(No Model.) 3 Sheets—Sheet 1.

J. J. WOOD.

REGULATOR FOR DYNAMO ELECTRIC MACHINES.

No. 406,494. Patented July 9, 1889.

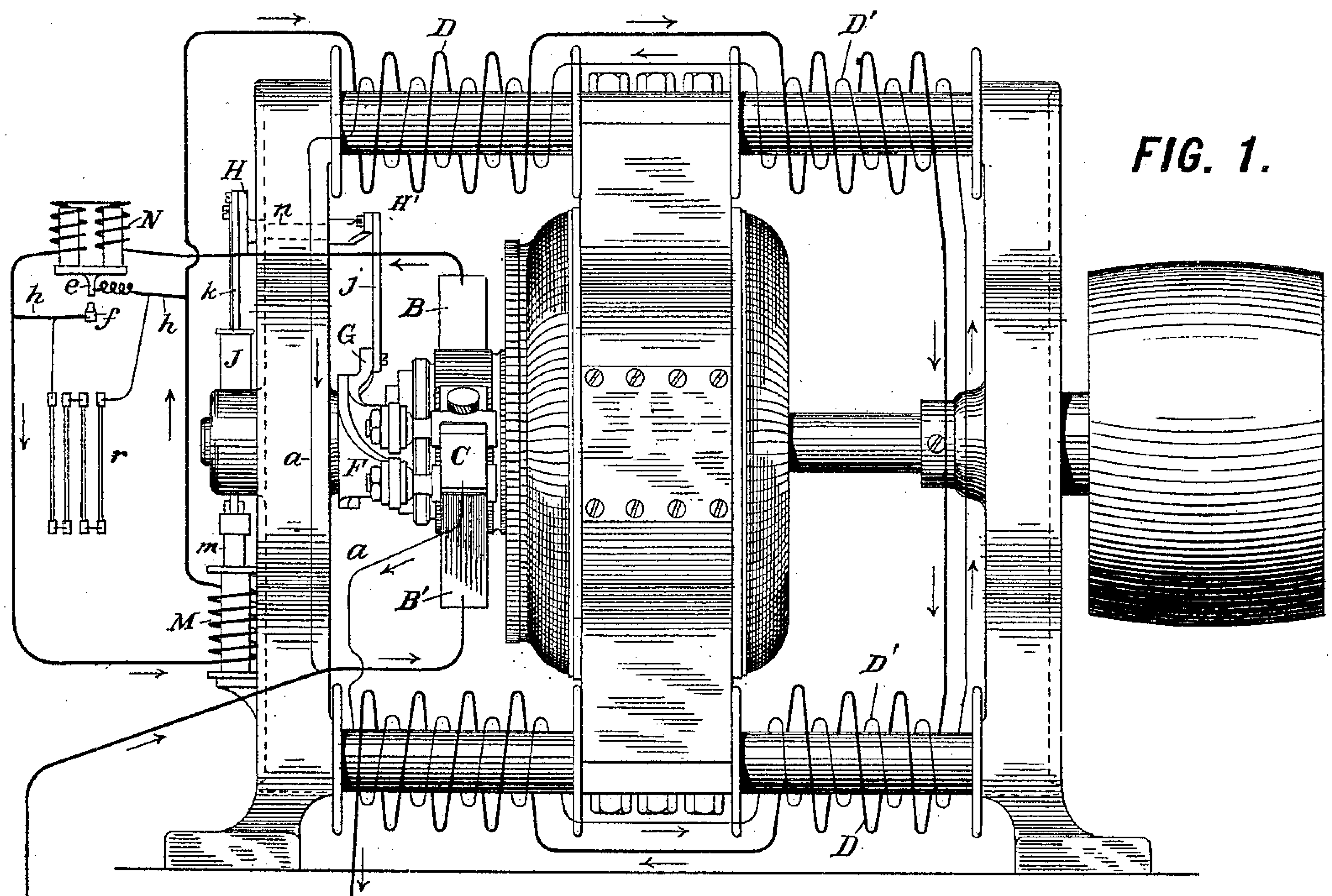

FIG. 1.

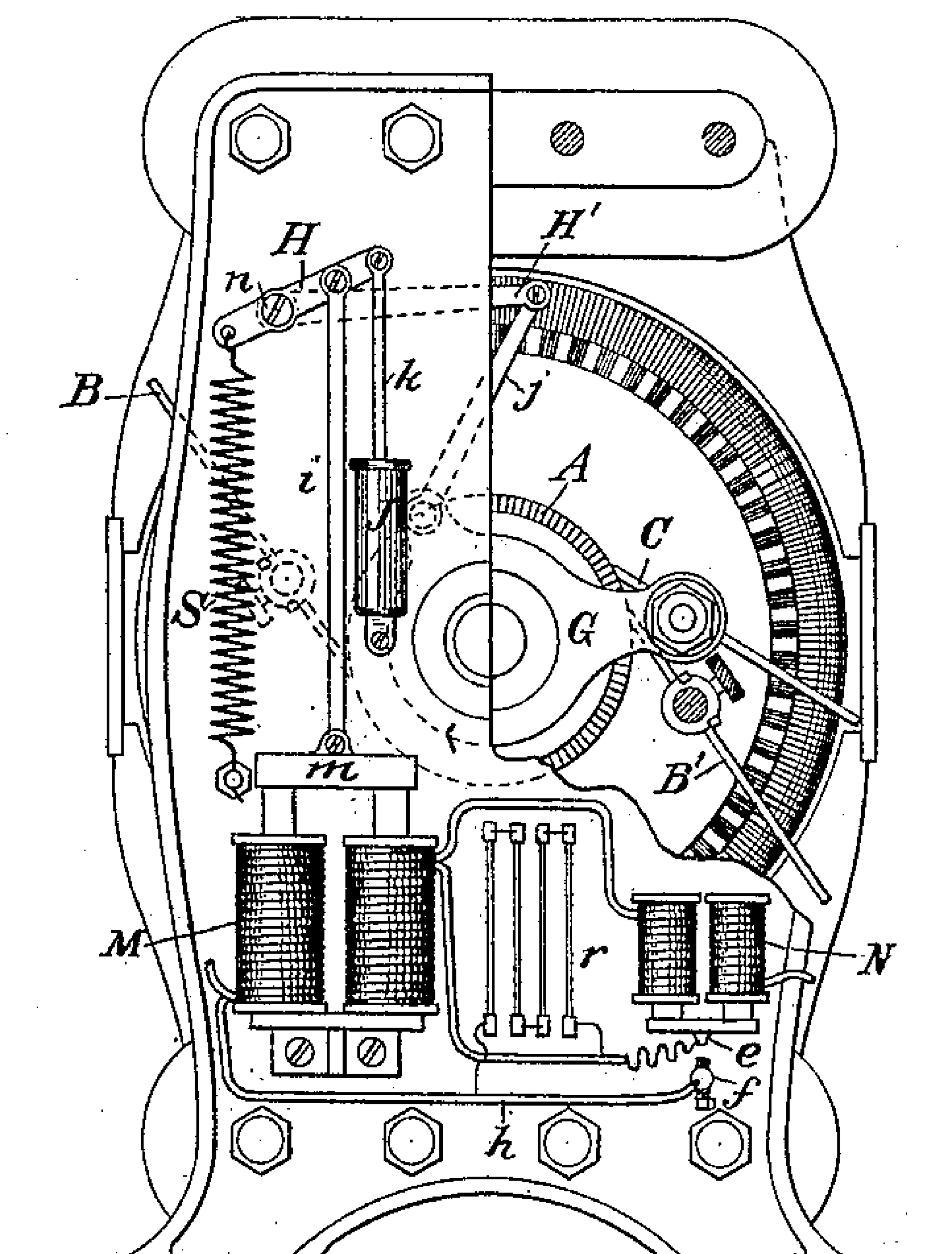

FIG. 2.

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(No Model.)

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FIG. 3.

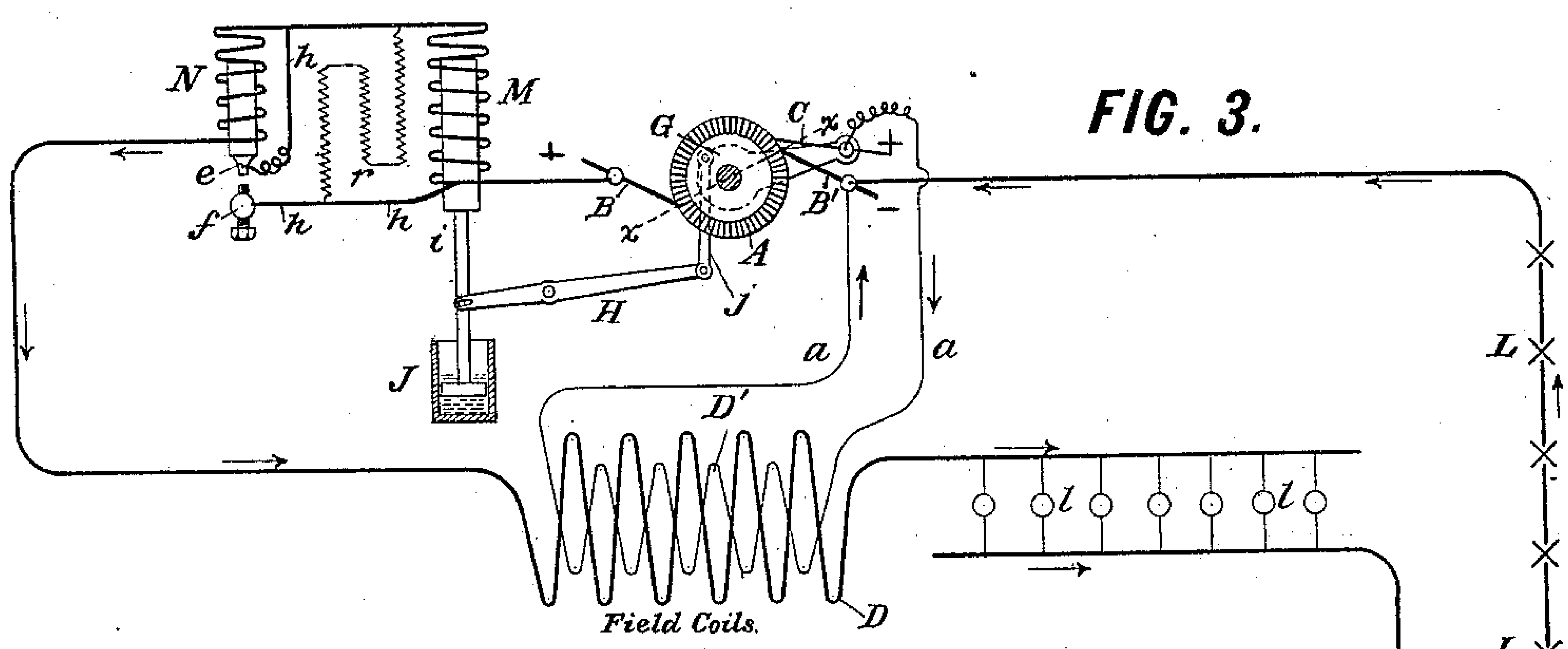


FIG. 4.

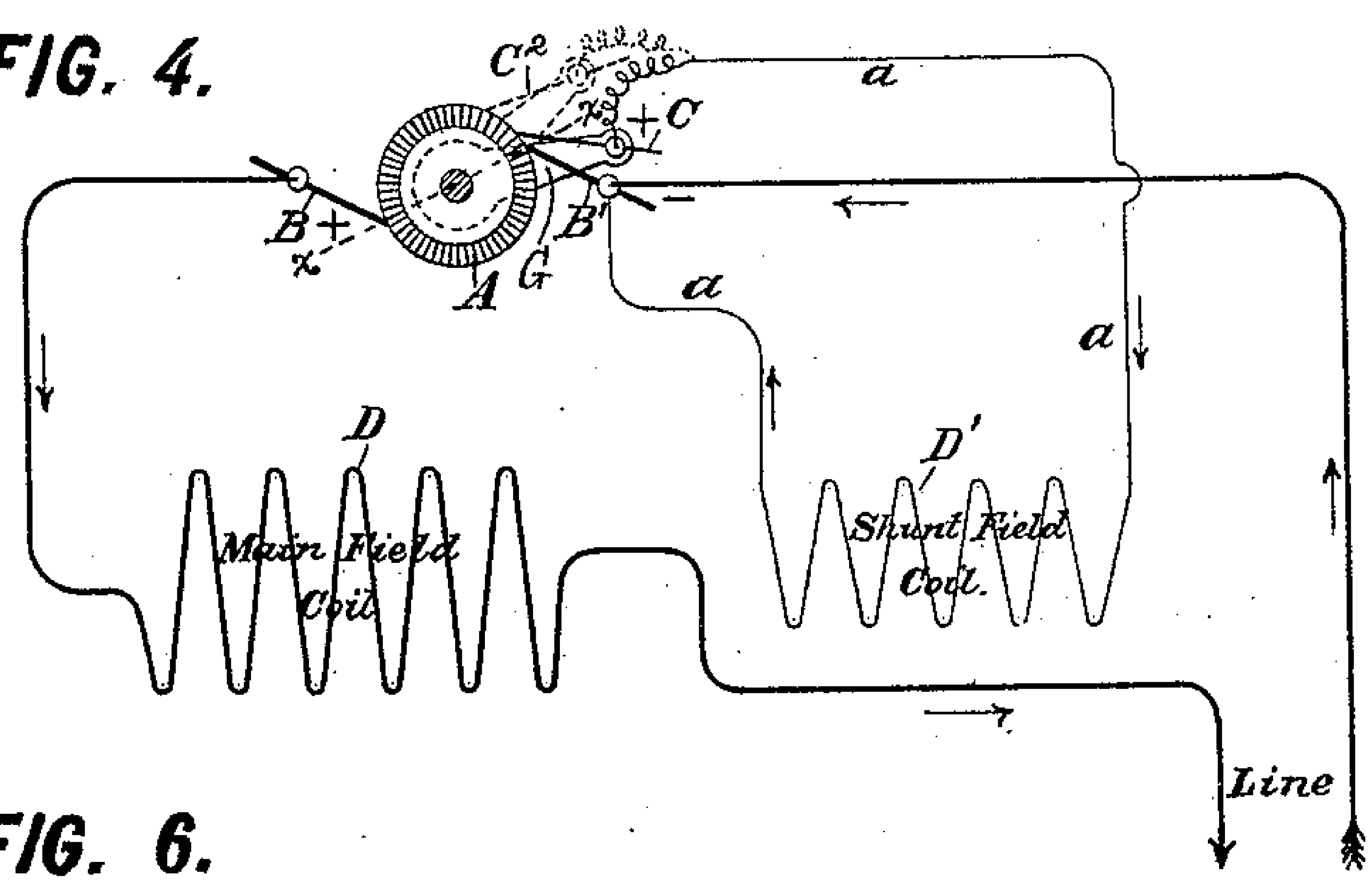


FIG. 6.

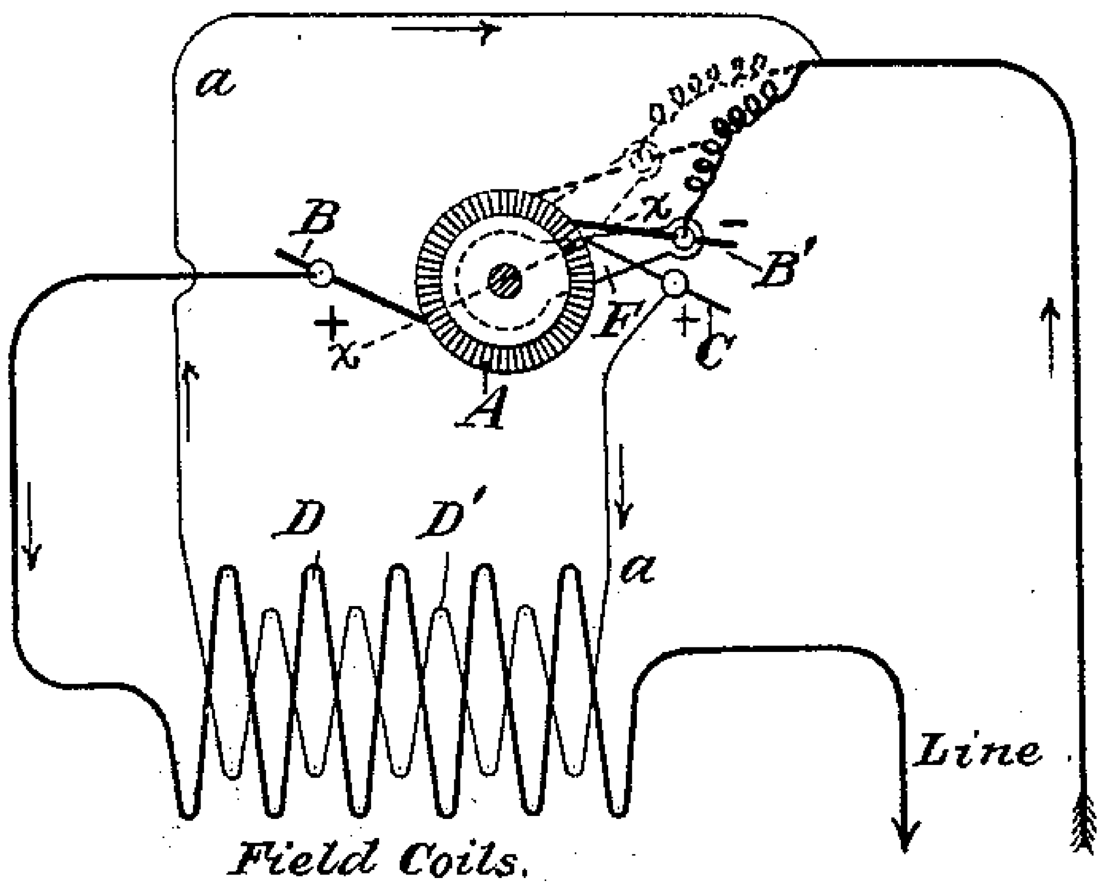


FIG. 7.

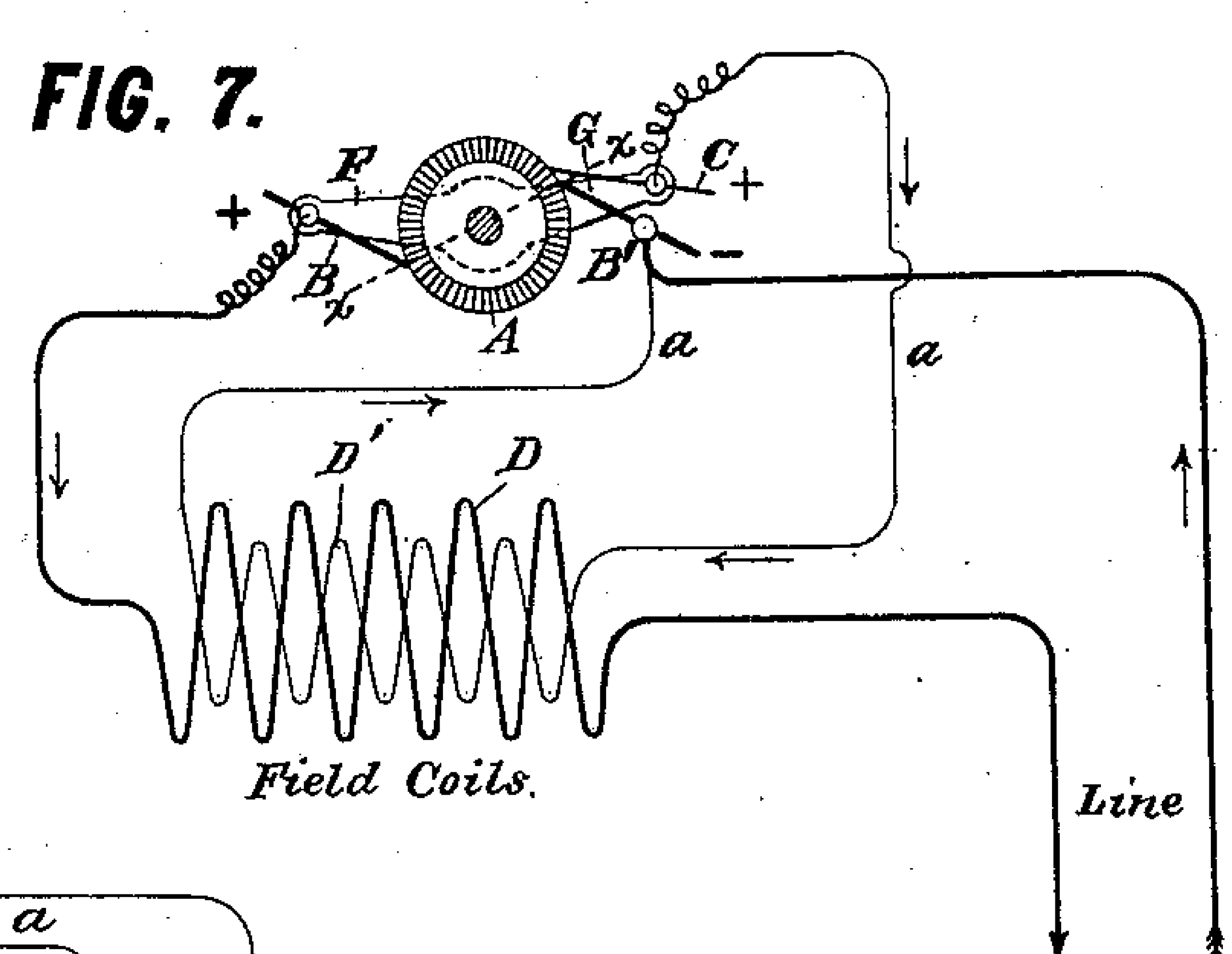
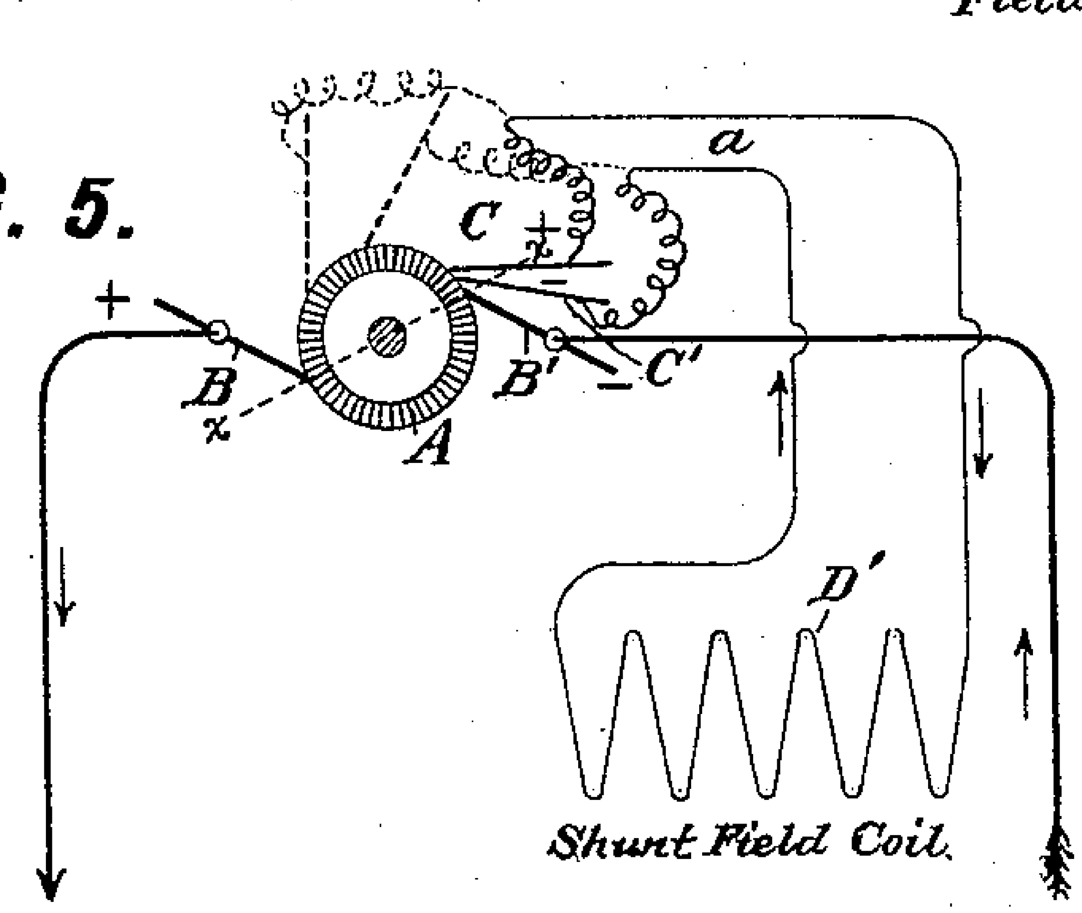


FIG. 5.



WITNESSES:

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(No Model.)

3 Sheets—Sheet 3.

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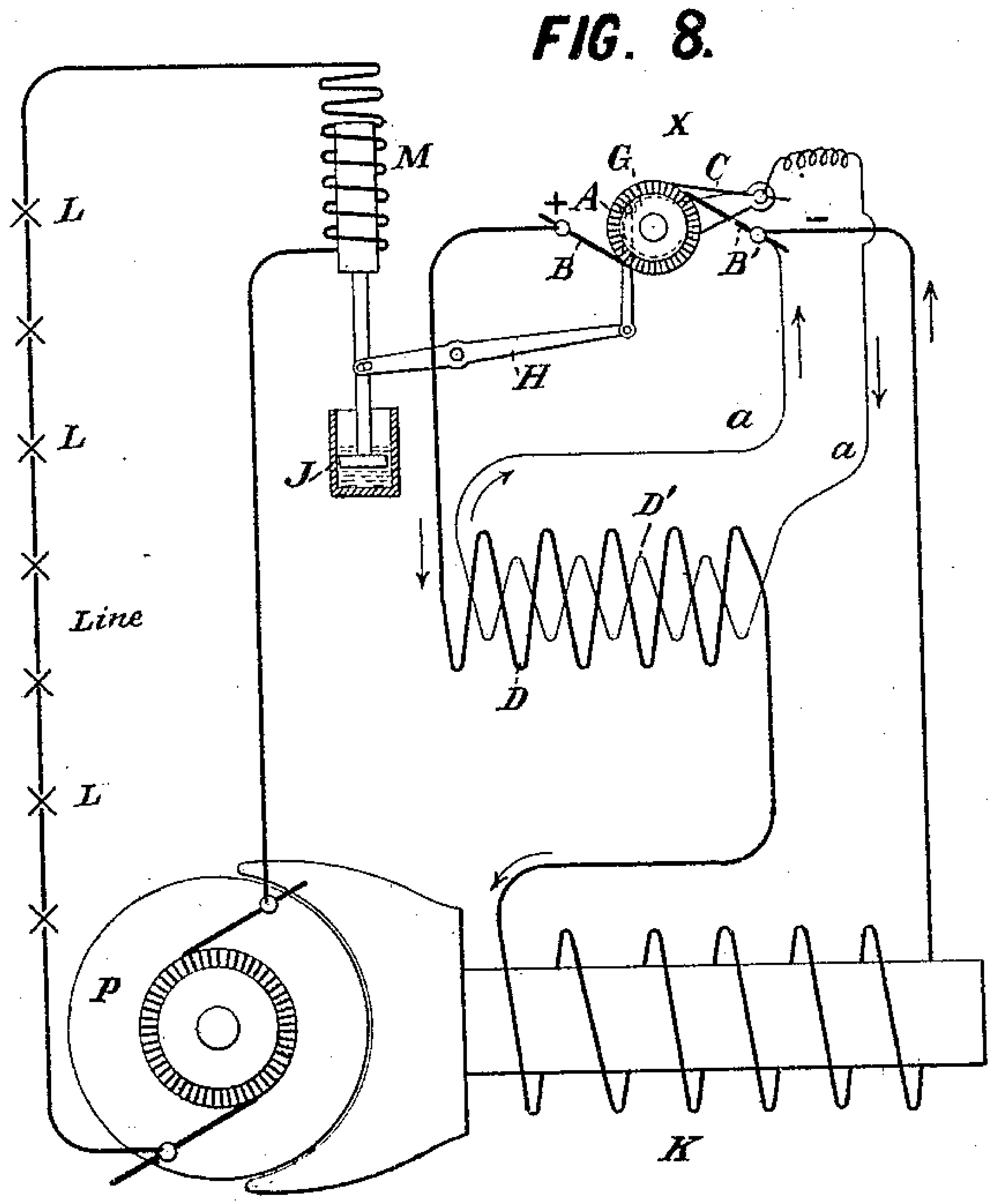
FIG. 8.



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UNITED STATES PATENT OFFICE.

JAMES J. WOOD, OF BROOKLYN, NEW YORK.

REGULATOR FOR DYNAMO-ELECTRIC MACHINES.

SPECIFICATION forming part of Letters Patent No. 406,494, dated July 9, 1889.

Application filed November 21, 1888. Serial No. 291,456. (No model.)

To all whom it may concern:

Be it known that I, JAMES J. WOOD, a citizen of the United States, residing in Brooklyn, in the county of Kings and State of New York, have invented certain new and useful Improvements in Self-Regulating Constant-Current Dynamos, of which the following is a specification.

This invention relates to dynamo-electric machines which automatically regulate themselves in order to generate at all times a constant current notwithstanding variations in the "load" or line-resistance. The invention applies to dynamo-machines having armatures of the Gramme or Pacinotti ring or Siemens drum type, such as are known as "closed-coil armatures." The regulation of such machines has been effected heretofore in different ways. Of these the most successful and satisfactory in practice has been by shifting the brushes on the commutator, moving them automatically away from the neutral line or position of maximum current whenever the current tends to become excessive, so that the brushes collect less current as they are moved away from the neutral line and more current as they are returned toward it. The automatic movement of the brushes is effected through the medium of a shifting mechanism moved or governed in its movement by an electro-magnet, solenoid, or other electro-motive device connected in the external circuit. Another method of regulation applicable to series-wound field-magnets consists in the application of a variable resistance in a shunt short-circuiting the field-magnet coil, the resistance being increased to increase the excitation of the field and decreased to lower its excitation. Field-magnets have also been regulated by winding them in sections and automatically switching more or less of the sections into or out of circuit. The inversion of the current in the successive sections has been proposed in order that the inverse current or currents should tend to demagnetize the field-magnet; but no means has been devised for applying this method in such manner as to preserve a uniform current in the external circuit. It has also been proposed to regulate both separately-excited and series-excited constant-current dynamos by the winding of the field-magnet with a directly-connected shunt-coil, but thus far without practical success, so far as I am aware. An inversely-connected shunt-coil has also been proposed, to be traversed by an intermittent or interrupted current on a branch of the main arc-lamp circuit, the relative duration of the closures and breaks being varied to vary the demagnetizing effect of the inverse current in order to regulate the generation of current; but this system has not been found practicable by reason of the inevitable heavy sparking and induction.

My invention provides an improved method of regulation differing from any heretofore applied. I wind the field-magnet with two coils—the usual main magnetizing or exciting coil connected in series and a supplemental demagnetizing-coil inversely connected in a shunt. The inverse current through this shunt-coil is a continuous current, which flows continuously during the normal running of the dynamo and is increased or decreased by the action of an automatic regulator responding to changes in the main or external circuit, and proportionately varying the electromotive force of the current in the shunt-coil, so that it more or less reduces the magnetization of the field-magnet, and thereby compensates for any increase or decrease of current due to variations of resistance in the circuit or to variations of speed of the dynamo.

In the accompanying drawings, Figure 1 is a side elevation of a Wood dynamo, showing the field-magnet winding and the circuit connections in diagram. Fig. 2 is an end elevation thereof, partly broken away to show the commutator-brushes. Fig. 3 is a diagram of the circuit-connections for the machine shown in Figs. 1 and 2. Fig. 4 is an explanatory circuit diagram of similar character to Fig. 3. Fig. 5 is a similar diagram showing a modification. Fig. 6 is a diagram showing a further modification. Fig. 7 is a diagram showing another modification. Fig. 8 is a diagram showing my invention as applied to a separately-excited dynamo.

I will first explain the principle of my invention with reference to Fig. 4, which is a simplified diagram thereof.

Let A designate the commutator of a dynamo-electric machine of the Gramme ring or closed-coil type, and B B′ the positive and negative main collecting-brushes thereof, arranged to touch the commutator on the neutral line x x or in the position of maximum current. Let D designate the main exciting-coil of the field-magnet, which is connected in series with the line between the brushes B B′. This is the ordinary arrangement for self-excited series-wound dynamos.

Let C designate an auxiliary commutator-brush touching the commutator A adjacent to the negative brush B′, and mounted on an arm or yoke G, by the movement of which it can be shifted around the commutator. A shunt-coil D′ has its terminals connected by shunt-circuit wires a a with the auxiliary brush C and the negative main brush B′. When the brush C is in contact with the brush B′, it is obvious that both will have the same potential, and consequently no current will flow through the shunt a D′. If, however, the brush C be advanced along the commutator away from the brush B′, it will rest upon commutator-segments of different potential from those with which the brush B′ makes contact. As the brush C will in such case be nearer the positive side of the commutator than the negative brush B′, it will exhibit relatively to the latter a positive potential, and a current proportional to the difference of potential will flow from the brush C through the shunt-circuit to the brush B′. The quantity of current thus flowing through the shunt-circuit will vary according as the brush C is moved away from or toward the brush B′. The position shown in dotted lines at C^2 may be assumed to be the limit of movement of the brush C away from the brush B′, so that when the brush is in this position the current in the coil D′ will be at its maximum.

If now we imagine the shunt-coil D′ wound upon the field-magnet along with the main coil D, but connected inversely thereto, it will be apparent that the current in the shunt-coil will act to neutralize more or less the current in the main coil, and consequently to reduce the magnetization of the field; and the magnetization will be more or less reduced according as the current in the shunt-coil is increased or diminished.

We have here all the conditions for a perfect regulation of the dynamo. If an attendant watching an ammeter were to move the yoke G from time to time whenever he observed any variation in the indication of the ammeter, he could regulate the output of the machine so as to compensate for any variations in the resistance on the external circuit. A more perfect control of the auxiliary brush C may, however, be effected by providing an automatic regulator for shifting this brush over the commutator in response to changes in the current on the line. Several different constructions of such automatic regulators are known in the art. They are of two classes—those in which the movable member of an electro-motive device—such as an electro-magnet or solenoid—is connected to the brush-carrier or yoke, so that its movement is transmitted to the latter, in which case the brushes move simultaneously with and to an extent proportional to the movement of said moving member, and those of the other class, in which the movement of such movable member serves to operate a clutch to connect a mechanical shifting mechanism with a source of power to drive it either in one direction or the other. An example of the former type of regulator will be described hereinafter. An example of the latter type is illustrated in my patent, No. 326,894, dated September 22, 1888.

Referring now to Fig. 3, I will describe the operation of my improved dynamo in connection with an automatic regulator of the class first above referred to. A regulating electro-magnet or solenoid M has its coil connected in the main circuit in series, with a shunt h h around it, by which it may be short-circuited. A relay-magnet N is connected in the main circuit exterior to this shunt, and serves by the attraction of its armature to break the shunt-circuit h. In the form shown the magnet N is a solenoid, the core of which carries a contact e, which touches a contact-screw f, both in the shunt-circuit h. To prevent sparking between the contacts e f, a resistance r is connected between these contacts across the shunt h and short-circuiting the coil of the solenoid M. The core m of this solenoid is connected to the auxiliary brush C, so that by its movement this brush is correspondingly moved, either at the same or at a faster or slower speed, according to the nature of the intervening connections. These connections in the construction shown consist of a lever H, one arm of which is connected by a rod or link i to the core m, and the other arm of which is connected by a link j to the auxiliary brush-carrier G. A dash-pot J is employed to prevent too sudden movements of the solenoid-core.

When the machine is running under maximum load—that is, with all the lamps in the circuit lighted—the brush C stands almost or quite in contact with the brush B′, so that the current through the main field-coil D is not neutralized (or not to any appreciable extent) by a counter-current in the coil D′; hence the field-magnet is excited to the normal extent and the machine is generating the normal current. If now one or more of the arc lamps are extinguished, thereby reducing the resistance and proportionally augmenting the volume of current, the relay N is excited sufficiently to attract its core and thereby break the shunt-circuit h, whereupon nearly the entire current, which until this instant has flowed in large part through the shunt h, thereby avoiding the solenoid M, is directed through this solenoid, strongly exciting it and causing it to draw up its armature m at as rapid a rate as the dash-pot J will permit, and thereby moving the auxiliary brush C around the commutator away from the brush B′. There results from this an increased current through the shunt-coil D′, which neutralizes proportionally the magnetizing effect of the main coil D and reduces the magnetism of the field, thereby diminishing the current generated and restoring an equilibrium in the external circuit.

The relay M and shunt h h are well-known accessories of a regulator of the type wherein the moving member of the regulating magnet or solenoid is connected to and communicates motion to the shifting brush-carrier. The practical operation of the relay is to impart increased sensitiveness to the solenoid M, so that it is capable of responding to minute changes in the current.

In practice the regulator effects an intermittent rise and fall of the current, due to the relay N shunting almost the entire current through the solenoid M whenever its excitation rises above the normal, and then, when the regulator has responded to the consequent increased excitation of the solenoid M and reduced the current, to the relay N, shunting the greater part of the current around the solenoid M, and thereby disproportionately reducing the excitation of the latter, which gives rise to the contrary regulating action, so that these effects follow alternately at momentary intervals.

Figs. 1 and 2 show the well-known type of Wood dynamo with its field-coils wound and connected according to my present invention. The electrical connections are the same as those shown in Fig. 3. The regulating-solenoid M, relay N, and rheostat r are mounted on one of the end frames of the machine. The solenoid-core is connected by a link i to a rock-lever H, against which a spring S pulls to retract the core, and the plunger of the dash-pot J is connected by a link k to the lever. The lever H is fixed on a rock-shaft n, passing through the end frame, on the inner end of which shaft is fixed a lever-arm H′, which connects through a link j with the brush-carrier G.

The circuit diagram in Fig. 1 shows a number of arc lamps L L connected in series. Fig. 3 shows a circuit in which both arc lamps are connected in series and incandescent lamps l l are connected in multiple.

My invention may be modified in various ways without departing from its essential features. I will proceed to describe some such modifications with reference to the remaining figures of the drawings.

Both terminals of the shunt-circuit may be connected to auxiliary brushes, instead of one terminal being connected to one of the main brushes, and in such case either one or both of the auxiliary brushes may be adjustable around the commutator. In such adjustment the brushes may move simultaneously in opposite directions or they may move in the same direction at differential speeds.

Fig. 5 shows the connection of the shunt-circuit to two auxiliary brushes C and C′, which are simultaneously adjusted upon the commutator at differential speeds and in the same direction. The full lines show the position of these brushes when the machine is running under maximum load, and the dotted lines show the position of the brushes when adjusted to draw a greater current through the shunt-coil in order to reduce the current-generation of the machine. In the movement of the brushes from the maximum to the minimum position they are not only separated but shifted to a part of the commutator where the difference of potential between successive segments is greater.

Instead of shifting the auxiliary brush, (when only one auxiliary brush is used,) the main brushes B B′, or one or other of them, may be shifted. In such case the shifting of the main brush or brushes away from the neutral line results in their taking off less current from the commutator, which itself in part compensates for the altered condition of the external circuit, as in the case of shifting commutator-current regulators heretofore existing; and at the same time this movement augments the inverse current in the shunt-circuit, which also compensates for such altered condition. Fig. 6 shows such adjustment of one of the commutator-brushes—namely, the one which forms one terminal of the shunt-circuit. The auxiliary brush C is mounted fixedly, as is also the positive brush B. The negative brush B′ is mounted on a movable arm or yoke F, in order that it may be shifted around the commutator. When it is moved toward the position shown in dotted lines, it takes off less current for the line, but by increasing the difference of potential between itself and the brush C diverts more current through the shunt; or the auxiliary brush and one of the main-circuit brushes may be adjustable together around the commutator, while the other main-circuit brush remains fixed. This is shown in Fig. 7. In this figure a double yoke F G carries both the positive brush B and the auxiliary brush C. The negative brush B′ is fixed in place. The position of maximum output of current is shown. In moving away from this position the brush C recedes from the brush B′, thereby increasing the shunted inverse current, while the movement of the brush B away from the neutral line causes it to draw off less current for the line. The movement of the brushes B and C might be differential instead of equal.

I believe my present invention to provide the first constant-current dynamo having its field-magnet wound with both series and shunt coils, inversely connected, the shunt-coil receiving a continuous current, with means for varying the current through the shunt-coil inversely to and in proportion to variations of resistance in the external circuit, in order to compensate for such variations. The best way of effecting such variations in the inverse shunted current is by the relative adjustment of the shunt terminal brushes.

My invention is also applicable in connection with separately-excited constant-current dynamos. In such case the inversely-connected shunt-coil is applied to the field-magnet of the exciter in such manner as to vary the current generated by the exciter, and which current traverses the field-coils of the main-circuit dynamo in compensation for variations in the resistance in the main or external circuit. Thus the regulator acts primarily to cause the exciting-dynamo to generate an inconstant current, which in turn causes the main or excited dynamo to generate a constant current.

Fig. 8 is a diagram showing one suitable arrangement for separate excitation according to my invention. P is the main dynamo with its field-magnet excited by a coil K, and X is the separate exciter-dynamo with its field-magnet excited by a series coil D and a shunt-coil D′, the latter connected inversely to the series coil and arranged in the shunt *a a*, terminating in the brushes C and B′. The arrangement is the same as with the self-excited dynamo illustrated in Fig. 3, with the sole difference that the circuit from the brushes B B′ traverses in addition to the coil D only the field-coil K of the main-circuit dynamo, and the coil of the regulating-solenoid M is in the line-circuit fed by the dynamo P.

The operation is as follows: A decrease of resistance in the main or external circuit augments the current therein and causes the solenoid M to shift the brush C away from the brush B′, thereby increasing the inverse current, decreasing the magnetization of the field-magnet of the exciter X and reducing the current generated thereby, and consequently proportionally reducing the excitation of the field-magnet of the main dynamo P until the current generated thereby is reduced to the normal volume.

I claim as my invention the following defined improvements in dynamo-electric machines for generating constant currents, substantially as hereinbefore specified, namely:

1. A dynamo for generating constant currents, combined with a shunt field-magnet coil connected to receive normally a continuous current and wound inversely, so that the current in it acts to reduce the magnetization of the field-magnet, and with automatic means for varying the electro-motive force of the current in the shunt-coil inversely to and in proportion to variations of the resistance in the external circuit in order to maintain the current in said circuit uniform.

2. A dynamo for generating constant currents having its field-magnet wound with an exciting-coil in series and with an inversely-wound coil in a shunt of uniform resistance, and with automatic means for varying the electro-motive force of the current in the shunt-coil inversely to and in proportion to variations of resistance in the external circuit in order to maintain the current in said circuit uniform.

3. In a dynamo, the combination, with the commutator and main collecting-brushes, of the field-magnet wound with a series coil in the main circuit and with an inversely-connected shunt-coil terminating in commutator-brushes relatively adjustable around the commutator to vary their relative potentials, and consequently to vary the inverse current in said shunt-coil, and an automatic regulator responsive to changes in the external circuit, connected to said brushes to effect such relative adjustment thereof in the direction to vary the current in said shunt-coil proportionally to and in compensation for the changes in the external circuit.

4. In a dynamo, the combination, with the commutator and main collecting-brushes, of the field-magnet wound with a series coil in the main circuit and with an inversely-connected shunt-coil joined at one terminal to one of the main collecting-brushes, an auxiliary brush to which its other terminal is connected, said brushes adjustable relatively around the commutator to vary their relative potentials, and consequently to vary the inverse current in said shunt-coil, and an automatic regulator responsive to changes in the external circuit, connected to said brushes to effect such relative adjustment thereof in the direction to vary the current in said shunt-coil proportionally to and in compensation for the changes in the external circuit.

5. In a dynamo, the combination, with the commutator and main collecting-brushes, of the field-magnet wound with a series coil in the main circuit and with an inversely-connected shunt-coil joined at one terminal to one of the main collecting-brushes, and an adjustable auxiliary brush to which its other terminal is connected, and an automatic regulator responsive to changes in the external circuit, connected to said auxiliary brush to adjust the same around the commutator toward or from said main brush, to vary the current in said shunt-coil proportionally to and in compensation for the changes in the external circuit.

In witness whereof I have hereunto signed my name in the presence of two subscribing witnesses.

JAMES J. WOOD.

Witnesses:

ARTHUR C. FRASER,
JNO. E. GAVIN.