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STUDENTS, APPRENTICES AND IMPROVERS IN ALL BRANCHES OF THE ELECTRICAL AND WIRELESS INDUSTRIES

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PART 2

A PRACTICAL WORK WRITTEN BY EXPERTS

machine has, with less risk of breakdown.

Operating on Different Voltages.

It is always well to have the motor of any portable tool wound for the exact voltage on which it is required to operate. In case of necessity, series wound machines of good design can be used as follows :—

220 volts motors on any voltage from	250 to	200
110 ,, ,, ,,	125 ,,	100
500 ,, ,, ,,	600 ,,	440

In such a case the need should be specified, as the motor would be wound with this end in view.

Voltage and its Effect on Speed.

An electric motor is unlike an electric lamp in that it is not sensitive to variation in pressure. All that happens is that the speed of the motor varies slightly with the voltage, but this makes very little difference to the spindle speed, as the ratio of reduction is so great that even a considerable variation of the motor speed does not appear to be more than a few revolutions at the spindle.

It is possible to obtain two and three speed machines for use on D.C., but leading makers consider a series motor type superior, as a much wider range of speeds is obtained without the complications of a three-speed gear.

Working Tools from the Lighting Circuit.

Electric tools are in many cases operated from the lighting circuit by means of lamp-holder adapters. In large works it is usual to operate from wall sockets placed at convenient points with the necessary protection afforded by the earth pin.

Earthing.

All machines should be fitted with three or four core cable, so as to give suitable earthing facilities in accordance with Home Office regulations, and reliable makers supply the tools with the earth wire of the cable indicated by means of a label. This should serve to remind the user that a 3-pin or 4-pin plug is obviously called for and should also prevent the possibility of his connecting one of the

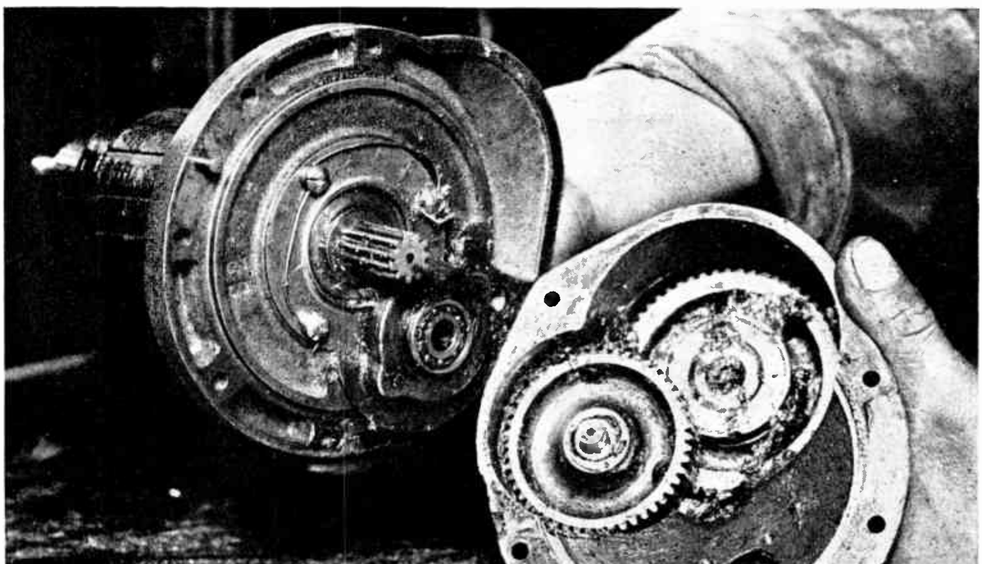

Fig. 3.—GEAR CASE OF A HEAVY DUTY ELECTRIC DRILL.
Showing the gear case dismantled.

A

line wires to the earth, a by no means infrequent happening, in spite of the precaution of the label.

Points to Consider.

In the choice of a machine the user will give due consideration to light weight, but important as this point is in a portable tool, just as essential is ease of manipulation and general "handiness" and a machine that is bulky and unwieldy in shape will not be found so convenient in use as a tool of neater design, though perhaps slightly heavier in weight.

Another type may be a thoroughly sound machine, but the weight is unbalanced and for this reason the design does not find favour with the operator.

Again, a type though heavy in weight may be frail in design and once out of order has little more working life left. This, of course, is found in a cheap class of tool, and suggests either lack of experience in its designing or the sacrifice of quality to cheapness.

Accessibility is an important feature and reflects favourably on maintenance costs by permitting the tool to be taken apart in the least possible time when sent to the tool room for overhaul.

Drilling Machines.

In drilling machines the side spindle type has entirely superseded the centre spindle machine, as it is better adapted to close quarter drilling.

Request is frequently made for a portable tool for the dual purpose of drilling and grinding, heedless of the fact that the two requirements are neither compatible nor practical—a very high speed being necessary for grinding and a comparatively slow speed for drilling. The differences are so great as to render compromise impossible except, perhaps, by giving a shaft extension driving straight off the armature. The speed of the armature of a drill motor may, of course, be as high as 10,000 to 11,000 r.p.m., being reduced by gearing to a speed at the drill spindle as low as 170 r.p.m.

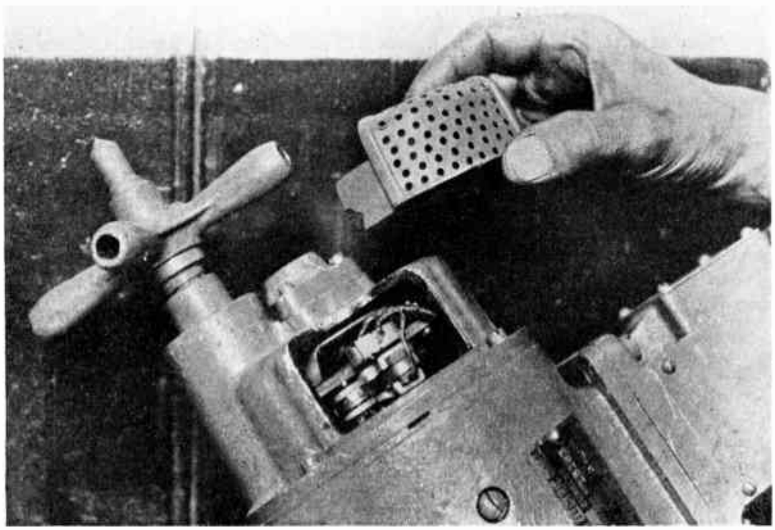

Fig. 4.—Examining the Commutator.

This can be done by lifting off the removable enclosing cover.

It will be obvious that such a combination will have its disadvantages and that if serious work be contemplated, "one tool, one job" is the better maxim.

A Common Error.

Another common error is to suppose that a "universal" motor will operate on any and every sort of voltage and periodicity. In this case the term "universal" is certainly misleading. The universal motor of the portable electric tool is limited to D.C. or A.C. single-phase supply of *the one voltage for which it is wound.*

Maintenance and Care of Tools.

On the question of maintenance of tools of this kind, they should in the ordinary course of events be opened out and thoroughly cleaned at least once a fortnight. Less than this is probably insufficient to keep the machines in good working order.

The bearings of the modern portable electric tool are of the ball type and care should be taken to see that these bearings are supplied with the necessary grease for lubricating. The slogan "Grease is cheaper than bearings" is equally applicable to the portable tool as to the automobile.

Cleaning the Gear Case.

Gears are intended to run in grease and an opening in the gear case is provided for its insertion. Every two months the gear case should be removed, the old grease cleaned out and a liberal quantity of fresh grease applied around the gears and bearings. The application of four to six ounces of high-grade non-fluid oil every two or three weeks is recommended when the tools are in constant operation.

Commutators.

Commutators should be kept clean and brushes should not be permitted to wear too short. Removable enclosing covers permit brushes and commutator to be examined without difficulty.

Switch contacts should be examined and cleaned occasionally.

How to Trace Overheating.

Defects which develop in a machine are more often than not caused by careless treatment. It may happen, however, that a machine recently purchased or newly returned from repair is giving trouble through overheating, or its output may be reduced. What is the cause of the trouble? Ascertain the class of work and rated capacity of the tool to ensure that the work is not beyond its capacity.

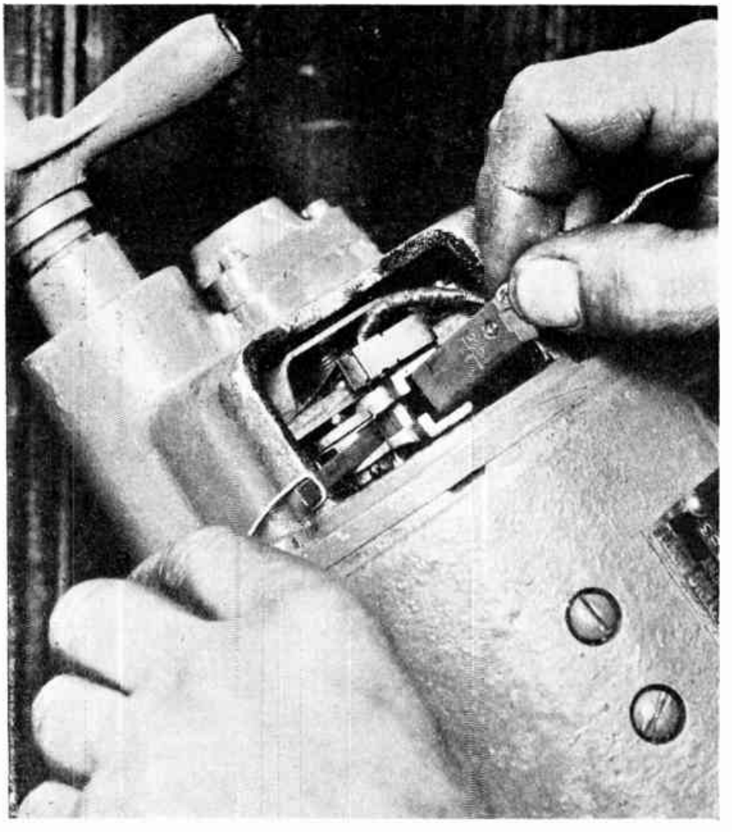

Fig. 5.—INSERTING A NEW BRUSH.
Showing how to hold back the spring that keeps the brush in position.

Examine the Cutting Edge of the Bit.

In the case of a drilling machine, look at the cutting edge of the bit. The bit may be blunted, in which case the edge should be sharpened and ground.

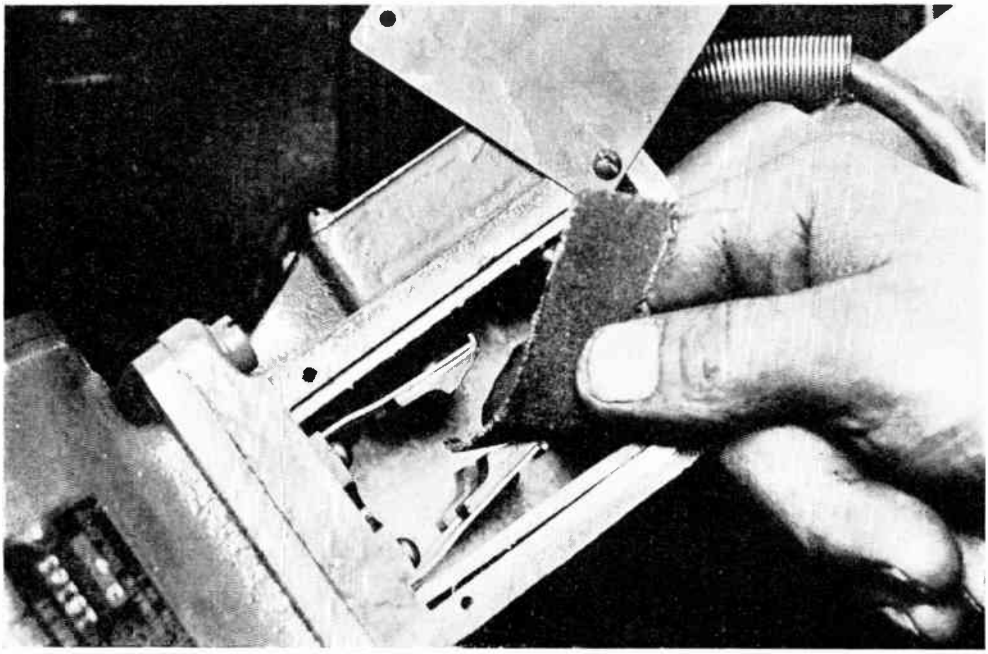

Fig. 6.—How to Clean the Switch Contact.

Switch contacts should be examined and cleaned occasionally, and the best method is to use a small piece of emery cloth.

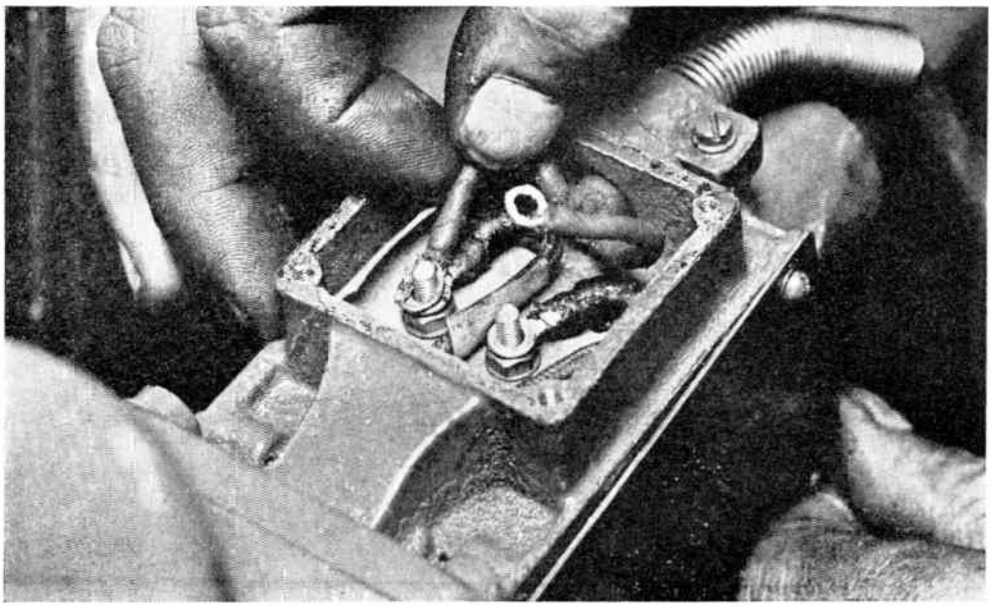

Fig. 7.—Fitting a New Cable.

When stripping back the covering of the wire in order to make the necessary eyelets for fitting to the screw of the terminal, do not strip the wire too far, or else you may cause a short circuit.

Running the Tool for Too Long.

If the bit is found to be in good condition, then look to the machine itself. The heating may be due to several causes, excessive feed or running the tool for too long a period being the chief. Excessive feeding is easily rectified by pointing out the fault to the operator.

If the tool is run continuously, the operator drilling hole after hole at top speed until the machine becomes too hot, the armature will be burned out if not allowed a short period to cool.

Portable electric tools are of intermittent rating, but given ordinary care, they can be operated throughout the day without difficulty.

It is not easy to give a specific time in which they will heat up, as much depends upon the class of work. A great deal must be left to the discretion of the operator. A fair guide is approximately 20 minutes for drills up to $\frac{5}{8}$-inch capacity and 30 minutes for large size machines when drilling continuously. Too much importance should not be paid to these figures, however, because, as already stated, a machine when skilfully handled will work satisfactorily over quite lengthy periods.

Sparking at the Commutator.

If there is considerable sparking at the commutator, look at the brush gear and commutator. The latter should be kept clean and free from carbon dust. The brushes must be of the correct size. Poor commutation is frequently caused by inferior brushes, incorrect size and also excessive spring tension. Too great a tension on the brush causes heating of the commutator, which in turn causes the melting of the solder on the armature connections, resulting in broken wires and a burn-out in the armature coils.

Spring Tension.

The tension of the spring should be neither too severe nor too weak, and the brush surface should rest fairly firmly, yet easily, against the commutator.

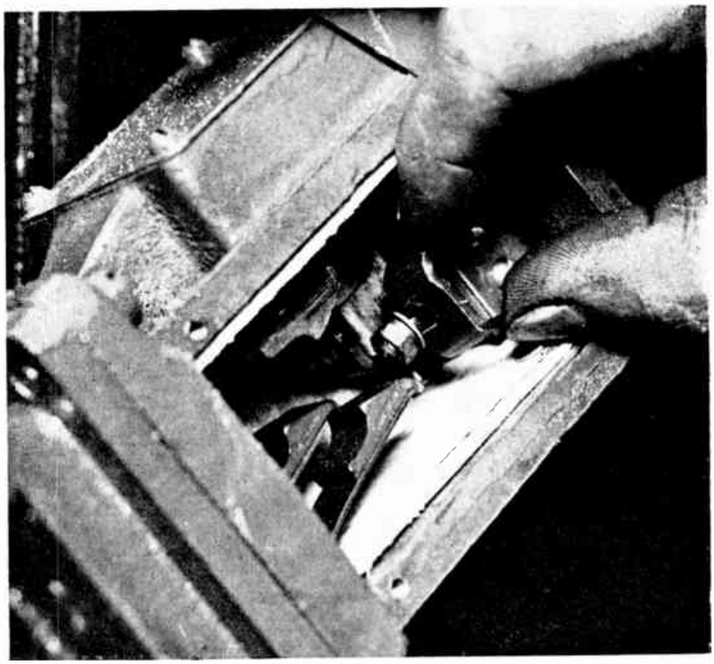

Fig. 8.—Inserting a New Switch Contact.

Should this examination fail to reveal the fault, the machine should be returned to the makers.

The best manufacturers send out machines under a guarantee of six or twelve months against defective material or workmanship. Where a machine is within the guarantee period, and if a fault develops which cannot be located under the methods suggested, it should at once be returned intact and without having been opened up.

It not infrequently happens that an operator will continue to use a tool until the armature arrives at such a burned condition that there is nothing whatever to prove whether the trouble commenced through a defect in the armature itself, and the subsequent repair is much more serious and extensive than the guarantee can legitimately be expected to cover.

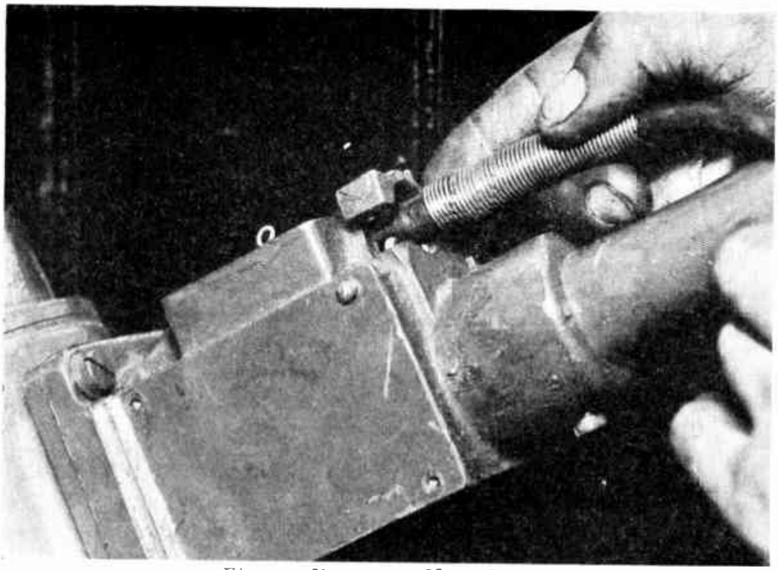

Fig. 9.—Fitting a New Cable.
Showing how to insert a new cable under the protector clamp.

When a machine has been in service for some time and refuses to function or heats up, the most probable cause is that thorough overhauling and cleaning are necessary and that bearings are worn.

How to Detect Worn Bearings.

Worn bearings can generally be detected by a slight rattling in the tool.

Immediately bearings show signs of wear they should be renewed, for apart from the decreased efficiency of the machine, the armature and field magnets are likely to be damaged. As the bearing becomes worn the armature shaft is given slight play and directly the current is switched on the field magnetism attracts the armature. The armature, not being held in its true position by the bearing, moves slightly and rubs against the pole pieces or stator.

The clearance or air gap between the armature and the field windings is extremely fine and even the slightest play on the part of the armature will result in damage.

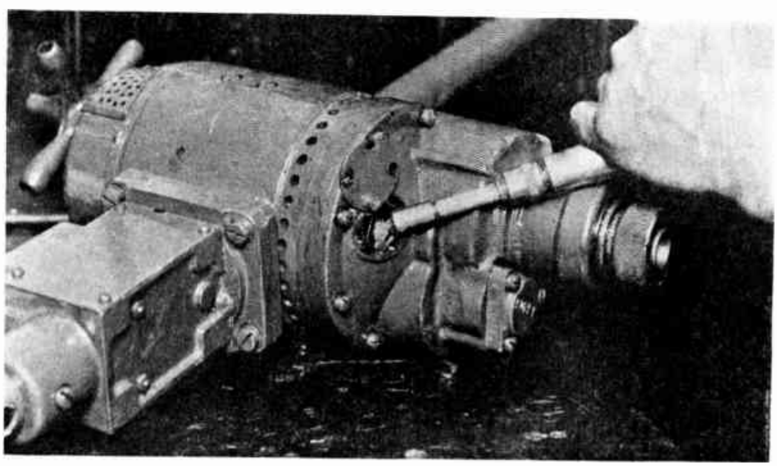

Fig. 10.—Greasing the Gear Case.

Gears are intended to run in grease and an opening is provided in the gear case for its insertion. Every two months the gear case should be removed, the old grease cleaned out and a liberal quantity of fresh grease applied around the gears and bearings.

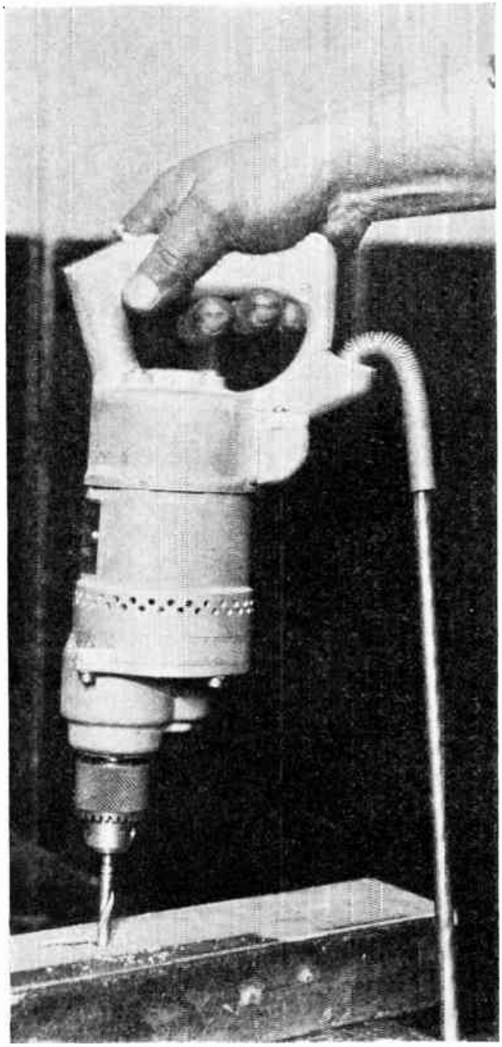

Fig. 11.—How Not to Use a Drilling Machine.

In the above illustration the cable is far too short. If the cable is of insufficient length to reach the work comfortably, the constant strain is liable to result in broken connections at the switch handle.

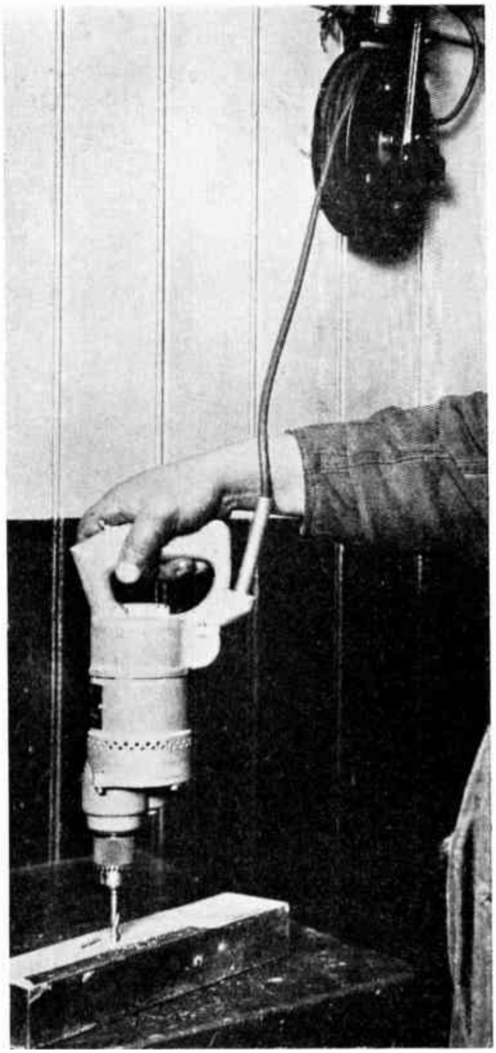

Fig. 12.—Using a Cable Reel with a Drilling Machine.

If it is possible a cable reel should be used to prevent cable breakage. This is especially suitable where long lengths of cable are in use.

Keep the Wheel Trued Up.

Perhaps the most important point to be observed in connection with a portable electric grinder is to *keep the wheel trued up*. A wheel which is out of balance will cause a heavy blow to be struck on the arbor each time the high spot hits the work and will result in uneven wear on the bearings. Unbalanced wheels, also, are very likely to fly to pieces.

The Importance of Correct Speed.

In the operation of grinders, care should be taken to keep to the speed indicated on the name plate of the machine. There should never be sufficient pressure to

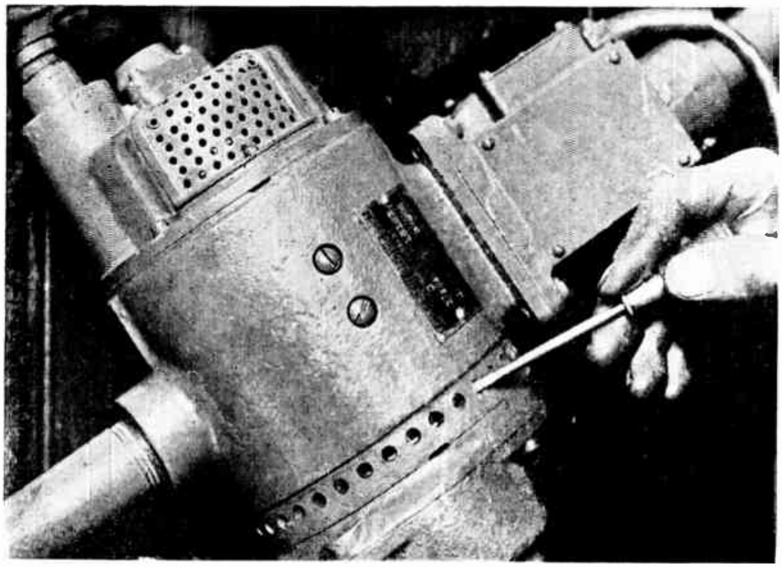

Fig. 13.—A FREQUENT CAUSE OF OVERHEATING.
It is important to see that the ventilation holes do not get clogged up, for this may cause overheating of a machine through the air-cooling action intended by the fan being rendered ineffective. This and the previous illustrations are those showing the working of apparatus manufactured by the Consolidated Pneumatic Tool Co., Ltd.

This is because the name plate of the machine has become detached and the operator has no idea as to the correct rating and thus uses any size drill bit or grinding wheel at hand.

Sometimes the cable fitted is of insufficient length to reach the work comfortably and the strain of the constant pull thereon results in broken connections at the switch handle.

reduce the speed below the normal. More work can be accomplished at the correct speed than by crowding it below normal in an attempt to remove more metal in a given period of time. There is, moreover, less energy consumption as well as less danger to windings.

An overload of tremendous proportions can be applied by the operator unless judgment is used in holding the wheel against the work.

Running the wheel too fast is another and likely cause of broken wheels.

Minor Causes of Overheating.

There are many minor causes of overheating or damage to machines.

For instance, ventilation holes may become clogged, causing overheating of a machine through the air cooling action intended by the fan being rendered ineffective by choked ventilation holes. The obvious remedy is to clean out the air holes in the housing and enclosing covers.

In the case of drilling machines too large a drill bit may be used, or, in portable grinders, a wheel larger than the capacity of the machine will warrant.

Fitting a New Cable.

When fitting a new length of cable and stripping back the coverings of the wires in order to make the necessary eyelets for fitting to the screw of the terminal plug, it is a common error to strip the wire too far, i.e., beyond what is needed for the eyelet itself, thus providing a chance for a short circuit.

Use a Cable Reel.

Where long lengths of cable are in use a cable reel can be provided to take the slack of the cable. This reel can be attached to ceiling or wall bracket and will keep the cable well off the floor, preventing damage and lifting it from damp, oil and dirt of the floor or yard. About 30 feet of 3-core cable is accommodated and will serve this area and only sufficient cable need be paid out to reach the desired point, the cable rewinding automatically on to the drum when not in use.

Broken Cables—a Cause of Trouble.

Do not permit a machine to be carried by means of the cable or drop heavy

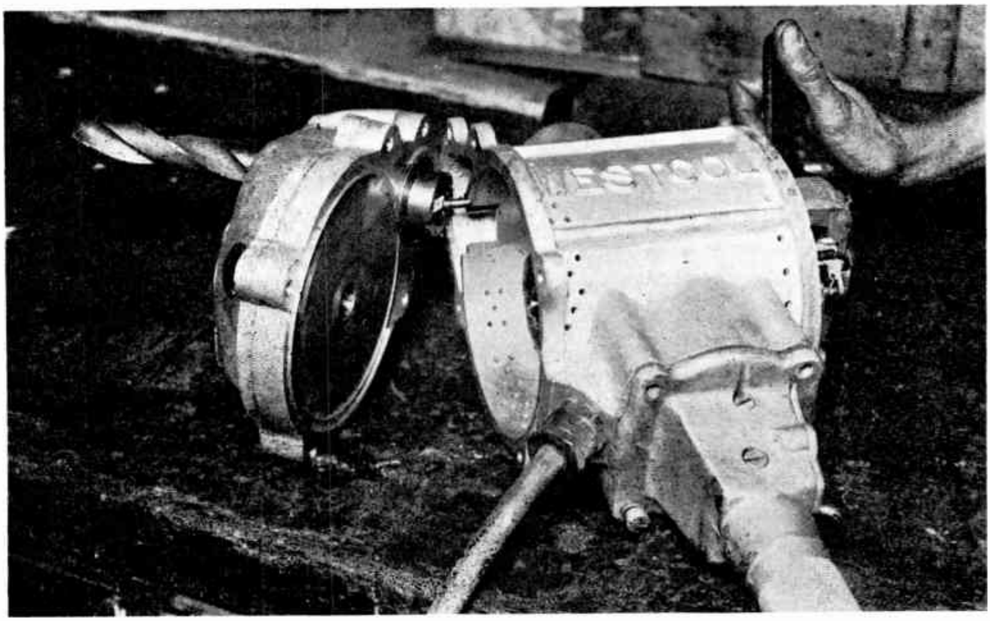

Fig. 14.—HOW TO EJECT THE DRILL BIT FROM A WESTOOL PORTABLE ELECTRIC TOOL.

The square-threaded feedscrew, which is long enough to allow a hole five inches deep to be drilled at one setting, is fitted with a hardened steel nose, which, when the feedscrew is turned down, presses against the drill bit tang and ejects the drill. This and the following illustrations in this article show the working of the apparatus of the Westminster Tool and Electric Co., Ltd.

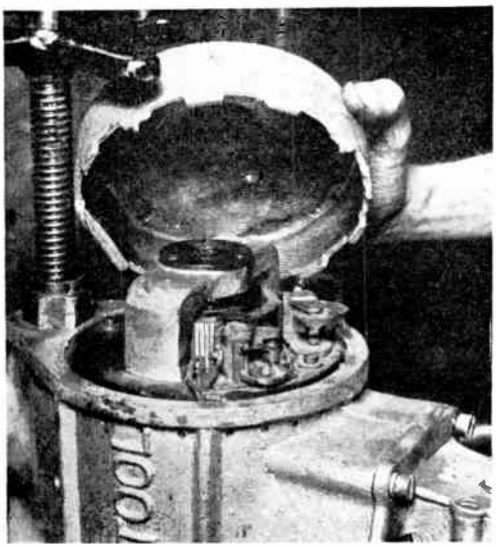

Fig. 15.—REMOVING THE TOP COVER OF AN ELECTRIC TOOL.

Either for inserting a new brush or for the general overhaul of the apparatus. The method of removing the armature when the top cover has been taken off is shown in Fig. 17.

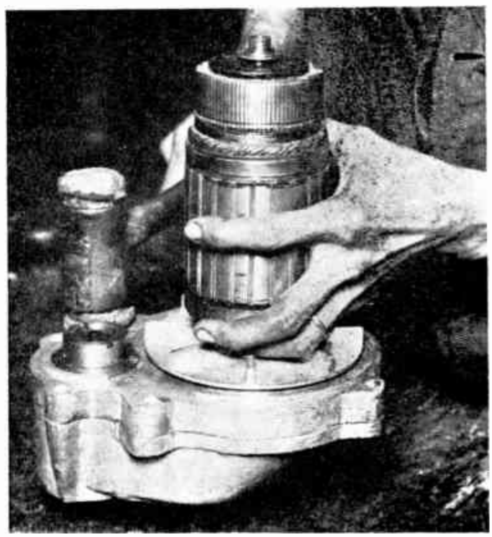

Fig. 16.—HOW TO REMOVE THE ARMATURE FROM THE GEAR CASE.

Note how the fibre or compressed rubber hammer is used for this purpose.

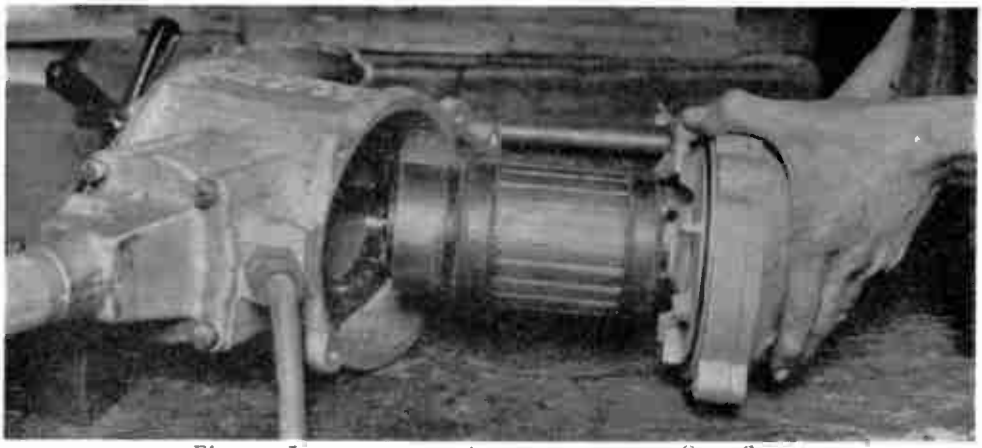

Fig. 17.—LIFTING OUT THE ARMATURE FROM THE GEAR CASE.
It will be seen that the gear case, armature and frame come out in one piece.

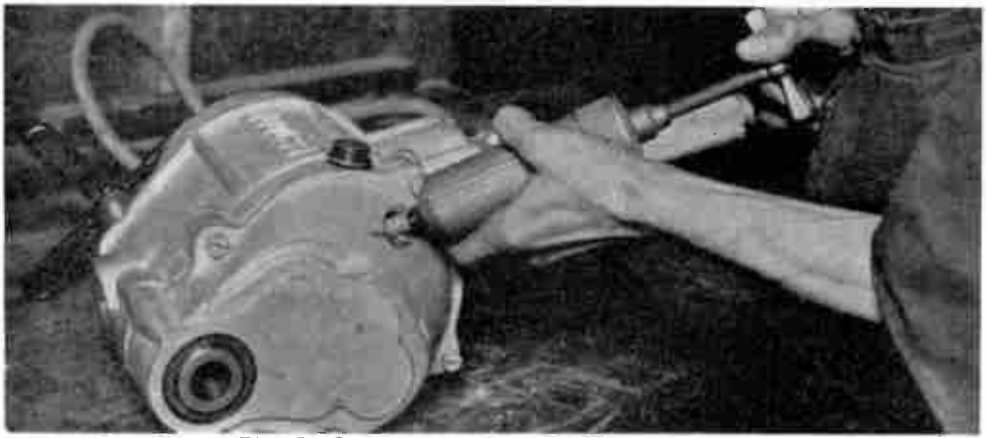

Fig. 18.—INSERTING GREASE IN THE GEAR CASE.
This is done by means of a grease gun, or failing this with a knife blade or similar tool.

Fig. 19.—HOW TO REMOVE THE STATOR FROM THE DRILL HOUSING.

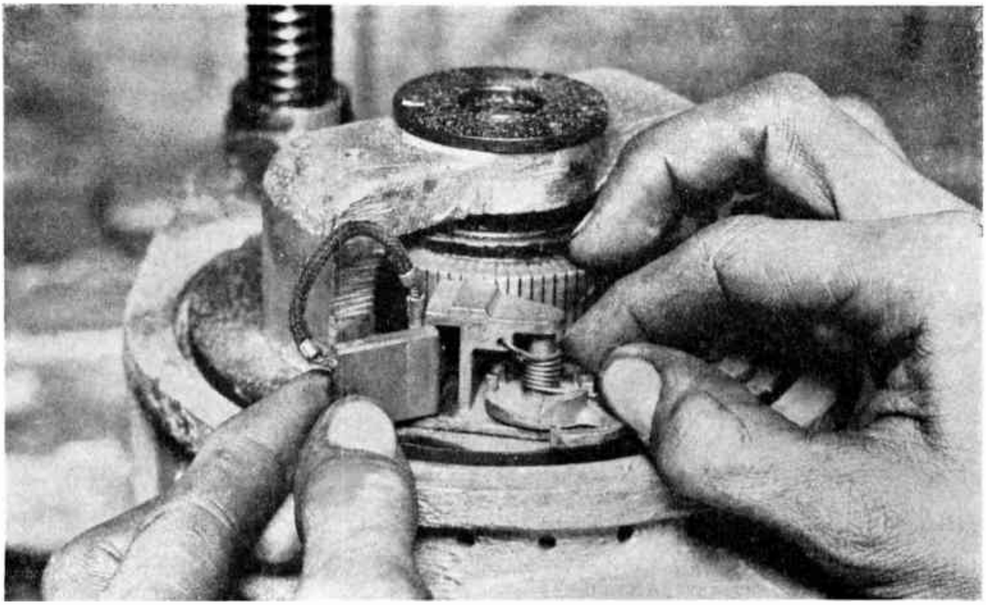

Fig. 20.—FITTING A NEW BRUSH.

When you have removed the top cover of the tool, you will find it quite easy to get at the brushes, and the above illustration shows a new brush being inserted. See that the brushes are well bedded down or excessive sparking will occur.

material on it. An apparent breakdown of a machine is sometimes merely due to the fact that the cable conductors are broken, causing an open circuit. The break can often be located in such a case by feeling the cable along its length.

A broken plug or socket may also be the cause of the mysterious refusal to function on the part of a tool.

With universal and direct current portable electric tools having brushes, it is to be expected that natural wear of brushes and commutator will take place. When it becomes necessary to apply new brushes they should be ground to fit the commutator so as to avoid sparking at the commutator.

Don't Use "Makeshifts."

Where repairs are necessary, it is always the greater economy to fit standard parts made for the machine, rather than to use "makeshifts." There is no difficulty in obtaining these from reliable makers at moderate cost. The serial number of the tool as well as the size and voltage should be given.

When a machine has given good service for some considerable time, it is a good investment to return it to the makers for thorough overhaul as soon as a slack period of work occurs. As to how frequently this should be done depends largely on workshop conditions and the material on which the tool is working.

Given ordinary care and regular cleaning, there are numerous instances of portable electric tools of reliable make in use for periods of 10 to 12 years without need of repair.

The photographs shown in Figs. 1 to 13 illustrate the tools made by the Consolidated Pneumatic Tool Company, Ltd., whilst the remaining illustrations show the products of the Westminster Tool and Electric Company, Ltd. These are typical examples of best modern practice. Should the reader experience any difficulty in connection with a particular make of electrical tool he is invited to communicate with the Publishers.

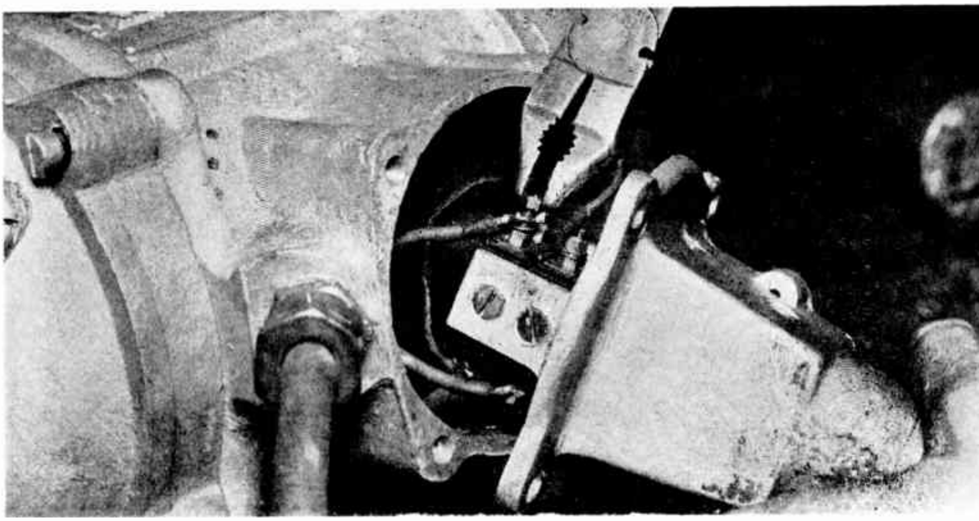

Fig. 21.—DISCONNECTING A CABLE LEAD BEFORE FITTING A NEW CABLE.
The end piece has been loosened and is held with the left hand, whilst the terminal screws on the switch block are loosened. Note that before the cable can be withdrawn, the earth wire must be disconnected from the switch housing. Fig. 23, below, shows where the connection will be found when the end piece has been removed.

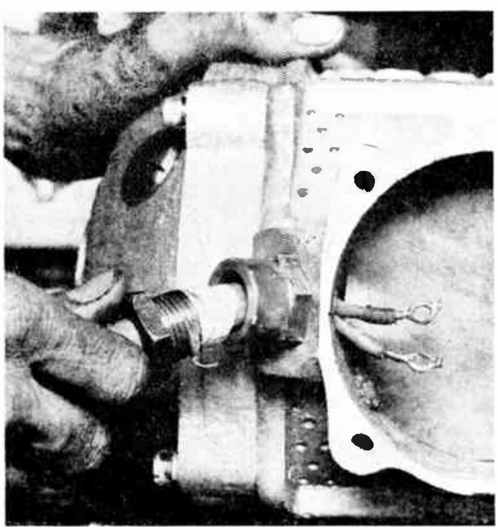

Fig. 22.—FITTING A NEW CABLE.
The old cable has been removed and a new one threaded through the gland in the manner shown. Slip gland nut over cable, followed by the hard rubber ring or any convenient packing. Pass cable through gland, slide ring, or packing, into the coned recess in gland, then tighten up gland nut, when cable will be firmly gripped, and the internal connections relieved of all external strain.

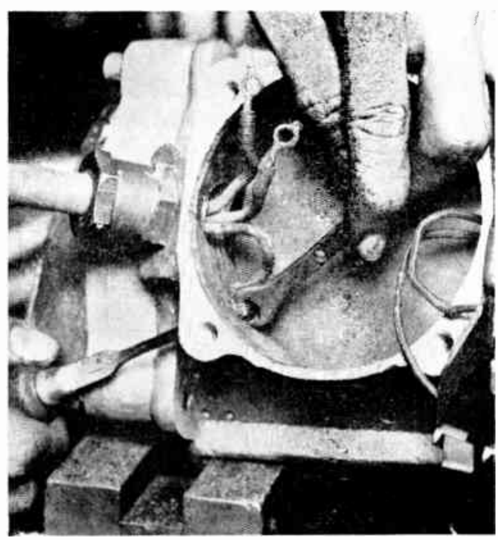

Fig. 23.—CONNECTING UP THE EARTH WIRE TO THE SWITCH HOUSING.
An effective earth is necessary to comply with Home Office requirements. The line end is fitted with a label marked "earth," so that no mistake can occur when connecting to supply. In the switch housing is fitted a terminal to which this wire must be attached. When fitting new cable, the best plan is to connect the earth wire first. Hold the cheese-headed screw and remove nut. Slip lead over screw, and replace nut. Always make a loop as shown in illustration.

DIMMER SWITCHES

THEIR FITTING, CARE AND REPAIR

THE electric "dimmer," so called because it is frequently used for the purpose of dimming the lights in theatres, cinemas, etc., is, of course, purely a variable resistance. It is by no means limited to dimming lights, many different types being manufactured to cover a variety of uses. One of the foremost of these types is the "Lowa" dimming switch. This is very similar in outward appearance to the ordinary tumbler switch, being about the same diameter across the base as the 10-amp. size, and in Fig. 1 it is shown being substituted by a wireman for a 5-amp. type tumbler switch, the latter having just been removed from the 3½-in. switch block shown.

Fig. 1.—FITTING A DIMMING SWITCH.
Showing how a 60 watt dimmer switch can be substituted for a 5 amp. tumbler switch on the same 3½-in. switch block.

How the Dimmer is Constructed.

The dimmer consists of resistance elements of nickel-chrome wire wound on mica. Tappings are taken from these to a semi-circular row of contact studs, over which a phosphor-bronze blade runs (see Fig. 2), and by this method five different degrees of light and an "off" position are obtained. The whole thing is mounted inside the switch cover, there being no external resistance boxes, etc. The dimmer has a "dolly" action, the dolly projecting through the top of the switch cover, as in a tumbler switch. The wiring, also, is exactly similar to that for an S.P. tumbler switch, and no alteration whatever is necessitated.

Some Uses of the Dimmer.

It will readily be seen, of course, that, as a variable resistance, this dimmer has many functions other than the domestic one of "dimming the lights" in nursery, hall or sickroom. It is largely used for controlling the speed of fans and fractional h.p. motors, regulating the light for photographic purposes, X-ray work, etc.

What to Do when the Moving Blade Goes Wrong.

The "Lowa" is very simple in construction, but, nevertheless, various more or less superficial faults do, at times, manifest themselves, the chief of these being, perhaps, catching of the moving blade on the contact studs. Should this fault occur, remove the "bridge" which carries the dolly operating the blade. A fibre disc will be found at the back of the switch, fixed by a single screw, and, on removing this, the screws fixing the bridge will be quite accessible. Having removed the bridge, next swing back the pair of

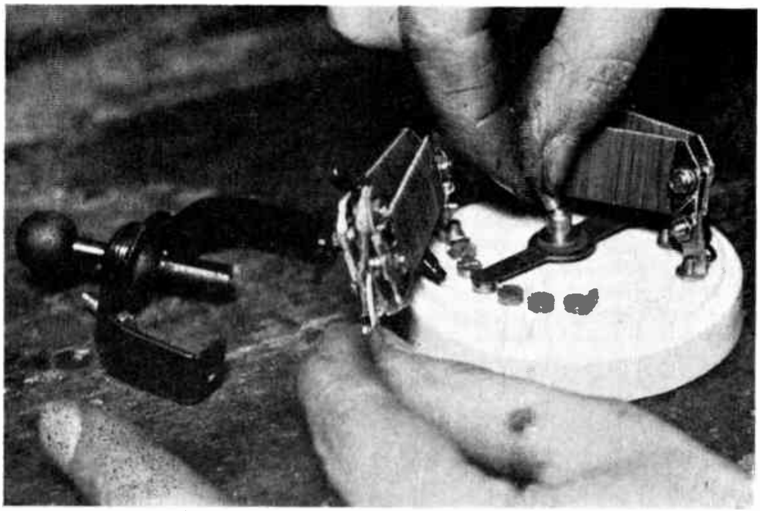

Fig. 2.—How a Dimmer is Constructed.
Showing how tappings are taken from resistance elements of nickel-chrome wire to a semi-circular row of contact studs over which a phosphor-bronze blade runs.

resistance elements which are mounted directly over the contact studs, as shown in Fig. 2. This is done by taking out the screw holding the pillar at one end of the resistance unit, and loosening off the one at the other end, when it will be found possible to swing the whole unit back on this latter screw, as shown in the illustration.

Making Adjustments.

It is now a simple matter to make such adjustments as are necessary. It may be that the blade has become twisted and is catching on the contact studs, in which case it should be gently

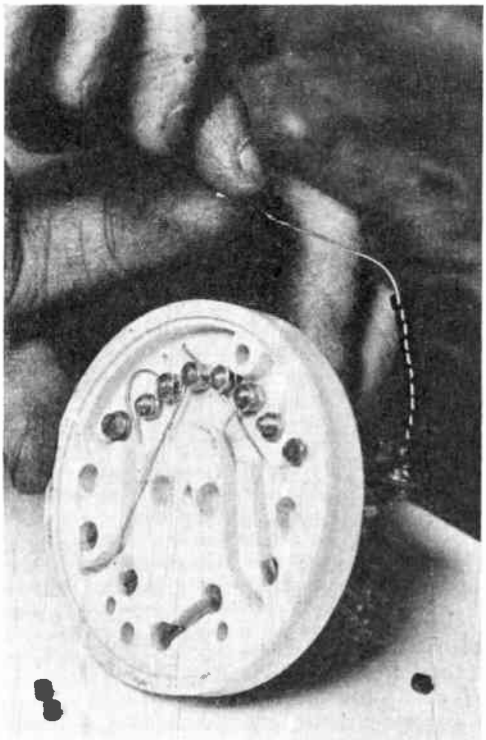

Fig. 3.—Repairing a Broken Insulating Bead.
Disconnect the wire on which the broken bead is, put another bead on, and re-connect.

lifted and twisted in the opposite direction, great care being taken not to force the blade and so destroy its spring. If it is found that this treatment does not entirely rectify the fault, and that the blade still has a jerky action when passing over the contact studs, the latter should be filed flat with a small, very smooth file, and then the blade should be slightly lifted and a piece of fine emery cloth placed under it, so that, when the blade is worked to and fro, the under side of it will be rubbed flat.

Remove Filings and Dust.

Great care should be taken to see that all brass filings, dust etc., caused by this process are removed and the switch should then be re-assembled. In screwing the various parts back into position, see that there is no danger of the elements touching the dolly, bridge or cover, and so making these alive.

Replacing a Broken Bead.

It is sometimes found that one of the beads insulating the connecting wires is broken, and this should be replaced immediately. Disconnect the wire on which the broken bead is, at the most convenient point (see Fig. 3), put the bead on and take care to re-connect the wire exactly as found. Unless this is done carefully, the sequence of the dimming effect may be upset. The "Lowa" dimming switch is constructed to control loads up to 200 watts, and will stand very heavy overloads before burning out.

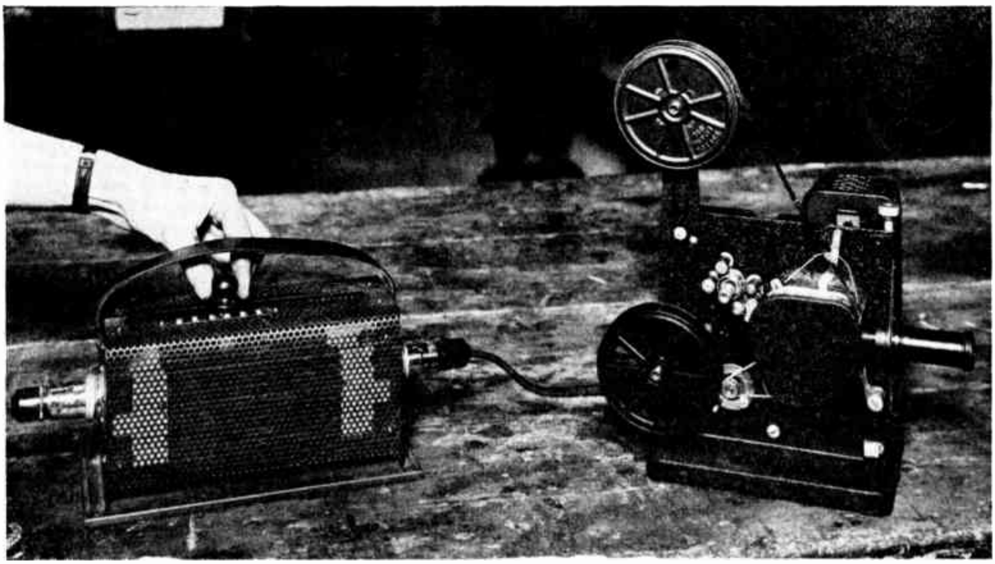

Fig. 4.—Using a Variable Resistance as a Voltage Regulator.
This enables the cinema projector which is intended for a 115-volt supply to be used on any voltage from 200 to 250.

How to Order a Dimmer.

As previously pointed out, the construction is simple and the wireman has very little in the way of mechanical faults to contend with. There is one error, however, which many otherwise competent electricians frequently fall into in connection with dimmers. Let us suppose that they require a dimming switch to control a 60-watt lamp. They intend to substitute this for an existing 5 amp. tumbler switch in, say, the dining-room of a customer. The voltage is 200. They therefore pass an order for "1-200 volt 5 amp. dimming switch," in other words, a variable resistance capable of controlling a load of 1,000 (200 × 5) watts, at 200 volts. The size of this piece of apparatus would be about 15 by 5 by 8 inches (to say nothing of the cost), and they propose to instal it in their customer's dining-room! The correct way to order a dimmer is to give the voltage of supply and the exact *wattage* which it is required to control.

Installation and Upkeep.

It would be impossible in the present article to deal with all the types of regulators and resistances which are manufactured to-day. Most of these, however, are of fairly simple construction and comparatively little electrical knowledge is required for their installation, upkeep and repair. Installation is usually a matter of fixing, and connection in series with the load to be regulated; there is practically no upkeep, beyond keeping the resistances free from dust and applying a little oil occasionally to such parts as require it, also seeing that the moving contact retains sufficient pressure and has a smooth, firm action. Repairs are only made necessary by the resistance burning out, due to overload. This latter is a very unlikely contingency, but should it occur, the best plan is to return the resistance to the makers for re-winding. Fig. 7 illustrates a small

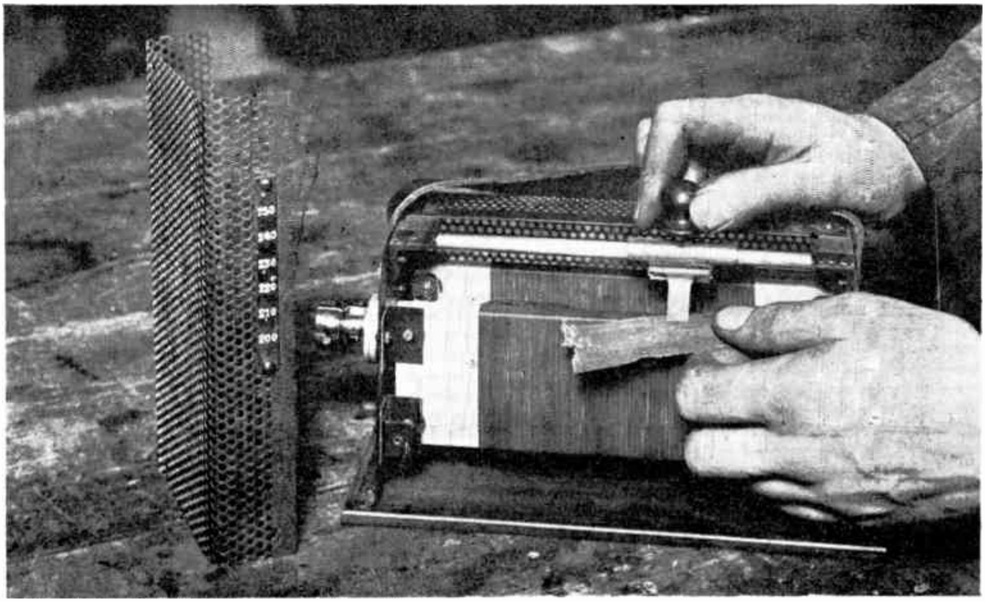

Fig. 5.—How to Remedy a Harsh Moving Contact—First Step.
Remove one of the perforated steel covers and very gently lift the blade of the moving contact from its resting place on one side of the resistance elements. Now place a piece of very fine emery cloth under the blade, and holding it firmly in position, work the contact to and fro along the element.

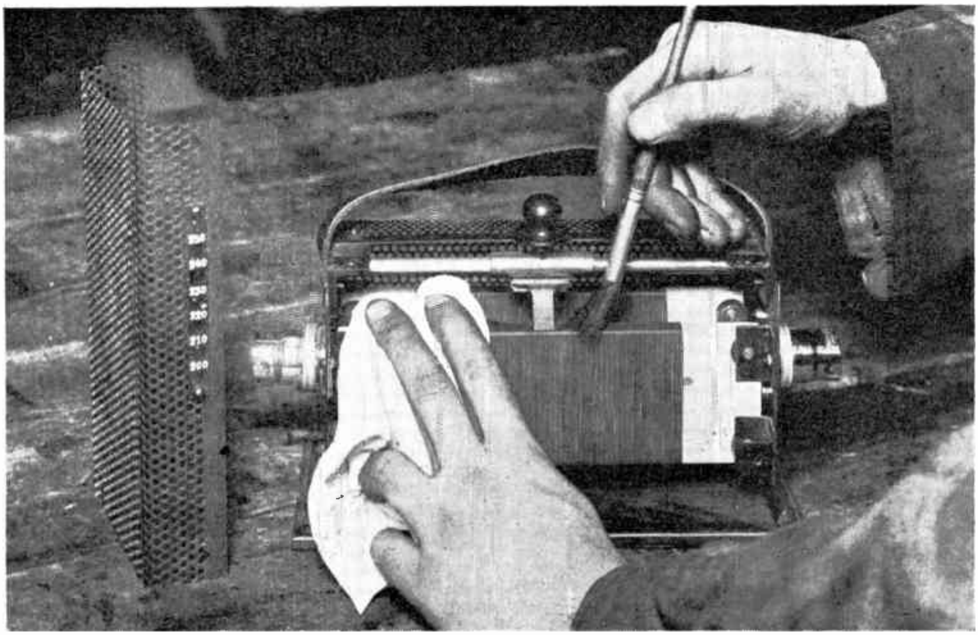

Fig. 6.—How to Remedy a Harsh Moving Contact—Second Step.
Slide the contact off the emery cloth and brush away every particle of brass dust from the element and contact before using it again.

regulator being used for fan control, the resistance being connected in series with the fan motor. This resistance, being of the sliding contact type, gives a very fine regulation.

How a Voltage Regulator Works.

In Fig. 4 is shown a variable resistance in use as a voltage regulator. The small cinema projector shown is intended for use on a 115-volt supply, and the regulator is wound so that the projector, when put in series with it, can be used on any voltage, 200—250. A small pointer is fitted to the sliding contact of the regulator, and, if the supply voltage is, for example, 230, the contact is moved along until this pointer is opposite the figure 230 on the voltage-indicating plate (which can be seen in the illustration). This throws into circuit the necessary amount of resistance to reduce the supply voltage of 230 to the voltage of the apparatus, viz., 115, and it is then possible (having, of course, made the necessary connections between regulator and projector) to proceed with the operation of the apparatus in the ordinary way. As will be seen, the supply is led into the resistance by means of a B.C. adapter plugged into the batten-holder at one end and out from the resistance, in a similar manner, to the projector.

Remedying a Harsh Moving Contact.

The most common fault with this type of resistance is a tendency of the moving contact to become harsh, but a smooth, even action can very soon be obtained by the method illustrated in Figs. 5 and 6. Remove one of the perforated steel covers, and very gently lift the blade of the moving contact from its resting place on one side of the resistance elements. Insert a piece of very fine emery cloth under the blade in the manner shown, and, holding this firmly in position, work the contact to and fro along the element. Slide the contact off the emery, and carefully brush away every particle of brass dust from the element and contact before operating the latter. This is most important as, if it is not done, the movement of the blade over the wire will grind the brass dust into the element, and will entirely ruin the action. Repeat the process with the blade on the other element and then rub up the contact surface of both elements with a piece of soft, clean rag. If these instructions are carefully carried out, a smooth, even action can be obtained.

Points the Maker Wants to Know.

The one outstanding trouble with regulators and resistances is the very insufficient and, in many cases, inaccurate information which is given to the makers when ordering, and it is therefore proposed to give a few hints in this connection.

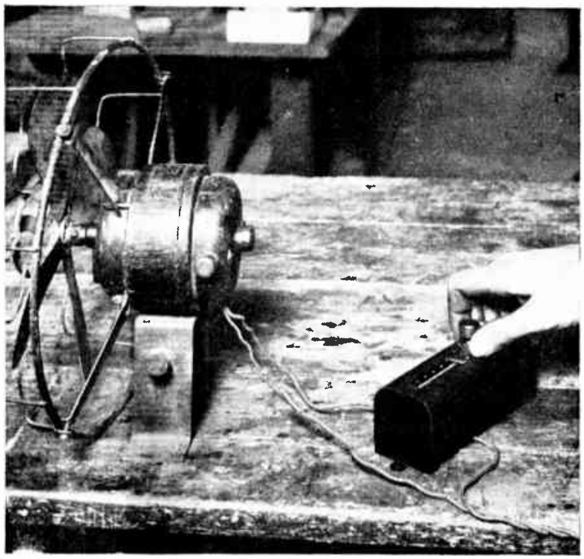

Fig. 7.—USING A SMALL REGULATOR FOR CONTROLLING A FAN.
The resistance is connected in series with the fan motor.

When choosing a resistance or dimmer for any specific purpose, there are several factors to be considered, the chief of these being size, heating effect, voltage of supply, degree of regulation required and whether fine or coarse capacity, ohmic value, whether the resistance is to be fixed or variable, and the conditions under which it will be installed.

Controlling the Lights in a Cinema.

For instance, a resistance which is to

be used to control lights in a cinema might be limited as to size, owing to lack of space in the operating room. The dimmer should be kept as long as possible, however, as it will readily be seen that, the greater the length of the windings, the finer will be the graduation of light obtainable, and it is highly undesirable, in a position such as this, to have a dimmer giving a jerky control owing to insufficient adjustment on the windings. It will therefore be seen that any limits imposed by lack of space should be stated.

Dimmers for Constant Work.

If it is desired to leave the lights at "dim," this should also be stated, as a dimmer which is constructed for intermittent control is not always suitable for constant work. The intermittent type is usually cheaper, as, not being required to be constantly in circuit, it is permissible to use a lighter gauge resistance wire than is used for the constant rated type, and so economy is effected in amount of resistance wire and size of the dimmer. Again, if the intermittently rated type were used in error, this would get exceedingly hot.

When a Variable Resistance is Not Needed.

Again, let us suppose that it is required to run a 110-volt motor on 230 volts. In this case, the voltage of the motor should be given, and its size in h.p. or watts, also the voltage of the mains on which it is to be run. There would be no point here in having a variable resistance (which is naturally more expensive), so specify fixed. It will at once be apparent to the makers that the full current will have to be carried by the resistance continuously, and they will wind it accordingly. In short, it is desirable to give the fullest possible information as to the performance required of the dimmer. *Always* give the voltage of the circuit and the total load to be controlled. Also, if possible, the ohmic value of the resistance. For high voltage circuits, i.e., over 100 volts, it is better to have an enclosed type of resistance. If the above simple rules and hints are followed, no one should have any difficulty in ordering, installing, maintaining and, if necessary, repairing the types of resistance described.

QUESTIONS AND ANSWERS

What are the principal uses for dimmer switches?

For controlling the lighting in cinemas and theatres; also for dimming the lights in the nursery and sick room.

Can a dimmer switch be used in place of an ordinary tumbler switch?

Yes; the whole thing is mounted inside the switch cover, there being no external resistance boxes, etc. The wiring is also exactly similar to that for an S.P. tumbler switch and no alteration whatever is necessitated.

How would you order a dimmer to control a 60-watt lamp in a customer's dining-room?

You should give the voltage of supply and the exact *wattage* which it is required to control. If you were substituting a dimming switch for a 5-amp. tumbler switch on a 200-volt supply, it would be wrong to order "1—200-volt 5-amp. dimming switch" for this would be equivalent to asking for a variable resistance capable of controlling a load of 1,000 (200×5) watts, at 200 volts, which, of course, is not what you really want.

What is the difference between a dimmer switch and a voltage regulator?

A dimmer switch simply controls apparatus at a certain voltage, while a voltage regulator enables apparatus designed for use on, say, a 115-volt supply, to be used on a supply of a higher voltage.

THE CONDUIT WIRING SYSTEM

DIFFERENT TYPES AND HOW TO ASSEMBLE THEM

By T. Linstead.

Types of Conduit Available.

ALTHOUGH conduit is the recognised premier method of encasing wires, a great deal depends upon the quality and manner of assembly. It is obtainable in two gauges known as heavy and light, and in various sizes. Heavy gauge is only supplied in screwed conduit; in this we have a choice of threads known as Electric and Gas, the latter being rarely used, and by studying the table on page 82 the exact relation of each gauge as to their diameters and thicknesses, etc., will be made quite clear.

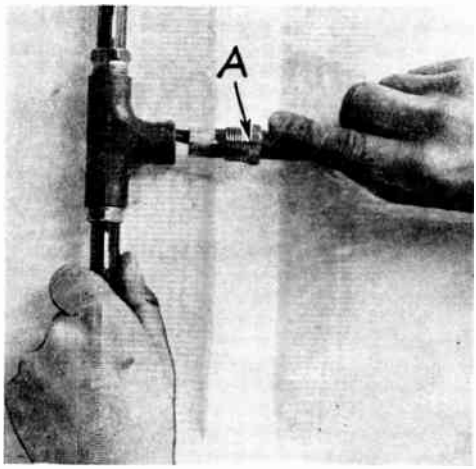

Fig. 1.—A " Simplex " Hexagon Tee.

The split bush A, when tightened in fitting, firmly grips the conduit, thus making mechanical and electrical contact. Remember when using this form of tee that a fitting is required in the next size larger than the conduit with which it is to be used. Another grip-fitting type of tee will be seen in Fig. 11.

These two gauges are in their turn made in different ways, heavy tubing being manufactured in either a seamless solid-drawn tube or as a jointed tube with the two edges of the seam welded together, while light gauge is made in seamless solid-drawn, or a jointed tube with the seam *brazed* together and lastly with a butted or close-joint seam. Fig. 2 illustrates a section of the tube constructed by each of these four methods.

Screwed Conduit.

There are two or three ways employed to assemble the tubing to ensure that when finished the whole conduit installation is *electrically* continuous (by this is meant that a current applied to any part of the conduit may be conducted to earth from a given point). When a *waterproof* conduit installation is required the only way to obtain it is by means of screwed joints and watertight fittings; it must, however, be remembered that all screwed fittings are not necessarily watertight and when required they must be distinctly specified. The conduit is supplied in standard lengths with ends threaded with a "British Electric Thread," and if required to be cut to shorter lengths dies are available for re-threading the new ends.

When to Put in Galvanised or Enamelled Conduit.

The choice of galvanised or enamelled conduit depends upon the position. Galvanised conduit is recommended for all exterior work and for interior if it is to be hidden in plaster and brickwork, but where it occurs in floors, roofs and on the surface, enamelled finish will suffice.

Screwed Fittings.

To enable continuous runs of conduit to follow curves and varied paths and also to overcome the necessity of separate runs of conduit for each circuit, various

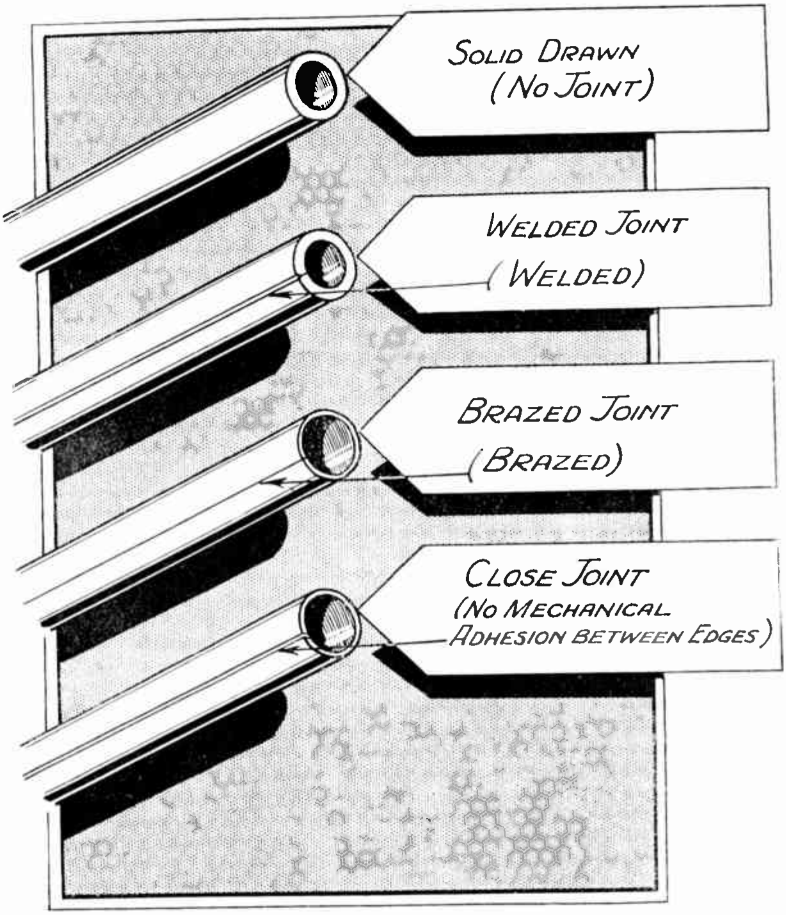

Fig. 2.—FOUR METHODS OF TUBE CONDUCTION.
Showing solid drawn, welded joint, brazed joint and close joint.

fittings such as elbows, T joint boxes, switch boxes, etc., must be used. These are supplied with their connecting points female threaded with the standard tapping, to allow the threaded conduit to be screwed into them. Their types and shapes are innumerable, being due to the desire of various manufacturers to produce fittings requiring a minimum of labour, yet giving a maximum of efficiency. They can, however, be summarised under two headings, namely, "inspection" and "non-inspection," the difference between them being shown in Figs. 3A and 3B.

Couplers.

Where greater lengths of conduit are required than those supplied, couplers are employed. Fig. 3C shows four types of these that can be used with screwed conduit, the inspection type being very useful on surface work owing to their neatness over the old type draw box, as shown in Fig. 5.

Conduit Boxes and Their Use.

The chief use of these boxes in conduit work is to allow the wires to be assisted in the drawing in by giving access to them at sharp bends, but the size of the internal diameter, viz., $2\frac{3}{8}$ inches, renders them unsightly for surface work in lieu of the smaller inspection type fittings, such as elbows, tees and bends. On sunk work, however, they are to be preferred. They are made in four patterns, two-way "through" as in Fig. 6A, two-way "angle" as in Fig. 6B, three-way as in Fig. 7, and four-way as in Fig. 8.

The covers employed are of varying

Fig. 3A.—A "NON-INSPECTION" TEE.

patterns, usually of sheet iron, and held in position by two small screws. Sometimes the outer rim of the cover is flush with the outer rim of the box. This type is quite good when the boxes are used under floors, but when sunk in plaster the best type to use is a cover of slightly larger diameter than the box; this allows the joint between the plaster and the box to be effectively concealed. In place of iron, fibre covers are sometimes used; these enable fittings such as switches or ceiling roses to be screwed to them. Other types of boxes, however, which are employed solely for housing switches or the like, are made with special tapped holes in the base, and the fittings are clamped by means of set screws. Fig. 12 shows such a box fixed in position. Another type of cover is made of cast iron and thicker than the first described. It has one face machined smooth. The box used with this type has its rim machined also, and when in position the joint is practically watertight. As an extra precaution a rubber or fibre gasket may be inserted between the surfaces.

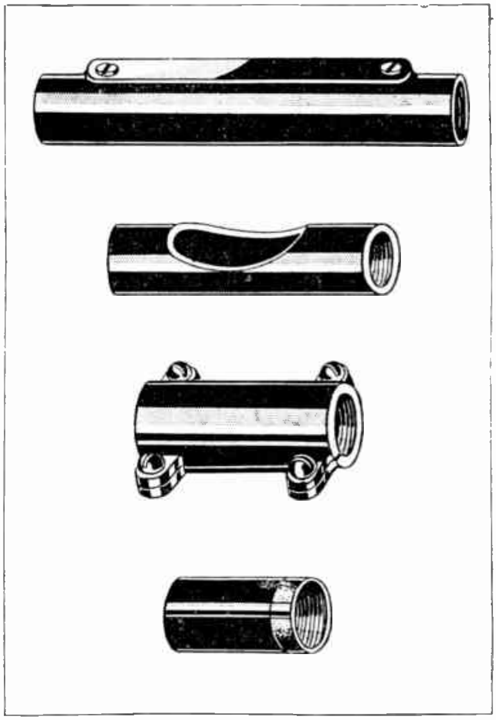

Fig. 3C.—Four Types of Couplers.
These can be used with screwed conduit.

Labour-Saving Fittings.

It has been explained earlier that certain manufacturers have introduced various labour-saving fittings, and an example of this is shown in Figs. 4 and 5. It will be noted that all setting of tubing is entirely eliminated and in addition a much neater appearance is obtained. From this illustration it will also be noted that circular boxes are not an indispensable necessity. Rectangular boxes are made with outlets in all the usual positions, and for the unusual, undrilled boxes can be supplied, and the position of the outlets drilled and tapped by the operative.

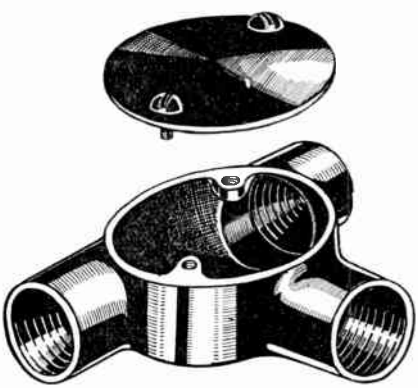

Fig. 3B.—An "Inspection" Tee.

Tees and Bends.

In place of conduit boxes, tees and bends of the "inspection" type may be used, although in practice these are only considered when neatness and restricted space are governing factors. Fig. 9 illustrates an inspection elbow and tee in position, and particular attention is drawn to the size of the "inspection" aperture. This is partly determined by the bore of the conduit and the available working space is necessarily small. Such fittings, however, have a decided advantage over the ordinary type.

Switch Boxes.

An essential fitting to all first-class screwed conduit work is the switch box in one form or another. In addition to

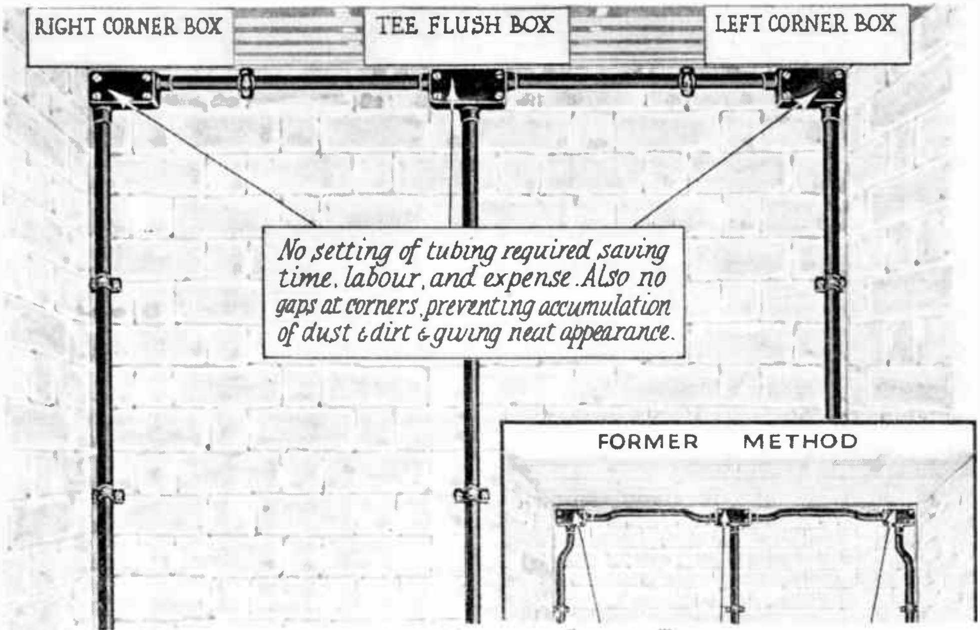

Fig. 4.—An Improved Method of Conduit Tubing.

The tubing enters the boxes without the need of setting, thus saving time, labour and expense. It will be seen that in the former method twelve sets were required to join the tubing to the boxes, leaving unsightly gaps at the corners. (*General Electric Company, Ltd.*)

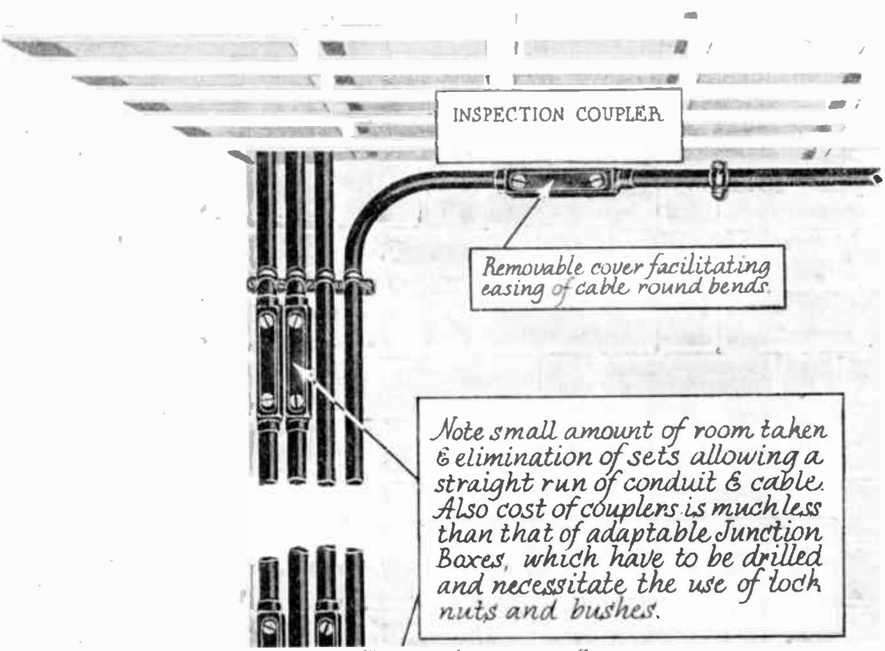

Fig. 5.—The Latest Type of Inspection Coupler.

These couplers allow a straight run of conduit or cable and as they do not have to be drilled and do not necessitate the use of lock nuts and bushes they are a much more convenient fitting than adaptable junction boxes. (*General Electric Company, Ltd.*)

forming a suitable housing for the switch for protective purposes, they are sometimes necessary to complete the "electrical continuity" of the system, as Fig. 10. Varying circumstances call for different types of boxes; for sunk work flush boxes of round or square pattern can be obtained. The number and positions of entries differ according to requirements, as back entry only, back and side entry, or side entry only. For exceptionally good-class work, boxes with adjustable grids are made. These allow the depth of the switch to be so regulated to suit any varying thicknesses of plaster, thus ensuring that the face of the switch is level with the wall surface and avoiding any unsightliness when the cover is in position.

This procedure cannot be adopted where semi-recessed switches are used on concealed work and it is essential that the box be placed in the correct position at the time of fixing, so that when the wall is plastered, the top of the box is level with the surface, the reason for this being that there is no satisfactory method of covering the joint between the plaster and the box. It is possible to fit a biscuit ring between the box and the switch as an expedient, but when used it is a certain admission of faulty workmanship.

The same type of box used for semi-recessed switches in sunk work may also be employed in surface installations, or, again, a type of surface box with flush switch is obtainable. Where two or more switches are required to be assembled in one position "multiple" boxes effect a great saving in labour and materials, with the added advantage of neatness, the description of types for single boxes being also applicable to these.

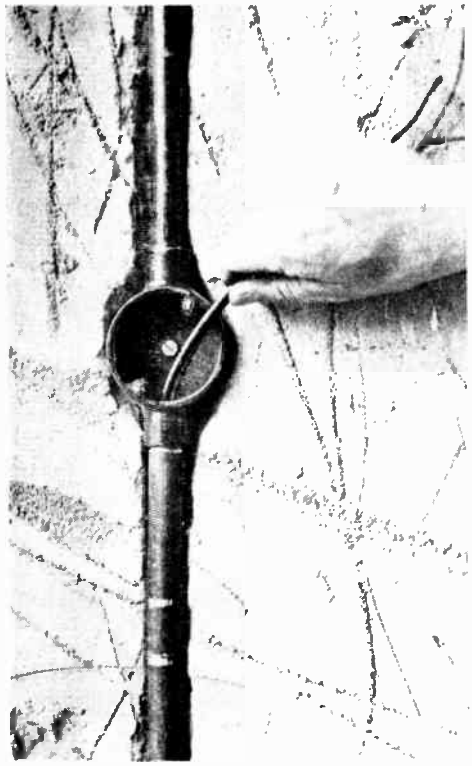

Fig. 6A.—CONDUIT BOXES.
A two-way "through" type for use with sunk work.

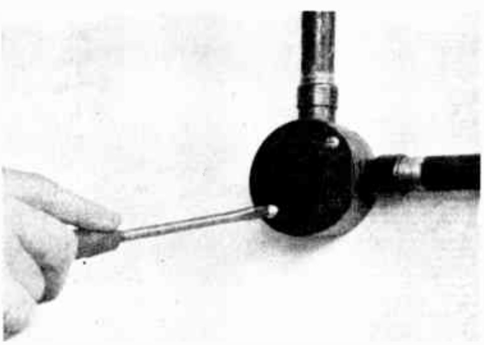

Fig. 6B.—CONDUIT BOXES.
A two-way "angle" box.

For watertight installations the foregoing boxes are not suitable, but a special switch and box complete is made, watertightness being effected by fitting the switch cover with a rubber gasket and the operating handle rotating in a gland or bush.

Grip Continuity.

In the early days of conduit wiring it was considered sufficient to protect the wires only and no thought was given to electrical continuity and earthing. The fittings used in those times were plain cast or stamped and were connected by simply inserting the end of the conduit into the elbow or tee, etc. As electrical knowledge advanced, rules for its safe

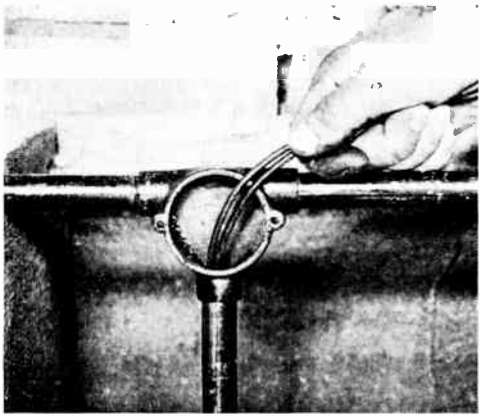

Fig. 7.—Conduit Boxes.
A three-way box. It will be seen that the large aperture makes for easy working in positions such as under floors, where neatness is not an essential factor.

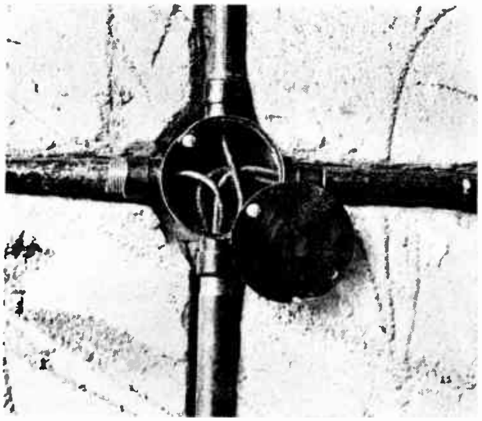

Fig. 8.—Conduit Boxes.
A four-way box for use in sunk work. The covers employed for conduit boxes are of varying patterns, usually of sheet iron and held in position by two small screws. In place of iron, fibre covers are sometimes used, as these enable fittings, such as switches or ceiling roses, to be screwed to them.

usage were laid down, among them being the necessity that all metal conduits shall be composed of some form of screwed or grip joint which will give continuous and permanent electrical conductivity and mechanical rigidity throughout. The old type of "slip" joint did not comply with this regulation and therefore the "grip" fittings were devised as a cheaper alternative to the screwed joint.

Pin Grip.

The forms of these fittings in most common use are known as the pin grip, and lug pattern, while one proprietary type is known as the "Simplex" hexagon grip. In the first type the fitting is drilled at each end and the holes tapped and fitted with a set screw, the conduit is inserted in the socket and the screw tightened; the conduit is thus held rigid, and the action of tightening the screw ensures perfect electrical contact, provided that that conduit has been properly cleaned.

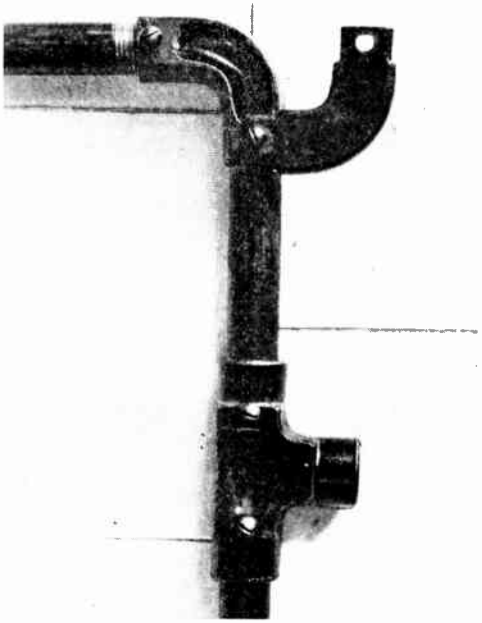

Fig. 9.—An Inspection Elbow and Tee.
Note particularly the size of the "inspection" aperture.

Lug Grip.

The lug pattern is more affectionate in its grip, embracing as it does the whole circumference of the conduit. From Fig. 11 can be seen the formation of the fitting, and that the tightening of the screw causes the whole interior surface to bind on the outer surface of the conduit. With this type care must be taken, when fixing, that they are placed the correct way round, particularly where they occur close to walls or ceilings, otherwise it will be impossible to tighten the screw if the latter

Fig. 10.—A SEMI-RECESSED "THROUGH" SWITCH BOX.

This type ensures continuity when wiring has to be carried beyond the switch point.

is between the wall and the fitting.

"Simplex" Hexagon Grip.

The "Simplex" hexagon grip differs entirely from others in its principle; in fact, it is a modification of screwed conduit. The fittings are similar in design in that they are female threaded with the standard thread. Examine Fig. 1 and it will be seen that the conduit is fitted into a hexagon nipple, this nipple is slit, and is threaded into the female thread of the fitting, and when tightened with a spanner, is perfectly rigid. Provided that both conduit and fitting are cleaned, electrical continuity is also maintained. When using the hexagon form of grip it must always be remembered that a fitting is required in the next size larger than the conduit with which it is to be used. The nipples are made of sufficient thickness to take up the difference between the external diameter of the conduit and the internal diameter of the fitting, and at the same time allows plenty of metal for cutting the thread.

Methods of Fixing the Conduit.

According to the method of installing the conduit, so that of providing a suitable fixing varies. Where screwing tubing is placed on the surface in exposed positions, this should be done with spacing saddles. In Fig. 16 two examples are illustrated, but there are others with wood or iron fixing, and if sound fixing to brickwork is required, a saddle with the shank formed as a rag bolt for building in, can be obtained. The important feature of spacing saddles lies in the fact that when the conduit is placed in horizontal positions, it is held clear of the wall, and water or moisture drains away instead of being held to cause corrosion.

With Saddles.

Internally, ordinary saddles such as Fig. 13 and Fig. 14 form a good fixing, and the latter, while not being so rigid, has the advantage that the conduit can be held close to the angle of a ceiling or wall. The second lug on the former type would prevent such close fixing. Fig. 13 is also supplied in longer varieties, known as multiple saddles, these being useful for holding two or more lengths of conduit at one fixing.

Fixing in Plaster.

When the tubing is buried in plaster or chased into brick walls, the plaster to

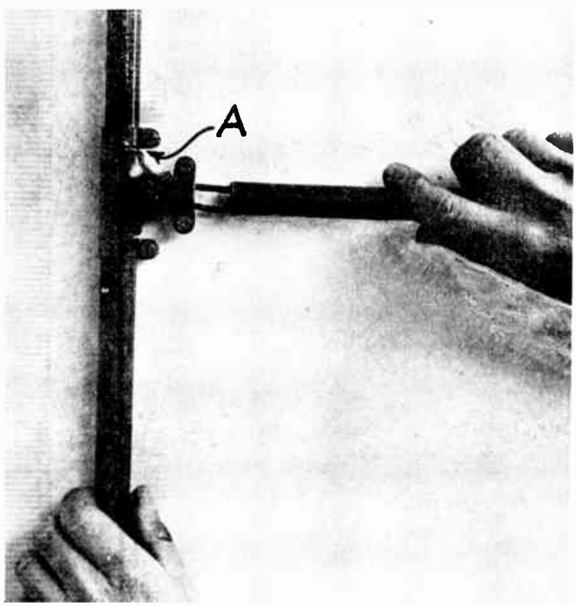

Fig. 11.—A GRIP-FITTING TYPE OF TEE.

The cut marked A enables the metal to grip the conduit when the screw is tightened.

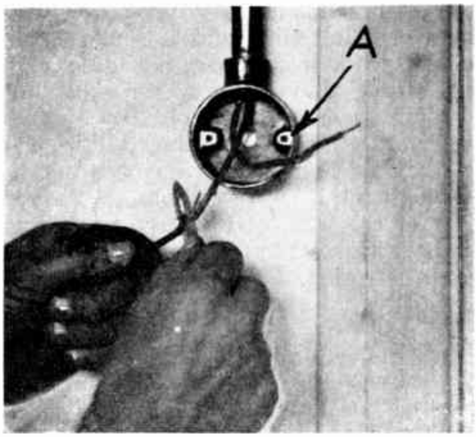

Fig. 12.—A SEMI-RECESSED SURFACE SWITCH BOX.

Note that the lugs marked A are tapped so that the fittings can be clamped by means of set screws.

Hints on Conduit Assembly.

The differences between faulty and successful workmanship usually depend on small matters, and the following hints on conduit assembly will, it is believed, enable the reader to avoid faults.

Preparing the Conduit for Assembly.

The first essential of all conduit work is that it shall be properly prepared, the ends should be rounded off with a file until they are smooth. Rough edges may mean abrasions in the cables. The interior of all fittings should be examined for any rough finish. It is expecting too much to assume that everyone engaged in their manufacture is thoroughly conscientious. The ends of conduit, however smooth you may make them, should always be terminated with proper bushes if boxes are not used. There are two or

TABLE SHOWING SIZES OF CONDUIT.

External Diameter (inches).	Light Gauge.		Heavy Gauge. Screwed Electric Thread.		Heavy Gauge. Screwed Gas Thread.			
	Internal Diameter (inches).	Thickness (inches).	Internal Diameter (inches).	Thickness (inches).	Nearest Gas Size (inches).	Actual External Diameter (inches).	Actual Internal Diameter (inches).	Thickness (inches).
½	.43	.036	.388	.056	¼	.518	.406	.056
[illegible]	.54	.040	.497	.064	⅜	.656	.528	.064
¾	.65	.048	.606	.072	½	.825	.681	.072
1	.90	.048	.856	.072	¾	1.041	.881	.080
1¼	1.13	.056	1.106	.072	1	1.309	1.149	.080
1½	1.38	.064	1.340	.080	1¼	1.650	1.490	.080
2	1.87	.064	1.816	.092	1½	1.882	1.698	.092
2½	—	—	2.316	.092	—	—	—	—
3	—	—	2.816	.092	—	—	—	—

some extent assists it to be held in position and in such cases it can be fixed with crampets or pipe hooks as Fig. 15, but on surface work these are unsightly and the little trouble expended in fixing saddles is well worth while.

Do Not Nail.

Another important factor not to be overlooked is the question of screws. Nailing is always considered bad, and where a good wood fixing cannot be obtained, as in tiles or brickwork, no better method can be employed than "Rawlplugs."

three types on the market, brass being used for screwed conduit. For the cheaper forms of installations rubber and fibre ones will be found quite efficacious.

Clean Ends Before Jointing.

Strange as it may seem, cleanliness is another factor. Paint, enamel and rust are poor conductors, therefore, if a perfect earthing system is to be obtained, all conduits and fittings must have the ends well cleaned before the joints are made. A loose joint also means poor contact and a loss of earthing efficiency: see that

Fig. 13.—ORDINARY SADDLE.
For surface fixing in indoor positions.

nuts or screws are properly driven home, and screwed ends tightly threaded. Above all, bear in mind that continuity throughout is very important. Avoid the use of wood boxes where possible, unless it be at the ends of branches. A wood junction box, for example, breaks continuity, and it is much easier to use an iron box than to connect effectively the conduits feeding it.

When Cutting a Thread Connection.

When engaged upon screwed work it may be found necessary to cut a thread on a shorter length of conduit, and a common error is to cut more than necessary for the required connection. The conduit is enamelled or galvanised for protection and this over-cutting leaves a small portion of exposed metal which should be painted with a non-corrosive paint after the joint has been made if future trouble is to be avoided.

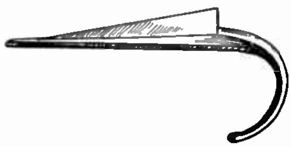

Fig. 15.—A CRAMPET OR PIPE HOOK.
For securing conduit where it is buried in plaster.

How to Make a Watertight System.

Fig. 14.—ORDINARY SADDLE.
For holding conduit in angles.

Water, possibly, is the electrician's greatest enemy, except when conveyed in pipes and used as an "earth." It is well, therefore, when installing a watertight system to be sure it is watertight. Joints should be painted in with a *metallic* paint, covers of boxes should be properly seated and where there is any doubt there should be no hesitation in the use of gaskets. If it is necessary to make a joint in the wiring, the added precaution should be taken of filling the box with molten pitch.

TABLE SHOWING CARRYING CAPACITIES OF STEEL CONDUITS.

Number and Size of Wires.		1 .036	1 .044	1 .064	3 .029	3 .036	7 .029	7 .036	7 .044	7 .064	19 .052	19 .064	19 .072	19 .083	37 .064	37 .072	37 .083
	ins.																
Size of Light Gauge Conduit.	½	3	2	2	2	—	—	—	—	—	—	—	—	—	—	—	—
	⅝	6	4	3	4	4	2	2	—	—	—	—	—	—	—	—	—
	¾	8	6	4	5	4	4	3	—	—	—	—	—	—	—	—	—
	1	16	10	8	11	13	7	6	4	2	—	—	—	—	—	—	—
	1¼	—	—	12	15	—	10	9	6	4	1	—	—	—	—	—	—
	1½	—	—	—	—	—	15	15	9	5	3	3	2	2	1	1	—
	2	—	—	—	—	—	—	—	—	10	5	5	4	4	3	2	2
Size of Heavy Gauge Conduit.	½	2	1	1	1	1	1	—	—	—	—	—	—	—	—	—	—
	⅝	4	3	2	3	2	1	—	—	—	—	—	—	—	—	—	—
	¾	5	5	3	4	3	2	—	—	—	—	—	—	—	—	—	—
	1	10	7	6	7	6	5	4	3	2	—	—	—	—	—	—	—
	1¼	—	—	—	10	9	7	6	4	3	1	—	—	—	—	—	—
	1½	—	—	—	—	—	10	10	7	4	2	2	1	—	—	—	—
	2	—	—	—	—	—	—	—	—	8	4	4	3	3	2	2	1
	2½	—	—	—	—	—	—	—	—	—	—	6	4	4	3	2	1
	3	—	—	—	—	—	—	—	—	—	—	—	—	—	4	3	2

Avoid Sharp Bends and Elbows as Much as Possible.

The planning of a conduit system also calls for some attention. The use of sharp bends and elbows should be avoided wherever possible. If it is necessary to make two bends in a length of conduit they should be as far apart as possible, and one at least should be of the inspection type, or the drawing in will cause a great amount of trouble. It sometimes happens that inspection fittings are not allowed, and when this is the case it is better that the bends should have as large a radius as possible. Difficulties in threading wires through acute and numerous bends are not likely to present themselves so readily if care is taken in choosing the size of conduit.

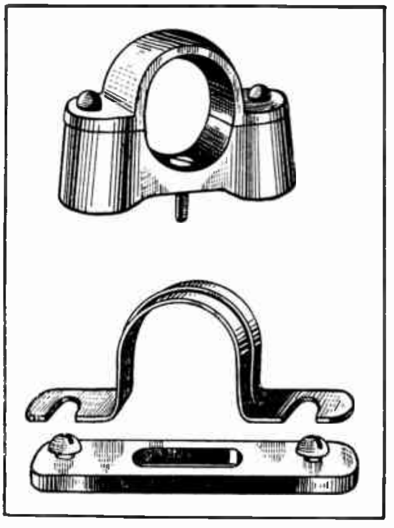

Fig. 16.—Two Types of Spacing Saddles.

How Many Wires Will the Conduit Carry?

It is false economy to try threading a larger number of wires than the bore of the conduit can comfortably accommodate, and in this matter also rules have been laid down for guidance. The table on the previous page will be found very useful if any uncertainty arises. Anyhow, it is better to err on the low side rather than risk the possible damage to the insulation, and its consequences.

Later articles will deal in detail with other systems of wiring and examples will be given of wiring installations for dwelling houses, flats, factories, shops, cinemas and public buildings.

QUESTIONS AND ANSWERS

What are the two gauges of conduit?

Heavy and light, the heavy gauge being only supplied in screwed conduit.

When can galvanised conduit be used?

Galvanised conduit is recommended for all exterior work and for interior work if it is to be hidden in plaster and brickwork.

What are the first essentials in assembling conduit?

It should be properly prepared, the ends rounded off with a file until they are smooth. The interior of all fittings should be examined for any rough finish and the ends of the conduit should be terminated with proper bushes if conduit boxes are not used.

What precautions should be taken when cutting a thread on a conduit?

1. Remove external burr from end of tube before screwing.

2. Do not cut more than necessary for the required connection, for over cutting leaves a small portion of exposed metal.

3. Remove internal burr with reamer after screwing.

What are the four patterns of conduit boxes?

Two-way "through"; two-way "angle"; three-way; and four-way.

What are the principal methods of fixing conduit?

1. For screwed tubing on the surface in exposed positions, use spacing saddles.

2. For fixing to brickwork, use a saddle with the shank formed as a rag bolt.

3. For tubing buried in plaster or chased into brick walls, use crampet or pipe hooks.

4. For surface fixing in indoor positions use ordinary saddles.

A PILOT LIGHT

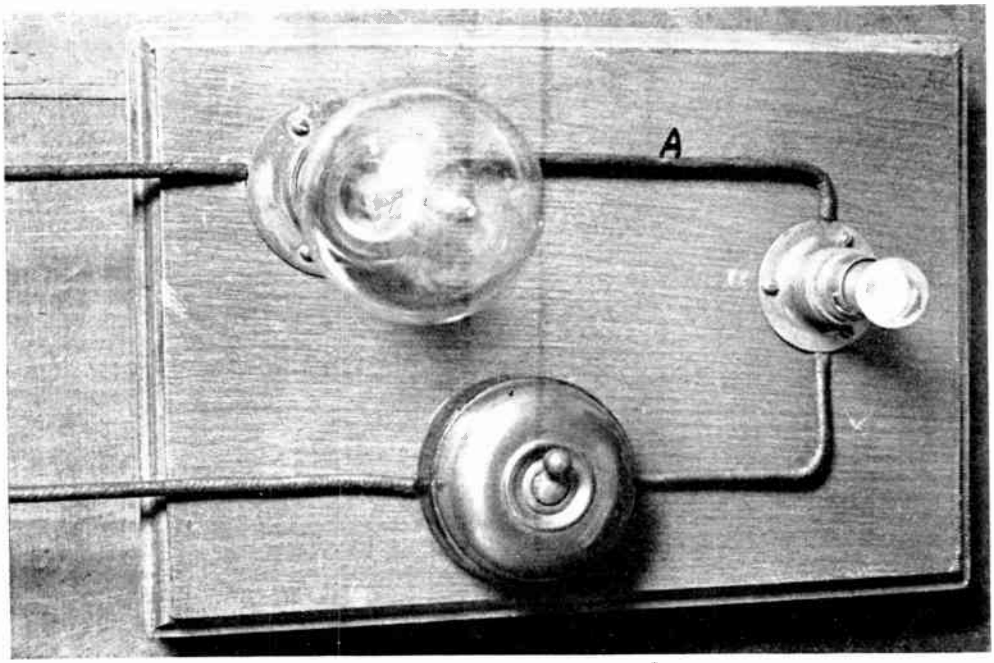

Fig. 1.—THE POSITION OF THE PILOT LIGHT.
This illustration is, of course, purely a diagrammatic one, and in actual practice the position of the main lamp might be some distance from the switch. It will be seen that the switch wire "A" has been disconnected from the switch and the pilot light inserted in series with the switch and the main lamp. The position of the pilot light in relation to the switch might quite conveniently be similar to that shown above. Although it may not at first seem feasible to run, say a 3.5-volt and 230-volt lamp in series, it is, as explained in the article, only necessary that their combined voltages equal or exceed the supply voltage and that the *current taken by each lamp* is identical.

ELECTRIC lighting has many advantages, but electric switches are so easy to put on that they are sometimes left on. If the switch is in the lighted room, sheer carelessness is indicated if it is left on, but sometimes, as in cellars, the switch is in such a position that the light is not so obvious and can thus be readily forgotten.

A simple arrangement is described below by which a light glows near the switch when it is on. Switching off when passing follows as a natural and certain action.

As will be seen from Fig. 1, a low voltage lamp is inserted in the lead from the big lamp to the switch.

How to Wire up the Pilot.

The wiring is extremely simple. Disconnect the wire A from the switch and reconnect through the small lamp. The pilot bulb may be of any voltage desired; 6-volt car type lamps are as good as any, and the necessary S.B.C. batten holders can be obtained without any difficulty. Flashlamp bulbs may be used if desired, and, in fact, are perhaps preferable when the lamp to be indicated is of low wattage. Batten holders for these may be obtained and look better if they are sunk in a small wood block, thus leaving no exposed connections. The lamp and pilot bulb are then in series, and if either fails, both go out, so that there are two points of failure to look for, and two spare lamps are necessary for security.

Suitable Lamp Voltage.

It may at first not seem feasible to run, say, a 3.5-volt and 230-volt lamp in series, but a consideration of the information below will render the matter clear.

For two lamps to run in series with equal brightness it is only necessary that their combined voltages equal or exceed the supply voltage, and that the *current taken by each lamp is* IDENTICAL.

This latter is most important. Thus on a 200-volt circuit two lamps of 100 volts, or one of 150 volts and the other 50 volts, or 200 volts and, say, 3 volts, all fulfil the conditions laid out as regards voltage.

Determination of current taken is equally simple. Divide the watts as marked on the lamp by the supply voltage, and the result is the current taken in amperes. Thus a 200-volt 60-watt lamp takes 6/20 of an ampere, approximately $\frac{1}{3}$ ampere; a motor-car side lamp, 6 volts 3 watts, takes $\frac{3}{6}$ or $\frac{1}{2}$ ampere, and can thus be run in series with any lamp taking this current.

A case in point would be a 200-volt 100-watt lamp—passing, of course, $\frac{1}{2}$ ampere (the side lamp would be suitable)—the voltage adds up to 206, and the light from the larger lamp will be diminished by the amount equivalent to 6 volts.

An ordinary 3.5-volt flashlamp or miniature screw bulb takes about $\frac{1}{3}$ ampere, and is thus suitable for, say, one 60-watt lamp on 200–230-volt circuit.

If two or more lamps are run off one switch their total wattage must be taken. Thus two 200-volt 100-watt lamps would require a pilot to pass 1 ampere, say a 6-volt 6-watt motor-car side lamp.

Remember that if the pilot lamp is removed there is a pressure of the supply voltage across its lamp-holder, so that "switch off" is sound advice while experimenting.

A NEW ELECTRICAL METAL

A NEW metal has recently been discovered and put on the market in this country under the name "Batterium"; it has somewhat remarkable properties for electrical and other purposes. Batterium is an alloy consisting of copper 89 per cent., aluminium 9 per cent., nickel and other metals 2 per cent., in specific proportions.

It is a silvery gold colour resembling a light brass in appearance.

Its most important property, from the electrical point of view, is its non-corrosive nature, for it is guaranteed to resist the corrosion of alkalies and all acids; this makes it a most suitable metal for battery fittings—hence its name Batterium.

A series of tests made by the Royal Technical College, Salford, showed that it was superior in resisting corrosion to Monel metal and Staybrite steel.

It has exceptional strength properties, and is actually as strong as good quality steel or drawn bronze. Thus, it has a tensile breaking strength of 36 tons per square inch, combined with excellent ductility.

Its specific gravity is 7.67 (i.e., less than steel or copper) and it melts at 1,035° C.

Batterium has good electrical properties, and is for this purpose used for electrical fittings such as electrical castings, battery plate terminals, etc.

It is supplied in the form of sheets, cold drawn tubes, extended rods in round, square, hexagon and other sections, screws, rivets, nuts, castings, forgings and stampings. It can easily be machined, soldered and welded.

THE REPAIR AND MAINTENANCE OF SMALL DYNAMOS

By H. E. J. Butler

THE upkeep of dynamos may be divided into two main categories, viz.: mechanical and electrical. Mechanical wear necessitates regular attention to the brushes, commutator, bearings and driving pulley or gears; while electrical breakdown involves rewinding the armature or field coils, or renewal of some part of the insulation. Periodical examination and testing of the machine and the rectification of any slight defect prevents breakdown under working conditions.

BRUSHES.

Fitting New Brushes.

When the carbon brushes have worn to about half their original length, they must be replaced by new ones. Brushes must never be allowed to wear so short that there is insufficient bearing in the brush holder, or the brush may twist and become jammed in the holder with consequent failure of the machine or damage to the commutator. The brushes are a vital part of a dynamo, and, being subject to constant mechanical wear, they need more attention than any other part.

Types of Brushes.

When fitting new brushes it is essential to use the same size and grade as before. Carbon brushes are almost invariably used and are made in several degrees of hardness. Hard brushes are used for machines of higher voltage where the current density in the brush is low, and soft brushes are used for dynamos giving a larger current and lower voltage.

With plating dynamos where the current is many times greater than the voltage output, brushes of copper - carbon compound are used. Carbon brushes can be used only when the commutator is copper. If the commutator is made of brass or bronze, as it may be on an old or very small machine, metal brushes of either copper gauze or strip brass give the most satisfaction.

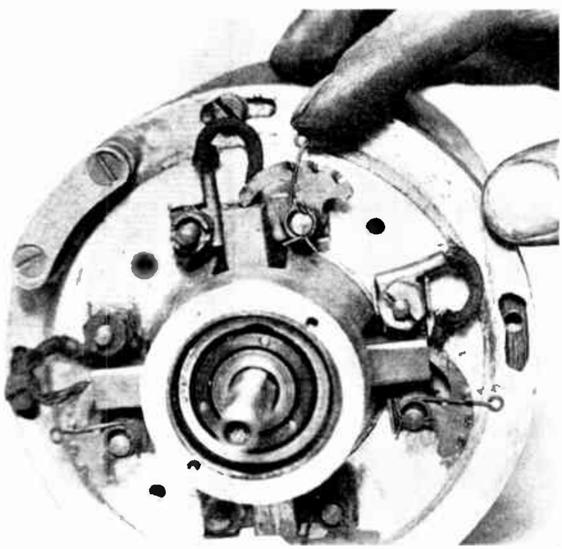

Fig. 1.—Adjusting Spring Tension on Brushes of Car Dynamo.

The tension finger has three notches which give three different pressures on the brush.

Bedding New Brushes.

The wearing surface of the brushes must exactly fit the radius of the commutator and bed evenly. New brushes are supplied with the ends flat so that it is necessary to shape them to fit the commutator before putting them into use. The bearing surface of the brush is first roughly filed to shape with an old crossing file, then inserted in its brush holder and the armature rotated, while a firm pressure is maintained on the brush.

The brush is then taken out and filed

where the commutator has marked it. This is repeated until a fairly good fit is obtained. Where the commutator is accessible, the brush may be formed to shape by placing a strip of glass paper between the brush and the commutator and the shaft rocked while the paper is held down firmly on the round surface.

When all the brushes have been dealt with in this way, the machine is run with the field circuit open until the brushes are bedded sufficiently to permit the machine to be loaded without injurious sparking.

Fit of Brushes in Holders.

The brushes must slide quite freely in the holders, but must not be a loose fit. The brushes should fit the holders so that there is a perceptible shake in either direction. If the fit is too loose the angle of the brushes will alter materially as they wear down, with consequent commutation trouble. Also a reversal of rotation causes the brushes to dig in between the commutator segments and break, should the micas be undercut.

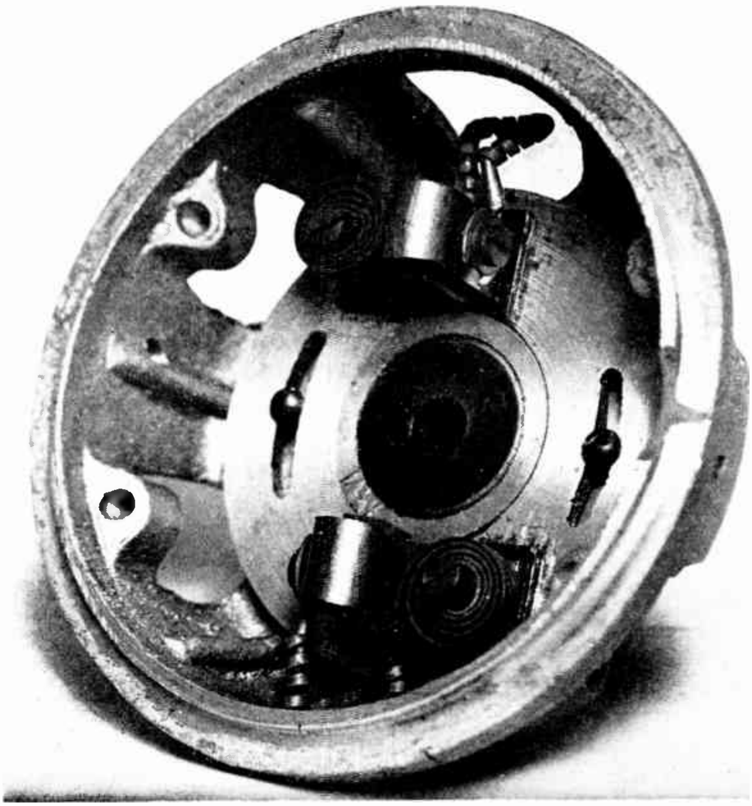

Fig. 2.—Brush Gear Assembly of Two-Pole Dynamo.

This type of spring does not require any adjustment as the brush wears. Note the two radial slots in the base of the brush rocker which permit the brushes to be moved round the commutator when the rotation is reversed, or to obtain sparkless commutation under different conditions.

Compensating for Wear.

As the brushes wear down it is necessary to adjust the tension of the retaining springs. A typical type of small brush holder is shown in Fig. 1. The pressure on the brushes is increased by stepping the spring back one or two notches. If one notch gives too much pressure on the brushes then the end of the spring must be bent back slightly to ease the tension. Slacken off each spring and remove the brushes so as to make sure that the brush retaining fingers are perfectly free to move into the brush holders as the brushes wear down.

The spiral brush spring shown in Fig. 2 does not require any adjustment as the brush wears down. This is because the small amount of extension caused by the wear of the brush does not alter the tension of the spring materially owing to its number of turns.

Brush Position.

In order to reduce sparking to a minimum for varying conditions of load, the brush rocker, that is, the whole assembly of the brushes, is made adjustable. Fig. 2 shows an adjustable brush rocker. This is held by two nuts and lock washers on the outer side of the casing. If the load is to be permanently increased, but, of course, still kept within the capacity of the machine, the brushes are moved round in the same direction as the rotation of the armature. That is to say, they must be given more lead.

The brush position should be set while the machine is running and properly loaded, when the position is easily found which gives the least or no sparking at the brushes. Conversely, if the output is to be reduced, the brushes are given less lead. When the output is variable, the brushes are set midway between the maximum load position and the best position for minimum load.

Larger machines with interpoles, that is, small pole pieces between each pair of main poles, do not require any adjustment of the brushes for varying conditions of load, as the interpoles are designed to correct the field distortion caused by variations in the output, and so give sparkless commutation for all currents within the capacity of the machine.

Brush Pigtails.

The brush pigtails should be examined occasionally to ensure they cannot make contact with any part of the frame, as the insulating covering is often only cotton. If the insulation on the pigtails is worn or of doubtful stability, the flexible wire is threaded with glass beads. This is the most satisfactory form of insulation for this type of short flexible lead, because it withstands handling and is not so liable to cause a breakdown through oil creepage from the bearings.

Very small machines with round brushes have the brushes and their pigtails enclosed in an insulating tube, in which case there is no necessity for any insulation on the brush leads.

Brush Springs.

When these springs are made of steel the chief enemy is rust. If a spring is allowed to rust it will be sure to break under working conditions, sooner or later. The springs are greased with a thin smear of vaseline about every two months. If any rusting should take place in spite of the precaution, clean off the rust to prevent further action and fit a new spring at the earliest possible moment. Two types of brush springs are shown in Figs. 1 and 2.

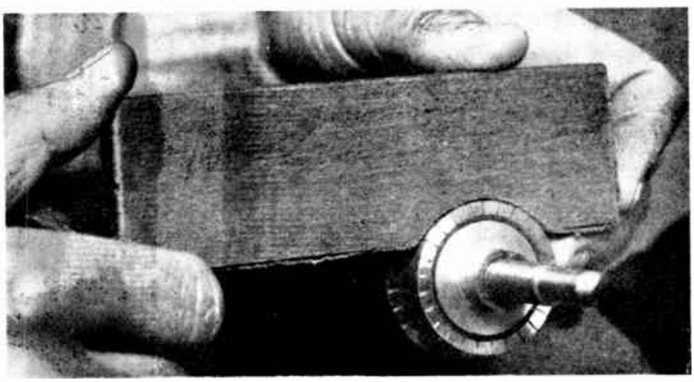

Fig. 3.—CLEANING COMMUTATOR WITH GLASS PAPER.
The paper is mounted on a shaped wooden block thinner than the width of the commutator.

COMMUTATORS.

Cleaning the Commutator.

The best method of cleaning a commutator is shown in Fig. 3. A piece of wood, thinner than the width of the commutator, has a segmental recess of such radius that when a strip of fine glass paper is placed in it the rough surface of the abrasive bears evenly on the commutator surface. The glass paper must not be used in the fingers, as when polishing an ordinary surface, or the edges of the commutator bars may be rounded, especially

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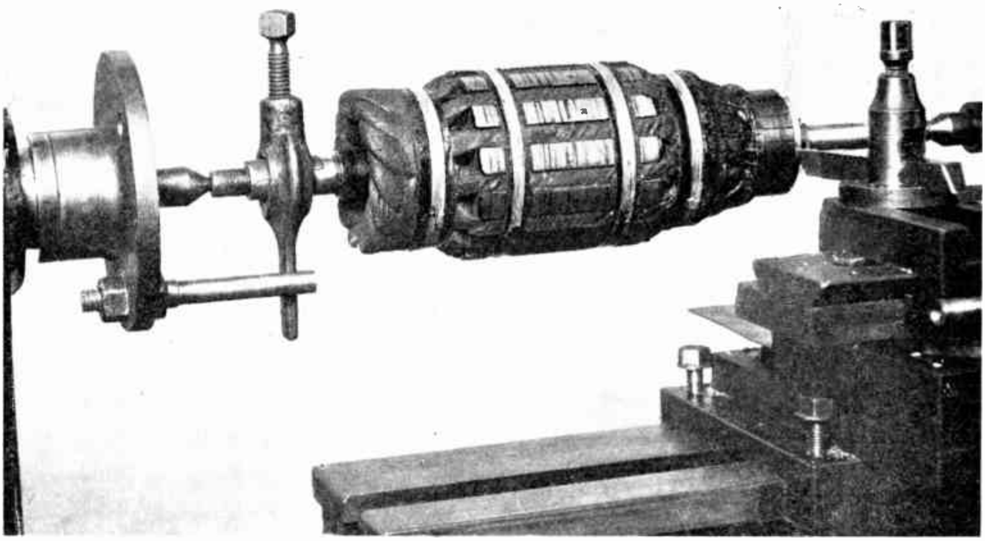

Fig. 4.—TRUING UP COMMUTATOR IN LATHE.

Make sure that the bearing sections of the shaft run truly before turning the commutator. A piece of soft metal is put between the set-screw and the shaft to protect the bearing surface.

if the micas are below the surface of the copper. A larger machine may be treated in this way whilst running, but a small machine must be removed and mounted in the lathe if the commutator is inaccessible.

Emery paper or cloth must not be used for this purpose because the emery dust, which, by so doing, gets between the bars or embedded in the surface of the mica, causes subsequent scoring of the brushes and commutator when the machine is run again.

If the commutator is at all worn or out of truth, it is useless to attempt to correct these faults by glass papering. The commutator must be turned.

Turning a Commutator.

Fig. 4 shows the method of turning a commutator in a lathe. In order to protect the bearing surface of the shaft, put a slip of copper or soft brass between the carrier set-screw and the shaft. A keen tool with plenty of rake is used for turning the copper, and, to avoid chatter, light cuts must be taken. The copper may be turned dry, or turpentine used to lubricate the turning tool if the copper shows any tendency to tear.

If the commutator has to be reduced more than one or two light cuts, it will be necessary to re-bed the brushes. A commutator should never be interfered with if there is no sparking at the brushes; it does not affect the commutation if the surface is uneven, provided that the brushes bed properly and the commutator runs truly. A commutator in perfect condition should have a light brown burnished appearance. A new commutator takes some time to obtain this condition and the brushes and commutator are best left alone while this state is maintained.

Oil on the Commutator.

A frequent cause of commutator trouble is oil creep. When oil or grease gets on to the commutator the brushes spark badly and a black deposit is formed on the commutator, which gives rise to worse sparking and the output of the machine falls with heating of the commutator. Under these circumstances, the machine must be stopped at once. The commutator is then cleaned with petrol and new brushes must be fitted if any oil has soaked into them.

The source of superfluous oil is then traced and the bearing cleaned and renewed with fresh oil. If a commutator end bearing repeatedly gives trouble in this way, it can usually be stopped by inserting a thin brass washer, larger in diameter than the commutator, between the commutator and the offending bearing. This trouble is usually confined to plain bearings with oil lubrication and is not encountered on machines with ball bearings if proper attention is paid not to over-oil them.

LUBRICATION.

Plain Bearings.

Unless large reservoir lubricators are fitted to plain bearings they require daily oiling if the machine is in continuous use. Do not use more oil than is necessary as any superfluous oil may injure not only the commutator but also the insulation of the field winding.

There are three main types of plain bearings, those with wick-feed grease lubricators, ring-oiled, and sight-feed lubricated bearings.

Wick-Feed Lubricators.

Wick-feed grease lubricators should be replenished with a good quality petroleum grease about once a week for machines running eight hours a day. Every three months the bearings and grease cups are washed out with petrol. The felt wicks should at the same time be renewed, or if still in good condition, they may be soaked in petrol, dried, and put into use again. It is essential to put some grease into the bearing itself when reassembling a dynamo with this type of lubrication, because the grease takes some time to soak through the wick. A spring is used to keep the wick in firm contact with the bearing, and this should be examined when replacing the wick. The grease cup should not be too tightly packed on this account, or the spring will not act freely. A wick oiler is illustrated in Fig. 5.

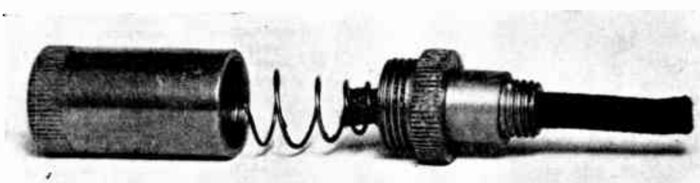

Fig. 5.—Wick-Feed Grease Lubricator.
This is taken apart to show the spring which keeps the wick in contact with the bearing.

Ring Oilers.

Ring-oiled bearings are the most satisfactory type of plain bearing for continuous running dynamos. The oil level in the sump should be kept so that a third of the diameter of the ring is immersed. Daily inspection of this type of bearing is desirable to ensure that the ring is rotating freely, for if the ring sticks the bearing cannot get any oil. Wash out the bearings every six months and replace the rings with new ones if they are damaged or worn. Larger machines have an overflow for the oil sump; this should be inspected from time to time to ensure that it functions properly when the bearings are over-oiled.

Sight-Feed Drip Lubricators.

This type of lubricator has the disadvantage that it can easily be adjusted to over-oil the bearing, but has the advantage that one can see that the bearing is getting a definite amount of oil. The drip-feed of the oil should be adjusted so that a film of oil is always maintained in the bearing, but should not be so much that the oil runs down the dynamo casing, or sprays off the shaft, giving rise to a long oily streak on the floor under the bearing. When the machine is not running the valve of the lubricator must be shut. Unscrew the lubricator about every six months and clean out to ensure a free passage of oil into the bearing.

Inspecting Fit of Bearings.

The fit of plain bearings is important for two reasons. If the bearings are a loose fit they will not hold any oil and consequently are as likely to seize as tight bearings. A bad-fitting bearing may also give rise to chattering of the armature, and where the air gap between the armature and field magnets is small, the pole pieces may foul one another and serious harm result.

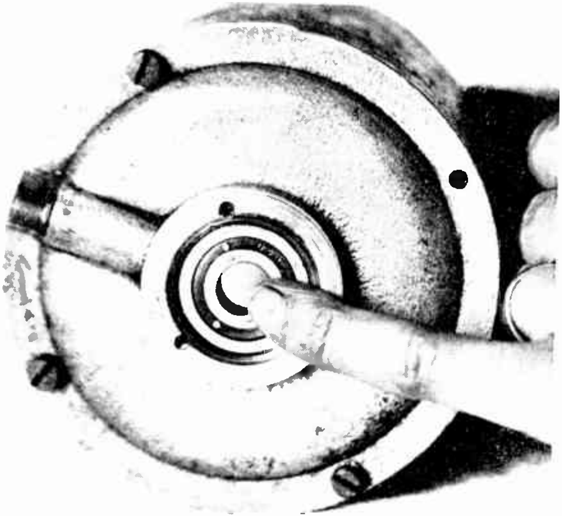

Fig. 6.—TESTING INNER RING OF BALL-RACE FOR FREENESS.

When the bearing has been washed out it should spin quite freely.

Examine the shake in the bearings every week so that the wear may be corrected before it reaches a dangerous amount.

BALL BEARINGS.

Ball bearings packed with grease may be safely run for six months without any attention apart from an occasional few drips of thin oil. After this period they should be cleaned out, dried and repacked with grease and put into service again.

Testing for Freeness.

When a ball bearing has been cleaned out it should spin freely without any scratching or stickiness. Fig. 6 shows testing a ball-race for freeness. The least trace of grit may ruin a ball bearing. If a bearing is stiff after being washed out, probably some hard grease remains between the balls. The race should be removed and soaked in petrol or turpentine and kept in motion until all the congealed grease has been dissolved.

Removing a Ball-race.

Fig. 7 shows a make-shift race extractor consisting of an old magneto gear wheel, a ¼-in. Whitworth bolt and a large-sized ¼-in. washer. Fig. 8 shows a ball-race being extracted. The head of the bolt is held on the inside of the bearing with a pair of pliers, while the race is drawn into the hollow side of the gear wheel by tightening the nut with a spanner. Removed in this way the ball-race comes out quite easily without any fear of damage. Never hammer a ball-race out of its housing, for they are made of hardened steel and can be easily broken.

Fitting a New Ball-race.

If the ball-races have become worn so that the spindle shakes laterally, or if the balls have been scratched through foreign matter entering the bearing, they must be replaced. Fig. 9 shows how to insert a ball-race into its housing by using the vice as a press. If the bearing is sunk below the surface of the housing a washer, somewhat smaller than the diameter of the bearing, must be interposed between the bearing and the front jaw of the vice to permit the bearing to be pressed right home.

Make sure that the bearing is perfectly free before inserting it. If it is hard to press home and the middle ring of the bearing becomes stiff to rotate when the

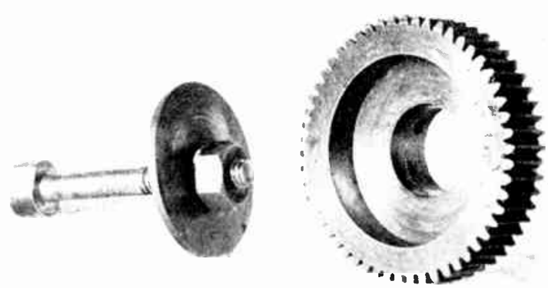

Fig. 7.—PARTS OF SIMPLE BALL-RACE EXTRACTING DEVICE.

This consists of a ¼-inch Whitworth bolt and nut with a washer and a hollow gear or disc such as may be found on old magnetos.

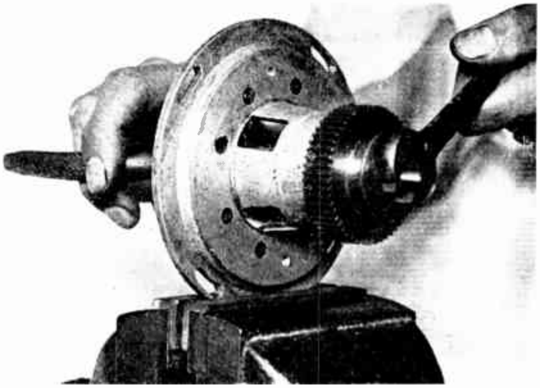

Fig. 8.—EXTRACTING BALL-RACE FROM DYNAMO END FRAME.

The head of the bolt is prevented from twisting by holding it with a pair of pliers. Note the use of smooth angle iron in the vice jaws to prevent injury to the rim of the end-frame.

bearing is in the housing, the ball-race is too tight a fit in the end-plate. To remedy this, chuck the end-plate in a lathe and bore out the housing so that the ball-race is a good push fit, but not free enough to rotate under working conditions. See Fig. 10. If the new bearing is loose in the housing, the end-plate is bored out and a brass bush fitted to accommodate this.

ARMATURES.

So long as a dynamo functions properly the armature requires no attention. Annual inspection is made to see if the slot wedges have shifted or if any part of the winding has become chafed through contact with the end-frames or field magnets.

Testing Armature Winding.

When it is suspected that the armature winding has broken down it may be tested in a few minutes if wired up as shown in Fig. 11. A current is passed through the winding by connecting a single cell accumulator, in series with a rheostat, to a pair of diametrically opposite commutator segments. The current is then adjusted to give a reading of somewhat less than half-scale deflection when a milliampere meter is connected to a pair of adjacent segments.

The meter is then connected to each pair of adjacent commutator bars and the reading noted in each case. The reading should not vary more than a point or two for a hand-wound armature and scarcely at all for a former-wound one.

A burned-out coil is located when the meter reading is found to be about double what it is for the others. If the armature is a former-wound type this coil may be replaced without a complete rewind, but if it is a hand-wound armature, a complete rewind is necessary.

If one pair of bars gives a low, or no reading on the meter, then this coil is partially or completely short-circuited. Examine the insulation between the bars

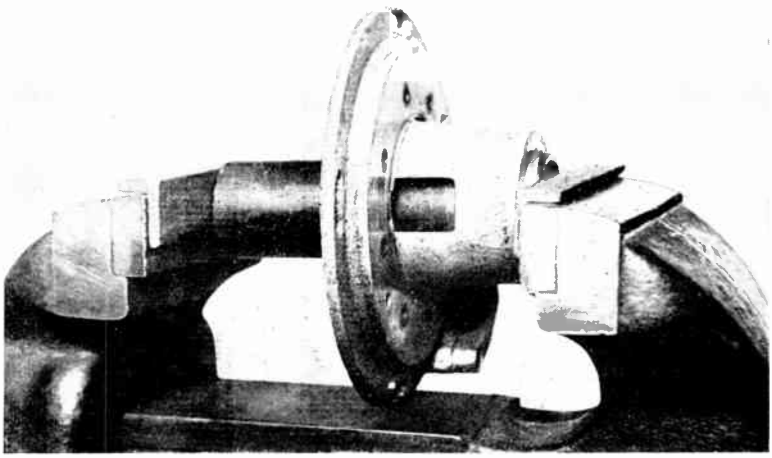

Fig. 9.—PRESSING IN BALL-RACE INTO ITS HOUSING.

A short bar is inserted behind the housing which must be larger than the hole in the housing.

and if this is in order the winding is at fault. Make certain of this before rewinding, by disconnecting the armature winding from the commutator and testing the winding alone in the same way.

Testing Armature Insulation.

The armature insulation is tested by connecting a battery to one of the commutator bars and the shaft in series with a milliampere meter. The insulation resistance can then be calculated by applying Ohm's law. A protecting resistance is inserted in the circuit as described under testing the insulation of the field coils.

Testing Field Winding for Continuity.

Fig. 13 shows the circuit arrangement for testing the continuity of the field windings. It consists of a single cell and a low-reading voltmeter wired in series with the field winding. If the windings are in order the meter will register voltage of the cell or nearly so. If a break is indicated by no deflection on the meter, then test each coil separately and thereby ascertain which coil requires rewinding. If the field coils are connected in parallel it is essential to test each coil separately because one may be burned out and the other completes the circuit.

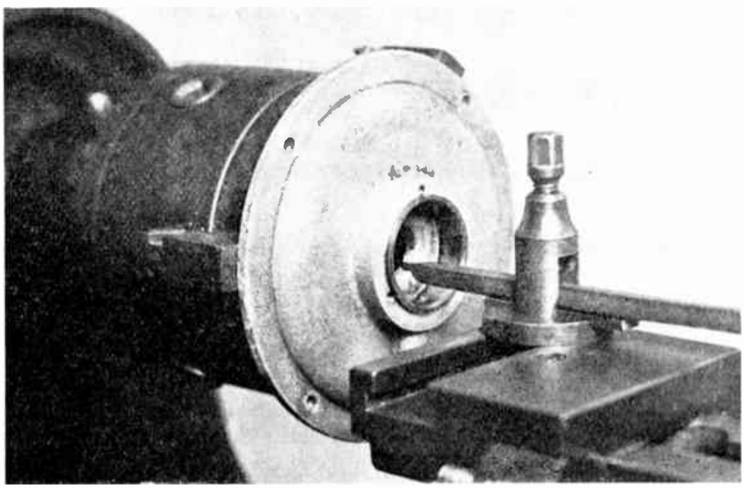

Fig. 10.—Boring Out Ballbearing Housing.

Such an operation is necessary when a new ball-race fits too tightly. An inside shoulder-boring tool is used. A round-nosed tool will not work into the corner.

Testing Insu'ation of Field Windings.

The circuit for testing the field winding insulation is shown in Fig. 12. Should a short-circuit be present a protecting resistance is inserted in series with the milliampere meter to protect it. In the arrangement shown, with a 2-volt cell and a meter reading to 100 milliamperes, 20 ohms resistance is sufficient. If the machine is a high voltage one, a 100-volt dry battery and a 1,000 ohms resistance is used for the test, so that a short to earth is shown by a full-scale deflection in each case. Fig. 14 shows a badly made field connection which is liable to give rise to a short to earth.

FIELD MAGNETS.

Permanent Magnets.

Permanent magnets, e.g., as used in magnetos, require remagnetizing from time to time. Their weakness is easily noticed, because the dynamo fails to give its usual output unless the driving speed is increased. The armature of a permanent magnet dynamo should never be removed unless it is absolutely necessary, as it is liable to weaken the magnet. If the armature has to be removed, take off the base-plate first and bridge the pole pieces with a flat piece of soft iron. This will prevent the magnet being weakened.

Residual Magnetism.

The presence of some residual magnetism in the field magnet is essential to make a dynamo excite. If the residual magnetism has been destroyed, such as by reversal of rotation, the terminals of the dynamo must be connected to a battery for a few seconds. If the machine is shunt-wound, the positive

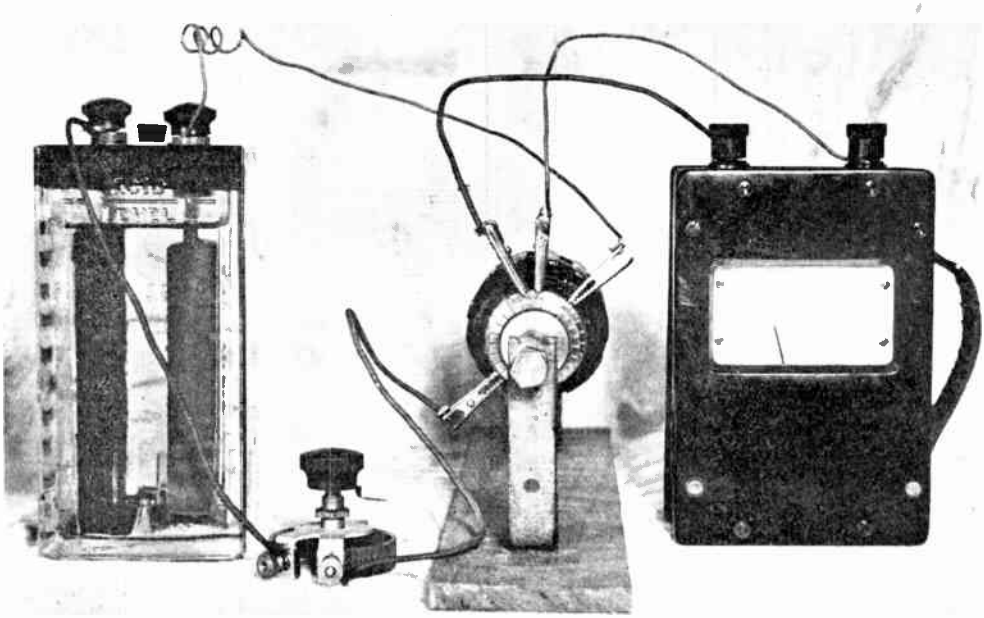

Fig. 11.—CIRCUIT ARRANGEMENT FOR TESTING COILS OF ARMATURE.
A current is passed from a battery through the armature by connecting it to a pair of diametrically opposite commutator segments. A rheostat is used in this part of the circuit to regulate the current so as to give a suitable reading on the milliampere meter. If the armature is in order, the milliampere meter gives the same reading when clipped on to any pair of adjacent commutator segments.

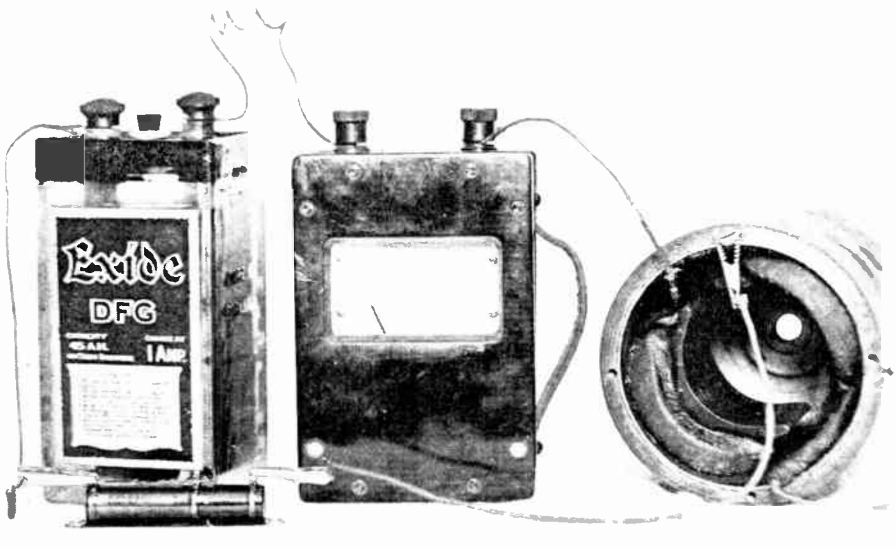

Fig 12.—CIRCUIT ARRANGEMENT FOR TESTING INSULATION OF FIELD WINDING.
One end of the battery is connected in series with a 20-ohm resistance to the magnet frame. The other end of the battery is connected in series with a 0-100 milliampere meter to one end of the winding. For a high-voltage machine a 100-200-volt supply and a 1,000 or 2,000-ohm resistance is used.

Fig. 13.—TESTING FIELD WINDING FOR CONTINUITY.

A small accumulator is connected to the ends of the field winding in series with the voltmeter.

terminal of the battery is connected to the positive terminal of the dynamo and the negative to the negative, but in the case of a series-connected field the positive terminal of the battery is connected to the negative terminal of the dynamo and the negative terminal of the battery to the positive of the dynamo.

FAULTS.

Sparking.

Sparking at the brushes may be caused by any one of the following :—

(1) One field winding short-circuited.
(2) One or more armature coils short-circuited.
(3) One or more armature coils open-circuited.
(4) One or more commutator segments short-circuited.
(5) Brushes not bedding properly.
(6) Brushes not making firm contact.
(7) Brushes out of position for the prevailing load.
(8) Wrong grade of brush used.
(9) Machine overloaded.
(10) Oil on commutator.
(11) Machine running too fast.

Flashing round the commutator is caused by carbon becoming embedded between the commutator segments, and by the commutator being of too few segments for the voltage output.

Overheating.

Overheating of the armature without much sparking indicates that the machine is overloaded. A short in the armature will give rise to overheating, but is accompanied by much sparking at the commutator. A short of one or more field coils will be located by some coils being hot and others cold. Overheating of the bearings is due to insufficient oil, a tight driving belt or excessive speed.

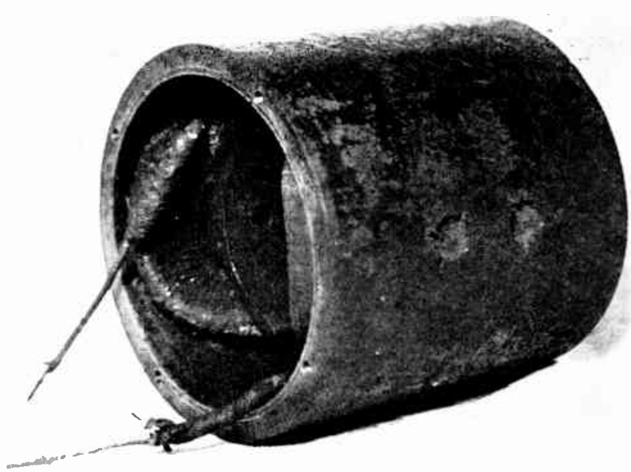

Fig. 14.—FIELD MAGNET OF SMALL DYNAMO SHOWING BAD FIELD LEAD.

This lead might give rise to a short to the frame. It must be bound up with a fresh piece of insulating tape. Empire tape must be used for a high voltage machine.

Failure to Excite.

The failure of a dynamo to generate may be due to any of the following causes :—

(1) No residual magnetism.
(2) Direction of rotation reversed.
(3) Break in field circuit.
(4) Break in shunt regulator.
(5) Break in armature.
(6) External short-circuit.
(7) External circuit resistance too high.
(8) External circuit broken (series field only).

Output Below Normal.

When the rated output cannot be obtained, one of the following causes may be present :—

(1) Brushes too hard.
(2) Too much shunt resistance in the field circuit.
(3) Armature wrongly wound.
(4) Field wrongly wound.
(5) Field partially shorted.
(6) Speed too low.
(7) Belt or pulley slipping, in which case the pulley gets hot.

Output Above Normal.

When the output rises above normal it may be concluded that the machine is being run too fast.

Output Unsteady.

One of the following is the cause of an unsteady output :—

(1) Intermittent short-circuit in external circuit.
(2) Part of driving belt glazed.
(3) Intermittent contact of brushes.
(4) Loose connection to brushes or other loose connection inside the machine.

MODIFICATION OF WORKING CONDITIONS.

Reversal of Drive.

When it is desired to drive a dynamo in the opposite direction, reverse the two connections to the brushes inside the machine. If this is done, the polarity of the output will be the same as before. When the direction of rotation is reversed, it is also necessary to re-set the position of the brushes to give sparkless commutation. They are given a small movement in the direction of the new rotation.

Alteration of Output.

A dynamo giving 5 amps. at 100 volts can be altered to give any lower voltage and a proportionally bigger current only by rewinding. A current of 5 amps. at a lower voltage may be obtained from the same machine if the armature is run at a lower speed. Alternatively, a resistance may be inserted in the field circuit to reduce the output if it is inconvenient to alter the driving speed.

The rated output of a dynamo may be increased within limits if the machine is run faster. This can only be done if the mechanical construction of the machine permits. Thus, a dynamo giving 100 volts 5 amp. at 1,500 revolutions per minute, would give about 130 volts 5 amps. at 1,850 revolutions per minute. It is important to note that only the voltage may be increased. The current output of a dynamo must not be increased beyond its rated value or the armature will overheat.

QUESTIONS AND ANSWERS

What happens if brushes are allowed to wear too short?

The brush may twist and become jammed in the holder with consequent failure of the machine or damage to the commutator.

Should carbon brushes be used with a brass or bronze commutator?

No ; carbon brushes can only be used when the commutator is copper.

How often should springs be greased?

About every two months, with a thin smear of vaseline.

What harm is caused by oil on the commutator?

The brushes spark badly and a black deposit is formed on the commutator.

How should oil be removed from the commutator?

By cleaning with petrol.

THE REMOTE CONTROL OF WIRELESS SETS

By H. E. J. Butler.

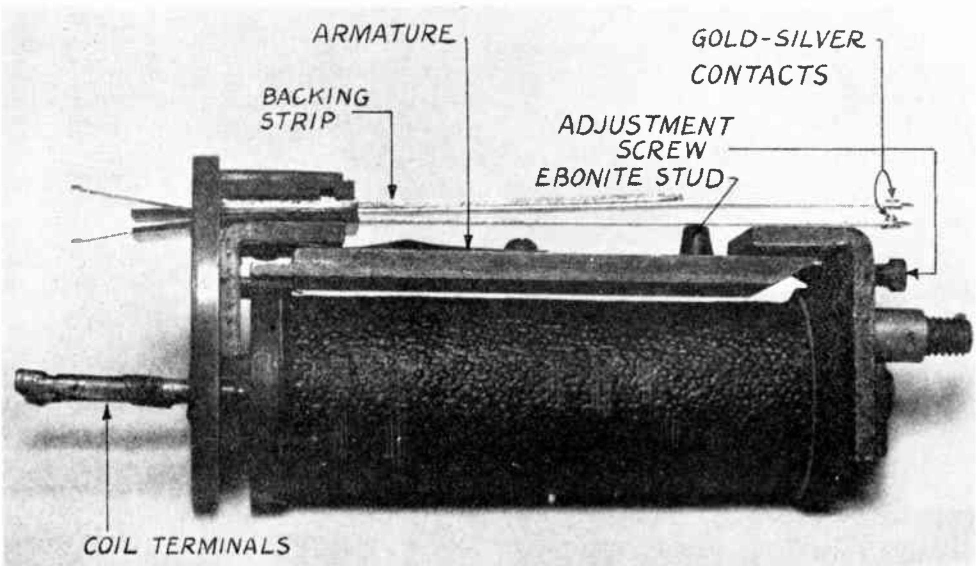

Fig. 1.—A Western-Electric Type of Relay.
Adapted for use in remote control circuits shown in Figs. 9 and 11.

When an outdoor aerial is used it is always advisable to have the wireless set in the room which gives the most efficient lead-in and earth. The set is therefore confined to one room, while extension leads to the loud speakers in other parts of the building are necessary, and it is an advantage to be able to switch the set on and off from any loud speaker point.

How Remote Control is Effected.

Remote control is effected by the use of electro-magnetic relays which enable the necessary circuits to be completed or broken at will, from each loud speaker point. It would be a comparatively simple matter to run two extension leads from the "on" and "off" switch of the set, but this necessitates carrying the total working current of the set around the house, which is very undesirable.

How a Relay Works.

An electro-magnetic relay consists essentially of an electro-magnet having an armature which actuates one or more pairs of contacts when a current is passed through its coil. The source of current for the operation of the relay may be the same as that which supplies the main circuit or it may be independent. Fig. 1 shows a Western-Electric relay with one pair of contacts. (This type of relay may be adapted for two or three pairs of contacts when the circuit conditions require it.) When a current is passed through the coil the armature is attracted towards the L-shaped yoke, and the ebonite stud, which is fixed on the armature, raises the lower contact and closes the circuit between the contacts. A brass or nickel pip is riveted in the air gap part of the armature to prevent actual contact between the armature and the yoke. If this is not done, the armature would stick to the yoke after the current in the coil ceased. If it is desired to break a circuit by the operation of a relay, the ebonite stud of the armature passes through a hole in the lower contact and operates the upper one. This is illustrated by the Siemens relay in Fig. 2.

Power to Operate.

The power required to operate a relay depends on the design, and also the number of contacts which have to be operated. A relay may work on 4 volts 5 milliamperes without any contacts, but would require from 7 to 10 milliamperes with one pair of contacts and from 12 to 15 milliamperes with two pairs of contacts. The resistance of the coil is therefore proportioned to give the necessary power for the required conditions. The resistance of a relay to work on

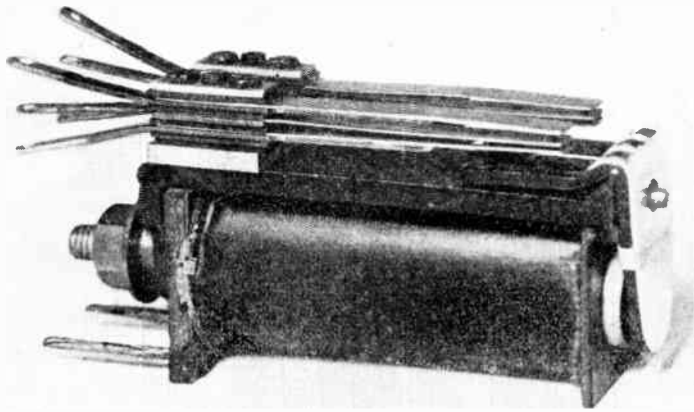

Fig. 2.—A SIEMENS TYPE OF RELAY.

With two sets of contacts suitable for the remote control of an eliminator and accumulator set. The relay may be conveniently mounted on an angle bracket by means of the nut shown. This relay may be adapted for single circuit switching by screwing one set of contacts in the middle of the contact base and removing the other set.

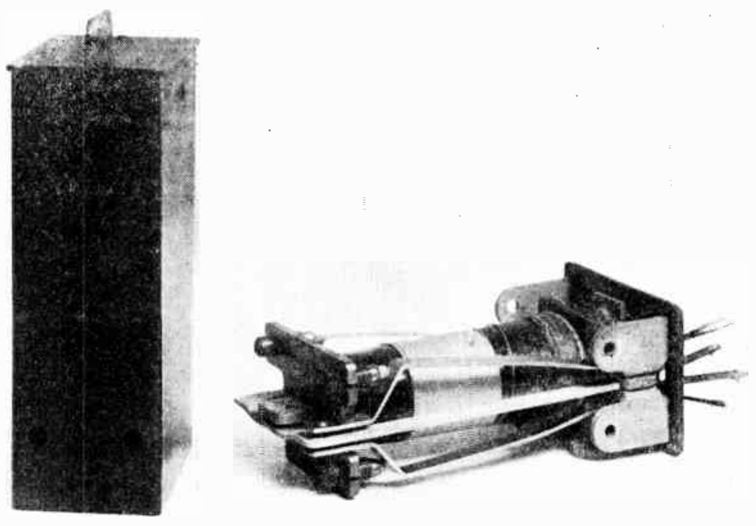

Fig. 3.—A SENSITIVE TYPE OF RELAY WITH COVER.

Suitable for the remote control of all-battery set only, as the armature forms part of the electrical circuit. The armature itself forms the movable blade which is attached to the yoke of the magnet by thin flat steel springs to give the required flexibility. Three adjusting screws are provided.

4 volts will therefore lie between 250 and 400 ohms, and the power required to hold the relay closed will be .04 to .06 watt. The addition of a relay to a three-valve battery set will therefore make only an extra 5 per cent. demand on the low tension battery at the most.

Types of Relays.

Three types of relays suitable for the remote control of wireless sets are shown in Figs. 1, 2 and 3. They are all of efficient design and are used chiefly for telephone exchange apparatus where reliability is essential. The type shown in Fig. 1 has the advantage that the sensitiveness can be adjusted very easily by means of a pointed screw which regulates the length of the air gap when the armature is at rest. This screw must be non-magnetic.

The relay shown in Fig. 2 may be adapted for single circuit switching by screwing one set of contacts in the middle of the contact base and removing the other set. This relay has an L-shaped armature pivoted on a knife-edge which is formed at the end of the yoke. A small brass stud projecting through the armature prevents the armature becoming dislodged from its knife-edge. This type has the advantage that the armature is balanced and there is no power expended in lifting the dead weight of the armature.

Fig. 3 shows an American type of relay which is suitable for switching one circuit only. The armature itself forms the movable blade which is attached to the yoke of the magnet by thin flat steel springs to give the required flexibility. Three adjusting screws are provided. The two adjusting screws which bear on the contacts have hard-wood ends so as to insulate them from the frame. The lower screw regulates the distance of the armature from the pole piece and the upper one gives the best spacing for the contacts. The spring on the opposite side to the contacts balances the pull on the armature. This type of relay is very sensitive owing to the lightness of the armature, but has the disadvantage that the frame and case is live because the armature forms part of the electrical circuit.

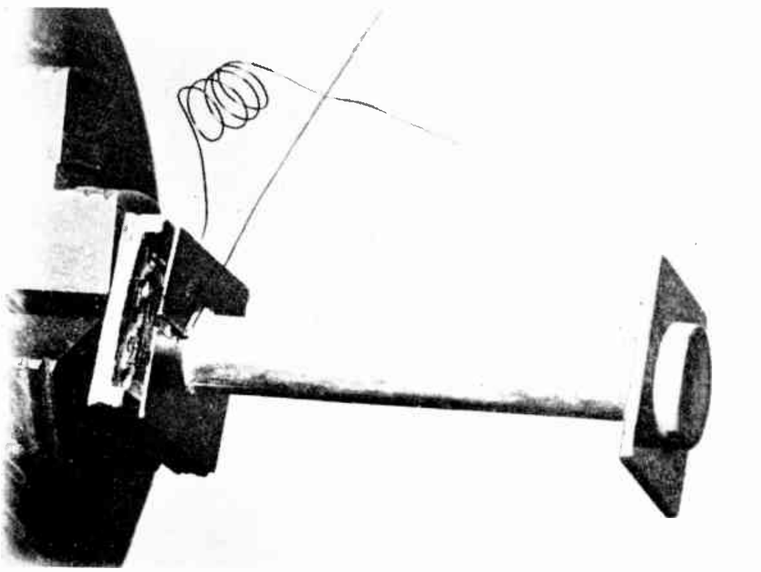

Fig. 4.—MAKING YOUR OWN RELAY.

Notice that the core is insulated with waxed paper ready to receive the winding.

WINDING A RELAY BOBBIN.

Size of Wire.

Although the correct gauge of wire for a relay coil may be arrived at by calculation it is best determined experimentally. The resistance of the bobbin, when wound, may be determined by multiplying the winding volume by the ohms per cubic inch for the size of wire to be used. As an example, consider the relay bobbin shown

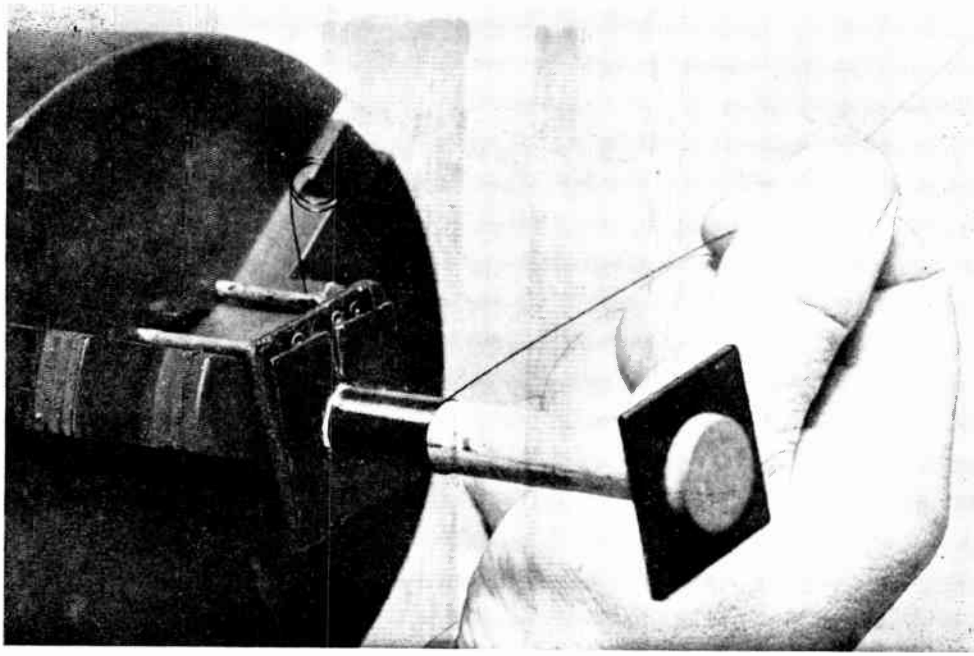

Fig. 5.—MAKING YOUR OWN RELAY—SECOND STAGE.

Winding the first layer of wire.

in Fig. 4. The diameter of the core when insulated is $\frac{3}{8}$ in. and the outside diameter of the coil, allowing for inter-layer insulation, is $\frac{7}{8}$ in. The length of the winding between the cheeks is $2\frac{3}{8}$ in.

∴ Volume of winding

$$= 3\tfrac{1}{7}\left(\frac{(\frac{7}{8})^2}{4} - \frac{(\frac{3}{8})^2}{4}\right) \times 2\tfrac{3}{8} \text{ cu. in.}$$

$$= 3\tfrac{1}{7} \times 2\tfrac{3}{8}\ \frac{(\frac{7}{8}+\frac{3}{8})(\frac{7}{8}-\frac{3}{8})}{4} \text{ cu. in.}$$

$$= 3\tfrac{1}{7} \times 2\tfrac{3}{8} \times 1\tfrac{1}{4} \times \tfrac{1}{2} \times \tfrac{1}{4} \text{ cu. in.}$$

$$= 1.17 \text{ cu. in.}$$

This figure, owing to irregularities in the winding, will be high so that one cubic inch of winding may be counted on. Thus the above coil wound with 37 S.W.G. enamel-covered wire would have a resistance of about 300 ohms and with 36 S.W.G. enamel-covered wire would give 200 ohms.

Enamel-covered wire gives the most efficient electro-magnet because more turns can be accommodated for a given resistance.

Insulating the Core.

The Swedish iron core of the magnet is insulated with waxed paper or empire cloth before the wire is put on. This should be cut just a fraction longer than the winding space so that there is no possibility of the end turns touching the core. Fig. 4 shows the bobbin, with waxed paper on the core, ready for winding.

Starting the Winding.

Unless the ends of the winding are to be connected to tags fixed on one of the end-cheeks, it is necessary to terminate the coil with short pieces of flexible wire. These are made by starting the winding with four strands of the same wire which are covered with cotton braiding. This short flexible lead is soldered to the start of the wire and the joint covered with a small piece of empire tape. The winding is finished off in the same way. Fig. 5 shows the provision made for protecting the winding from the connections. The cheek of the bobbin is channelled out on the connecting tag side and a thin bakelite spacer is placed over it. This has a slot to enable the start of the winding to pass through to the hollow connecting tag, as shown in Fig. 5. When two or three layers have been wound, the bakelite spacer is squared up to register with the bobbin cheek.

Inter-layer Insulation.

When the bobbin is wound with silk-covered wire, no inter-layer insulation need be used if care is taken to maintain the winding even. Enamel-covered wire requires thin paper insulation about every five layers for heavier gauges such as 36 S.W.G. and every other layer for 40 S.W.G. Coils wound with wire finer than 40 S.W.G. should have paper between each layer.

The object of using paper in winding fine wire coils is not only to insulate adjacent layers, but to prevent the end turns from slipping down the ends of the winding and making contact with turns at a considerably different potential. The use of paper also keeps the main part of the winding even and allows the wire to expand and contract freely with changes in temperature due to the passage of a current through the coil.

The paper is cut about $\frac{3}{32}$ in. longer than the winding space and the edges serrated each end so that the paper takes up the form shown in Fig. 6.

Finishing the Coil.

When the correct amount of wire has been put on, the end of the winding is tied with silk thread to prevent the winding becoming loose. The coil is then wrapped with a layer of empire cloth, as shown in Fig. 7. The coil is finally covered with linen-faced black paper, which should be stuck with an insulating varnish, and not water paste. The coil is now removed from the winding chuck, the ends cleaned and soldered to their tags or terminals.

RELAY CIRCUITS.

All-Battery Set.

Fig. 9 shows the connections for the remote switching of a wireless set with batteries for both high and low tension. This circuit shows how the housing wiring may be done with three wires if a choke-feed output is used for the loud speaker. One end of the relay coil is connected to low tension battery positive, and the other end is connected to negative in series with a pair of contacts on the loud speaker jack, which are closed when the plug is inserted. Thus the set is switched on by simply plugging the loud speaker into a remote jack. The contacts of the relay are connected in series with the positive supply of the low tension to the set. The high tension battery is permanently connected to the set, as no current flows when the valves are cold.

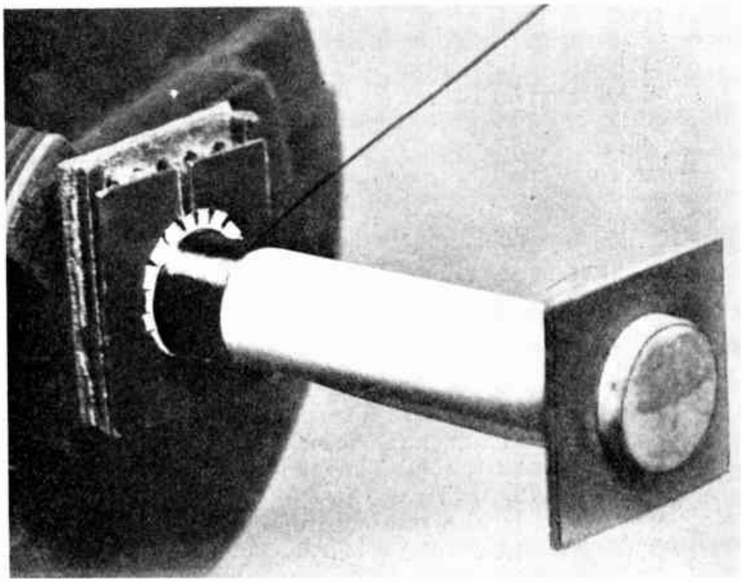

Fig. 6.—MAKING YOUR OWN RELAY—THIRD STAGE.

You will see that paper insulation is used between the layers to separate the winding and is spread over at the ends to prevent the ends becoming untidy. The paper should not be stuck.

House Wiring.

As the wiring carries very little current, ordinary bell wire is amply heavy enough for the house wiring. If the wiring does not exceed twelve yards, triple bell wire may be used. When the total length of the house wiring exceeds this figure, it is better to run three single wires spaced apart so as to minimise the capacity across the loud speaker.

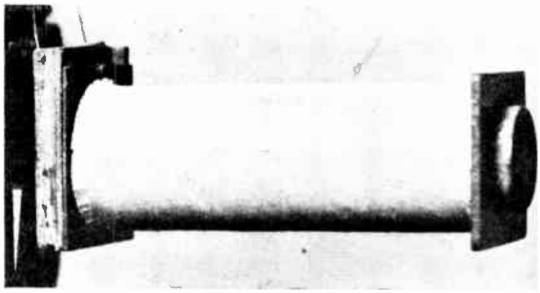

Fig. 7.—THE FINISHED WINDING COVERED WITH EMPIRE CLOTH.

Control of H.T. Eliminator.

Where the source of high tension is drawn from an eliminator while the low tension supply is a battery, two pairs of contacts are necessary on the relay: one pair to switch the low tension, and the second pair to make and break the supply mains to the eliminator. The circuit for this type of set is shown in Fig. 10. This shows the use of remote switches to control the relay, but, as with the all-battery set, jacks may be used instead if desired. It will be seen that no part of the mains has any connection with the house wiring to the remote switches, so that, provided the insulation of the relay is good, there is no fear of shock from this part of the system.

Safeguarding Condensers.

When an eliminator is used with a separate low tension battery, it is always safer to switch the low tension on first and off last, so as not to strain the condensers in the eliminator. The use of a relay in this type of set prevents the high tension from being switched on first or switched off last because the contacts operate simultaneously. When both circuits are made simultaneously the valve filaments heat up before the eliminator condensers can be fully charged up, and when both circuits are broken together the eliminator condensers discharge before the valves have time to become cold. The need for safeguarding the condensers of an eliminator in this way is more important with A.C. than with D.C., because a 100-volt A.C. supply has a peak voltage of 141 volts.

Control of D.C. All-Mains Sets.

The circuit for the remote control of D.C. all-mains receiver is shown in Fig. 11. Although the mains could be used to operate the relay by having a coil wound to suit the supply voltage, it necessitates better house wiring than when a small local battery is used as shown. The double-pole, double-throw switch provides a means of charging the accumulator without any trouble. When the switch is "up" the mains have no connection with the relay circuit. When the switch is "down" the battery is put in series with the supply to the set, so that it is charged while the set is in use. If the switch is connected in the earthed side of the main there is no danger of shock from the house wiring. Where it is found that the accumulator distracts from the efficiency of the receiver when on charge, owing to the small decrease in voltage applied to the set, the accumulator must be charged independently.

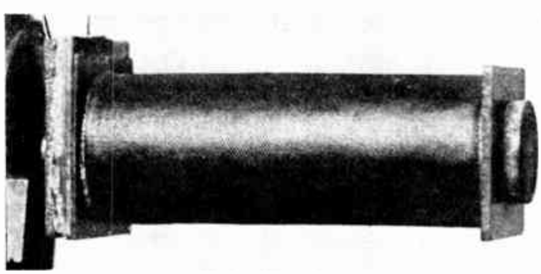

Fig. 8.—THE FINISHED COIL COVERED WITH LINEN-FACED BLACK PAPER.

A.C. All-Mains Set.

The three preceding types of wireless sets all give a ready method of obtaining a low voltage source of direct current supply for the operation of the relay. An A.C. mains set, to be self - contained, must dispense with the accumulator. The relay is therefore operated by alternating current, which is supplied by a small step-down transformer such as is used for working bells. The relay must be specially wound for an A.C. supply and the iron circuit must be laminated. The circuit is shown in Fig. 12.

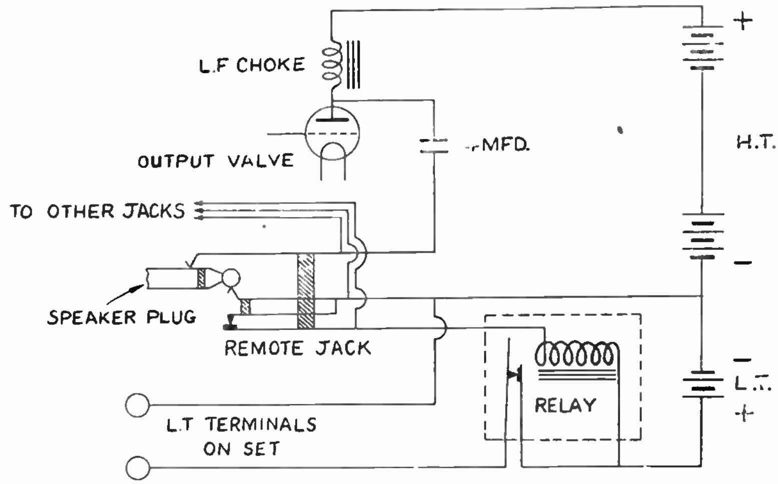

Fig. 9.—The Circuit for the Remote Control of an All-Battery Set.

Showing the use of a jack and plug to operate the relay. To switch on the set it is only necessary to insert the loud speaker plug into a remote jack.

Other Uses of Relays in Wireless.

The foregoing uses of relays indicate their simplest applications to wireless receivers. Further refinements may be achieved by arranging relays to switch the tuning circuits from remote points, which, of course, means more house wiring. By arranging, say, 5 relays to short-circuit different portions of the tuning circuit it is possible to obtain a selection of 5 programmes. Another refinement may be added by arranging the relay to short-circuit the aerial and earth when the set is off. This is done by using a relay of the type shown

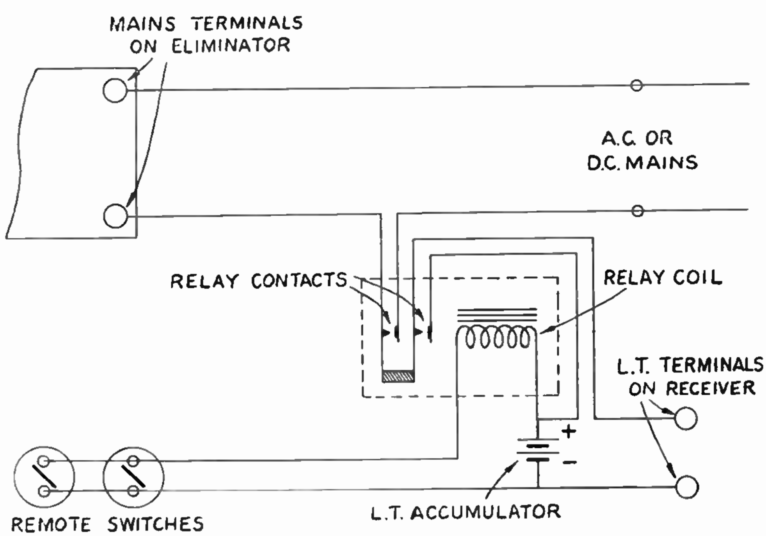

Fig. 10.—The Circuit for the Remote Control of a Wireless Receiver using a High Tension Eliminator and a Low Tension Accumulator.

A double-contact relay is necessary for this.

This article on Remote Control of Wireless is continued in Part 3, published October 30th. Order your copy to-day.

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