SIMPLE ELECTRIC MOTOR.

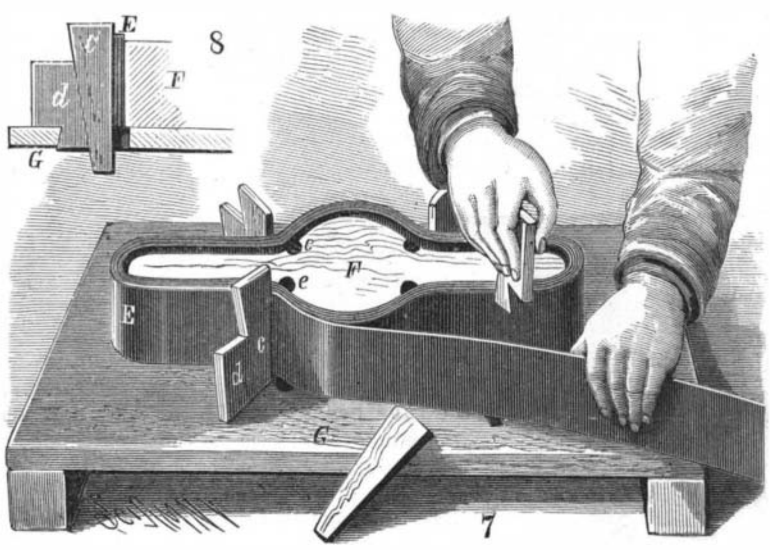
BY GEO. M. HOPKINS.

It is generally understood that an efficient electric motor cannot be made without the use of machinery and fine tools. It is also believed that the expense of patterns, castings, and materials of various kinds required in the construction of a good electric motor is considerable. The little motor shown in the engravings was devised and constructed with a view to assisting amateurs and beginners in electricity to make a motor which might be driven to advantage by a current derived from a battery, and which would have sufficient power to operate an ordinary foot lathe or any light machinery requiring not over one man power.

The only machine work required in the construction of the motor illustrated is the turning of the wooden support for the armature ring. The materials cost less than four dollars, and the labor is not great, although some of the operations, such as winding the armature and field magnet, require some time and considerable patience. On the whole, however, it is a very easy machine to make, and if carefully constructed will certainly give satisfaction.

Only such materials as may be procured anywhere are required. No patterns or castings are needed.

Beginning with the armature, a wooden spool, A (Fig. 2), should be made of sufficient size to receive the soft iron wire of which the core of the armature is formed. The wire, before winding, should be varnished with shellac and allowed to dry, and the surface of the spool on which the wire is wound should be covered with paper to prevent the sticking of the varnish when the wire is heated, as will presently be described. The size of the iron wire is No. 18 American wire gauge. The spool is 2$\frac{3}{16}$ inches in diameter in the smaller part and 2 inches in length between the flanges. It is divided at the center and fastened together by screws. Each part is tapered slightly to facilitate its removal from the wire ring. The wire is wound on the spool to a depth of $\frac{3}{8}$ inch. It should be wound in even layers, and when the winding is complete the spool and its contents should be placed in a hot oven and allowed to remain until the shellac melts and the convolutions of wire are cemented together. After cooling, the iron wire ring, B, is withdrawn from the spool, and covered with a single thickness of adhesive tape, to insure insulation.



Figs. 7 & 8.—FORMING THE FIELD MAGNET.

The ring is now spaced off into twelve equal divisions, and lines are drawn around the ring transversely, dividing it into twelve equal segments, as shown in Fig. 3. Two wedge-shaped pieces, C, of hard wood are notched and fitted to the ring so as to inclose a space in which to wind the coil. This coil consists of No. 16 cotton-covered copper magnet wire, four layers deep, each layer having eight convolutions. The end, *a*, and the beginning, *b*, of the winding terminate on the same side of the coil. The last layer of wire should be wound over two or three strands of shoe thread, which should be tied after the coil is complete, thus binding the wires together. When the first section of the winding is finished, the wire is cut off and the ends (about two inches in length) are twisted together to cause the coil to retain its shape. After the completion of the first section, one of the pieces, C, is moved to a new position and the second section is proceeded with, and so on until the twelve sections are wound. The coils of the ring are then varnished with thin shellac varnish, the varnish being allowed to soak into the interior of the coils. Finally the ring is allowed to remain in a warm place until the varnish is thoroughly dry and hard.

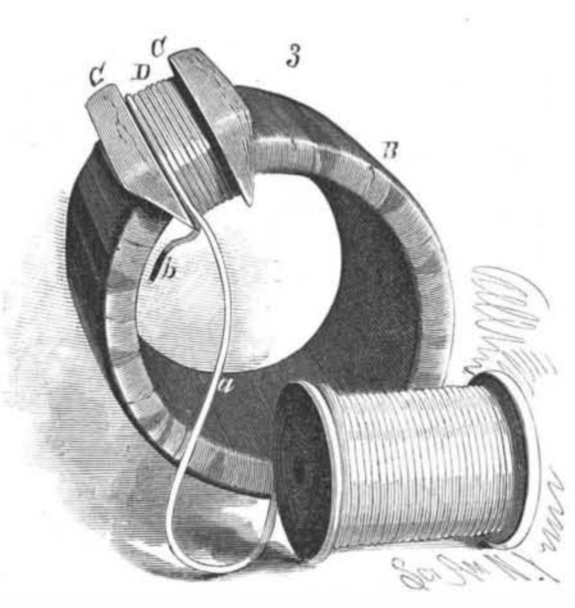


Fig. 3.—WINDING THE ARMATURE.

Care should be taken to wind all of the coils in the same direction and to have the same number of convolutions in each coil. A convenient way of carrying the wire through and around the ring is to wind upon a small ordinary spool enough wire for a single section, using the spool as a shuttle.

The ring is mounted upon a wood support or hub, G, and is held in place by the wooden collar, H, both hub and collar being provided with a concave flange for receiving the inner edges of the ring. The collar, H, is fastened to the end of the hub, G, by ordinary brass wood screws. Both hub and collar are mounted on a $\frac{3}{32}$ steel shaft formed of Stubs' wire, which needs no turning. A pulley is formed integrally with the collar, H. The end of the hub, G, which is provided with a flange, is prolonged to form the commutator, and the terminals, *a b*, of the ring coils are arranged along the surface of the hub and inserted in radial holes drilled in the hub in pairs. The wires are arranged so that one hole of each pair receives the outer end of one coil and the other hole receives the inner end of the next coil, the extremities of the wire being scraped before insertion in the holes. The distance between the holes of each pair is sufficient to allow a brass wood screw to enter the end of the hub, G, and form an electrical contact with both wires of the pair, as shown in Fig. 4.

There being twelve armature sections and twelve pairs of terminals, there will of course be required a corresponding number of brass screws. These screws are inserted in the end of the hub, G, so as to come exactly even with the end of the hub. This completes the armature and the commutator.

Before proceeding to mount the armature shaft in journal boxes, it will be necessary to construct the field magnet, as the machine must, to some extent at least, be made by "rule of thumb."

The body, E, of the field magnet consists of strips of Russia iron, such as is used in the manufacture of stoves and stove pipe. The strips are 2½ inches wide, their combined length being sufficient to build up a magnet core seven-sixteenths inch thick, of the form shown. The motor illustrated has 15 layers of iron in the magnet, each requiring about 26 inches of iron, approximately 33 feet altogether.

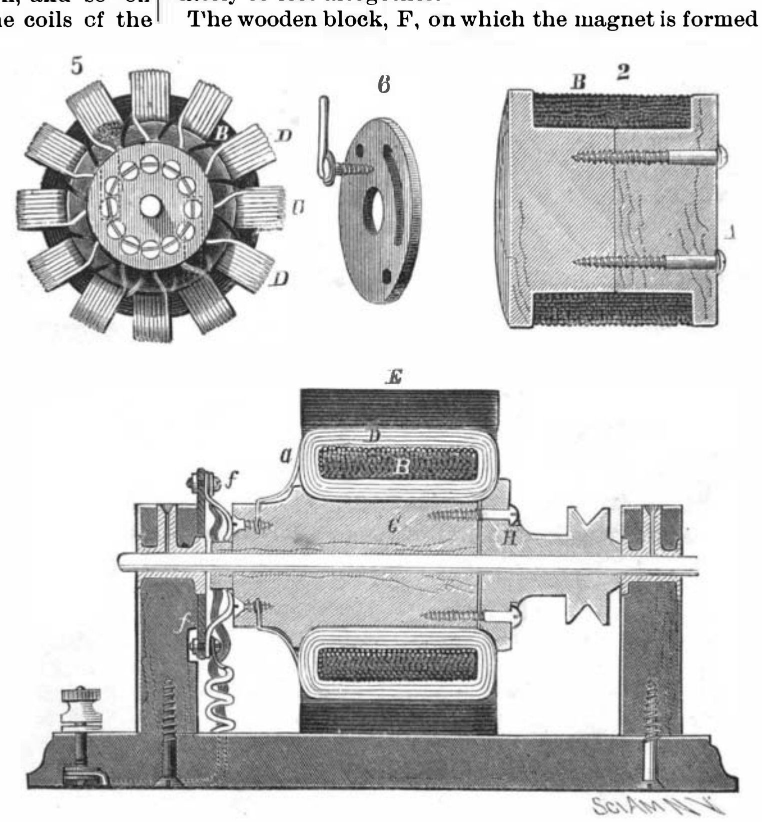


Fig. 2.—ARMATURE CORE. Fig. 4.—TRANSVERSE SECTION. Fig. 5.—END VIEW OF ARMATURE, SHOWING COMMUTATOR. Fig. 6.—BRUSH-HOLDING DISK.

The wooden block, F, on which the magnet is formed is secured to a base board, G, as shown in Fig. 7, and grooves are made in the edges of the block, and corresponding holes are formed in the base to receive wires for temporarily binding the iron strips together. Opposite each angle of the block, F, mortises are made in the base board, G, to receive the keys, *d*, and wedges, *c*. Each key, *d*, is retained in its mortise by a dovetail as shown in Fig. 8. By this arrangement, each layer of the strip of iron may be held in position, as the formation of the magnet proceeds, the several keys, *d*, and wedges, *c*, being removed and replaced in succession as the iron strip is carried around the block, F. When the magnet has reached the required thickness, the wedges, *c*, are forced down so as to hold the iron firmly, then the layers of iron are closely bound together by iron binding wire wound around the magnet thro' the grooves, *e*, and holes in the base board, G.

The next step in the construction of the machine is the winding of the field magnet. To insure the insulation of the magnet wire from the iron core of the magnet, the latter is

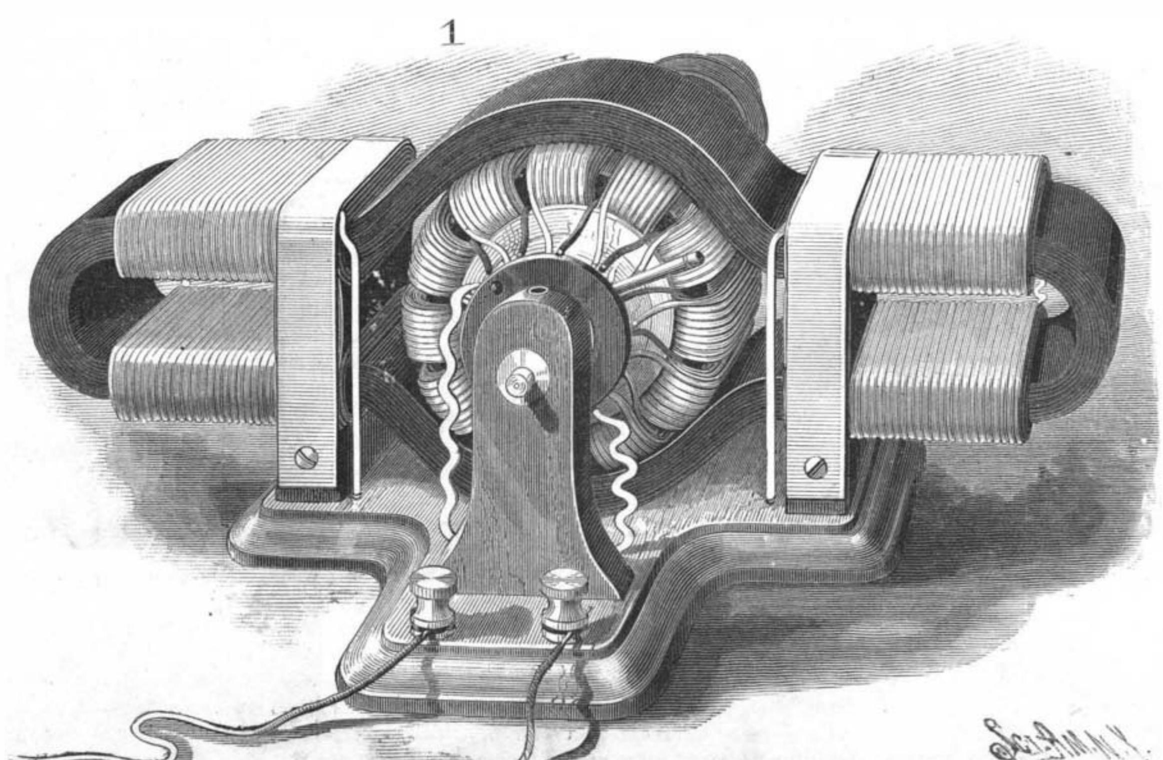


Fig. 1.—SIMPLE ELECTRIC MOTOR (ABOUT HALF SIZE).

covered upon the parts to be wound by adhesive tape or by cotton cloth attached by means of shellac varnish.

The direction of winding is clearly shown in Fig. 9. Five layers of No. 16 magnet wire are wound upon each section of the magnet, the winding of sections 1 and 2 being oppositely arranged with respect to each other. In like manner the winding sections 3 and 4 are oppositely arranged. The winding of section 1 is also opposite to that of 3, and that of 2 is opposite to that of 4. The winding begins at the outer end of the magnet, and ends at the inner end of the section. When the winding is completed, the temporary binding is removed. The outer ends of 1 and 2 are connected together, and the outer ends of 3 and 4 are connected. The inner ends of 2 and 4 are connected. The inner end of 3 is to be connected with the commutator brush, *f*. The inner end of 1 is to be connected with the binding post *g'*, and the binding post, *g*, is to be connected with the commutator brush, *f'*.

The field magnet is now placed upon a base having blocks of suitable height to support it in a horizontal position. A block is placed between the coils to prevent the top of the magnet from drawing down upon the armature, and the magnet is secured in place by brass straps, as shown in Fig. 1.

The armature is wrapped with three or four thicknesses of heavy paper, and inserted in the wider part of the field magnet, the paper serving to center the armature in the magnet. The armature shaft is leveled, and arranged at right angles with the field magnet. The posts in which the armature shaft is journaled are bored transversely larger than the shaft, and a hole is bored from the top downward, so as to communicate with the transverse hole. To prevent the binding of the journal boxes, the exposed ends of armature shaft are covered with a thin wash of pure clay and allowed to dry. The posts are secured to the base, with the ends of the armature shaft received in the transverse holes. Washers of pasteboard are placed upon the shaft on opposite sides of the posts, to confine the melted metal, which is to form the journal boxes. Babbitt metal, or, in its absence, type metal, is melted and poured into the space around the shaft through the vertical hole in the post. The journal boxes thus formed are each provided with an oil hole, extending from the top of the post downward. If, after cleaning

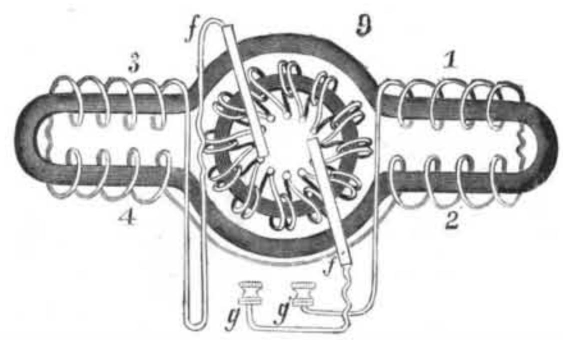


Fig. 9.—CIRCUIT OF SIMPLE ELECTRIC MOTOR.

and oiling the boxes, the shaft does not turn freely, the boxes should be reamed or scraped until the desired freedom is secured.

All that is now required to complete the motor is the commutator brushes, *f f*. They each consist of three or four strips of thin hard rolled copper curved as shown in Fig. 4, to cause them to bear upon the screws in the end of the hub, G. The brushes are secured by small bolts to a disk of vulcanized fiber, or vulcanite, at diametrically opposite points, as shown in dotted lines in Fig. 5, and the brushes are arranged in the direction of the rotation of the armature. In the brush-carrying disk is formed a curved slot for receiving a screw, shown in Fig. 6, which passes through the slot into the post and serves to bind the disk in any position. The disk is mounted on a boss projecting from the inner side of the post concentric with the armature shaft. The brushes are connected up by means of flexible cord as shown in Figs. 1 and 9. The most favorable position for the brushes may soon be found after applying the current to the motor. The ends of both brushes will lie approximately in the same horizontal plane. When the motor is in operation the direction of the current in the conductor of the field magnet is such as to produce consequent poles above and below the armature.

Eight cells of plunging bichromate battery, each having one zinc plate 5 × 7 inches, and two carbon plates of the same size, will develop sufficient power in the motor to run an ordinary foot lathe or two or three sewing machines.

The dimensions of the parts of the motor are tabulated below:

Length of field magnet (inside)	10½ in.
Internal diameter of polar section of magnet	3⅝ "
Width of magnet core	2½ "
No. of layers of wire to each coil of magnet	5
No. of convolutions in each layer	34
Length of wire in each coil (approximate)	95 feet.
Size of wire, Am. W. G.	No. 16
Outside diameter of armature	3½ in.
Inside diameter of armature core	2 3/16 "
Thickness " " "	⅜ "
Width " " "	2 "
" " " wound	2½ "
No. of coils on armature	12
No. of layers in each coil	4
No. of convolutions in each layer	8
Length of wire in each armature coil (approximate)	30 feet.
Size of wire on armature, Am. W. G	No. 16
Length of armature shaft	7¼ in.
Diameter of armature shaft	9/32 "
" " wooden hub	1¾ "
Distance between standards	5⅜ "
Total weight of wire in armature and field magnet	6 lb.

THE LOCKS OF THE PANAMA CANAL.

We illustrate herewith the new system of locks devised by Mr. Eiffel for use on the Panama canal.

The gates (Figs. 1 and 2) consist essentially of a hollow, balanced, movable caisson, capable of sliding above at right angles with the axis of the canal, on a track carried above the canal by a revolving bridge. This track is prolonged above the lateral chamber. The motion is analogous to that of the doors which slide at the top that are generally used in locomotive shops. When the flood gate is placed in the chamber,

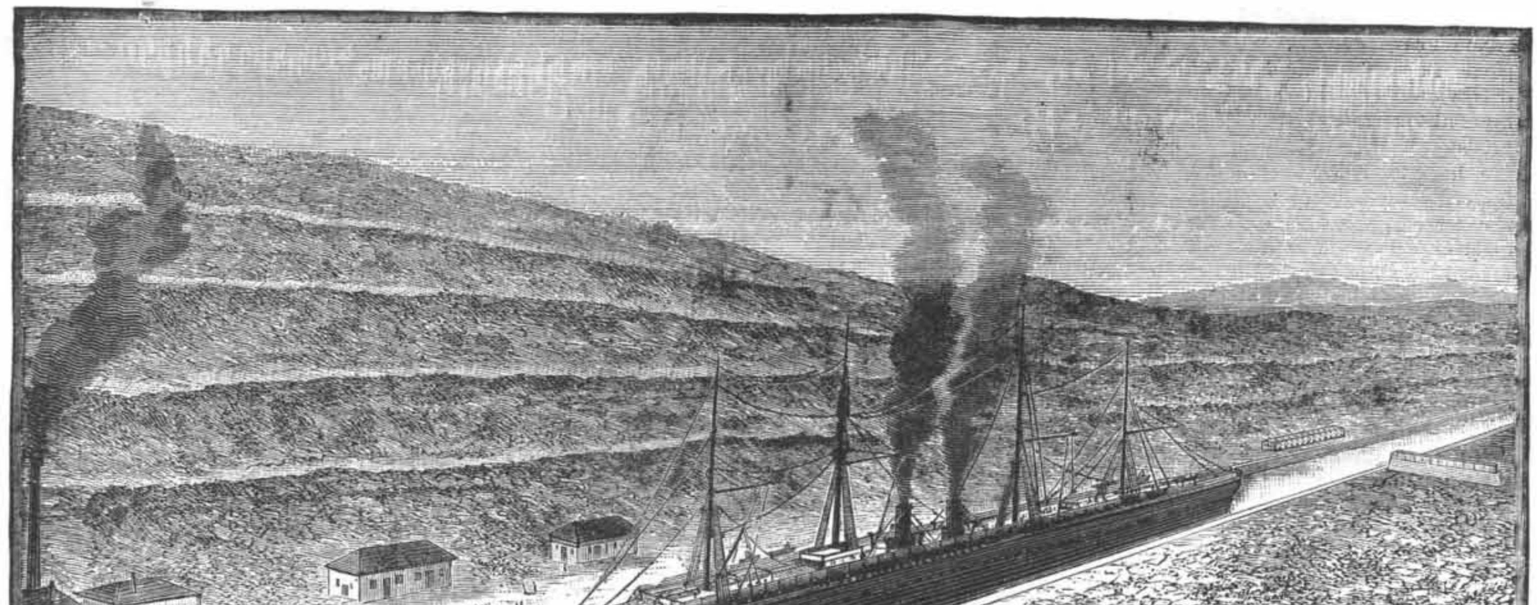


Fig. 1. LOCKS OF THE PANAMA CANAL FLOOD GATE OF 11 METERS FALL.