(No Model.) 2 Sheets—Sheet 1.

E. T. & D. HIGHAM.

ELECTRIC MOTOR.

No. 343,176. Patented June 8, 1886.

FIG. 1.

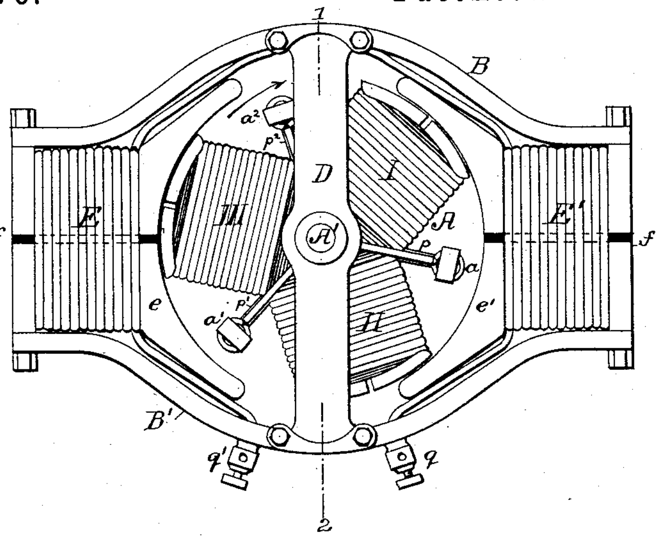


FIG. 2.

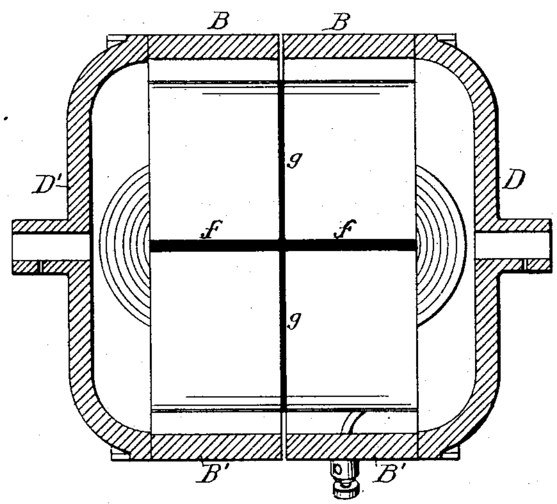
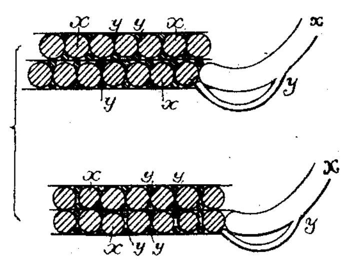


FIG. 5.



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(No Model.) 2 Sheets—Sheet 2.

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FIG. 3.

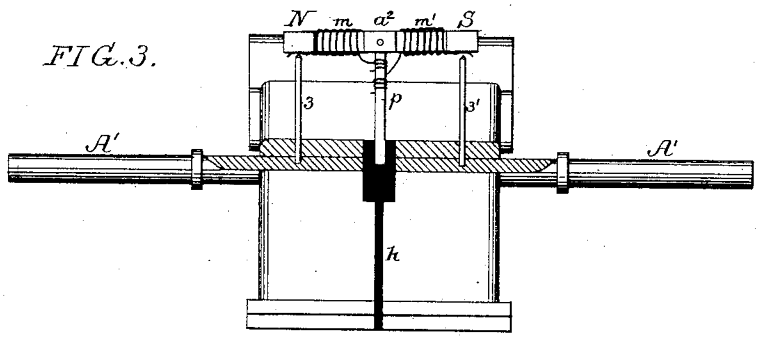


FIG. 4.

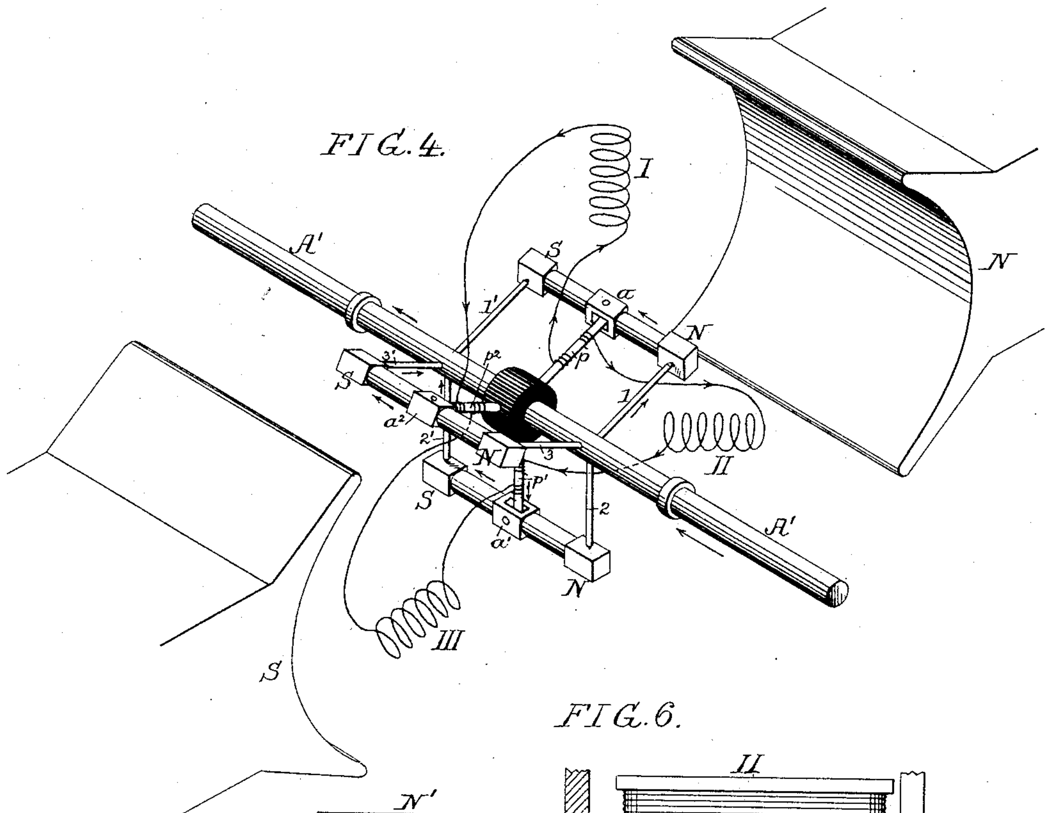
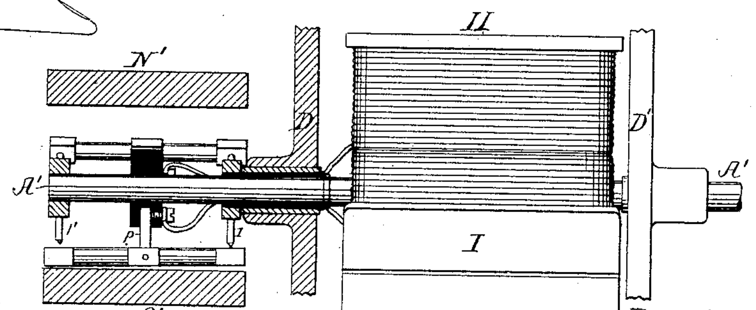


FIG. 6.



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UNITED STATES PATENT OFFICE.

ENOS T. HIGHAM AND DANIEL HIGHAM, OF PHILADELPHIA, PA.

ELECTRIC MOTOR.

SPECIFICATION forming part of Letters Patent No. 343,176, dated June 8, 1886.

Application filed July 28, 1885. Serial No. 172,903. (No model.)

To all whom it may concern:

Be it known that we, ENOS T. HIGHAM and DANIEL HIGHAM, both citizens of the United States, and residents of Philadelphia, Pennsylvania, have invented certain Improvements in Electric Motors, of which the following is a specification.

Our invention consists of certain improvements in the construction of electro-magnetic motors, designed with the view of increasing their efficiency, as more fully described hereinafter.

In the accompanying drawings, Figure 1 is a side view of an electric motor embodying our improvements. Fig. 2 is a transverse section on the line 1 2, Fig. 1, but with the armature removed. Fig. 3 is a detached view of the armature, partly in section. Fig. 4 is a perspective diagram illustrating the construction and operation of our preferred form of commutating device. Fig. 5 is a diagram illustrating the manner of winding the coils; and Fig. 6 is a diagram of a modification.

In these drawings we have illustrated our improvements as applied to a motor in which the armature has three poles revolving between the two opposite poles of the field-magnets; but it should be understood that our improvements are applicable to different constructions of electric motors, and also to dynamo-electric machines.

In the construction of motor shown in Fig. 1, E and E′ are the electro-magnets, with pole-pieces *e e′*, between which the armature A revolves. To the back ends of the field-magnets are secured the curved connecting-plates B B′, united by central cross-bars, D, on opposite sides, these central cross-bars being provided with bearings for the axis A′ of the armature.

In winding the coils of the field-magnet and armature, we prefer, in order to get the largest number of coils with the necessary conducting-surface within the smallest space, to wind in between the usual coarse-wire coils, *x*, Fig. 5, coils of fine wire, *y*, the terminals of which are electrically connected to the coarse-wire coils, so that the two kinds of wire are wound on the same core in parallel circuits and connected together at their terminals.

We prefer to slot the pole-pieces of the armature, as shown in Fig. 1, with the view of breaking up or preventing the formation of interfering magnetic currents, and for the same reason we prefer to divide the core and pole-pieces of each electro-magnet into two parts on a horizontal line, and to insulate the two parts from each other. We do this, however, for a further reason, which we will explain.

It will be observed in Fig. 1 that the curved pole-piece of each field-magnet is of such a length with relation to the poles of the armature that two of the poles of the armature will be within the field of one magnet at the same time, these two poles of the armature being north and south, so that if the pole of the field-magnet were in one continuous piece it would to a certain extent form a connecting-piece for the two poles of the armature, and thus retard the action of the machine; but by introducing the strip of insulation at *f*, as described, this is avoided, and the machine works to a much greater advantage.

One of the features of our invention consists in making the cross-bars D and the armature-shaft A′, as well as the connecting-plates B B, of magnetic metal, so as to form a complete magnetic circuit from the upper part of the pole E—for instance, through the connecting portion of the plate B, cross-bar D, shaft of the armature, and core and pole-piece of the coil *l*, so as to increase the magnetic action between the poles of the field-magnet and armature. The cross-bar D practically forms a neutral part of the magnetic circuit of the field, just as the armature-shaft constitutes practically the neutral part of the magnetic portion of the armature, and the cross-bars D bear such relation to the armature-coils that as the armature-coils pass the bars D the electric currents traveling in the said coils will generate in the bars D magnetic currents, which will be in a direction that will augment the magnetic currents set up in the attracting-poles of the field-magnet.

Another important feature of our invention relates to the commutating of the currents in the armature, one of the objects of our invention being to dispense with the brushes and segments almost universally used in electric motors and dynamo-electric machines, for it is well known that these are the parts of the machine which give the greatest trouble and are the most difficult to keep in order and repair. For this purpose we replace the mechanical commutator by an electro-magnetic commutator, the construction of which will vary somewhat with the construction of the machine and its requirements; but in the drawings we have illustrated the form of magnetic commutator which we prefer to use. With this construction of magnetic commutator the entire metallic portion of the machine in both the field-magnet and the armature and its shaft is divided vertically into two parts, insulated from each other, either by air or other means. This will be understood on reference to Figs. 2 and 3, the poles of the field in Fig. 2 being shown as divided by the vertical insulating-plate g, while there is a corresponding insulation, h, for the two parts of each pole of the armature and armature-shaft. It is not essential, however, that this insulation should be central or that the metallic portion of the field-magnet should be divided, as shown, so long as the bearing for the armature-shaft on one side is insulated from the bearing for the armature-shaft on the other side.

In the construction of machine shown, there being three poles to the armature, there are three sets of commutating devices, each set consisting of a permanent magnet, a, (or a' a^2,) pivoted to an insulated radial post, p, carried by the armature-shaft, the opposite ends of the permanent magnet being north and south, of course. The pivoting-point of the permanent magnet is central, so as to get as perfect a balance as possible. These permanent magnets a a' a^2 are preferably parallel with the armature-shaft A', and projecting radially from the shaft are the contactpoints 1 1' 2 2' 3 3', in pairs corresponding with and parallel to the several posts p p' p^2. The lengths of these pairs of contact-points are such as to allow a slight tilting motion to each of the balanced magnets a a' a^2, so that these magnets may make contact through one or the other of their ends with one or the other of their contact-posts. It will be seen, then, that as the armature revolves when one of the balanced magnets comes within the field of one of the poles of the field-magnet—say the north pole—the south pole of the balanced magnet a^2, for instance, Fig. 4, will be attracted, and the opposite end or north pole of this balanced magnet will be thrown into contact with its post 3, while the opposite end is thrown out of contact with the post 3'.

The manner of connecting up the coils of the armature to these commutating devices above described is not a very material part of our invention, as they may be connected in different ways, as may be desired; but in the diagram, Fig. 4, we have shown the opposite terminals of each intermediate coil connected to the adjoining posts p p' p^2. Thus one terminal of the coil I is connected to the post p^2, while the other terminal is connected to the post p, and to the latter is connected also one terminal of the coil II, while the other terminal of this same coil II is connected to the post p', and the terminals of the coil III are connected to the posts p' p, as indicated.

The field-circuit is illustrated in Figs. 1 and 2. The current entering the post q passes through the coil of the core E', and is thence conducted to the cross-piece D, and to the portion of the armature-shaft A' having its bearings therein. It then passes to the armature-coils and out at the other insulated end of the armature-shaft A'. The current thence goes through the bearing of the said shaft in the cross-piece D' to the coil of the magnet E and out at q', the circuit being such, as will be seen, that the armature is in series between the coils of the field-magnet.

Take an example armature-circuit: When the armature is in the position shown in Figs. 1 and 4, the current will be entering through the contact-post 1, Fig. 4, balanced magnet a, and through the post p, where the current will split, one half going through the coil I, and the other half through the coil II, whence the two portions of the current may pass to the posts p' p^2 and out through the balanced magnets a' a^2 and contact-posts 2' 3'. The coil III will thus be out of circuit at the moment when it is in a position, Fig. 1, to be of little or no use.

In order to preserve the magnetism of the magnets a a' a^2, we prefer to place coils m m', as shown in Fig. 3, around the legs thereof, to both of which coils the terminals of the adjacent armature coils are connected, (instead of to the post, as described above with reference to the diagram, Fig. 4,) the opposite terminal of the coil m or m' being connected to the platinum point which is to make contact with the post 1 1', &c., as the case may be. The direction of each coil m m' is such as to maintain the desired magnetism and polarity of the balanced levers a a' a^2.

It will be understood that instead of mounting the reversing bars and conductors or magnetic commutating devices within the field-poles they may be arranged to rotate with the armature outside the field, and be acted on by north and south poles of either an electro-magnet or permanent magnet specially provided. For instance, in Fig. 6 we have shown the magnetic commutator as mounted on an extension of the armature-shaft outside the frame of the motor, and adapted to be acted on by poles N' S' of a separate permanent magnet or magnets.

In reversing the motor by changing the connections of the line-conductors at the binding-posts q q', Fig. 1, where a permanently-magnetic commutator is used, it will be observed that the result will be to reverse the fields only, and not the armature, as in motors of the usual construction. This is one of the advantageous features of our invention.

We claim as our invention—

1. An electric motor, provided with an armature and a magnetic commutator carried by the armature.

2. An electric motor provided with a ro-

tary armature carrying an automatic magnetic commutator, and poles to act thereon as the armature revolves.

3. An electric motor having automatic magnetic reversing-bars adapted to rotate with the armature, magnetic poles to act on said bars, and contact-points with which the armature-terminals communicate, substantially as specified.

4. An electric motor having pivoted and balanced magnetic reversing-bars adapted to rotate with the armature, magnetic poles to act on said bars, and contact-points with which the armature-terminals communicate, substantially as described.

5. An electric motor having automatic magnetic reversing-bars provided with coils adapted to be thrown into circuit, as the bars operate, to maintain the magnetism of the bars, substantially as and for the purpose set forth.

6. The combination of the armature-shaft in two parts insulated from each other, and field-magnet frame having the bearings for the shaft insulated from each other, with magnetic reversing-bars and contact-points therefor carried by the two parts of said shaft, substantially as set forth.

7. The combination of the armature-shaft in two parts insulated from each other, and field-magnet frame having the bearings for the shaft insulated from each other, with magnetic reversing-bars and contact-points therefor carried by the two parts of the shaft, the terminals of the armature-coils being connected to the magnetic reversing-bars, as and for the purpose described.

8. An electric motor having an armature, magnetic reversing-bars, to which the terminal coils are connected and carried by the armature, and contacts to which the field-terminals are connected, as set forth.

9. An electric motor or dynamo-electric machine having its electro-magnets wound with fine and coarse wire coils on the same cores, with their terminals directly connected to each other in parallel circuit.

10. An electric motor having each field-pole piece adapted to extend over the north and south poles of the armature, the two parts of the field-pole adjacent to the two armature-poles being magnetically insulated from each other.

11. An electric motor having its field-pole pieces and cores in parts insulated from each other at *f*, as described.

12. An electric motor having its pole-pieces and cores in parts magnetically insulated at *f*, but each pole magnetically connected to the opposite one through the frame.

13. An electric motor having a rotary armature with its poles magnetically connected with the poles of the field through the frame, substantially as set forth.

14. An electric motor having bars D, crossing the coils of the armature and connected magnetically to the neutral parts of the field-magnets, for the purpose set forth.

In testimony whereof we have signed our name to this specification in the presence of two subscribing witnesses.

ENOS T. HIGHAM.
DANIEL HIGHAM.

Witnesses:
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HARRY SMITH.