cap cemented on each end. A piece of fine gauge fusible wire is threaded through the tube and soldered to the caps. The fuse is specified to operate within 30 seconds of the current reaching 3 ampères after having been increased from zero to this value during 30 seconds. It is held at the ends between spring clips which engage the bevels on the caps and maintain a constant inward pressure in order to secure a reliable electrical contact between the fuse and the springs.

A fuse of somewhat different type has recently been introduced in which the wire is enclosed in an asbestos tube. This tube is held in a thin framework of bakelite material. A metal cap is pressed on at each end which has knife edge extensions for fitting in side clips. The fusing current is the same as for the standard. An illustration of this fuse is given in Fig. 10.

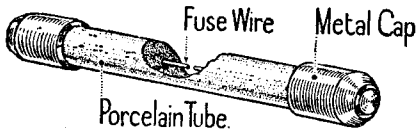


Fig. 9.

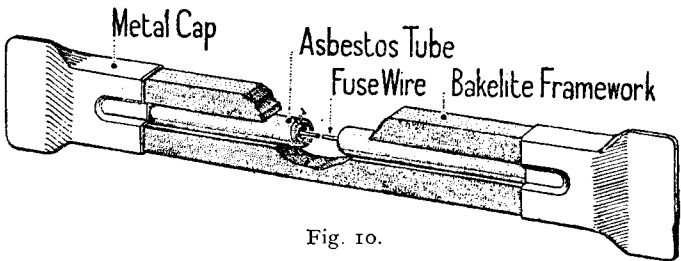


Fig. 10.

### HOW PROTECTIVE DEVICES OPERATE.

The manner in which these three devices—the protector, the heat coil and the fuse—co-operate in affording protection against external currents may now be considered. It will be most convenient to take the case where all the three items are connected in the line and a heat coil of the *earthing* type is employed. The external line is connected first to the fuse, then to the carbon protector, and, lastly, *via* the heat coils, to the internal apparatus, the various items being mounted in pairs so as to



provide full protection on each wire of the circuit. The conditions are illustrated diagrammatically in Fig. 11.

Assume first that the external line is subjected to a lightning discharge. This will pass along the line, through the fuse to the outer plate of the carbon protector, where it will spark across the gap to the inner block, whence it will be safely conducted to earth and dissipated.

The next condition to be considered is a contact between the external line and a source of high-pressure power supply, e.g., the 500-volt trolley wire of an overhead tramway system. The pressure, being 500 volts or over, is sufficient to spark across the carbons of the protector, and, being maintained, sets up an arc which, as has already been seen, melts the fusible plug and puts the line to earth. The earth connection results in a comparatively heavy current, which blows the fuse in circuit between the external line and the protector, thereby disconnecting the line entirely from the internal equipment.

Finally, assume that the line is placed in contact with a power or lighting circuit whose pressure is less than 500 volts. Such a pressure does not operate the carbon protector, and the foreign current passes along through the heat coil on to the exchange equipment, where it ultimately finds a path to earth. If the current reaches a sufficient magnitude to do harm to the exchange equipment, the heat coil operates and earths the line before any damage can be done. As in the previous case, this earth causes the fuse

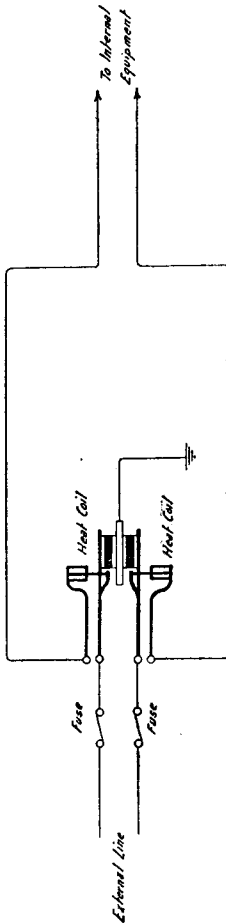


Fig. 11.

FULL PROTECTION WITH EARTHING HEAT COIL.

to blow and completely to isolate the faulty line.

It will be seen that, apart from lightning discharges, the final safeguard in every case is the fuse, and that the carbon protector and earthing heat coil are but the necessary adjuncts whose function it is to ensure its operation.

It should be noted that the earth connection, applied to the line by the carbon protector or earthing heat coil in an automatic signalling exchange, produces a false signal either on the subscriber's calling lamp or on the supervisory lamps in the connecting cord circuits, thereby calling attention to the defect if it has not already been brought to notice.

In the older exchanges, where fuses are not fitted, the break heat coil associated with the carbon protector has usually been employed (see Fig. 12). The heat coil disconnects the external line whenever a current passes of sufficient magnitude to harm the internal equipment, but, as the carbon protector is between

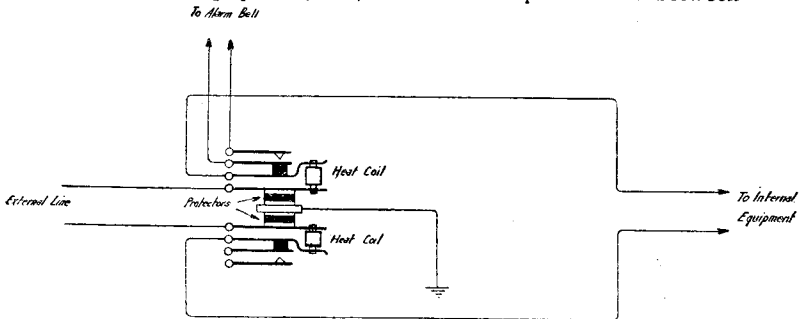


Fig. 12.

#### BREAK HEAT COIL AND PROTECTOR.

it and the external line, the heat coil does not necessarily operate when a high voltage current actuates the carbon protector, and in such an event the foreign current flows to earth across the protector carbons, and operates the fuse which, in such areas, is fitted in the external line adjacent to power crossings.

#### MOUNTINGS.

The protective fittings described are mounted in two different types of mountings, according to whether they are to form a portion of an exchange equipment or are to be installed in a subscriber's office.

(a) Exchange Equipment.—In an exchange the fuses are installed on the Main Distributing Frame at the point where the external cables terminate. The mountings are made in units, each accommodating 40 fuses and providing for the termination of 20 circuits. The standard unit has 20 fuses on each side of a centre plate of mild steel, which is zinc plated to prevent

corrosion. Clamped to this plate, and insulated therefrom and from each other, are the sets of German silver springs between which the glass tube fuses are held; opposite fuses on either

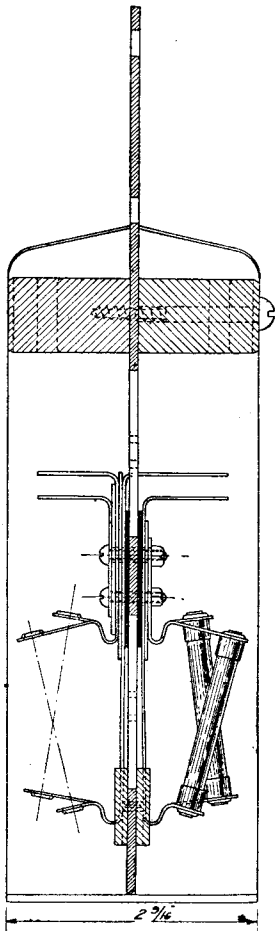


Fig. 13.  
M.D.F. FUSE MOUNTING.

side of the mounting plate constitute a pair and are connected to the A and B conductors, respectively, of one telephone circuit. The connections for each pair of fuses are brought out at the rear on tabs. To facilitate wiring, the tabs for the corresponding ends of the two fuses of a pair are arranged on the same side of the central plate. This necessitates carrying connections through from one side of the mounting plate to the other. The manner in which this is done can be followed in the cross section in Fig. 13. Considering the two top fuses, it will be seen that the front left hand spring is bent at right angles at the end remote from the fuse, where it passes across through a slot in the centre mounting plate. The similar cross connection from the rear right hand spring is made by means of the bolts which clamp the springs in position and an extra spring on the left hand side of the plate.

Alternate fuses are mounted at different angles or, to employ the usual term, are "staggered." This is done to give ease of access in removing and replacing fuses, and to lessen the risk of contacts between the metal portions of adjacent fuses without sacrificing compactness of design.

The noteworthy features of this type of fuse mounting are:—

- (1) Its low production cost, all its component parts being stampings;

- (2) The unit principle embodied in its design, which enables additional blocks of fuses to be fitted readily from time to time as required; and
- (3) The ease with which fuses can be removed and replaced for testing purposes without the use of a special tool.

In order that no troubles may arise from loose contact between the fuses and the springs, stringent precautions are necessary in manufacture to ensure the glass tube fuses being of uniform length and to secure springs of permanent resiliency.

An alternative type to the standard has recently been introduced for trunk, loaded, and other lines where a higher standard of insulation has to be maintained. It is shown in Figs. 14 and 15. Clips to accommodate the knife-edge type of fuse illustrated in Fig. 10 are mounted on ebonite strips which are fixed in a skeleton or gate form of framework. This framework is in two halves which are hinged separately and can be opened outwards. The soldering tags are merely short projections from the bases of the clips and in this respect are quite different from the older fitting where all tags are extended to the back. The external and internal line wires are brought through holes in the fanning strip (a separate hole being provided for each individual wire) and soldered to the tags. The hinging feature permits the two sides of the fitting to be opened out to facilitate wiring operations. Normally, however, the fitting is kept closed and latched. With this type of mounting extra care has to be taken to keep the wires from dragging taut and straining the connections. It may be mentioned that the fuses are easily removable without tools and the clips are convenient as testing points. A dust proof cover is provided for this mounting.

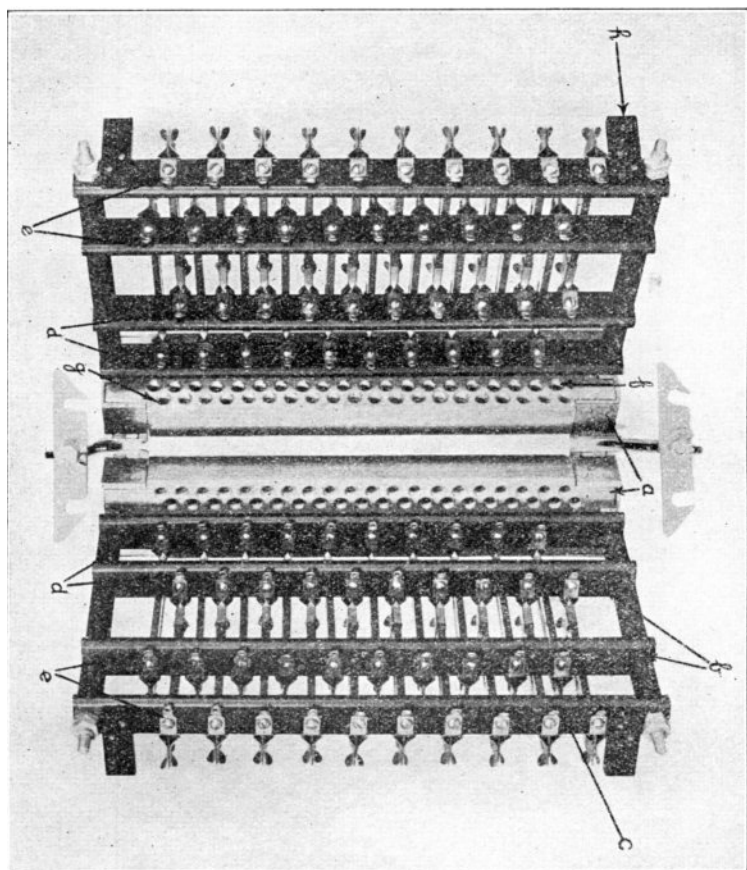


Fig. 14.

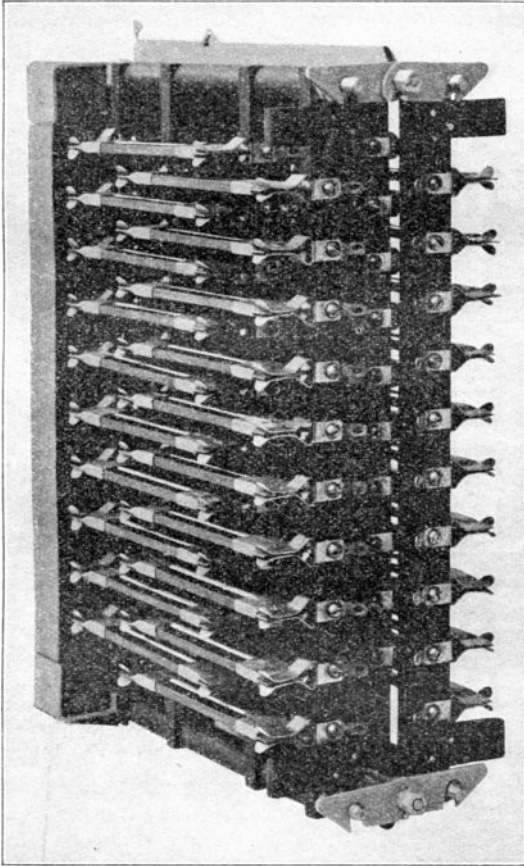


Fig. 15.

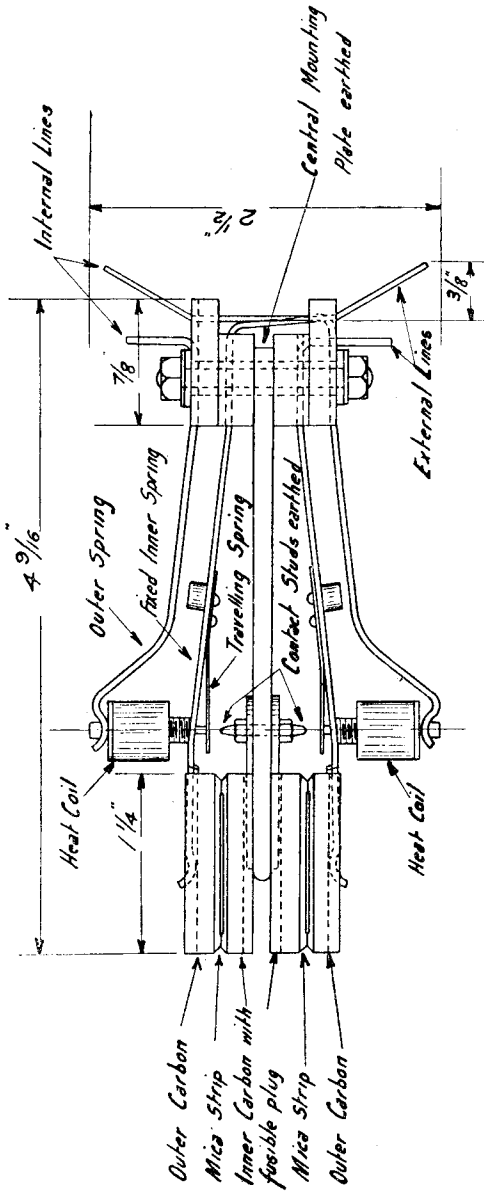


Fig. 16.

PROTECTOR AND EARTHING HEAT COIL MOUNTING.

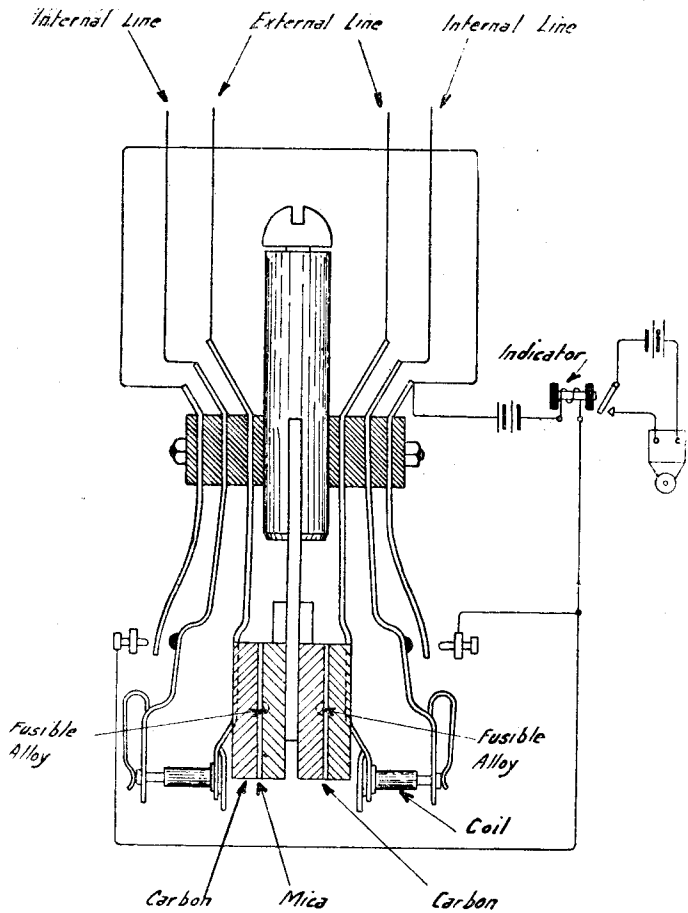


Fig. 17.  
 PROTECTOR AND BREAK HEAT  
 COIL MOUNTING.



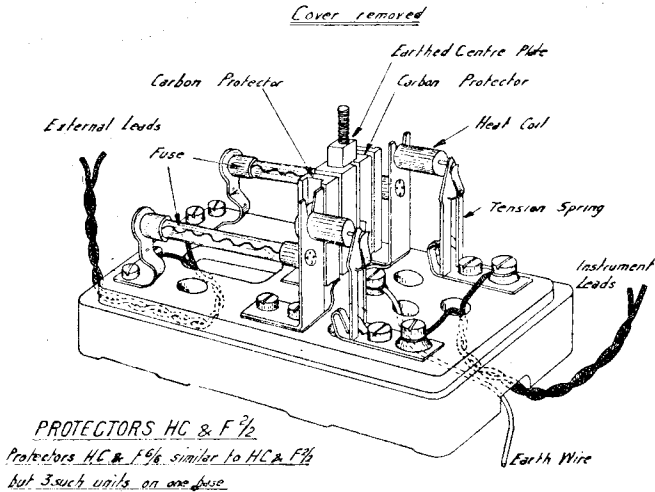


Fig. 18.

The carbon protectors and heat coils are mounted together in a combined fitting in the Main Distributing Frame on the opposite side to the fuses. This fitting is shown in plan in Fig. 16, which illustrates the earthing heat coil, and indicates clearly the manner in which the various springs are assembled on either side of a central mounting plate. The plates are made up in units 11 inches long, each unit accommodating heat coils and protectors for 20 circuits. As in the case of the fuse mountings, opposite heat coils and protectors on either side of the mounting plate are arranged to serve the two conductors of a subscriber's line, and the connections are crossed over from one side to the other in much the same manner as on the fuse mountings. It should be noted that the external line is connected to the springs abutting on the carbon lightning protector. If it were connected to the outer springs, then the impedance of the heat coil winding coming between the line and the protector would render the latter less effective on lightning discharges.

Fig. 17 shows a similar mounting arranged for break heat coils. These are usually made up in units accommodating 51 pairs of wires. The general construction of the mounting

and the points of difference as compared with the mounting for earthing heat coils will be readily appreciated if Figs. 16 and 17 be compared.

(b) **Subscribers' Equipment.**—Fig. 18 illustrates the standard mountings for protective fittings installed in subscribers' premises. This consists of a rectangular porcelain base on which are mounted the necessary springs and connectors to carry the fuses, protectors and heat coils. If the figure be carefully studied it will be seen that the external line is connected first to the fuse, thence through the heat coil to the internal wiring, the carbon protector being teed across to earth at a point between the fuse and the heat coil. The general conditions and operation of the protective devices are, therefore, identical with those described in connection with protective apparatus at the exchange. It should be noted, however, that a break heat coil is employed. When the heat coil is operated the tension spring flies forward, disconnecting the line. The fuse in this instance is operated only when the carbon protector is actuated, or when there is an earth connection on the internal wiring.

A moulded cover is fitted over the whole mounting to protect the fittings from dust.

On circuits where there is no risk of contact with power wires, and only lightning discharges have to be guarded against, the fuses and heat coils are replaced by dummies. This protector is known as "Protector H.C. & F. Incomplete."

# 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.