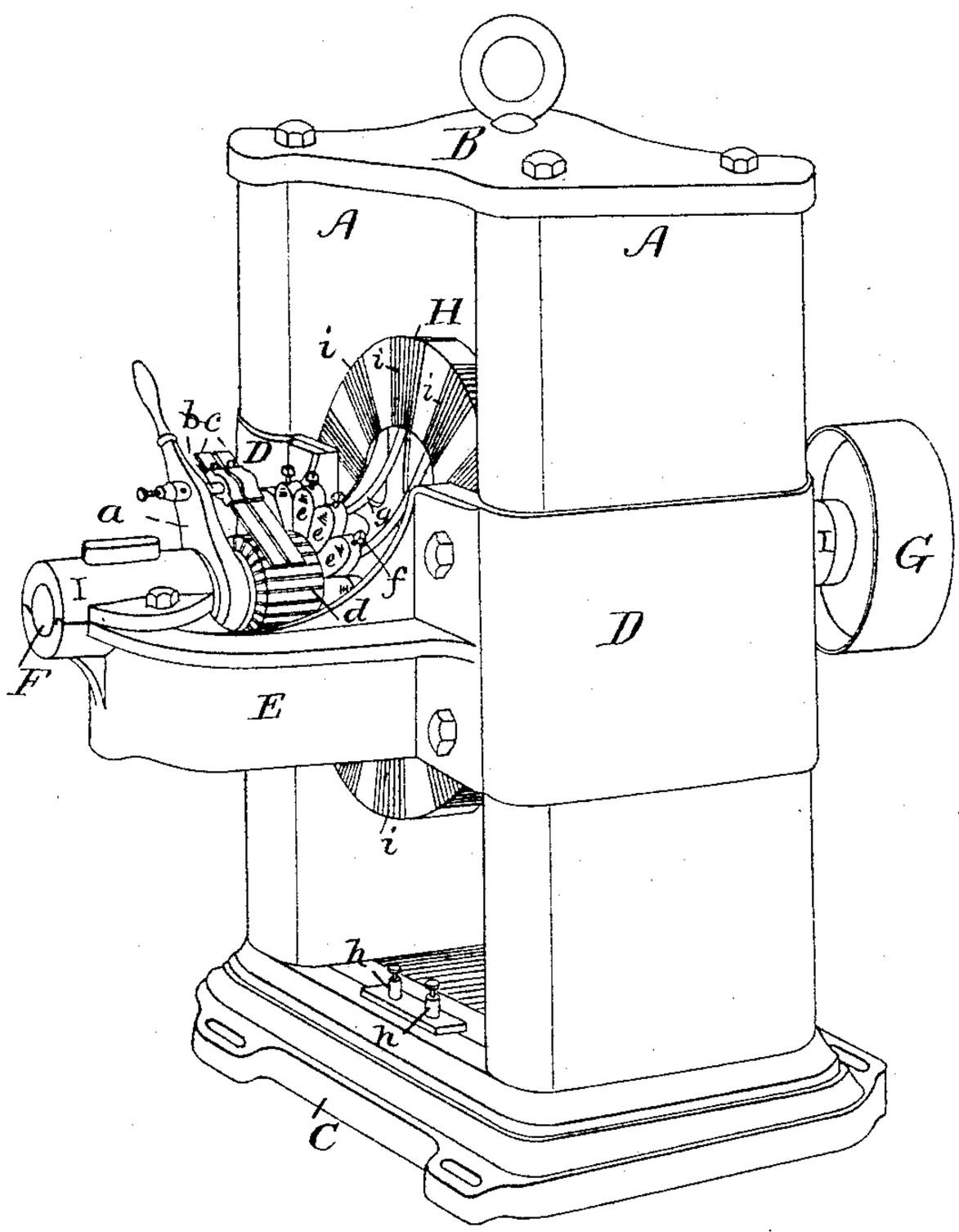
(No Model.) 3 Sheets—Sheet 1.

# A. BERNSTEIN.

## DYNAMO ELECTRIC MACHINE.

No. 284,999. Patented Sept. 18, 1883.

*Fig. 1.*




Witnesses.
Fred'k. F. Schwartz
Geo. Willis Pierce

Inventor.
Alex. Bernstein.
by his Attorney,
Thos. D. Lockwood

(No Model.) 3 Sheets—Sheet 2.

# A. BERNSTEIN.

## DYNAMO ELECTRIC MACHINE.

No. 284,999. Patented Sept. 18, 1883.

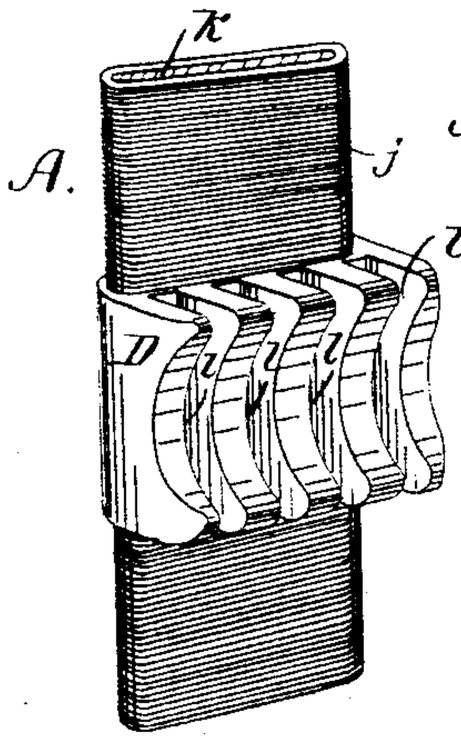



Fig. 2.

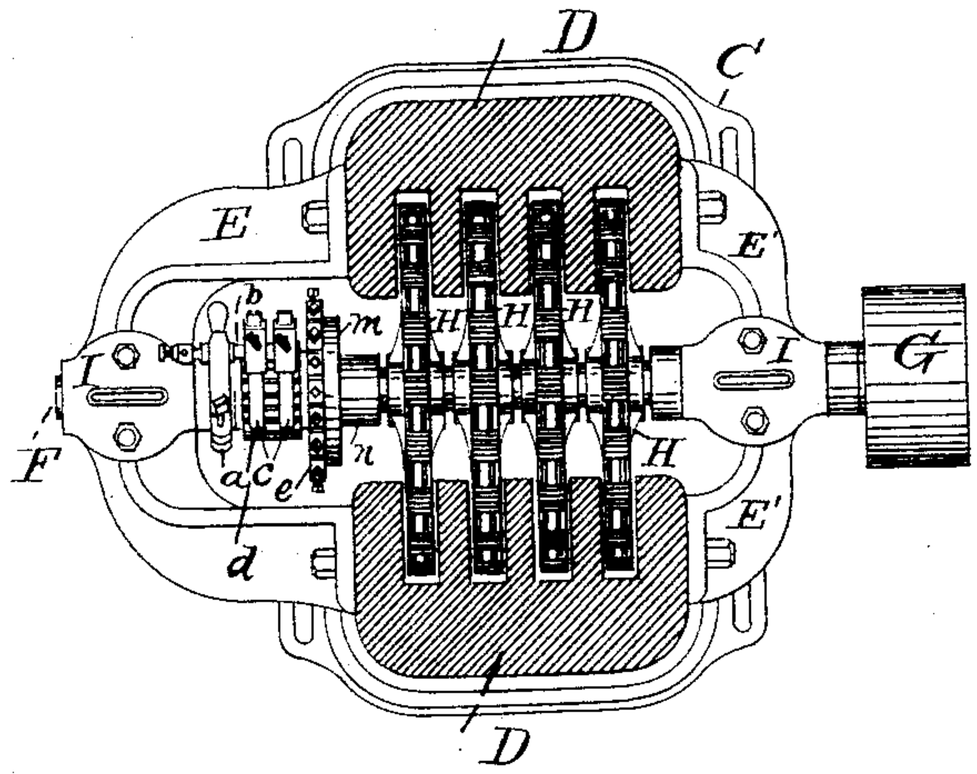



Fig. 3.

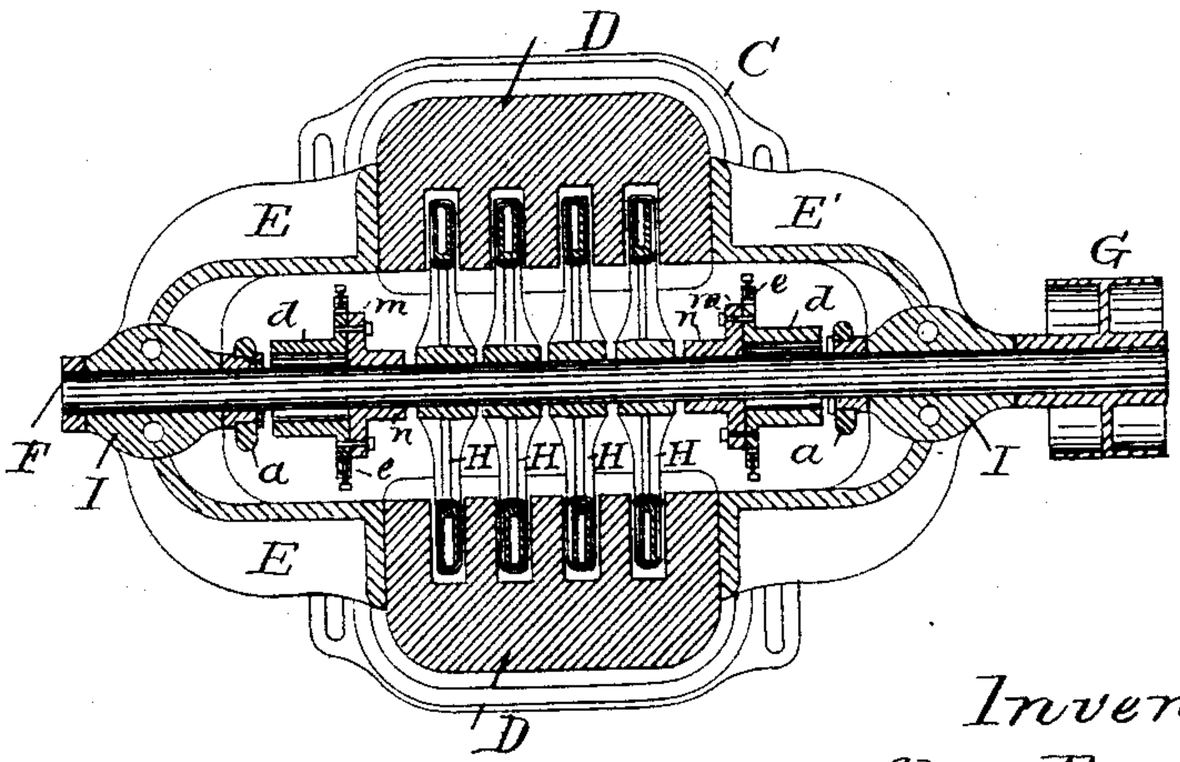



Fig. 4.

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(No Model.) 3 Sheets—Sheet 3.

# A. BERNSTEIN.

## DYNAMO ELECTRIC MACHINE.

No. 284,999. Patented Sept. 18, 1883.

Fig. 5.

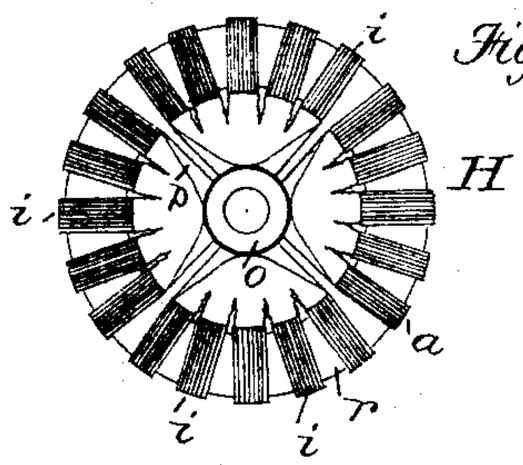



Fig. 6.

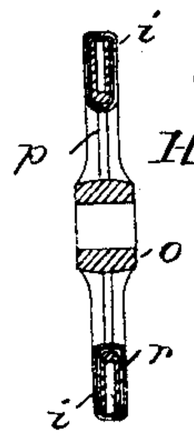



Fig. 7.

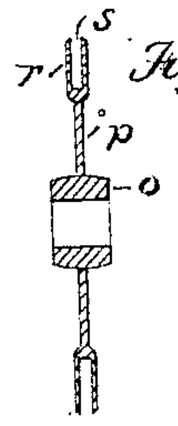



Fig. 8.

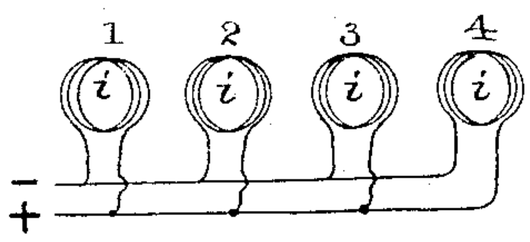



Fig. 9.

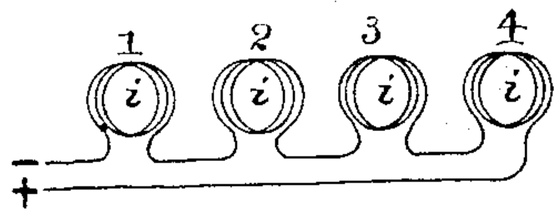



Fig. 10.

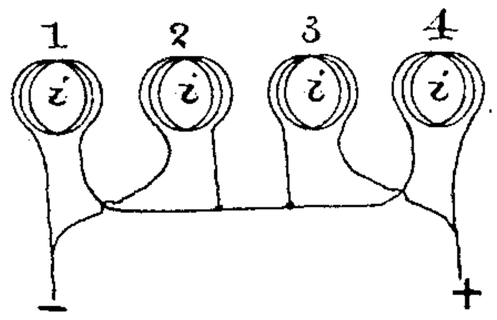



Fig. 11.

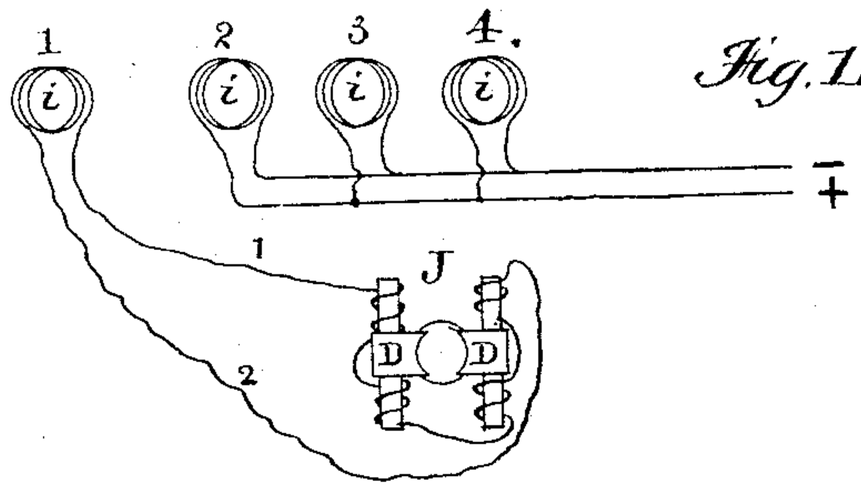



Fig. 12.

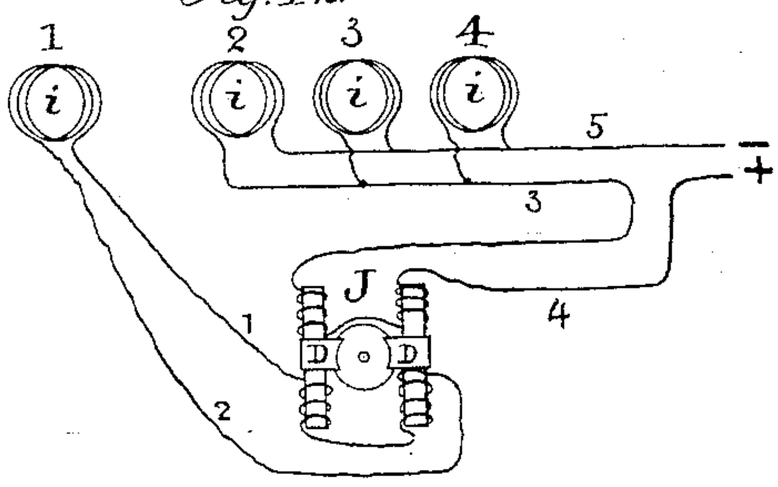
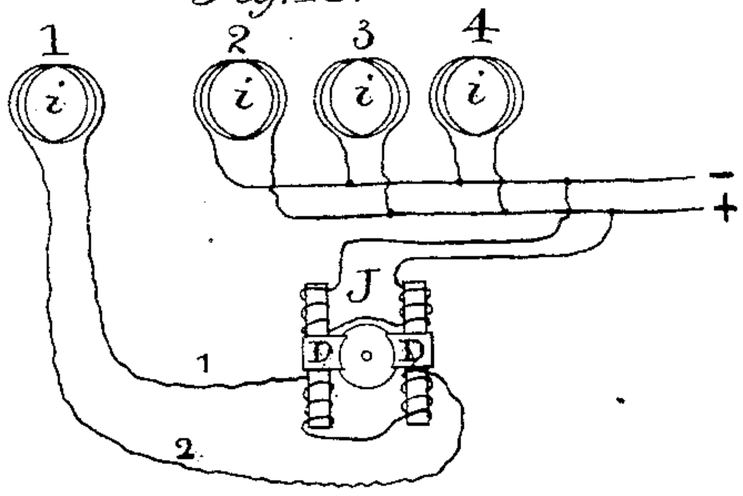



Fig. 13.




Witnesses.
Fred'k. F. Schwartz.
Geo. Willis Pierce.

Inventor:
Alex. Bernstein,
by his Attorney,
Thos. D. Lockwood

# UNITED STATES PATENT OFFICE.

ALEXANDER BERNSTEIN, OF BOSTON, MASSACHUSETTS.

## DYNAMO-ELECTRIC MACHINE.

SPECIFICATION forming part of Letters Patent No. 284,999, dated September 18, 1883.

Application filed April 24, 1883. (No model.)

*To all whom it may concern:*

Be it known that I, ALEX. BERNSTEIN, of Boston, in the county of Suffolk and State of Massachusetts, have invented certain Improvements in Dynamo-Electric Machines, of which the following is a specification.

My invention relates to that class of machines in which mechanical is transformed into electrical energy, and which are commonly known and designated as "dynamo-electric machines." It especially relates to devices for establishing a very intense magnetic field of force, in which the armatures of said machines are to rotate, for allowing the development of currents of any desired electro-motive force, and for regulating the strength of the magnetic field, and consequently the production of electricity, by the character and amount of work to be done in the external circuit. My invention is applicable to such machines, whether they are employed for converting mechanical power into electricity, which may be used for electric lighting or plating or other purposes, or whether they are employed, conversely, for converting an electric current into mechanical power, as in the transmission of power to a distance.

The object of my invention, broadly stated, is the construction of a dynamo-electric machine in which the generation or development of electric currents is accomplished efficiently yet economically, and which will present certain practical advantages by allowing the production of currents of definite electro-motive force, which may be of any required degree of strength or intensity. I aim also at the construction of a machine which shall be self-regulating with reference to the varying requirements of the external circuit. I attain these objects by producing a very intense magnetic field, and using in the production of the same as much effective surface of the field-magnets as possible. I also prevent all undue heating of the armature-wires and other working parts of the machine by exposing as much of the wire as possible to the cooling influence of the air. The armature being made in several parts, and formed in a manner well adapted to expose much of its surface to the atmosphere, is also kept cool, and, furthermore, allows a rapid change of polarity in its cores or throughout its substance, and the self-regulation of the machine and its producing-power results from the novel and peculiar method of charging the field-magnets and arranging the several connections of the helices thereof, which will be more particularly described hereinafter, reference being made to the accompanying drawings.

Figure 1 is a perspective view of the complete machine; Fig. 2, a similar view of two of the field-magnets with channeled pole-pieces common to both. Figs. 3 and 4 are horizontal sections taken through or near the center of the pole-pieces, the ring-armature in Fig. 3 being represented as entire. Fig. 3 also is shown as being provided with but one commutator. In Fig. 4 the ring-armature is shown in section, and the machine has two commutators. Fig. 5 is a face view of one of the armature-rings. Fig. 6 is a vertical section of the ring with generating-coils attached; and Fig. 7 is also a vertical section, as it appears before winding. Figs. 8, 9, 10, 11, 12, and 13 are diagrams which graphically represent the various methods of connecting the armature-coils and field-magnet helices with reference to the external circuit.

The machine, as constructed on my improved plan and as delineated in perspective in Fig. 1, may be described as follows:

A A are the field-magnets, consisting, as usual, of iron cores surrounded by convolutions of insulated wire. These are provided at the center with pole-pieces D, the peculiar form of which will be hereinafter specifically described. A crown-plate, B, of iron, unites the cores of the two magnets at the top, while a base-plate, C, similarly unites them at the bottom. This may either be the plate upon which the machine stands or may consist of a plate supported on a suitable base.

Between the pole-pieces D, and suitably supported by the pedestal or bracket E and journal I, (a similar journal being also provided at the opposite side,) is a shaft, F, which, with the annular armature H carried thereon, is adapted to rotate when influenced by power conveyed thereto by means of the pulley G and a suitable belt actuating the said pulley from any convenient motor or source of power.

The armature may consist of any desired number of separate rings fixed upon and adapted to rotate with a common shaft or spin-

dle, as more clearly shown in Figs. 3 and 4, and in practice I have found four to answer very well for general purposes. Each ring is furnished with a series of inducing-coils, *i*, and the corresponding coils of all the rings, after being connected in series or multiple arc with one another, according to the work to be done, are then connected, in a manner well understood by those skilled in the art, with the commutator *d*.

It will of course be understood that the present description is general, and refers especially to the perspective view shown in Fig. 1, the peculiar electrical connections of the armature-coils being hereinafter described more particularly.

The coil terminals are, by means of screw-connectors *e e e*, connected with commutator *d*, and by means of metal brushes *c* the currents are led out from the commutator to wires communicating with screw terminals *h*, to which the external circuit-wires may be attached. *a* is an adjusting-lever for the regulation of the said brushe.

I will now proceed to describe the peculiar form of the field-magnets and pole-piece.

Each of the field-magnets A consists of an iron core, *k*, surrounded with coils of insulated wire *j* at its upper and lower part, while a large and heavy pole-piece, D, is fixed to the middle of the core, and projects inwardly, as shown in Fig. 2. The cores and pole-piece may be made in one piece, or the upper and lower cores and the pole-piece may be made severally and afterward bolted together. The pole-pieces D are provided with two or more channels, *l*, (in the drawings I show four,) and these channels are made just wide enough to embrace the coil edges of the armature-rings and allow the free rotation of the same, as shown in Figs. 3 and 4. By adopting this arrangement I am enabled to bring a large magnetic inducing-surface to bear upon the rotating armature-coils with the constant result of a very intense magnetic field, through which the said armature-coils must necessarily pass. The upper and lower sections of field-magnet coils *j*, which surround the cores, are so wound with reference to one another as to develop the same magnetic polarity in their common pole-piece, that of the other pole-piece being of the opposite polarity. The armature-cores, or that portion of the substance of the ring which at any moment is entering or passing through the pole-piece channels, will acquire by induction a polarity of an opposite character to that of the pole-piece they are passing.

The construction of the armatures is shown in Figs. 5, 6, and 7. These consist of a series of iron rings, H, corresponding in number to the channels or grooves of the pole-piece. The figures represent one only of the rings; but as they are all identical in character it is not necessary to show or describe the others. Each ring H consists of an annular iron core, *r*, with a channel or deep depression, *s*, passing completely round the same, leaving the sides of the said channel very thin. This circular core is attached to the spokes or radial arms *p* of a brass spider, and the central part or hub, *o*, of the spider is keyed or otherwise fixed to the armature-shaft F. As shown in Figs. 5 and 6, the generating-coils *i* are radially wound upon the cores *r* of the rings in a similar way to that of the well-known Pacinotti machine. The circular channels *s*, grooved into the peripheral edge of the rings, may, if desired, be filled with iron wire, or may be left unfilled. With respect to the several coils of each individual ring, the leading-out wire of each coil is connected with the leading-in wire of the next, and a branch wire from each of the coil-junctions thus formed is led to its respective commutator-bar.

The mechanical features of the machine are shown in Figs. 3 and 4.

In Fig. 3 the rings H (four in number) compose the compound rotating armature of the machine, and are keyed or otherwise attached to the shaft F, which rests in the bearings I, these being suitably supported by the brackets E and E′, which are bolted to the framework of the machine. A collar, *m*, attached to the armature-shaft, carries a number of binding-screws, *e*, which receive the wires from the armature-coils and direct them to the bars of the commutator *d*. As in Fig. 1, the brushes are designated by the letter *c* and the adjusting-lever by *a*. The figures also show clearly the mode in which the coiled edge of the ring is embraced and adapted to be acted upon on three sides by the channeled pole-pieces of the field-magnets. One commutator is in the machine represented in Fig. 3, intended to serve all of the rings.

The machine shown in Fig. 4 differs in no material detail from that represented by Fig. 3, with the exception that Fig. 4 is fitted with an additional commutator, one commutator being provided at each side of the machine. The purpose of this will be hereinafter explained in detail. The commutators *d* are at each side closely connected with the binding screw-collar *m*, which, by a bushing, *n*, is fitted to the shaft. It is obvious that in this machine some of the rings may have their coils connected with the right-hand and some with the left-hand commutator. Owing to the conformation of the substance of the iron rings and the continuous groove which channels its edge, and to which the air has free access by means of the apertures or spaces between the coils, the armature and coils are maintained in a very cool condition, and currents generated by induction in the iron are effectually prevented.

The remaining figures are explanatory of the different circuit arrangements which I may use in connection with the field-magnets, helices, and generating-coils in order to suit the widely-varying requirements of the work to be done and the character of the external circuit.

The first three diagrams, Figs. 8, 9, and 10,

refer to the machine shown in Fig. 3, and illustrate the different methods of arranging the connections of the inducing-coils so as to produce with a given degree of magnetism a current of high, low, or medium electro-motive force. The second coils, *i*, in each of the diagrams are intended to represent the corresponding coils of the four rings. Thus if 1 is the particular coil on the ring at the extreme left which is passing a given point, 2, 3, and 4 are the coils upon the other rings, which will pass the same point at the same time. This being understood, Fig. 8 shows a case in which the corresponding coils of the four rings are connected with one another in multiple arc, the wire marked with the negative or minus sign being led to one of the commutator-bars and that marked positive or plus to the adjacent commutator-bar. In this case, after passing the commutator, the current will be divided also in multiple arc between the four field-magnet helices, the result being a strong magnetic field and a current of low electro-motive force, but of considerable volume, the latter feature being due to the low internal resistance of the arrangement. In the second method of arranging the connections shown in Fig. 9 the corresponding coils of the several rings are connected in series, and the currents developed in them will have the combined electro-motive force of the entire number of coils, which in this case is four. The current, after passing the commutator, traverses the field-magnet helices also in series, and the general result will be a working-current of high electro-motive force. This arrangement will be preferably adopted when the resistance of the external circuit is considerable.

It is frequently convenient to produce currents of medium electro-motive force, and in such cases I connect the armature-coils of corresponding radius, as shown in Fig. 10, in which coil 1 is connected in parallelism with coil 2 and coil 3 in parallelism with coil 4, thus making two pairs, the pairs being then connected in series with one another. The field-magnets would again be similarly arranged; but although in many cases the foregoing arrangements, as shown, are convenient and useful, I prefer, in order to produce the best results, to construct the machine with two separate commutators, as in the horizontal section, Fig. 4. In this case one or more of the armature-rings are used for the exclusive purpose of charging the field-magnets, and they may either perform this office unaided, or aided by and in connection with the other rings. In the drawings I have shown but one armature as being devoted to this purpose—*i. e.*, that at the extreme left of the machine. The object of the additional commutator is thus made manifest. The several terminals of the coils of the left-hand ring, No. 1, all connect with the commutator at the left-hand side, and from thence the currents are, as usual, taken off by brushes and directed through the field-magnet helices or a portion thereof, to subserve the purpose of magnetizing the cores. Those of the remaining rings, combined either in series, in multiple, or in multiple series, according to the character of current which is desired, and as hereinbefore described, unite in passing to the right-hand commutator, and from thence connect either with the external circuit direct, or to the external circuit arranged in series with a portion of the field-magnet helices, or to the external circuit connected in multiple arc with a portion of the said helices. The different modifications of this method of maintaining a permanent magnetic field are explained by the diagrams Figs. 11, 12, and 13, in which the armatures are represented by the coils *i*.

Although, as hereinbefore stated, the rings composing the compound rotating armature are in practice fixed upon a shaft or spindle between the pole-pieces D, I have, for facility of explanation and for convenience in illustrating the connections, shown them apart from the said magnets and pole-pieces. In Fig. 11 the first ring of the armature is used exclusively to charge the field-magnets, and performs that work without any connection with or aid from the others, the corresponding coils of rings 2, 3, and 4 being connected together in any of the ways hereinbefore described, and, through the instrumentality of the right-hand commutator, caused to supply the current for the external circuit. By this arrangement the field of force is maintained permanent independently of the condition of the external circuit, and its intensity is variable only by variations in the velocity of rotation of the armature. In Fig. 12 the first ring is utilized to charge one-half only of the field-magnets, and, although I have represented it as charging the lower helices and magnetizing the lower cores only, it is obvious that I might with identical results charge the upper portion of the magnets only, it being immaterial for the purposes of this invention which portion is charged by the first coil. The remaining cores—in this case the upper ones—are charged by the main current generated by the coils of the remaining armatures, and their coils are connected directly in the main circuit, the entire arrangement being a combination of those shown in Figs. 8 and 11. The outer terminals of the generating-coils are united to the wire 3, and the circuit then continues through the upper field-magnet coils and out by wire 4 to the external circuit. Returning, the wire 5 leads to the inner-coil terminals. In Fig. 13 still another method of connection is shown. The coils of the first ring, as in the immediately-preceding case, magnetize the lower field-magnets; but the upper helices are in a shunt from the external circuit, and are thus charged by a portion of the main current, the amount of current flowing through the shunt being dependent on the condition of the outside circuit. The actions and reactions of the foregoing dispositions of circuits are

such that in those last described, although there is no time when the magnetic field ceases to exist so long as the machine is in operation, the strength of the said field being partly dependent upon the condition of the outside circuit, varies with every variation in strength of the current flowing in the outside circuit, and by the said variation regulates the strength of the maintaining-current in the coil 1. In the arrangement shown in Fig. 13, especially, the self-regulation of the machine is well exemplified. A magnetic field of definite intensity is established as soon as the rotation of the armature begins first by the electricity evolved by the armature or ring No. 1. This, as soon as the external circuit is closed, is strengthened by the current developed by the other rings by means of the shunt-circuit. A due portion of the latter current passes to the outside circuit to perform work therein. If, now, the work to be done increases in amount, or, in other words, if the external resistance increases, a larger amount of the current is transferred to the short circuit of the upper field-magnets and tends to increase the magnetic force developed therein, which, reacting both upon the ring 1 and also upon the rings 2, 3, and 4, increases the strength of current first in the coils of ring 1, thus still further augmenting the strength of the field of force, and, secondly, in the coils of the other rings, whereby a stronger current is sent to the outside circuit to overcome the increased work of resistance. Conversely, if the work in the external circuit decreases in amount, a larger amount of the generated current passes in that direction and the field of force diminishes in intensity. This arrangement in each of its modifications differs materially from all other arrangements in which the field-magnets are energized from an independent source of electricity.

I have in the drawings shown but one of the armature-rings as being in circuit with and used solely to excite the whole or a portion of the field-magnets; but I may, if I so elect, employ more than one ring for the purpose, it being evident that the work of the several rings may be divided in any desirable way.

It must be understood that in describing the rotating armature I have sometimes designated by the term "armature" the compound piece of mechanism, consisting of the entire number of rings attached to their common spindle, while at other times I have designated the individual rings by the same term. I have, moreover, sometimes designated the latter by the generic term of "ring," and have, in fact, used the terms interchangeably. I have been led to this by consideration of the fact that the said rings, though component parts of the entire armature, are equally complete armatures in themselves and operate as such.

In the foregoing specification, where I have referred to a permanent field of magnetic force, it is to be understood as meaning a field of force which is permanent so long as the rotation of the armature continues, in contradistinction to the magnetic field of a machine whose field-magnets are arranged in series with the external circuit, and which is consequently totally dependent upon the closing of the external circuit for the establishment and maintenance of a magnetic field of force.

Having now described my invention, I claim—

1. The combination, in dynamo-electric machines, of field-of-force magnets with a compound armature consisting of a number of coil-carrying rings, the generating-coils of one or more of the said rings being in circuit with a portion of the field-magnet helices, and adapted to excite them, and the coils of the remaining rings being in circuit with another portion of the field-magnet helices and with the external circuit, substantially as and for the purposes described.

2. The combination of field-magnets and a number of rotating armatures therefor, one or more of the said armatures being connected in circuit with a portion of the field-magnet helices, and adapted exclusively to excite the same, and the remaining armatures being in circuit with and adapted to produce electrical currents in the external circuit, and in a shunt-circuit consisting of the remaining field-magnet helices, substantially as described.

3. A dynamo-electric machine in which the coils of some of the field-of-force magnets are placed in the circuit of one or more of a number of armatures rotating in the magnetic field of the said magnets, the remaining coils of the said magnets being placed either in a serial circuit comprising the remaining armatures and the external circuit or in a shunt-circuit parallel to the external circuit, and energized by the current of the remaining armatures, substantially as described.

4. The combination, substantially as hereinbefore described, in a dynamo-electric machine, of field-of-force magnets, one or more rotary armatures therefor, a local or internal circuit including the generating-coils of one or more of the said armatures and a portion of the field-magnet helices, the generating-coils of the remaining armatures being included in the main or external circuit, and the remaining field-magnet helices being also included with the said remaining armature-coils in the said main circuit, or in a shunt therefrom, whereby a permanent field of force may be maintained by means of the generating-coils in the local or exciting circuit, and whereby the said field of force may be modified and regulated by the current generated by the remaining armatures and flowing in the main circuit.

5. A dynamo-electric machine consisting of the following elements: a compound rotating armature composed of a number of independent annular sub-armatures, field-magnets pro-

vided with pole-pieces channeled to receive and overlap the several armature-cores, for the purpose of establishing a magnetic field of force, a closed exciting-circuit including one or more of the sub-armatures and a portion of the field-magnet helices, a partial or incomplete circuit including the remaining armatures, and adapted to be closed or completed through an external circuit, and a closed shunt-circuit also comprising the said remaining portion of the field-magnet helices, substantially as described.

In testimony whereof I have signed my name to this specification, in the presence of two subscribing witnesses, this 18th day of April, 1883.

ALEX. BERNSTEIN.

Witnesses:
GEO. WILLIS PIERCE,
THOS. D. LOCKWOOD.