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PART 6

A PRACTICAL WORK WRITTEN BY EXPERTS

Fig. 50A (Left).
FITTING THE DRIVING PULLEY TO A GEARED MOTOR.

The pulley is secured in position on the shaft by means of a grub-screw. When the exact position of the pulley has been settled to suit the line of drive, use a twist drill, as shown, to spot the position of the grub-screw on the shaft.

Fig. 50B (Right).
FITTING THE DRIVING PULLEY TO A GEARED MOTOR.

After the position of the grub-screw has been spotted, as shown in Fig. 50A, a small recess should be drilled in the shaft, as shown on right, so that the grub-screw can be located in this. Remember that when a geared motor is used, a secure fixing of the pulley, spur wheel or coupling is of great importance owing to the large torque with which it has to deal. (*Normand Electrical Co., Ltd.*)

A

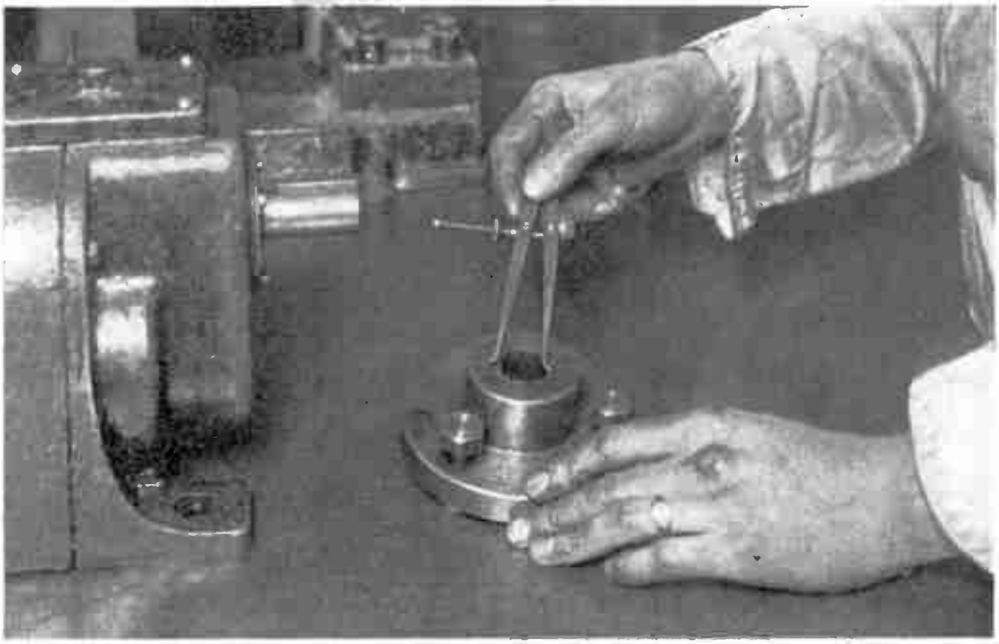


Fig. 50C.—FITTING A COUPLING TO A GEARED MOTOR SHAFT.

Before attempting to place the driving half of the coupling in position, measure the depth of the keyway in the coupling, using internal calipers, as shown above. (*Normand Electrical Co., Ltd.*)

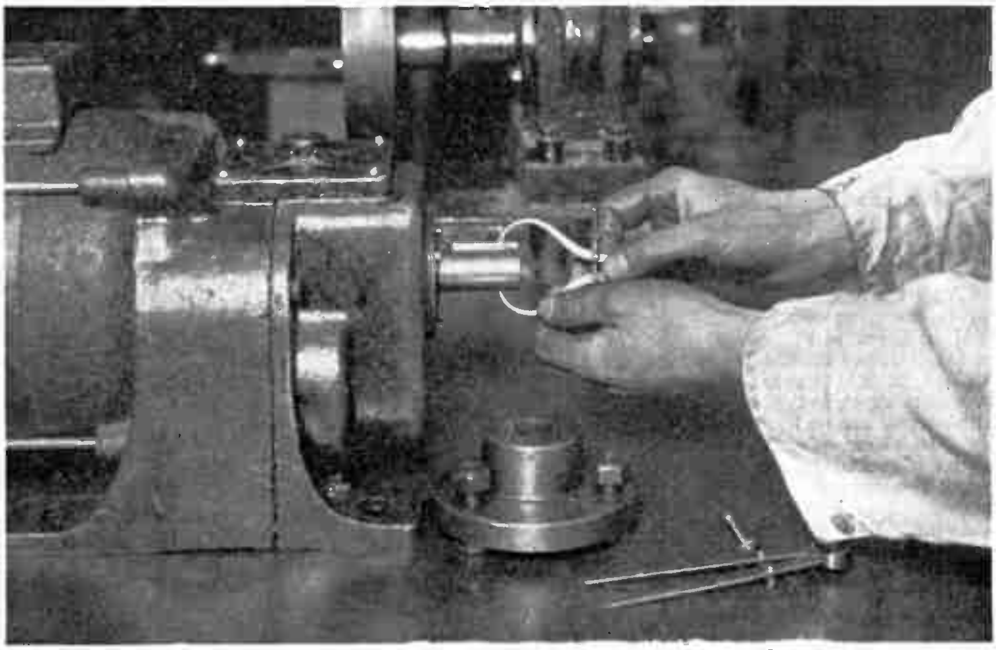


Fig. 50D.—FITTING A COUPLING TO A GEARED MOTOR SHAFT.

The next operation is to caliper the shaft and key, as here shown. The further operations in fitting this coupling are illustrated in Figs. 53 to 55. (*Normand Electrical Co., Ltd.*)

When to Use a Solid Pulley.

A solid pulley is advisable for the motor shaft, and these can be got in wood with an iron bush having a keyway and two setscrews, so that either method of fixing can be used, Figs. 37 and 38. For round belts metal pulleys are almost invariably used and are generally sold in the cone form, carrying several speeds, though single groove pulleys can be purchased, Fig. 22. Where the belt does not have to be "shifted," that is moved from fast to loose pulleys as on a countershaft, Figs. 5 and 6, "crowned" pulleys should always be used. The faces of these pulleys are slightly "crowned" or rounded, Fig. 39, which tends to keep the belt centrally on the pulleys.

See that the Shafts are Parallel.

It is essential for satisfactory driving that the shafts are parallel in both planes. A belt will always tend to run to the high side of a pulley. In Fig. 41 two shafts are shown which, while quite parallel in the horizontal plane, are not parallel in the vertical. This causes the pulleys to have high sides, AA Fig. 41, and the belt will run upon these sides, and if the fault is very pronounced, it will be impossible to keep the belt on the pulleys. After the main shaft has been levelled with the spirit level, the motor and all other drives in connection with the shaft should also be levelled. Then will come the task of what is termed "lining up" the pulleys, and which involves shifting the machines to bring the pulleys in line.

Testing Pulleys on Machines.

The method of testing is shown in Fig. 42. A string is stretched tightly across the faces of the two pulleys clear of the shaft, and must, to bring the pulleys in line, touch all four edges, Fig. 42. If the pulleys are of unequal width, the spaces between the string and each side of the narrower pulley must be equal, Fig. 43.

Use a Straightedge.

If the distance is short and a straightedge is available, this can be laid across the edges of the two pulleys and will be better than a cord. A length of wood, if quite straight on the edge, can be used for longer distances if desired. If the shafts and pulleys are lined up in this manner, the belts will run truly on the pulleys. If a belt persists in running to one side of the pulley, or running off, with a normal load, it is certain that the pulleys are not in line. An overloaded belt will slip on one pulley or the other, and then run off even if the pulleys are truly in line. It is equally important that the pulleys for

Fig. 51.—PORTABLE MOTOR DRIVING A CATTLE CAKE-BREAKING MACHINE. (*J. Harrison & Co., Ltd.*)

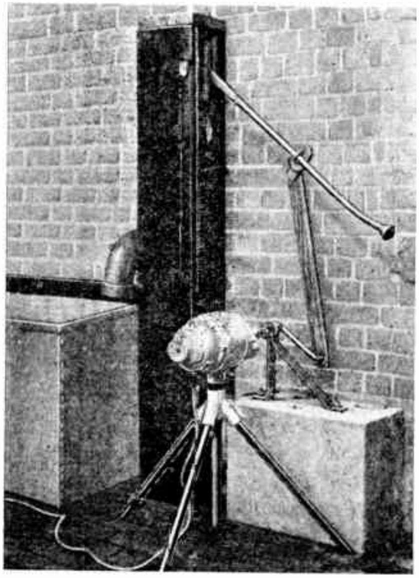


Fig. 52.—PORTABLE MOTOR DRIVING PUMP ON FARM. (*J Harrison & Co., Ltd.*)

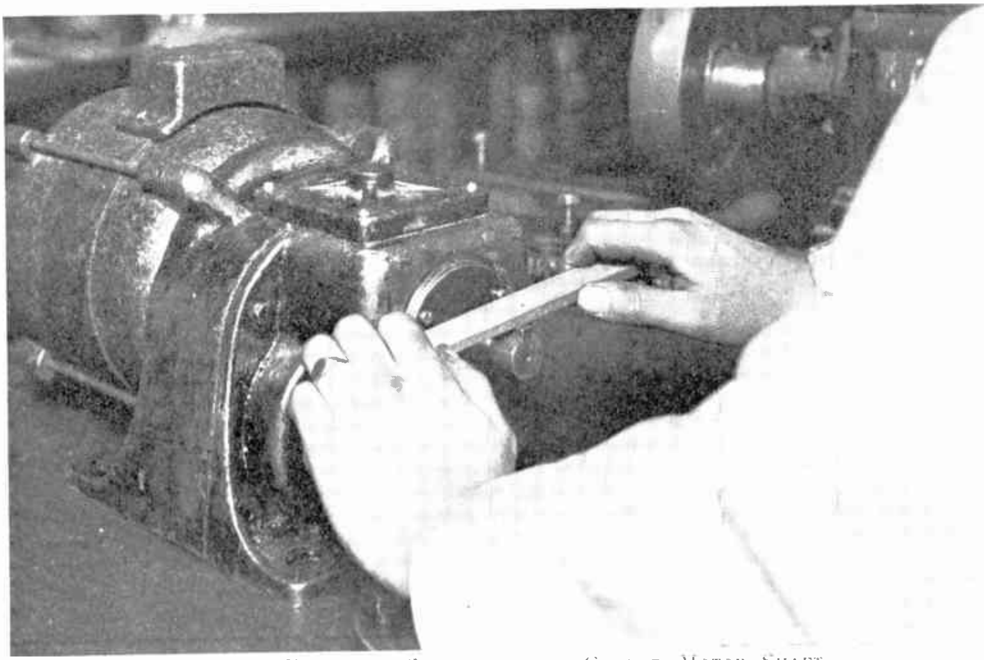


Fig. 53.—Fitting a Coupling to a Geared Motor Shaft.
The key should next be draw-filed, as here shown, a slight taper being given so that the coupling will be a drive-on fit. (*Normand Electrical Co., Ltd.*)

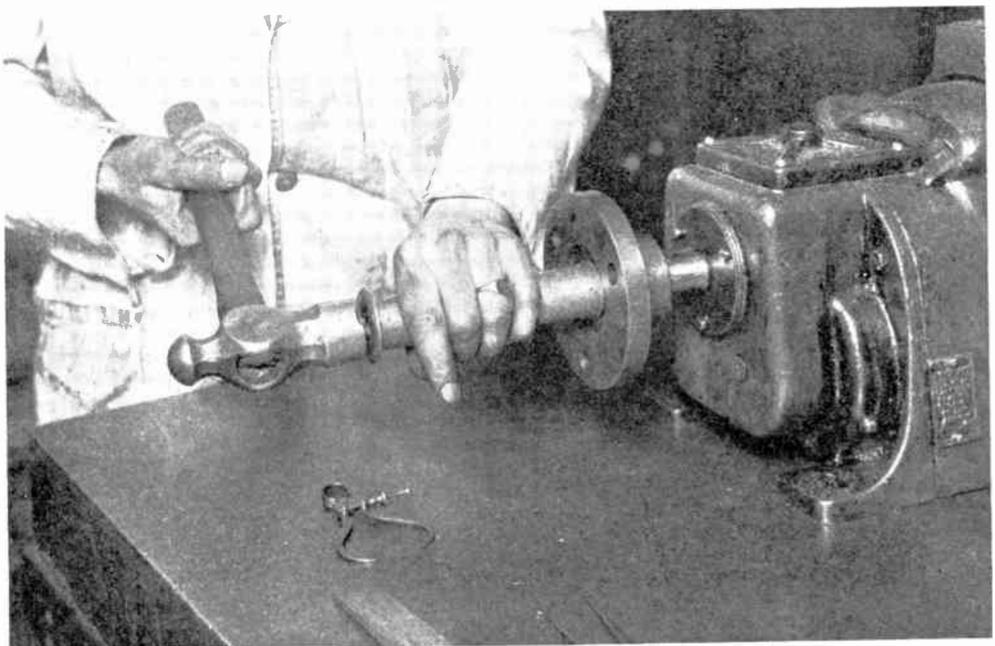


Fig. 54.—Fitting a Coupling to a Geared Motor Shaft.
The coupling can now be driven on to the end of the shaft, as shown above. Note the piece of lead interposed between the coupling and the hammer to prevent damage to the former. (*Normand Electrical Co., Ltd.*)

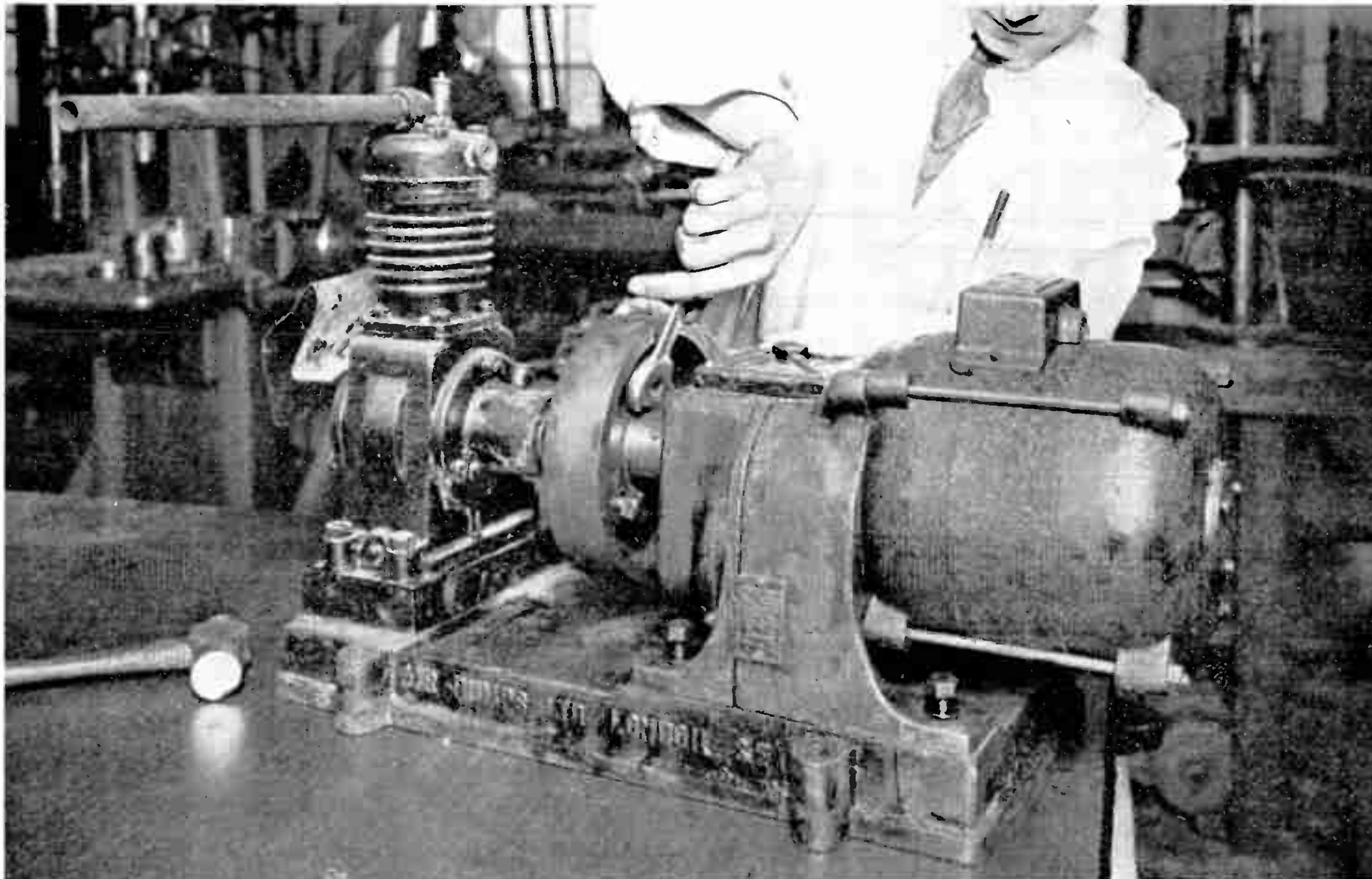


Fig. 55.—FITTING A COUPLING TO A GEARED MOTOR SHAFT.

The final stage. The two halves of the coupling are now bolted together securely. *Note that the holding down bolts of the motor are left slack whilst the coupling is being tightened.* (*Normand Electrical Co., Ltd.*)

V or round belts should be in line, as although the belts cannot run off unless the alignment is very much out, the belts will chafe or cut on the edges of the pulleys and will not last long.

ELECTRIC MOTORS FOR FARM WORK.

The best form of motor for farm work is the portable type. Agricultural machinery is generally scattered about the farm buildings, not concentrated in a workshop, and the cost of fitting a motor to each machine would be prohibitive. Also the speeds and powers required vary very much, so a motor capable of dealing with the full load of the machine taking the most power should be chosen.

How to Erect a Portable Motor.

Fig. 44 shows a portable motor supplied by the English Electric Company for farm purposes, but if a cheaper arrangement is required a second-hand motor can be purchased and fitted to a strong truck, either of steel as shown, or wood with iron wheels. The cost of motors from 5 to 10 h.p. varies in the second-hand market from £1 to 30s. per h.p. complete with starter. A variable speed motor is a great advantage, but would not be obtained at these prices.Therefore a slow speed motor of the required power should be purchased. A " cone " pulley, Fig. 40, having three or four steps should be fitted to the motor shaft, and this will give the necessary speed variations to suit the separate machines which can be fitted with pulleys of suitable sizes. Note that for this purpose both the faces of the cone pulleys and those on the machines must be " crowned " to retain the belt in place, as it is impossible to line up the machines and the motor perfectly true on this class of work.

Mounting the Motor, Switch and Starter.

The motor, switch and starter should be mounted on a trolley with a good length of cab-tyre sheathed cable, long enough to reach the source of supply wherever the motor may be working. A drum should be provided to wind the cable on when the motor is being moved. The truck will have to be scotched with blocks of wood when the motor is working to take the pull of the belt, so the wheels should be fairly broad on the face, which will also assist the passage of the truck over soft ground.

Lengthening the Motor Spindle.

If the motor spindle will not allow the fitting of a cone pulley, it can be lengthened by fitting a coupling, Fig. 10, and a short length of shaft with an outer bearing, the motor then being mounted longitudinally on the truck as in Fig. 45. The only drawback to this is that an endless belt cannot be used, as it could not be got on or off without removing the outer bearing, but this is not an important matter. A waterproof cover or a canopy is essential, as these motors frequently have to stand out in the open for long periods. A portable motor on these lines was recently constructed at a cost of £15 for a 10-h.p. motor, the items being as follows: One 10-h.p. slow-speed motor, 220-volt, 600 revs., complete with main switch and starter, £10. Wheels and material for trolley, including angle and channel iron, iron tube for handle and 1½-inch axle, planks for platform, bolts, etc., £2. 8s. 20 yards of twin cab tyre sheathed cable at 1s. 6d., £1. 10s. Niphan cable terminal plug, £1. 2s. The motor was, of course, second-hand. Such a portable power plant is of immense use about the farm or estate, and need never be idle. The assembly and making of the truck is well within the capabilities of any man who can do the usual tractor and machinery repairs about the farm.

A Useful Motor.

Smaller types of portable motors are now available, and one of these is illustrated in Fig. 52. The attachment by which it is working the farm pump was made by the farm blacksmith. This motor is manufactured by Wm. Harrison, of Liverpool. It is of ½ h.p. and a variable speed gear is combined in the motor casting giving a range from 0 to 280 revs. per minute. The motor will run in either direction, the speed and direction of rotation being controlled by the hand-wheel at the end of the motor. The motor is adjustable in height, so can be attached to almost any machine within its capacity. Fig. 51 shows the motor driving a cattle cake-breaking machine.

THE ERECTION OF WIRING SYSTEMS IN BUILDINGS

By H. W. Johnson.

THE following survey of the chief methods of electric wiring will be useful to the installation engineer in that it will help him to decide which method is most suited to any given conditions. First cost, reliability and ease of erection are the main factors to be considered. When quoting for installation work it is often advisable to give the customer a choice of two systems, with a brief statement of the advantages and disadvantages of each. Separate articles are devoted to the more important systems e.g., the conduit system is dealt with in detail on pages 75 to 84; and the reader is referred to these for a more detailed treatment of the methods of erecting.

Wiring Systems.

There are several wiring systems in general use. Each of them has its own special advantages and disadvantages in any one set of circumstances. The choice of system must be made with due consideration of the conditions under which the installation will have to work.

The most used systems include :—

(1) The porcelain cleat ;
(2) Steel conduit ;
(3) Lead covered ;
(4) Copper covered (Stannos) ;
(5) C.T.S. and Matecanite;
(6) Helsby eboni system ;
(7) Wood casing.

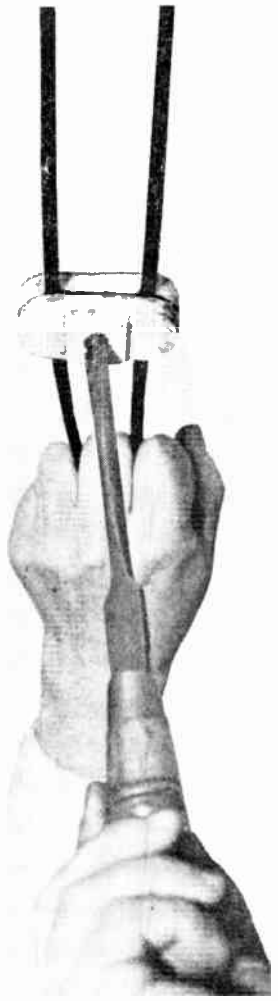


Fig. 1.—Fixing Wires in a Cleat.

The wires are placed in the grooves of the porcelain cleat, and the cover of the cleat placed in position over the wires. The wires are held taut and the screw is driven up tight to hold the wires between the base and cover of the cleat.

THE CLEAT SYSTEM.

This system is the easiest of all to erect. Ordinary V.I.R. cables are gripped between specially shaped pieces of porcelain. The fixing positions for the cleats are first determined. These will lie along the runs of cable ; on walls, ceilings, or constructional steel work. Under no circumstances must the cable run between floors, on wet walls, underneath water or other pipes, on which water might condense and drip on to the cable, or in any place where the cable might be attacked by moisture or chemical fumes. The system is also unsuitable where the cable might be subjected to rough treatment, or accidental damage. Its chief advantages are ease and convenience of erection, easily accessible cables for making alterations and extensions, and its cheapness.

Fixing Cleats on a Brick Wall.

Cleats should be fixed about 2 feet apart. Each cleat position is chosen at a joint in the brickwork. Here a hole is drilled, the shape of which will depend on whether the cleat is a single or two-hole fixing one. If it is of the latter type, the hole should be rectangular in shape, and large enough to accommodate a wooden plug that will hold both fixing crews securely, without its sides breaking away when the screws are tightened up. A circular plug

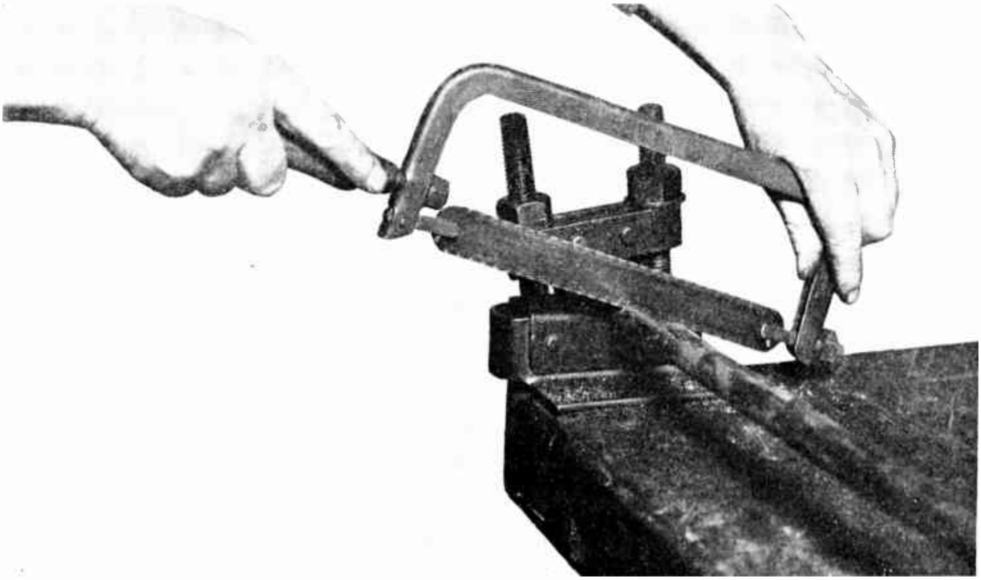


Fig. 2.—How to Cut Steel Conduit.

Steel conduit is cut with a hack saw. The teeth of the saw are very small and have a big set. This prevents the saw jambing in the saw cut and the teeth being stripped by the edges of the conduit. The burr caused by the saw is carefully removed from the inside and outside edges of the conduit. (*See also pages* 23 *and* 24.)

may be used for a one-hole fixing cleat. The hole for this can be drilled with a tube drill or a diamond pointed drill.

The plugs themselves should be of well seasoned wood, and should be a good driving fit in the holes. Particular care should be taken that the end of the plug does not stand above the surface of the wall. This prevents the cleat from bedding properly on the wall. It is impossible to make a satisfactory job by cutting off the end of the plug flush with the wall after the plug has been driven in.

A cleat is now screwed to each plug. The shanks of the fixing screws should be dipped in oil before they are screwed in the plugs. This will prevent the screws rusting, and allow them to be easily tightened up when the cables are gripped between the bases and covers of the cleats.

Running and Fixing the Cables.

The lengths of cable required for a run should first be wound off the coil, care being taken not to twist or kink the cable. The ends of the lengths are then placed in the grooves of the cleat at the beginning of the run, and the cover moved over the cables so as to be in line with the base of the cleat. The cleat is then screwed up tightly, causing the cable to be squeezed tightly between the base and cover of the cleat. To prevent the cable from slipping out, the under surface of the cover is roughened.

The cables are then inserted in the second cleat. When the cables have been stretched tight and have no twists or kinks, the cleat is screwed up. This process is repeated to the end of the run.

When the run is broken for connections to be made to any electrical fitting or accessory, sufficient cable must be left loose to make this connection, and the run continued. If the run is vertical, always commence fixing the cable at the uppermost cleat. This facilitates the fixing and stretching of the cables.

Fixing Cleats to Constructional Steel and Girders.

Cleats cannot be fixed directly to steel work. Wooden battens may be wedged between the flanges of girders, or clamped to other steel work. The actual design of the clamp will depend on the shape of the steel to which the battens are to be fixed.

Fixing Cleats to a Ceiling.

If the run is across the direction of the ceiling joists, mark the direction the cables will take on the ceiling, and fix a cleat under each joist with a screw long enough to penetrate the laths and plaster and take a firm hold of the joist itself. Should the run be parallel to the joists, short wooden battens are fixed along the run at frequent intervals with thin screws which pass into the plaster laths. The cleats are then fixed to these battens.

Branching off From a Main Run of Cables.

Where a branch wire is taken off from a set of main cables, the crossing wires must not touch one another, but must be insulated with a piece of hard rubber tube slipped over the branch wire. Where cables cross gas or water pipes, or come near any other metal work, they also must be insulated with hard rubber tube.

CONDUIT SYSTEMS.

In this system, steel tubes are fixed to the walls, etc., and V.I.R. cables are drawn through them afterwards. The full advantages of this method are realised in a building which is in the course of erection, as the conduit may be fixed to the unplastered walls, which is easy to do, and then completely covered up with plaster. The cables are not drawn in until the plaster is quite dry. Thus they are protected from any moisture which might leak in the tubes from the wet plaster, and from a certain amount of rough treatment.

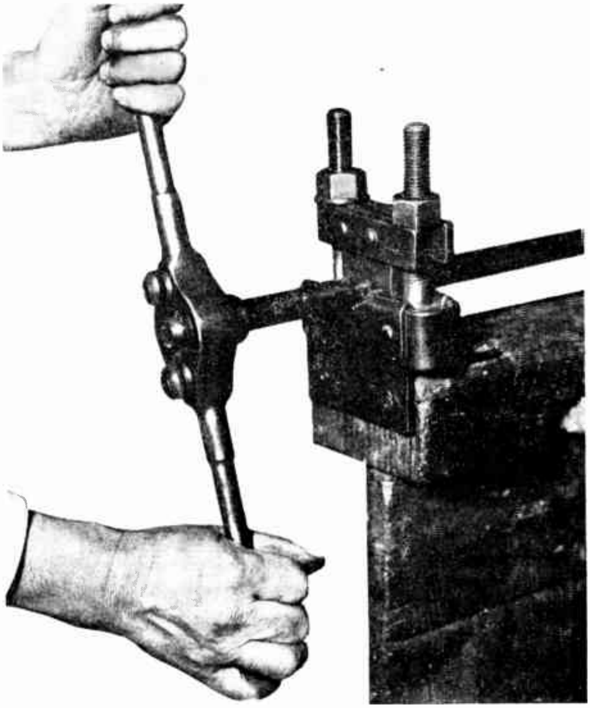


Fig. 3.—SCREWING CONDUIT.
Conduit is screwed with a special electrical thread. Lubricating oil should be liberally used on the die during the screwing process. (*See also pages 24 and 25.*)

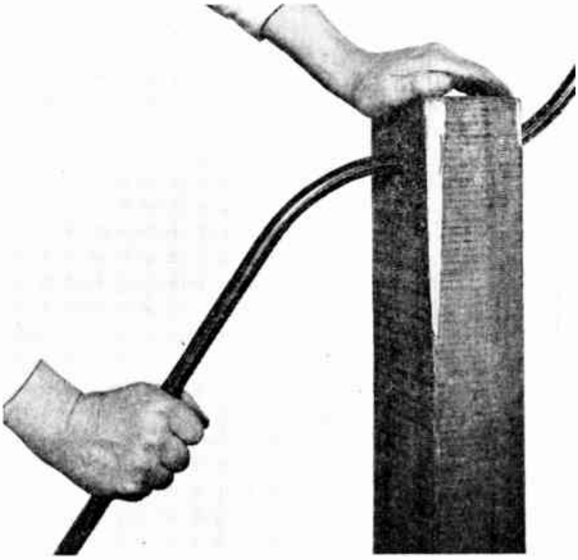


Fig. 4.—MAKING A "SET-OFF" ON A PIECE OF CONDUIT.
A bending block made of 4-inch square wood is used. The seam of the conduit should always be at right angles to the direction of bending.

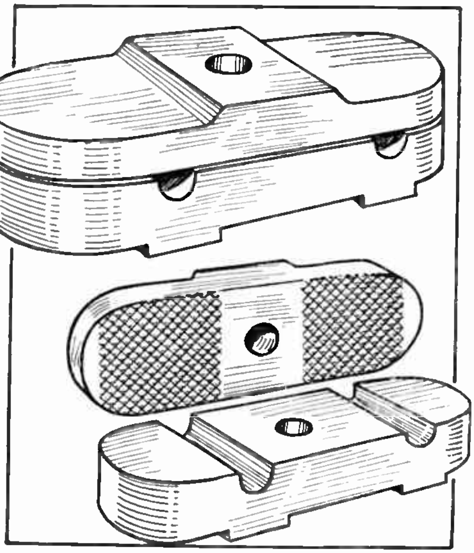


Fig. 5.—A SINGLE-HOLE FIXING PORCELAIN CLEAT

The lower face of the cleat cover is made rough so that it may grip the cables and prevent them from slipping. The cables are kept apart by placing them in the grooves of the cleat base.

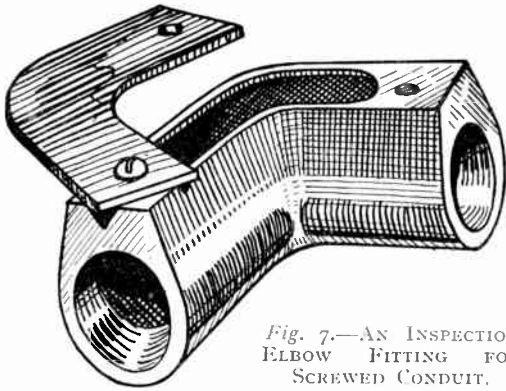


Fig. 7.—AN INSPECTION ELBOW FITTING FOR SCREWED CONDUIT.

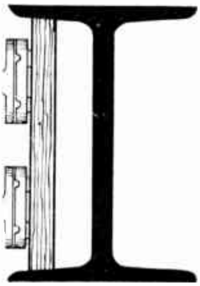


Fig. 8.—THE CLEATS FOR A CABLE RUN PARALLEL TO A STEEL JOIST ARE FIXED ON WOODEN BATTENS, WHICH ARE WEDGED TIGHTLY BETWEEN THE FLANGES OF THE JOIST.

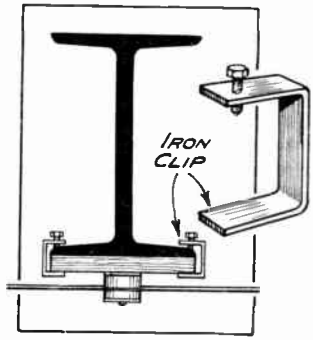


Fig. 9.—THE CLEATS FOR A CABLE RUN ACROSS JOISTS ARE FIXED ON WOODEN BATTENS, WHICH ARE SECURED TO THE FLANGE OF THE JOIST WITH IRON CLIPS FITTED WITH A SET SCREW.

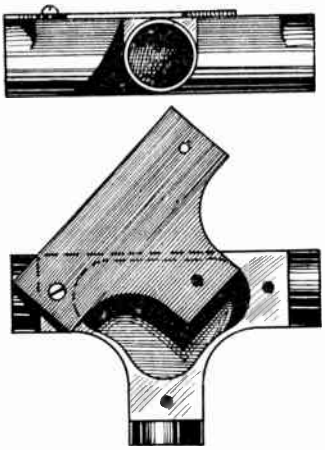


Fig. 6.—AN INSPECTION T FITTING FOR SCREWED CONDUIT.

The cover of inspection fittings is removed when "drawing-in" the wiring.

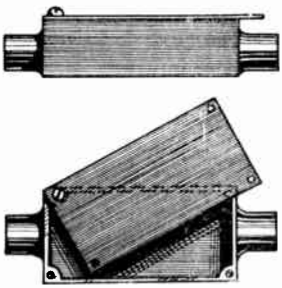


Fig. 10.—A STRAIGHT THROUGH JUNCTION BOX FOR SCREWED CONDUIT.

The box is used as a centre for the "drawing-in" of the cables.

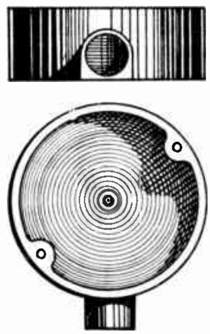


Fig. 11.—A CAST IRON SWITCH BOX FITTING FOR SCREWED CONDUIT.

The box is fitted with a vulcanised fibre cover to which the switch is fixed.

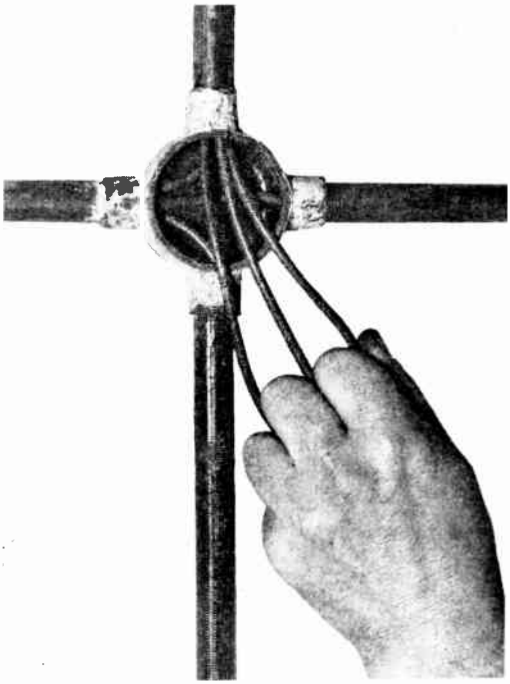


Fig. 12.—DRAWING THE WIRES INTO THE CONDUIT AT A JUNCTION BOX.

They are kept parallel to each other as they pass into the box by allowing the wires to slide through the fingers of the hand.

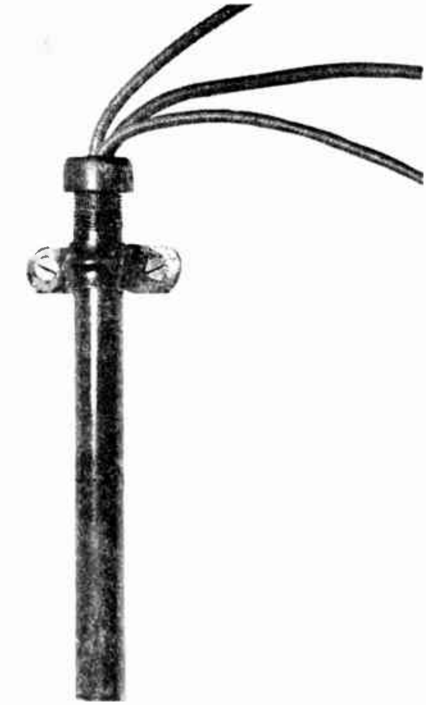


Fig. 13.—FITTING AN INSULATING BUSH TO END OF CONDUIT.

Where the wires emerge from a run of conduit, an insulating bush made of hard rubber or ebonite is fitted on the end of the conduit. The bush protects the insulation of the wires from damage which the edge of the conduit may cause.

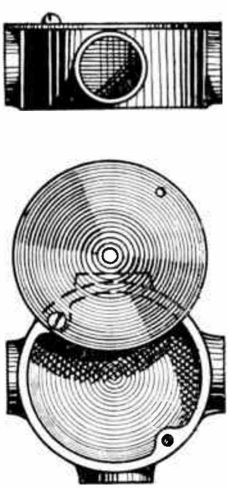


Fig. 14.—A FOUR-WAY JUNCTION BOX FOR SCREWED CONDUIT.

Arranging the Main Runs and Draw-in Boxes.

The main runs are first taken from the plans of the installation, and places for junction and draw-in boxes selected, from which branch circuits will radiate to the various points served by that main run. One branch run may be arranged to carry the cables which supply several switch positions near together. The same method can be adopted for several adjacent light points. Draw-in boxes are included in the runs to facilitate the drawing-in of the cables to supply the various points.

Wiring Capacity of Conduits.

A common mistake is the overcrowding of cables in a conduit. Excessive strain when drawing cables into the tube may fracture some of the copper strands, thus lowering the current-carrying capacity of the cable. The insulation may also be damaged, and the

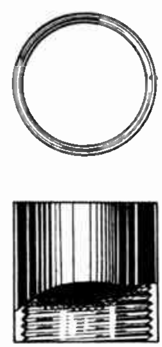


Fig. 15.—A COUPLING FOR JOINING LENGTHS OF SCREWED CONDUIT.

cable rendered useless. In a well-planned installation it should always be possible to withdraw any wiring from a conduit which may prove faulty without disturbing the rest of the wires in the same conduit.

Fixing the Conduit.

Commence fixing the conduit at the furthest point of the installation and work towards the supply point or the distribution board. Where the conduit is to be concealed with plaster, it may be fastened to the walls with pipe hooks. These are driven into the joints of the brickwork at intervals, so that the conduit is held firmly to the wall.

Conduit which runs between floors is fixed to the joists with metal saddles. If the run of the conduit is across the joists, they must be recessed at every point of crossing. The recess should be cut to the correct size. An excessive cutting of the joists materially weakens the building, and should be avoided.

Right-angle bends and T joints should be fitted with inspection fittings, and should be arranged in accessible positions. This will help on the drawing in of the cables.

Runs of conduit which are exposed to extremes of heat and cold should always be drained. The horizontal runs should be slightly tilted and a T piece fitted at the lower end of the run to allow any moisture

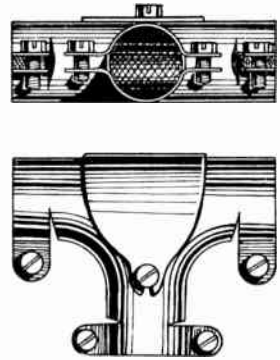


Fig. 17.—A "Grip" Inspection T Fitting for use with Plain Joint Conduit.

The end of the conduit is scraped clean and then inserted in the end of the fitting. The set screw on the lug of the fitting is then screwed tight, which closes the end of the fitting on the conduit, making a good mechanical and electrical joint.

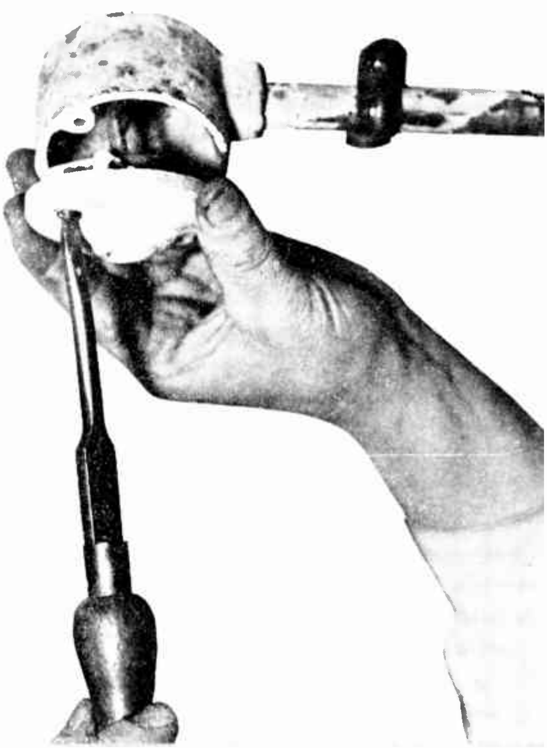


Fig. 16.—Connecting Wire to Ceiling Rose.

The wiring is connected to the ceiling rose, which is then screwed to the conduit box. The flexible pendants are wired up after all the conduit fittings are fitted.

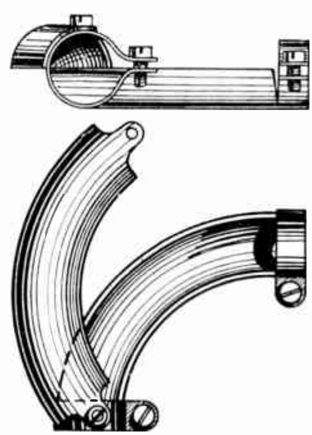


Fig. 18.—A "Grip" Inspection Bend Fitting for Plain Joint Conduit.

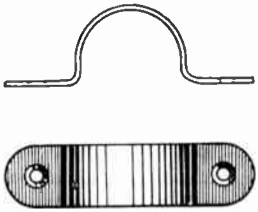


Fig. 19.—A SADDLE FOR FIXING CONDUIT ERECTED ON THE SURFACE.

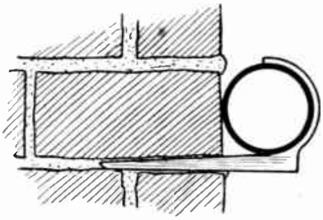


Fig. 20.—A PIPE HOOK FOR FIXING CONDUIT.
This is sunk in the plaster, etc.

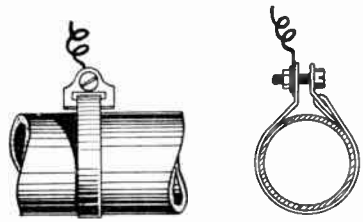


Fig. 21.—AN EARTHING CLIP.
The conduit is scraped clean where the clip is placed on. The earth wire is then placed under the washer of the set screw on the clip and the screw tightened up, a good connection being made between the conduit and wire.

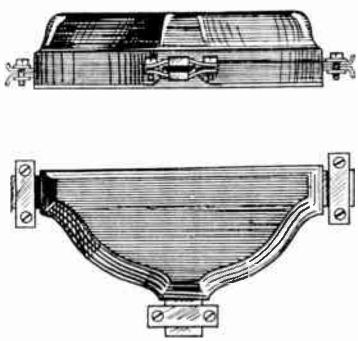


Fig. 22.—A T JUNCTION BOX USED WITH LEAD COVERED WIRING.
The lead coverings of the wires entering the box are gripped by the lugs, which are screwed tightly to the coverings. In this manner the electrical continuity of the lead coverings of the wires is maintained.

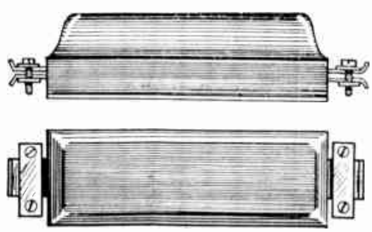


Fig. 23.—A STRAIGHT THROUGH JUNCTION BOX FOR LEAD COVERED WIRING.

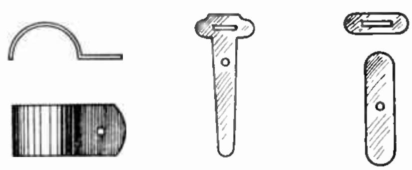


Fig. 24.—A FIXING SADDLE AND FIXING CLIPS FOR LEAD COVERED WIRING.

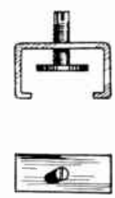


Fig. 25.
THE HENLEY BONDING CLAMP FOR LEAD COVERED WIRING.
The clamp is used to maintain the continuity of the lead covering of the wires at junction boxes (see Fig. 29).

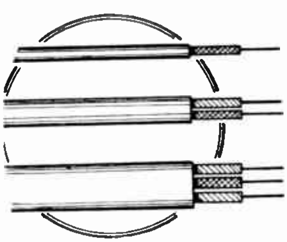


Fig. 26.—SINGLE, TWIN AND TRIPLE LEAD COVERED V.I.R. INSULATED WIRES.

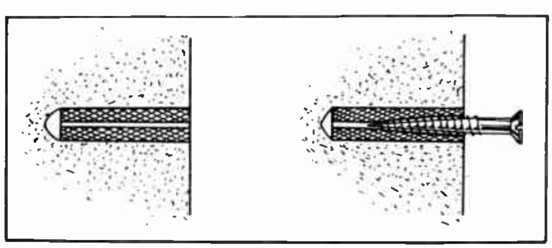


Fig. 27.—RAWLPLUGS ARE SUITABLE FOR FIXING LEAD COVERED WIRING TO SURFACES WHICH REQUIRE PLUGGING.

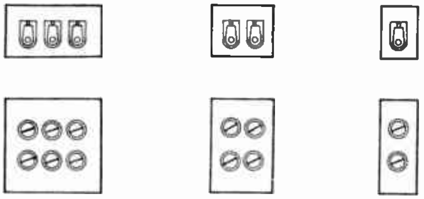


Fig. 28.—Porcelain Sheathed Connectors.
Porcelain connectors are used for joining lead covered wires. They must be placed inside a metal joint box.

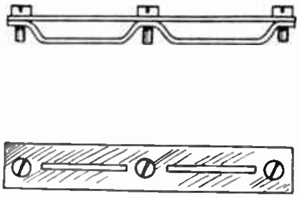


Fig. 30.—A Bonding Bar used to Maintain the Continuity of the Lead Covering of Wires at Distributing Board Positions.
This is also used where several parallel runs of lead covered cables have to be bonded together. The lead coverings of the wires are clamped between top and bottom of the bar, which are screwed together with the three cheese-headed screws.

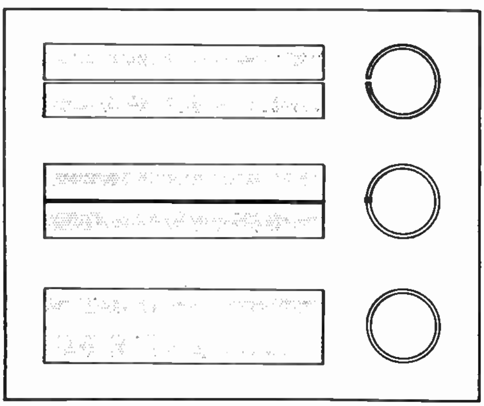
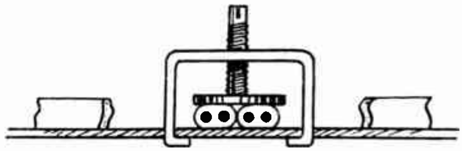


Fig. 31.—Three Types of Steel Conduit.
(Top) Closed joint steel conduit. (Centre) Welded seam steel conduit. (Bottom) Seamless steel conduit.



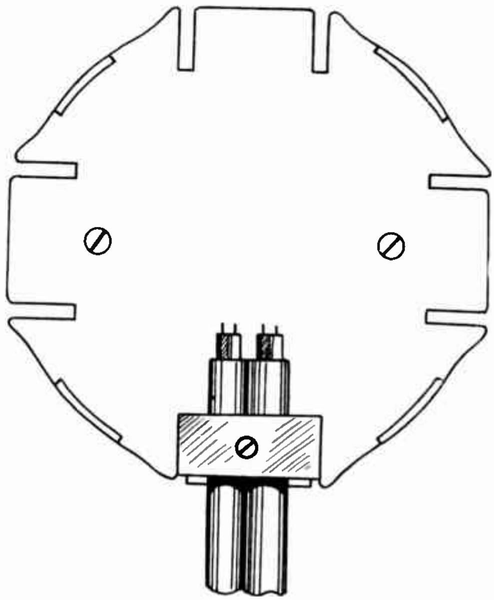


Fig. 29.—The Bonding Clamp fixed in position on the Base of a Four-way Junction Box.
The metal disc on the end of the screw is screwed down on to the lead coverings of the wires which enter the box (see Fig. 25).

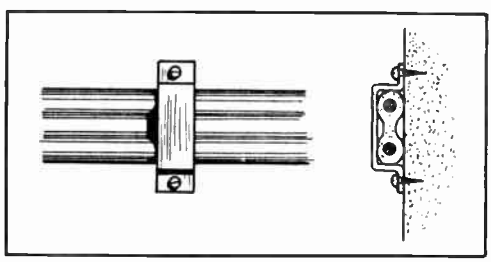


Fig. 32.—Macanite Wiring is Fixed to a Surface with Lead Clips.
The clips are made on the job from a piece of sheet lead.

formed by internal condensation to drip away.

Treatment of the Ends of Conduit.

Conduit is generally cut with a hack-saw blade. This leaves sharp burrs on the end of the tube. These sharp edges must be filed completely away. All outlets to switch and light positions should be bushed with hard rubber bushes, to prevent abrasion of the cable against the end of the conduit.

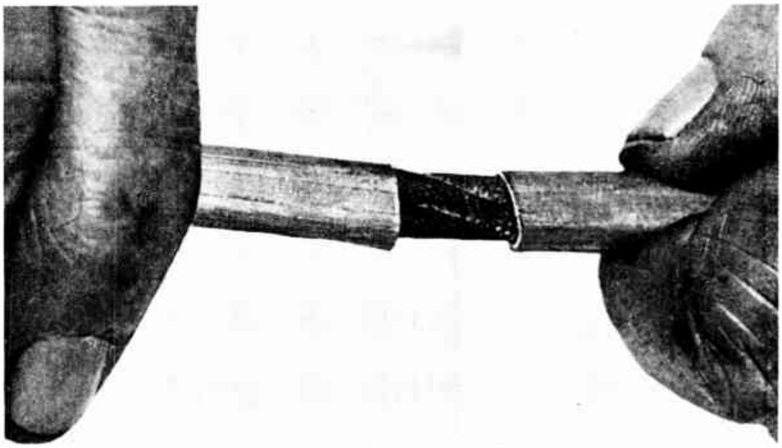


Fig. 33.—How to Make a Fracture in the Covering.
An incision is made round the lead covering and the wire bent first in one direction and then in the opposite direction. The covering will now fracture and may be drawn from the end of the wire.

Fig. 34.—Steel Channel Covering used as an Extra Mechanical Protection.
This is for lead covering wiring fixed in positions where exposed to rough treatment.

Bonding and Earthing.

Where breaks are made for connections to distributing boards and main switches, the incoming and outgoing runs must be bonded together with a copper wire large enough to carry the maximum current normally taken by the installation. The whole run of conduit must be electrically continuous, and efficiently earthed. One end of the earthing wire is connected to the conduit through an earthing bar or with a special clip, and the other end clipped on to a water pipe or other efficient earth. In a private house the most convenient place for earthing the conduit is in the lavatory.

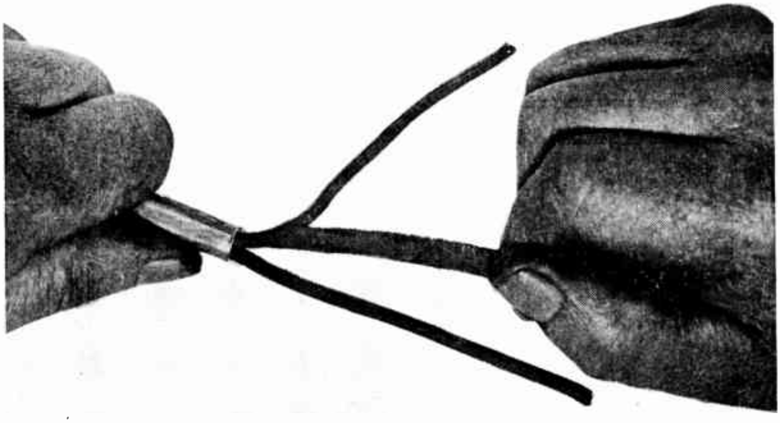


Fig. 35.—Removing Proofed Tape from the Outside Insulation.
When making terminal connections to lead-covered wiring always remove the proofed tape from the outside of the vulcanised rubber insulation of the wires, up to the point where the lead covering has been removed. The removal of the tape prevents "surface leakage."

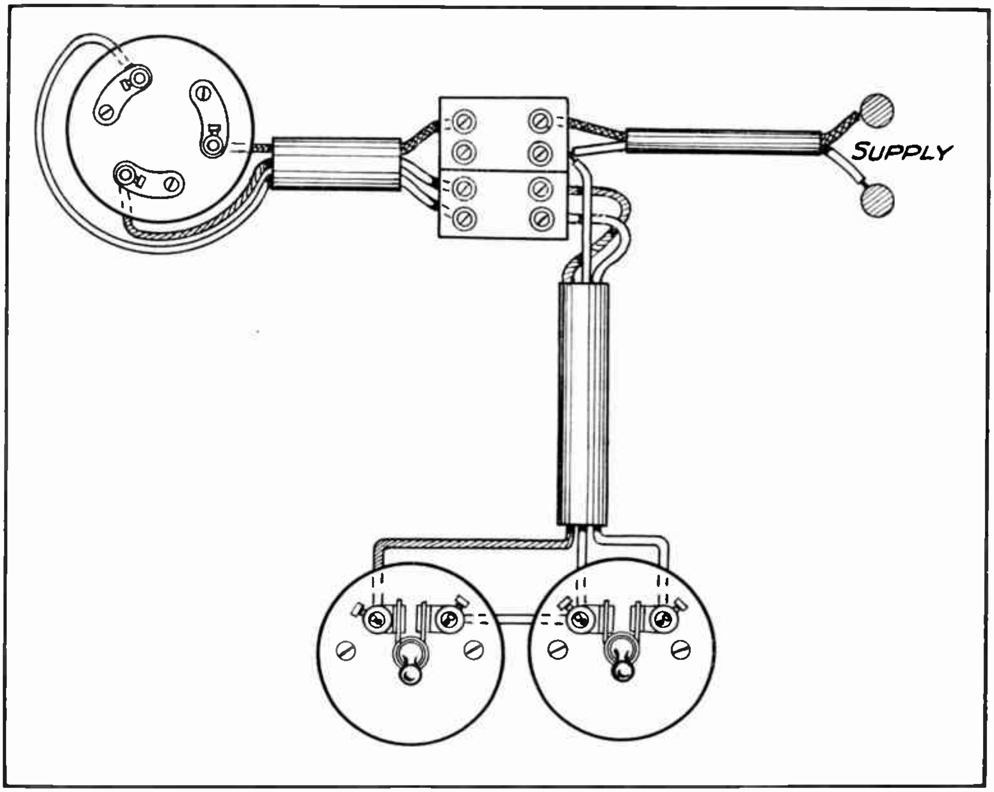


Fig. 36.—WIRING A TWO-LIGHT POINT WITH LEAD-COVERED WIRING.

Each light is controlled with a switch. Porcelain connectors, which are fitted inside a T joint box, are used to join up the several runs of cable.

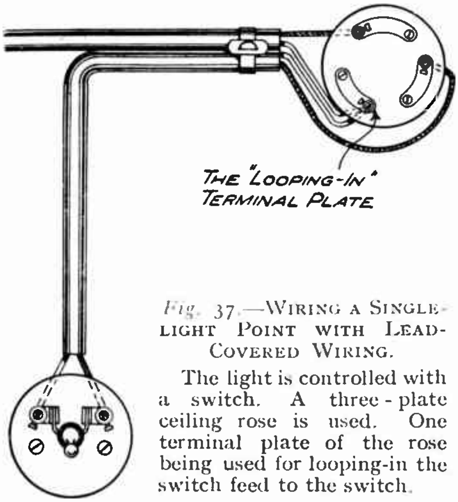


Fig. 37.—WIRING A SINGLE-LIGHT POINT WITH LEAD-COVERED WIRING.

The light is controlled with a switch. A three-plate ceiling rose is used. One terminal plate of the rose being used for looping-in the switch feed to the switch.

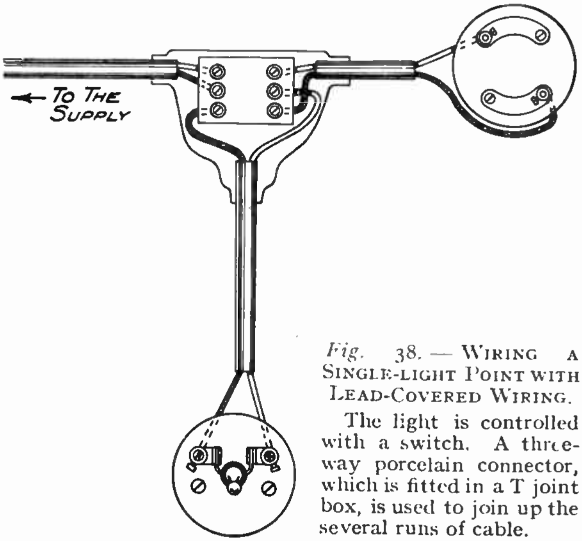


Fig. 38.—WIRING A SINGLE-LIGHT POINT WITH LEAD-COVERED WIRING.

The light is controlled with a switch. A three-way porcelain connector, which is fitted in a T joint box, is used to join up the several runs of cable.

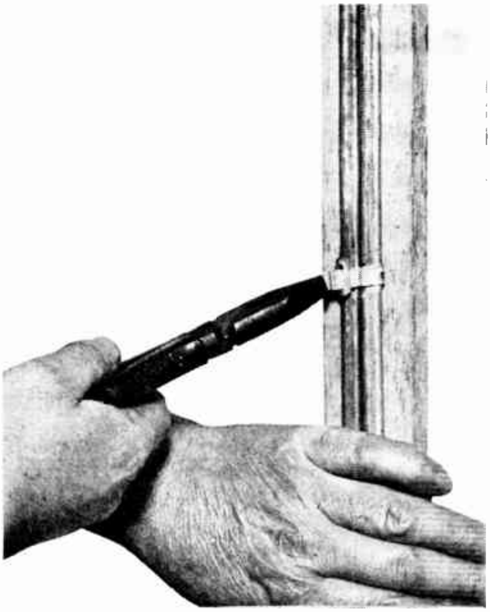


Fig. 39.—FIXING LEAD-COVERED WIRING TO A STRIP OF WOOD.
This is done when the wall or ceiling is unsuitable for direct fixing. The strip of wood is previously fixed and metal strap clips secure the wires to the wooden strip.

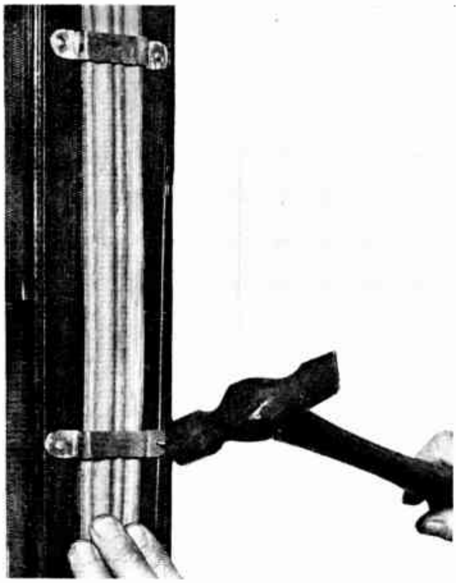


Fig. 40.—HOW MACANITE WIRING IS FIXED.
This is done with lead clips, which are made on the job from a piece of sheet lead. The appearance is improved if the wiring is fixed to a strip of wood. The strip of wood is secured to the fixing surface.

Screwed Conduit.

The junctions of the conduit with the various fittings, such as elbows, T pieces, junction boxes, etc., may be either screwed or plain. A special shallow thread known as Electrical Conduit thread is used for screwed junctions. The end of the conduit is screwed with the appropriate die, for a short distance. The screwed portion should only be just long enough to fit inside the accessory, as exposed thread is detrimental to the system.

Fish Wires.

Fish wires must be left in any conduit runs where difficulty is likely to be experienced, through sharp bends, etc., in drawing wires through that run. Runs with double set-offs always require fish wires to be left in them.

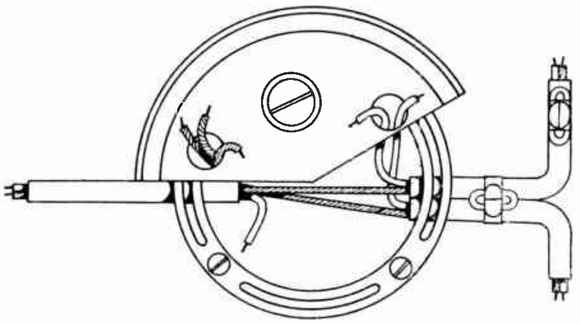


Fig. 41.—A CIRCULAR CONTINUITY BONDING CLAMP.
Used for maintaining the continuity of the lead covering of lead-covered wiring at light and switch positions. The bonding clamp is fitted underneath the pateras.

Bending and Setting Conduit.

Conduit runs often pass from one direction to another which is not at right angles to the first, or small changes of level may be necessary. When conduit is used in conjunction with iron-clad switchgear and distributing boards, a small set off of the conduit is required to make a secure mechanical and electrical contact with the accessory. In these cases the conduit must be bent. Welded and seamless conduit are the only varieties which may be bent with success. They are generally bent cold. When the welded variety has to be bent, the seam should always be on the side of the bend, to prevent the seam from opening. Small sizes, such as $\frac{1}{2}$ inch and $\frac{5}{8}$ inch may be bent across the knee, provided the bend has a large radius.

A steady pressure should be applied while bending.

A bending block or machine is used for bending and making set offs in conduit of larger sizes, such as $\frac{3}{4}$, $\frac{7}{8}$, 1 inch and above.

LEAD COVERED SYSTEMS.

In cases where the wiring is installed on the surface of walls, a steel conduit system becomes expensive to install, if it is to fit cornices, etc., without looking unsightly. Insulated cables which are protected with a soft lead sheath are used in these circumstances. Three varieties are made, containing one, two, or three cables in the same lead sheath. The twin conductor is the most useful. This system is essentially designed for surface work, and must not be buried in plaster without the further protection of steel troughing or conduit.

Corrosion of the Lead.

Lead-covered cable should not be fixed direct on a plaster surface, or on any surface containing lime. Lime attacks the lead sheath, and in time causes serious corrosion. In such circumstances cover the lead in contact with the wall with a paint which will attack neither the lead nor the lime. Lead-covered cable should never be fixed in a position where there are alkaline fumes, for example in stables. Extra protection, in the form of a steel trough, or a piece of wood casing should be afforded where the cable is likely to be damaged or interfered with.

Fixing the Cable.

Special metal fixing clips are used for fastening the cable to the wiring surface. These are fixed at frequent intervals along the run of cable. On surfaces which have to be plugged, small rawlplugs are generally employed. The amount of cutting away of plaster, etc., which is necessary to fix these plugs is very small, and is easily covered up by the conductors.

Methods of Looping In.

Twin lead-covered wiring, feeding a lighting system, may be arranged so as to loop out to switch points by using porcelain sheathed connectors placed in metal joint boxes, or by using three-plate ceiling roses. The third terminal plate of the rose is used as the looping terminal to the switch positions. The latter method is generally the better. The labour involved is much less, and the extra wire used balances the cost of the junction box, and labour involved in making the connections. Joint boxes must be fixed in accessible positions, and if the situation is damp, they are often a source of trouble.

Cutting and Fixing the Cable.

When all the clips are fixed, the runs of cable are rolled off the coils, which are fixed on a drum or reel and cut to the required length. Special care is taken to avoid kinks with the case of lead-covered cable as the sheath is very easily damaged. Should it be necessary to straighten out a kink or twist in the cable, use a rounded piece of wood as a beater. As with wiring on the cleat system, commence fixing vertical runs from the top. Avoid sharp right-angle or acute bends in the cable, as the lead often fractures at these points.

Electrical Continuity and Earthing.

Special continuity fittings are made for bonding together the lead coverings of the cables where breaks occur in the run at the various accessories. These continuity fittings at the switch and light points are placed underneath the pateras.

At the distributing boards the incoming and outgoing sets of lead-coverings of cables are bonded together with bonding bars. The earthing of a lead-covered system must be efficient, and may be carried out in the same way as for steel conduit.

Fig. 44 (Below).—How to Fix a Pateras.
The side of the pateras is recessed to allow the casing and capping to pass into the back. The wires are brought through holes drilled through the face of the pateras for connection to a switch, slack wire is pushed into the space at the back of the pateras. The pateras is screwed to the fixing surface with two countersunk head screws.

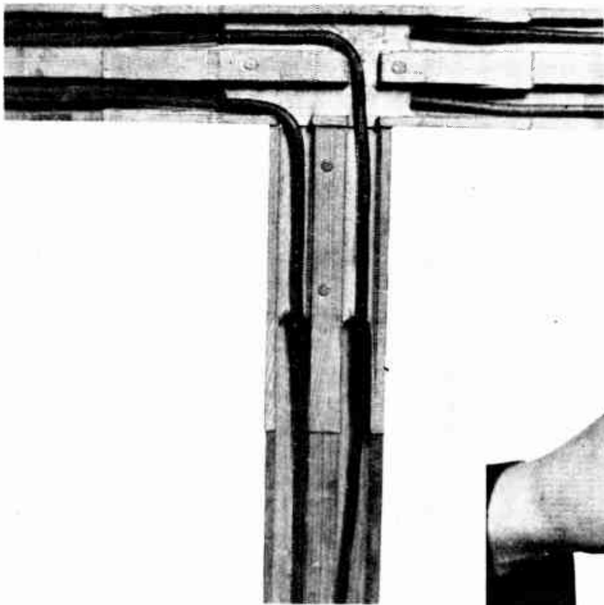


Fig. 42 (Above).—A T Bridge Crossing.
The bridge crossing is fitted in the wooden casing system of wiring, to allow wires to be branched away from a main run. The branch wires are looped from a light position on the main run.

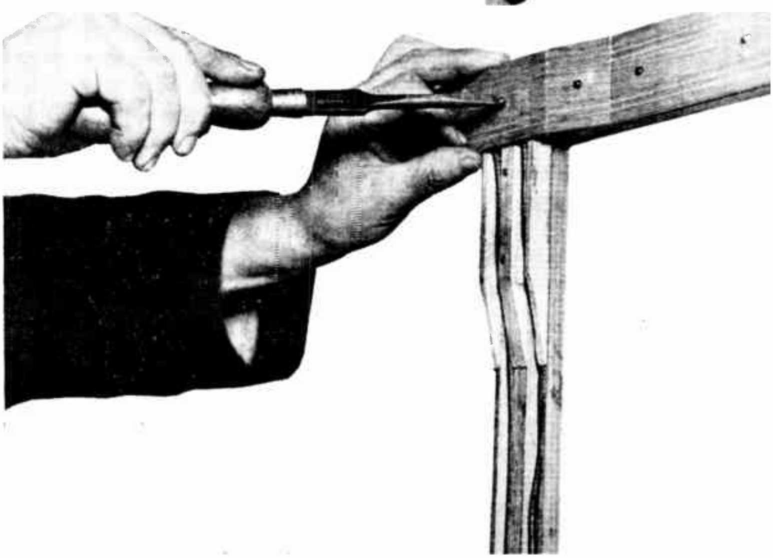


Fig. 43 (Left).—Covering a Bridge with Capping.
A bridge is covered with capping which is in one piece. The capping is cut half way through on its upper face where the chamfer of the bridge commences, and half way through on its lower face where the chamfer finishes. Round head Japanned iron wood screws secure the capping to the casing.

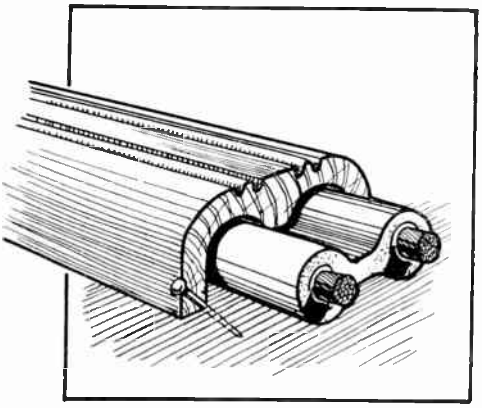


Fig. 45.—Macanite Wiring may be covered with a Moulded Wooden Casing.

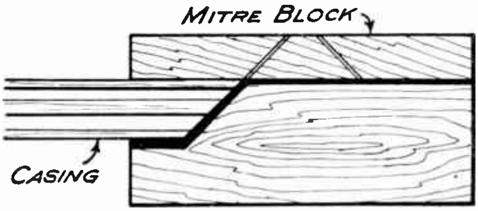


Fig. 46.—The End of a Piece of Wooden Casing Mitred in a Mitre Block.

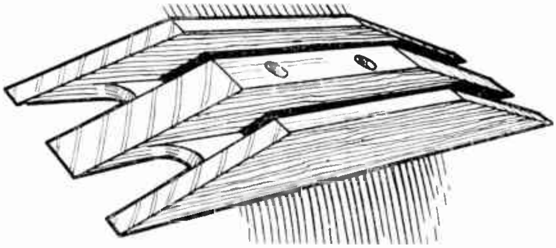


Fig. 47.—A Bridge used for the Crossing of Cables in the Wooden Casing System of Wiring.

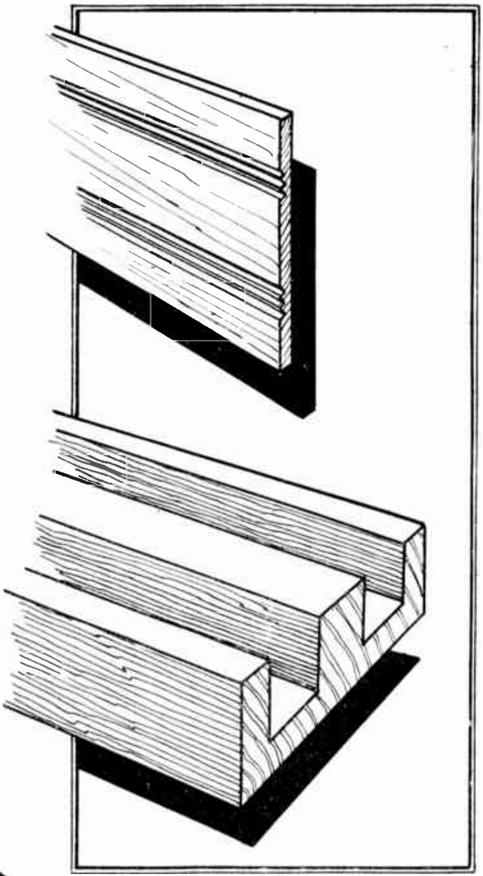


Fig. 48.—Capping and Casing used for the Wooden Casing System of Wiring.

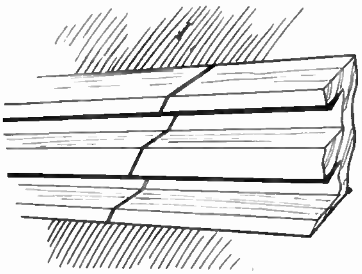


Fig. 49.—A Mitred End-to-end Joint with Wooden Casing.

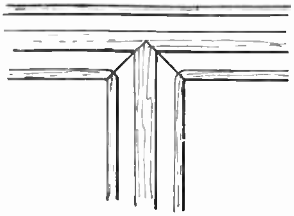


Fig. 50.—A Mitred T Joint.
Note rounded corners.

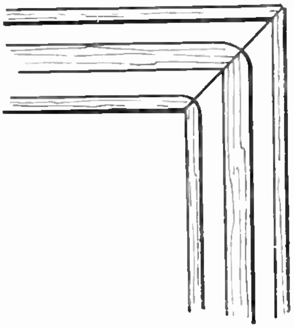


Fig. 51.—A Mitred Right-angle Joint.
Note rounded corners.

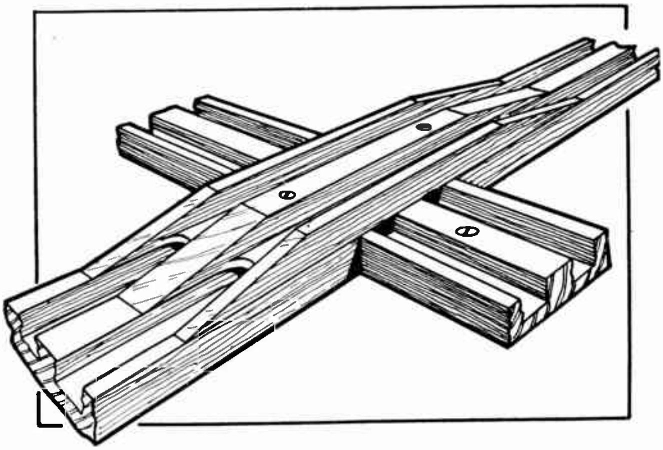


Fig. 52.—A CROSSING IN THE WOODEN CASING SYSTEM OF WIRING.

Enabling one run of casing to cross another and keep each set of cables apart. A bridge is fixed on one of the runs at the point of crossing and the cables in this run are passed over the bridge from one side of the crossing to the other side.

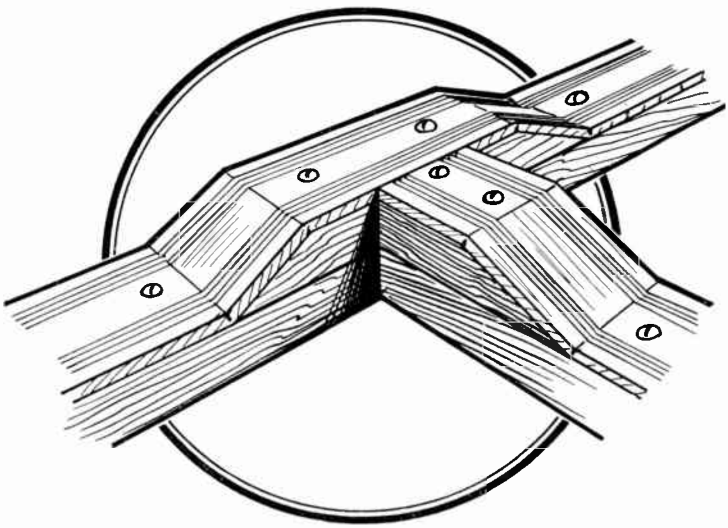


Fig. 53.—THE T BRIDGE CROSSING IS COVERED WITH CAPPING, WHICH IS FIXED TO THE CASING.

The capping for the bridge is fitted in one piece. The capping is sawn half way through on its lower face where the chamfers on the bridge commence, and half way through on its upper face where the chamfers end. This allows the capping to be bent down to the face of the bridge without breaking into three pieces.

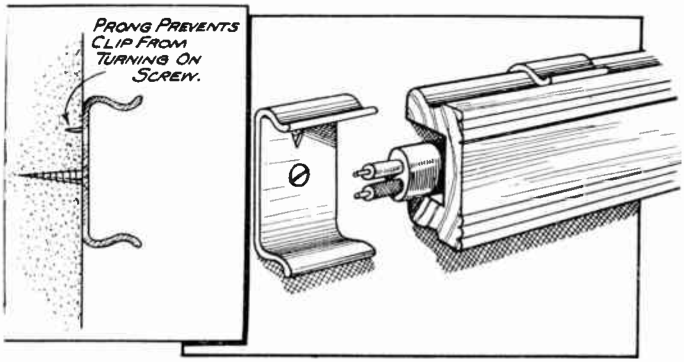


Fig. 54.—SPRING CLIPS USED FOR HOLDING CASING FOR USE WITH C.T.S. SYSTEM OF WIRING.

The spring clips are fixed at suitable distances apart to the surface on which the C.T.S. wiring is run. The run of C.T.S. wiring is now placed across the clips and the casing is placed in position over it. The casing is held firmly to the surface with the spring clips.

Preparing the Cables for Terminal Connections. The lead covering is removed from the end of the cable by making an incision round the covering at the point where it has to be removed. Then ,bend the cable backwards and forwards at this point until the covering is fractured. The broken piece of covering is then drawn from the end of the cable. The proofed cotton tape which is wound round the vulcanised rubber insulation is unwound and cut off at the point where the lead covering has been removed. The removal of the cotton tape will prevent surface leakage which may take place from the "live conductors" to the lead covering.

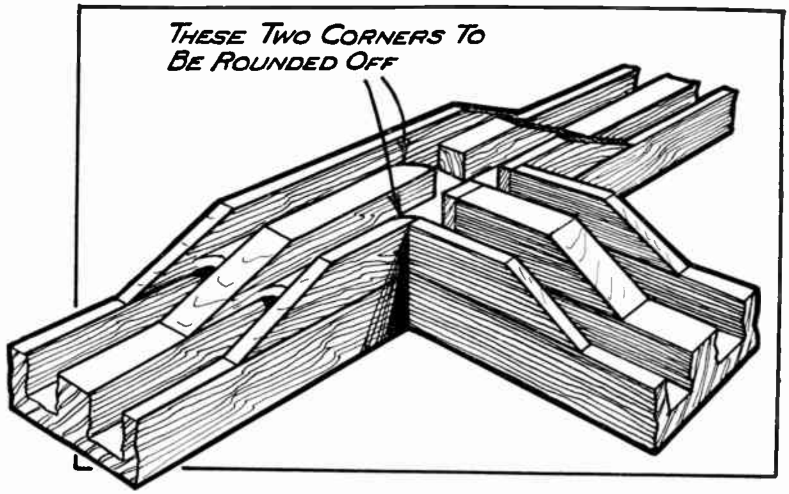


Fig. 55.—A T Bridge Crossing with the Wooden Casing System of Wiring.

Wires may be passed into the branch run of casing without touching the wires in the main run at the point of crossing. A full bridge is fitted on the main run of casing and a half bridge fitted up to it on the branch run of casing.

SPECIAL LEAD-COVERED WIRING SYSTEMS.

These systems are designed to endure more severe conditions than the ordinary lead-covered systems. Watertight junction boxes, accessories, and fittings are employed. The lead coverings of the cables are soldered to the metal coverings of boxes, etc., or a screwed gland connection is made. In one system a very heavy lead covering is used This covering is threaded so that a screwed gland connection is made between the covering and any accessories or boxes which are connected to the system. The Kaleeco, the Magnet, the Prescott, the J. & P., and the Glo Clad, are all examples of a

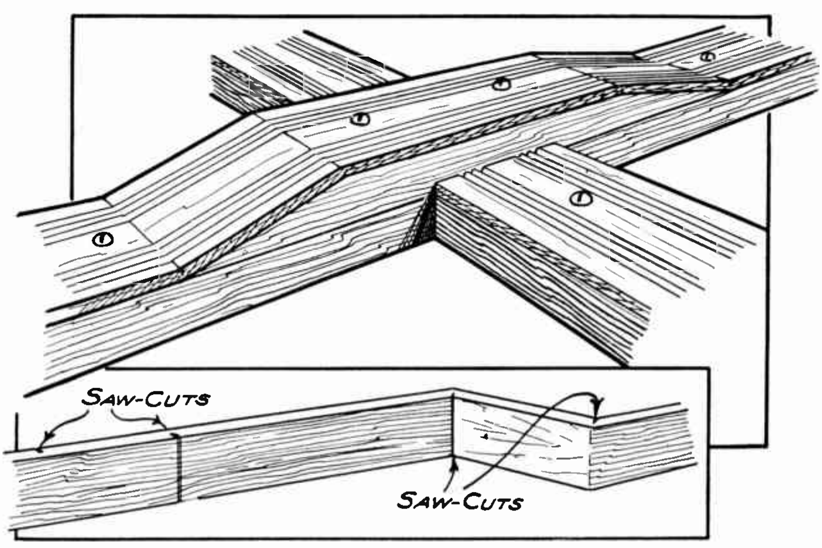


Fig. 56.—A Bridge Crossing Covered with Capping.

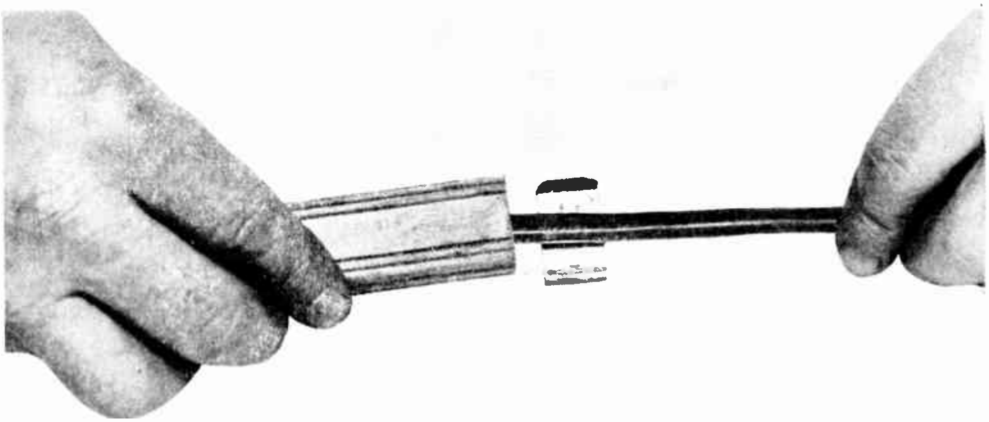


Fig. 57.—WOODEN CASING FOR C.T.S. WIRING.
The appearance of C.T.S. wiring may be improved by covering it with a wooden casing. The casing is held over the wiring with spring clips, which are fixed along the line of run of the wiring. The clips grip the sides of the casing, which are recessed.

special lead-covered wiring system.

THE STANNOS SYSTEM.

A copper covering is used for the protection of the wires in this system. The copper affords a better mechanical protection than the lead covering in a lead-covered wiring system. Two varieties of cable are used, single cored and concentric. The method adopted for fixing Stannos wiring is similar to that for a lead-covered system.

Precautions to be Taken when Making Terminal Connections.

Care should be taken to prevent the sharp edge of the copper covering cutting into the insulation of the wires where it is removed for the making of terminal connections.

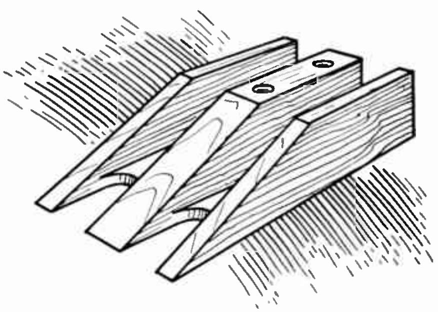


Fig. 58.—A HALF BRIDGE.
This is fitted on the branch run at a T bridge crossing with the wooden casing system of wiring.

Concentric Wires.

Stannos concentric wiring has a tinned copper tape wound spirally round the insulation of the inner conductor. This copper tape is known as the outer conductor and is not insulated.

No Break Allowed in the Outer Conductor.

No break of any description in the continuity of this outer conductor is allowed. Switches and fuses must be connected to the inner conductor only.

Bonding of the Outer Conductors.

Special continuity bonding fittings are used to maintain the continuity of the outer conductor at all terminal connections to the wiring system.

Earthing.

The outer conductor is always earthed. An earth wire is clipped to the copper covering, which is in intimate contact with the outer conductor.

Conditions of Erection.

Permission must be obtained from the Supply Authority to erect this system.

This system is generally used when the supply is given from a low-pressure private generating plant.

THE C.T.S. AND MACANITE WIRING SYSTEM.

In these systems the mechanical protection of the insulated wires is given by a thick hard rubber covering which surrounds the insulated wires.

Fixing the C.T.S. System.

The C.T.S. or Cab-Tyre Sheathed system of wiring is fixed with lead clips or saddles. The clips or saddles are made on the job to the required size from sheet lead.

Connections to Accessories and Fittings.

Twin C.T.S. is generally used, and "looping" to switch positions is made by using 3-plate ceiling roses for light points, the third terminal plate of the rose being the "looping-in" terminal. If desired, junction boxes made of moulded insulation, and containing porcelain sheathed connectors, may be used for "looping-in" to switch positions. If any joints are made in the wiring, this type of box should be used.

Positions Where C.T.S. System is Satisfactory.

C.T.S. wiring is waterproof and resists successfully the action of corrosive fumes. It is suitable for outside erection, and in situations where there are corrosive acid or alkali fumes. In these situations the pins which secure the lead clips or saddles to the fixing surface should be painted with acid-resisting paint.

MACANITE WIRING SYSTEM.

In addition to the protection of hard rubber covering round the insulated wires, a hard rubber strip separates the wires.

Fixing.

The system is a surface one, and the conductors may be fixed with metal clips such as are employed for lead-covered wiring or lead clips when the system is erected in positions where there are corrosive fumes. A special moulded wooden casing may be fixed over the wiring when it is desired to improve the appearance of the system.

Positions Where C.T.S. is Satisfactory.

Macanite wiring may be successfully installed in chemical works, stables and in other positions where there are corrosive fumes.

THE HELSBY EBONITE SYSTEM.

This system has been designed for use in chemical works, bleaching crofts and under all conditions where moisture, acid and alkali fumes are present in the atmosphere. The vulcanised rubber insulated wires and all accessories used in this system are encased in ebonite.

Preparing the Conductors for Fixing.

The coils of wires are immersed in hot water for a short time to soften the ebonite casing. The length of wiring required for the run is then cut off and straightened out, or bent to the shape required for the run, before the ebonite casing hardens.

The wiring is fixed to the surface with special clips.

Terminal Connections.

The ebonite casing is removed at terminal connections of the wiring to accessories and fittings by making a slight incision round the ebonite. Then give the wire a sharp bend at this point. The casing will now fracture, and may be drawn from the end of the wire. All junctions between the ebonite casing of the wiring, and entry points to accessories and fittings, are made with a watertight gland.

THE WOODEN CASING SYSTEM OF WIRING.

This system of wiring was the first to be employed, but is now not much used. It is neither waterproof nor fireproof and requires considerable skill in the use of woodworking tools to make a sightly and reliable job. The system is essentially a surface one, and casing may not be buried in plaster or other hygroscopic material, and is only suitable for use in dry situations.

Positions Where Casing System is Satisfactory.

The wooden casing system is employed for tramcar lighting and surface jobs which must be sightly, so as to harmonise with wood panelling and similar decorative work.

Fixing the Casing.

The casing is fixed to the surface with countersunk head wood screws through holes drilled or countersunk in the centre fillet of the casing.

Cutting the Casing.

The casing is cut with a tenon saw. Right-angle and T joints are cut with a mitre block, and the sharp edges of the mitred grooves are rounded with a chisel to prevent abrasion of the insulation of the wires when they pass round the mitred joint.

Crossings and Branches.

A bridge piece which is made from a piece of the casing is fitted where crossings or branch runs of casing occur. This prevents the several runs of wire coming in contact at the point of crossing, or branching off, and allows the junction to be efficiently covered with capping.

Running the Wires.

When all the runs of casing are fixed, the wires are placed in the grooves, and are held in position, until the capping is fitted, with a clip which slides under the lower face of the casing, or with small french nails which are driven into the sides of the grooves. The clip or french nails are removed before the capping is finally screwed over the casing.

Fixing the Capping.

When the casing is less than 2 inches in width, the capping is fixed over the casing with $\frac{3}{8}$ inch round head wood screws, which are screwed into the centre fillet of the casing. Where the casing is 2 inches or more in width, the capping is fixed with screws which are screwed into the side fillets of the casing.

Fixing a Pateras.

The side of the pateras into which the casing and capping pass is cut with a tenon saw, and the wood between the saw cuts removed with a chisel. The pateras is drilled for two fixing screws and fixed to the surface with them. On no account should the pateras be fixed to the casing which passes into it.

Fixing Casing in Between Floors.

Casing may be run between floors provided it is kept away from water and gas pipes. It may be fixed to the sides of the floor joists when the run is parallel to them. When the run is across the joists, a recess is cut in each joist where the casing will cross it. The recesses should only be of sufficient size to accommodate the casing and capping as recessing the floor joists materially weakens the building.

QUESTIONS AND ANSWERS

What is the easiest system to erect?

The cleat system.

What distance apart would you fix cleats on a brick wall?

About 2 feet apart.

How would you fix cleats to girders?

By using wooden battens as shown in Figs. 8 and 9 on page 258.

What are draw-in boxes?

Conduit junction boxes provided with lids which facilitate drawing-in of cables.

What is bonding as applied to wiring systems?

Maintaining the continuity of the metallic covering of the wiring throughout the system.

What are the advantages of the C.T.S. system of wiring?

This system is particularly suitable for: (A) outside erection; (B) for use in positions where exposed to corrosive fumes.

HOW TO RE-MAGNETISE MAGNETS

ALTHOUGH the ordinary alloy steel magnets now so widely employed for electrical purposes are known as "permanent" magnets—to distinguish them from the electro-magnet type—it is a well-known fact that they are not really permanent, but, in the course of time, lose their magnetism progressively. The principal causes of this loss of magnetic strength are as follows: (1) Shocks, vibrations or blows; (2) use at temperatures above ordinary atmospheric ones; and (3) unsuitable steel, e.g., unhardened carbon steel or incorrectly heat-treated.

Fig. 1.—TESTING POLARITY OF A MAGNETO. A small compass is used, and if the N. seeking side of the compass needle is repelled, the pole of the other magnet is N. (*Euston Lighting and Ignition Co.*)

The newest alloy steels, such as tungsten, cobalt and cobalt-chrome steels, are more permanent and of greater magnetic strength than the earlier hardened carbon steels.

Car Magnetos.

The ordinary electrician will occasionally be asked to re-magnetise the magnets of car or motor-cycle magnetos, for these electrical machines are subjected to much vibration and usually are fitted in warm places, such as under the bonnet of the car, near the engine. The magnets, in consequence, lose their magnetic properties much quicker than those of other electrical machines and instruments used under more favourable positions and under better conditions of working.

After an automobile magneto has been used for three or four years—more particularly if it is one of the ordinary carbon types—it will be found necessary to re-magnetise it.

Testing the Magneto.

The usual test is to spin the armature spindle of the magneto by hand, and notice the length and nature of the spark from the high tension cable end to the frame; or base of the magneto. A thin white spark of not more than one-sixteenth of an inch denotes a weak magneto. If the contact-breaker, brushes and rest of the magneto are clean and properly adjusted, one may conclude that it is the magnets which are at fault.

At the end of this article will be found details of two methods used for remagnetising magneto magnets. Before proceeding to this we will explain briefly the simpler methods for magnetising ordinary bar magnets and horse-shoe magnets.

How to Re-magnetise Bar Magnets.

Straight magnets of rectangular or round section, or the curved bar magnets used in certain electric clocks, may be re-magnetised without difficulty, by the aid of another magnet, or other magnets, in the manner illustrated in Fig. 2.

In this case the magnet is laid flat on a wooden surface, a strong permanent magnet taken in the hand and, keeping it inclined as shown, is drawn along the surface of the other magnet repeating the operation for several minutes. After the end of the stronger magnet leaves the other magnet it should be taken well away from the latter and brought back to the other end in a wide oval sweep.

The pole of the stroking magnet should be opposite to that of the magnet to be re-magnetised at the last point of stroking. Thus, in Fig. 1, it will be seen that whereas

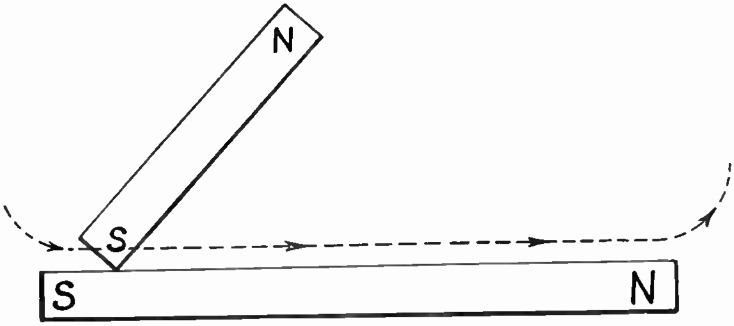


Fig. 2.—RE-MAGNETISING A BAR MAGNET.

A strong permanent magnet is drawn along the surface of the other magnet for several minutes. Note that the poles are opposite.

the S. pole of the stroking magnet first touches the S. pole of the other one, there is a N. pole where the stroking magnet leaves.

Another Method.

Another method of magnetising, or re-magnetising, a bar magnet is illustrated in Fig. 3. In this case two stroking magnets *A* and *B* are used—one in each hand. They are held with their opposite poles abutting at the centre of the other magnet *C*, and are then moved outwards, *A* to the left and *B* to the right. They are then brought back in wide oval sweeps to the central position again. The poles of the magnet *C* are opposite to those of the stroking magnets at the points of leaving. The same rule for determining the poles of *C*, or for choosing the poles of the stroking magnets to re-magnetise magnet *C*, applies here as in the preceding example, viz., *that the polarity at the end where the stroking magnet leaves is opposite to that of the stroking magnet.*

Small Thin Magnets.

Long magnets of small section are often made by holding them in a slanting position, viz., at about 65° to the horizontal and with the vertical plane containing the bar pointed towards the North Pole of the earth. When in this direction the bars are tapped several times with a light mallet when they become magnetised.

In this case the bars are pointed towards the earth's north magnetic pole, and are actually magnetised by the latter. In this case the lower end of the bar becomes a N. pole.

Incidentally, it may here be mentioned that it is easier to magnetise thin bars, a bunch of such bars giving a stronger magnet than a solid bar of equal section.

Testing the Polarity.

Before attempting to re-magnetise a magnet it is important to ascertain the polarity of its ends, i.e., which is the N. and which the S. pole.

The simplest method is to use a small compass magnet and to bring one pole of the other magnet up to one of the sides of the former as shown in Fig. 4. If the N. seeking side of the compass magnet is repelled, the pole of the other magnet is a N. one; if attracted, it is a S. one.

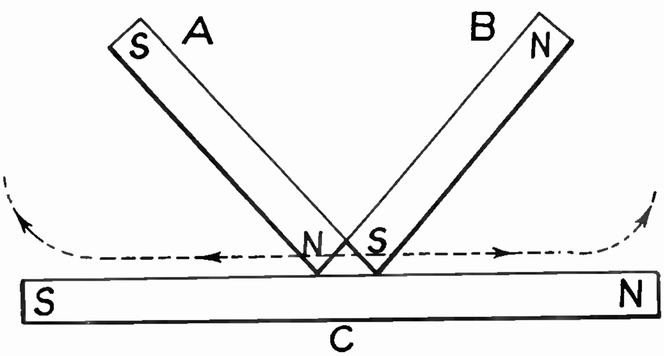


Fig. 3.—ANOTHER METHOD OF RE-MAGNETISING A BAR MAGNET. In this case two strong permanent magnets are used. They are held with their opposite poles abutting at the centre of the other magnet and are then moved outwards.

Special Magnets.

Before attempting

to re-magnetise any special type of magnet, ascertain that it is not a complex magnet, i.e., one having more than two poles. The magnets used in certain electric clocks, such as the Bulle, have intermediate poles (otherwise known as "*consequent points*"). The latter are readily ascertained by placing a sheet of white paper over the magnet, sprinkling iron filings on the paper and tapping the paper to allow the filings to assume their proper positions. For an ordinary two-pole magnet they should lie as shown in Fig. 5; for a three-pole magnet the lines will be as indicated in Fig. 6.

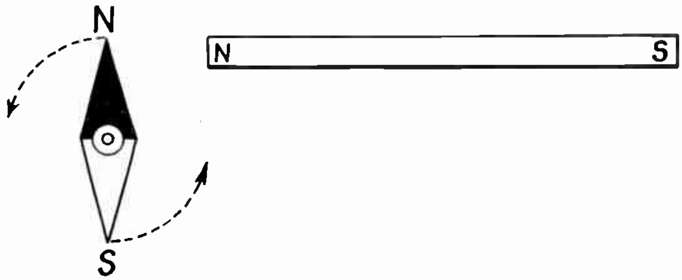


Fig. 4.—TESTING FOR THE POLARITY OF A MAGNET.

This can be done in the same manner as that described in Fig. 1.

Horse-shoe Magnets.

Although horse-shoe magnets may be re-magnetised by stroking them with strong bar magnets in a similar manner to that shown in Fig. 2, it is now the practice to use a pair of electro-magnet coils for this purpose. If, however, bar magnets are used we may regard the horse-shoe magnet as a straight magnet (Fig. 2) and commence by stroking from the S. pole with the S. end of the stroking magnet, and leaving off at the N. pole end. The method shown in Fig. 3 may equally well be used, commencing at the top of the middle of curved side of the magnet and stroking towards the two poles.

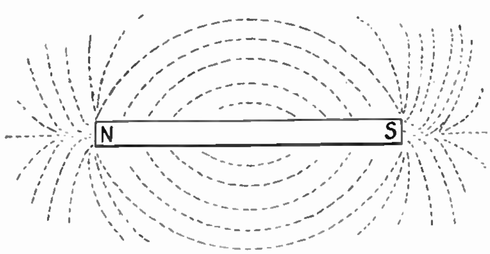


Fig. 5.—TESTING POLARITY WITH IRON FILINGS (1).

The filings should be sprinkled on a sheet of white paper placed over the magnet and the paper tapped. The above illustration shows how they should lie for an ordinary two-pole magnet.

Electrical Method of Magnetising.

Practically all new magnets are magnetised, and nearly all re-magnetising work is now done, by electro-magnetic means.

Let us first consider how this method applies to the ordinary bar or rod-type magnet.

The electric wire, suitably insulated, is wound around the rod as shown in Fig. 7. If the current is arranged to flow in the direction indicated by the arrows, the polarity of the bar magnet will be as shown in the illustration. Since we may regard a horse-shoe magnet as an ordinary bar magnet bent to a horse-shoe shape, it is not difficult for the reader to see how to wind a coil of insulated wire for the purpose of making a horse-shoe magnet.

We have only to imagine the helix or spiral coil shown in Fig. 7 to be bent to horse-shoe form, as shown in Fig. 8. In practice, however, it is usual to employ two separate coils made of suitable wire wound on bobbins, the latter being slipped over the poles of the magnet as shown in Fig. 9.

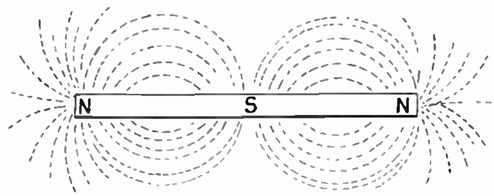


Fig. 6.—TESTING POLARITY WITH IRON FILINGS (2)

Showing how the iron filings should appear on the paper when a three-pole magnet is being tested.

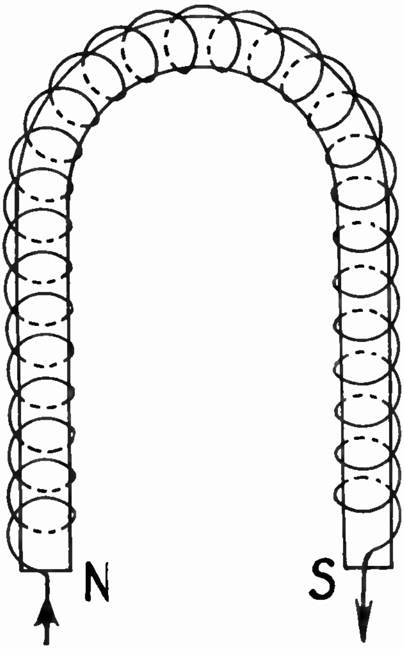


Fig. 8.—MAGNETISING A HORSE-SHOE MAGNET.

This shows the direction for winding the wire when re-magnetising by electricity. Actually, however, the method shown in Fig. 9 is usually employed.

Use the Maximum Number of Ampere Turns.

In order to obtain the greatest magnetising effect it is necessary to use as many turns of wire as can conveniently be obtained, and to use the largest safe current that the wire of the coils will take. In other words, *use the maximum number of ampere-turns.*

Re-magnetising Car Magneto Magnets.

Having described the various methods of re-magnetising, we shall conclude by considering the practical method of re-magnetising the magnets of a car or cycle magneto. Having removed the magnets from the magneto, place a piece of soft iron or annealed mild steel bar, about ¼ inch thick, and the full width of the magnets, across the poles as shown in Fig. 11A, at *A*.

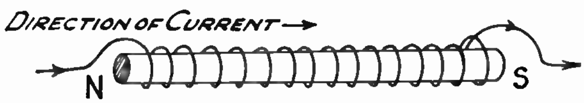


Fig. 7.—MAGNETISING A BAR BY ELECTRICITY.

An electric wire suitably insulated is wound round the rod and the current is arranged to flow in the direction indicated. To obtain the greatest magnetising effect it is necessary to use as many turns of wire as can conveniently be obtained.

Next make a pair of coils *B* and *C* by winding on suitable wooden bobbins about one half pound of No. 24 d.c.c. copper wire for each bobbin. The latter should be made to just slip over the magnet ends.

After placing the coils in the position shown (Fig. 11A), slip on the armature plate A, and connect up the two coils so that the current flows in an "S" path, as shown in Fig. 11B.

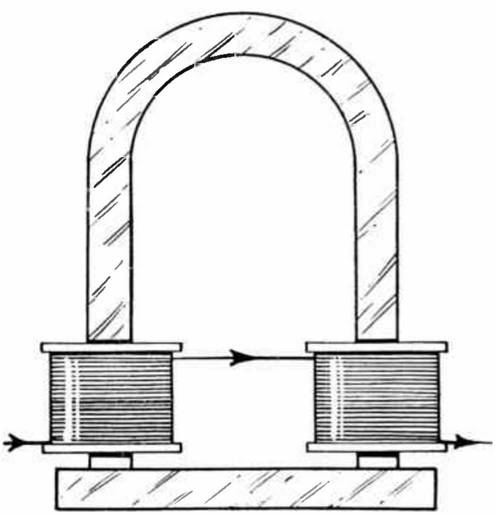


Fig. 9.—MAGNETISING A HORSE-SHOE MAGNET.

Instead of the method shown in Fig. 8, it is usual to employ two separate coils made of suitable wire wound on bobbins, the latter being slipped over the poles of the magnet as shown.

D.C. Supply Must be Used.

Next connect up the coil leads to a *direct current* source of supply—alternating current is totally unsuitable—and insert a resistance lamp (or lamps) *L* and ammeter *S* in the leads to the wall-plug *W* as shown. Switch on the current and, starting with a big resistance in *L*, note the amperes given by the ammeter. Adjust this value up to the safe working current of the wire used in the coils, viz., about 2 amperes for the wire used in the present case. In the case of 220/250 volt D.C. supply, a lamp of about 50 c.p. will be found to give the right current value; for a 110-volt supply no resistance will be required for *L*, i.e., it may be short-circuited.

Switching the Current on and off.

Having adjusted the current to its proper value, *it should be switched on and off* at frequent intervals, in order to obtain the best magnetising effect; this intermittent current is very much more effective than a continuous one. After a few minutes the magnets will be fully restored to their original strength. It is important to make quite certain about the polarity of the coils and of the magnets; this can readily be done in each case by the method illustrated in Fig. 4. The coils should be tested for polarity before slipping them over the magnet poles.

Make Certain there is a Fuse in the Circuit.

If a compass magnet is not available, a small bar magnet with its poles marked or coloured, may be used. In this case, remember that "like poles repel," and "unlike poles attract." Finally, make certain that there is a fuse in the circuit so that the coils or main supply wires are protected.

In Fig. 11A—A is a soft iron keeper across the poles of magnet; B and C are coils wound on wooden bobbins and consisting of about one half pound of No. 24 d.c.c. copper wire for each bobbin; M is the magnet; L the resistance lamp; S the ammeter, and W the wall-plug.

The Commercial Method of Re-magnetising Magneto Magnets.

In up-to-date electrical repair shops special equipment is provided for this purpose. It consists of a very powerful electro-magnet arranged under the bench with its pole pieces projecting above the surface of the bench. The magnet coils are connected to the main supply through a step-by-step resistance, somewhat similar to that used in an ordinary motor starter.

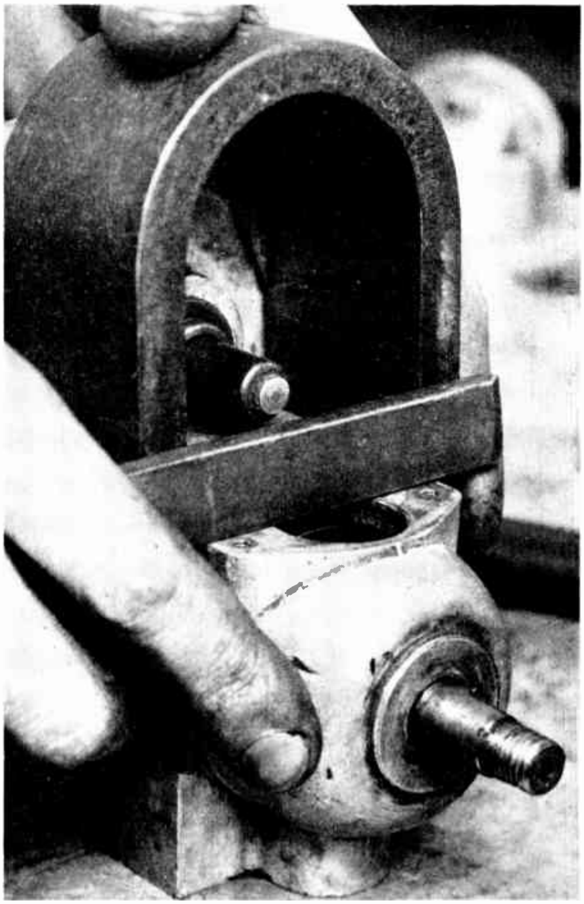


Fig. 10.—Removing Magnet from a Motor-car Magneto.
Showing the soft iron keeper in position. (*Euston Lighting and Ignition Co., Ltd.*)

Using the Magnetiser.

First find the north and south poles of the magneto, using a small compass for this purpose, as shown in Fig. 1. Now place the magneto between the poles of the magnetiser so that the north pole of the magneto rests against the south pole piece of the magnetising magneto, and

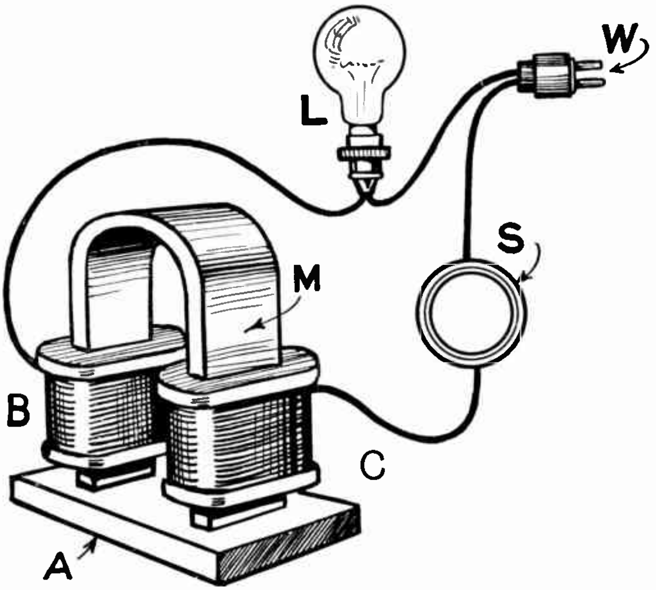


Fig. 11A.—RE-MAGNETISING THE MAGNET OF A MAGNETO. Each of the coils B and C consist of about half a pound of No. 24 d.c.c. wire.

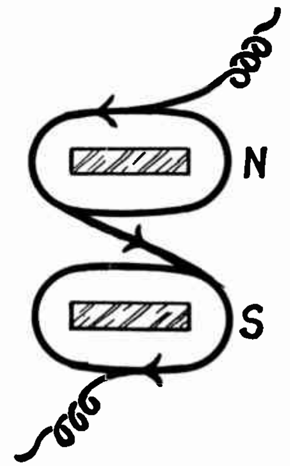


Fig. 11B.—SHOWING CIRCULATION OF CURRENT AS IT MIGHT BE SEEN IF VIEWED FROM UNDERNEATH A IN FIG. 11A.

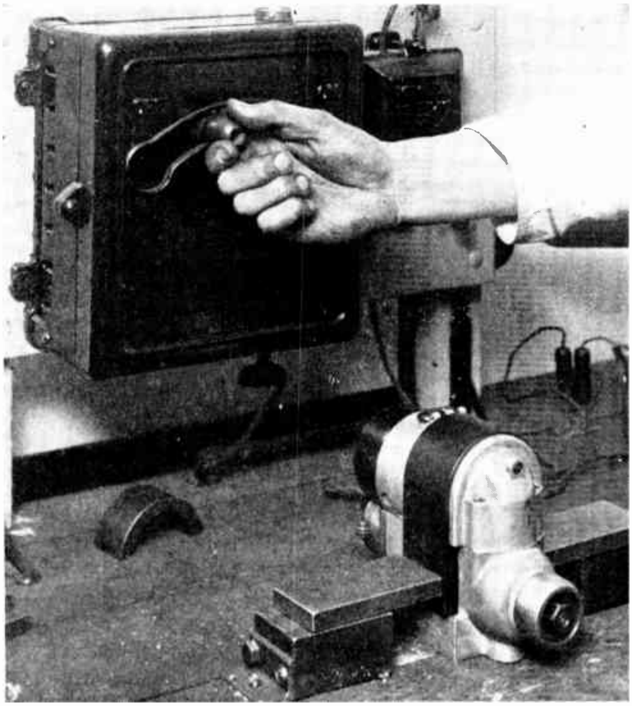


Fig. 12.—RE-MAGNETISING THE MAGNET OF A MOTOR-CAR MAGNETO. (*Euston Lighting and Ignition Co., Ltd.*)

vice versa (see Fig. 12). The current can now be switched on to the magnetiser, using the regulator as illustrated in Fig. 12.

This method may be used for "freshening up" a weak magneto, without removing the armature. To obtain the most satisfactory results, however, the magneto should be dismantled before the magnets are placed in position for remagnetising. The whole of the flux then passes through the magnet frame and a very powerful remagnetising effect is produced. A keeper bar should be placed across the poles before the magnet frame is removed from the bench, to prevent loss of magnetism on removal.

STARTERS AND CONTROL GEAR FOR D.C. INDUSTRIAL MOTORS

By A. T. Dover, M.I.E.E.

PROCEDURE IN STARTING FRACTIONAL H.P. MOTORS.

Motors up to ¾ h.p., *if series or compound wound*, may be started by switching directly on to the supply. But this procedure must not be adopted with shunt wound motors above ¼ h.p. on account of the excessive current which would be taken during starting. These motors must be started by using a starting rheostat.

Reasons for Excessive Starting Current.

The excessive current, in the case of a shunt-wound motor started directly, is due to the following causes: (1) the resistance and inductance of the main circuit of this motor are both lower than those of the corresponding series or compound wound motor, and, therefore, the initial current is higher; (2) the main flux builds up relatively slowly on account of the high inductance of the field winding; (3) the torque available for acceleration is initially very small and increases slowly; (4) in consequence of (2) and (3) the counter e.m.f. in the armature (which is initially zero) increases slowly, and, therefore, the initial current decreases at a slow rate. This prolonged current causes heating which may damage the armature winding.

On the other hand, with a series or a compound wound motor: (1) the initial current is lower than that for the corresponding shunt wound motor due to both the additional resistance and inductance of the main circuit; (2) the main flux builds up extremely rapidly due to the series excitation and the laminated frame; (3) a large torque is available for acceleration; (4) in consequence of (2) and (3) the counter e.m.f. in the armature increases rapidly, and, therefore, the initial current decreases at a rapid rate. Thus, although the initial current may be several times the full-load current of the motor, this current lasts for only a brief fraction of a second, and the heating effect on the armature and series field windings is small.

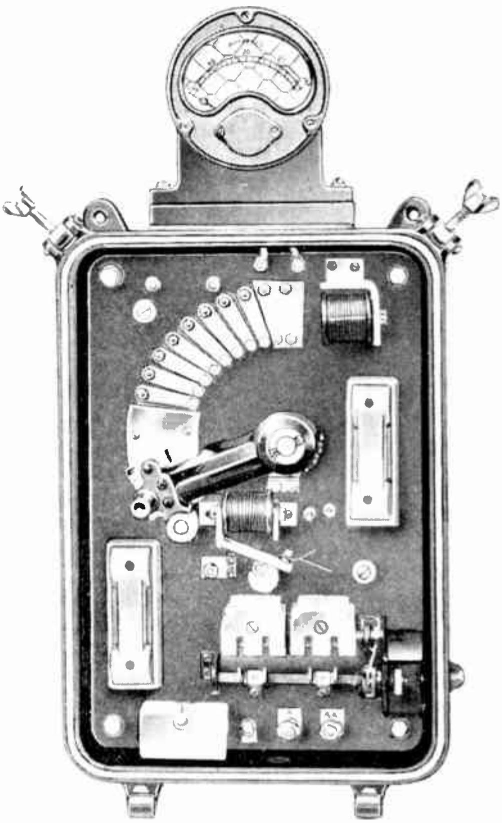


Fig. 1.—Self-contained Control Panel for Small Motor.

The starter, d.p. main switch, and d.p. fuses are mounted on a common panel enclosed in an iron case. The main switch is interlocked with the cover (which has been removed to show the panel), and the "live" supply terminals are protected by a porcelain cover (shown at the extreme bottom left of the panel). (*B.T.-H. Co.*)

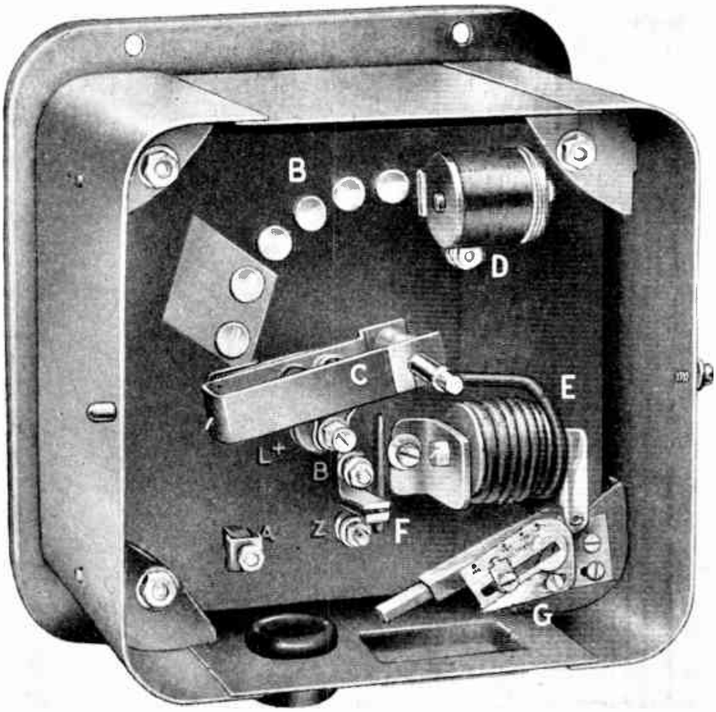


Fig. 2.—STARTER FOR 3 H.P. MOTOR.
The front cover and operating handle have been removed to show the faceplate. The starting resistances are fitted to the back of the faceplate, and the cables enter through the bushed hole. (*B.T.-H. Co.*)

starting would be for the current to remain constant while the starting resistance was being cut out. These conditions are represented graphically in Fig. 13. Thus constant torque would be available during starting, there would be no mechanical shocks, and the commutating conditions would be ideal. But to obtain these conditions in practice either a liquid rheostat or a metallic rheostat with continuous sliding contacts would be necessary, and in either case some device would be necessary to ensure that the resistance was cut out at the required rate.

PROCEDURE IN STARTING MOTORS LARGER THAN FRACTIONAL H.P. SIZES.

These motors must be started by inserting resistance temporarily in the armature circuit in order to limit the starting current to a safe value. It is important to observe that, in the case of shunt and compound wound motors, this starting resistance must be inserted in the *armature* circuit and *not* in series with the motor, as full excitation is essential to obtain the full starting torque.

Series-wound fan motors of 1 to 2 h.p. may usually be started without starting resistance.

Ideal Conditions for Starting.

The ideal conditions for

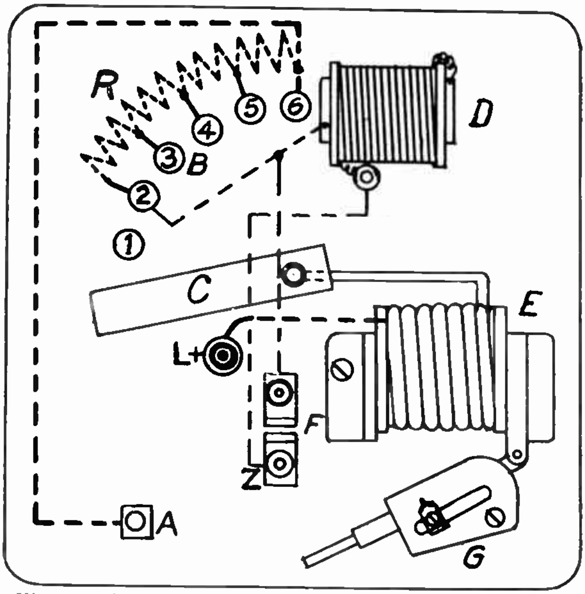


Fig. 3.—CONNECTIONS OF STARTER SHOWN IN FIG. 2.
The starting resistances are denoted by *R*.

Practical Conditions for Starting.

In practice the starting rheostat takes the form of a metallic resistance divided into sections which may be cut out successively step by step. In this case the best conditions for starting would be those represented graphically in Fig. 14, in which the *mean* current on each step has a constant value and the same variation of current occurs on each step. Thus the acceleration is practically uniform, but the time and speed increments for the steps are unequal.

With motors above 7 h.p. the initial current must be made lower than the peak value or upper limit in order to lessen the shock at starting. Accordingly the best starting conditions for these motors are represented graphically in Fig. 15.

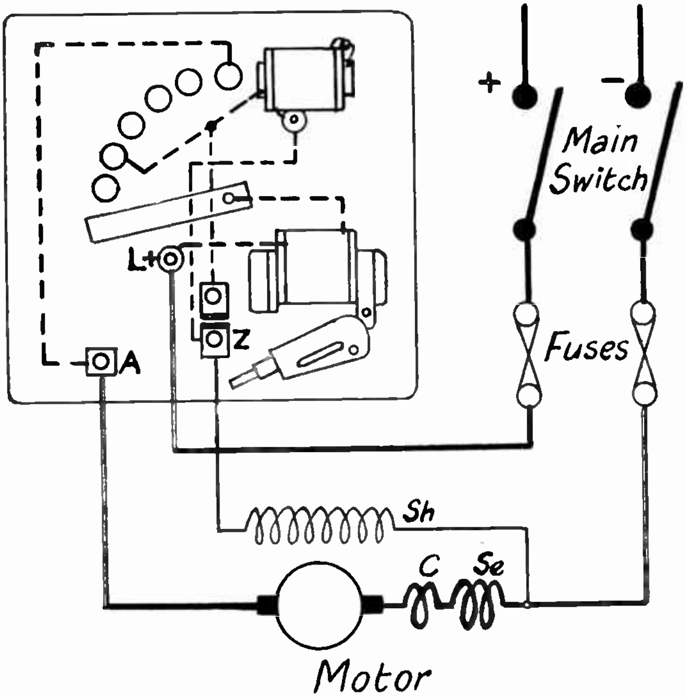


Fig. 4.—External Connections for Faceplate Starter and Compound-wound Motor.
The field windings are denoted by *Sh*, shunt field; *Se*, series field; *C*, commutating-poles.

It is important to realise that to obtain the results shown in Figs. 14 and 15 the resistances of the sections must be graded correctly and a section must be cut out only when the current has fallen to its lower limit.

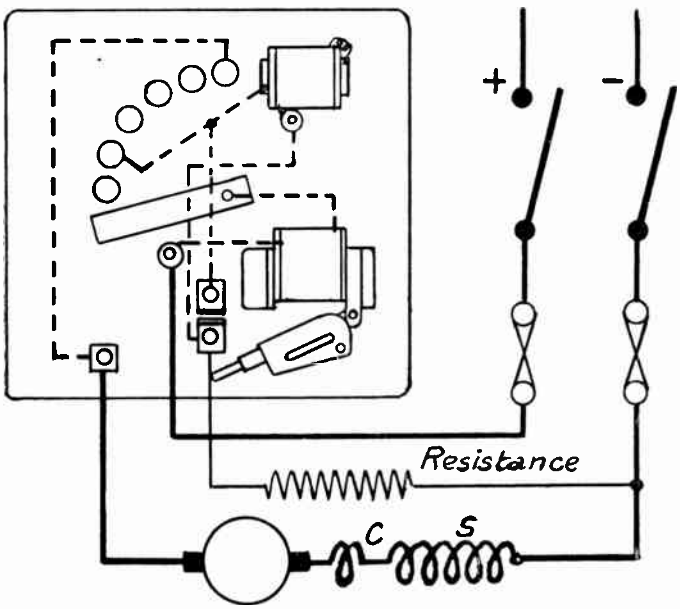


Fig. 5.—External Connections for Faceplate Starter and Series-wound Motor.

Why the Number of Sections Depends upon the Size of the Motor.

The number of sections in the starting rheostat for a shunt motor depends upon the permissible variation of current on each step and on the *percentage* voltage drop

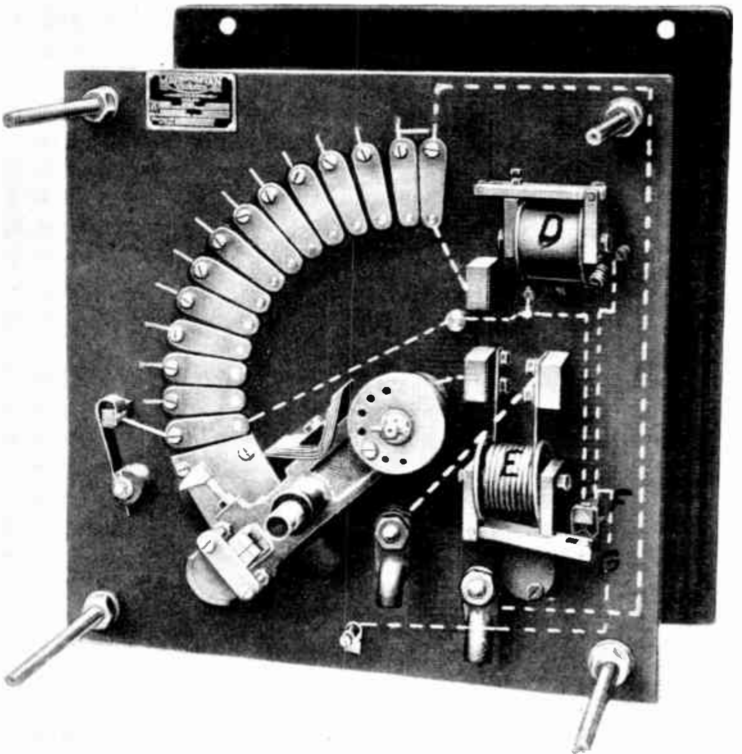


Fig. 6.—FACEPLATE STARTER FOR MEDIUM-SIZE MOTORS. The dotted lines show the internal connections. The letters D, E, F, G refer to parts which are similar to those in the starter illustrated in Fig. 2. The front and side covers and the operating handle have been removed to show the faceplate. (*Metropolitan Vickers.*)

in the armature circuit at full-load current. For given current limits, a large motor (in which the percentage voltage drop at full load has a low value) will require a larger number of sections than a small motor (in which the percentage voltage drop has a larger value). In practice, mechanical requirements at starting usually permit larger percentage variations of current and torque with small motors than with large motors, and in consequence, starters for small motors can be built with relatively few steps, especially if the current variation can be maintained strictly to specified limits.

CLASSIFICATION OF STARTERS.

The sections of the starting rheostat are cut out in the correct order by either a multi-contact switch or a group of contactors (electromagnetic switches).

The multi-contact switch is usually of the *faceplate type* and is hand operated. Typical examples are illustrated in Figs. 2 and 6.

Faceplate starters are intended for *infrequent* starting, and are suitable for motors up to 75 h.p. at 400 volts (or lower h.p. at lower voltages). The limitation is due to the unsuitability of the faceplate type of switch for large currents.

When *frequent starting* is necessary, either hand-operated drum-type controllers or power-operated (electromagnetic) contactors must be used. The choice depends upon the service conditions and starting duty.

Hand-operated lever switches may be used for infrequently starting larger motors when the conditions are suitable, i.e., these starters are intended for power stations or works where skilled attendants are available.

Contactor starters are suitable for any starting service and for motors of any size. They are intended for remote control, and also for fully automatic or semi-automatic operation.

SUMMARY.

The types of starters and their uses are summarised in Table I on page 290.

CONSTRUCTION OF FACE-PLATE STARTER FOR SMALL MOTOR.

A typical starter for a 3 h.p. motor is illustrated in Fig. 2. This starter has button contacts B, and a U-shaped steel switch lever C, with a copper contact shoe. The switch lever is shown in the "off" position, to which it is biased by a spiral spring in the hub. The spindle is extended to engage with an insulated operating handle fitted into the front cover.

The sections of the starting rheostat (which are located behind the faceplate) are connected to the contact buttons, and are cut out of circuit by moving the switch lever in a clockwise direction.

The switch lever is retained in the full-on position by an electromagnet D, which forms one of the protective devices described below.

Protective Devices.

The starter is provided with two protective devices, which cause the switch lever to return to the "off" position in the event of either the supply failing (*under-voltage release*) or the current input to the motor exceeding a predetermined value (*over-current release*).

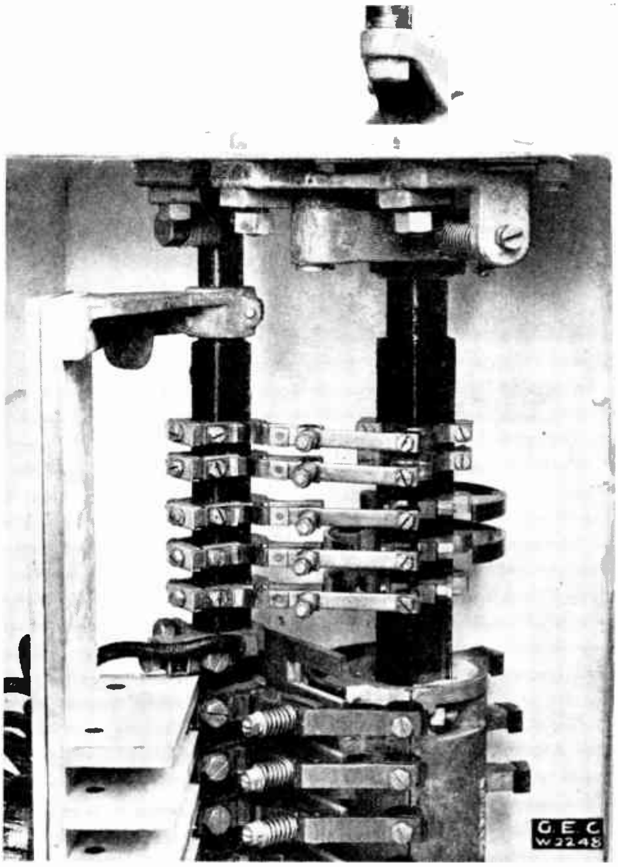


Fig. 7.—PORTION OF DRUM-TYPE CONTROLLER. (*G.E.C.*)

Under-Voltage Release.

This is the electromagnet D, which is wound with fine wire and is connected in series with the shunt field winding when the starter is used with shunt and compound wound motors. In a starter for a series motor this coil, together with an additional series resistance, is connected across the supply. The number of turns in the coil depends upon the normal shunt-field current of the motor, and is such that the electromagnet will hold the lever in the "full-on" position over a wide range of field currents. The switch lever is released and returned to the "off" position if the electromagnet is deprived of its excitation by: (1) a break in the field circuit; (2) failure of the supply; (3) action of the over-current release.

Over-Current Release.

This is an electromagnetic device for short-circuiting the coil of the under-voltage release when the current input to the motor exceeds a predetermined value. It consists of a series wound electromagnet E, fitted with a hinged armature, which, when it is attracted to the horizontal position, closes the contacts F, to which the coil of the under-voltage release D is connected. The armature normally rests against an adjustable stop G, which is calibrated at 100 per cent., 133 per cent., 166 per cent. and 200 per

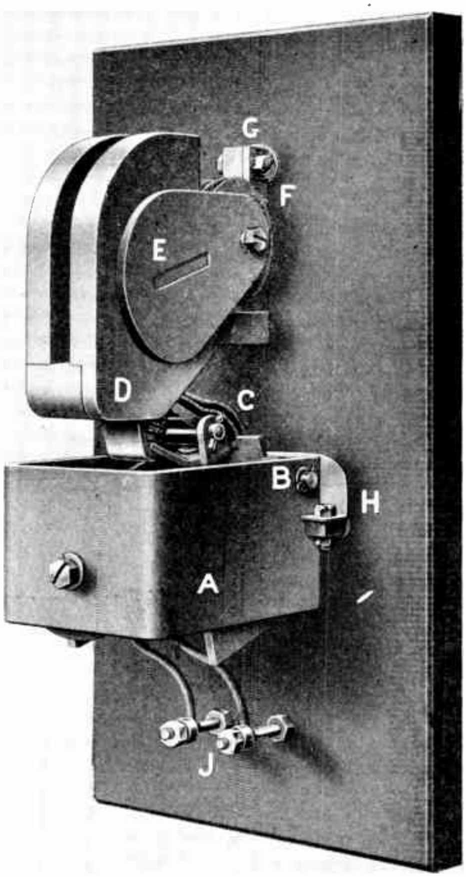


Fig. 8.—ELECTROMAGNETIC SHUNT-WOUND CONTACTOR. (*B.T.-H. Co.*)

cent. of the full-load current of the motor. Thus the over-current release can be set to operate at any predetermined overload.

Internal Connections.

The internal connections of this starter are shown in Fig. 3. The chief items to be noted are: (1) the last, or "full-on" contact button (No. 6) is connected to terminal A; (2) the over-current release coil is connected between terminal L+ and the hub of the switch lever; (3) the under-voltage release coil is connected to the terminals B, Z, to which are fitted the short-circuiting contacts operated by the over-current release; (4) the end of the under-voltage coil which is connected to B is also connected to the first "live" button (No. 2) and to the iron core of the under-voltage release.

This scheme of connections is common to all starters of the faceplate type. Item (4), however, is subject to modification in starters for larger motors which have higher shunt-field currents.

External Connections for Shunt or Compound Wound Motor.

These connections are shown in Fig. 4 from which the following details should be carefully noted:—(1) one terminal of the shunt field winding and one of the armature or series-field terminals of the motor must be permanently connected together and then connected directly to the main switch (negative); (2) the positive pole of the main switch is connected to terminal L+; (3) the remaining armature terminal is connected to terminal A; (4) the remaining shunt-field terminal is connected to terminal Z.

Tracing the Connections.

When the switch lever is on the first "live" contact button, two parallel circuits are completed, viz. (1) the main circuit, via terminal L+, over-current coil, switch lever, starting resistance, terminal A, armature of motor to negative pole of main switch; (2) the shunt-field circuit, via terminal L+, over-current coil, switch lever, under-voltage coil, terminal Z, shunt-field winding of motor to negative pole of main switch.

On the next contact button a section of resistance is cut out of the main circuit and is included in the shunt-field circuit since the switch lever connects the supply to *both* main and shunt-field circuits. Similar conditions occur on the other steps until finally all resistance is cut out of the main circuit. The starting resistance is also cut out of the shunt-field circuit when the switch lever touches the iron core of the under-voltage release. Thus the motor operates with full voltage on both armature and shunt-field circuits.

To Start and Stop a Motor Correctly.

Starting.—First see that the starter switch lever is in the "off" position. Then close the main switch and move the starter handle *slowly* towards the full-on position, holding it on the first step for about 2 seconds and on the other steps for progressively shorter periods, so as to complete the movement in about 7 seconds for a motor of 3 h.p. With a larger motor a longer period is necessary, the duration of the period for ordinary starting duty being $(5+\frac{1}{2}\times\text{rated h.p.})$ seconds.

Stopping.—Always stop the motor by switching off at the main switch. Do not knock the switch lever to the off position, as this procedure will result in burnt contacts which may cause sticking of the switch lever and its failure to release automatically on overload.

When the main switch is opened the switch lever of the starter does not return immediately to the off position, because if the connections are traced through, it will be found that the machine is acting as an unloaded shunt-wound generator, the armature being driven by its momentum and that of the load. The shunt-field current, therefore, decreases slowly according to the decrease in speed, and the switch lever will be held until the field current has decreased to low value. Thus no current is broken at the switch contacts and no high voltages are induced in the shunt-field winding.

When, however, the motor is stopped automatically by the action of the over-current release, the contacts are liable to be burnt, but such occurrences should be rare. In order to provide a long break for the arc when the switch lever leaves button No. 2 two dummy buttons (one of which, No. 1, is visible in Fig. 2) are fitted. A thin sheet of fireproof material is fitted between buttons Nos. 1 and 2 and the faceplate (which is made of moulded insulation) to protect the latter from the burning action of the arc.

Re-starting.—The starting resistance in a starter intended for ordinary duty will overheat if the starter is used at frequent intervals. The resistance is usually designed for four starts per hour against full-load torque, and therefore, an interval of about 15 minutes must be allowed between successive starts against full-load torque.

External Connections for a Series Wound Motor.

These connections are shown in Fig. 5. A special under-voltage coil (designed for a small current) and a suitable series resistance are necessary. The coil and resistance are connected across the supply.

FACEPLATE STARTERS FOR MEDIUM SIZE MOTORS (UP TO 75 H.P.).

These starters differ from those for small motors in the following features:—(1) renewable contacts of segmental form; (2) contact brushes (metal and carbon) instead of a copper shoe; (3) carbon

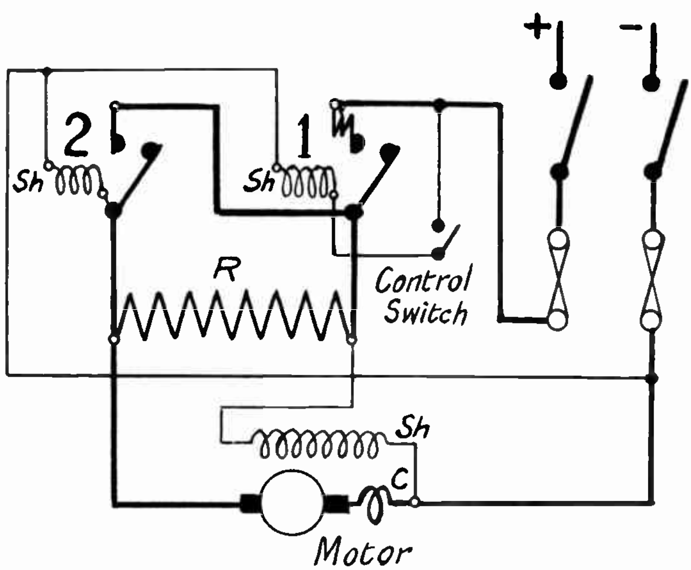


Fig. 9.—CONNECTIONS OF COUNTER-E.M.F. STARTER AND SHUNT-WOUND MOTOR.

This starter has two shunt-wound contactors, 1, 2, and a single section of starting resistance R. The action is as follows: When the control switch is closed the operating coil of contactor No. 1 is excited and this contactor closes, thus completing the main circuit through the starting resistance and the motor. Contactor No. 2 closes, and short circuits the starting resistance, when the voltage across the motor armature reaches a predetermined value.

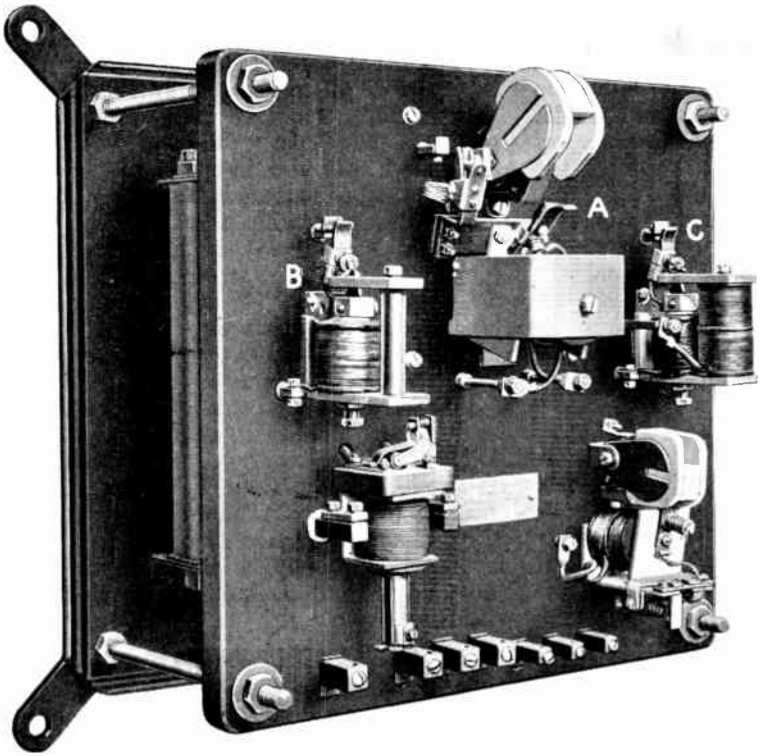


Fig. 10.—NON-REVERSING AUTOMATIC STARTER WITH SERIES LOCK-OUT CONTACTORS.

This starter has a shunt-wound contactor, A; two series lock-out contactors, B, C; an overload relay; and an auxiliary shunt-wound contactor for electric braking. (*B.T.-H. Co.*)

sparking contact for first step; (4) laminated brush and contact blocks for short circuiting the switch-lever contacts in the full-on position; (5) special contacts (button and finger) for maintaining full field in "full-on" position of switch lever.

A typical starter is illustrated in Fig. 6 in which the above features can readily be observed.

The internal connections are shown by dotted lines.

Heavy Duty Faceplate Starters.

More care, and a longer starting period, are necessary for motors driving loads having considerable flywheel effect (such as punch presses, circular saws, centrifugals, etc.) than for ordinary machine-tool drives. Starters for such heavy duty have the resistances designed for a starting period of one minute. The main contact segments are usually supplemented by carbon rollers to prevent burning of the segments and brushes due to sparking.

Inching Faceplate Starters.

Heavy duty faceplate starters may be adapted to inching service by the addition of a contactor and an interlocking switch on the switch lever. The arrangement is such that the main circuit is closed by the contactor when the switch lever is moved forward and is opened by the contactor when this lever is moved slightly backward. Thus all arcing is confined to the contactor.

CONTROL GEAR.

Control Gear for Small Motors.

Additional to the starter industrial motors require a double-pole switch and double-pole fuses. These items may be fitted into a common case as shown in Fig. 1, and mechanical interlocking can be provided to ensure that :—(1) the case cannot be opened unless the switch is open; (2) the switch cannot be closed when the cover is open.

Control Gear for Medium Size Motors.

The starter, etc., is usually fitted into an ironclad pillar with interlocked doors. Instead of a double-pole switch and fuses a pair of shunt-wound contactors are used which are electrically interlocked with the starter and over-current release, so that a forward movement of the switch lever from the "off" position causes the contactors to close, and the operation of the over-current release causes the contactors to open. Normal stopping of the motor is effected by opening the operating-coil circuit of the contactors by a push button. Thus all arcing is taken by the contactors which are provided with magnetic blow-outs and arc chutes.

For the smaller motors the starter is of the faceplate type, but for the larger motors it is of the drum type, with a slow-motion device.

Field Rheostats.

When field rheostats are necessary for speed variation they are fitted in the pillar and are electrically interlocked with the starter so that the motor cannot be started with a weak field.

DRUM CONTROLLERS.

These are used for controlling reversing motors, or for giving special circuit combinations, when a hand-operated control system is desired. A drum controller consists essentially of: (1) A series of fixed contacts (called "fingers") arranged in line, and usually mounted on a mica-insulated bar fitted in a suitable frame; (2) a series of moving contacts (called "segments") fitted to the periphery of an insulated drum or barrel, which is mounted in bearings in the frame, and so arranged that contact between certain fingers and segments is made when the drum is moved to certain positions; (3) a magnetic blow-out and arc shields for suppressing arcing at the contacts; (4) an operating handle; (5) a star-wheel and pawl for locating the drum in the operating positions.

Internal details of a controller are shown in Fig. 7. The main segments are of copper, and are screwed to projecting lugs on split "body-castings," which are clamped to a mica-insulated square shaft. The fingers are mounted on a mica-insulated bar, and the main fingers are provided with a magnetic blow-out and arc shields.

CONTACTOR STARTERS.

In these starters the sections of the starting rheostat are cut out by electro-magnetic switches (called "contactors"),

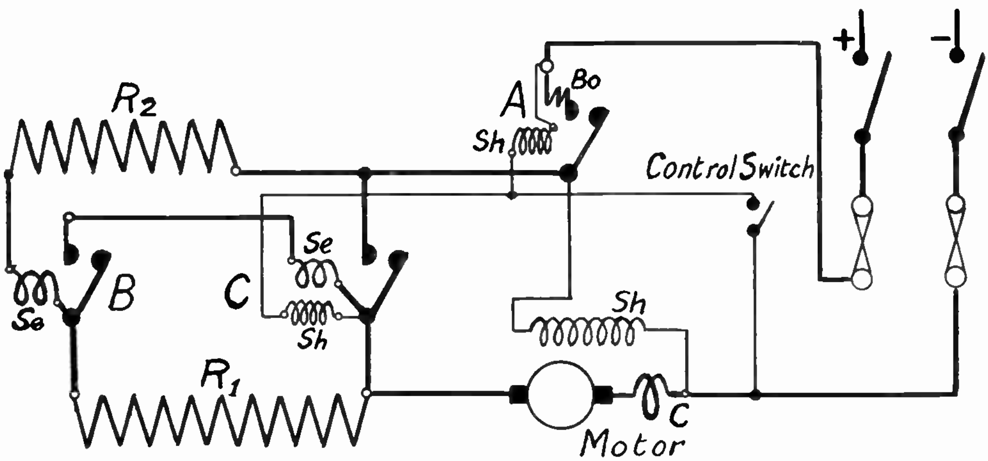


Fig. 11.—CONNECTIONS OF SERIES LOCK-OUT STARTER AND SHUNT-WOUND MOTOR.
This starter has a shunt-wound contactor, *A*, and two series lock-out contactors, *B*, *C*. There are two sections of starting resistance, R_1, R_2. The operating coils of the contactors are denoted by *Sh*, shunt; *Se*, series. *Bo* denotes the blow-out coil on the "line" contactor. The action is as follows: When the control switch is closed the operating coil of *A* is excited and this contactor closes, completing the main circuit through R_2, operating coil of *B*, R_1, and the motor. *B* locks out until the current falls to a predetermined value, and on closing cuts out R_1. *C* then locks out until the current falls again, and on closing short circuits the whole of the starting resistance. *C* remains closed by the action of an auxiliary shunt coil *Sh*.

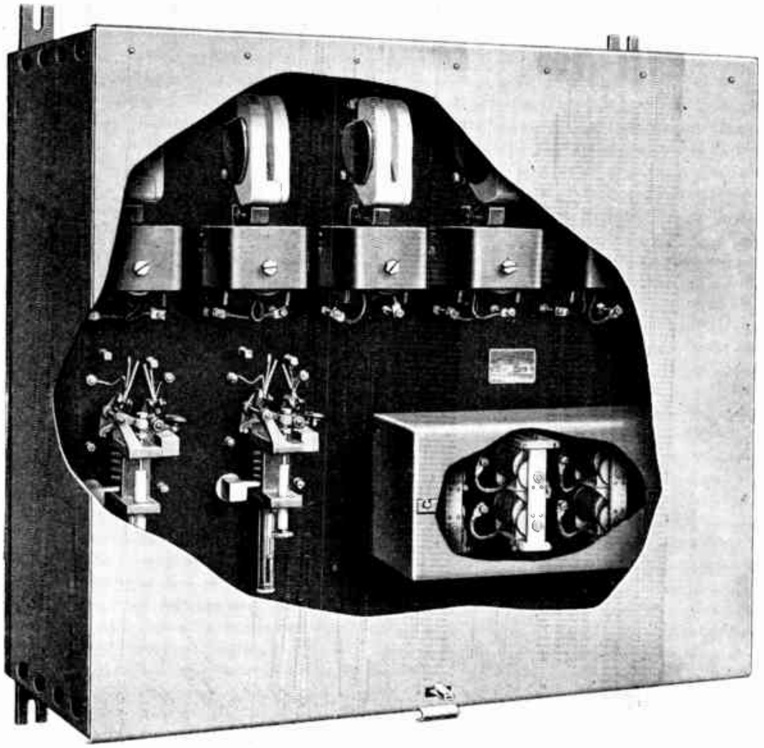


Fig. 12.—NON-REVERSING AUTOMATIC STARTER WITH SHUNT-WOUND CONTACTORS, CONTROL RELAYS AND OVER-CURRENT RELAYS.

This starter has five shunt-wound contactors, which are identical. One of these is a "line" contactor and the other four are "accelerating" contactors for short-circuiting sections of the starting resistance. The accelerating contactors are controlled by the four relays shown inside the inner cover (which is normally locked). The relays operate the contactors according to a combined current-limit and time-limit principle, i.e., when heavy loads are started the current is maintained within prescribed limits (similar to the conditions shown in Fig. 3.), but when light loads are started, too rapid starting is prevented by time-limit devices on the relays. (*B.T.-H. Co.*)

a separate switch being necessary for each section.

Advantages of Contactor Starters.

These starters have a number of advantages over faceplate and other types of hand-operated starters. Thus (1) they are suitable for *any* class of starting duty or service, e.g., light duty, heavy duty, non-reversing, reversing, dynamic braking, etc.; (2) frequent heavy-duty starting and stopping does not cause burning of the contacts because these contacts open and close rapidly and they are provided with magnetic blow-outs to suppress arcing; (3) they are remote controlled; (4) non-automatic, semi-automatic or fully automatic operation, can be used according to the service requirements; (5) they possess inherent protection against low voltage which can be arranged to give automatic restarting upon the restoration of normal voltage.

A Typical Contactor.

Fig. 8 illustrates a shunt-wound contactor. The essential parts are:—(1) a shunt-wound electromagnet with a pivoted armature carrying a moving contact; (2) a fixed contact; (3) a magnetic blow-out.

The electromagnet has a U-shaped yoke, A, with a cylindrical core and operating coil. The armature is also U-shaped and is hinged to the yoke at B. The moving contact, of which only a portion is visible in the illustration, is fixed to the outer end of an arm which is hinged at C to the armature. The outer end of the arm is flexibly connected to a bracket on the armature by a compression spring, which serves the double purpose of providing the requisite pressure between the moving and fixed contacts in the closed position of the contactor and of giving a combined rolling and sliding action between these contacts during closing. This action effectively removes any rough-

TABLE I.
TYPES OF STARTERS AND THEIR APPLICATIONS.

	Type.	Max. h.p. for which starter is suitable.	Max. duration of starting period (seconds).	Max. number of starts per hour at full-load torque.	Minimum interval between successive starts at full-load torque.	Suitable for
Hand Operated	Faceplate (ordinary duty)	50	$(5+\frac{1}{2}\times h.p.)$	4	14 times starting period.	Infrequent non-reversing light-duty starting (i.e. loads with no flywheel effect) at full-load, or lower torque. Machine tools, fans, centrifugal pumps, boiler house plant and general industrial drives.
Hand Operated	Faceplate (heavy duty)	75	60	4	14 times starting period.	Infrequent non-reversing heavy-duty starting (i.e. loads with flywheel effect) at full-load, or lower, torque. Punching machines, centrifugal machines, reciprocating pumps, air compressors.
Hand Operated	Inching faceplate (heavy duty)	25	60	4	14 times starting period.	"Inching" operations on printing presses, boring mills, etc.
Hand Operated	Self-contained control pillar with drum-type starter	350	60	4	14 times starting period.	Infrequent non-reversing heavy-duty starting. Applications similar to those of heavy-duty faceplate starters.
Hand Operated	Multiple Switch	1,500	60 [up to 250 h.p.] $60+\frac{1}{10}$ (h.p. − 250) [above 250 h.p.]	4	14 times starting period*	Infrequent starting of large non-reversing motors in power stations.
Hand Operated	Drum-type Controller with external rheostats	120	According to starting conditions and requirements.			Frequent reversing, heavy duty starting, and special starting requirements, e.g. specially slow speeds, dynamic braking, etc. Cranes, hoists, and steel works auxiliary motors.
Power Operated	Contactor	Any	For details see Table II.			Any starting requirements, and any service conditions.

*Two starts in succession, without the prescribed interval, may usually be made, provided that an interval of 30 times the starting period is allowed after the second start.

TABLE II.—TYPES AND APPLICATIONS OF CONTACTOR STARTERS.

Type.	Max. h.p. for which starter is suitable.	Max. duration of starting period (seconds).	Max. Number of starts per hour against full-load torque.	Suitable for.
Time limit (Automatic).	15 (Multiple finger type)	10	40	Non-reversing motors driving machines for which the starting conditions are constant; e.g., machine tools, organ blowing equipment, lifts, etc. NOTE.—For lifts a separate electrically operated reversing switch is necessary with a multiple-finger starter.
	150 (Individual contactors with multiple-finger timing relay).	15	40	
Counter-e.m.f. (Automatic).	5	5	15	Non-reversing motors and light-load starting; e.g., small machine tools (started light).
Series lockout (Automatic).	25	15	40	Reversing and non-reversing motors and heavy or light load starting, including inching and dynamic braking; e.g., large machine tools, wood-working machines, etc.
Relay (Automatic)	500 (medium size)	15	40	All classes of heavy starting service (reversing and non-reversing); e.g., pumps, blowers, fans, air compressors, large lifts, etc.
	2000 (large size).	According to load and starting conditions.		
Non-Automatic.	Any.	According to load and starting conditions.		Reversing motors and special starting service; e.g., all classes of cranes, hoists, auxiliary motors on rolling mills, etc.

ness, and maintains the contacts in a clean condition.

The Magnetic Blow-out.

Both contacts are located in an arc chute, D, of fireproof material which forms part of the magnetic blow-out. The latter consists of two pole pieces, one of which is shown at E, fitted to a core which is magnetised by a coil, F, connected between the fixed contact and the upper terminal, G. This coil (called the " blow-out coil ") carries the main current, and the pole pieces direct the

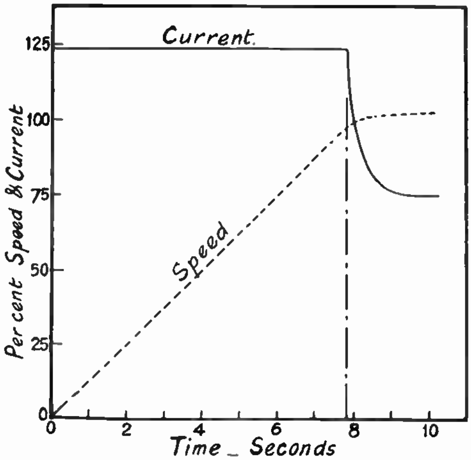


Fig. 13.—Ideal Conditions for Starting Small Motors.

Notice how the current is maintained at 25 per cent. above normal for eight seconds during which time the speed of the motor increases at a uniform rate. This condition can be achieved by using a liquid rheostat.

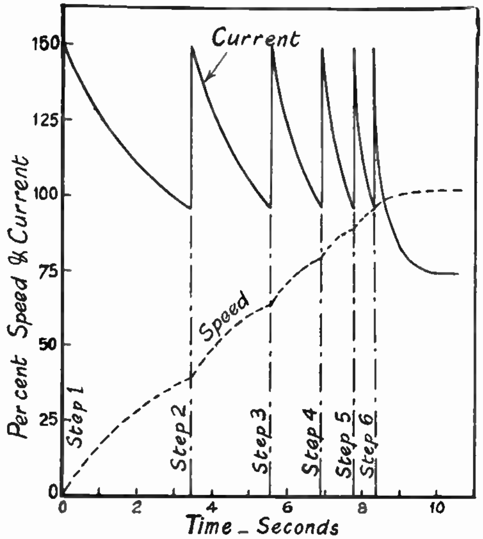


Fig. 14.—Practical Starting Conditions for Small Motors up to 7 h.p.

It will be seen that the current starts at 50 per cent. above normal, drops to normal after three seconds and then rises and drops at rapidly decreasing intervals. The speeding up of the motor fluctuates slightly as the starting handle is moved over each successive stud on the faceplate.

flux horizontally across the arc chute in which the main contacts are located. Hence, when the main circuit is broken the arc is blown outwards, i.e., away from the contacts, and the latter are, therefore, protected from burning.

Non-Automatic Operation.

A non-automatic starter is built up of a number of contactor units similar to Fig. 8, and the requisite sections of starting resistance. The operating coils of the contactors are connected to a small hand-operated drum-type controller (called a "master controller") which controls the order of closing of the contactors.

Automatic Operation.

In this case the contactors must close automatically in the correct order and at the correct rate when a pilot, or master, switch is closed, and must open when this switch opens. Obviously, some automatic device is necessary to ensure that the contactors close at a predetermined rate.

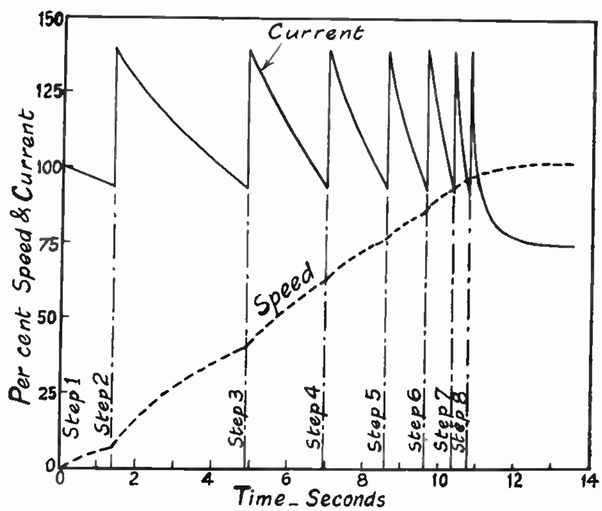


Fig. 15.—Practical Starting Conditions for Medium-size Motors from $7\frac{1}{2}$ to 75 h.p.

In this case the current starts at normal and rises to about 40 per cent. after $1\frac{1}{2}$ seconds and then rises and drops in a similar manner to that shown in the previous figure. Here again the speeding up of the motor fluctuates slightly at each stop. The ideal increase in speed should, of course, be constant, as shown in Fig. 13.

This device may take the form of either a *timing mechanism* for completing the starting operations in a given time (called "time-limit" starting), or *electromagnetic relays* which energise the contactors at a predetermined current input to the motor so as to obtain, with correctly graded rheostats, the starting conditions shown in Figs. 14 and 15. This method is called "current-limit" starting. Alternatively, for small motors, which may be started with large variations of current (i.e., two or three sections in the rheostat), special contactor operating coils, either shunt or series wound, may be used instead of relays. Starters having these special coils are called "counter-e.m.f. starters" (shunt-wound coils) and "series lock-out starters" (series-wound coils).

Practical Applications.

Fully automatic operation is used for machines which should start and stop according to the service conditions; e.g., *pumps* supplying a tank or reservoir are controlled by a float switch so as to start and stop as the level in the tank falls or rises; *high-pressure pumps* supplying a hydraulic accumulator are controlled by tappet switches so as to start and stop as the accumulator descends or ascends; *air compressors* are controlled by a pressure switch so as to start and stop as the air pressure in the reservoir falls or rises; *automatic, or push-button, lifts* are controlled by push-buttons and tappet switches, the push buttons being located at the loading platforms and in the cage, and the tappet switches being fixed in the lift shaft so as to be operated by the cage.

Semi-automatic operation is used for machines which should complete their starting operation automatically when a pilot switch or push-button is closed, and should continue to run until the pilot switch or control circuit is opened by hand. For example, in the planer equipment shown on p. 154, the planing machine motor starts automatically when the "start" push-button, 8, is pressed and continues to run until the "stop" button is pressed.

Time Limit Contactor Starter.

For small motors (up to 15 h.p.) a multiple-finger contactor operated by a single coil or solenoid is used. The moving fingers are "stepped back" so as to close against the stationary contacts in a fixed sequence. The timing device consists either of a dashpot or a clockwork mechanism.

Counter e.m.f. Starter.

This is the simplest form of current-limit starting, but is only suitable for small motors (5 h.p. max.) which can be started with a single section of resistance. Only two contactors are necessary. The operating coil of one contactor (called the "line" contactor) is connected across the supply and is controlled by the master switch. The operating coil of the other contactor (called the "accelerating" contactor) is connected across the armature of the motor. This coil is adjusted to close the contactor when the voltage across the armature reaches a predetermined value.

The connections of a counter-e.m.f. starter are shown in Fig. 9. When the main and control switches are closed the operating coil of contactor No. 1 is connected across the supply. This contactor closes, and connects the starting resistance *R*, in series with the motor. The operating coil of contactor No. 2 is permanently connected across the main terminals of the motor. Hence when the voltage across the armature builds up to a predetermined value contactor No. 2 will close and complete the starting operations.

When the control switch is opened, contactor No. 1 opens immediately, and after a brief interval No. 2 opens.

Series Lock-out Starter.

In this type of starter (which is suitable for motors up to 25 h.p.) the accelerating contactors are *series wound* and are of a special design to give current-limit starting. A typical starter is illustrated in Fig. 10. It consists of a shunt-wound "line" contactor (similar to Fig. 8), two series lock-out contactors, an auxiliary shunt-wound contactor and an overcurrent relay. The series lock-out contactors are of the plunger type. The moving contact is carried by a bell crank lever, which is operated by a pin fixed through the top of the plunger.

The Lock-out Feature.

The lock-out feature (which causes the contactor to hold open, or lock out, when the current in the series-wound operating coil exceeds a predetermined value) is obtained by an air gap and combined iron path at the lower end of the plunger. The magnetic pull at the lower air gap (which tends to hold the plunger down and prevent the contactor closing) follows a different law—with respect to the current in the operating coil—from that at the upper air gap (which tends to lift the plunger and close the contactor). The lower air gap is so adjusted that for currents above a predetermined value (called the calibrated value) the downward pull on the plunger is greater than the upward pull, but for currents below this value the upward pull is the greater. Hence, when the operating coil of such a contactor is connected in series with the starting rheostat of a motor the initial rush of current causes the contactor to hold open, and to remain so until the current falls to the calibrated value, when the contactor will close and cut out a section of the rheostat. The sudden increase of current will then cause the succeeding contactor to lock out until the current falls again to the calibrated value.

Connections of Series Lock-out Starter.

Owing to the series-wound operating coils of the lock-out contactors the connections differ considerably from those of the main-circuit of a starter with shunt-wound contactors. A simple diagram showing the general scheme is shown in Fig. 11. The essential features to be noted are:—(1) the line contactor, A, is shunt wound and its operating coil is controlled by the master switch; (2) the two sections of the starting rheostat are separated from each other (i.e., they are not connected directly in series as in an ordinary starter) and are connected through the operating coil of the first accelerating contactor, B; (3) the contacts of B are connected in series with the operating coil of the second accelerating contactor, C, and this circuit is connected in parallel with the first section of the rheostat; (4) the contacts of C short circuit the whole of the starting resistance together with the operating coils of contactors B and C; (5) a shunt retaining coil is necessary on C to retain this contactor in the closed position.

Relay Contactor Starters.

These are suitable for general starting service for motors above 25 h.p.; they are also suitable for all classes of special starting service. Shunt-wound contactors are used, and the operating coils of the accelerating contactors are controlled by electromagnetic relays to give current-limit starting. Formerly the relays were series wound, but modern equipments usually have shunt-wound relays because current-limit starting can then be combined with time-limit starting, and too rapid starting at light loads can be avoided. A typical starter is illustrated in Fig. 12.

Summary.

The types of contactor starters and their uses are summarised in Table II on page 291.

QUESTIONS AND ANSWERS

At what power does a starter become essential for a d.c. motor?

(A) For shunt-wound motors—above ¼ h.p.

(B) For series-wound motors (starting under load)—above ¾ h.p.

(C) For series-wound motors (driving fans, etc.)—above 2 h.p.

(D) For compound-wound motors—above ¾ h.p.

In using a starting rheostat for a smal motor, what precaution must be taken?

In the case of shunt and compound-wound motors, care must be taken to insert the resistance *in the armature circuit*—not in series with the motor.

What is the function of a "no-volt" or "under-voltage" release?

To disconnect the motor from the mains in case of:—

(A) Temporary failure of supply;
(B) Break in the field circuit.

HEADPHONES AND LOUD-SPEAKERS

PRACTICAL NOTES ON THEIR CONSTRUCTION, REPAIR & USE

By A. E. Watkins.

TELEPHONE HEADGEAR

The telephone headgear is one of the oldest links in the wireless receiver for translating electrical waves into sound vibration. In all the commercial types the moving parts are either a metal diaphragm of magnetic material or a non-magnetic diaphragm operated by a magnetic reed linked to the diaphragm, as shown in Figs. 2 and 6.

The electrical arrangement of both types is practically the same and, as a rule, the permanent magnet is of U or ring shape.

On the ends of the U-shaped magnet are fixed soft iron pole pieces, as in the above figures, but in the ring-shaped magnet the poles are placed across the centres, as in Fig. 4.

Fig. 1.—How to Loosen a Tight Earpiece.

It sometimes happens that earpieces get very tight. Force must not be used to make them unscrew, but instead carefully warm over a gas ring until they turn without undue pressure having to be used.

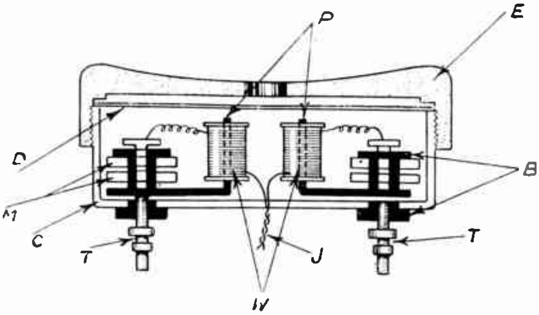


Fig. 2.—The Components of a Magnetic Diaphragm Type of Receiver.

E, ear cap; *D*, magnetic diaphragm; *P*, soft iron poles; *M*, magnets; *B*, insulating bush; *T*, terminals; *J*, joint between coils; *W*, windings.

An Important Point with Bobbins.

Fitted over the extensions of the iron poles are bobbins on which the wire is wound to form the coils. The coils are connected in series, as Fig. 5, and the ends connected to the terminals. If the bobbins are both wound in the same direction, which is nearly always the case in practice of manufacture, the two inside ends are joined together so as to produce N and S poles at the tips of the soft iron poles; therefore, when rewinding, follow the practice of winding both bobbins in the same direction, starting at the bottom and finishing at the top end, as Fig. 5.

How Vibration is Produced.

The thin metal diaphragm, or the reed, is supported a little way above the tips of the pole pieces. Now, as the varying currents, due to speech and music, are passed through the windings, the magnetic pull is made alternately weaker or stronger, since the electro-magnet works with and against the permanent magnet, with the result that when the pull is increased, the diaphragm moves towards the poles, and when decreased it springs away from the poles.

It is thus caused to vibrate and so translate the electrical waves into sound waves by agitating the air above; it is on this principle that all magnetically moving iron speakers work.

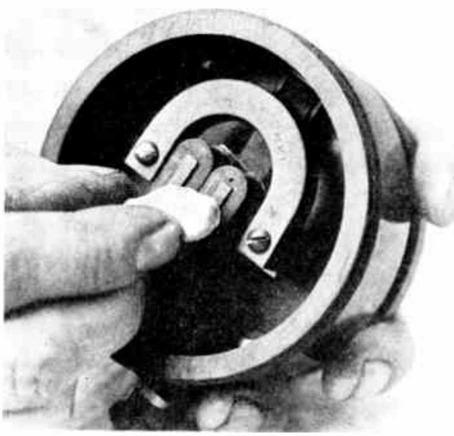


Fig. 3.—CLEANING THE TIPS OF THE POLES.
A piece of plasticine or putty should be used to remove any small pieces of iron that collect on the tips of the poles.

A Common Fault.

One of the commonest faults in this type of unit is small pieces of iron which collect on the tips of the poles and so prevent the free movement of the diaphragm or reed; this also causes poor sensitivity.

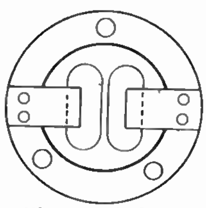


Fig. 4.—A RING-SHAPED MAGNET.

How to Remove Iron Pieces.

One of the best ways to remove these iron pieces is with a piece of plasticine or putty (see Fig. 3), for the small pieces of iron will imbed into the putty and leave the magnet poles clean; this is the best way, to the writer's knowledge, of satisfactorily cleaning the magnet, and it is a tip worth remembering, as one small filing can cause a lot of trouble, resulting in singing and crackling.

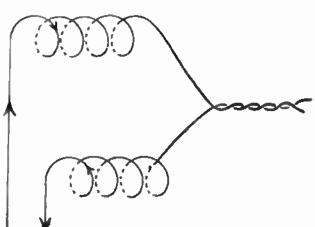


Fig. 5.—CONNECT THE COILS IN SERIES.

Faulty Winding.

Another fault common to all types of speakers is that of a faulty winding, and if the receivers or speakers fail to give a click when the ends of the cords are touched on the terminals of a battery of, say, approximately 6-20 volts, or by a voltmeter and battery (see Fig. 7), then it is certain that either the cords or the windings are broken (care must be taken to see that the diaphragm or reed is correctly adjusted).

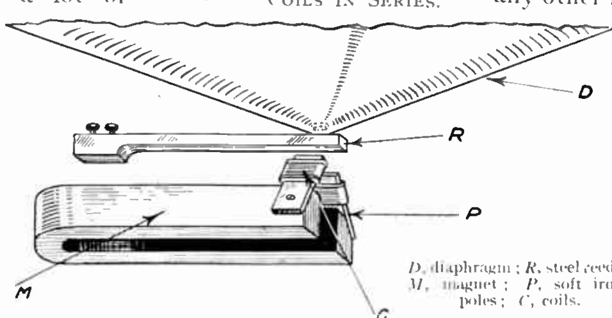
Locating the Break.

To locate the seat of the break, proceed in the following manner:—

Unscrew the ear-pieces, sometimes these get very tight, and if they cannot be unscrewed by hand, do not use force, for the material from which these are made is often brittle, but very carefully warm the earpieces until they can be unscrewed by hand. (See Fig. 1). Of course, care must be taken in warming, usually only a very slight heat is required.

Testing with a Battery.

Now disconnect the cords of the terminals and connect a piece of flexible wire to each terminal, taking care that the ends do not touch any other metal part but the terminals. Replace the diaphragm and earpieces and test across the battery. We shall now easily find out which of the receivers, if any, are faulty; if both test out satisfactorily, it then



D, diaphragm; *R*, steel reed; *M*, magnet; *P*, soft iron poles; *C*, coils.

Fig. 6.—THE COMPONENTS OF A MAGNETIC REED TYPE OF RECEIVER.

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