

Mr. C. F. Claus, whose method for purifying coal gas is now under trial on a large scale in the Belfast gas works, has invented a method of obtaining sulphur from sulphureted hydrogen which is as simple and inexpensive as it is efficient. This method, which is already in extensive use in chemical works where sulphureted hydrogen is evolved, consists in mixing the gas with air enough to oxidize the hydrogen, but not the sulphur, and then passing the mixture through what is known as the Claus kiln. This is merely a brick chamber with a false bottom, which contains a layer of oxide of iron, or some other suitable substance, which, reacting on the mixture of gases, causes the formation of sulphur and water without permanent alteration of the oxide. The necessary temperature is maintained by the heat of the reaction. The vapors which leave the kiln consist mainly of sulphur and steam with nitrogen. They pass into a receiving chamber, in the first part of which melted sulphur collects and can be drawn off into moulds, while a little further on flowers of sulphur of the finest quality are obtained.

The commercial importance of this system is easily understood. At present the whole of the sulphur of the sulphuric acid, amounting in England to about 100,000 tons a year, is thrown away. Now all this will be altered. The sulphur can be recovered at a slight expense, and with very little trouble. It may be converted into sulphuric acid, in which case very little pyrites will be wanted, or by the Claus process it can be obtained in an almost chemically pure state. Pyrites sulphur at present costs about £1 10s. per ton, whereas pure sulphur sells in the market at from £4 to £9 per ton. The alkali waste after the new treatment is perfectly innocuous. It may be thrown anywhere without the possibility of a nuisance arising from it. But doubtless it will be utilized either in the black ash process or in the manufacture of cement. Altogether, it is not surprising that so large and influential an audience should have assembled in Burlington House to hear Mr. Chance's paper. Every sanitarian, as well as every one interested in the commercial prosperity of the country, must wish success to the new enterprise.

#### HOW TO MAKE A SIMPLE ELECTRIC MOTOR.

By GEORGE 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 of the core is No. 18 American wire gauge. The spool is  $2\frac{1}{8}$  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. If adhesive tape is not at hand, very thin cotton tape or strips of cotton

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

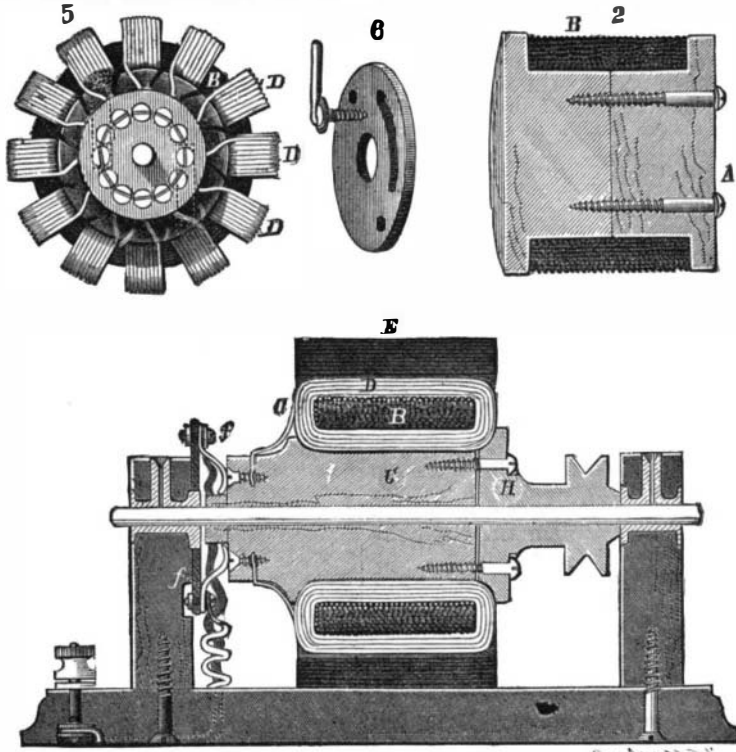
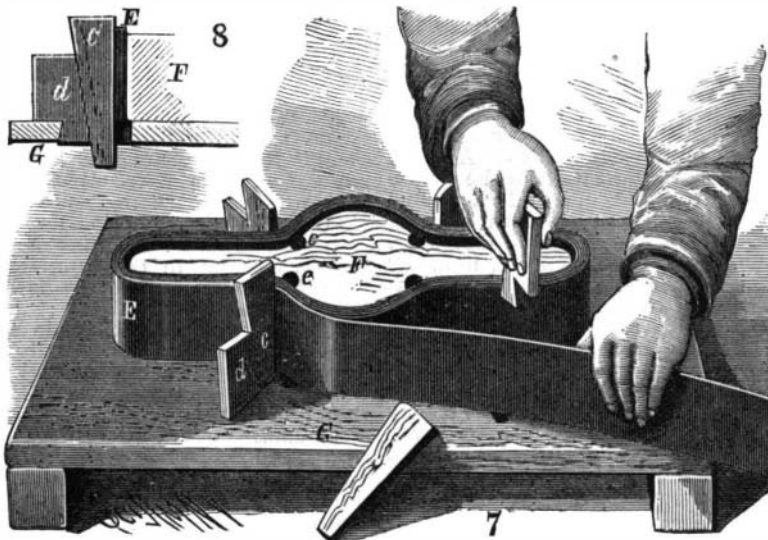


FIG. 2.—ARMATURE CORE. FIG. 4.—TRANSVERSE SECTION. FIG. 5.—END VIEW OF ARMATURE, SHOWING COMMUTATOR. FIG. 6.—BRUSH-HOLDING DISK.

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

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 pro-



FIGS. 7 AND 8.—FORMING THE FIELD MAGNET.

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. These blocks may be clamped in any convenient way. The coil, D, consists of No. 16 cotton covered copper magnet wire, four layers deep, each layer having eight convolutions.

ceeded 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.

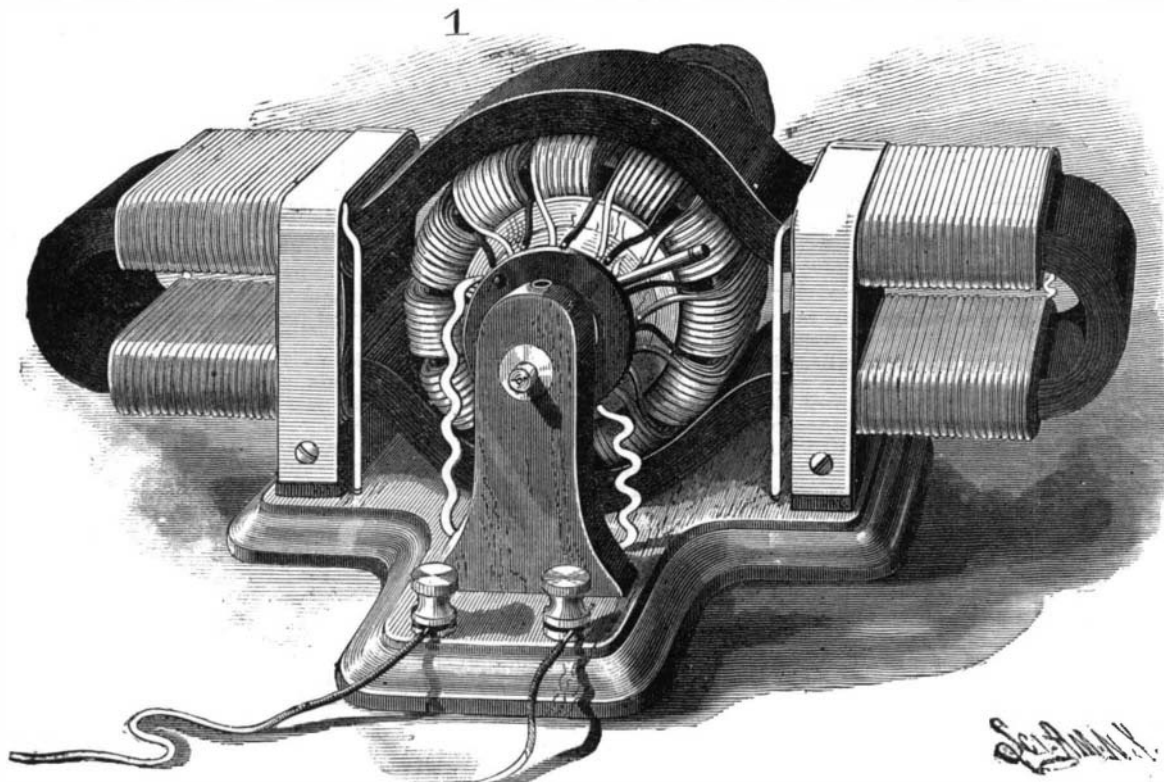


FIG. 1.—SIMPLE ELECTRIC MOTOR—ABOUT HALF SIZE.

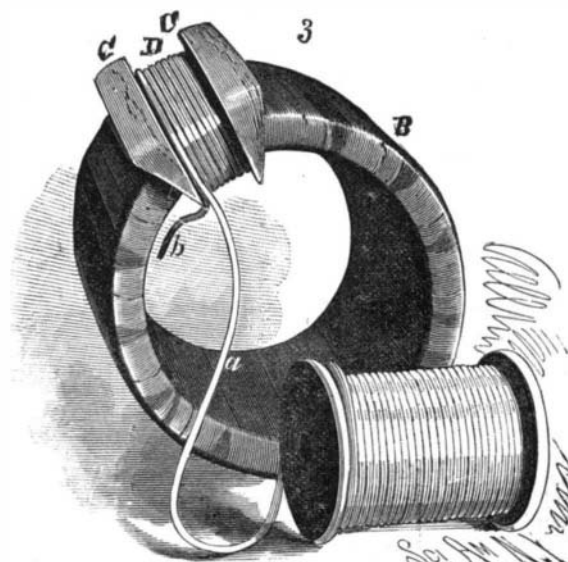


FIG. 3.—WINDING THE ARMATURE.

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  $\frac{1}{2}$  inch 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

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  $2\frac{1}{2}$  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. The ends of the strips are simply abutted. The motor illustrated has 15 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. 7, and

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.

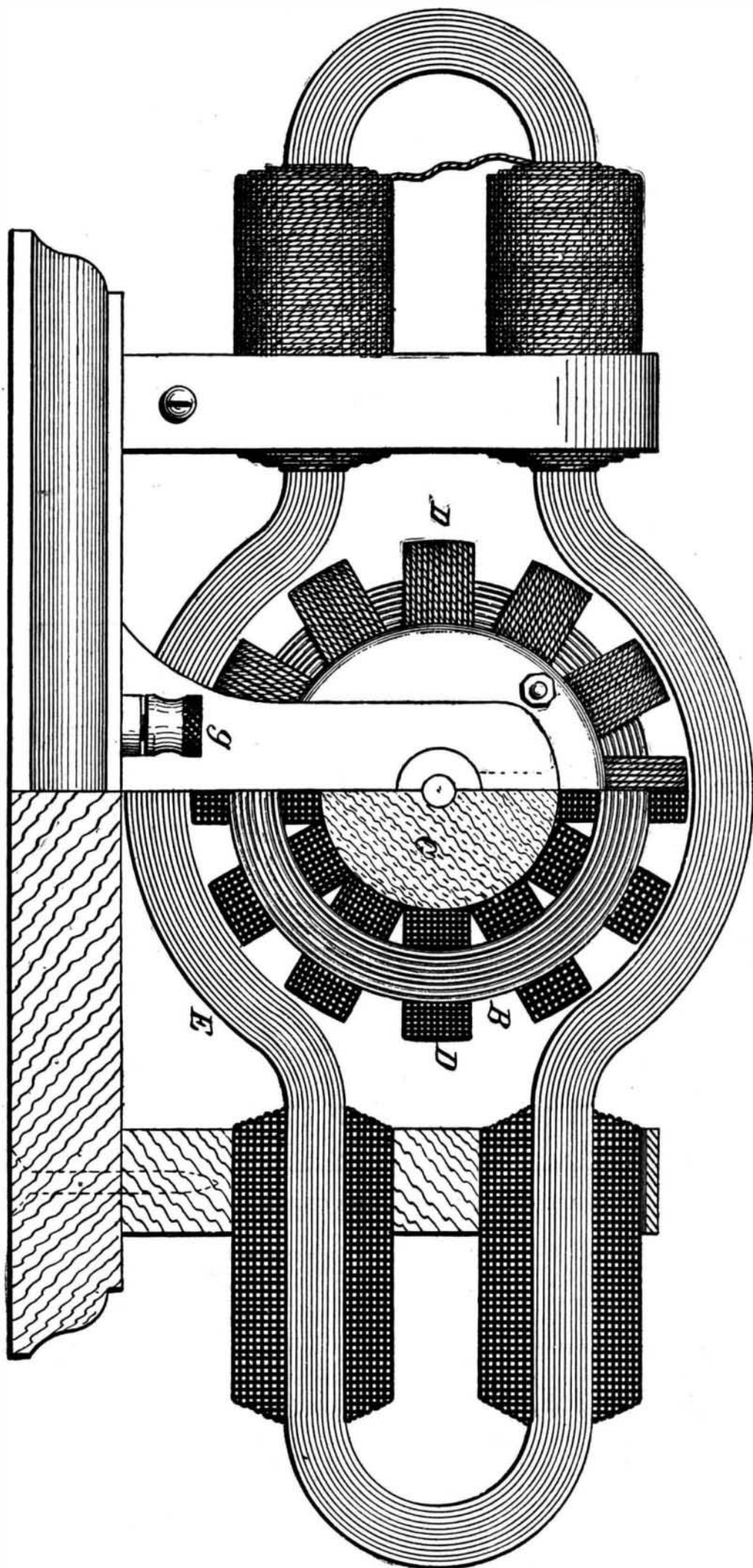
The direction of winding is clearly shown in Fig. 9. Five layers of No. 16 magnet wire are wound upon each section of the magnet. The winding begins at the outer end of the magnet, and ends at the inner end of the section. When the winding is completed, the temporary binding is removed. The outer ends 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. 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 Figs. 1 and 10.

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 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

FIG. 10.—SIDE ELEVATION—PARTLY IN SECTION—OF SIMPLE ELECTRIC MOTOR—FULL SIZE.



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 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."

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 through the grooves, e, and holes in the base board, G.

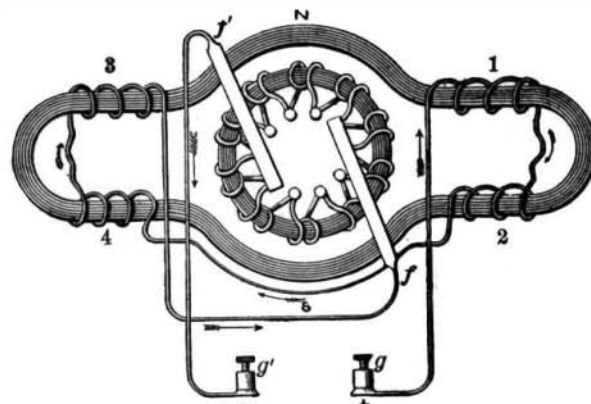


FIG. 9.—CIRCUIT OF SIMPLE ELECTRIC MOTOR.

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, or by a wire spiral, 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, as indicated in Fig. 9.

Eight cells of plunging bichromate battery, each having one zinc plate 5x7 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).....	10 in.
Internal diameter of polar section of magnet.....	3 1/2 "
Width of magnet core.....	2 1/2 "
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.....	3 1/2 in.
Inside diameter of armature core.....	2 1/2 "
Thickness.....	3/8 "
Width.....	2 "
..... wound.....	2 1/2 "
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).....	15 feet.
Size of wire on armature, Am. W. G.....	No. 16.
Length of armature shaft.....	7 1/4 in.
Diameter of armature shaft.....	1 1/8 "
..... wooden hub.....	1 1/4 "
Distance between standards.....	5 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, 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.

If it is desirable to adapt the motor to a battery of higher resistance, the armature and field magnet may be wound with finer wire. No rules can be given here for altering the proportions of the motor to adapt it to different currents, but if the motor is wound with wire of any size between Nos. 16 and 20, a battery may be adapted to it.

#### PIG IRON, INCLUDING THE RELATION BETWEEN ITS PHYSICAL PROPERTIES AND ITS CHEMICAL CONSTITUENTS.\*

By ALEX. E. OUTERBRIDGE, Jr.

AFTER a few introductory remarks, the lecturer said that the subject is an interesting one, not only to the producer of pig iron, but also to the practical founder, the architect and engineer, the machinist and mechanic, and in fact to every one who has to do with iron or steel in any way. He was glad, therefore, to see so large a proportion of young men in the audience, who had come, no doubt, from the various workshops of this great manufacturing city, and hoped that he would be able to impart to them some new facts which might prove valuable in their daily toil.

Continuing, the lecturer said that although his sub-

quity for the process of making iron and steel. The Chinese record minutely describing these methods is still preserved, to which almost fabulous age is accredited by archæologists.

These brief allusions must suffice to indicate the rich store of knowledge upon this branch of our subject which is available to those who have the time and inclination to pursue it to its fountain head.

It has often been asked, in view of the frequent allusions to the use of iron and steel in ancient times, "Why are iron relics of antiquity far more rare than those of gold, silver, or bronze?" If you reflect for a moment, the true explanation will be apparent. It is owing to the oxidizable character of the metal, which causes it to rust and crumble away, when exposed to the elements, in a comparatively brief period of time. However, the British Museum is fortunate to have secured, through the labors of Sir Henry Layard, during his explorations at Nineveh, a magnificent and most valuable collection of ancient Assyrian iron armor, shields, battle axes, saws, and other objects which antedate the Christian era almost 1,000 years. Other specimens were so completely oxidized that although retaining their shape when discovered in the ground, they crumbled to powder on being touched.

Iron is a very widely distributed metal, and is found combined with almost all known elements. Minerals are called iron ores when they contain a sufficient proportion of the metal to pay for its extraction. The ore receives its name either from the locality in which it is found, from its chemical composition, or from its general appearance. Thus we have "bog ore," "magnetic ore," "iron mountain ore," "red and black hematite," "spar ore," etc.

The ancient methods of reducing the metal were exceedingly simple and correspondingly crude. A cylindrical cavity was excavated in the side of a hill and the

out Pennsylvania, Ohio, and all through the South. We are informed by Mr. Swank that such a furnace, producing four tons of iron a day, or twenty-eight tons a week, was considered to be doing well. We now regard an output of 100 tons a day from one furnace, or even 1,000 tons a week, as quite an ordinary matter. This extraordinary increase has been accomplished, not by a proportionate enlargement of the furnace, but by lessening the time of reduction of the metal, and thus increasing its capacity.

It occurred to some one more than half a century ago, that the waste heat escaping from the furnace might be utilized to warm the air blast before entering the furnace, and thus save a part of the fuel. The air was accordingly passed through iron tubes, arranged in a chamber of fire brick, and thus heated. A very moderate degree of warmth (say 330° F.) imparted to the air produced a remarkable effect both in saving the charcoal and in hastening the operation of melting. The iron produced by this method is called "warm blast charcoal iron," to distinguish it from "cold blast charcoal iron." Furnaces of this class are extensively used to-day along the Ohio river, in the Hanging Rock region and elsewhere. Improved hot blast stoves were soon devised, whereby a much higher temperature could be imparted to the air, accompanied by increased efficiency and economy of time, fuel, and money.

About 1840 a revolution in the manufacture of pig iron in this country was created by the successful introduction of anthracite coal as fuel in place of charcoal in the blast furnace, although some experiments with anthracite had been made at an earlier date. I recently found upon the shelves of the Franklin Institute library a printed report, published in 1842, of a commission sent from England to investigate this matter, which stated that iron could never be made with anthracite fuel, and deriding the whole scheme. It was

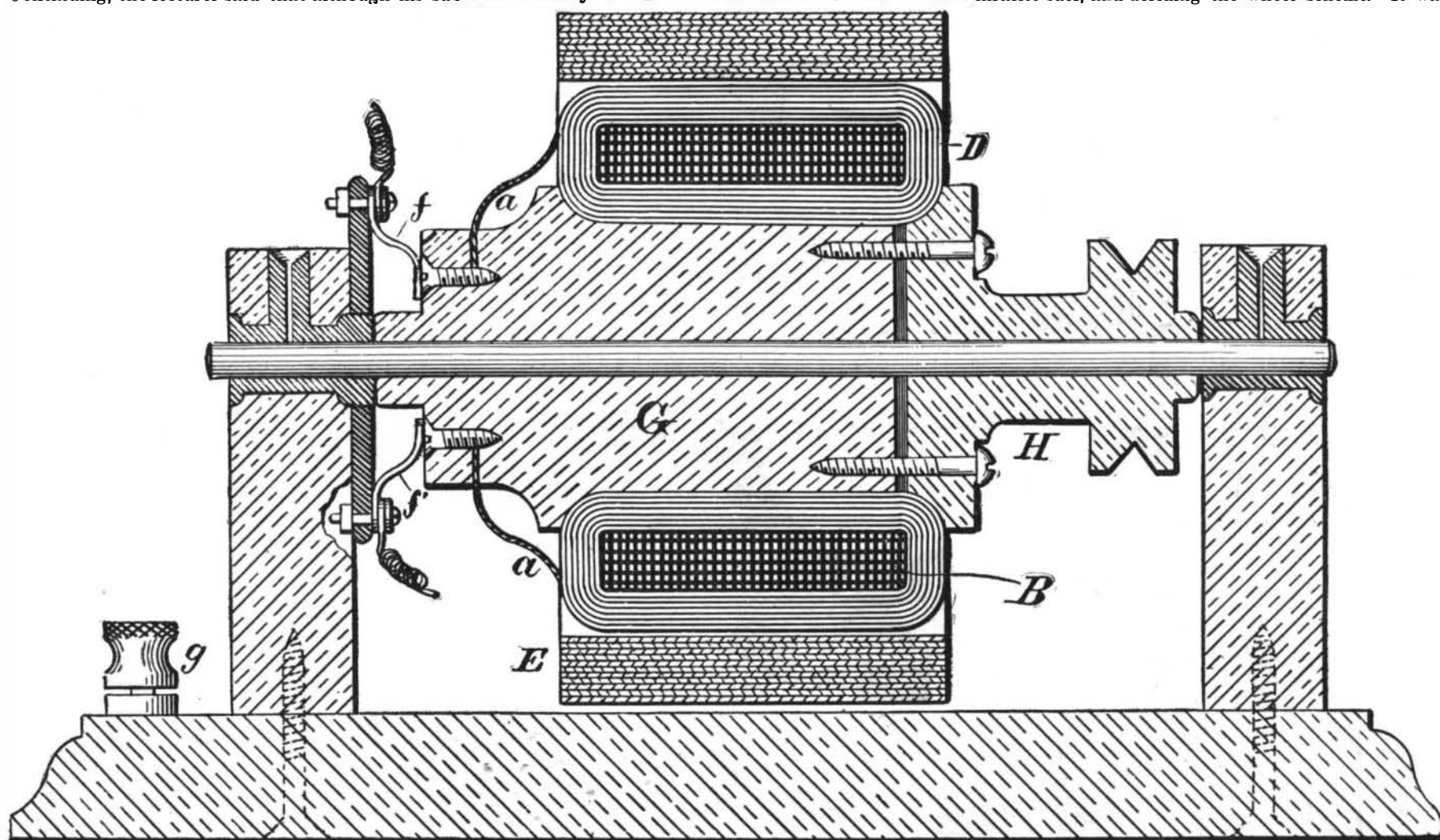


FIG. 11.—VERTICAL TRANSVERSE SECTION OF SIMPLE ELECTRIC MOTOR, TAKEN THROUGH THE CENTER OF THE ARMATURE—FULL SIZE.

ject was a "cast iron" one, it was not devoid of literary and even of romantic features, which time would not permit him to dwell upon at any length. He then spoke substantially as follows:

It is proper, however, to indicate that the subject has a history of great antiquity and interest, and to point out very briefly this path which you may explore more fully at your leisure, and I would commend to your careful study the admirable "History of Iron in all Ages," by Mr. James M. Swank, the secretary of the American Iron and Steel Association.

The earliest records of iron are to be found in the books of the Old Testament, which make frequent allusions both to iron and steel. In the fourth chapter of Genesis, Tubal Cain is spoken of as "an instructor of every artificer in brass and iron," and the biblical chronology places this expert in the seventh generation from Adam. When David was about to build the temple (nearly 1,000 B. C.) "he prepared iron in abundance for the nails for the doors of the gates and for the joinings." An "iron pen" is mentioned in the nineteenth chapter of Job, which was used to engrave upon rocks, and in the next chapter a "bow of steel" is spoken of.

Iron was a familiar metal to the Egyptians, Chaldeans, Babylonians, Assyrians, and other ancient peoples. It is frequently mentioned by classical authors, among whom are Homer, Aristotle, and Pliny. Homer speaks of iron disks being given as prizes to the contestants in athletic games, and also of the method of tempering steel by plunging the hissing ax into cold water. Pliny knew of the magnetic qualities of iron, and alludes to the inexhaustible deposits of ore in the island of Elba and in Spain. These mines are still worked, and thousands of tons are annually shipped from them. India has been celebrated for ages for the quality of its steel, and China also claims great anti-

ore and fuel (charcoal) packed into it, a hole being left at the top and bottom for the draught. When the fuel was all consumed, the metallic iron was recovered amid the ashes. The *regulus* was an impure mass, sometimes resembling wrought iron, sometimes cast iron, sometimes steel, and often a mixture of all three, according as the crude process accidentally altered the proportion of carbon, silicon, etc., in the mass.

The next improvement was in the "Catalan forge," so named from Catalonia, where it originated. The forge was provided with an artificial draught of air from a rude bellows made of goat skins. Then came the invention of the earliest form of blast furnace, which was a decided improvement, owing mainly to the fact that the process of feeding the ore and fuel and reduction of the iron could be made continuous, thus effecting a considerable saving of labor and also increasing the output of metal. The blast furnace is a very simple affair, consisting of a high stack, lined with refractory clay or firebrick, oval in shape, having one or more orifices near the bottom, called *tuyeres*, for the admission of air under pressure, and an opening at the top, called the "tunnel head," for the admission of ore, fuel and flux. The fuel formerly used was charcoal, and the quality of the metal (called "pig" iron, from the shape into which it is cast as it runs from the furnace) was far superior, for certain special uses, to that made by modern processes.

I do not mean to say that I think this is necessarily so, or that it will always be true, but I am compelled to admit that, at this stage of evolution in the iron industry, modern improvements have all been in the line of increased output from a furnace with decreased consumption of fuel, but at the expense of the character of the metal and consequent depreciation of value.

In the old fashioned charcoal furnace, air was blown into it at the ordinary temperature. Furnaces of this character were commonly found fifty years ago through-

quite a surprise to find such an amusing volume among these dusty archives.

Of late years, coke made from bituminous coal has been extensively used as fuel in the manufacture of mill iron, and the product is called "coke iron," to distinguish it from "anthracite iron."

What is the character of the metal produced by these different processes?

Pig iron varies so greatly in general appearance, color, hardness, ductility, tensile and transverse strength and specific gravity, that one not having expert knowledge upon the subject might reasonably doubt that the specimens which I propose to exhibit to you, by means of the megascope, even belong to the same class of metal. One specimen is soft and ductile like lead, and shows a rich, dark color and coarse granular fracture. Another is hard as steel, brittle as glass, and white as silver, while between these extremes we have a great range of specimens having intermediate qualities.

You now see upon the screen a photograph taken from a series of "test pieces" (see illustrations, Figs. 1 and 2) made from different grades of pig iron, in moulds of uniform size, cast in "green sand," against an iron "chill plate" for the purpose of suddenly cooling one side of the casting. The pieces are arranged in a series with the chilled side uppermost, beginning with a sample which shows no tendency to produce white or chilled metal, and passing, by gradual steps, to metal which crystallizes as white iron through the whole mass. All of these specimens were cast from iron which was perfectly gray in the pig, sufficiently soft to bore readily, varying but slightly in specific gravity, and ranging in transverse strength from 5,000 to 7,000 pounds per square inch. The effect of sudden cooling has developed the white crystalline structure in some of the specimens, rendering them so hard that they cannot be touched with a file, and so brittle that they may be readily broken, and increasing their density to

\* Abstract of a lecture delivered before the Franklin Institute, February 6, 1888.