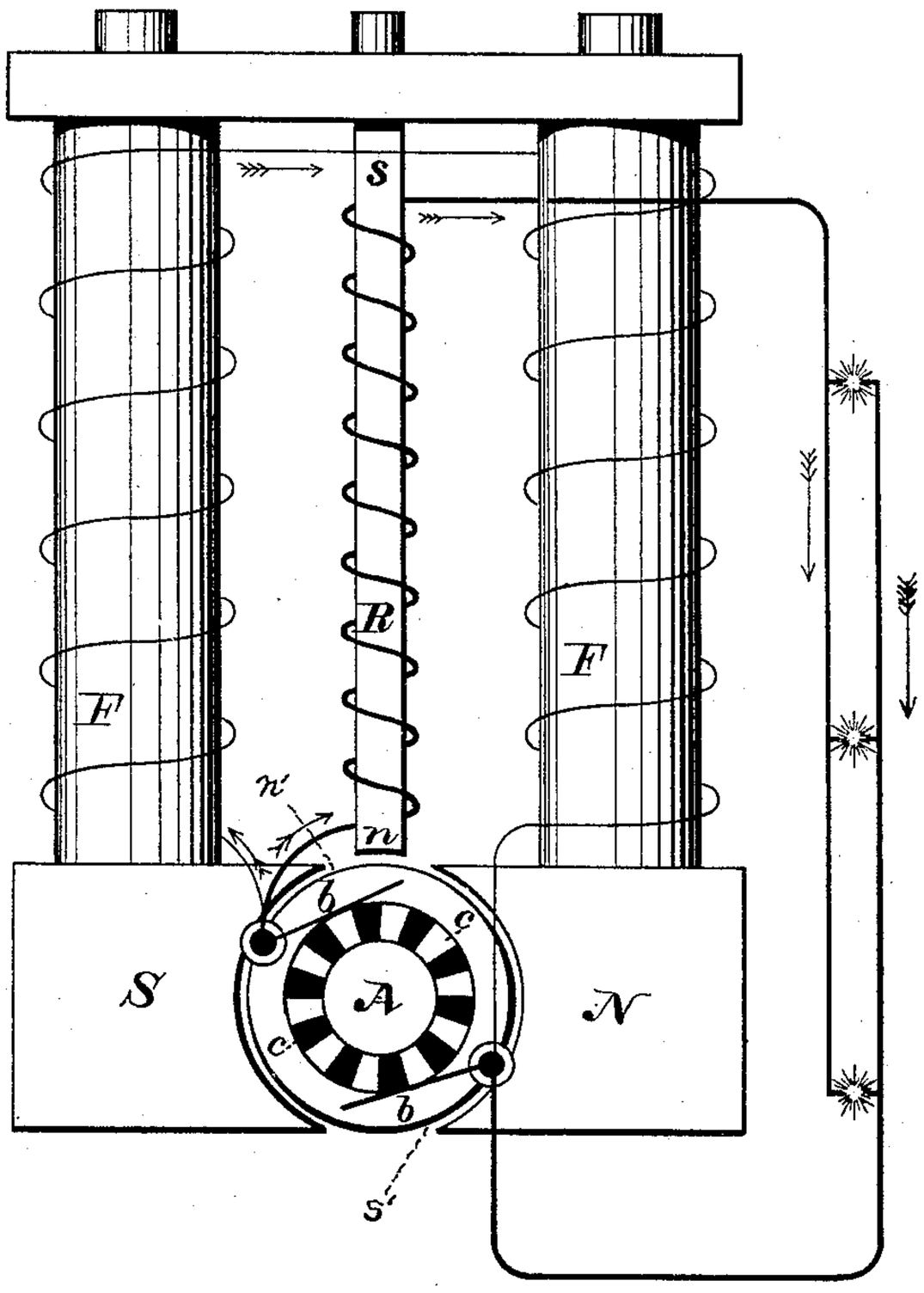
(No Model.) 3 Sheets—Sheet 1.

R. H. MATHER.

REGULATOR FOR DYNAMO ELECTRIC MACHINES AND MOTORS.

No. 324,862. Patented Aug. 25, 1885.

Fig 1.



Witnesses:
Frank H. Pierpont
Wm. Bjorkman.

Inventor:
Richard H. Mather,
By Willard Eddy, Atty.

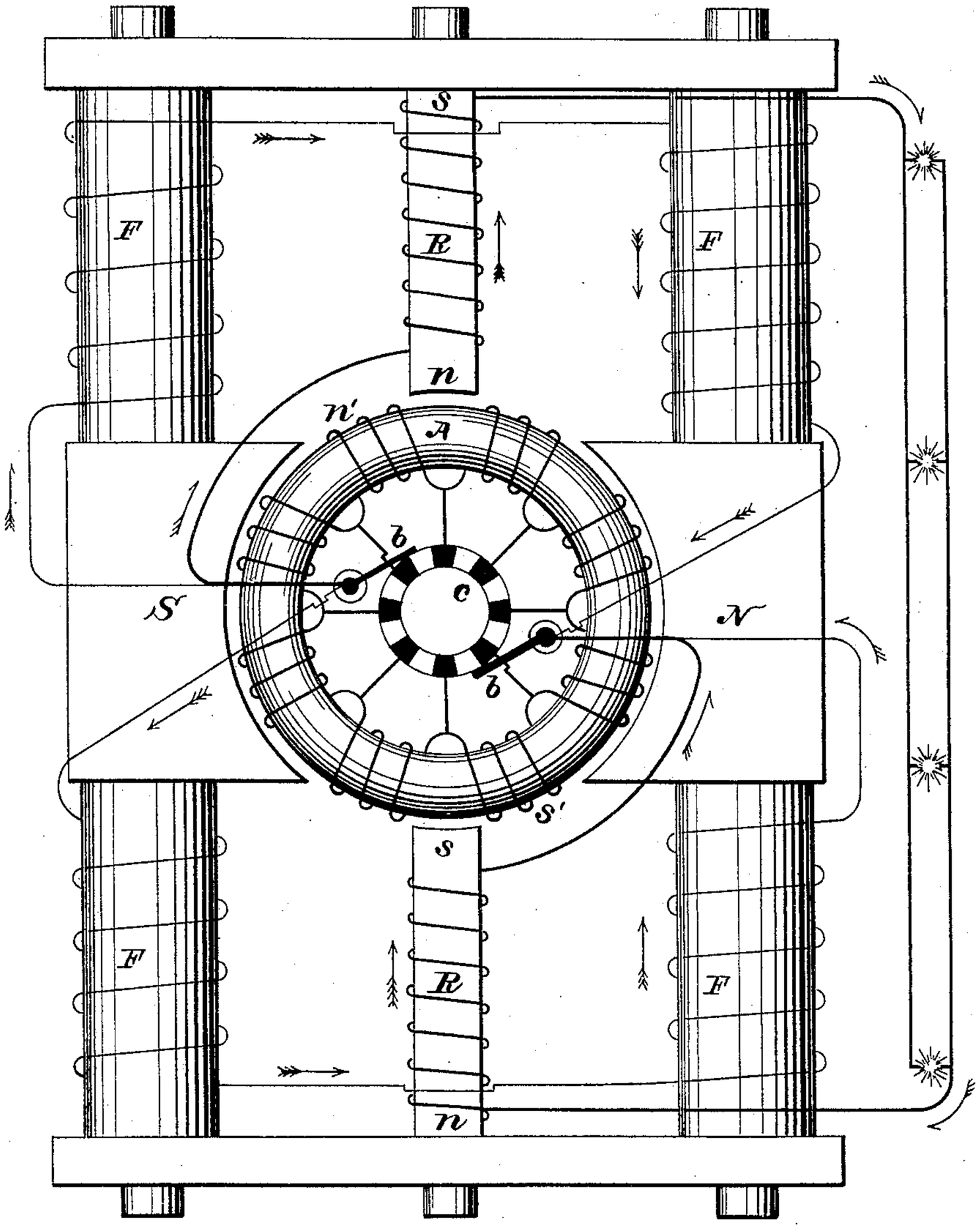
(No Model.) 3 Sheets—Sheet 2.

R. H. MATHER.

REGULATOR FOR DYNAMO ELECTRIC MACHINES AND MOTORS.

No. 324,862. Patented Aug. 25, 1885.

Fig. 2



Witnesses:
Frank H. Pierpont
Albert H. Walker

Inventor:
Richard H. Mather,
By Willard Eddy, Atty.

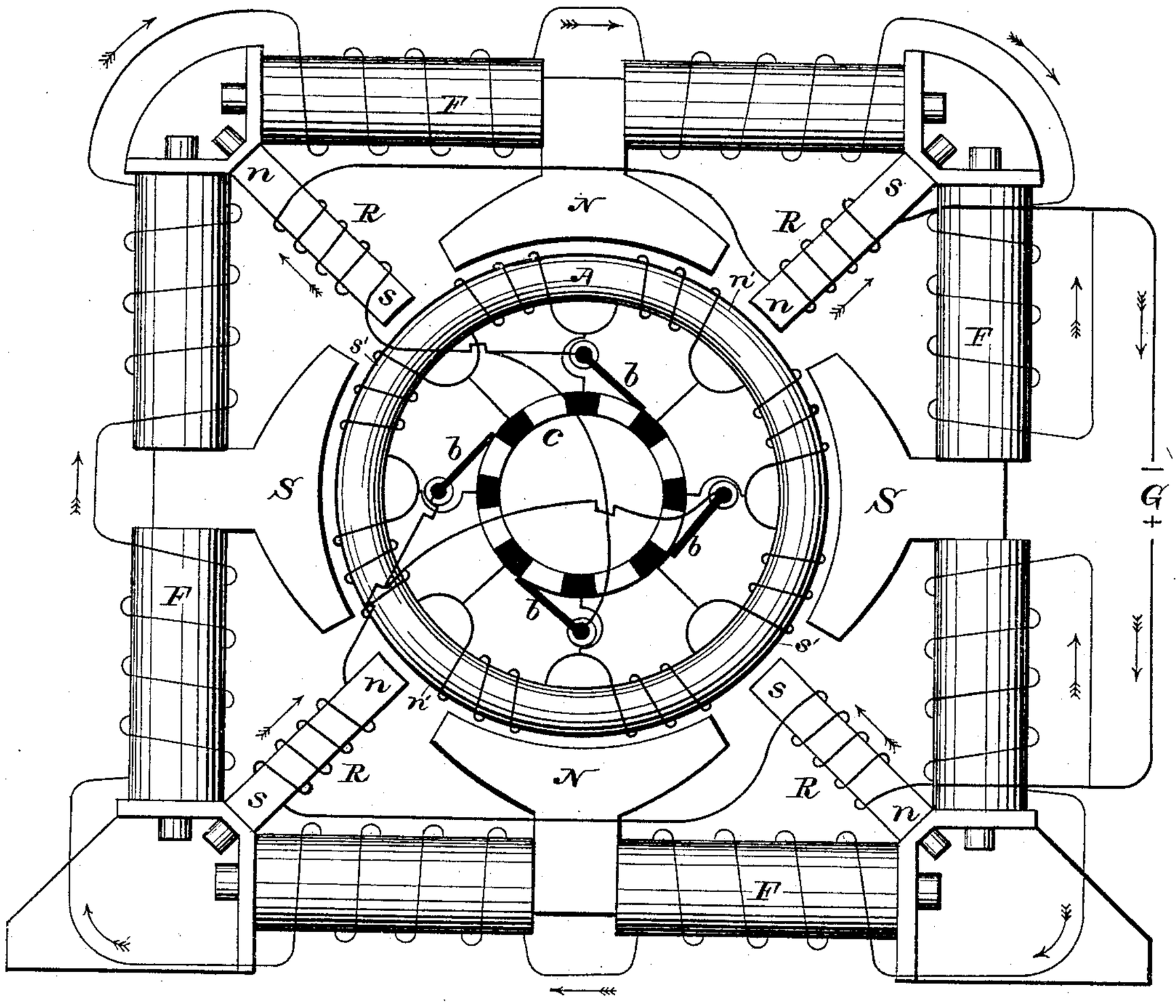
(No Model.) 3 Sheets—Sheet 3.

R. H. MATHER.

REGULATOR FOR DYNAMO ELECTRIC MACHINES AND MOTORS.

No. 324,862. Patented Aug. 25, 1885.

Fig. 3



Witnesses:
Frank H. Pierpont
Albert H. Walker

Inventor:
Richard H. Mather,
By Willard Eddy, Atty.

UNITED STATES PATENT OFFICE.

RICHARD H. MATHER, OF WINDSOR, CONNECTICUT.

REGULATOR FOR DYNAMO-ELECTRIC MACHINES AND MOTORS.

SPECIFICATION forming part of Letters Patent No. 324,862, dated August 25, 1885.

Application filed October 23, 1884. (No model.)

To all whom it may concern:

Be it known that I, RICHARD H. MATHER, a citizen of the United States, residing in the town of Windsor, county of Hartford, and State of Connecticut, have invented certain new and useful Improvements in Dynamo-Electric Machines, of which the following is a full, clear, and exact description, such as will enable others skilled in the art to which it appertains to make and use the same, reference being had to the accompanying drawings, which form a part of this specification.

My invention relates to the construction of dynamo-electric machines of the classes commonly known as "shunt-dynamos," "magneto-dynamos," and "separately-excited dynamos."

The object of my invention is to render dynamo-electric machines of the specified classes self-regulating in such a sense that, with a constant speed of driving, and with a constant position of the brushes, any such machine will maintain a constant potential regardless of variations of resistance in the working-circuit—in other words, it is the object of my invention to prevent the occurrence of sparking at the commutator without any change in the position of the brushes, and at the same time to produce a constant electromotive force regardless of variations of resistance in the main circuit, a result which is particularly desirable in incandescent lighting and in the electric deposition of metals. The principal feature of the invention by means of which these objects are secured consists of an electro-magnet, or a number of electro-magnets, as the case may be, in addition to or in extension of the ordinary field-magnet of such a machine, which additional magnet may appropriately be termed a "regulating field-magnet," from the fact that in the operation of a dynamo embodying the present invention this magnet regulates the intensity of the magnetic field in which the armature revolves, as against the effect of unequal variations of intensity in the relative magnetization of the field-magnet and armature of the machine, as hereinafter explained.

I proceed to point out the best mode in which I have contemplated applying my invention.

Figure 1 is a diagrammatic representation of my invention as embodied in a dynamo electric generator provided with a drum-armature and shunt-wound field-magnet, and having incandescent lamps in the main circuit. Fig. 2 is a diagrammatic representation of my invention as applied to a dynamo-electric generator which is provided with a ring-armature, and with a shunt-wound field-magnet with incandescent lamps in the main circuit. Fig. 3 is a diagrammatic representation of my invention embodied in a multiple polar electric motor in circuit with a generator and having a shunt-wound field-magnet.

In these drawings, and with special reference to Fig. 1, F is the field-magnet proper, the particular form of which is unimportant in this connection. The north and south poles of the field-magnet are lettered, respectively, N and S. The corresponding poles of the armature are lettered, respectively, *n'* and *s'*. The arrows indicate the direction of the current. The armature A is provided with commutator *c* and brushes *b b* in the usual manner, as shown. As it is unnecessary in view of the mode of operation of this invention to adjust the brushes during the operation of the machine, as has heretofore been practiced, for the purpose of preventing sparking, the brushes *b b* are set in a permanent position, indicated in the drawings, and determined in the manner hereinafter explained.

R is the regulating field-magnet, which consists of a core of soft iron wound as an electro-magnet and having north and south poles, which are lettered, respectively, *n* and *s*. The figure presents an edge view of the magnet R, whose core should preferably be in the form of a solid bar or plate, and whose size is determined in the manner hereinafter explained. This magnet may conveniently be suspended in a perpendicular position midway between the arms of the field-magnet, as shown. The same should be placed in a fixed position, such that one of its poles—in Fig. 1, the north pole, *n*—shall be in close proximity to the armature A, as shown. The best attachment of the magnet R is by bolting the same to the field-magnet proper in the position mentioned, as shown in the drawings. The position of the magnet R over the armature, as in Fig. 1, possesses an incidental advantage in the circumstance that in the operation of the

machine the magnet R, placed in that position, tends to lift the armature A, and so reduces friction at the bearings.

Premising that the helix of the magnet R is of coarse wire, and is in the main circuit, as shown, I proceed to point out more particularly the construction of this magnet both in respect of the size of its core and in respect of the size and length of wire contained in its helix.

In the construction of any particular dynamo embodying the present invention I determine these particulars in the following manner: Having completed the dynamo as to all parts thereof, except the regulating-magnet and the adjustments dependent thereon, I run the machine without this magnet at such speed as is necessary to produce the desired electro-motive force with a minimum of work in circuit. The work to be done may be assumed to be the operating of incandescent lamps, on which assumption I run the generator at such speed as will bring a single light to the normal brilliancy, and place the brushes in such a position as will prevent sparking when but a single lamp is in operation. This determines the normal speed of the machine. Then I assume a regulating-magnet core, which is of convenient length, and is supposed to contain a sufficient quantity of iron to produce, when duly magnetized, the desired degree of regulation. This necessary quantity of iron will be found to vary in different machines inversely as their comparative external and internal resistances. Next I wind upon the assumed regulating-magnet core such a quantity of wire of a size selected for the purpose as is sufficient, when wound upon said core, and when placed in the main circuit with the maximum number of lights which the machine is designed to operate, to produce in said core the necessary degree of magnetization. The wire which is taken for this purpose should be so large as not to become heated during the operation of the machine, and the degree of magnetization here called for is such that when the maximum number of lights is in circuit the magnet R approaches saturation, yet not so far as to prevent a practically uniform variation in that magnetization proportionate to the variations in the electric current producing the same whenever the number of lights in actual operation is diminished. Then placing in the working-circuit of the machine the maximum number of lamps which the same is designed to operate, and fixing the regulating-magnet in position, wound and connected as described, I run the machine at normal speed and observe the result. If the lights are too bright I diminish the power of the regulating-magnet by removing some of the iron from its core, and if too dim I increase the power of this magnet by increasing its mass until the standard brilliancy is attained. This operation determines with a fair degree of accuracy the size of the regulating-magnet core and the amount of wire in its helix. If a greater degree of accuracy is desired, the same process may be repeated by assuming at the outset the regulating-magnet core already ascertained as above. I place the brushes in such a position that no sparking will occur when the maximum number of lights is in operation. By this means the commutator-segments which are at any particular time in contact with the brushes are those whose corresponding armature-coils are at the same time beginning to pass under the influence of the regulating-magnet. This fixes the permanent position of the brushes. The remaining features of construction involved in this invention, as well as the appropriate connections, will sufficiently appear from the drawings and from the mode of operation, as hereinafter explained.

The mode of operation which results from the foregoing construction is that of a combined series and shunt dynamo, in which the constant lead of a series-machine and the self-regulating qualities of a shunt-machine are united. It has been the common fate of those shunt-machines which have hitherto been devised for the purpose of securing a constant lead, to operate more or less imperfectly by reason of their failure to produce a constant neutral point or a constant diameter of commutation in the armature. In such machines this defect is due to the fact that the field-magnet and armature are unequally and disproportionately affected as to degree of magnetization by variations of resistance in the main circuit. This inequality is apparent from the fact that in the operation of such machines the maximum range of variation in the intensity of magnetization in the field-magnet does not commonly exceed ten per cent. of its minimum normal strength, while the corresponding range of variation in the magnetization of the armature commonly exceeds two thousand per cent. of its minimum normal strength; and this defect, which is particularly conspicuous in those machines in which a superior construction has been sought to be gained through diminished range of variation in the field-magnet, does not altogether disappear, however powerful the construction of the field-magnet and however weak the armature may be. It has also been a defect common to those dynamos which have been designed to secure a constant electro-motive force by means of a compound winding of the field-magnet that the same have required for their successful operation a certain critical speed of driving. These defects are remedied by the present invention in the following manner:

It follows from the described construction that the intensity of the magnetic field in which the armature revolves is variable, according to the number of lights or other units of resistance in the main circuit, in a manner which is the effect of the combined operation of the field-magnet proper and of the regulating-magnet R. The field-of-force when most reduced is so weak that a single lamp when

placed in circuit will not receive an excessive or insufficient current, and when most increased is so strong that the maximum number of lamps when placed in circuit will receive so much current as they require for standard brightness, and no more; and when affected by said magnets to any intermediate degree the intensity of the magnetic field is such that the intermediate number of lamps producing that varied effect will receive so much current as is necessary to bring those lamps to standard brightness, and no more.

This practical result in the operation of the machine may be theoretically explained as follows: The machine being constructed and adjusted as already described, and the maximum number of lights being thereby brought to standard brightness, then if any number less than all of those lights be turned out, the electro-motive force of the machine tends to increase by reason of the increase of resistance in the main circuit, and by reason of the consequent increase of magnetization of the field-magnet, and this increase of electro-motive force in turn increases the energy of the field-magnet; but at the same time the diminution of current in the main circuit diminishes the magnetization of the regulating-magnet R; hence the field-of-force tends to be weakened by the diminished energy of the magnet R, and at the same time to be strengthened by increased action of the field-magnet proper, whereby an equilibrium of effects is produced and a practically uniform electro-motive force is preserved regardless of the extinction of lights, as last stated; and, conversely, starting with one light in operation, if additional lights be turned on within the capacity of the machine, then the electro-motive force tends to diminish by reason of diminished resistance and by reason of the consequently-diminished current energizing the field-magnet, and at the same time tends to increase by reason of the increased magnetization of the magnet R. A like equilibrium of effects is produced and a constant electro-motive force with the same result, as is above stated, and this result follows whatever be the constant speed predetermined, as above described.

By placing the regulating field-magnet in the main circuit with the armature 1 cause the magnetization of both to vary alike, whatever be the variations of resistance in that circuit, and whatever be the speed of driving; hence the neutral points of the armature have a constant position, and the position of the brushes need not be changed in order to prevent sparking. It is a well-known fact that in those dynamos whose brushes are normally set with a positive lead the magnetization of the armature tends by its direction to oppose the magnetization of the field-magnet, while in those dynamos whose brushes are normally set with a negative lead the magnetization of the armature is in such a direction as tends to increase the magnetization of the field-magnet; but in the dynamo which constitutes the present invention this lead is negative, and, accordingly, the magnetization of the armature assists the magnetization of the field-magnet, and from this fact it follows that in my improved dynamo all variations in the degree of magnetization of the armature tend to produce corresponding variations in the magnetization of the field-magnet; hence it is obvious that the self-regulating character of my improved dynamo above set forth is largely, although not wholly, due to the reaction of the armature upon the field-magnet in the manner here pointed out. In the case of a separately or permanently excited field-magnet the reaction of the armature upon such magnet is a particularly important factor of the described self-regulation.

From the foregoing explanation it is obvious that by means of this invention a uniform electro-motive force is preserved, whatever be the number of lights or other resistances in the working-circuit, and whatever be the constant speed of driving, and at the same time any strength of current which the armature is capable of carrying can be taken from the commutator by the brushes without sparking; also that this improved dynamo, regarded as a generator, is not self-regulating as against variations of speed.

In the case of a dynamo which has a ring-armature the regulating-magnet affects those armature-coils only which are directly opposite and adjacent thereto; hence it is necessary in dynamos of that class to place a second regulating-magnet upon the opposite side of the armature, as shown in Fig. 2, and in dynamos which have multiple polar armatnres additional regulating-magnets are necessary, as shown in Fig. 3. In this figure it will be understood that G is a generator whose positive and negative poles are designated by plus and minus signs, respectively.

The foregoing explanation is primarily applicable to a dynamo-electric machine regarded as a generator; but by the same mode of construction and the reverse mode of operation my improved dynamo becomes a self-regulating electric motor, which, upon being supplied with a constant electro-motive force, yields a constant speed regardless of variations in the load which may be placed upon the armature. In the latter case the direction of rotation and the position of the brushes are the same as in the generator, but the direction of the current through the armature as well as the polarization of the regulating field-magnet is reversed, as shown in Fig. 3.

In my application No. 136,534, for a patent for a device for preventing sparking in dynamo-electric machines, filed July 1, 1884, I have shown a magnet which is adjacent to the armature, but which is not strictly a field-magnet, for the reason that the same is productive of no external current or motion. As respects the present application, therefore, I disclaim all electro-magnets which are productive of

no external current in generators, and are productive of no motion in electric motors, so far as any such magnets are described and claimed in that application. The regulating-magnet R is a true field-magnet.

I claim as my invention and desire to secure by Letters Patent—

1. In a dynamo-electric machine of that class in which the field-magnet proper is not in the main circuit, a regulating field-magnet located in said circuit and having one of its poles adjacent to that part of the armature which lies between a like pole of said armature and a like pole of the field-magnet proper of such machine, operating as a generator, and between a like pole of said armature and an unlike pole of said field-magnet proper of such machine, operating as a motor, substantially in the manner and for the purpose specified.

2. In a dynamo-electric machine, whether motor or generator, whose field-magnet proper is separately or permanently excited or is shunt-wound, a regulating field magnet wound and connected in series with the armature of such machine and placed with one of its poles adjacent to said armature at a point immediately in advance of the like pole of said armature, substantially in the manner and for the purpose specified.

3. A dynamo-electric machine in which the brushes are in a fixed position, and in which an electro-magnet in the working-circuit of such machine co-operates with the field-magnet thereof and locates the diameter of commutation, substantially as shown, and operating as described, for the purpose specified.

4. In a dynamo-electric machine, whether motor or generator, an auxiliary field-magnet consisting of an electro-magnet which is located in the main circuit of the machine and has one of its poles just in advance of a like pole of the armature, substantially in the manner and for the purpose specified.

5. A dynamo-electric machine, whether motor or generator, provided with an auxiliary field-magnet which is attached to the principal field-magnet of such machine, is located in the main circuit, and has a pole slightly in advance of a like pole of the armature, substantially in the manner and for the purpose specified.

6. A dynamo-electric or electro-dynamic machine provided with a principal and an auxiliary field-magnet, the latter being an electro-magnet which is wound to a greater electro-magnetic efficiency than the armature of said machine, is placed in the main circuit, and has a magnetic pole adjacent to a like magnetic pole of said armature, substantially in the manner and for the purpose specified.

In testimony whereof I hereunto set my hand in the presence of two subscribing witnesses.

RICHARD H. MATHER.

Witnesses:
WILLARD EDDY,
MORGAN W. BEACH.