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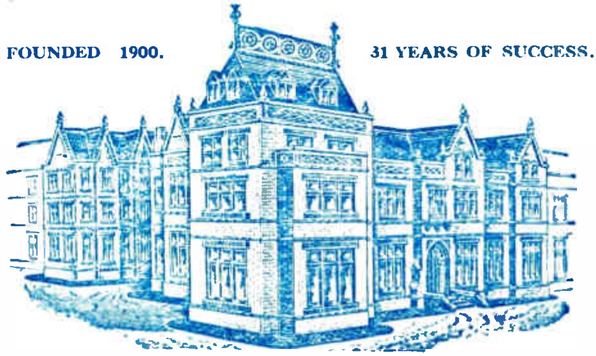

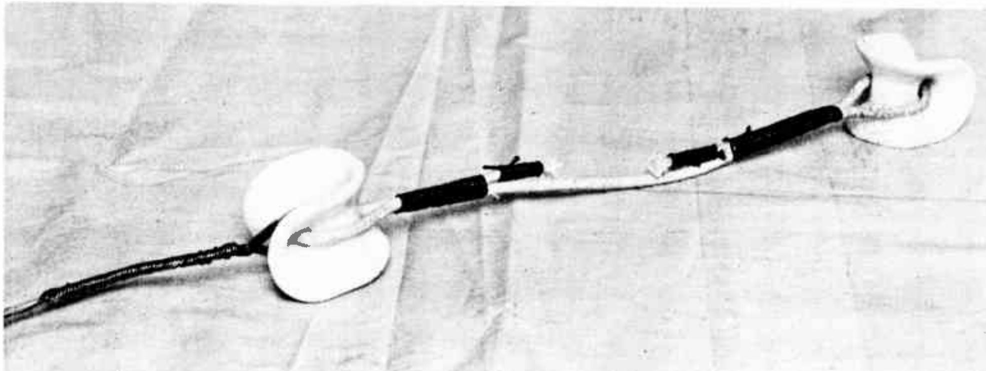

Fig. 11.—How the Insulators should be Linked up.
At least three insulators should be used at each end of the aerial, and they should be placed about one foot apart. The method of joining the rope to the insulators is shown in Fig. 1.

A very highly satisfactory earth clip is one that can be adjusted round the pipe, tightly, by the action of screwing two clips together, which successfully binds the copper tape to the waterpipe.

Outside Earth.

If it is not possible to find a main waterpipe close by the receiver, and the receiver is close to a window, the earth lead may be taken out through the window and a long tube driven into the ground. A very satisfactory form of tube for this earth is about 6 feet of ½-inch galvanised iron piping. This can be driven well down into the ground and an earthing clip, similar to that used for the waterpipe, fitted to the top. The short earth tubes that one often sees on the market, while being satisfactory if the ground is moist, are no use in dry weather.

Whenever an earth tube is used it should be well watered in dry weather, particularly if the earth tube is at the side of the building, but when using a galvanised tube about 6 feet long little trouble will be experienced. Remember, the shorter the earth lead, the higher the selectivity of the receiver, and the more efficient it will be.

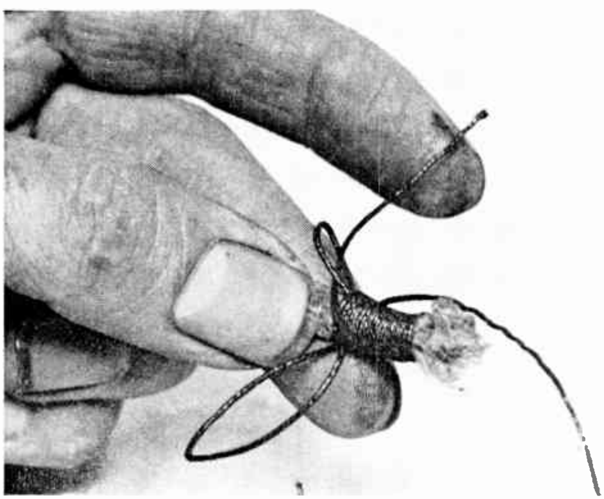

Fig. 12.—Whipping the Ends of the Rope.
About half-an-inch of the end of the rope should be tightly wrapped round with twine in the manner shown.

Indoor Aerials.

We will now deal with the question of indoor aerials. If the receiver is of modern design with the H.F. amplification then it is not always necessary to use an outside aerial. If, however, an indoor aerial is used where there is only the ordinary detector and L.F. amplification, it cannot be expected to do more than give the local stations, and that only if the stations are within reasonable distance.

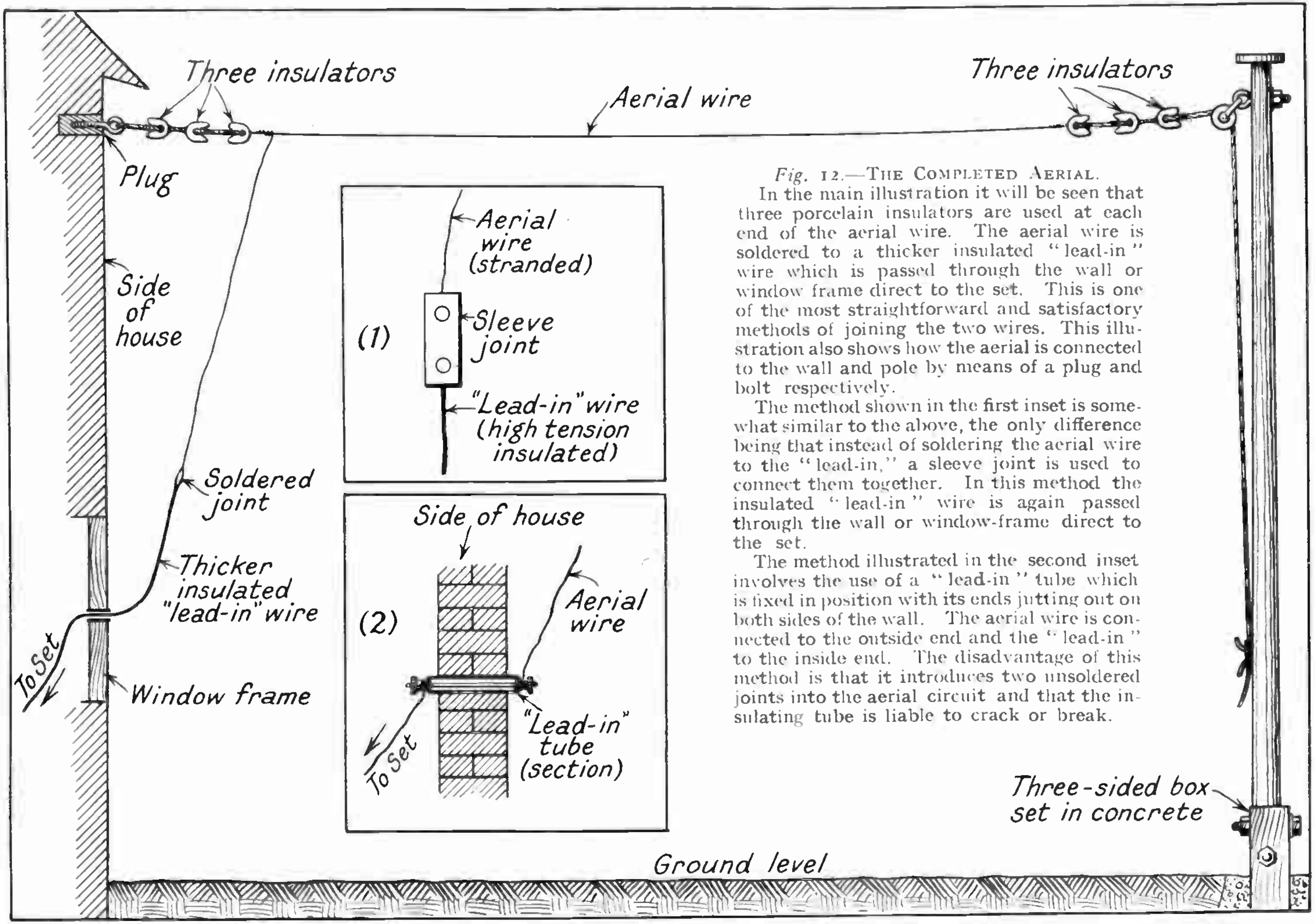

Fig. 12.—The Completed Aerial.

In the main illustration it will be seen that three porcelain insulators are used at each end of the aerial wire. The aerial wire is soldered to a thicker insulated "lead-in" wire which is passed through the wall or window frame direct to the set. This is one of the most straightforward and satisfactory methods of joining the two wires. This illustration also shows how the aerial is connected to the wall and pole by means of a plug and bolt respectively.

The method shown in the first inset is somewhat similar to the above, the only difference being that instead of soldering the aerial wire to the "lead-in," a sleeve joint is used to connect them together. In this method the insulated "lead-in" wire is again passed through the wall or window-frame direct to the set.

The method illustrated in the second inset involves the use of a "lead-in" tube which is fixed in position with its ends jutting out on both sides of the wall. The aerial wire is connected to the outside end and the "lead-in" to the inside end. The disadvantage of this method is that it introduces two unsoldered joints into the aerial circuit and that the insulating tube is liable to crack or break.

Fixing an Aerial in the Loft.

The most useful form of indoor aerial is that which is slung in a loft and can be fitted in a similar way to the outdoor aerial between the insulators fixed to the rafters, but do not be misguided and fix an aerial in the loft and then use many yards of wire to bring it down to the receiver.

This will not only lower the efficiency of the aerial but will also be useless for selectivity. It is far better, if you cannot obtain a short lead to the loft, to use a length of wire fixed round the picture rail about 6 inches away. This wire need not be thick but can be of a fine copper wire such as black enamelled insulated, about 20 gauge. This would not be objectionable and would be scarcely noticeable to the eye. There are various forms of insulators which could be attached to the rail.

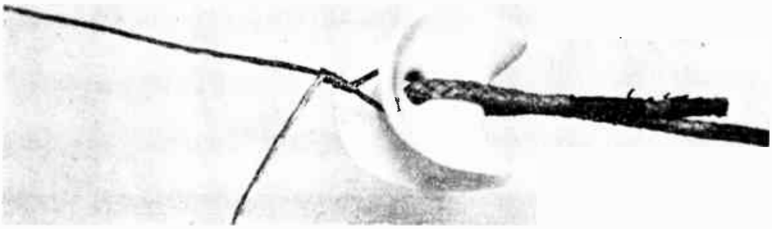

Fig. 13.—Joining the Wire to the Insulators.
Pass the aerial wire through the last insulator and twist over to about three inches.

Look for Broken Strands.

Again, sometimes when the aerial wire is stranded one strand becomes broken, and in swaying continually makes and breaks contact. One broken strand can give a lot of trouble, so it is therefore advisable to replace the aerial with new wires.

Similarly, the earth connections need attention occasionally and the clip removed, the pipe cleaned and new connections made.

Frame aerials and other special types will be dealt with in a later article, which also touches on the theoretical aspects.

Faults due to Aerials.

Crackling noises in the receiver or alterations in tuning are always the fault of the aerial, and sometimes the lead-in wire has become broken, particularly in the insulated portion. This would not be observed unless the wire was pulled in such a manner as to locate the break. Again, occasionally the aerial should be lowered and the insulators cleaned.

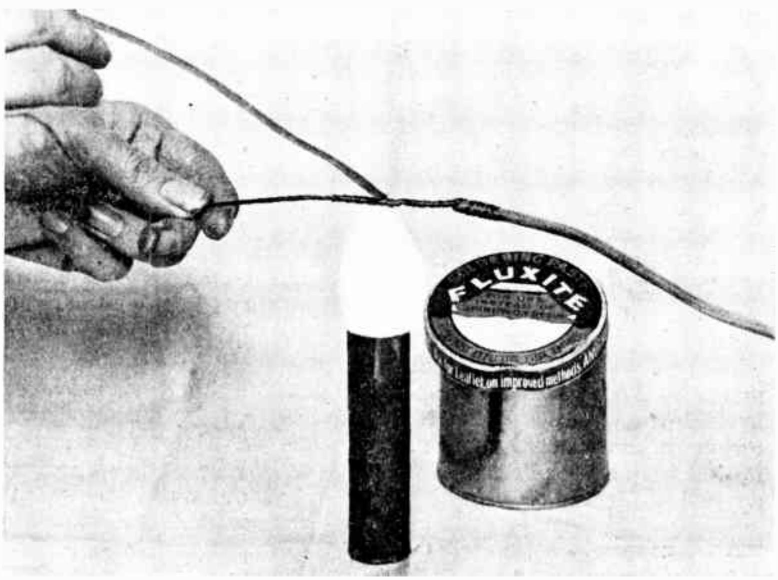

Fig. 14.—Soldering a Lead-in Wire.
Both ends of the wire should be cleaned with emery cloth, the wires twisted together, and soldered with a spirit lamp or blow lamp. Instructions for making the simple spirit lamp shown above are given on page 200.

SMALL POWER TRANSFORMERS

AND HOW TO MAKE THEM

By H. E. J. BUTLER.

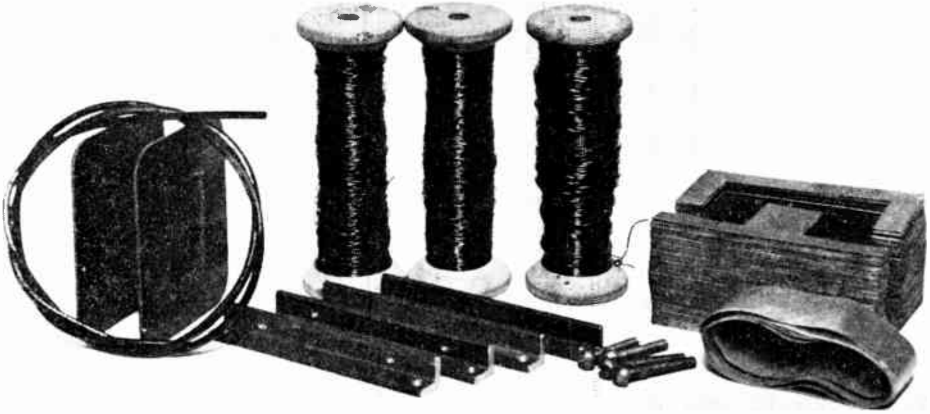

Fig. 1.—THE ESSENTIAL COMPONENTS USED FOR THE CONSTRUCTION OF THE TRANSFORMER FOR A HIGH TENSION ELIMINATOR.

The Essentials of a Transformer.

A TRANSFORMER consists essentially of a primary winding, and a secondary or output winding wound on an iron core which forms part of a closed magnetic circuit. The primary winding is connected to the supply mains and the secondary or output winding to the apparatus for which it is designed.

Power is transmitted from the primary winding to the secondary winding whenever a current is drawn from the secondary. When there is no current in the secondary winding, the power taken from the supply mains by the primary winding is negligible in small transformers. Therefore a transformer primary may be permanently connected to the supply mains without any appreciable power consumption.

THE USES OF SMALL TRANSFORMERS.

Transformers are used to convert the voltage of an alternating current supply to any desired value. Thus a supply of 200 volts may be stepped up to 1,000 volts or reduced to 2 volts, without any appreciable loss of power. Static transformers, as they are called, can be used only on alternating current, the output is also alternating and requires rectifying if it is to be used for charging accumulators, for operating electro-magnets or for supplying high tension to wireless sets. A transformer isolates the supply mains from the secondary circuit, because the primary and secondary windings are electrically insulated from one another.

Bells and Alarms.

Small electric bells may be worked on alternating current equally as well as on a direct current supply from batteries. Where the house supply is alternating the wet batteries may be replaced by a small transformer, thus saving the trouble and expense of reconditioning the batteries at regular intervals, besides giving a more reliable service. Although small bells may be obtained for working directly off the supply mains, the use of a transformer with a low voltage bell permits the existing wiring to the pushes and indicators to be used. If battery-operated bells are replaced by mains-operated types, the wiring must be renewed. A big saving is effected by using a transformer in place of batteries on closed circuit fire and burglar alarms where a current flows continuously.

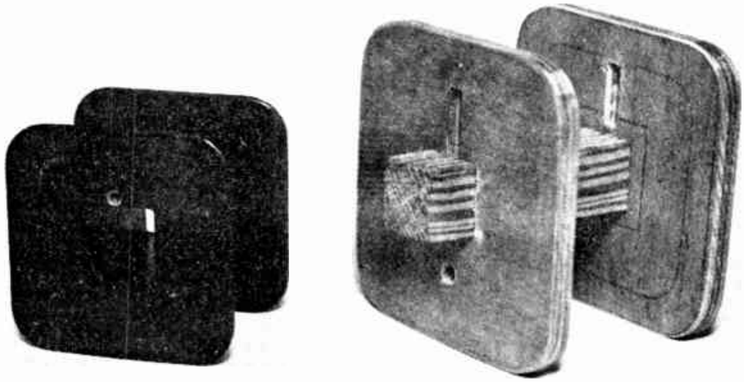

Fig. 2.—The Black Bakelite Bobbin of the Bell Transformer. Showing the wooden winding jig used to support the bobbin during winding. Note the hole in the bobbin for the start of the primary winding. The size of the holes in the bobbin cheeks should be such that the systoflex sleeving fits in them.

Bell and Alarm Circuits.

Fig. 16 shows the circuit of a bell installation using a transformer in place of batteries. When installing the transformer it is only necessary to remove the batteries and connect the secondary terminals of the transformer to the two wires formerly connected to the batteries and run two leads from the lighting circuit to the primary of the transformer. The application of a small transformer for working a closed circuit fire or burglar alarm system is shown in Fig. 17. A fuse is put in the primary circuit of the transformer in each case, as a safeguard, should the transformer break down. As the secondary winding has no electrical connection with the supply mains, there is no fear of shocks from any part of the system.

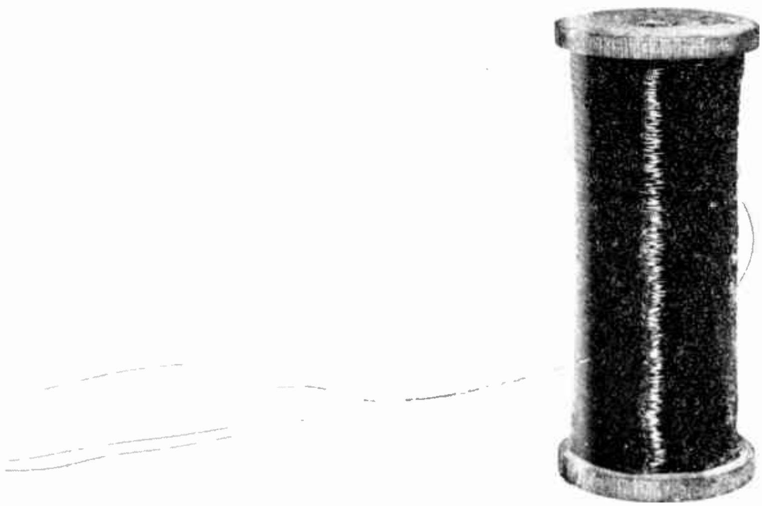

Fig. 3.—Preparing the Wire for Winding. Before the wire is started on the fine wire coils, a four-strand lead is formed on the end of the wire.

Toy Motors, Model Locomotives and D.C. Low Tension for Wireless.

Miniature electric motors with laminated field magnets may be run on alternating current as well as from batteries. Shunt

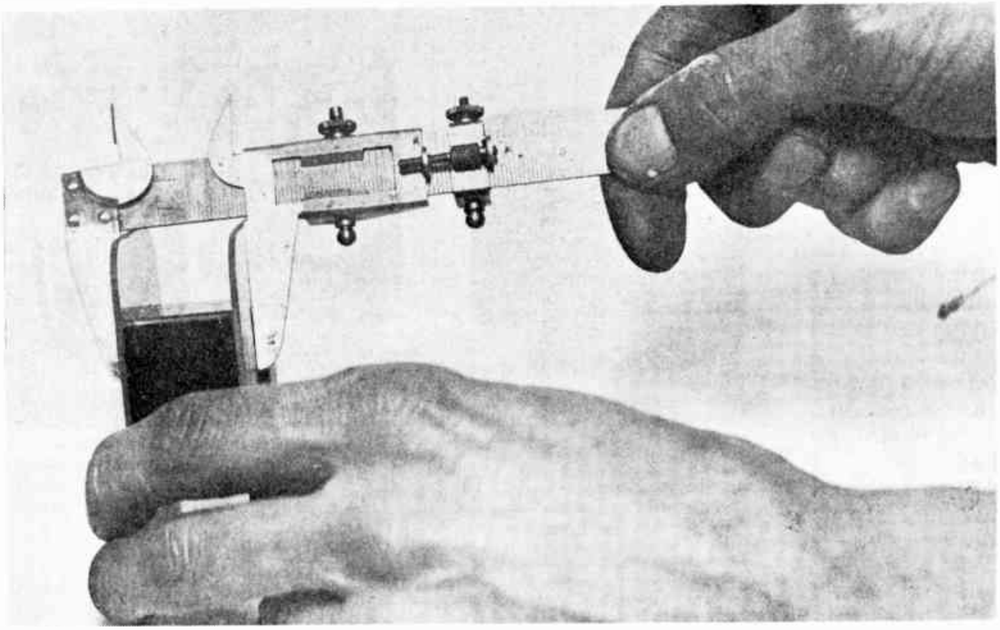

Fig. 4.—Testing the Bobbins for Size.

Before using the bobbins make sure that they are not oversize at any point. If the bobbins are too long the stampings will not close up properly.

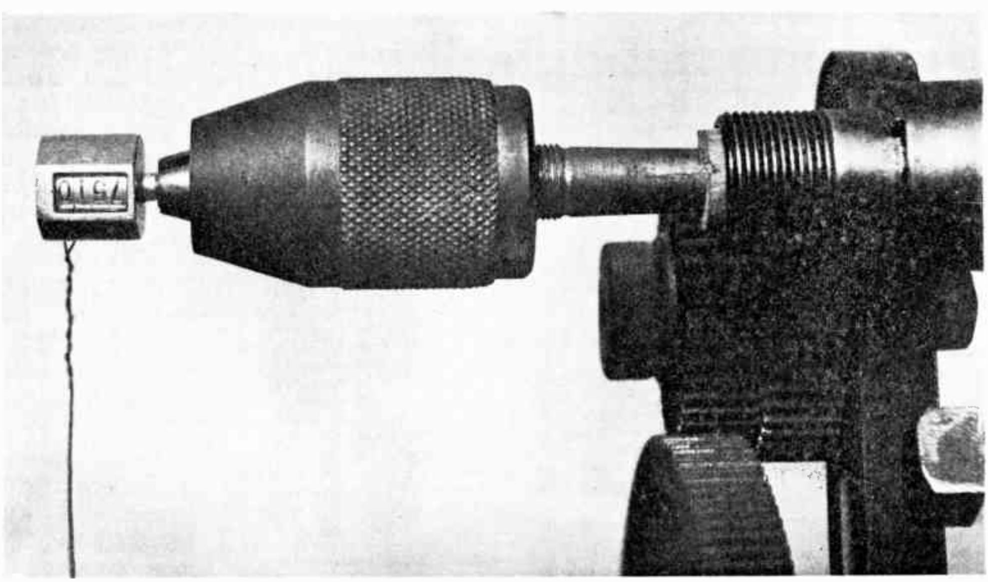

Fig. 5.—A Simple Method of Mounting a Counter on the Lathe.

This is to count the turns as they are wound on.

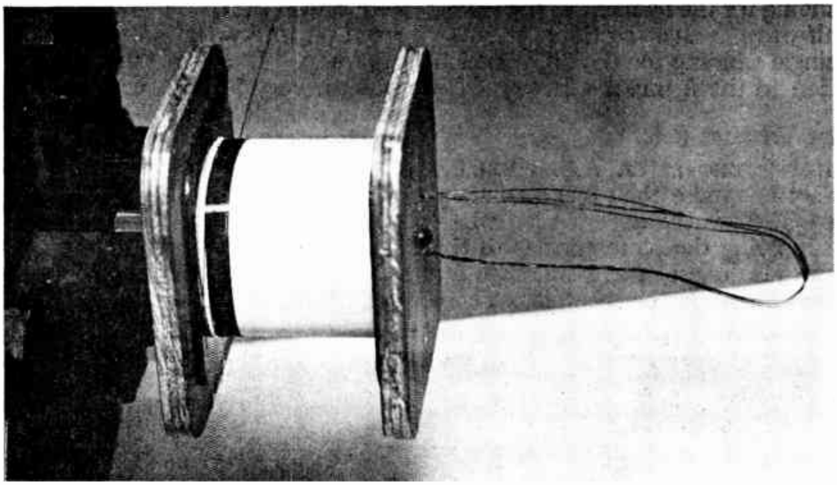

Fig. 6.—FINISHING OFF THE PRIMARY WINDING (1).
The last few turns of the primary winding frequently only partly fill a layer, but this does not matter. Note the use of a sheet of white paper underneath the bobbin to provide a contrast with the black wire and make it easy to follow.

wound motors, and motors with permanent magnet or solid iron fields cannot be run satisfactorily on alternating current. A rheostat may be used for regulating the speed in the same way as it is used when the motor is driven from batteries. Alternating current is not suitable for working model locomotives incorporating automatic reversing gear.

Motors which are suitable for direct current operation only may be worked from an alternating current supply by using a rectifier and smoothing devices which convert the alternating current into direct current. The circuit of a low tension battery eliminator is shown in Fig. 18. This is suitable for operating small motors and electric locomotives as well as supplying current for battery heated valves of wireless sets. The meter shown in the diagram is not essential for working toy motors, although its use will show when the rectifier is over-loaded. For operating valves a meter is essential to set the rheostat so as to obtain the correct working current for the filaments.

Accumulator Charging.

Fig. 19 shows a circuit for charging accumulators from alternating current mains. It incorporates a transformer giving an output of 14 volts 2-3 amps., the construction of which is described here. For a 2-ampere output a Westinghouse metal rectifier style A4 is used. The rheostat is about 10 ohms maximum resistance and the ammeter is a moving coil type. This arrangement will charge four cells in series, that is, an 8-volt battery. A fuse and a switch is included in the primary circuit of the transformer. Although a fuse may also be put in the charging circuit, it is not essential because any extra current which flows in the secondary circuit causes a proportional increase in the flow of primary current.

High Tension Supply for Wireless.

A transformer is used in high tension eliminators for working on A.C. mains. By this means any desired high tension voltage may be obtained from any voltage of supply, whereas the output voltage of a D.C. eliminator is limited to that of the supply. The character of the secondary winding on the transformer depends on which type of rectifier is used. A metal rectifier requires only one secondary winding of approximately the same voltage as the D.C. output for both full-wave and for half-wave rectification. On the other hand, a valve rectifier requires a double voltage centre-tapped secondary winding for full-wave rectification and also an extra winding for the filament of the valve. The half-wave valve rectifier requires only a single winding for the high tension in addition to the filament winding.

All-Mains Wireless Sets.

The transformer in an A.C. all-mains wireless set has more than one secondary winding. There is the high tension winding for supplying the plate current to the valves and also one or more windings for the valve filaments or heaters. There may also be a separate winding for supplying the grid bias voltages, but it is more usual to obtain the grid bias from the voltage drop on resistance inserted in the negative high tension leads.

Small Lamps.

Miniature electric lamps for decorative purposes may be worked from the mains by using a small transformer. The lamps are connected in series and the voltage of the transformer secondary is designed to give the voltage of one lamp multiplied by the total number in series. That is to say, if eight 3.5 volt .15 amp. bulbs are connected in series the transformer is required to give an output of 28 volts at .15 amp. A small transformer is used when a very low power lamp is required, because high voltage lamps cannot be made below about 15 watts for 100-volt supplies and 25 watts for 200 volts.

HOW TO MAKE A SMALL TRANSFORMER.

The smallest of three useful transformers described here is dealt with in detail to show how a transformer can be made when the necessary data is available. The principles of construction of all small transformers is the same, but they differ in such details as the size of stampings, number of turns and arrangement of windings. Where there are several secondary windings and the size of the stampings permits, the different windings are divided into two or more sections on separate bobbins so as to obtain the best linkage between the windings.

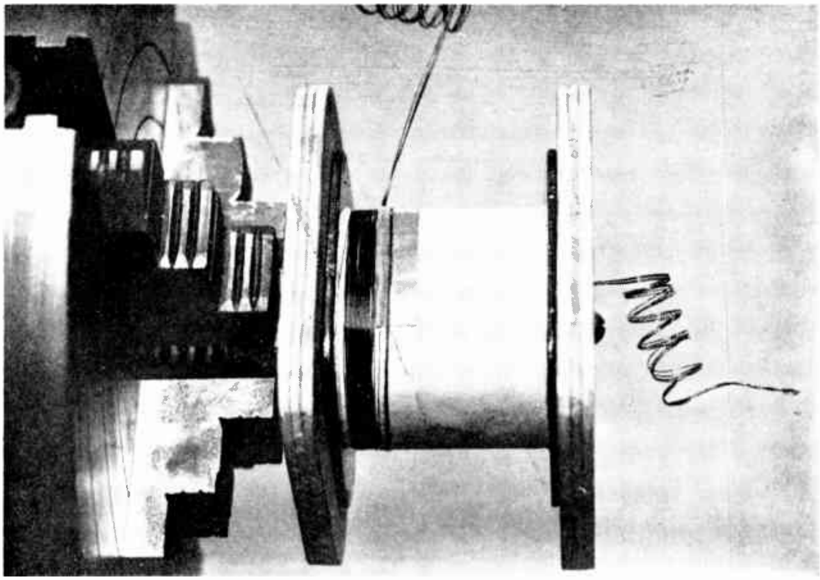

Fig. 7.—FINISHING OFF THE PRIMARY WINDING (2).
This is done with a four-strand lead. Note how the empire cloth, which is used to cover the soldered joint, is tied down with silk thread.

Material for Bell Transformers.

The materials for small transformers are

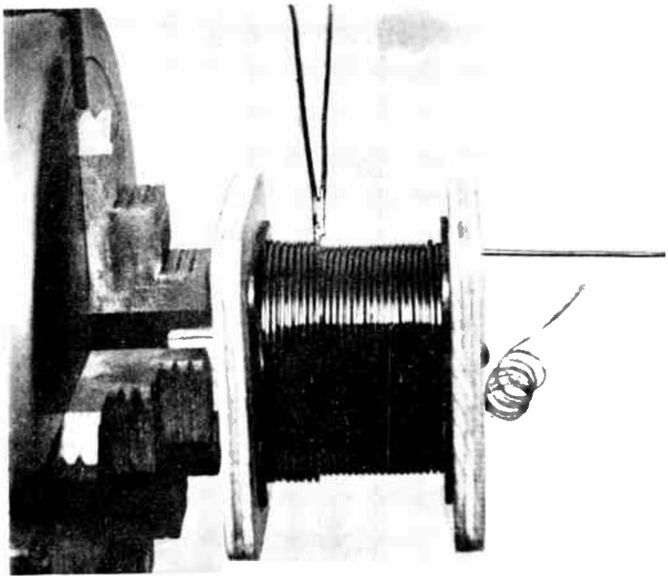

Fig. 8.—Making a Tapping on the Secondary Winding of the Bell Transformer.

This is done by soldering a lead on to the wire without cutting the winding.

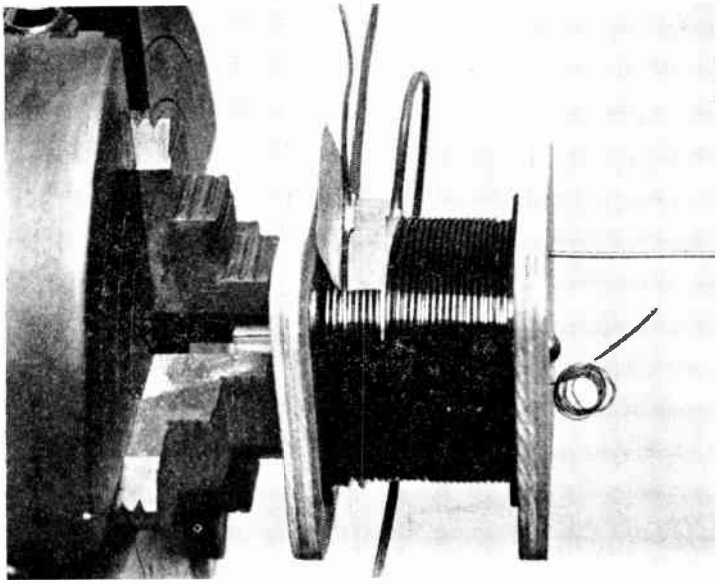

Fig. 9.—How the Joint of the Second Tapping is Insulated with Empire Cloth.

Note how the first tapping has been wound in.

obtainable in several standard sizes. The different sizes of stampings and bobbins are known by numbers, but as different manufacturers use different notation for the same thing, the actual sizes are given in the schedules. For the smallest transformer, with an output of 4-6 or 8 volts at 1 ampere, the following material is used :—

40 pairs of No. 15 "Stalloy" stampings, .014 inch thick (window $1\frac{1}{2} \times \frac{3}{4}$ inch, middle limb $\frac{5}{8}$ inch wide).

1 bakelite bobbin No. 15 with $\frac{5}{8}$ inch square hole.

8 oz. of 20 S.W.G. enamel covered copper wire for secondary.

6 oz. of enamel covered copper wire for primary, the size depending on the mains voltage (see table).

1 pair of cast clamps or 16 inches of $\frac{1}{2} \times \frac{1}{2}$ inch angle iron.

4 steel 2 B.A. screws 1 inch long for clamps.

Short lengths of .75 mm. systoflex, and empire cloth $1\frac{1}{2}$ inches wide.

6 terminals and ebonite or bakelite terminal block.

The Primary Winding.

The size of wire and the number of turns put on the primary winding depends on the voltage and frequency of the supply. The table on next page gives the necessary data for 50-cycle supplies

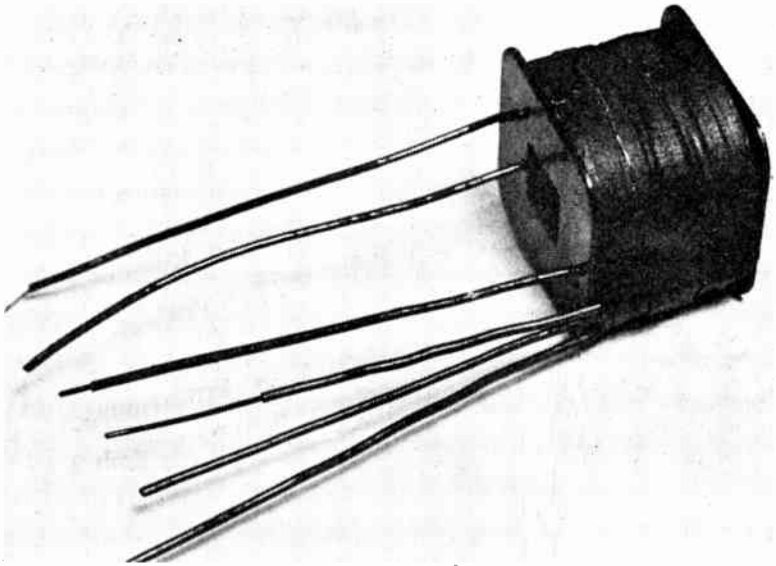

Fig. 10.—THE FINISHED BOBBIN.
Taped up with the leads covered with .75 mm. systoflex sleeving, ready to receive the stampings.

(the standard frequency), also the maximum primary current which it is necessary to know when a fuse is included in the primary circuit.

Supply Volts.	Max. Primary Current (Amps.).	No. of Turns.	S.W.G
100	.1	2,000	32
110	.091	2,200	33
120	.083	2,400	33
200	.050	4,000	36
210	.048	4,200	36
220	.045	4,400	36
230	.043	4,600	37
240	.042	4,800	37
250	.040	5,000	37

Where the voltage of the supply is different from any of the values given in the table, the number of turns may be estimated by multiplying the voltage by twenty. If the frequency is higher than 50, less turns are necessary. Thus, if the frequency is 100, half the number of turns are required, because the reactance is directly proportional to the frequency. For a lower frequency, such as 25 cycles, a larger iron core must be used or the number of turns becomes excessive with consequent high copper losses.

Winding Jig.

Before commencing the winding a wooden jig is made to support the bakelite bobbin. These bobbins are made necessarily very thin to accommodate the maximum amount of wire on a given core and they must be provided with some extra support during winding or the cheeks will bulge out and prevent the stampings from being properly assembled. The jig shown in Fig. 2 consists of a square piece of wood $\frac{5}{8}$ inch square and $2\frac{1}{2}$ inches long with two plywood cheeks $\frac{1}{4}$ inch thick. The cheeks of the jig may be larger than those of the bobbin so that the same jig may be used for other sizes of bobbins. One cheek of the jig is screwed to the wooden core and the other has a square hole made to fit tightly on the wooden core. The excess length of the core is utilised to hold the jig in a lathe chuck or other winding arrangement. The wooden cheeks are provided with slots and holes to enable the ends of the different windings to be brought out where necessary. When the winding has been made the removable cheek is taken off and the bakelite bobbin pushed into position and the cheek replaced and firmly pressed home. If the removable cheek is not a tight fit on the core, two screws are put in to hold the cheek firmly against the bobbin. Before winding the bobbin make sure that it is not oversize or the stampings will not close up properly, see Fig. 4.

Winding the Primary.

The primary winding is put on first,

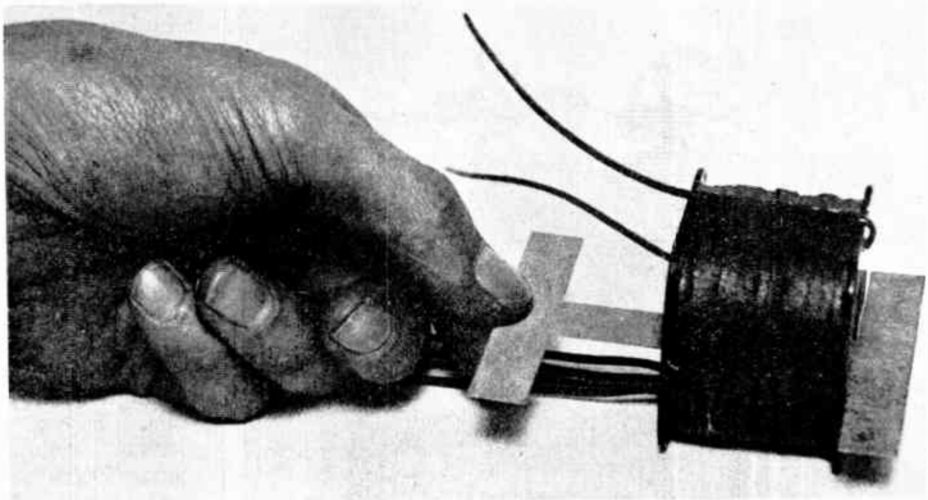

Fig. 11.—ASSEMBLING THE STAMPINGS. FIRST STAGE.
Take care to keep the paper-covered sides of the stampings all the same way up.

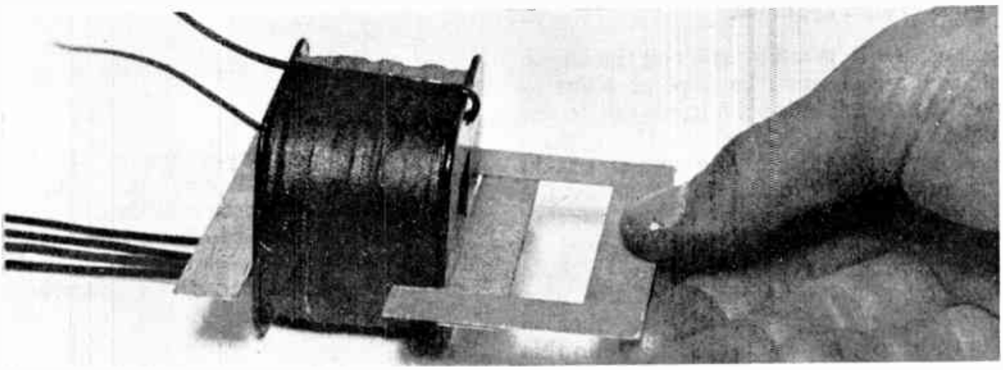

Fig 12.—ASSEMBLING THE STAMPINGS. SECOND STAGE.

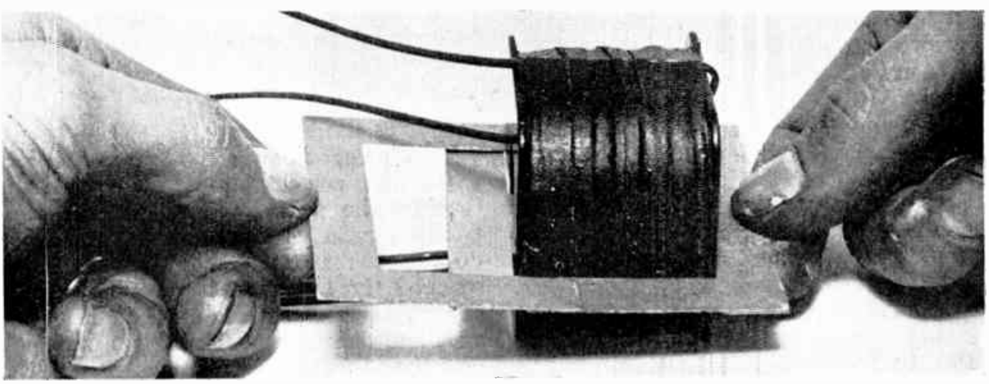

Fig. 13.—ASSEMBLING THE STAMPINGS. THIRD OPERATION.

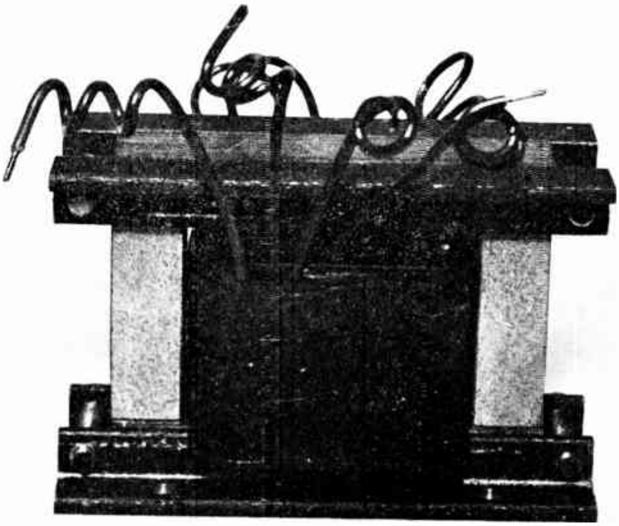

Fig. 14.—THE FINISHED TRANSFORMER PROVIDED WITH FLEXIBLE LEADS IN PLACE OF TERMINALS.
This method is adopted when the transformer is to be permanently wired to other apparatus.

because as it is a fine wire coil the length of the turns must be kept as short as possible to minimise the losses due to the higher resistance of the wire. The primary is also wound close to the core to obtain the maximum choking effect when the transformer is unloaded. Before starting the actual winding a flexible lead is formed on the end of the wire. This is done by doubling a length of the wire twice and soldering the ends together as shown in Fig. 3. It is essential to do this to provide a strong flexible lead which will not easily break off at the entrance to the hole in the cheek of the bobbin. The next step is to draw the flexible end of the wire through the hole in the bobbin shown in Fig. 2 so as to leave just less than one turn of the four-strand wire inside the bobbin. The soldered joint is then insulated with a small channel of empire cloth and the winding commenced.

Some difficulty may be experienced at first in keeping the turns even on the square core when the winding is done by hand, but after the first few layers and paper insulation have been put on, the winding becomes more rounded and easier to handle. Once the knack has been accomplished it will be found easier to keep the winding even if the bobbin is revolved at a good speed, although when the wire does run back there is more to unwind. It is essential to keep the turns side by side and to put thin ($1\frac{1}{2}$ mils) paper between each layer for high voltage coils. Pay particular attention to the ends of the layers. Much space is wasted if the paper is cut too long, and the end turns will slip down to preceding layers if the paper is cut too short.

Counting the Turns.

This is the most trying part of the job if a counter is not available. Fig. 5 shows how an improvised counting arrangement may be attached to the back end of a lathe headstock. A chuck is fixed in the hollow spindle and the countershaft is held in the chuck. A length of wire twisted round the counter base and fastened to the nearest fixed point is all that is required to prevent the counter from twisting round. A cyclometer may be used for this, if the ratio is determined beforehand, as these counters make several revolutions to each integer. It is very important to count the turns accurately.

Finishing the Primary.

It almost invariably happens that when the correct number of turns is reached the final layer of wire is only partly wound as shown in Fig. 6. This does not matter. When this stage is reached the last turn is unwound and a stranded lead is formed on the end of the wire and one turn of the lead is put back on the winding after insulating the soldered joint, as shown in Fig. 7. The finishing end of the primary is brought out through a hole in the cheek of the bobbin. The two ends of the primary are brought through the opposite cheeks, but on the same side of the coil. When the primary has been finished off two layers of empire cloth are put on to insulate it from the secondary, which is now wound on.

Winding the Secondary.

The secondary winding is started through a hole in the bobbin cheek, but there is no need to provide multistrand leads with this thick gauge. The total number of turns for 8 volts is 170. When 85 turns have been put on, a lead is soldered on as shown in Fig. 8. After insulating the joint the winding is carried on winding on either side of the lead. Fig. 9 shows the second tapping, at the 127th turn, being insulated. A piece of .75 mm. systoflex is put on the lead as far down as it will go and the joint is then lapped with empire cloth. This method of making the tappings on a winding of few thick turns is more economical of space than when each tapping is brought through the bobbin cheek.

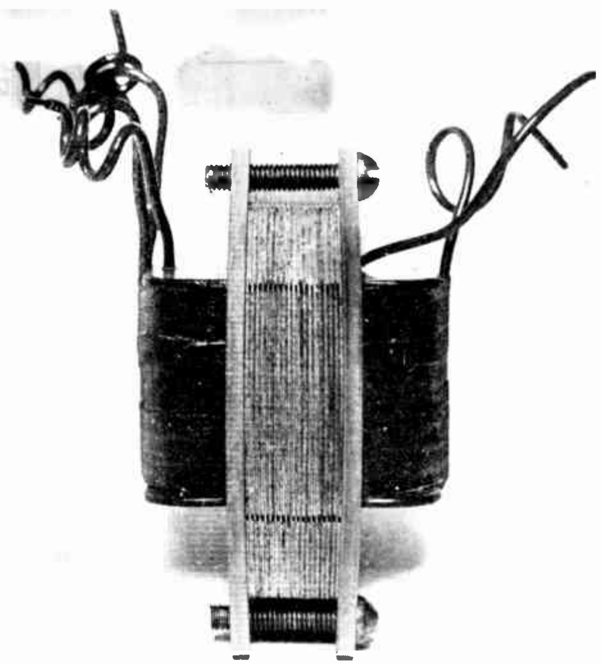

Fig. 15.—HOW NOT TO CLAMP THE STAMPINGS. The use of flat strips should be avoided. When tightened up the flat strips bend and produce an unsightly job. This illustration also shows the result of using a bobbin too big for the stampings or allowing the winding to spread the cheeks of the bobbin. The stampings do not close up properly.

Finishing the Coil.

After threading systoflex sleeving on the remaining leads, the secondary leads are bent back over the winding and the coil taped up with empire cloth or black tape as shown in Fig. 10. The bobbin is now ready to receive the stampings.

Assembling the Stampings.

Figs. 11, 12 and 13 show the order of assembling the stampings. Two of the T-shaped stampings are threaded through the core first, one from each side as shown in Fig. 12. A U-shaped stamping is laid on next from the opposite side to the second T-stamping and then a U-stamping from the other side (see Fig. 13). The process is then repeated until the bobbin is tightly packed with stampings. It will be noticed that one side of the stampings is covered with very thin paper, and it is important to keep the papered side the same way up throughout so that each stamping is insulated from the next. The purpose of laminating would be nullified if there were no insulation at all between the leaves. For most uses the black oxidised surface of the metal provides sufficient insulation between the laminations.

The object of laminating the iron core is to minimise the eddy currents which would otherwise be set up in the core by the rapidly alternating flux.

Clamps.

When the stampings have been assembled and carefully tapped square and level, a pair of clamps are screwed on to hold the stampings rigid. Fig. 14 shows the bell transformer finished off

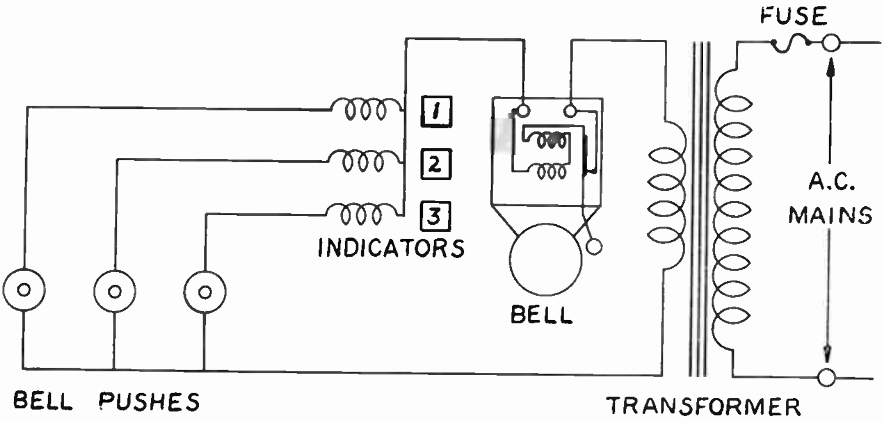

Fig. 16.—CIRCUIT DIAGRAM OF AN ELECTRIC BELL INSTALLATION.
Showing the use of a small power transformer to enable the system to be worked from the supply mains.

with clamps made from ½ × ½ inch angle-iron ⅛ inch thick. Nuts may be used instead of tapping a thread in the clamps. One pair of the clamps is provided with fixing holes and the terminal block, if required, is screwed to the top pair of clamps or fixed between the ends of the clamp

When the transformer is mounted with the longest side horizontal with angle clamps, as shown in Fig. 14, the limbs of the outside U-stampings are not clamped, so that about two-thirds of the length is cut off. Rectangular clamps, which clamp all four sides of the stampings, are preferable because they prevent the stampings from bulging and so producing an unsightly job.

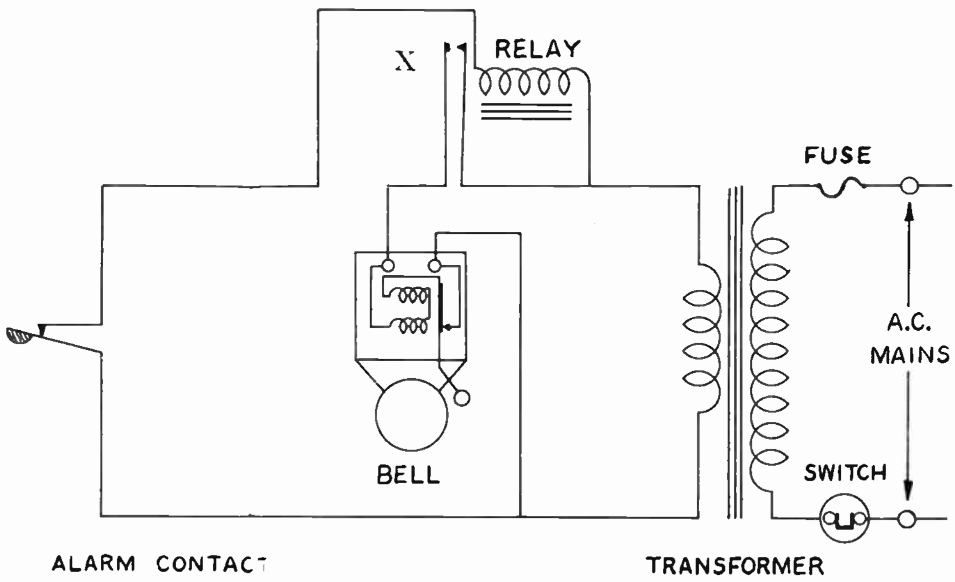

Fig 17.—WIRING DIAGRAM OF A CLOSED CIRCUIT FIRE OR BURGLAR ALARM SYSTEM.
A switch is provided in the primary circuit to prevent the bell ringing during the day time The relay, when energised, keeps the contacts X apart. When the alarm contact is broken the bell circuit is completed through X.

What to Avoid.

Do not use flat strips of metal to clamp the stampings. Fig. 15 shows the result of so doing. Although the strips shown are steel $\frac{1}{8}$ inch thick and $\frac{1}{2}$ inch wide they bend quite easily when tightened up and produce a very unsightly job. Fig. 15 also shows another defect caused by the cheeks of the bobbin not being properly supported when winding. They have bulged and prevent the stampings from being assembled properly, leaving a small air gap between each, which lowers the efficiency of the iron circuit.

Finishing Touches.

The clamps of the transformer should be enamelled, especially if they are made from angle iron; green and black are suitable colours. The exposed edges of the stampings are given a coat of insulating varnish. Clear brushing cellulose is very suitable for this.

TRANSFORMER FOR LOW-TENSION CHARGER.

Materials Required.

100 pairs of "Stalloy" stampings No. 30 (window $1\frac{1}{8} \times \frac{7}{8}$ inch, middle limb inch wide).

1 bakelite bobbin No. 4F, $1 \times 1\frac{1}{2}$ inches hole.

8 oz. of 18 S.W.G. enamel covered copper wire for secondary.

9 oz. of enamel covered copper wire for primary, size depending on the mains voltage (see table).

1 pair of cast clamps or 20 inches of angle iron $\frac{1}{2} \times \frac{1}{2} \times \frac{1}{8}$ inch.

4 steel 2B.A. screws $1\frac{3}{4}$ inches long.

Short lengths of .75 mm. systoflex and empire cloth 1 inch wide.

4 terminals and ebonite or bakelite terminal block.

Primary Winding.

The following table gives the primary winding data for 50-cycle supplies, based on 6.5 turns per volt :—

Supply Volts.	Max. Primary Current (Amps.).	No. of Turns.	S.W.G.
100	.35	650	25
110	.318	715	25
120	.292	780	26
200	.175	1,300	28
210	.167	1,365	29
220	.159	1,430	29
230	.152	1,495	29
240	.146	1,560	30
250	.140	1,625	30

The Secondary Winding.

The secondary, which gives an output of a little over 12 volts at 2 amperes,

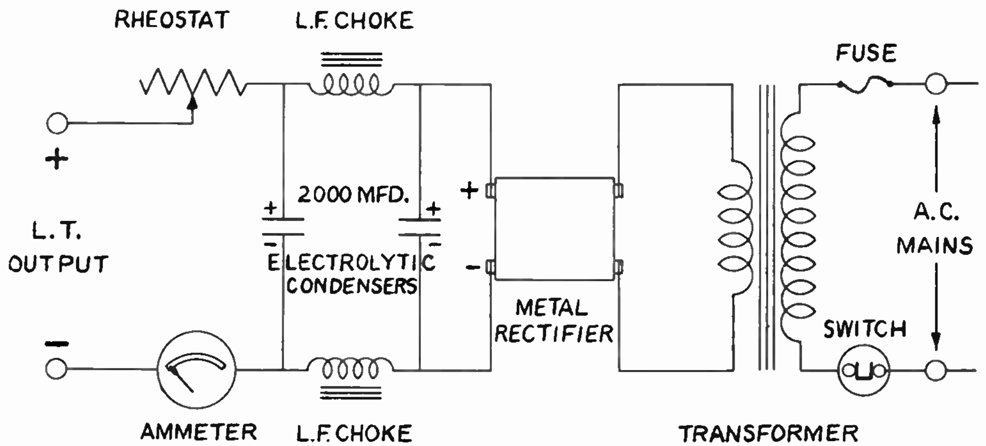

Fig. 18.—Circuit Diagram Showing the Application of a Small Power Transformer in a Low Tension Eliminator.

This is an eliminator giving a smoothed output of about 6 volts 1 ampere with a Westinghouse Style A3 rectifier and the 8-volt tapping on the bell transformer described here. The chokes are .05 to .1 henry at 1 ampere, depending on the degree of smoothing required.

consists of 91 turns of 18 S.W.G. wire wound without any tappings. There is no need to interleave paper between the layers of the secondary winding. The primary winding is wound on first in the same way as for the bell transformer.

"Manufacturer's Type."

If the transformer is to be permanently screwed into a box with the other charging gear there is no need to provide terminals. The leads from the bobbin are left long enough to connect directly to the rectifier and the mains terminals on the charger. The practice of using long leads direct from the bobbin in place of the familiar terminal block is the general practice in commercially made sets and therefore instruments finished in this style are known as "Manufacturer's Type."

TRANSFORMER FOR H.T. ELIMINATORS.

This transformer is designed to give a high tension output of 135 volts at 30 milliamperes to feed a Westinghouse metal rectifier style H.T.7, which gives a D.C. output of 200 volts at 28-30 milliamperes. A low tension winding is also included for heating mains valves. This winding gives an output of 4 volts at 2 or 3 amps., depending upon whether a two or three valve set is being used. The details of an eliminator incorporating this transformer are given in a special article dealing with making a High Tension Eliminator.

Material Required.

The material used for the construction of this transformer is shown in Fig. 1. It is composed as follows :—

100 pairs of "Stalloy" stampings No. 30 (window $1\frac{1}{8} \times \frac{7}{8}$ inch, middle limb $\frac{13}{16}$ inch wide).

1 bakelite bobbin No. 4F. $1 \times 1\frac{1}{2}$ inches hole.

4 steel 2B.A. screws and a set of clamps.

Systoflex sleeving and a yard of empire cloth 1 inch wide.

4 oz. of No. 35 S.W.G. enamel covered copper wire for the high tension secondary winding.

8 oz. of No. 16 S.W.G. double silk covered copper wire for the low tension secondary winding. 8 oz. of enamel covered copper wire, the gauge of which is found from the following table:

Supply Volts.	Max. Primary Current. (Amps.).	No. of Turns.	S.W.G.
100	.2	650	26
110	.182	715	26
120	.166	780	27
200	.100	1,300	30
210	.095	1,365	30
220	.091	1,430	30
230	.087	1,495	31
240	.083	1,560	31
250	.080	1,625	31

The Secondary Windings.

After winding the primary turns a layer of paper and a layer of empire cloth are put on to insulate the primary from the H.T. secondary. The high tension secondary, consisting of 910 turns of 35 S.W.G. wire is put on next and this insulated in the same way after winding the final layer. The low tension or heater winding is wound on last. This consists of 27 turns of 16 S.W.G. double silk covered wire for a 4 volt 2 ampere winding or 28 turns of 16 S.W.G. for a 4 volt 3 ampere winding. It will be noticed that the gauges of wire are very liberal on this design, and the transformer will actually give a higher output quite safely. The object in using a heavier gauge than is necessary to carry the required current is to minimise the voltage drop in the windings, and so give a better regulation.

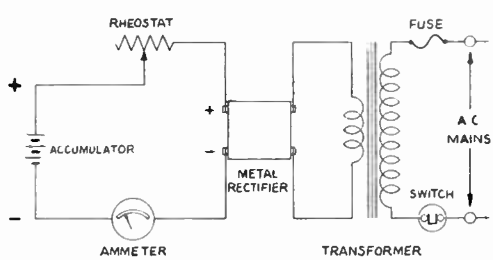

Fig. 19.—AN ACCUMULATOR CHARGING CIRCUIT. Showing the use of small transformer in conjunction with a Westinghouse Style A4 rectifier With the transformer giving an output of 12-14 volts at 2 amps., this arrangement will charge an 8-volt battery. The rheostat is 10 ohms max., and the ammeter a moving coil type.

WIRING A SMALL HOUSE FOR ELECTRIC LIGHT

WHEN wiring property of the smaller type, such as small dwelling houses, shops, garages, etc., academic principles cannot always be followed closely, and in some cases a small percentage of quality must be sacrificed to allow the cost to be kept to its minimum. It is with this type of installation in mind that this article is written. The house is in course of erection and therefore the methods described will differ somewhat from those that would be employed if the installation was being carried out in a completed building.

Studying the Specification.

The work, whether being executed privately or by a contractor, must be governed by certain rules and conditions, setting out the type and quality of materials to be used, the method to be employed, viz., screwed conduit, grip conduit or any other system. The number and power of the lights must also be determined, and any further instructions for the proper execution of the work. In the trade a specification is usually supplied for this purpose, and when the work is done privately it is well to draw up a brief specification and to follow it during the progress of the installation.

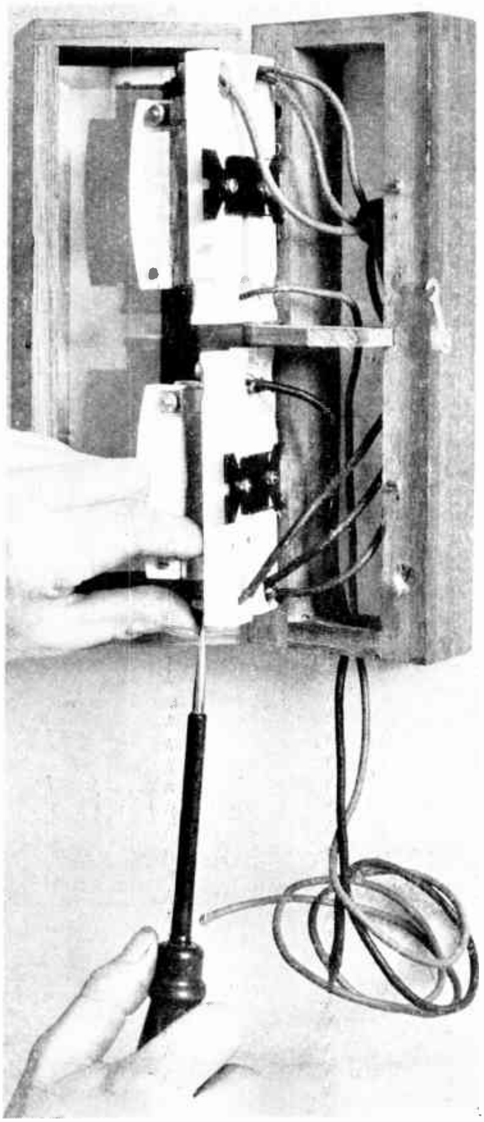

Fig. 1.—A TWO-WAY FUSE BOARD, SHOWING CONNECTIONS.

When connecting up fuse wires care must be used to ensure that the red and black wires of each circuit are connected to the upper and lower carriers opposite each other, as these form a pair.

In this instance let us assume that grip conduit is to be used with non-inspection fittings, and that the wires are to be drawn in as the work proceeds. This, while not being the best method, is that usually employed in buildings of the cheaper type. All conduit is to be concealed, but switches, ceiling roses, etc., are to be of the surface mounting type.

The Positions of Points and Accessories.

In most cases a plan is supplied showing the position of points, etc., and where this is not so, a pre-determined scheme must be fol-

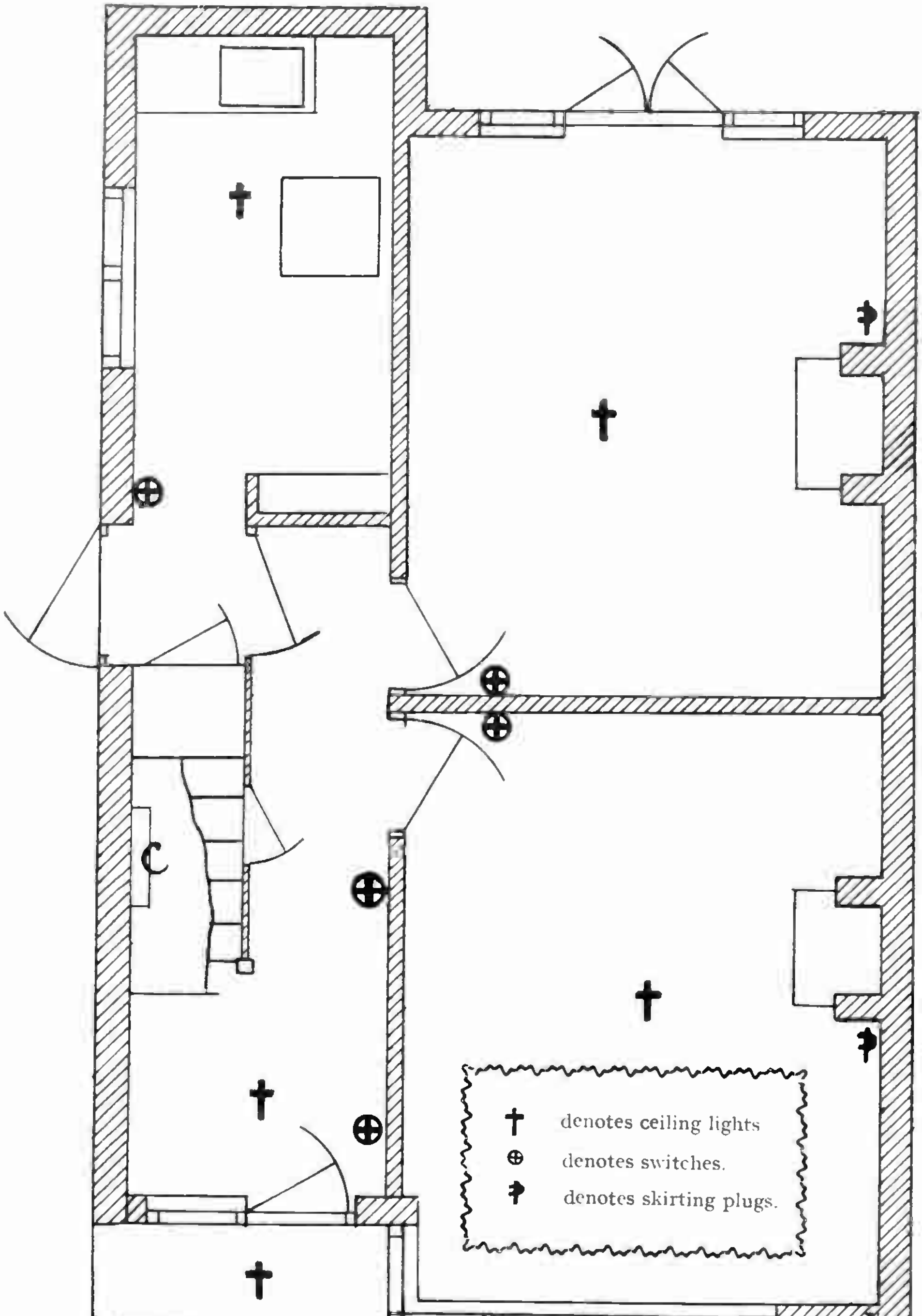

Fig. 2A.—GROUND FLOOR.
This is a plan of the house mentioned in the article, and shows the points of installation described.

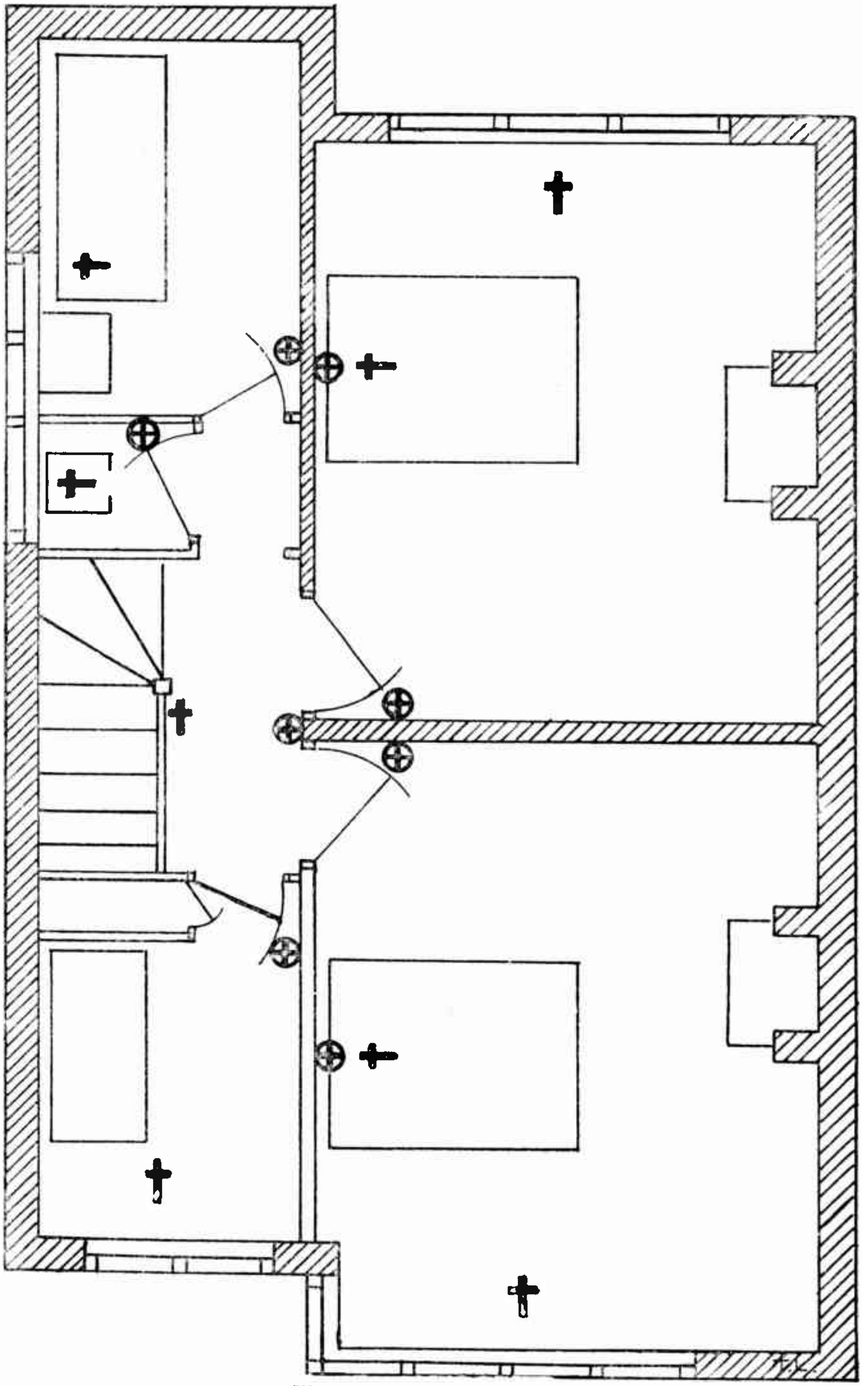

Fig. 2B.—FIRST FLOOR.

It is usual in the trade for a plan to be supplied showing the position of lights, switches, distribution board, etc., and it should be used in conjunction with the specification.

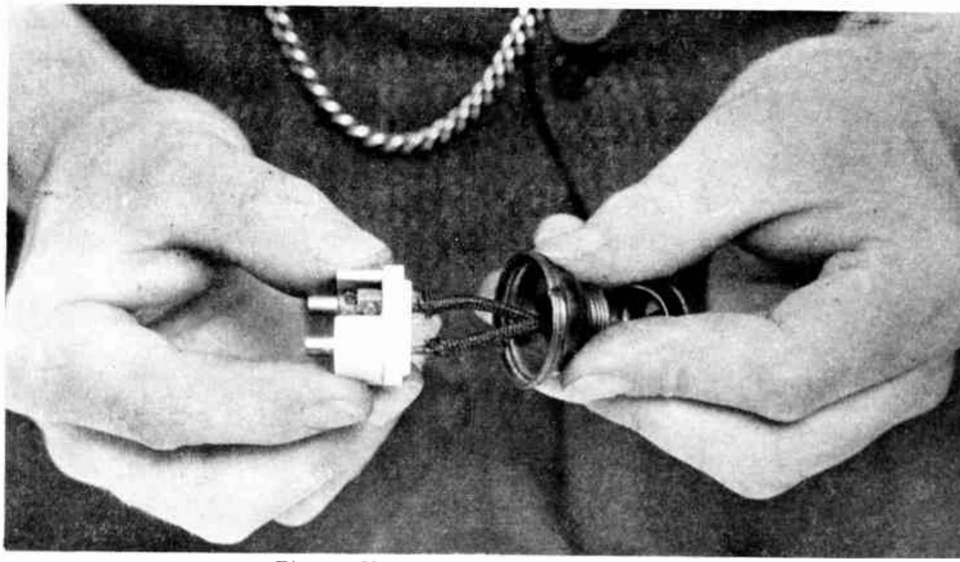

Fig. 3.—HOW TO ASSEMBLE A LAMPHOLDER.
Care should be taken to see that the pins are at right angles to the slots taking the pins on the lamp.

lowed. It is not enough to commence the wiring, having only a mental knowledge of this. For example, the light in a kitchen requires consideration as to its relation to a sink or a cooker, so that the maximum light is obtained, and not obscured, by the person using these appliances. Similarly, in a dining-room a light must not be placed in the centre of the ceiling—a very common mistake—but the distance between the outer edge of the hearth and the opposite wall should be halved and this point taken. This is, of course, assuming that the table will be placed in the centre of the room.

The position of the meter, main switch and distribution board must also be decided.

Figs. 2A and 2B show a plan of the house, showing the points of the installation being described.

The Number of Circuits Required.

Having studied the number and positions of the lights, some thought must be given to the number of circuits to be used. In this small house the number of points on the ground floor is seven, and on the first floor, eight. For these, one separate circuit for each floor will be enough, as the current likely to be carried will not exceed 3 amps. unless lamps of more than 75 watts are used. The following rule of the Institute of Electrical Engineers will, however, be found useful, and instructions for calculating the amperage in relation to wattage will be found in the article on "Installation Faults, Dangers and Remedies."

A maximum number of points that may be connected in parallel to a final sub-circuit shall be as follows :—

Where the total current of the points supplied from the sub-circuit does not exceed

6 *amperes*	..	10 *points.*
8 ,,	..	6 ,,
10 ,,	..	4 ,,
20 ,,	..	2 ,,

Final sub-circuits supplying one lamp or appliance are not limited as to current-carrying capacity.

The Method of Procedure.

The house being under erection it is essential to work in conjunction with the builders, and conduit to be laid under

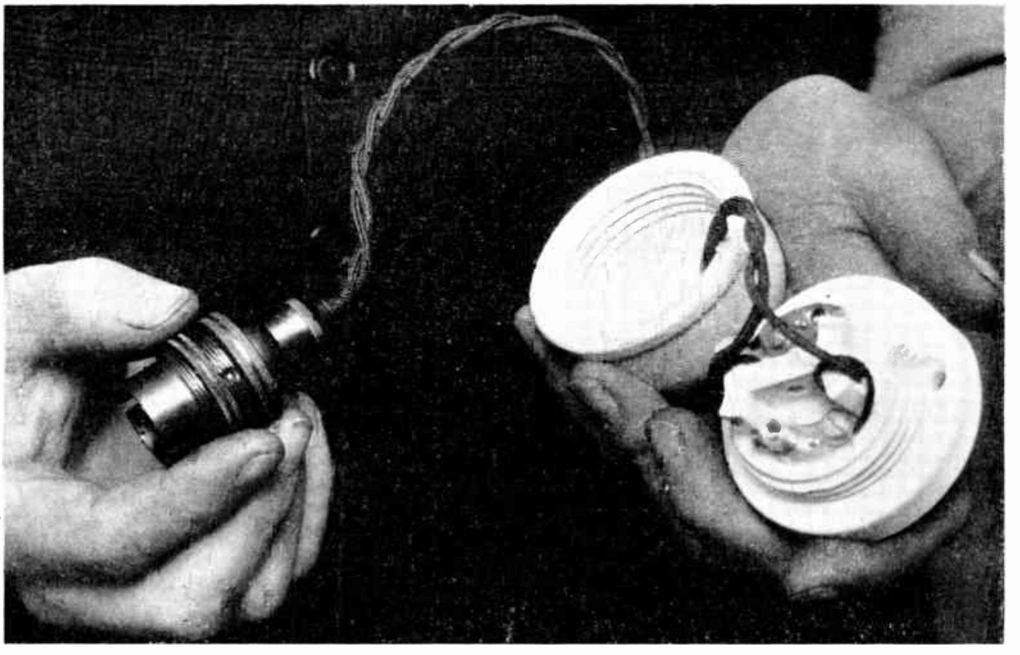

Fig. 4.—A Complete Pendant with Ceiling Rose and Lampholder.
In assembling the ceiling rose it should be remembered that where more than one black wire occurs they must all be bunched in one terminal, and the solitary red in the remaining terminal.

floors or concealed in plaster must be fixed before this work is finished, since cutting away and making good add to expense and very often produce an antagonistic builder.

Now examine Fig. 5A and note that points "A" and "B" are the positions of skirting plugs, and therefore the conduit will be concealed in the ground floor, and assuming that the builder wishes to lay the ground floors, this wiring must be done first.

Cutting the Conduit.

For a house of this type, ⅝ in. conduit would be large enough, since no more than four wires are likely to be run in together, except in one short length. Reference to the table of conduit capacities on page 83, however, will show the correct size required. Measure the distance from 1 to 2 and 2 to 3, in Fig. 5A, also from the position of plug "A" to a point immediately beneath it between or under the floor joists. Cut three pieces of conduit to these lengths, clean the ends, remove the burr with a file and assemble them with an elbow at 1 and 2 and a tee at 3, leaving them loosely in their sockets. Next measure the distance from 3 to 4 and 4 to 5, allowing a short piece to extend up the wall at "B." Assemble this as previously done. Now cut a length of conduit to reach from 3 to 6, but remembering that conduit must not be cut across the centre of joists and therefore, if necessary, bends should be used to enable it to run between the joists until it reaches a point 18 inches from the bearing, as in Fig. 6, and then continued across the joists until the position is reached.

Fitting Rubber Bushes.

By laying the conduit to this point we have assumed that the distribution board, mains and meter, etc., are to be placed in the position "C," and all work so far has been executed under the floor. Fix an elbow at 6 and continue in a sloping direction with a piece of conduit through the floor to the point 7. As the plaster is often insufficient to cover the conduit completely, a small chase should be cut in the wall to accommodate it, and this procedure should be adopted at the short lengths "A" and "B," where they will be covered by the skirting. Rubber bushes must now be placed on the naked ends of conduit "A," "B" and "C."

Threading the Wires.

The builder now requires to lay his floor, and before we commence the next section of conduit we must wire these two points. As they will be used for lighting purposes, V.I.R. wire of 1/.044 ins. diameter will be required. Take one end each of a coil of red and a coil of black wire and remove the conduit 2 to 3 at the tee, and thread these two wires in the direction of the arrow until point "A" is reached, removing the elbows as you proceed to make easy threading. From the tee measure backward sufficient of both wires to reach to "B," and cut them. We now have four ends where we have cut, and these four ends should be passed straight through the tee and elbows until they reach "B," short lengths being left at "A" and "B" to make the necessary connections. Measure sufficient wire along the two still joined to the coils, to reach from 3 to 6, and on to 7, with two or three feet to spare for connections. These should now be threaded through the conduit from 3, and when finished the wires should lay in the tee as shown in Fig. 7. The grip connections on tees and elbows to this section may now be screwed rigid. Fix the conduits firmly with crampets either to the side or bottom of the joists, where they do not lay across them.

Fixing the Conduit for Ground Floor Lights.

The next step is to mark the exact positions of the switches to control the lights, on the walls of the ground floor in their respective rooms, and to mark the actual position of the light on the nearest first floor joist, since the floor has not yet been laid. Commence at the light "D" and assemble the conduit with a tee at 8 and elbow at 9, proceed to a point immediately above "E," using another elbow with sufficient conduit to reach downwards on the wall to the position of the switch, this latter piece being chased in the brickwork. From the tee 8 continue to 10, where another tee is inserted, and a straight piece of conduit continued to "F." From the tee 10 insert another length reaching to a point immediately above the switch "G," where a tee is used to connect another piece to the switch, in the same manner as was carried out at "E." From the remaining outlet of this tee continue the conduit to point "J," inserting tees at positions 11 and 12. From point 11 continue with an elbow immediately above "K," to the switch point "K," and from point 12 continue to "N," inserting tees at points 13, "L" and 14. From 13 continue to point 15, where an elbow is inserted and a length of conduit chased in the wall to reach to the meter point "C." From point 14 continue to a point above the switch "M," insert an elbow and continue to "M," chasing the conduit in the wall as before.

Points "D," "E," "F," "G," "J," "K," "L," "M" and "N," and also the end of the conduit at the meter "C," should have rubber bushes fixed on the open ends.

Completing the Wiring for the Ground Floor Lights.

Provided that all the ends of the conduit have been properly smoothed and cleaned, we can now commence to thread the wires. This requires particular care to ensure that the correct wires connect their respective points, and since we must start with a complete coil each of red and black, it is always advisable to commence at a point farthest from the meter, the reason for this being that the lengths of wires to be drawn through diminish as the work proceeds.

How to Run the Wire through the Conduit.

Commencing at the tee 8, remove the conduit leading to "D" and through it pass the two ends of the red and black wire, always remembering to leave sufficient at lighting and switch points for connections. Measure backwards along the red wire and cut off sufficient to reach

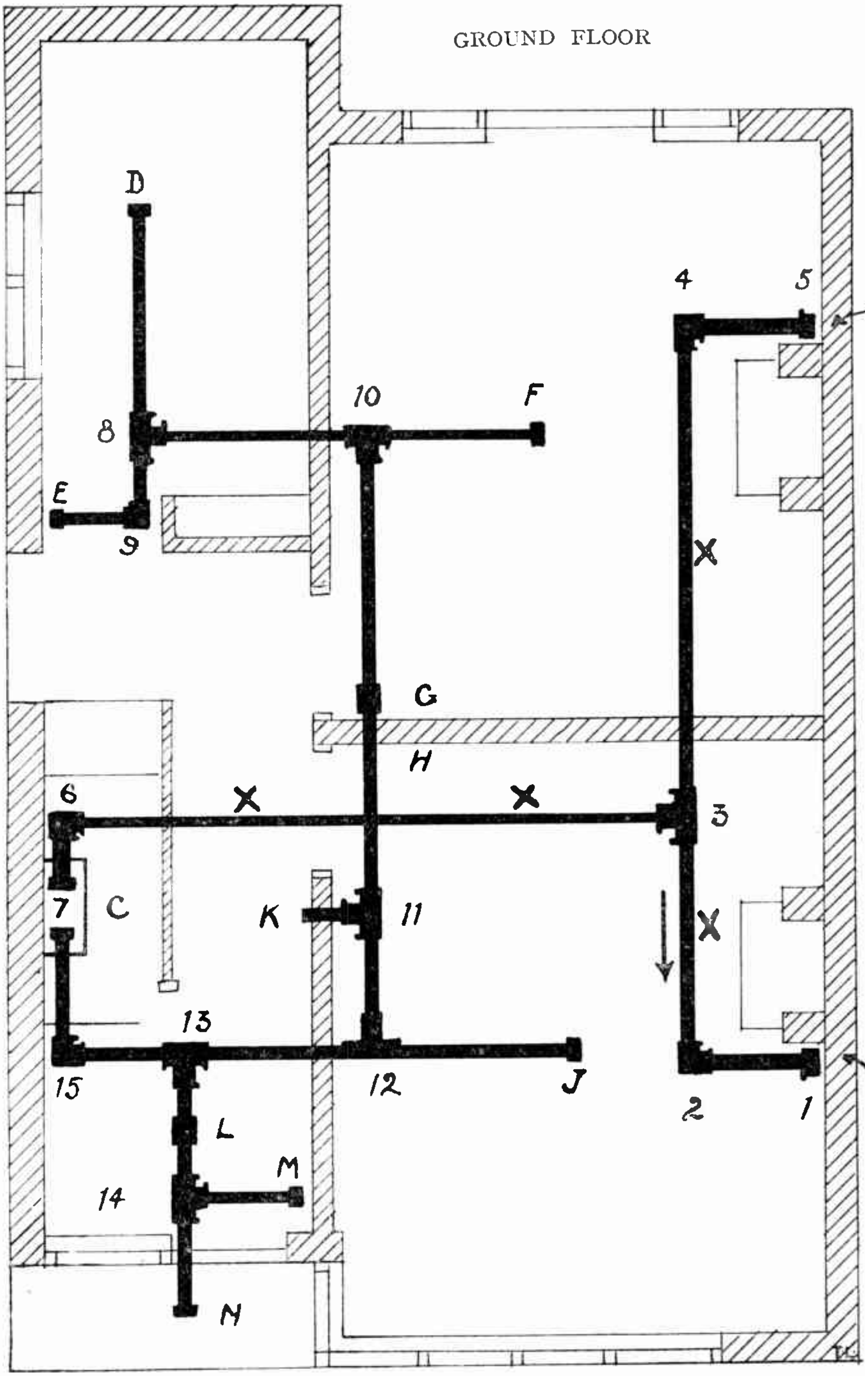

Fig. 5A.—THE CONDUIT LAID IN POSITION (1).

The conduit is shown here as it would appear in practice, with all elbows and tees in position. In this plan those marked X are laid under the ground floor and the remainder under the first floor. (See text for explanation of letters and figures.)

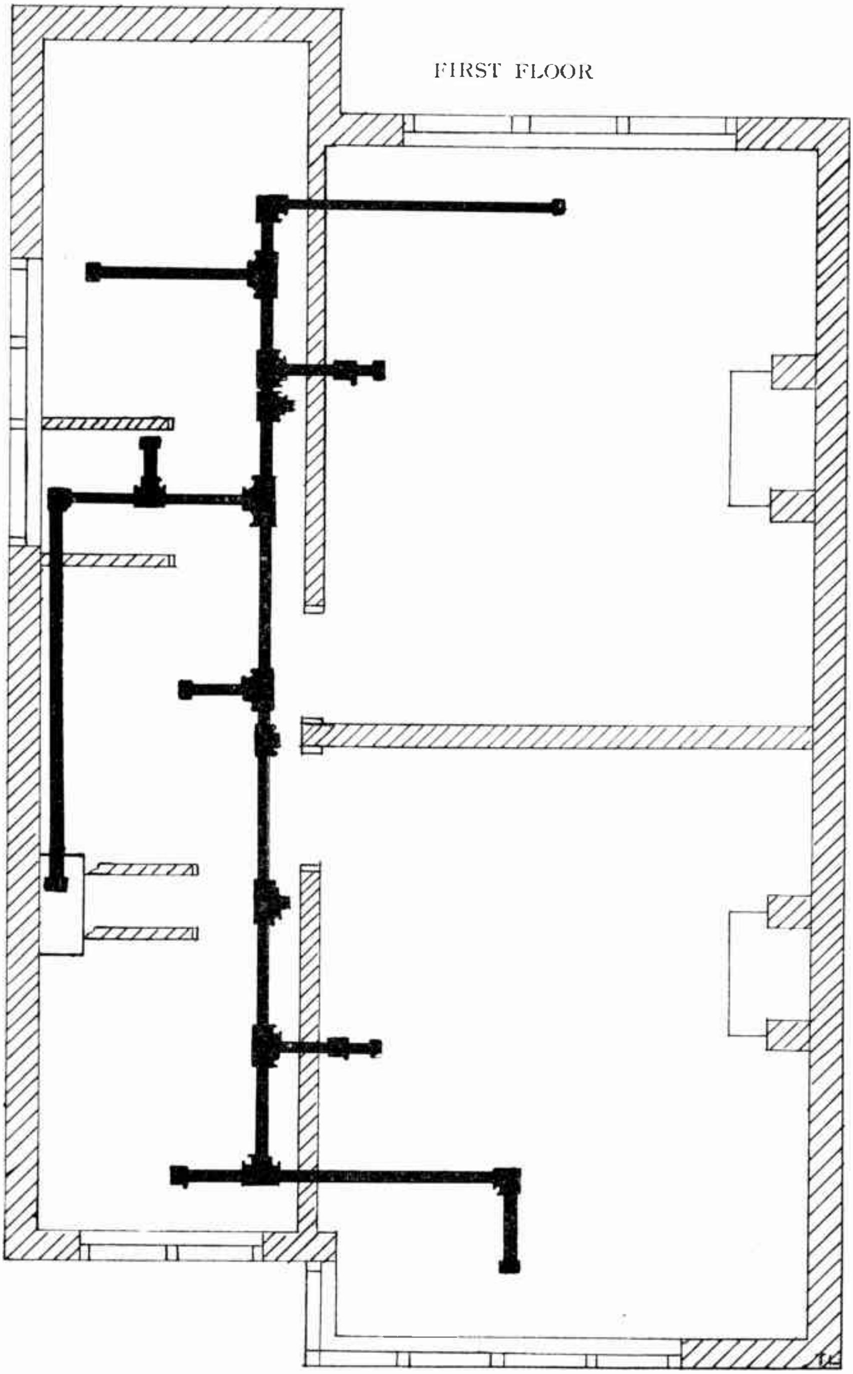

Fig. 5B.—The Conduit Laid in Position (2).
The same method as that described for wiring the ground floor is used for the first floor. It is usual to lay the conduit across the ceiling joists in the roof, and as flooring is not laid it is unnecessary to notch the joists.

to the switch point " E." Cut a small notch in the covering of this end to mark this as the switch wire. The end of the red connected to " D " should now be passed straight through the arm of the tee and the end of the red coil passed through the upright of the tee and turned in a left-hand direction, both ends then being taken through the conduit, elbow 9, and on to the switch point " E." Measure backwards along the black wire and cut off sufficient to reach to point " F." Measure backwards along the red wire and cut off sufficient to reach to point " G," always working along the direction of the conduit. Pass these two ends through the conduit until the tee 10 is reached. Continue the black wire through the conduit to the point " F," and the red to the switch " G." Take the end of the coil of red wire and also the end of the black coil, pass the ends through the tee 10 and on to " F," measure backwards along the red wire to the switch " G," cutting it at this point, and making a small mark as before. This is the second switch wire. Measure backwards along the black wire sufficient to reach to the point " J." Thread these two ends from the tee 10 to the tee immediately above the switch " G," passing the black through the arm of the tee and the red downwards through the centre. We should now have two reds passing through the centre of the tee and one black through the arm.

What To Do Next.

A length of red wire should now be cut to reach from " J " to switch " G " and through the wall to " H." Cut *two* marks in both ends of this wire and pass one end, with that of the red coil, through the tee and down to " G." Measure backwards along the red coil enough wire to extend to " K," and cut.

At the tee above " G " we should now have two reds and one black, these should be passed through the conduit to tee 11. The marked red wire and the black must be passed straight through the tee arm, and the remaining red through the centre leading to " K."

Marking the Wire.

Cut from the red coil a length to reach from switch " K " to point " L," and put one mark in both ends. Thread this, with the end of the red coil, through the tee and down to switch " K," cutting off enough from the coil to reach to " M." From this tee should protrude one black and three reds, these are passed through the conduit to the tee 12. The red with *two* marks and the black must now turn in a right-hand direction to point " J," and the two remaining reds in the opposite direction. Pass the end of the black through the arm of the tee 12 and on to " J." Measure backwards along this coil enough to reach to " L," and cut it. Thread this with the two reds from the tee 12 on to tee 13, passing them through the centre towards tee " L.

Take the ends of the red and black coils and thread them from the end of the conduit at point 7, through the elbow 15 and on to tee 13, leaving enough on the black to reach to point " L " and on the red to reach to switch " M." Pass these two wires together with the three already at tee 13 on to tee " L," the marked red and the two blacks being threaded through the centre of the tee, and the other two reds passed through the arm.

The Job Nearly Completed.

Cut a length of black wire from the coil to reach from " L " to " N," and pass one through the centre of tee " L " with the opposite end towards tee 14. This black is now passed through the arm of tee 14 and the two reds from tee 13 are passed through the centre of tee 14. A length of red to reach from " M " to " N " is now cut from the coil, and one end marked. This is threaded through the centre of tee 14 with the two reds from tee " L," down to switch " M." The opposite end is passed with the black from tee 14 to point " N."

Final Points.

We now turn to switch " G," where we have four red wires. Two of these are unmarked and the others with one and two marks respectively. Fix a tee on the end of this conduit with the wire having two marks passing through the centre and through the wall to "H," and the remaining three wires passing through the arm. A short piece of red wire must now be passed from "H" to "G." Fig. 8 shows the arrangement at this point.

How Each Light is Fed.

This completes the wiring to the ground floor rooms, and all the clamping screws in tees and elbows should be properly tightened and conduit securely fixed where necessary. The diagram Fig. 9 illustrates the exact runs of the wires we have threaded, and it can be seen that each light is fed by a red wire from the switch and a black wire from the previous light. From each switch a second red wire is carried to the next switch, and so on throughout the installation. Thus we have "looped" from switch to switch and light to light.

Lighting the First Floor.

The same method as has been described is now followed for the wiring to the first floor. In this case it is usual to lay the conduit across the ceiling joists in the roof, and as flooring is not laid it is unnecessary to notch the joists. This means that the runs may be considerably shorter and take more direct routes, instead of avoiding the centres of joists.

The positions of the lights and switches having been determined, commencement must be made from the furthermost point as before, and the conduit laid in position. The wires are then threaded in exactly the same manner, always being sure that the black wires are looped from each light and from the last light to the position of the distribution board, and a red wire from switch to switch, a wire from the last switch also being taken to the position of the distribution board. Each switch

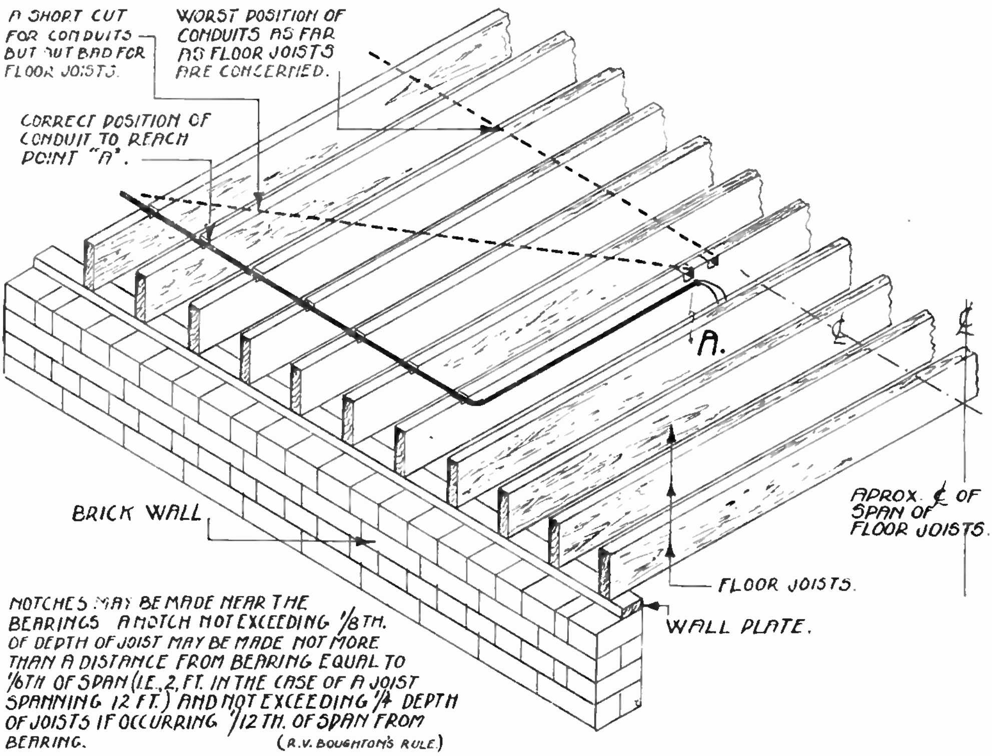

Fig. 6.—How to Cut the Floor Joists.

This illustration shows the method of cutting joists to reach a point in the centre of the room.

and its corresponding light should also have been connected by a second red wire.

Fixing the Ceiling Roses and Pendants.

The best procedure to adopt for this part of the work is to assemble the complete pendant before fixing it to the ceiling. The usual height of a lampholder is about 7 feet to 7 feet 6 inches from the floor, and the flex should be cut in lengths to allow for this. Figs. 3 and 4 show a completed pendant and its connections.

As the ceiling roses are mounted on wood blocks, these latter should be drilled for the passage of the wires and fixed in position. A sufficient fixing for these can usually be found in the laths, but where an extra heavy fitting is likely to be suspended, a stout block must be spiked in the floor above, between the joists, and longer screws used for mounting the ceiling block from the under side.

The Connections to the Ceiling Rose.

No difficulty should be experienced in this respect if it is remembered that where more than one black wire occurs they must all be bunched in one terminal, and the solitary red in the remaining terminal.

Fixing the Switches.

It has been assumed throughout this installation that the fittings are of the surface mounting type, and switch-blocks will therefore require to be fixed. These must be drilled in a similar manner for the passage of the wires, having marked the position by placing the switch in the centre of the block and piercing with a bradawl through the terminals. The fixing to the wall should be done by means of Rawlplugs.

Connecting the Wires to the Switches.

At these switch positions we have all wires of the same colour, but at each point one wire has a distinguishing mark. This wire should be fixed in one terminal of the switch, and the remaining ones bunched together into the other terminal.

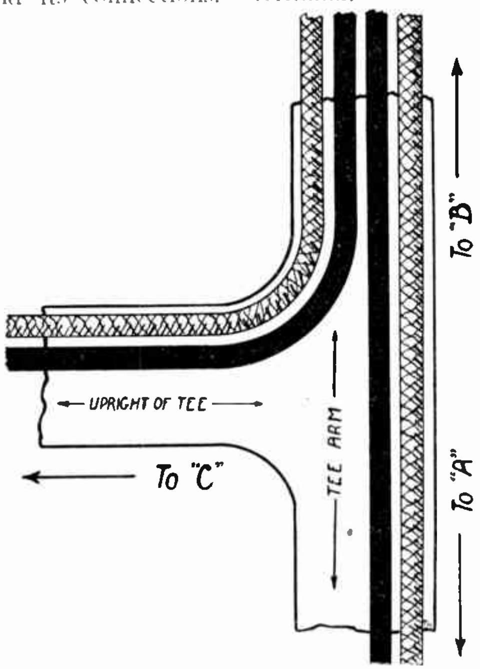

Fig. 7.—THE WIRES IN THE TEE.
Showing the position of the wires at tee No. 3 in Fig. 5A, after looping from plug "B" and carrying on to distribution board "C."

Choose Short Fixing Screws.

When fixing ceiling roses and switches to their blocks, short screws must be used, and exceptional care taken that the points do not protrude and damage the wires at the back of the blocks.

Earthing the Conduit.

The position of the distribution board is marked in Figs. 2A and 5A by letter "C," and this is usually near the entry of the supply company's main cable and meter, and to which point we have brought the conduits and wires from the ground and first floors. These conduits must be connected to "earth" at some point, and the most convenient position is usually at the distribution board, since all the conduits terminate at this point. Clean the enamel from all the conduits for about 2 inches at their ends, and clamp an "earth" clip to each. A piece of 7/.029 bare copper wire must be connected to the first clip and looped to the second and third, etc., and carried to the nearest water pipe, where it is fastened to it by a similar clip.

Fixing and Wiring the Distribution Board.

In this installation we have two circuits, one for the ground floor and one for the first floor. We therefore require a two-way distribution board of 5 amp. capacity. Fig. 1 shows such a board.

The fuse carriers are usually mounted on wood battens, and these battens are hinged or screwed to the frame of the case. Remove these carriers from the frame and fix the latter to the wall in such a position as to cover the ends of the conduit at point 7, Fig. 5A.

How the Fuse Carriers are Connected.

Examine the fuse carriers and it will be found that the top set is connected to one common bar, and the bottom set likewise. The ends of the wires having been prepared, the reds from the two ground floor conduits must be connected together in one of the top terminals of the upper set of carriers, and the red from the first floor conduit in the remaining upper terminal. Similarly, the two black wires from the ground floor must be connected to one of the terminals on the lower carriers, and the remaining black on the other terminal. Care must be used in making these connections to ensure that the red and black wires of each circuit are connected to the upper and lower carriers opposite each other, as these form a pair. This is shown in Fig. 1.

In the centre of each common bar is a large terminal. To the upper terminal a short length of 3/.036 red wire must be connected, and a similar length of black 3/.036 to the lower. These wires must be brought out from the bottom of the case in such a manner as not to prevent the opening and closing of the cover.

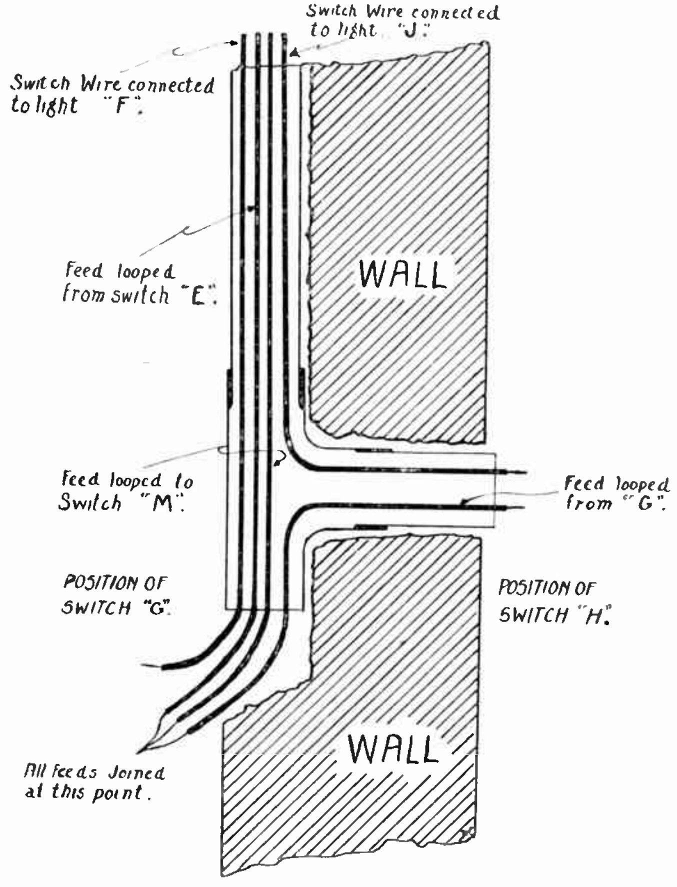

Fig. 8.—FEEDING A SWITCH.

This shows how switch "H" in Fig. 5A is fed. The wires are carried in the conduit to switch "G" and a live feed is obtained on the opposite side of the wall by taking a third loop, the second being taken to feed switch "M."

Fixing the Main Switch and Fuses.

The types of main switches are so numerous as to prevent a full description, but one in common use is a small 5/10 amp. combined double-pole switch and two single-pole fuses in an iron case. With this type the cover can only be removed when the switch is "off." One of these switches should be fixed immediately below the distribution board. The pair of 3/.036 last connected to the distribution board should now have their free ends prepared and connected to the top pair of terminals in the switch and a length of red and black 3/.036, sufficient to reach to the supply company's meter, should be connected to the lower terminals; the red being placed in the terminal immediately beneath that connected to the red wire above. These wires must be coiled and left for the supply company's inspector to connect to the meter.

Inserting the Fuse Wires.

Some makers of distribution boards and switch fuses are thoughtful enough to wire the fuse bridges before sending them from the factory. When this is not done it will be necessary to connect a small piece of 5 amp. tinned copper wire between the terminals of the bridges before testing the installation.

The Need for Testing the Installation.

It must be remembered that this installation has been carried

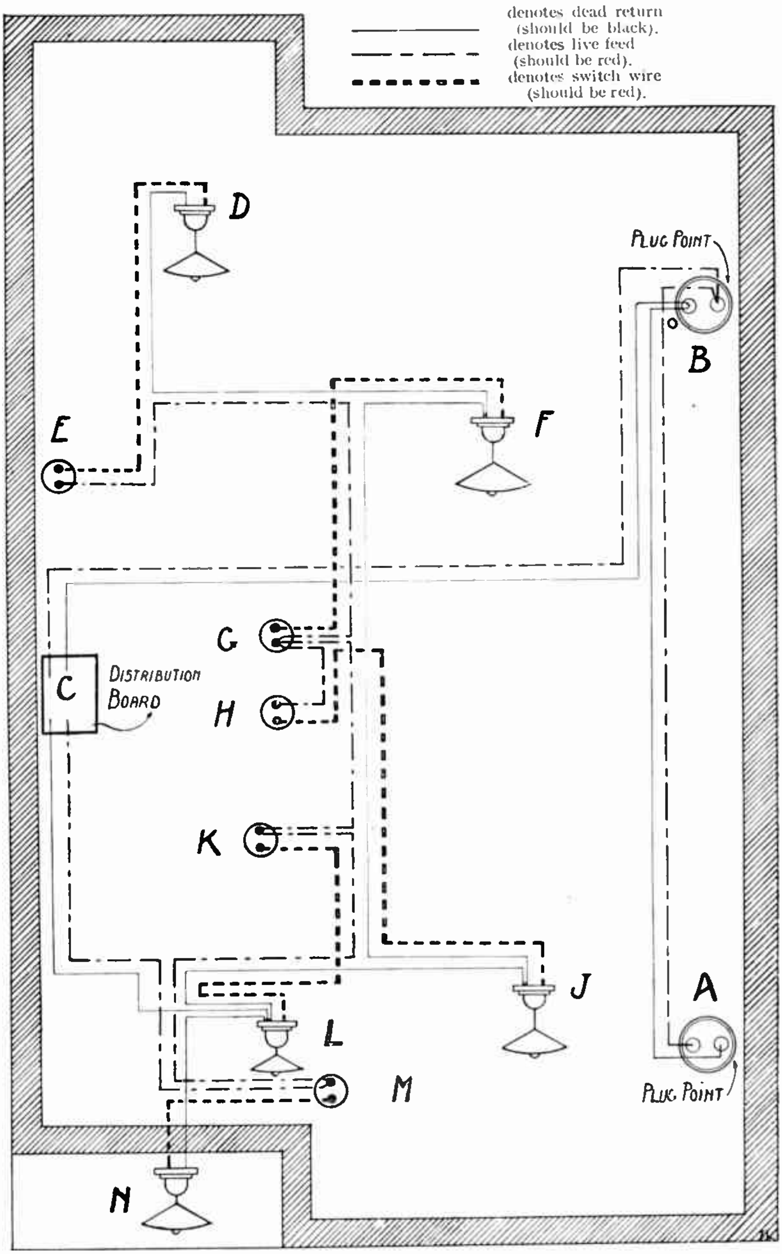

Fig. 9.—Tracing the Wires in the Conduit.

The actual runs of the wires on the ground floor are shown as they appear in the conduit. This illustration also shows the method of carrying a live feed from switch to switch and a return from light to light.

out during the erection of the building, and although great care may have been taken, accidents will happen. Nails may have been driven in the conduit, or even wires broken, and it is therefore very necessary to carry out a complete test before leaving the work.

Testing the Wires for Continuity.

For this purpose connect a bell and dry battery in series across the pair of red and black wires left for the meter. Place all switches in the "on" position. Now short-circuit the pins in one lamp-holder and the bell should ring. When the switch controlling this point is "off," the bell should stop ringing. Carry out this test at each point in turn.

Testing the Insulation Resistance.

This test can only be carried out with the aid of an ohmmeter, which is an instrument for measuring the resistance in ohms or megohms and is usually coupled with a hand machine capable of developing a high electrical pressure; usually 500 volts. Two readings with this instrument are necessary. The first is the resistance between poles or wires, and the second between wires and "earth."

Testing between Wires.

For the first test, connect the meter across the two free ends of the wires leaving the main switch. Place all switches in the "on" position, insert all fuses and remove any lamps that may have been placed in position. A reading can now be taken.

The Resistance that should be Recorded.

It is difficult to lay down any hard and fast rule as to the exact reading that should be required, as this is largely dependent upon the supply company concerned, and also the state of the building, whether new or old. In the case of new buildings an excess of dampness may prevail causing the resistance to be low, and allowance may be made by the company's inspector for its drying out. As a general rule, a company will not connect any installation to its mains when the insulation resistance between wires falls below 75,000 ohms, and any installation having a resistance below 2 megohms is considered to be below the desired standard.

Testing Poles to Earth.

This is the second test that must be made. In this case it is necessary to join together the same *two* wires, leaving the main switch, and connect them under the "line" terminal of the ohmmeter. The other terminal must be connected to a water pipe by a separate wire, and a reading taken.

What Supply Companies Require.

As in the last test, it is difficult to give a definite standard of resistance that should be recorded. The following table, however, shows the requirements of the same supply company, and should serve as a guide to the requirements of most companies:—

The company will not supply current to any installation:—
If, when testing with a pressure of 500 volts, the insulation resistance to earth is below the following standard:—

For	6	lamps	15	megohms.
,,	12	,,	7	,,
,,	25	,,	4	,,
,,	50	,,	2	,,
,,	75	,,	1.5	,,
,,	100	,,	1.25	,,
,,	150	,,	1.0	,,
,,	200	,,	0.75	,,
,,	250	,,	0.5	,,
,,	300	,,	0.4	,,
,,	350	,,	0.3	,,
,,	400	,,	0.2	,,

The methods employed in practice for running the wires and fixing the switches and fittings are dealt with in detail in later articles.

INSTALLING SMALL MOTORS

By Lt.-Col. D. J. Smith, M.I.Mech.E.

The increasing use of electricity has rendered it possible to consider the installation of a power drive in home workshops or for domestic purposes, and to escape the many drawbacks and disadvantages inherent to all but the electric motor when used for purposes of this kind. The small oil and gas engines, previously the only prime movers which could be installed, were quite satisfactory as far as the cost of power was concerned, in fact in many cases they furnished power at a cheaper rate than is possible with the electric motor, but if the workshop was situated in the home, or even adjacent to it, the noise, vibration and exhaust fumes more than outweighed the cheapness of the power supplied.

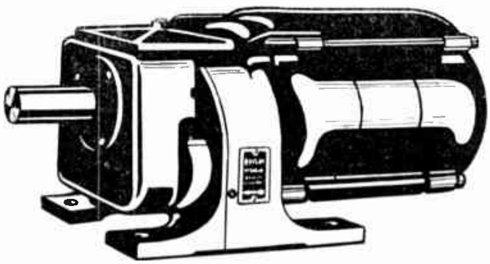

Fig. 1.—A Small Power Geared Motor. Made in sizes ¼, ½ and ¾ h.p., with final speeds ranging from 26 revs. to 480 revs. per minute. (*Normand.*)

Disadvantages of Gas Engines.

The cost of installation also was considerable as a substantial foundation had to be provided, and if a gas engine was fitted, a separate meter and gas pipes had to be installed. Also there were few positions possible in which to place the engine and this rendered the grouping of the tools, etc., difficult. The electric motor can be fitted almost anywhere, it has not to be started up like gas or oil engines and runs without noise, vibration or smell.

Added to these advantages are those of first cost, either for new or second-hand motors, which is generally far less than that of internal combustion engines, and simplicity of starting and contact.

The weight also is much less than that of an internal combustion engine with its accessories and this is a valuable point for many users.

What to do Before Installing a Motor.

Before installing a motor it is advisable to consult the local electric supply company to see if there are any special rules relating to the fitting of motors, and these rules must be adhered to. Generally, the companies will give all necessary information and assistance and will advise whether it is necessary to inform the fire insurance company with which the premises are insured that an electric motor is being fitted. The electric work in connection with fitting in a motor is dealt with elsewhere, only the mechanical features will be described here. A power-driven workshop is

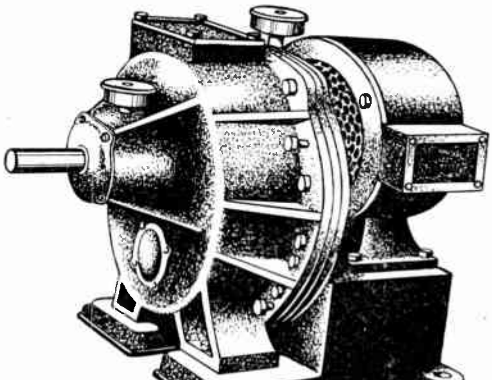

Fig. 1a.—Crypto Geared Motor. Another type of small power geared motor.

the ideal of many amateur mechanics and it is often only the consideration of expense which prevents this ideal being realised.

Cost of Shafting.

Actually, the fitting up of shafting, etc., is by no means expensive, and to illustrate this the prices of most of the material required have been given, while in many cases considerable saving can be effected by the purchase of second-hand plant. The rules regarding power transmission, sizes of pulleys, etc., will apply equally well to installations of considerable power. The National Grid is now bringing current to many isolated districts and electric drive is becoming available for many purposes on farms, and one or two examples of applying motors to farm machinery will be given. Here again the cost of installation is preventing many farms using electric motors, but this need not be so as the notes *re* cost of motors, etc., will demonstrate.

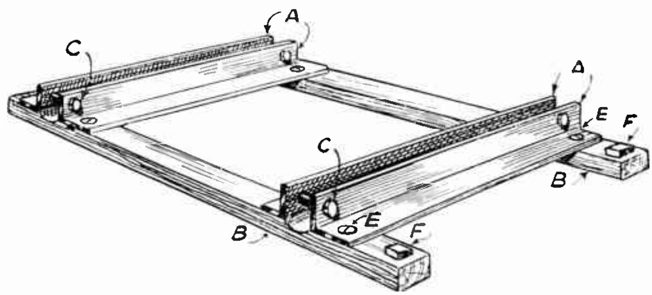

Fig. 2A.—Slide Rails for Small Motor.

A A A A four lengths of 1 in. × 1 in. angle steel, 18 in. long. B B, two strips of hardwood, 1 in. × 2 in., as long as necessary. C C, bolts with distance piece of tube holding angles together. Angles secured to wood by wood screws countersunk in angle iron E. F, coach screws securing wood strips to floor or joists.

"One Motor One Machine" if Possible.

Actually, one motor one machine is the cheapest and best method, as it enables shafting to be dispensed with and the machines placed in the most convenient positions, which is not always possible where they have to be driven from shafting. The average amateur workshop also is not generally structurally suitable to carry the shafting. From the point of expense there is little in it, as

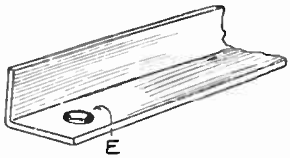

Fig. 2B.—Showing Countersunk Hole for Wood Screw.

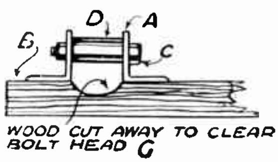

Fig. 2C.—Showing Rails Fixed to Floor or Joists.

THE CHOICE OF A MOTOR.

The first consideration governing the selection of a motor is the power required. If only one machine is to be driven the matter is a simple one, but if several machines are to be driven and two or more will be used at the same time, it must be decided whether one large motor is to be purchased capable of driving the combined load or separate motors for each machine, or perhaps each group of two or more machines.

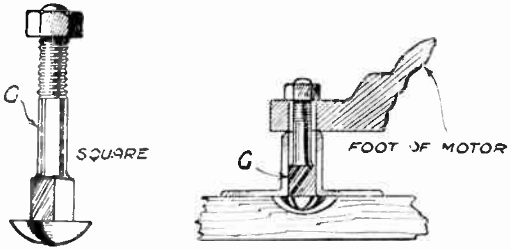

Fig. 2D.—Bolt Used for Holding Motor to Rails.

The distance apart of rails will be made to suit lugs of motor.

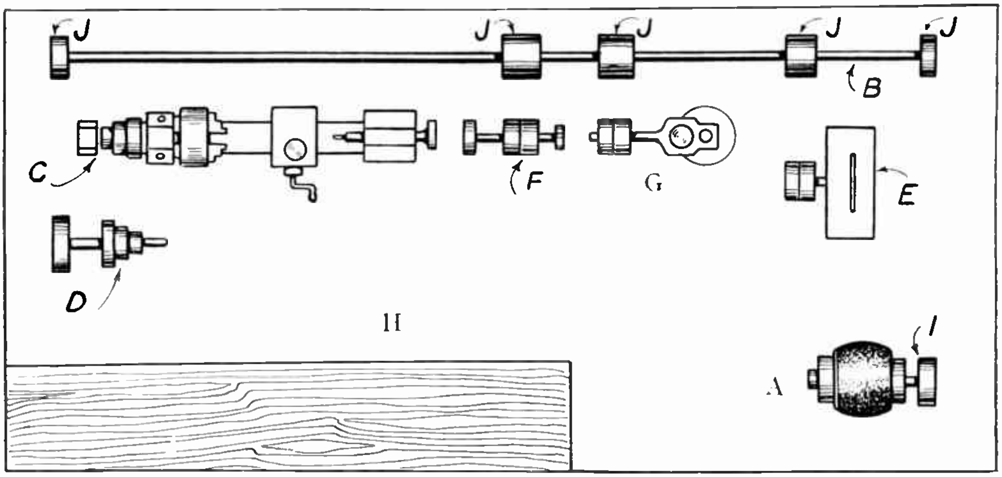

Fig. 3.—PLAN OF LAY-OUT OF SMALL WORKSHOP.
A, Motor. B, Main shaft. C, Lathe. D, Lathe overhead. E, Circular saw. F, Grinder. G, Drilling machine. H, Bench. I, Motor pulley. J J, Pulleys on main shaft.

small powered motors can be purchased very cheaply to-day and cost little more, if any, than suitable shafting with its hangers or wall brackets and plummer blocks. Both methods will be dealt with.

A Single Machine.

The first case to be taken is that of a single machine, such as a small lathe up to 4-inch centres, either for wood or metal, a small drilling machine, grinder or circular or band saw, though these latter tools are rather greedy on power, especially the circular saw.

A ¼ h.p. Motor for Driving a Lathe.

The lathe is the most popular tool, and up to 4-inch centres a ¼ h.p. motor will give ample power to drive this alone. Motors of smaller power are sometimes advised but are not to be recommended, being mere toys in most cases. The details of the supply being known—A.C. or D.C. voltage, etc., a suitable motor can be selected

In these small motors there are three types to choose from, high speed, low speed, and geared. The two latter, if means permit, should always be favoured. As an example, a ¼ h.p. high-speed motor weighs 28 lb. and

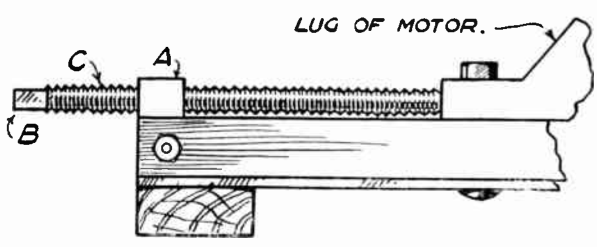

Fig. 4A.—APPLICATION OF TENSIONING DOG FOR USE WITH SLIDE RAILS IN FIG. 2A.

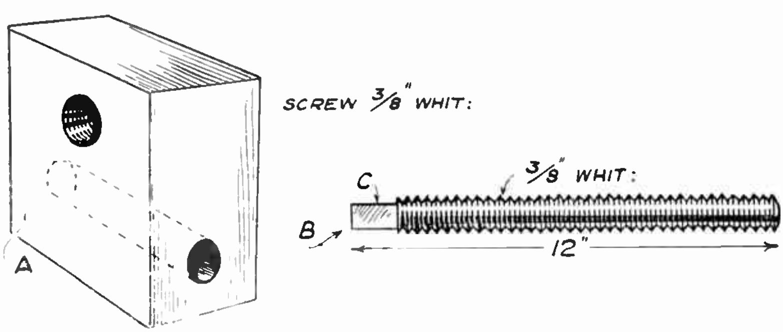

Fig. 4B.—HOW TENSIONING DOG IS CONSTRUCTED.
Block A of brass replaces distance piece D in Fig 2c. B, 12 in. length of ⅜ in. Whitworth screwed rod with end C squared for spanner. (*Adams.*)

runs at 2,700 revs. per minute. A $\frac{1}{4}$ h.p. slow speed motor runs at 700 revs. per minute and weighs 49 lb. The latter machine is much to be preferred as being more robust, having greater overload capacity, longer life and being much easier to rig up as extremes in pulley sizes are avoided.

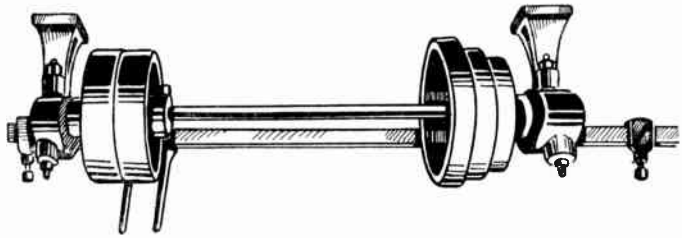

Fig. 5.—OVERHEAD FOR LATHE.
Note fast and loose pulleys on left.

Geared Motors.

The geared motors, Fig. 1 and 1A, incorporate a silent reduction gear in the same unit and a very wide range of speeds is available, from 1,000 revs. per minute of the motor to 26 revs. per minute of the shaft. For small workshop driving a shaft speed of 200 revs. would be the most suitable, and then the pulleys on the shaft of the motor and the main shaft would be of equal size giving the maximum amount of belt contact surface. Geared motors are, however, relatively expensive, $\frac{1}{2}$ h.p. motor costing £12, as against £6. 15s. for a plain motor.

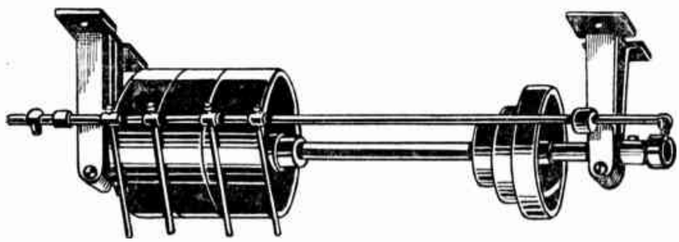

Fig. 6.—COUNTERSHAFT WITH EXTRA LOOSE PULLEY FOR SECOND SPEED OR REVERSE BELT. CENTRE PULLEY IS THE FAST PULLEY.

Purchasing a Second-hand Electric Motor.

Electric motors can be safely purchased second-hand if bought from a reputable firm who will generally offer a six months' guarantee with any motors purchased from them.

Motors of $\frac{1}{4}$ to 1 h.p. can be purchased second-hand at from 30s. to £3. 10s., this being the cheapest form of power unit for the small shop.

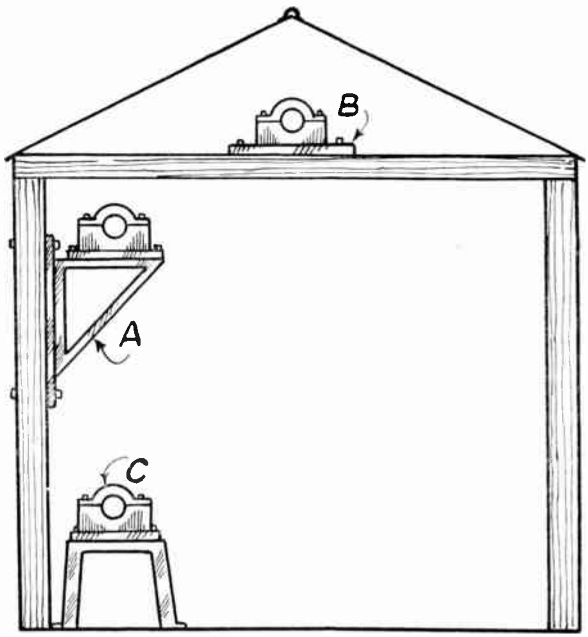

Fig. 7.—THREE ALTERNATIVE POSITIONS FOR MAIN SHAFT.
A, on wall brackets; B, on crossbeams or joists; C, on floor stands.

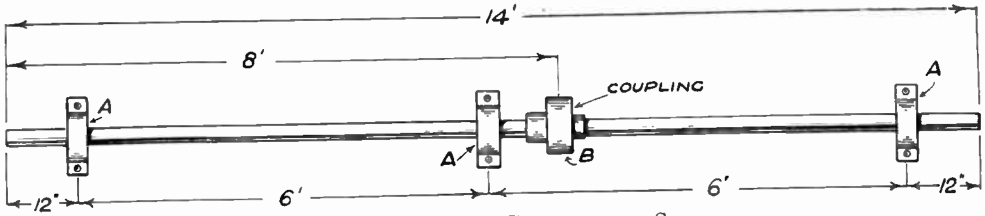

Fig. 8.—Spacing of Bearings on Shaft.
A A A, Bearings. B, Coupling.

Fig. 9A.—Wall Bracket, Showing Slot along the Top Face.

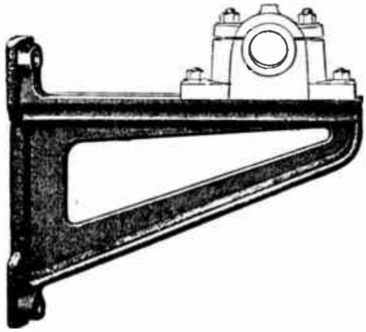

Fig. 9B.—Wall Bracket, Showing Bearings in Position.

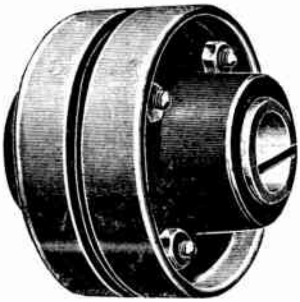

Fig. 10.—Compression Coupling for Joining Shafting.
The split bush is compressed by drawing up the two flanges by the bolts and so grips the shaft.

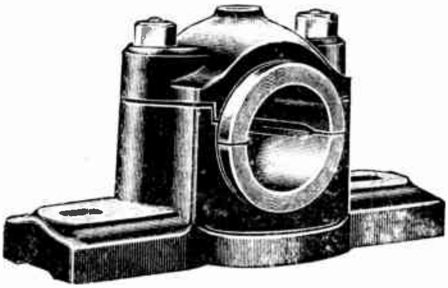

Fig. 11.—Plummer Block or Bearing.

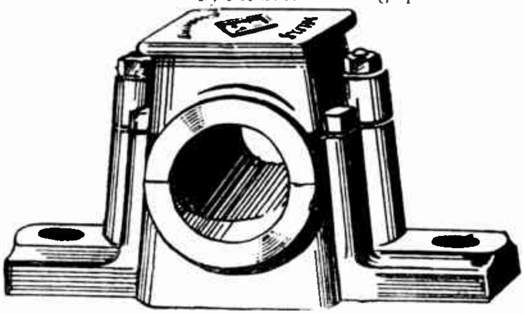

Fig. 12.—" Diamond " Plummer Block.
Box in top is filled with grease which lasts about a year without refilling.

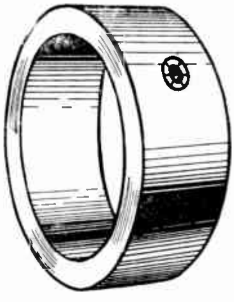

Fig. 13.—Collar for Locating Shaft.
Note setscrew to grip shaft.

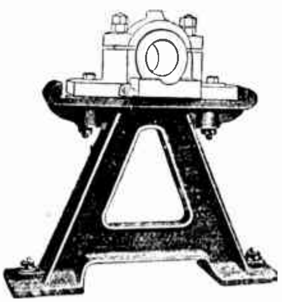

Fig. 14.—Floor Standards for Method C, Fig. 7.

Fig. 15.—Coach Screw

Adjusting the Belt Tension.

Under ½ h.p. slide rails are seldom used, but with belt drive it is necessary to have means of adjusting the belt tension and if these are not supplied with the motor a pair can easily be made up on the lines of Fig. 2A, and can be screwed down to a floor, joists, overhead beams etc., as required. For small belts it is sufficient to move the motor by hand when the holding down bolts have been slacked off, but with larger belts, say over 1½ inches wide, screw dogs are advisable and these can be made up as in Fig. 4A, the cost of the rails and the dogs only being a shilling or so. If the motor is belted directly to the machine as in Fig. 21, and has to start up a heavy fly-wheel from rest or start the machine against a part load, a repulsion start motor is advisable and these are sold by several well-known firms in fractional h.p. sizes.

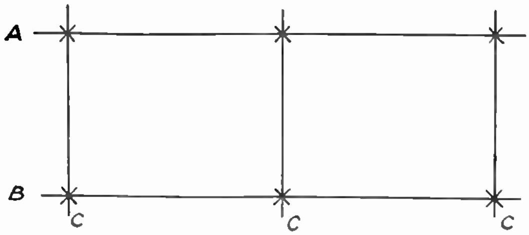

Fig. 16.—Marking Position of Wall Brackets. Lines marked on wall with a chalk line to give bolt-hole centres of wall brackets shown in Fig. 10. A and B must be level and parallel and lines C C C give position of brackets, the intersecting points giving the bolt holes.

Danger of Overloading.

Although an electric motor will stand a considerable overload without damage for a short time, it is very advisable to have the motor well master of its work, the extra cost of the motor if it is larger than generally required is not much, and the consumption of current is practically in proportion to the load, so there is no extra expense in operating the motor for periods at considerably under its full power, while repeatedly to "stall" a motor through overloading is to incur grave risk of burning it out, the cost of repair then being almost equal to a new motor.

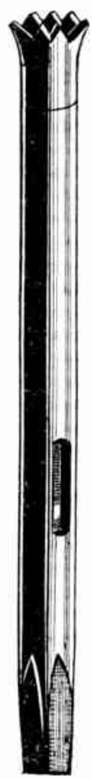

Fig. 17.—Wall Drill. This will drill a clean hole through a brick wall without breaking the plaster.

Small power motors are made by many of the leading electric plant manufacturers, while firms like the Normand Electrical Company only cater for small power and geared motors.

Reversing motors are not often required in workshop practice but are available if needed, and it should be considered before purchasing if this feature is considered necessary.

METHODS OF DRIVING.

Except in the case of single small machines, or where the plan of one motor per machine is adopted, it is always advisable to fit up a main shaft from which the machines can either be driven direct or through their overhead shafts as in the case of lathes, etc. The main shaft allows of easier arrangement of machine speeds and for several machines to be in use at once if desired, or one machine to be stopped without stopping others or the motor. Fig. 3 shows the layout of a small workshop having four machines, a lathe, drilling machine, small milling machine or circular saw, and a grinder. The grinder, saw, and drilling machine are driven direct from the main shafting as these machines have no overheads; the change speed device is usually incorporated in the drilling machine construction.

Power Driven Lathes.

Power-driven lathes are always equipped with overheads (see Fig. 5) which shows a plain overhead, but for screwcutting work it is very convenient to have a reverse, and this is obtained by fitting another pulley on the overhead shaft and using a crossed belt (see Fig. 6). Milling machines also generally have overheads, but these are identical with those used for lathes.

The Position of the Tools and Shaft.

The position of the tools will be regulated by ease of access, light, etc., but when this has been arrived at the position of the main shaft can be settled. Here again the construction of the building forming the workshop will to some extent regulate the position of the shaft. Three alternative positions are shown in Fig. 7. Of these A and B are the most convenient, as C tends to take up valuable floor space and often means putting in a countershaft, where otherwise one could be dispensed with, in order to get a drive on the machine. The cheapest to instal is B, as no brackets are required, the bearings or plummer blocks resting directly on the cross beams of the workshop.

The power transmitted by shafting is regulated by its diameter and speed. A 1½ inch diameter steel shaft at 100 revs. per minute will transmit 5 h.p.; at 200 revs., 10 h.p.; at 400 revs., 20 h.p.

Distance Between the Bearings.

Another point which must be considered is the distance between the bearings. For a 1½ inch shaft this should not be more than 6 feet to avoid spring. While a smaller diameter shaft might be adopted, it is not advisable, as 1½ inch is the smallest commercial shafting in general use, and if a smaller size is adopted there will be difficulty in getting fittings, pulleys, etc., in any variety, while the cost of say 1 inch shafting and fittings is practically the same as 1½ inch. Also, as the supports of the small workshop are seldom very rigid, the 1½ inch will not spring so much as 1 inch.

How to Purchase the Shaft.

It will be assumed, therefore, that the main shaft is to be 1½ inch diameter and will run at 200 revs. per minute, and the length as shown in Fig. 8 will be 14 feet, but any less or greater length can be adopted as desired. The bearings will be spaced as in Fig. 8, leaving 1 foot overhang on either end. Although this length could be purchased in one piece, it is not advisable, as it would be difficult to handle and install and liable to be bent in transit. Either two 7 feet lengths or one 8 feet and one 6 feet should be obtained. If bought as shafting, this should cost 1s. per foot, but if purchased as bright drawn mild steel bar, which is quite suitable for shafting in this size, it will cost less, but when ordering state that it is required for shafting, so that two dead straight lengths are obtained. For arrangement A, Fig. 7, three wall brackets will be required, Figs. 9A and 9B.

These, as will be seen, have a slot along the top face which allows the bearings to be adjusted over a considerable distance laterally. Brackets to take 1½ inch shafting and having a maximum distance from the wall to the centre of the shaft

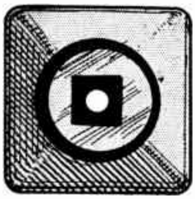

Fig. 18.—Wall Plate to go on Bolts Holding Wall Brackets.

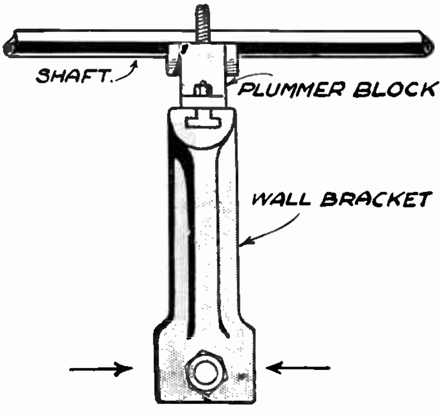

Fig. 19.—Tap Bracket in Direction of Arrows to Ensure Bearing Touching Shaft over its Whole Length.

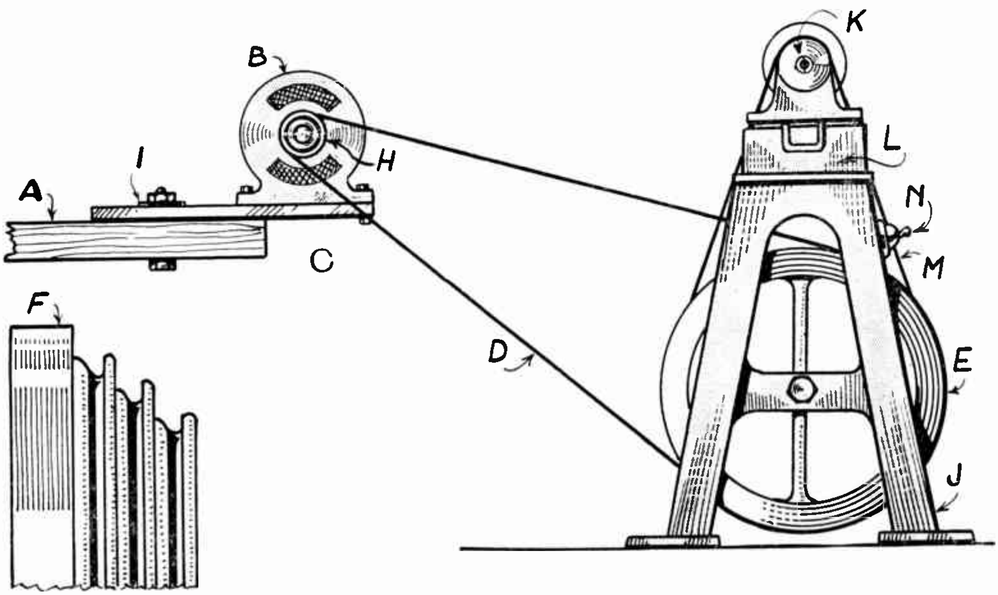

Fig. 20.—MOTOR DRIVE FOR FOOT LATHE.

Note bolt I with large washer under nut to clip motor to bench. J, Lathe standard. N, Switch. A, Bench. B, Motor. C, Hardwood board carrying motor. D, Belt from motor to lathe flywheel E. M, Lathe driving band. On the left is an enlarged view of flywheel E. The belt from the motor runs on flat rim F.

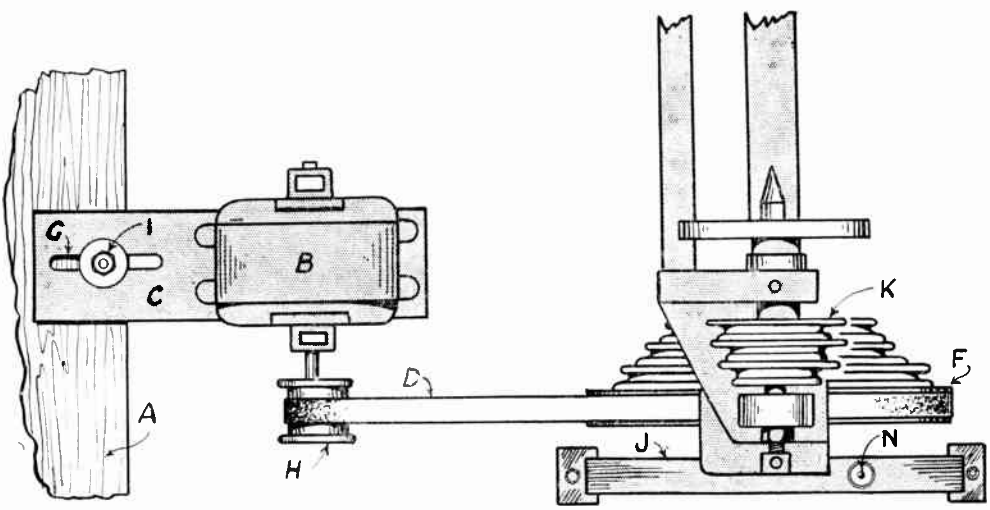

Fig. 21.—PLAN OF MOTOR DRIVE FOR FOOT LATHE.

Note slot G in board C, allowing it to be adjusted in or out to tighten belt. H, Motor pulley. K, Lathe headstock. L, Lathebed.

of 13 inches cost about 10s. each, but can generally be purchased secondhand for much less. Plummer blocks, Fig. 11, for these brackets cost 4s. each, but there are many varieties of these blocks, a good one being the Diamond, Fig. 12, which, if filled with grease, requires no further attention for a year or more; the advantage of grease is that it does not run or drip and make a mess.

Completing the Main Shaft.

To complete the main shaft a coupling, Fig. 10, is required and two set collars, Fig. 13, to locate the shaft in the bearings. The coupling shown is known as a "Compression" coupling, it requires no keys or fitting, the split bush is conical on its outside diameter, and tightening up the bolts of the flanges grips this sleeve on the shaft. The couplings cost 10s. each, the collars, Fig. 13, 1s. each. For method C, Fig. 8, the items required are the same, except that the wall brackets, Fig. 9B, are replaced with floor standards, Fig. 14, the cost of these being the same as the brackets. If method B is adopted, no brackets or standards will be required, the plummer blocks, Fig. 11, being simply screwed to the beams with coach screws, Fig. 15. Plain cast-iron bearings called "dead eyes" can be used in this method to still further reduce the cost, these being about 3s. each, but they cannot be used with the brackets or standards in Figs. 9B or 14.

Erecting the Shaft.

To erect the shaft: Stretch a line on the wall to give the level of the top bolt holes in Fig. 9B. By a spirit-level see that this line is quite level, and then at the distance of the other bolt holes, stretch another line below it, Fig. 16. Mark the position of the brackets and with a plumb bob mark both holes on the wall at the places where the plumb line crosses C, Fig. 16.

Drilling a Hole Through the Wall.

Then with a wall drill, Fig. 17, the size known as ½ inch by 18 inches, price about 2s., drill a clean hole through the wall where marked. Hit the drill lightly, turning it all the time, and the hole will be made without even disturbing the plaster. Suitable length ½-inch bolts can be purchased at any ironmongers, also a large square washer to go on the other end to the bracket, or special cast-iron plates can be used if desired, Fig. 18. These cost 1s. each. Mount the brackets on the bolts but do not bolt up tightly. Put on the plummer blocks, leaving the caps off and lay the shafting in the blocks, do not bolt the blocks down to the brackets yet.

Fig. 22.—Grooved Pulley for Motor Shaft if a Round Belt is Used.
These can be bought from 1½ in. to 9 in. dia. with various size bores.

Testing the Shaft With a Spirit Level.

With a spirit level test the shafting for truth, turning it round by hand once or twice and again testing. Adjust by tapping the brackets up or down on the wall until it is dead level. Tighten the brackets on the wall and again test. Put a little blacklead mixed with oil on the shaft in the bearing and turn. See that the bearing is marked equally all along its length, if not, tap the bracket on the wall to the right or left at the bottom as required, Fig. 19, and again tighten.

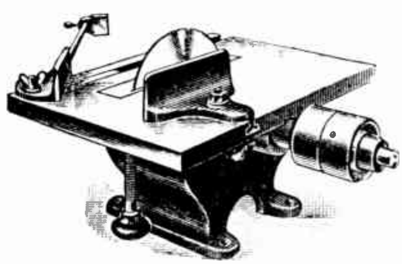

Fig. 23.—Small Bench Circular Saw with 6-in. Diam. Saw, Spindle on Ball-bearings.
Will cut wood to 2 in. thick.

Final Adjustments.

For the final fine adjustment strips of paper may be used between the plummer block sole and the bracket face, as the surface of a brick wall is not usually very accurate. When the shafting is quite true put on the caps of the plummer blocks and bolt up, and test that the shaft is quite free to turn by the hand. Put the set collars, Fig. 13, on either end to prevent the shaft moving endways and see that the flange coupling is screwed tight up. The same rules apply for methods B and C, apart from drilling holes in the wall. The floor stands are generally screwed down to the joists with coach screws, Fig. 15.

Fixing the Position of the Motor.

The main shafting now being up, the other countershafts and tools can be set from it. First fix the position of the motor. Allow as long as possible for the belt-drive, short belt-drives are not very satisfactory. Taking the speed of the main shaft at 200 revs., it will be quite easy to work out by the rule given the sizes of pulleys which will be required to drive each machine at its correct speed. Where only one machine has to be driven, or in the case of one motor to each machine, the matter becomes much simpler. Taking the case of a small lathe, say a $3\frac{1}{2}$-inch Drummond or similar, the drive can be arranged as shown in Fig. 20.

Mounting the Motor.

The motor is mounted on a hardwood board wide enough to take the feet or bolt lugs. This board is clamped to the bench by a bolt passing through it and the bench, a long slot being provided in the board to allow for adjustment of the belt. A large diameter washer should be fitted to the bolt to bear on the board. The projection of the board from the bench allows the belt to clear the edge of the bench as shown. Most of these small treadle lathes have a flywheel which resembles that shown in E, Fig. 20, and the belt from the motor can be arranged to run on the flat part of the wheel. If this is absent, a round belt can be used, a suitable pulley such as Fig. 22 being fitted on the motor and one of the grooves in the flywheel being used for the drive. The treadle motion will, of course, be disconnected while the motor is in use.

When the Motor is Not in Use.

When the motor is not in use, by taking off the belt and slackening out the holding bolt, the board with the motor can be swung round on the bench out of the way, or used for some other drive. These motors generally have no starter, but start

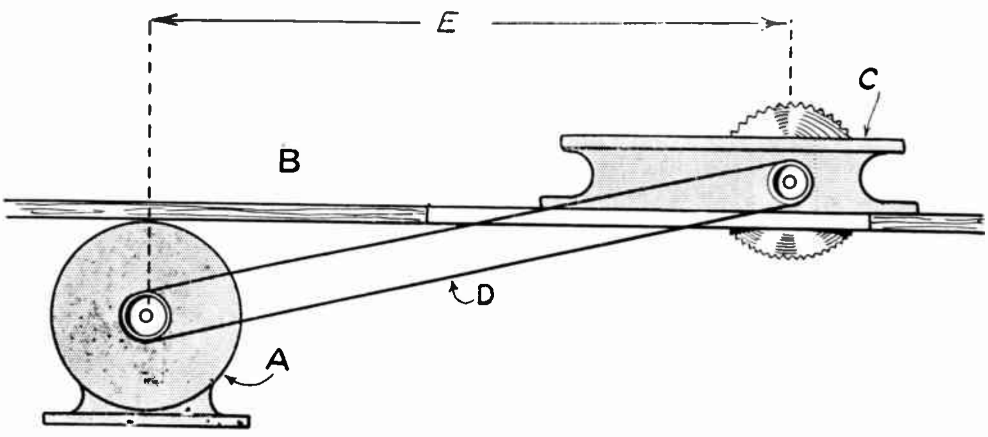

Fig. 24.—Drive of Saw Bench.
Motor A mounted under bench. B, Bench. C, Saw bench. D, Belt driving through slot in bench. A detachable wood case should be made to cover belt where it passes above bench. The distance E should be as long as possible, not less than 3 feet.

straight from the switch, so a convenient place for the switch is on the lathe standard as shown on X, Fig. 20.

What to Do when Starting the Motor.

If the lathe belt is given a slight pull when switching on, it greatly reduces the starting effort of the motor. For lathes and similar machines, small motors are sold fitted with clutches

The motor is fitted as in Fig. 20, or it can be fixed permanently under the bench if desired, and the clutch connected with a foot pedal. When the motor is started with a tumbler switch it runs continuously. By depressing the pedal a brake is released and the motor pulley revolves. By releasing the pedal, the pulley and the machine it is driving stops. By this means perfect control is obtained. A ¼-h.p. motor of this type runs at 2,000 revs. and is fitted with a 2-inch grooved pulley and costs, new, about £7 10s. A small bench type circular saw such as shown in Fig. 23 is a very useful tool for those who do a considerable amount of wood-working, or it can be used to saw vulcanite or thin brass plate, etc. It is usually fitted with a 6-inch diameter saw and will cut up to 2-inch wood.

Regulating the Power.

The power required by a circular saw is largely regulated by the way the work is fed. If it is fed easily, a ¼-h.p. motor would suffice, but if a greater output is required a ½-h.p. motor must be fitted. It is essential that the belt should be clear of all work or the usefulness of the saw will be greatly restricted. For this reason the saw should be under driven as shown in Fig. 24 To get a reasonably long drive the motor must be put some distance from the saw. In this case the motor is fitted with a wide flat-face pulley, about 25 per cent. over twice the belt width, to allow the belt to run on either the fast or loose pulleys on the saw spindle. The belt switching gear can be foot-operated if desired, and leaves the hands free. A sloping wood box or belt race made to lift off for access to the belt and pulleys should be fitted to keep the belt clear from saw-dust, etc. (see Fig. 24).

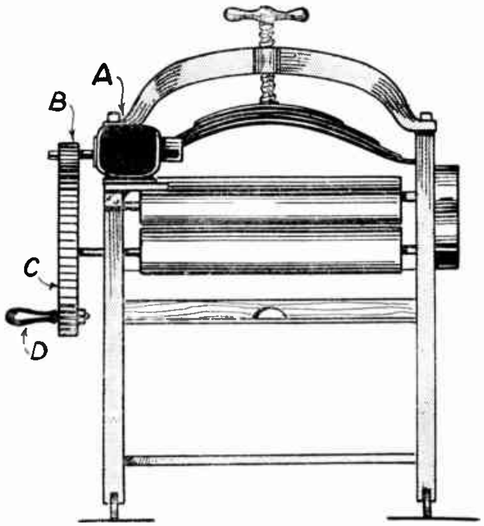

Fig. 25.—MOTOR DRIVE FOR DOMESTIC WRINGER.

Motor A is fixed on a bracket at rear of wringer and drives by pinion B on to fly-wheel C which has teeth cut on rim. Handle D is removed when the motor is in use. A guard must be fitted over gear wheels.

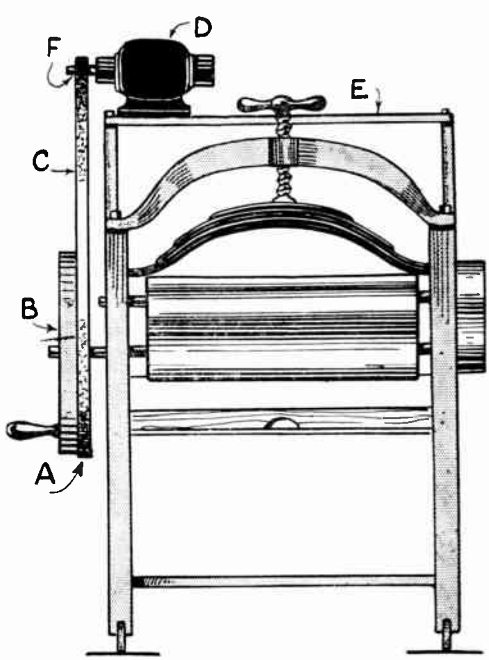

Fig. 26.—A, V-belt pulley clipped to flywheel B. C, V-belt, ¾ in. D, motor mounted on frame E, bolted to frame of wringer. F, small V-pulley on motor.

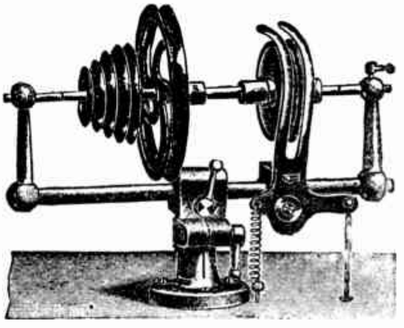

Fig. 27.—SMALL COUNTERSHAFT TO FIX ON BENCH.

Fast and loose pulleys on right. Note that striking gear is foot controlled. (*George Adams.*)

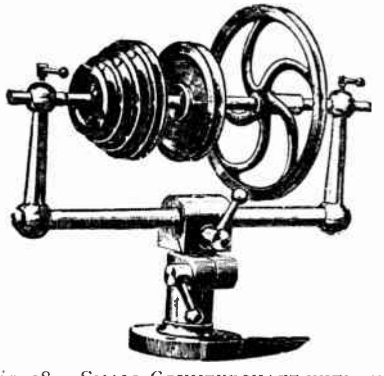

Fig. 28.—SMALL COUNTERSHAFT WITHOUT FAST AND LOOSE PULLEYS.

Arranged to swing over for tightening belts.

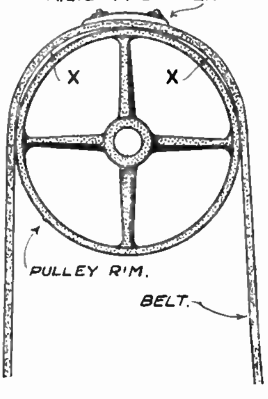

Fig. 29.—RIGID TYPE BELT FASTENER.

Note gaps X X between belt and rim. Belt will break at ends of fastener, which shows unsuitability of rigid fasteners for small diameter pulleys.

Driving a Mangle or Wringer.

A machine which it is often desired to drive, though not usually found in workshops, is the domestic mangle or wringer. The best way to drive this is by gearing. The speed of the wringer spindle should be about 100 revs. per minute. Assuming that the motor runs at 1,000 revs., a reduction of 10 to 1 is required. The motor can be fixed on a bracket at the back of the wringer, as shown in Fig. 25, and a ¼-h.p. reversing motor will be required.

Using a Pedal-operated Switch.

The motor *must* be controlled by a pedal operated switch so arranged that the motor stops when the foot is removed. This is essential to avoid accidents, as if the fingers were caught in the rollers, it would be impossible to operate a hand-controlled switch. A motor fitted with a foot-controlled clutch can be used if desired, and is described elsewhere.

The flywheel of the wringer should be removed and sent to Messrs. Greenwood Bros., of Halifax, who will turn it up and cut the teeth round the rim and also supply a pinion for the motor to give the correct speed reduction. The cost of this will be a few shillings.

If silence is essential, a raw hide pinion can be fitted to the motor at a slight extra cost. Sometimes standard gear wheels are obtainable and, if so, it will be cheaper to use these than to have the flywheel cut. A pitch of not finer than 10 diametral should be used, that is, 10 teeth to 1-inch diameter of pitch line, so from this the diameter of the two wheels will be easily ascertained. The width of the teeth should not be less than ¾ inch. Another method, used successfully for some years, is shown in Fig. 26. A motor cycle V belt rim to take a ¾-inch wide belt was clamped to the flywheel of the wringer. The motor was mounted on a wood platform above the wringer, giving clearance under it for the roller adjusting screw, and a small V pulley was fitted to the motor; the speed reduction in this case was 7 to 1. The same remarks regarding foot-control apply in this case also.

For driving odd machines about the workshop, small self-contained countershafts are very useful. Fig. 27 shows one of these, and it will be noted that fast and loose pulleys with switching gear for the belt are fitted, with a cone pulley having several speeds for round belts and a single groove round belt pulley. A clip on the standard allows the pillar carrying the countershaft to be raised or lowered in height and also to be swung over to tension the belts. A model without fast and loose pulleys is shown in Fig. 28, the motor driving on to the big grooved pulley on the right. This countershaft is also adjustable in both directions. For the amount of work in them the prices are low, Fig. 28 costing £1 only, Fig. 27, 30s. The striker of Fig. 27 can be arranged to work by a foot-pedal, the spring shown pulling the belt on to the loose pulley when the pedal is released.

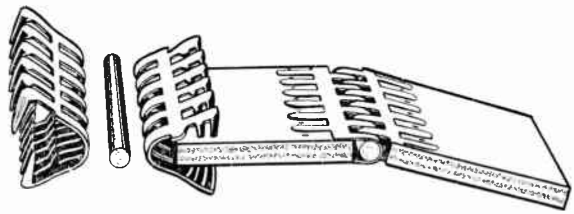

Fig. 30.—ALLIGATOR TYPE BELT FASTENER.
The belt can adapt itself to any size of pulley. The fastener is simply hammered through the belt and clinched over.

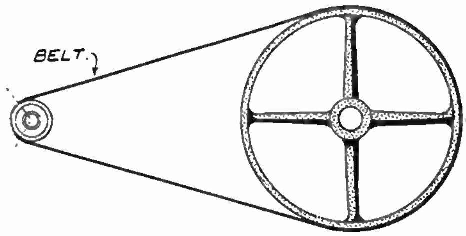

Fig. 31.—OPEN BELT DRIVE.
The slack side of the belt should be at the top. This method is suitable if the pulleys are nearly the same diameter or spaced a good distance apart.

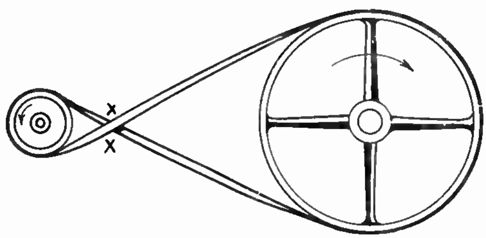

Fig. 32.—CROSSED BELT DRIVE.
If centres of the shafts are close together the friction of the belt at the point of crossing is extreme.

TRANSMITTING THE POWER.

For transmitting the power from the motor to the machines, belt drive is almost invariably used. Providing certain simple rules are adhered to, belt driving is a very satisfactory method of transmitting power, but neglect of these rules will involve endless trouble being experienced.

Make Sure the Belt is of Ample Size.

The first point is to be sure that the belt is of ample size for the work it has to do. An overstressed belt will slip, run off the pulleys, or if repeatedly tightened will cause great friction in the bearings and probably break. The power a belt will transmit is determined by its width and speed in feet per minute. A single leather belt 1 inch wide will transmit 1 h.p. at a belt speed of 800 feet per minute. At 1,600 feet it will transmit 2 h.p. A 2-inch wide single leather belt will transmit double these powers and a 4-inch wide belt four times. Assuming that a 1 h.p. motor is installed, running at 1,000 revs. per minute, and the belt pulley is $3\frac{1}{2}$-inch diameter, the speed of the belt in feet per minute will be

$$\frac{1{,}000 \times 3\frac{1}{2}\text{-inch} \times 3\frac{1}{7}}{12} = 916 \text{ feet,}$$

so that a 1-inch belt will transmit the power satisfactorily.

In practice, a considerably smaller pulley would probably be fitted to such a small power motor, perhaps only 2-inch diameter, in which case the width of the belt will have to be increased, unless the motor has a considerably higher speed than 1,000 revs. per minute. Double leather belts will transmit much more power than single, 1 h.p. for 1-inch width at a speed of 550 feet per minute. Such thick belts are, however, totally unsuitable for high-speed work on small diameter

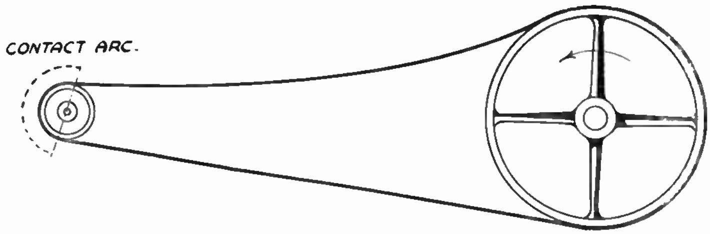

Fig. 33.—Showing same Drive as Fig. 31 but Longer Centres. Note how belt covers larger arc of small pulley.

pulleys—the belt will not fit round the small pulley unless very great tension is used and this sets up big frictional losses.

Belts for High-Speed Work.

For high-speed work with small diameter pulleys, thin, wide leather belts are best, and the next best is the belt made out of rubbered cotton fabric and sold under various names such as "Contirex," etc. This is very flexible and the rubbered surface gives good gripping power. Here again only the thinner plies should be used on small diameter pulleys, nothing over 3-ply should be used on pulleys under 6-inch diameter. The fasteners used on these belts must be of a type which does not project above either surface of the belt or an annoying tap, tap, will be set up each time the fastener passes round the pulleys.

Some fasteners are also not flexible enough to adapt themselves to the small radius of the motor pulley and cause breaking of the belt at the fastener (see Fig. 29). The fastener known as the "Alligator" can be got suitable for belts of all widths and plies, and makes a very good job, the hinge pin allowing it to adapt itself to the pulley, however small its diameter, Fig. 30. By pulling out the pin, the belt can be slipped off the shafts if desired. Having dealt with the belt and its fastener the next thing is the length of the drive. This should be as long as possible within reason.

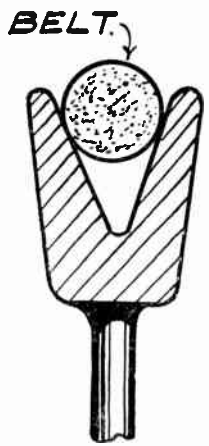

Fig. 34.—Section of a V Groove Pulley for Round Belts.

Note that the belt must not "bottom" in the groove.

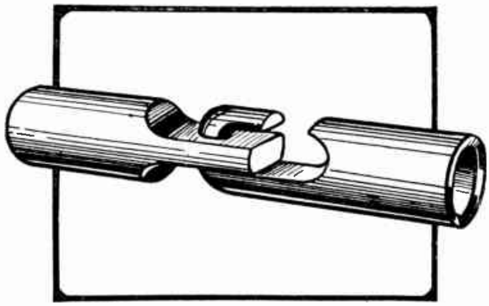

Fig. 35a.—Hook and Eye Fastener for Round Belts.

The fasteners are screwed on to the ends of the belt.

Belts Used on Pulleys.

Belts used on pulleys of considerable difference in diameter and short shaft centres are seldom satisfactory. Fig. 31 shows such a case, and it will be seen what a small arc the belt touches on the small pulley, which necessitates undue tension to enable it to transmit the power. Fig. 33 shows the same drive but with larger centres, and it will be seen that the slack side of the belt automatically increases the contact surface and provides the tension. The underside of any drive should be the tight or power side in an "open" drive, that is, not crossed.

Crossed Belts.

Circumstances often necessitate the use of a crossed belt to reverse the direction of rotation, and while this greatly increases the contact arc on the pulleys, it is even more necessary for the centres to be long than in the case of an open drive. Fig. 32 shows a crossed belt drive, and it will be seen that if used with short centres the strain on the belt is severe and soon causes its disintegration. The distance between shaft centres with a crossed belt drive should never be less than six times the diameter of the large pulley. For powers up to $\frac{1}{2}$ h.p. round leather or gut belt gives quite satisfactory results if used on properly designed V pulleys, the belt should not bottom in the V (see Fig. 34). At one time all round belting was made from gut, but now leather has taken its place with better results, the gut was liable to be affected considerably by weather conditions.

How the Belt is Joined.

The belt is joined either by hooks and eyes, Fig. 35A, which are tapped Whitworth thread and screw on to the leather direct and give quite sufficient hold, or by wire clips, Fig. 35B, which are hammered through the ends of the belt and clinched over. If for space considerations it is desired to use other than a flat belt for powers over $\frac{1}{2}$ h.p., V belts can be obtained in various sizes to transmit up to very large powers, but can only be used with suitable pulleys. With round or V belting, short centres are not so objectionable, as the belt relies on the grip on the sides of the groove for its adhesion. For higher powers in confined spaces chain drive is often employed, the chains being of the type termed inverted tooth, and which provides a silent and positive drive.

Direct Gear Drive.

Such drives are outside the range of the small workshop, but where space is very limited a direct-gear drive may be

Fig. 35B.—ROUND WIRE FASTENERS.
The wire is put through a hole in end of belt and clinched over.

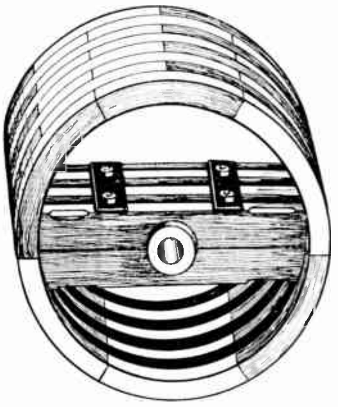

Fig. 36.—SPLIT-WOOD PULLEYS.
These are made from 3 in. to 60 in. dia. in various widths, and by loose wood bushings can be made to fit any size of shaft.

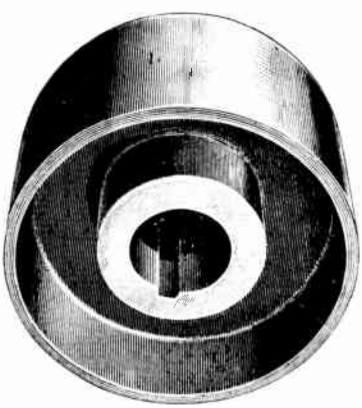

Fig. 37.—CAST IRON MOTOR PULLEY.
Note solid web to ensure balance.

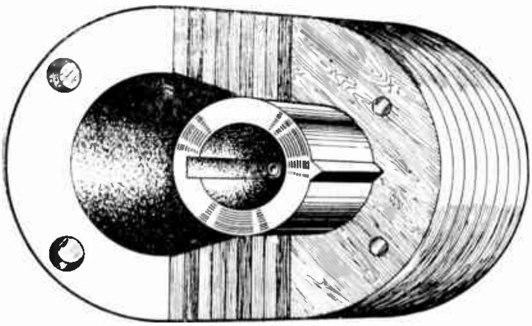

Fig. 38.—Section of Wood Motor Pulley with Iron Bush Forced in.

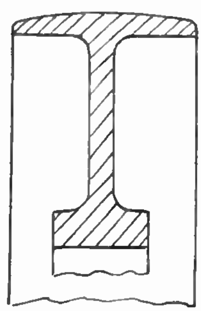

Fig. 39.—Face of Pulley "Crowned" or Rounded to Ensure Belt Keeping Evenly on Pulley.

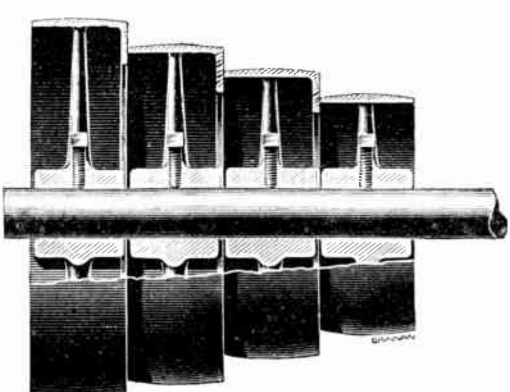

Fig. 40.—"Cone" Pulley Built up from Separate Pulleys with One Side Web.

By this means any combination of pulley sizes can be obtained. Note that all pulleys are "crowned."

employed, the motor being placed alongside the shaft and the pinion on the motor shaft gearing in direct with the spur wheel on the main shaft. For the sake of silence the pinion must be of either shrouded Bakelite or raw hide, when a perfectly silent drive will be obtained. Any desired speed reduction can be obtained in this manner by suitable ratios between the pinion and the wheel.

How to Find the Size of the Pulley Required.

In most cases belt drive will be used, and it will be necessary to arrive at the sizes of the various pulleys to give the speeds required by each machine. Taking the main-shaft speed as 200 revs. per minute and the motor at 1,000 revs. per minute, it will seen that the ratio is 5 to 1. Any size of pulleys comprising this ratio will give the correct speed, such as 2-inch on the motor and 10-inch on the shaft, or 3-inch on the motor and 15-inch on the shaft. The rule for finding the sizes of pulleys is as follows, and is useful in odd sizes, most cases being able to be worked out without it, where even speeds are involved. If the diameter of the driving pulley and number of revolutions are known, and it is desired to find what size driven pulley would give the speed required, proceed as follows: Multiply the diameter of the driving pulley by the number of revolutions, and divide by the number of revolutions required for the driven pulley. The quotient is the diameter. Example, a motor running at 700 revs. has a 3-inch diameter pulley. It is required to drive a shaft at 150 revolutions. What size pulley must be fitted to the shaft?

$$\frac{700 \times 3}{150} = 14\text{-inch diameter.}$$

If the pulley diameter is inconvenient, any pair having the same ratio can be used, such as 6-inch and 28-inch, or $1\frac{1}{2}$-inch and 7-inch.

If there is a pulley on the main shaft and the speed of the shaft and the motor is known, but it is desired to know what size pulley will be required on the motor to give this speed, proceed as follows: Multiply the speed of the driven wheel

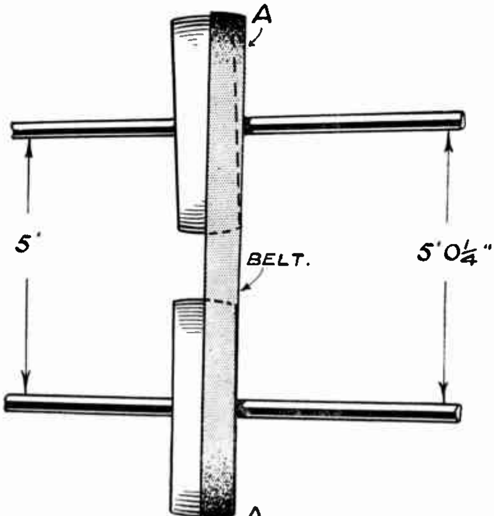

Fig. 41.—TWO SHAFTS, LEVEL BUT NOT PARALLEL.

Belt will run on high sides A A of pulleys, as shown.

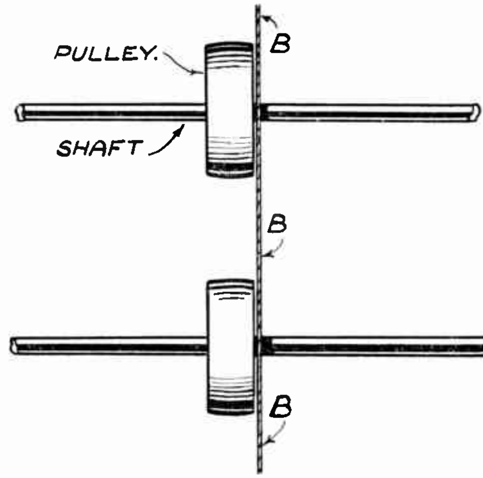

Fig. 42.—LINING UP PULLEYS.

A string B B is stretched tightly across the faces of both pulleys and must touch all four edges, if pulleys are in line.

by its revolutions and divide by the speed of the motor and the quotient will be the pulley diameter required. Example: A shaft has an 18-inch diameter pulley and runs at 250 r.p.m. The motor has a speed of 900 r.p.m. What size pulley will be required on the motor to give this speed?

$$\frac{250 \times 18}{900} = 5\text{-in. dia.}$$

Final Hints about Belts.

To sum up. Favour wide, thin belts. Use fasteners that do not project above the belt, and which will allow the belt to accommodate itself to the small pulley. Have the belt drive as long as possible. Arrange for the underside of the belt to be the driving or tight side. Avoid crossed belts as much as possible, but when used the shaft centres must not be less than six times the diameter of the large pulley apart. The best form of belt pulley for the small workshop is the split-wood pulley, Fig. 36. These can be got in almost every possible combination of diameter and width. Interchangeable split-wood bushes are provided to enable the pulleys to fit any diameter of shaft. Such pulleys are cheap, easy to fix—they are simply clipped on the shaft, they are very light and the wood face gives an excellent grip to the belt. Also, an important point for high speed work, they are well balanced.

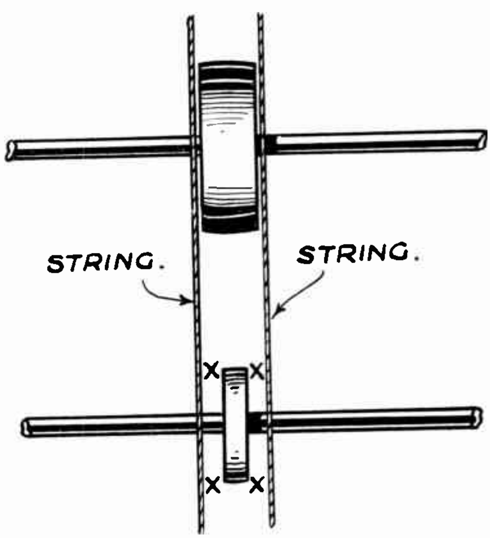

Fig. 43.—LINING UP PULLEYS OF UNEQUAL WIDTH.

The spaces X X X X between the string and edges of the narrow pulley must be equal.

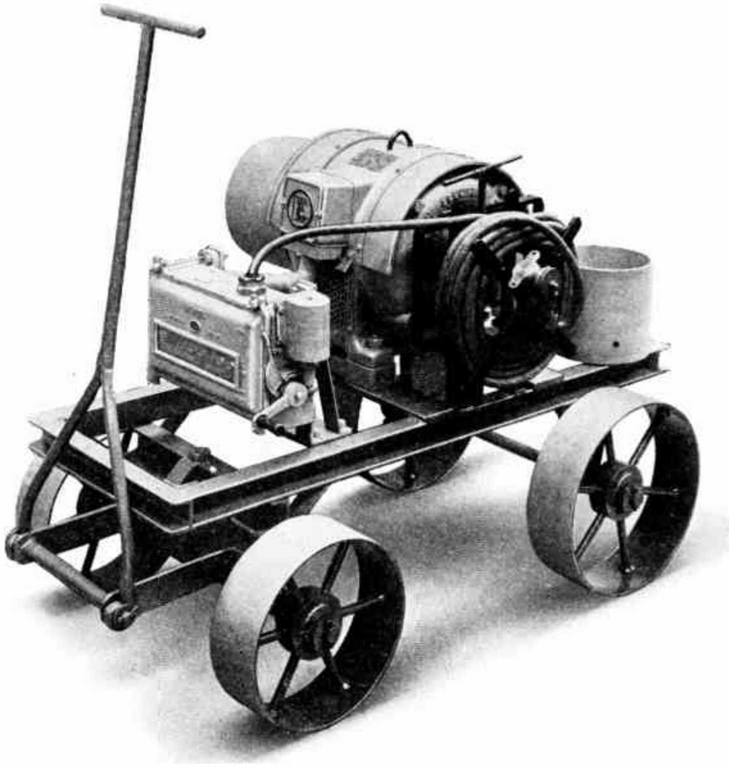

Fig. 44.—PORTABLE ELECTRIC MOTOR WITH SWITCH AND STARTER MOUNTED ON TROLLEY.
Note coil of cable at side. (*English Electric Co.*)

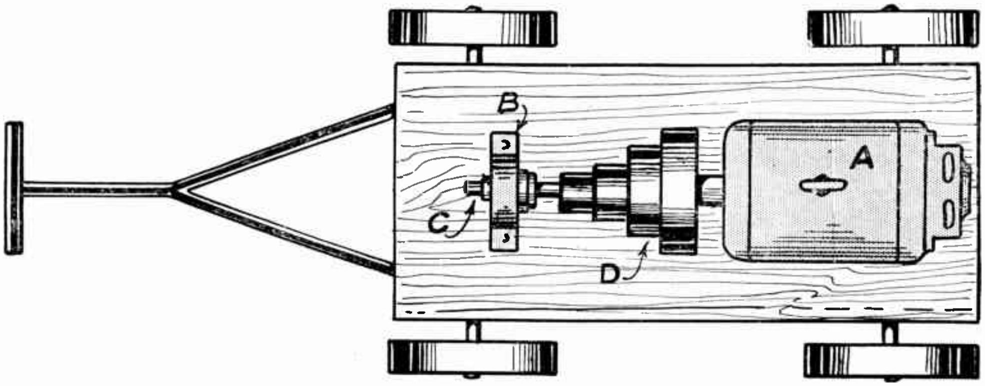

Fig. 45.—ALTERNATIVE POSITION OF MOTOR ON TRUCK,
To allow of a cone pulley being fitted. A, Motor. B, Outer bearing. C, Short length of shaft. D, Cone pulley.

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Printed in Great Britain for the Proprietors, GEORGE NEWNES, LTD., 8-11, Southampton Street, Strand, W.C. 2, by WILLIAMS, LEA & Co., LTD., Clifton House, Worship Street, E.C. 2. Sole Agents: Australasia: GORDON & GOTCH (Australasia), LTD. South Africa: CENTRAL NEWS AGENCY, LTD.