(No Model.) 3 Sheets—Sheet 1.

# E. THOMSON.

## DYNAMO ELECTRIC MACHINE.

No. 432,655 Patented July 22, 1890.

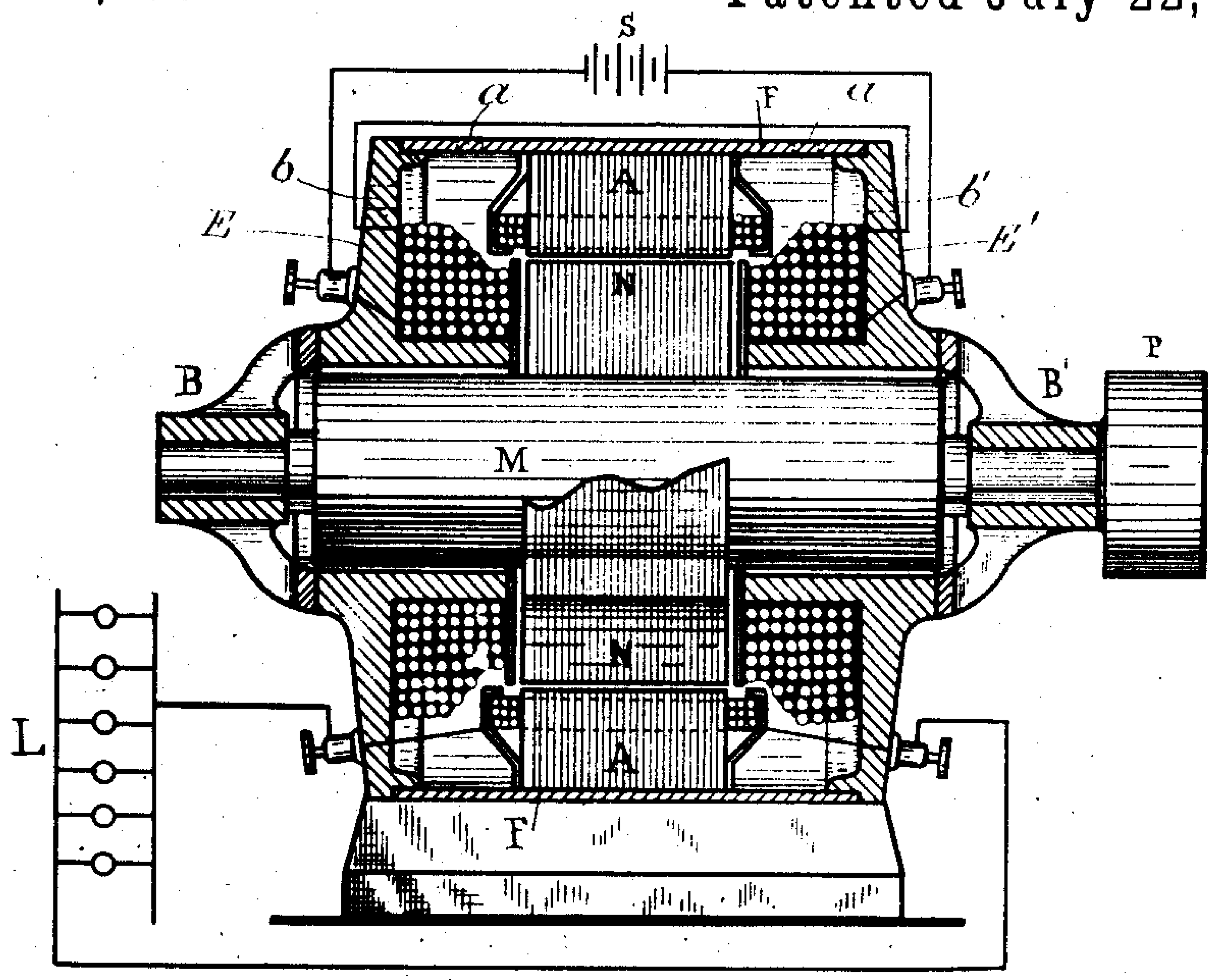



Fig 1.

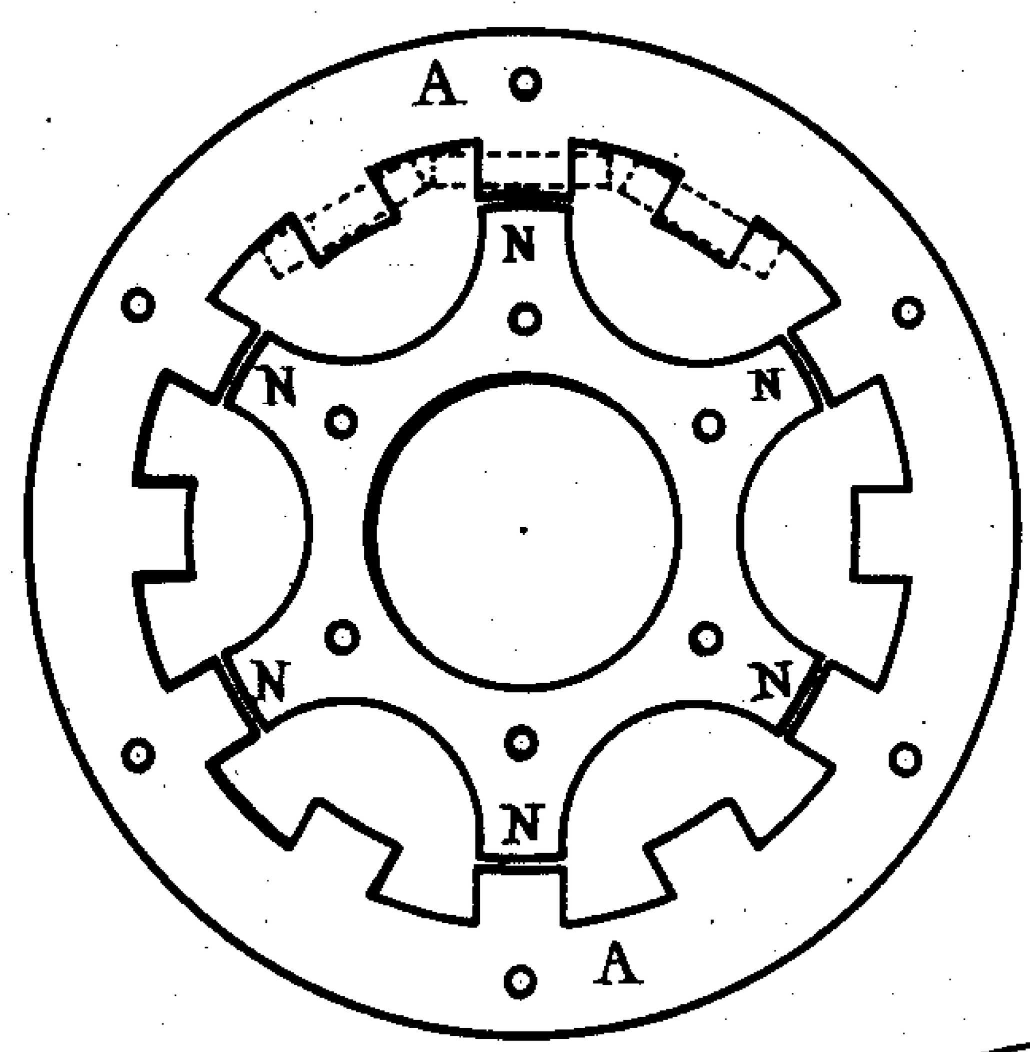



Fig 2.

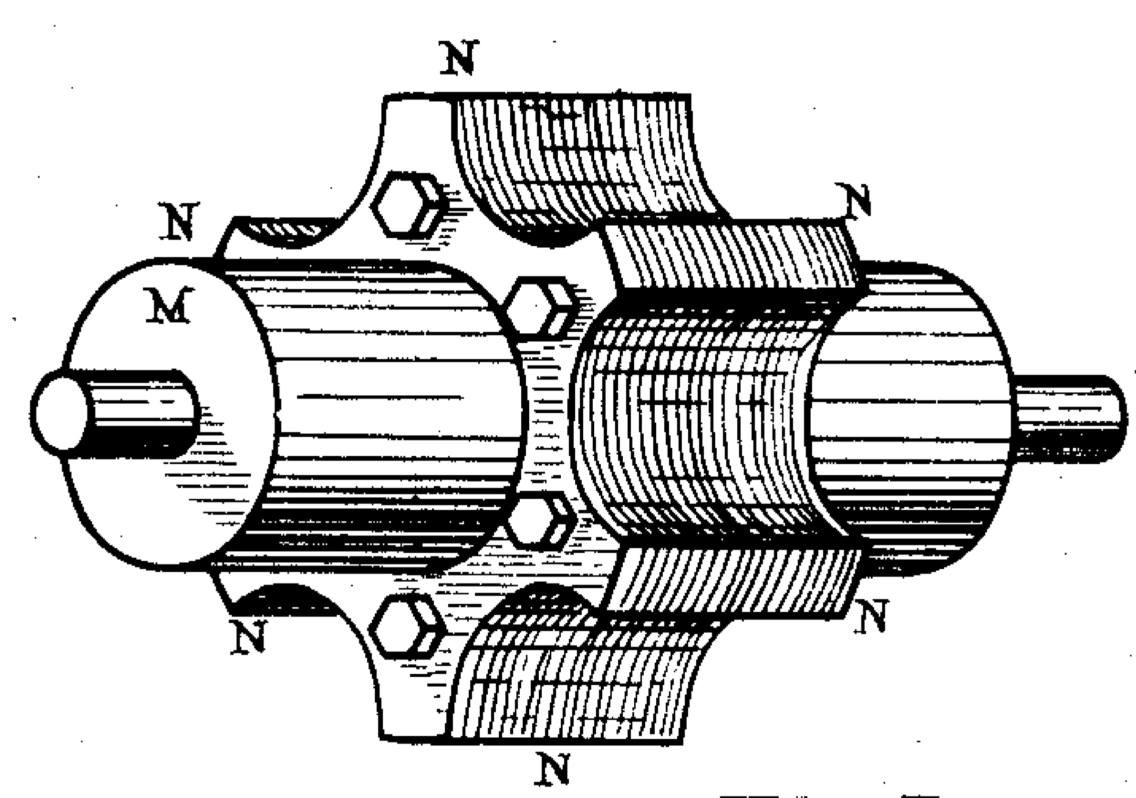



Fig 3.

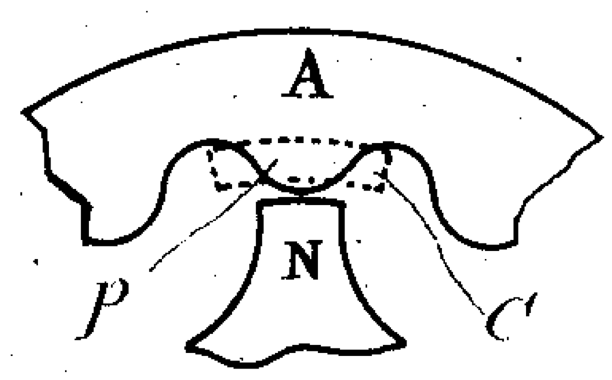



Fig 3½.

Witnesses:
J. A. Hurdle
Wm. H. Capel

Inventor:
Elihu Thomson
By E. H. C. Townsend
Attorney.

(No Model.) 3 Sheets—Sheet 2.

# E. THOMSON.

## DYNAMO ELECTRIC MACHINE.

No. 432,655. Patented July 22, 1890.

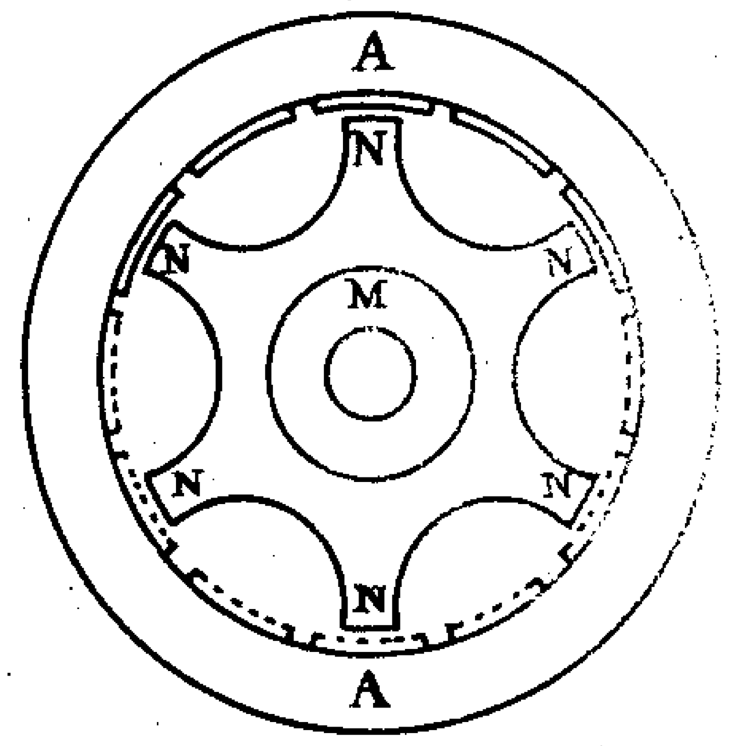



Fig 4.

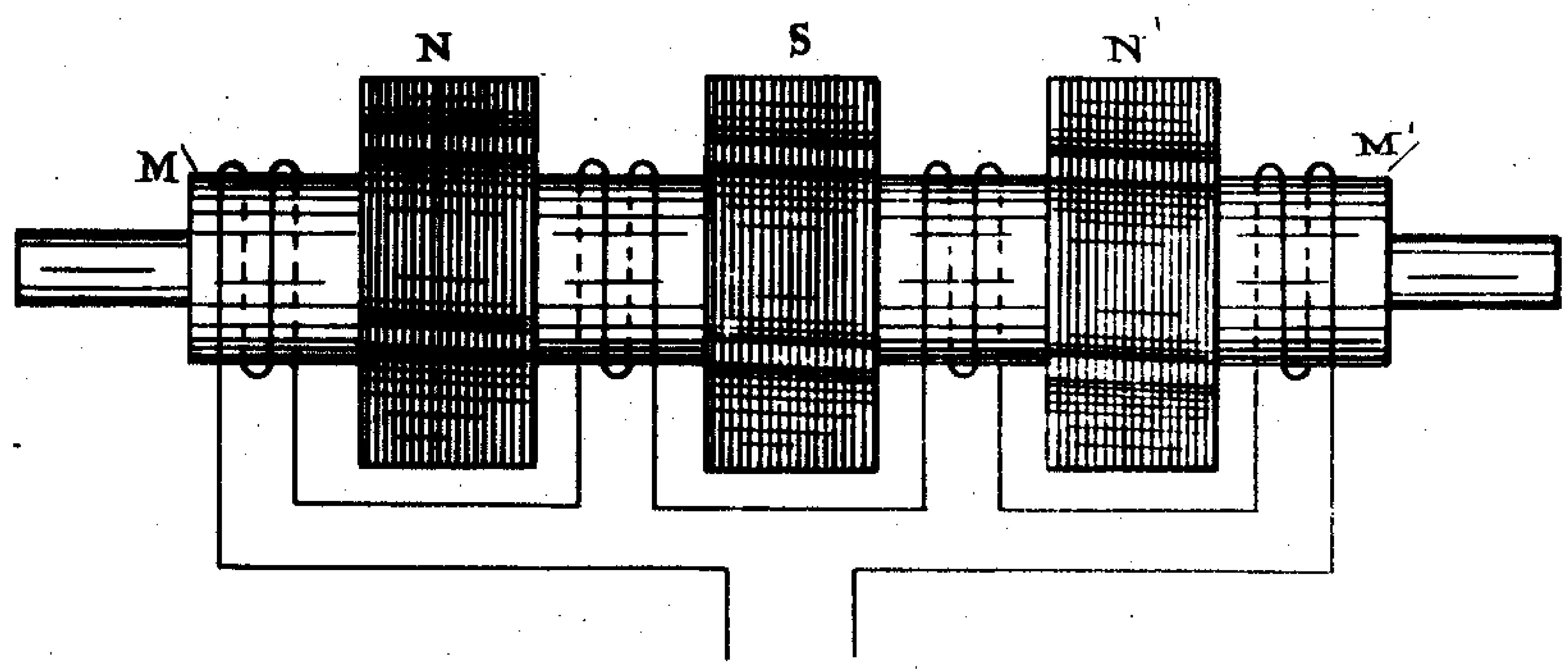
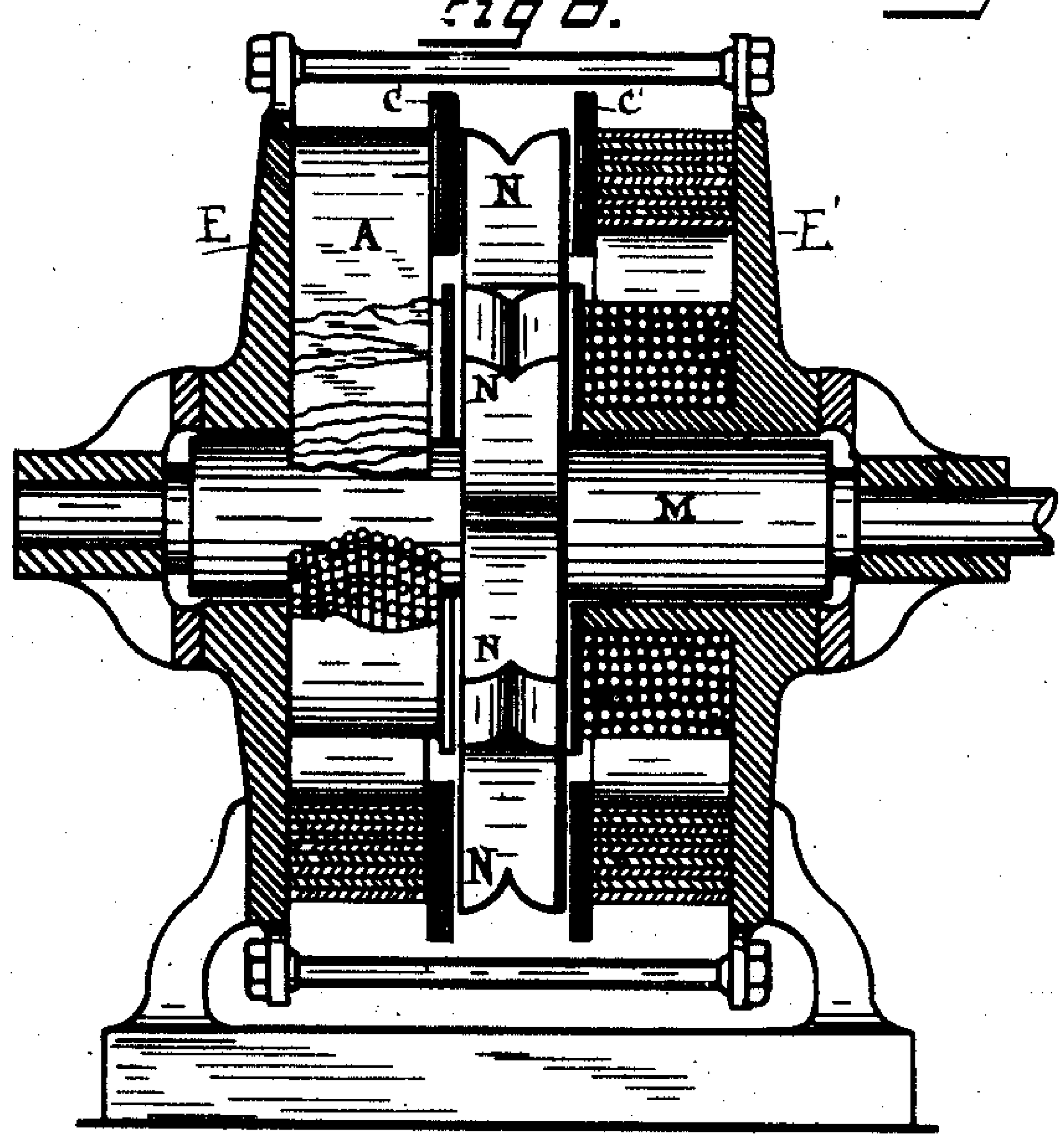



Fig 5.

Fig 6.



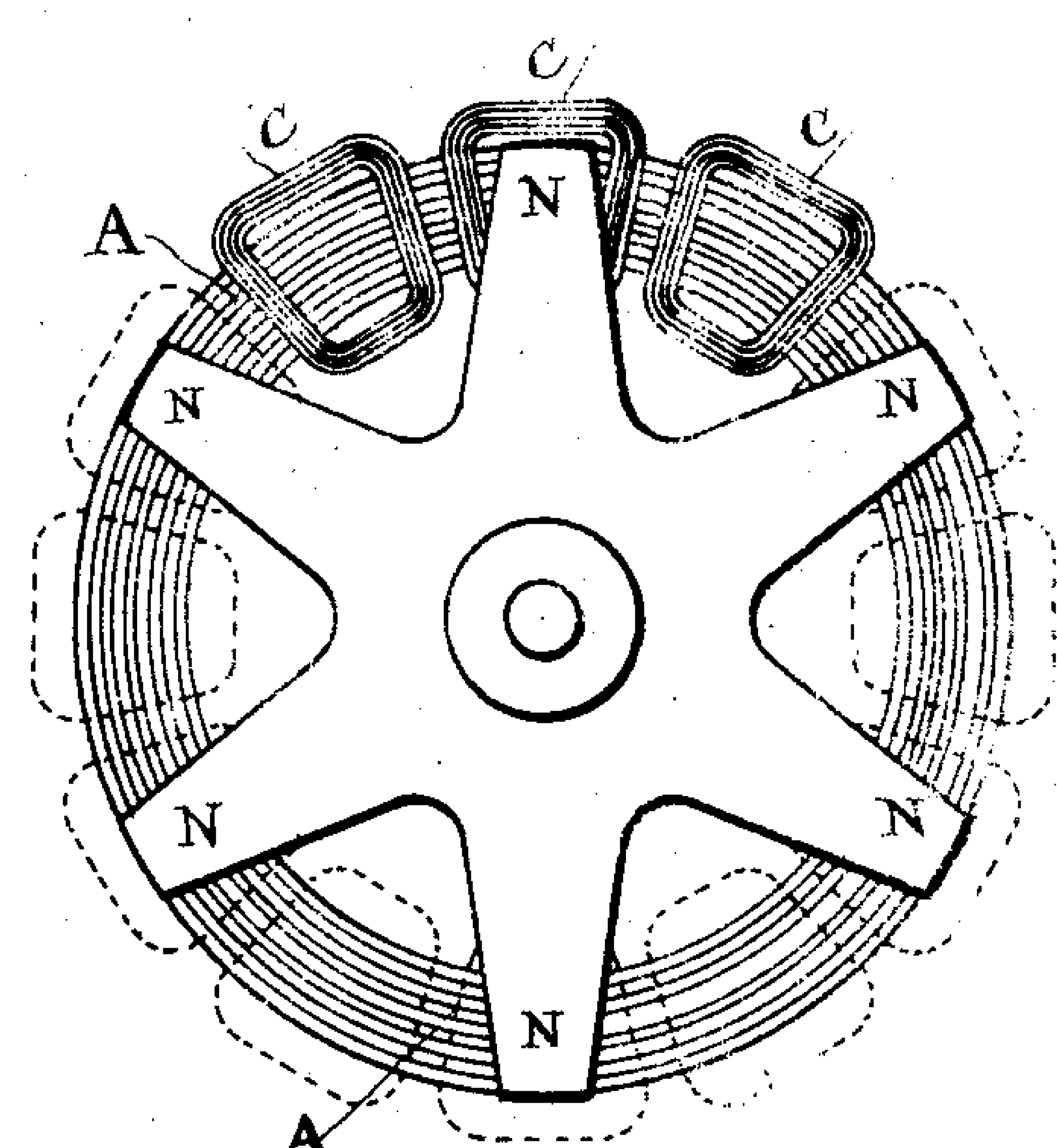




Fig 7

Witnesses:
J. A. Hurdle
Wm. H. Capel

Inventor:
Elihu Thomson
By [signature]
Attorney.

(No Model.)

3 Sheets—Sheet 3

E. THOMSON.

DYNAMO ELECTRIC MACHINE.

No. 432,655. Patented July 22, 1890.

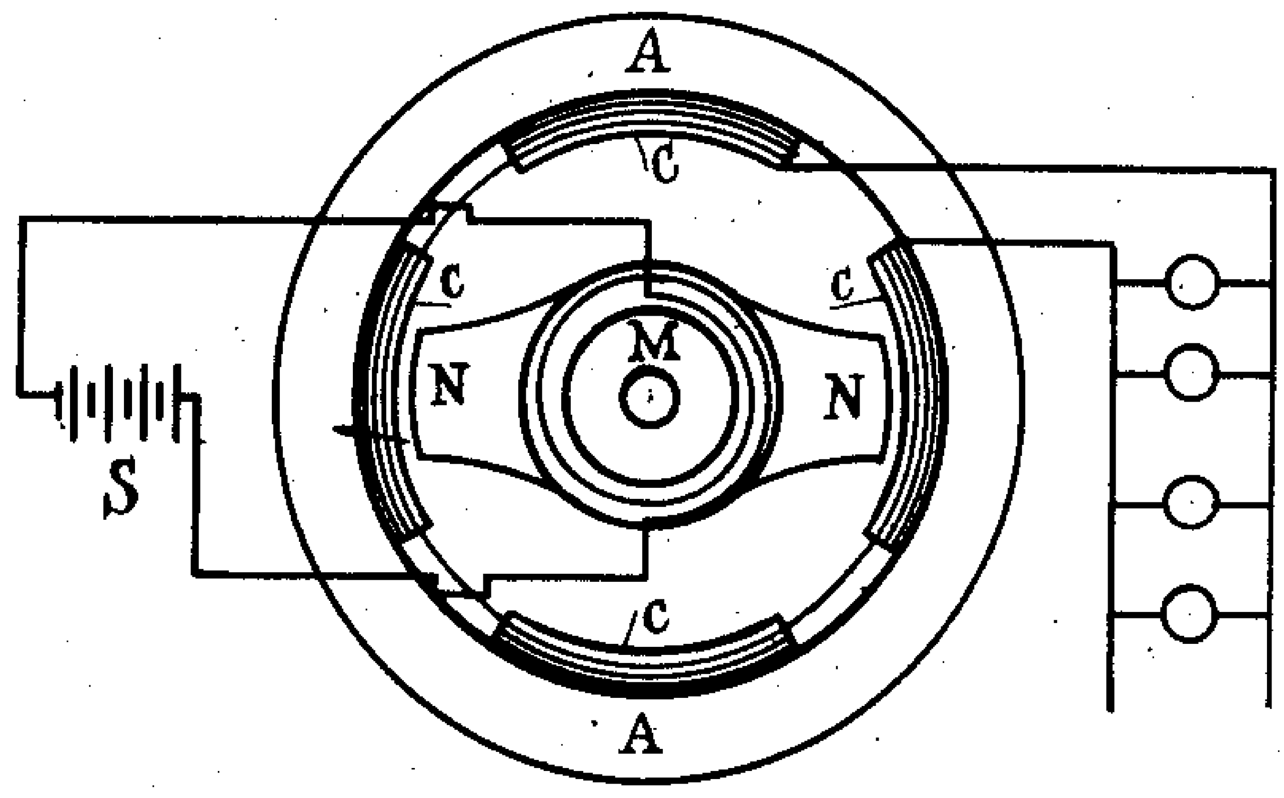



Fig 8.

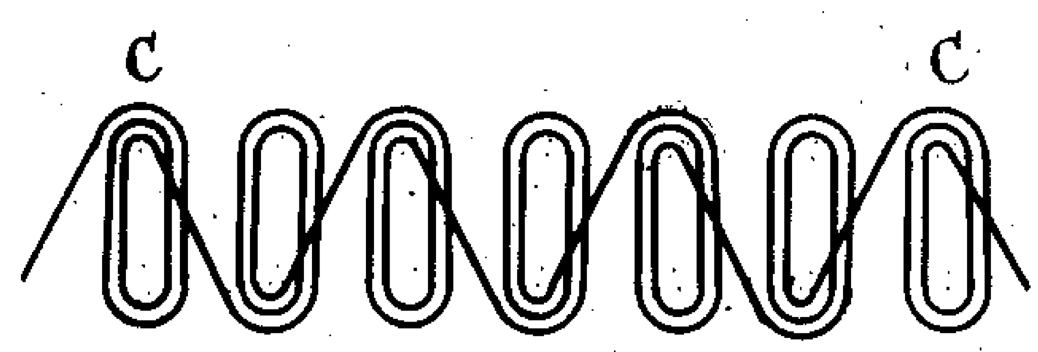



Fig 9.

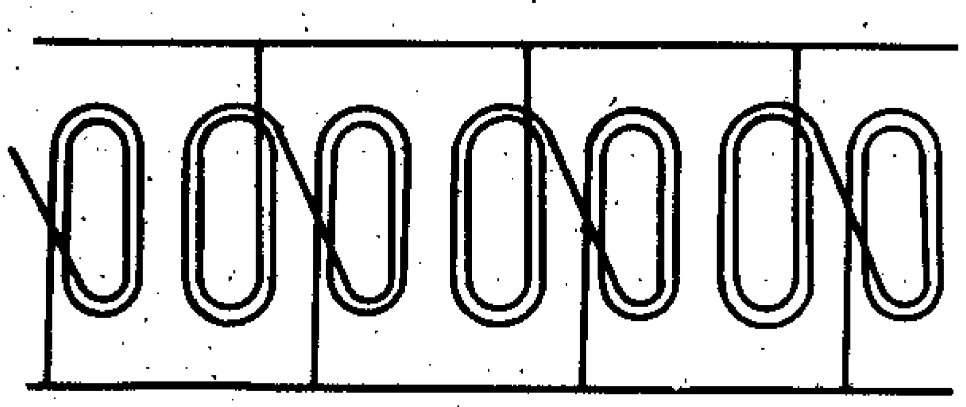
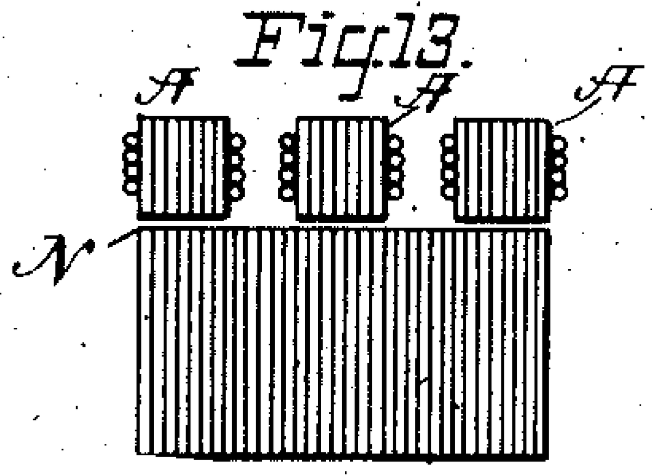


Fig 10.

Fig 13.



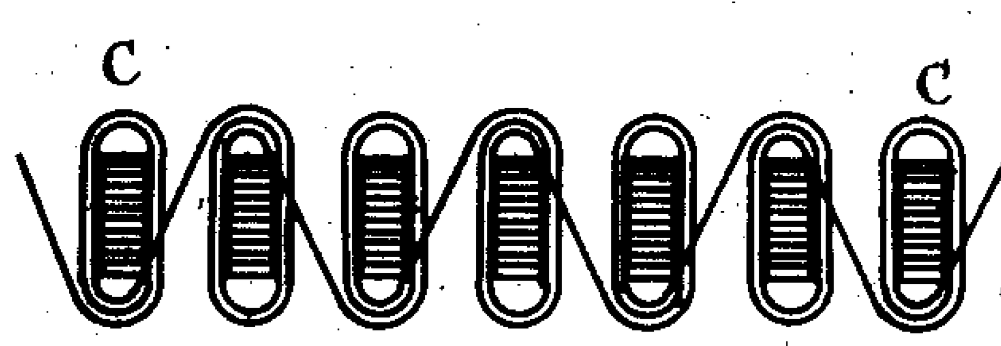




Fig 11.

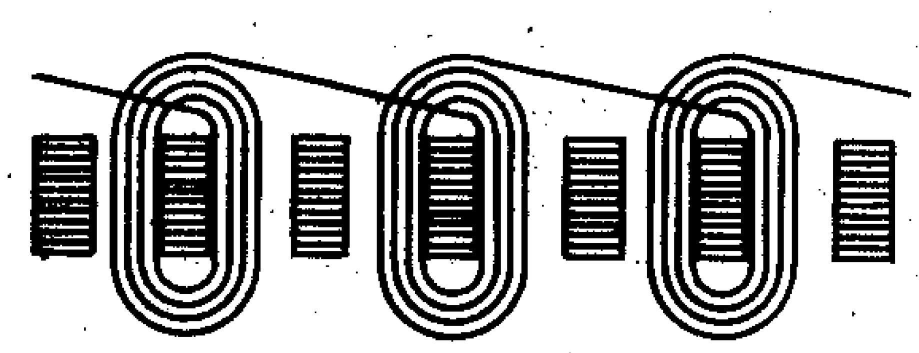


Fig 12.

Witnesses:
J. Hurdle
Wm. H. Capel

Inventor:
Elihu Thomson
By H. C. Townsend
Attorney.

# UNITED STATES PATENT OFFICE.

ELIHU THOMSON, OF LYNN, MASSACHUSETTS.

## DYNAMO-ELECTRIC MACHINE.

SPECIFICATION forming part of Letters Patent No. 432,655, dated July 22, 1890.

Application filed October 21, 1889. Serial No. 327,715. (No model.)

*To all whom it may concern:*

Be it known that I, ELIHU THOMSON, a citizen of the United States, and a resident of Lynn, in the county of Essex and State of Massachusetts, have invented certain new and useful Improvements in Dynamo-Electric Machines, of which the following is a specification.

My present invention relates to the construction of dynamo-electric machines or motors, but is particularly applicable to machines adapted to the production of alternating currents in a circuit, although by the addition of a suitable commutator the alternating impulses can be commuted to a continuous current wherever necessary.

One of the objects of my invention is to simplify the construction of the machine and secure at the same time high efficiency and great power and compactness with any given size of apparatus. In my machine the coils in which currents are induced, and which currents are alternating in character, are preferably fixed in position instead of revolving, and may therefore have their terminals carried out without moving contacts to the binding-posts of the machine.

While I have described but one induced circuit as existing in the machine, it will be understood that the circuits may be divided in manners well known in the art to secure two or more circuits. Thus if there are twelve coils in which currents are induced they may be coupled into sets of six, four, three, or two, or in a set of nine and three, &c. The coils may also be coupled together with any set in series or in multiple, or in multiple series or in series multiple, care being taken to connect only those terminals in multiple that are of the same polarity at any one instant, and in series those that are of opposite polarity at the same instant. The field of magnetism of my machine is provided by a set of coils, preferably stationary and generally only two in number, though I do not restrict myself in this respect, as the field-coils may be wound on a revolving portion, as will appear. Fixed coils are preferable, as they would not require sliding contacts for making connection with them. It will thus be seen that in the machines embodying my invention I propose to make both the inducing and the induced current—that is, the currents in the field-conductor and what corresponds to the armature-conductor—traverse stationary coils with fixed terminals, the only part of the machine which revolves being an iron mass suitably constructed. Notwithstanding this arrangement I find it possible to obtain a very high yield and economy from such apparatus.

I will now proceed to describe some of the forms of my invention, selecting those which I have found successful in practice, with modifications therefrom, and leaving to the electrical engineer the making of other and equivalent modifications not departing from the essential elements of my invention.

In the accompanying drawings, Figure 1 shows an elevation, in part section, of a machine containing preferred forms and arrangements and embodying the improvements of my present invention. Fig. 2 is a view showing the relation of the inducing-poles to the coils acted on by them. Fig. 3 shows in perspective the revolving iron structure of my invention. Fig. 3½ shows a modification in the form of a pole-piece of the machine. Fig. 4 illustrates a modification in the arrangement suitable for large machines. Fig. 5 shows a still further modification of the revolving iron portion for increasing the capacity of the machine. Fig. 6 is another elevation, in part section, of a modified form, of which Fig. 7 is an end view, certain portions being taken away. Fig. 8 shows the circuit arrangements simplified as far as possible and is only a diagram. Fig. 9 is a diagram of the winding of the induced bobbins in series. Fig. 10 shows the connection of such bobbins in pairs in multiple, so that the arrangement is series multiple. Fig. 11 shows the relation of the winding of the iron core or iron plates adjacent to the induced coils, or in which the successive coils are connected in series and reversed in direction as to their winding. Fig. 12 shows the winding, which consists of coils connected in series, the direction of each of the coils being the same. Fig. 13 illustrates a modification in the form of the machine.

In Fig. 1, P is the driving-pulley, carried by the shaft which goes through the center of the machine in bearings, preferably of brass or non-magnetic metal, at B B′. The shaft is either enlarged at its center in the form of a long core or it is slipped through a mass of iron M in the form, preferably, of a cylinder capable of revolution by the rotation of the shaft. This revoluble cylinder or mass of iron is constructed at one or more intermediate points, or, in the form of machine shown in this figure, at or about its middle portion, with a laterally-projecting mass or masses of iron divided circumferentially into separate polar projections. Such laterally-projecting portion of the iron mass or the core-piece M may be an attached body strung upon the cylinder and secured thereto near its center, as a bundle of iron plates or laminæ-pieces when completed give the form shown in Fig. 3—that is, somewhat like a pinion of laminated or subdivided iron, laminated especially at the polar projections or ends of the teeth, which are marked in Fig. 3 N N N N N N, six of which are shown, though their number may be varied with the construction of the machine from two up—such as, for example, three polar projections, four, five, six, seven, &c.

The laminated central mass is bolted together firmly, and magnetically forms a good connection with the core which it surrounds or upon which it is carried. The core M might, if desired, be divided in planes parallel to its length, especially near its center; but in ordinary cases such division will not be necessary. The laminated portion may consist of punched pieces in the form of washers slipped over the part M or sections bolted thereto, and the laminations may be insulated laterally one from the other. It is well to have them magnetically separated near their polar extremities N N, and substantially electrically insulated, not necessarily so at the center, where they meet the core M, but particularly at their outer extremities. The ordinary black oxide on sheet-iron will be found generally sufficient for the electrical insulation of the sheets laterally. Where economy of action is not especially desired, the lamination of the core pieces or projections may be entirely dispensed with, and the structure may be made solid, with the projections N N, &c., integral with the portion M and as an extension of the same. This is particularly the case where the induced coils are "pancake" coils without iron cores, as in Fig. 4, to be afterward referred to. Surrounding the core-piece M, Fig. 1, and partially inclosing the same at the outer ends, are end plates (marked E E′) supported on the base of the machine and fitted to the outline of the core M and separated therefrom by a slight space. On the plates E E′, alongside and surrounding the core-piece M, are wound the field-energizing coils shown in section supported by such plates. The plates E E′ serve the double purpose of a support for the energizing-coils and as part of a magnetic circuit extending laterally from the ends of the core-piece, as will be presently described. It is therefore apparent that the laterally-extending portions of the plates should be of iron. The cylindrical or circular portions of the plate are also preferably of iron and in one piece with the other portion, though they need not be made of iron, inasmuch as they serve mainly as bobbins or supports for the field-coils by which the said coils may be supported in close proximity to the core-piece M, so as not to interfere with the rotation of the same, but yet to act strongly in magnetizing the same. These coils around M may be connected into any exciting-circuit carrying continuous currents for magnetizing the machine. They are wound in opposite directions relatively to one another, so that they tend to form strong consequent magnetic polarity at the center of the bar or core M, which is conducted outward by the lateral extensions at the intermediate portion of the core and produces strong poles of a north polarity or a south polarity, according to the direction of the current at the projecting leaves or portions N N N, &c., Fig. 3.

The end plates E E′ are joined at their outer portions by an iron frame-work or casing F, shown as consisting of a simple tube or cylinder surrounding the machine; but it may be made of divided sections, and in large machines would be preferably so made. It is simply designed to connect the outer edges of the end plates E E′ magnetically with the stationary ring A, of iron, preferably laminated, and more distinctly shown in Fig. 2 as surrounding the core M at or about the central portion of the same, or so as to embrace the laterally or centrally projecting portions of the core or mass M. To the inner side of the structure A, and, when preferred, upon projections extending radially inward, are applied, in the ordinary and well-known way, other coils, the said ring and coils thus being made to resemble a multipolar ring or cylindrical-shaped magnet whose poles are on the inside.

The structure A is built up of a number of ring-shaped plates or sections of rings bolted together to form practically a compound laminated ring. It might be made of iron wire or otherwise subdivided ring, provided the subdivisions were made in a direction to cut off Foucault currents, which might otherwise be induced in the mass. It corresponds in a measure to a fixed laminated armature and is supported in the interior of the outside casing or frame, being firmly secured in place. This outer frame, while shown entire, might be perforated with openings at *a a*, as indicated in dotted lines, so as to allow a measurable ventilation of the interior of the machine, such perforations only requiring to be placed so as not to interrupt the magnetic continuity to too great an extent. Perforations might also be made in the end plates E E′ outside of the field-winding, as indicated in dotted lines at *b b′*, and the bearings B B′ may, as shown, be supported on ribs, which allow the entrance of air at the ends of the machine, which air would, if perforations were made near the exterior, circulate through the machine and be discharged. It may be said, also, that wherever laminated pieces are united by bolting or otherwise, if the bolts run in directions to connect sheets at differences of potential, the bolts themselves should be insulated. These are matters well understood in the art.

The ring structure A A, Fig. 2, may have interior projections of double the number of the projecting poles N N N, &c., carried by the ring core-piece M. On these projections are firmly secured coils of wire in which currents are to be induced, three of such coils being indicated in dotted lines as being placed over the three upper projections, Fig. 2. Such coils are also shown in section as bound in place both above and below in Fig. 1. Fig. 3½ shows how the form of the projection may be modified to be a rounded interior projection $p$, opposite which the moving pole N of the core-piece M passes, the induced conductor or coil being slipped over these rounded projections, as indicated at C.

In large machines it will be preferable not to use any projections, but to make, as shown in Fig. 4, the ring A a plain laminated ring, on the interior surface of which flat pancake coils are placed and properly secured. These coils are wound in alternately-reversed direction, proceeding around the interior of the ring, and should be double in number to the number of polar projections N N N, &c., standing toward them and revolving on the core structure M; but if the coils are all wound in the same direction, or connected so that the current flows through them in the same direction relatively, they should be of equal number to the number of polar projections and spaced accordingly. Where several circuits or sets of coils are to be used, they may be otherwise placed or connected, and two sets of coils may be even superposed on each other in such an arrangement as Fig. 4, where the coils are flat and there are no iron projections, and, if connected into different circuits, may even be displaced relatively one set to the other in the interior of the ring. In some cases there may be several rings surrounding the same core structure and shaft, as indicated in Fig. 13, in which case a polar extension will be sufficient to act upon the whole interior surface of the rings; or, as indicated in Fig. 5, the core structure may be extended from M to M′, and may carry on it three sets of polar extensions or consequent poles like three laminated pinions, or where the laminations are not necessary, as in the case like Fig. 4, where no interior projections on the ring A exist, the poles may be made solid with the core-shaft M M′ or of pieces of metal secured thereto. The field-energizing coils in the case of Fig. 5 are mounted so as to surround the core-piece M M′, both outside of and between the sets of projections, the coils either being carried independently of the revolution of the piece or wound directly thereon, while the end plates, like those in Fig. 1, carry an outer casing for three ring structures like A A, corresponding to the three sets of polar projections, Fig. 5. The polarities which the windings on M M′ must give are alternate. Thus those to the left may be all of north magnetic polarity, while the middle section is south and those to the right all north again. These are indicated by the letters N S N′, indicating the positions of the polar projections or series of consequent poles on the inner core-piece M M′. It will readily be seen that in this manner the machine may be extended and its capacity greatly increased, for the reason that the coils on each ring may become a separate source of current, or may be coupled with the coils of other rings, or the coils on each core-ring may be divided into sets and coupled or not.

Fig. 6 shows a modification in which the inner core-piece, revolving as before, carries on it a star-shaped set of poles or pinion-shaped piece, (more distinctly seen at N N N, Fig. 7.) This piece is shown in Fig. 6 as situated between coils C C′, two ranges of such coils existing, whose planes are at right angles to the axis, and which are seen in position in Fig. 7, one range there being indicated. The end plates E E′ in this case simply carry on their inner faces and on their outer edges a laminated ring constructed so that the divisions between the sheets are concentric, as shown. The edges of the sheets are shown in Fig. 7, while in Fig. 6 they are shown in part section. This portion of the machine may be made of hoop-iron wound up into the form of a ring. Alongside this compound hoop or band are situated the field-energizing coils, as before in Fig. 1, carried by the end plates and magnetizing the core-piece M to produce strong consequent polarity in its pinion-shaped pole-piece, the polarity of the projections being alike. In this case the magnetic inductions are exerted laterally from the revolving set of consequent poles to the coils C C′, instead of directly and radially outward, as in the previous figures. The end plates E E′ may be held at their proper distance apart by bolts of brass or non-magnetic metal, as shown in Fig. 6.

Fig. 8 is a diagram illustrating the actions produced when the core structure is energized and is revolved, and shows the ring-piece A A, with the core-piece M centering therein and revolving therein, which latter is provided in the figure with two polar projections N N, diametrically placed. In the interior of the ring A are indicated four coils C C C C, the direction of the winding of each in this instance being reversed alternately. They are connected, as shown, in series, and an external work-circuit L is to be fed by current from them, the field-energizing coils being supplied from a source of current for excitation S. In case only two coils C C are used they would be placed diametrically opposite as to their centers. They would extend over a larger area of the interior of the ring than when four are used, and would be connected in the same relative direction. The coils in Fig. 8 to utilize all the space should be large enough to meet edgewise in their position in the interior of the ring, but are shown in that figure widely separated, as it is merely a diagram.

Fig. 9 simply indicates the successive connections of a range of coils laid flat against the interior of the ring structure A A or slipped on projections extending inwardly from the same. Here the coils are supposed to be double in number to the field projections, and are therefore wound reversely or connected alternately reversed. In Fig. 10 the same set of coils is otherwise connected into a series-multiple arrangement with two coils in series and each of these series put in multiple.

Fig. 11 shows the laminated projections, over which the coils C C have been slipped when wound reversely, as in Fig. 9. Fig. 12 shows a similar set of projections, which are provided with coils not wound or connected reversely, but in the same direction, every alternate projection only being in this case provided with a coil. This same arrangement may be used when no projections from the ring-structure A A exist, and the coils are then equal in number to the polar projections from the field and spaced apart accordingly.

The action of the machine or its modifications is as follows: The moving field-poles N N N, &c., carried around on the revolution of the core-piece M pass in front of the coils in which the currents are to be induced. The lines of magnetic force projecting from these pole-pieces cut across the wire on the coils transversely, since the coils lie in the proper direction to be so cut, or at least the sides of the coils parallel to the axis so lie and generate in the coils' impulses of current. The direction of the winding and the connection is such as to make the effects accumulative in the coils—that is, so that if a polar projection N passes, as in Fig. 2, over the center of one coil to that of the next its lines are caused to cut the wire lying between those centers, half of which would belong to that coil the center of which is being left by the traveling pole and half to the coil toward the center of which the traveling pole is moving. An impulse of current would thus be set up in both coils, and if the direction of connection is like Fig. 9 each impulse will be superadded, or in case the connection of the coil is made such that the impulses developed are carried to the external circuit L L, Fig. 8, in the same direction a similar result will follow. Where the number of coils equals the number of projections, as in Fig. 12, then the action is the simple cutting in succession, by the lines emanating from the pole projections, of one side of a coil or of one side of all the coils taken together, and immediately thereafter the other side of the same coil or set of coils taken together, the winding being all in the same direction and the impulses therefor being directed in the same way in each coil. These actions of cutting by the lines emanating from the poles will be repeated in the coils every time the polar projection passes the wire on either side of a coil, so that if there be six poles, as indicated in Figs. 1, 2, 3, 6, and 7, and the revolution of the machine be made at the rate of one thousand turns per minute, the alternations of current or impulses will number six thousand positives and six thousand negatives, or a total of twelve thousand alternations during one minute. These actions of induction repeatedly following one another will be accomplished without a reversal of magnetism in the core-piece or even in the laminated ring structure supporting the coils in which the currents are induced; but, on the contrary, the lines of force will simply be carried rapidly past wire whose virtual direction of winding is opposite alternately, and this will generate impulses without the necessity of magnetic changes of polarity taking place in any of the core-pieces. I am thus enabled to save a large portion of the loss due to magnetic changes or "hysteresis," as it is called, in the iron of the machine, while still utilizing the iron to the best advantage in the construction of the magnetic bodies subject to the magnetizing actions of the field-energizing coils. I also secure a strong magnetic field by the expenditure of a minimum of energy in sustaining the same, besides which none of the wire of the machine need revolve, and I therefore dispense with rubbing-surfaces or sliding contacts when the machine is used for the generation of alternating impulses or alternating currents.

The construction of the machine itself is comparatively easy, as the parts are of simple form and easily mounted in a substantial manner. The constructions, Figs. 6 and 7, do not even require that the revolving magnetic mass shall be laminated and subdivided, and the laminated ring-pieces A A of Figs. 6 and 7, upon the faces of which the coils C C are mounted opposite the revolving poles, can be, as before indicated, wound up out of strip sheet metal—a procedure very easily practiced and not requiring special machinery. The revolving core-piece, with its star-shaped center, may be made of one solid piece of cast-iron, if desired, or better of cast soft iron, such as Mitis iron. The end plates E E' may in like manner be so constructed, and the revolving portions of the machine inclosed in such manner as not to be liable to cause injury or to be injured.

While I have described my invention as particularly useful for machines when employed for developing electricity from power, it will readily be understood by electricians that the same general features of construction are also of utility in electric motors in which the action and reactions produced by the influence of alternating electric currents set up a motive influence of torque, as is now well understood in the art.

What I claim as my invention is—

1. In a dynamo-electric machine or motor, the combination of a magnet structure having a consequent pole and extensions therefrom at its position of such developed polarity, such extensions being separated into separate polar projections constituting a series of like poles, iron masses surrounding and in proximity to the said magnet structure at an opposite polar portion thereof and forming magnetic extensions of such opposite polarity to a laminated ring for closing the magnetic circuit exteriorly, and electric coils on the face of said ring, said poles and coils being one or both movable with relation to one another.

2. A dynamo-electric machine containing the following elements in combination: a revolving field-core with a consequent pole or poles at an intermediate portion of its axial length and extending outwardly into a number of separate polar projections, stationary energizing-coils surrounding the axially-projecting ends of the core, plates or magnetic carriers in close relation to the revolving core, but disconnected therefrom and extended to support a laminated ring or coil-carrier, and induced coils supported upon the face of said ring and presented to the revolving field-poles.

3. In a dynamo-electric machine or motor, a fixed armature-coil and field system having a revolving magnetic core provided with a number of like poles presented to the armature-coils or induced coils, and consisting of separate polar extensions from a consequent pole produced in the common field-core, in combination with two coils or sets of coils wound or applied reversely, as described, at opposite sides of the consequent polar portion, so as to produce a consequent pole in said magnetic core.

4. In a dynamo-electric machine or motor, the combination of two or more oppositely wound or connected field-magnetizing coils, a revolving field-magnet core centering therein carrying between each pair of oppositely-wound coils extensions of its consequent pole into a number of polar projections, a laminated ring surrounding such polar projections, bearing on its face a series of coils laid flat against such face, and magnetic casings or extensions of magnetic material serving to convey magnetism from the other portion or outer face of the laminated ring to those ends of the field core which project into and through the field-coils outwardly.

5. In a dynamo-electric machine or motor, a field-core mounted on an axis parallel to its magnetic axis and bearing at its middle portion a series of polar extensions of like polarity, field-coils surrounding said core, iron shells surrounding that portion of the core which projects through the field-coils, and a laminated ring bearing induced coils outside or adjacent to the polar projections.

6. In a dynamo-electric machine or motor, an induced-coil system consisting of a laminated ring bearing on its inner face a system of coils in which the windings are successively reversed and connected, as described, into one or more circuits, in combination with a revolving field structure having polar extensions equal in number to half the number of coils or coil positions existing on the inner surface of the ring.

7. In a dynamo-electric machine or motor, the combination of a magnet structure having a consequent pole divided into separate polar projections or extensions, a series of coils carried on a suitable support and having their same sides or poles presented to all of said polar projections, and iron masses in proximity to the said iron magnet structure for closing the magnetic circuit exteriorly from the opposite pole thereof through all of said coils, as and for the purpose described.

8. In a dynamo machine or motor, a revolving magnetic core-piece mounted on an axis parallel with its magnetic axis and having a consequent polar portion subdivided into several polar projections which are continuously magnetized, a coil or coils surrounding said core-piece at opposite sides of said polar portion and traversed continually by exciting-current, and another set of coils inductively presented to the polar projections and applied to a magnetic extension from said core-piece.

9. In a dynamo-machine, the combination, with a revoluble pole-piece mounted to turn on its magnetic axis, of two exciting coils or sections of coil combined to produce a consequent pole in such core-piece between them, a series of separate polar projections at such consequent polar portion of the core-piece, and a series of coils having their same poles or sides inductively presented to the said polar projections.

10. In a dynamo machine or motor, the combination of a revoluble core-piece having a consequent polar portion subdivided into a set of separate radial arms, a magnetic extension from an opposite pole of said core-piece, and a series of fixed coils presented to the sides of said polar arms and mounted on said magnetic extension so as to be in a magnetic circuit from the consequent polar portion closed exteriorly by said extensions.

11. The combination, substantially as described, of an electro-magnet having a series of polar projections from a consequent pole, two energizing-coils at opposite sides of said pole, and a series of separate coils inductively related to said consequent poles and applied to iron masses forming magnetic extensions from the core having such consequent pole.

12. In a dynamo-electric machine or motor,

a moving element consisting of a core having a consequent polar portion extending transversely outward into a number of separate poles of the same name, in combination with a fixed coil for said core and another set of fixed coils mounted on a magnetic extension of the core presented to said poles.

13. The combination, with the iron core-piece M, mounted on its longitudinal axis, of energizing-coils combining to produce a consequent pole in said core-piece between them, a bundle of iron plates secured to the consequent polar portion of the core-piece and each divided at its periphery into a series of polar projections, and a second set of coils mounted on a magnetic extension from said core-piece and presented to the end of said projections.

14. In a dynamo machine or motor, a revoluble iron core-piece mounted on its longitudinal axis and having a laminated mass of iron secured to it and divided peripherally into separate poles, in combination with fixed energizing-coils for developing polarity at the portion of said core-piece where the laminated mass is located and a series of fixed coils presented to the ends of said separate poles.

15. In a dynamo machine or motor, the combination, with an iron core having fixed energizing coil or coils continually traversed by exciting-current, of a series of projections extending radially outward from a central revoluble polar portion of the mass of iron energized by such coils, all such projections being of the same polarity and continually polarized, and a fixed magnetic extension from an opposite pole of said core carrying a series of fixed coils arranged in the periphery of a circle around said polar projections and presented to the same, as and for the purpose described.

Signed at Lynn, in the county of Essex and State of Massachusetts, this 18th day of October, A. D. 1889.

ELIHU THOMSON.

Witnesses:

J. WESLEY GIBBONEY,

A. L. ROHRER.