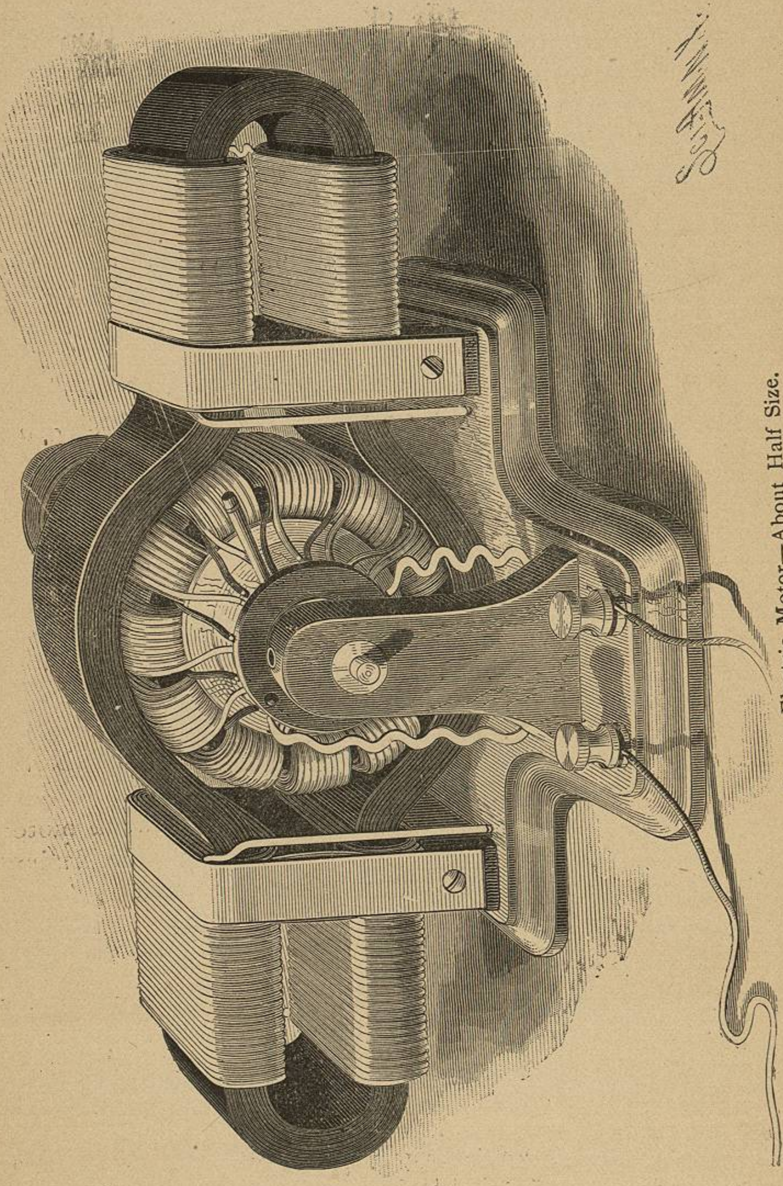


Fig. 485.

Simple Electric Motor—About Half Size.

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

Fig. 489.

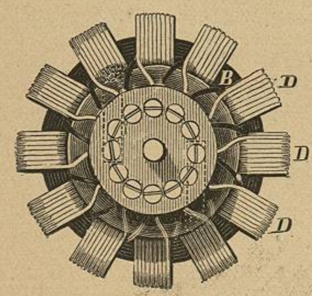


Fig. 490.

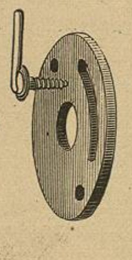


Fig. 486.

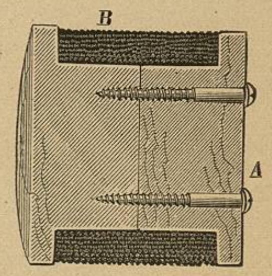
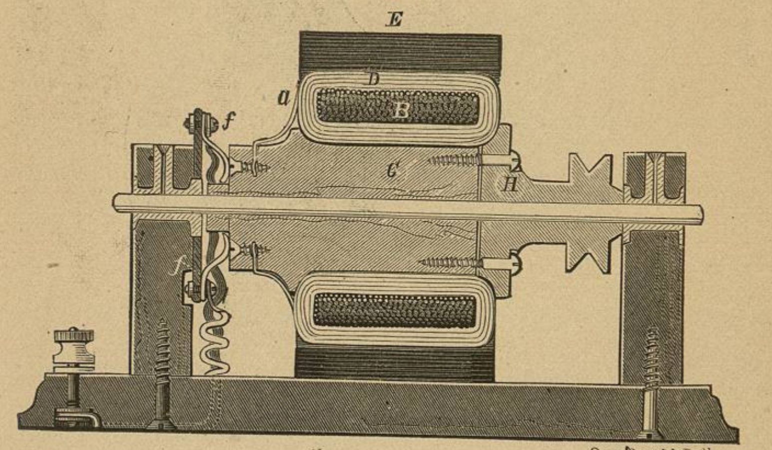


Fig. 486.—Armature Core. Fig. 489.—End View of Armature, showing Commutator. Fig. 490.—Brush-holding Disk.

Fig. 488.

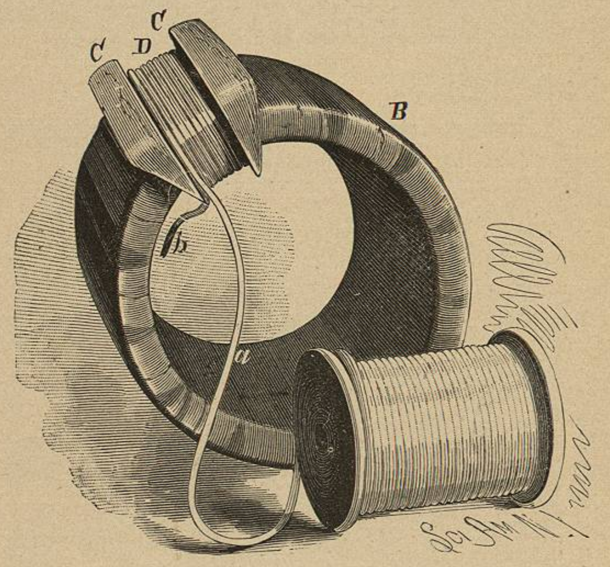


Transverse Section.

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. 486), 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 of the core 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

FIG. 487.



Winding the Armature.

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. If adhesive tape is not at hand, very thin cotton tape or strips of cotton cloth may be substituted. A single coat of shellac varnish will hold the covering in place.

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. 487.

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. These blocks may be clamped in any convenient way. The coil, D, consists of No. 18 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.

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 wooden hub, G, Fig. 488, 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 $\frac{9}{32}$ 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. 488.

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 without touching each other. This completes the armature and the commutator.

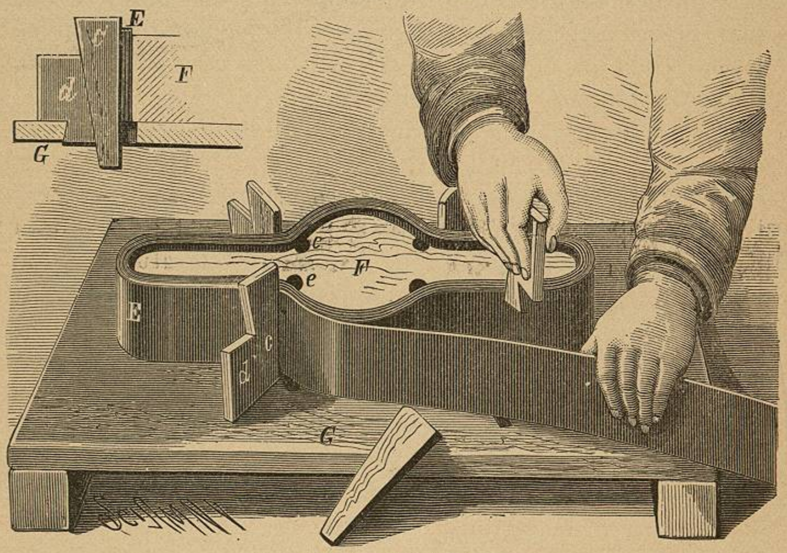
Before proceeding to mount the armature shaft in journal boxes, it will be necessary to construct the field magnet, as the machine must, to some extent at least, be made by "rule of thumb."

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, and of any convenient length, their combined length being sufficient to build up a magnet core seven-sixteenths inch thick, of the form shown in Fig. 485. The ends of the strips are simply abutted. The motor illustrated has fifteen layers of iron in the magnet, each requiring about 26 inches of iron, approximately 33 feet altogether.

The wooden block, F, on which the magnet is formed is secured to a base board, G, as shown in Fig. 491, 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 re-

tained in its mortise by a dovetail, as shown in Fig. 492. 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

Figs. 491 and 492.



Forming the Field Magnet.

iron binding wire wound around the magnet through 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 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. 493. Five layers of No. 16 magnet wire are wound upon each section of the magnet. 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 coils 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. Blocks are 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. 485.

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 the armature shaft are covered with a thin wash of pure clay and allowed to dry.

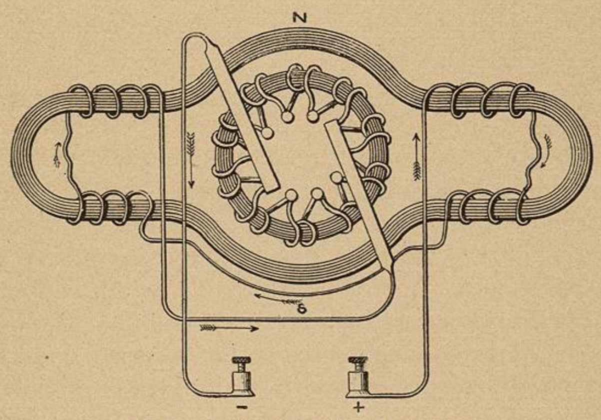
The posts are secured to the base, with the ends of the armature shaft projecting into the transverse holes. Washers of pasteboard are placed upon the shaft on opposite sides of the posts, to confine the melted metal which is to form the journal boxes. Babbitt metal, or, in its absence, type metal, is 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 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. 488, 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. 489, 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. 492, which passes through the slot into the post and serves to bind the disk in any

Fig. 493.



Circuit of Simple Electric Motor.

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, or by a wire spiral, as shown in Figs. 485 and 493. 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, as indicated in Fig. 493.

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

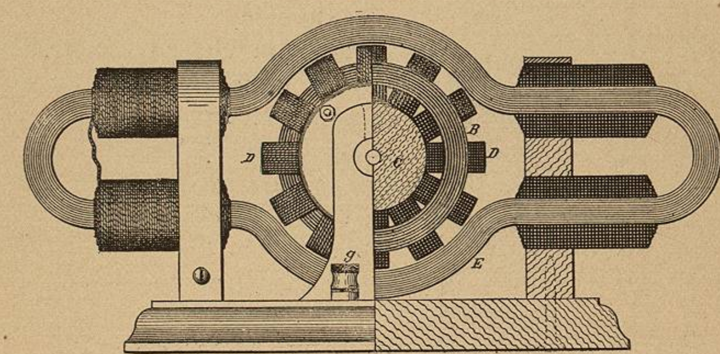
Length of field magnet (inside)	10 inches.
Internal diameter of polar section of magnet	$3\frac{9}{16}$ "
Width of magnet core	$2\frac{1}{2}$ "
Number of layers of wire to each coil of magnet	5
Number of convolutions in each layer	34
Length of wire in each coil (approximate)	95 feet.
Size of wire, Am. W. G	No. 16
Outside diameter of armature	$3\frac{1}{2}$ inches.
Inside diameter of armature core	$2\frac{3}{16}$ "
Thickness " " "	$\frac{3}{8}$ "
Width " " "	2 "
" " " wound	$2\frac{1}{2}$ "
Number of coils on armature	12
Number of layers in each coil	4
Number of convolutions in each layer	8
Length of wire in each armature coil (approximate)	15 feet.
Size of wire on armature, Am. W. G.	No. 18
Length of armature shaft	$7\frac{1}{4}$ inches.
Diameter of armature shaft	$\frac{9}{32}$ "
" " wooden hub	$1\frac{11}{16}$ "
Distance between standards	$5\frac{1}{2}$ "
Total weight of wire in armature and field magnet	6 lb.

This motor is designed for use in connection with a battery of low resistance, preferably one of the plunging type (Fig. 394), as such a battery permits of readily regulating the speed and power of the motor by simply plunging the plates more or less.

This form of battery has the additional advantages of being more powerful for its size than any other and of being very easily cleaned and kept in order. It has, however, the disadvantage of becoming exhausted in three or four hours, but this is partly compensated for by the ease with which it may be renewed.

Eight cells of plunging bichromate battery like that shown in Fig. 394 will develop sufficient power in the

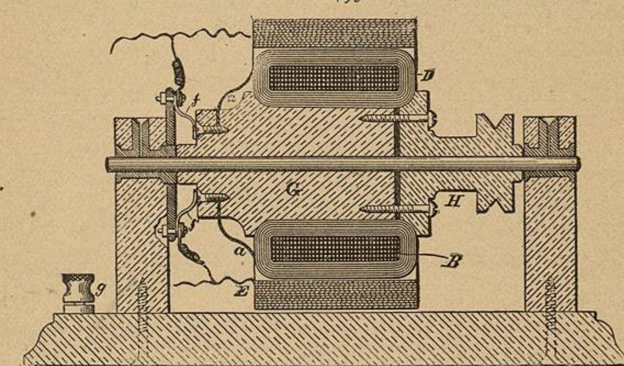
Fig. 494.



Side Elevation, Partly in Section, of Simple Electric Motor—One-third Size.

motor to run an ordinary foot lathe or two or three sewing machines. If it is desirable to adapt the motor to a battery of higher resistance, the armature and field magnet may be

Fig. 495.

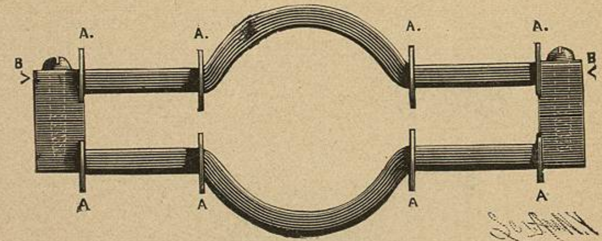


Vertical Transverse Section of Motor, taken through the Center of the Armature—One third Size, showing the Field Magnet in a Shunt.

wound with finer wire. For a dynamo circuit the field magnet of the motor should be placed in a shunt. (See diagram of Plating Dynamo.) If the motor is wound with wire of any size between Nos. 16 and 20, a battery may be adapted to it. When the field magnet is wound with finer wire and connected as a shunt around the armature, the motor becomes self-regulating.

The foregoing description of the small motor was written for the purpose of assisting amateurs who have few tools and no machinery. If all necessary tools are available, the motor may undoubtedly be modified in several particulars, to facilitate the work of construction, but without securing better final results. Fig. 496 shows a magnet made of cast iron. Instead of being formed of a single casting, it consists of two like halves, both made from the same pattern. The ends, which are square, are fitted together accurately either by planing or filing, and fastened together by screws or bolts, two at each end. The body of the cast iron field

Fig. 496.



Cast Iron Field Magnet.

magnet should be fully one-half inch thick, and the ends one inch thick.

The flanges, A, which confine the wire as well as the portions of the magnet on which wire is wound, should be covered with thin cloth and shellacked before winding. The halves of the magnet are wound separately in a lathe, the ends being supported by the centers, B B, as shown.

When the cast iron field magnet is adopted, the motor may be used as a dynamo. In this case, however, it would be advisable to use smaller wire, say No. 20 or 22 on the armature and No. 18 on the field magnet. It would also be well to double the number of coils on the armature, at the same time doubling the number of convolutions and layers,

so as to greatly increase the length of the wire in each section. Where the exact dimensions of the machine are not known the armature should be made first, the field magnet being adapted to the armature.