(No Model.) 2 Sheets—Sheet 1.

W. H. CHAPMAN.

ELECTRIC REGULATOR FOR DYNAMOS.

No. 599,892. Patented Mar. 1, 1898.

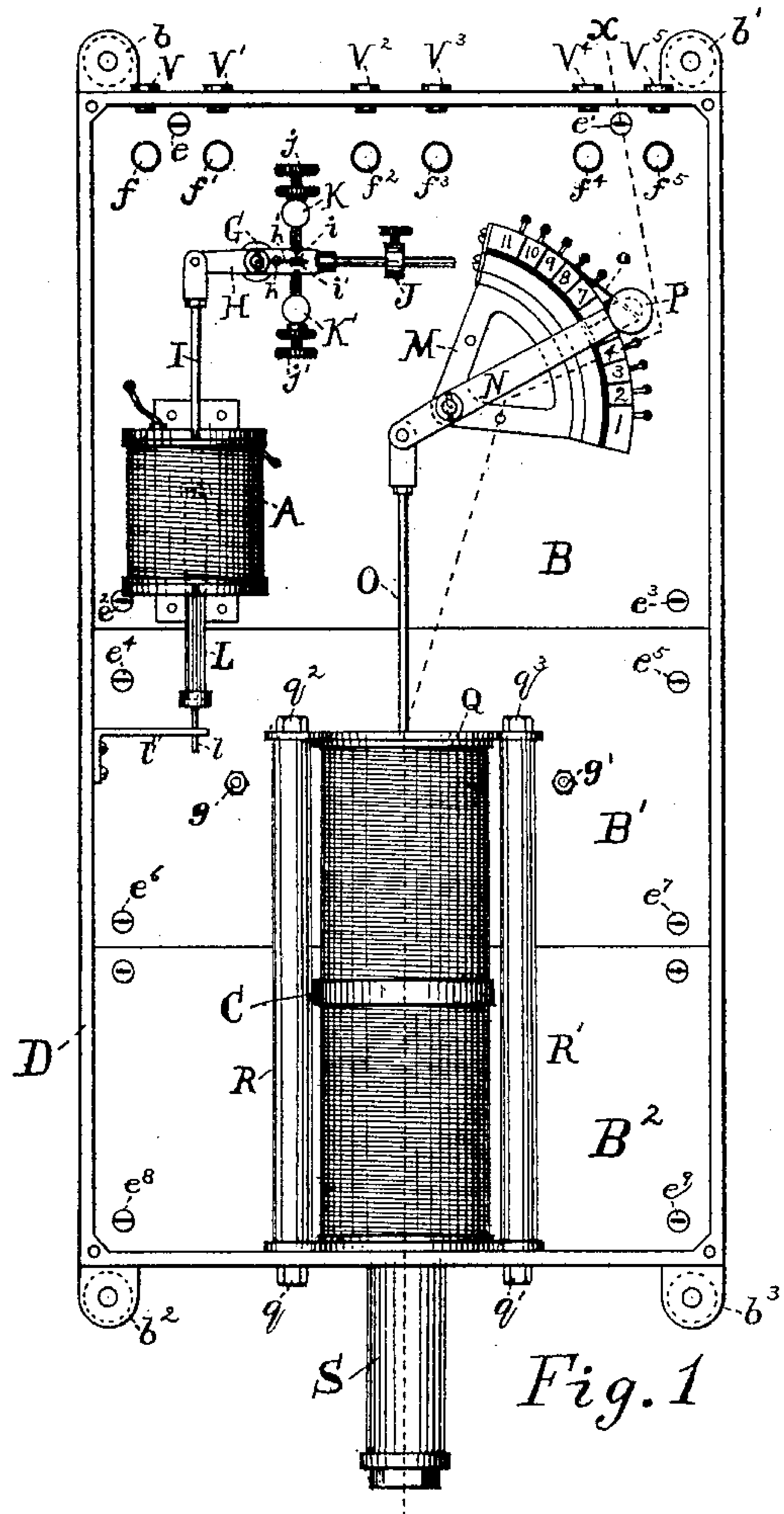

Fig. 1

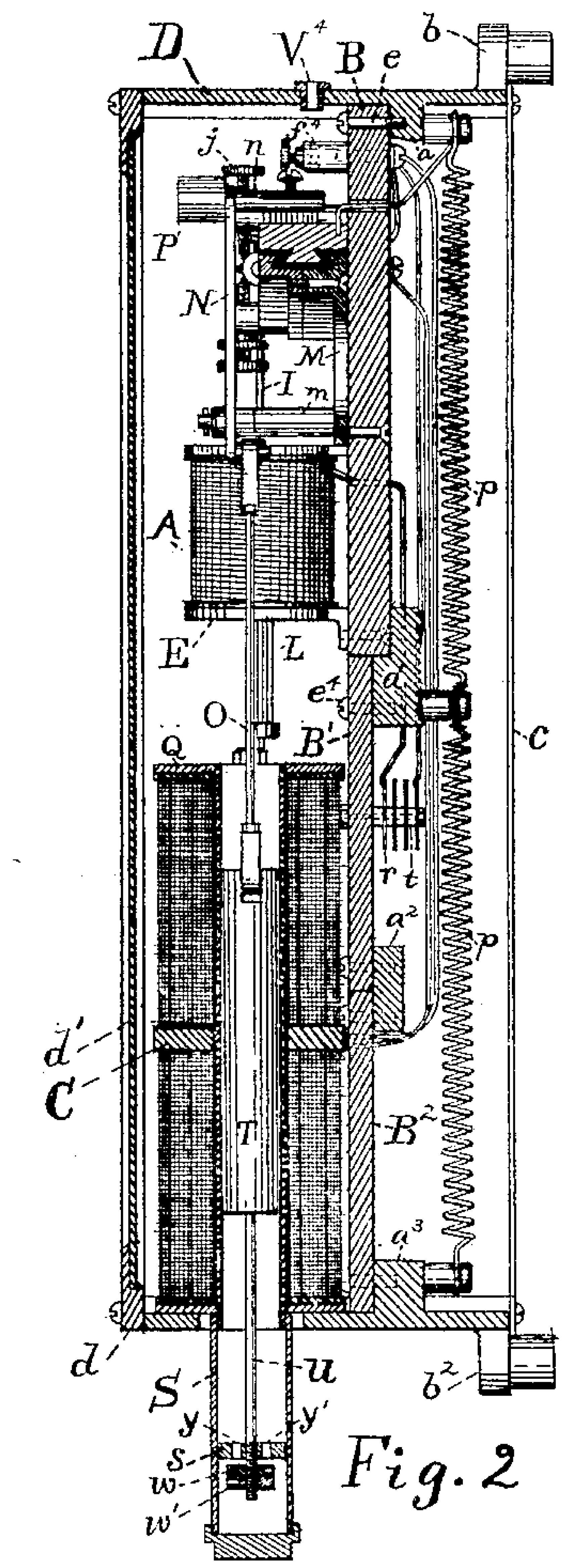

Fig. 2

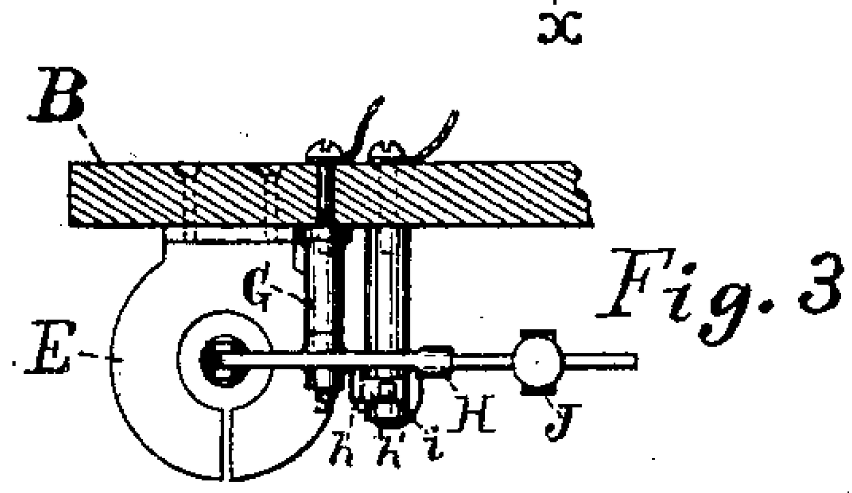

Fig. 3

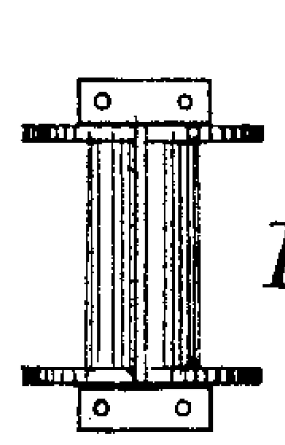

Fig. 4

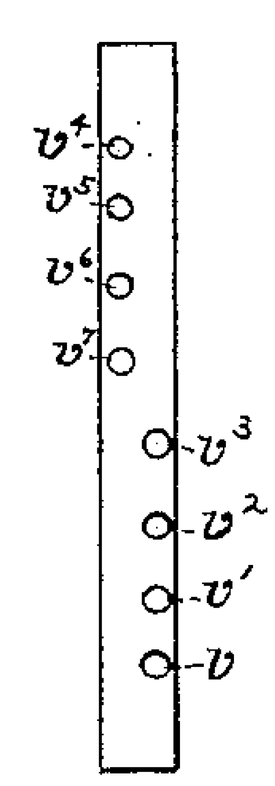

Fig. 5

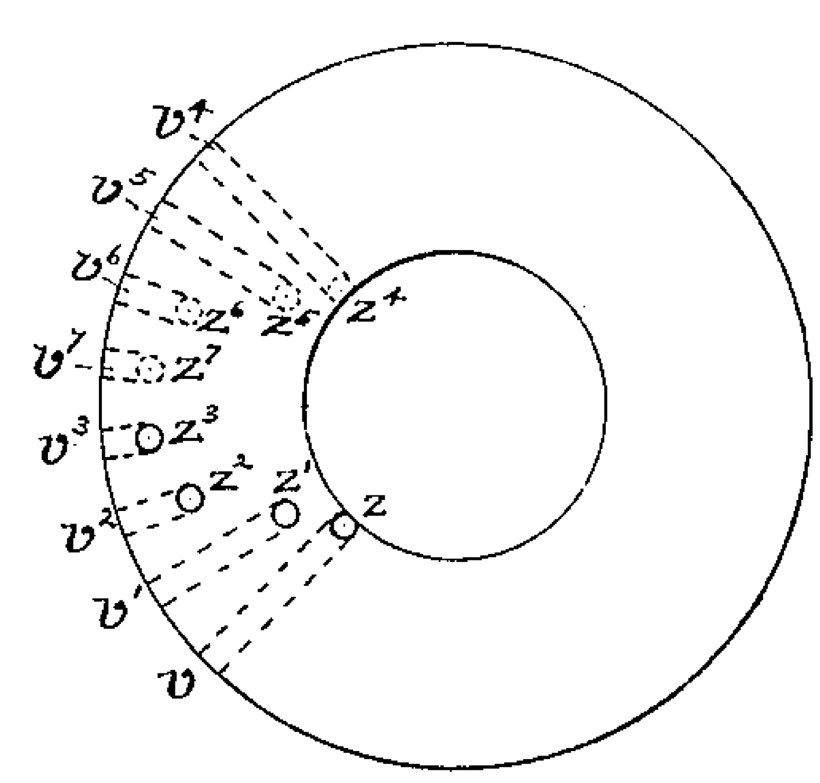

Fig. 6

Witnesses:

Geo. W. Brown

E. M. Rines

Inventor.

Wm. H Chapman

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

(No Model.)

2 Sheets—Sheet 2.

W. H. CHAPMAN.

ELECTRIC REGULATOR FOR DYNAMOS.

No. 599,892

Patented Mar. 1, 1898.

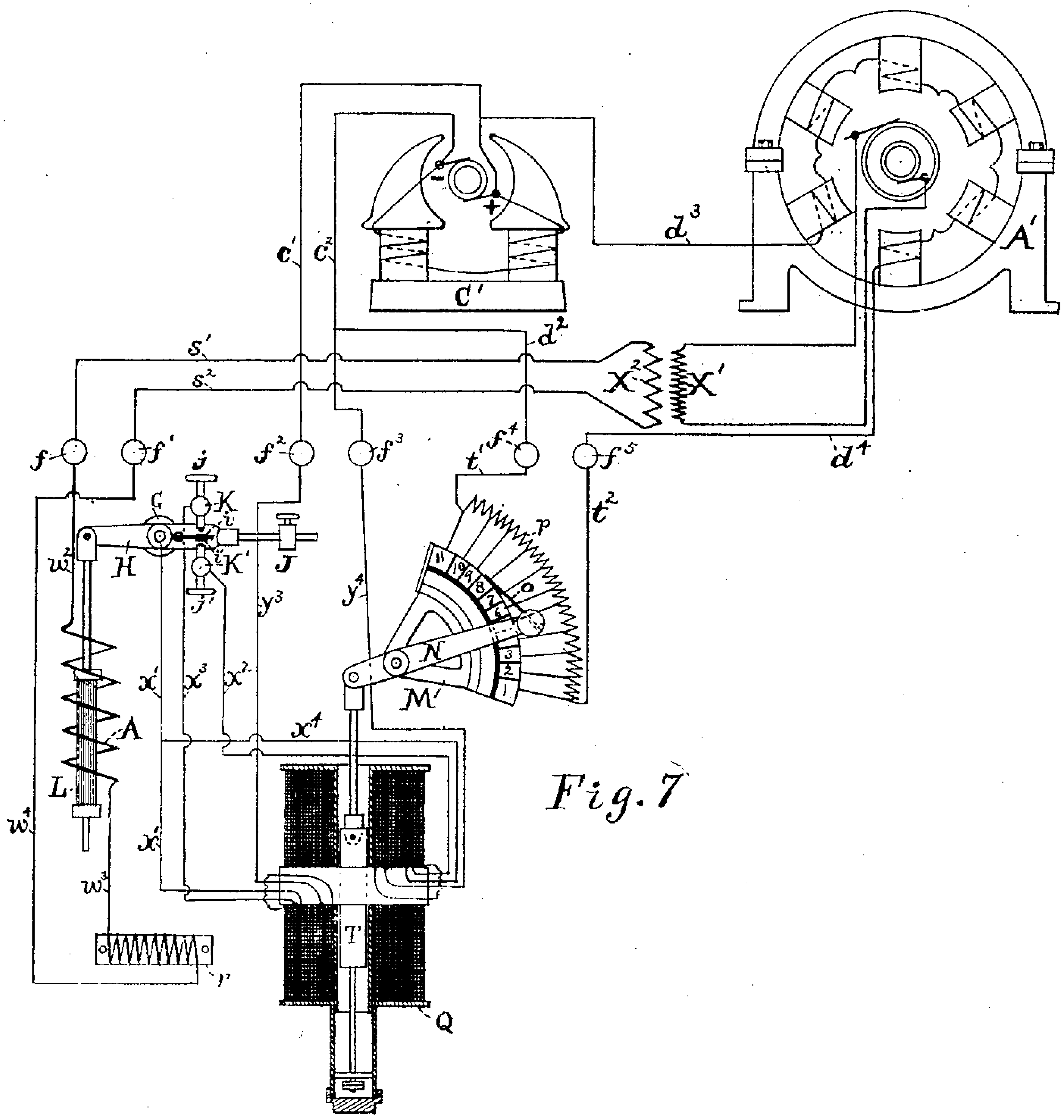

Fig. 7

Witnesses:

Geo. W. Brown

E. M. Rines

Inventor.

Wm. H. Chapman

UNITED STATES PATENT OFFICE.

WILLIAM H. CHAPMAN, OF PORTLAND, MAINE, ASSIGNOR TO THE BELKNAP MOTOR COMPANY, OF SAME PLACE.

ELECTRIC REGULATOR FOR DYNAMOS.

SPECIFICATION forming part of Letters Patent No. 599,892, dated March 1, 1898.

Application filed February 10, 1897. Serial No. 622,811. (No model.)

To all whom it may concern:

Be it known that I, WILLIAM H. CHAPMAN, a citizen of the United States, residing at Portland, in the county of Cumberland and State of Maine, have invented a new and useful Improvement in Electric Regulators for Dynamos, of which the following is a specification.

My invention relates to regulators in which resistances are automatically put in or taken out of circuit with the field-magnet of the dynamo, thereby varying the degree of excitation of the field and controlling the voltage independently of the speed or load applied to the dynamo; and it is designed as an improvement on the regulator for dynamos described in my application filed April 4, 1896, Serial No. 586,197.

The object of my invention is to provide an auxiliary controlling coil or solenoid and contact-points to control the admission of current into the working solenoid and to so construct the working solenoid and contacts and connect them together that the spark at contact-points may be neutralized and the action of the apparatus thereby rendered more accurate and reliable than any hitherto invented. I attain this object by the mechanism shown in the accompanying drawings, in which—

Figure 1 is a front elevation of the complete device with the front of the inclosing box removed. Fig. 2 is a cross-section of the complete device, taken on the line *x x* of Fig. 1. Fig. 3 is a plan view of the auxiliary solenoid and core and its supporting-lever, together with a portion of the supporting-slate in cross-section. Fig. 4 is an elevation of the naked spool on which the auxiliary coil or solenoid is wound. Figs. 5 and 6 are two views of the fiber ring C, showing the position of the holes for the exit of wires from the working solenoid. Fig. 7 is a diagram which illustrates the method of applying the device to an alternating-current generator and shows the connections of the various parts of the device with each other and with the alternating-current generator, with its exciter, and with its transformer.

D is a cast-iron box having cross-bars a a' a^2 a^3 cast in it for the support of the resistance-coils and slates. At the upper and lower ends of the box it has lugs b b' b^2 b^3 cast on it for convenient attachment to the wall of a building. The back of the box is closed by a sheet-iron plate c and the front of the box is closed by a frame d, having a plate of glass d' set in it.

B, B', and B^2 are slabs of slate which are secured into the box by screws e, e', e^2, e^3, e^4, e^5, e^6, e^7, e^8, and e^9, which enter tapped holes in the cross-bars a a' a^2 a^3.

E is a brass spool secured to the front side of the slate B. This spool is slit from one end to the other at one side of its axis, as seen in Figs. 3 and 4, in order to prevent induced currents from circulating around it, as they otherwise would when the apparatus is used in connection with an alternating-current dynamo.

A is a coil of insulated wire wound on the spool E, but insulated therefrom. One end of the coil A is connected by wire w^2, Fig. 7, to the binding-post f, mounted on the slate B, and the other end of the coil A is connected by wire w^3, Fig. 7, to one end of a non-inductive resistance mounted on the back side of the slate B'. The other end of the non-inductive resistance is connected by wire w^4, Fig. 7, to the binding-post f', mounted on the slate B. The non-inductive resistance is constructed in the well-known manner and consists of German-silver wires wound onto sheets of mica r, which are kept apart by washers t, slipped over the bolts g g', that hold the whole to the slate B'.

G is a brass stud mounted on the slate B and projecting forward from its surface.

H is a brass lever which is pivoted to the end of the stud G. At one end of the lever H is pivoted the connection-rod I, and on the other end of the lever H is placed the balance-weight J, which is adjustable along the lever to different distances from the center or fulcrum. On the front of the lever H, near its center or fulcrum, is fixed the brass stud h.

h' is a thin flat spring, one end of which is secured to the stud h. Near the free end of the spring h' are two little pieces of sheet-platinum i i', one soldered onto the upper side of the spring and the other onto the lower side of the spring.

K and K' are two brass posts which are secured to the slate B with their ends projecting forward, one at each side of the lever H. Near their projecting ends they are tapped to receive the thumb-screws $j j'$. The screws $j j'$ are each tipped with platinum at the end toward the lever H and are set so as to make contact with the platinum pieces $i i'$, but far enough apart so that the lever H may have a short range of free movement without making contact at either side with the screws.

Within the coil A and along the line of its axis is the core L, which is made up of a large number of small soft-iron wires secured together in a bundle and suspended from the lower end of the connection-rod I. The core L is preferably a little longer than the coil A, and its upper end is situated about two-thirds of the way up from the bottom toward the top of the coil A when the lever H is in a horizontal position and the points of the screws $j j'$ equidistant from the contact-pieces $i i'$. At the lower end of the core L is a projecting wire l, which passes freely through a hole in the piece l', attached to the side of the box D, and serves as a guide to prevent the lower end of the core from swinging about.

M is a sector-shaped brass frame secured to the front of the slate B and having mounted upon it a series of brass contact-segments 1 to 11, arranged in the arc of a circle, at whose center is located the hub m, which is cast onto the frame M. All of the contact-segments except the last one at the top, 11, are electrically insulated from the metal of the frame M, but the segment 11 is in metallic connection with the frame M.

N is a brass lever pivoted on the hub m. At one end of the lever N is pivoted the connection-rod O and at the other end is secured the brass stud n, which supports the copper brush o. The brush o is arranged to come into contact with the peripheral surface of the series of segments 1 to 11.

P is a balance-weight attached to the lever N.

In the back part of the box D is a series of German-silver resistance-coils p, supported on porcelain insulators attached to the crossbars a, a', a^2, and a^3. The two extremes of the series of resistance-coils are connected, respectively, with segments 1 and 11, and the segments between 1 and 11 are connected to intermediate points in the series of coils in the usual manner of field-rheostats. The two segments 11 and 1 are also connected by wires t' and t^2, Fig. 7, respectively, to the two binding-posts f^4 and f^5, attached to the front side of the slate B. These two binding-posts therefore form the terminals of the series of resistance-coils, and the brush o, by its contact with one segment or another and by its metallic connection through the lever N and frame M to the segment 11, serves to short-circuit the portions of the resistance-coils that are connected to segments situated between segment 11 and the particular segment with which the brush may happen to be in contact.

On the bottom of the box D is secured the brass spool Q, having two iron bars R R' extending from one head of the spool to the other. The screws q q' serve to secure the bars R R' to the lower head of the spool and also to hold the spool firmly onto the bottom of the box D, and the other screws q^2 q^3 secure the bars R R' to the upper head of the spool. Inside of the spool Q and along the line of its axis is the cylindrical-shaped iron core T, which at its upper end is pivotally connected to the lower end of the connection-rod O. The core T is made, preferably, of a length about five-eighths as great as the length of the spool Q. S is a dash-pot attached to the lower end of the spool Q and projecting through a hole in the bottom of the box D. Within the dash-pot is the piston s, secured on the rod u, which is attached to the lower end of the core T. The piston has holes y y' through it from bottom to top. Below the piston s on the lower end of the rod u are two nuts w w', the rod u being threaded to receive them. These nuts are both considerably smaller in diameter than the piston; but one of them at least (the upper one w) is large enough to cover the holes in the piston and to close them tightly when it is screwed up tight against the piston. Normally the nut w is set a very short distance away from the piston and the lower nut w' is screwed against it to act as a check-nut to prevent it from becoming accidentally displaced.

The dash-pot S is normally filled with a liquid like oil or glycerin, and the setting of the nut w serves as an adjustment of the leakage by the piston, and consequently is an adjustment of the retarding action of the dash-pot.

The spool Q is wound full of insulated copper wire in a manner that constitutes a double differential solenoid. The whole solenoid is divided into two distinct portions by the center ring of fiber C. (Shown in detail in Figs. 5 and 6.) This fiber ring has eight radial holes drilled in it. Four of them, $v v' v^2 v^3$, are nearest to the upper side and open out on that side of the ring at the points $z z' z^2 z^3$, and the other four, $v^4 v^5 v^6 v^7$, are nearer to the lower side of the ring and open out on that side of the ring at the points $z^4 z^5 z^6 z^7$. The windings at each side of the spool Q are divided into three sections, which will be better understood by describing in detail the actual process of winding on the wire. The spool is placed on an arbor in a turning-lathe with the end of the spool that is first to be wound—say the upper end—situated to the right of the operator, and the winding is done with the upper periphery of the spool moving away from the operator. The starting end is first put through the hole $z v$, and then a number of layers are wound on, sufficient to make this end of the spool very nearly one-quarter full. At this point a short piece of wire is soldered at one end to the wire that is being wound, and the other end of the short piece of wire is thrust out through the hole $z' v'$, and the winding is continued until the spool is nearly three-quarters full at this end. The wire is here cut off and the end of the winding thrust through the hole z^2 v^2. Then several layers of insulating-paper are put on and the winding is continued after putting the new starting end through the hole $z^3 v^3$. When this end of the spool is full, the wire is cut off and the end of the winding is connected permanently with the first starting end—that is, the end that comes out through the hole z v. Having finished one portion of the solenoid, the spool is then removed from the lathe and placed with its other end to the right of the operator, and this end is also wound full in precisely the same manner as was the first end of the spool—viz., the end of the wire is put through the hole z^4 v^4, and nearly one-quarter of that end of the spool is filled while the upper periphery moves away from the operator. Then one end of a short piece of wire is soldered to the winding and the other end thrust out through the hole z^5 v^5. The winding is then continued in the same direction until three-quarters of the space is filled, and the wire is cut off and the end of the winding put through the hole z^6 v^6. Several layers of insulating-paper are then put on and the winding continued in the same direction as before, the new starting end being put through the hole z^7 v^7. When the space is all filled, the wire is cut off and the final end of the winding is connected permanently to the first end coming out of the hole z^4 v^4. Thus it will be seen that each end of the spool Q has on it really two distinct coils of wire. One coil is made up of the two sections that occupy, respectively, the first quarter and the last quarter of the winding and will hereinafter be referred to as "coil first," and the other coil is the other two quarters, composing the middle section of the winding, and will hereinafter be referred to as "coil second." Coils first and second of the upper half of the spool have one terminal in common, which is the wire that was put through the hole z' v', while the other ends of the two coils are separated from each other by having been put through the separate holes z^2 v^2 and z^3 v^3. Coils first and second of the lower half of the spool also have one terminal in common, which is the wire that was put through the hole $z^5 v^5$, while the other ends of the two coils are the wires from z^6 v^6 and z^7 v^7. The common terminal coming from hole z' v' is connected to the binding-post f^3 by the wire y^4, Fig. 7, and the common terminal coming from hole z^5 v^5 is connected to the binding-post f^2 by the wire y^3, Fig. 7, both of which binding-posts are attached to the front of the slate B. The coil-terminal coming from hole $z^2 v^2$ and the coil-terminal coming from hole z^6 v^6 are connected together and to the stud G by wire x', Fig. 7, and through the stud G and lever H they are in electrical connection with the contacts i i'. The upper coil-terminal coming from hole z^3 v^3 connects to the post K', situated below the lever H, by the wire x^2, Fig. 7, and through K' to screw j', and the lower coil-terminal coming through hole z^7 v^7 is connected to the stud K, situated above the lever H, by the wire x^3, Fig. 7, and through K to screw j. The two separate sections constituting coil first on either end of Q being of different diameters, one larger and the other smaller than coil second, render the average length of a convolution of wire practically the same for coil first as it is for coil second, and as the depth of winding in coil second is made just the same as the sum of the depths in the two sections of coil first the total electrical resistance of coil first is almost exactly the same as the resistance of coil second. This is a matter of some importance, as an equal resistance in the two is necessary in order to have them neutralize each other, as will be described later on in this specification.

The top of the box D has six holes through it, and in these holes are placed the bushings V V' V^2 V^3 V^4 V^5, made of hard rubber or other insulating material, for the entrance of the wires to be attached to the binding-posts f, f', f^2, f^3, f^4, and f^5.

Referring to Fig. 7, A' is an alternating-current generator whose voltage is to be controlled. C' is the direct-current exciter, which supplies current to charge the field-magnets of the generator A'. X' is the primary coil of a transformer, and X^2 is the secondary coil of the transformer. One end of the field-magnet wire of the generator is connected by wire d^4 to the binding-post f^5, and the other end of the field-magnet wire of the generator is connected by wire d^3 to one terminal of the exciter, and the other terminal of the exciter is connected by wire c^2 and wire d^2 with the binding-post f^4. Thus the circuit through which the field-magnet of the generator is charged include in it the resistances p or such portion of them as are not short-circuited by the brush o. The two terminals of the secondary coil X^2 are connected by wires s' and s^2 with the two binding-posts f and f'. Thus an alternating current is maintained through the circuit of the coil A and the non-inductive resistance on the mica strips r whenever the alternating generator is running. The two terminals of the exciter are connected by wires c' and c^2 to the two binding-posts f^2 and f^3.

The connections having been made as shown and described the operation of the device may be explained as follows: We will first suppose the generator and its exciter to be running under normal conditions and that the voltage of the generator is at its normal amount. The alternating current that is then flowing through the coil A has a certain lifting force on the core L. The weight J is then moved on the arm of the lever H until its counterbalancing force, together with the normal lifting force of the core L, will just balance the lever H in a horizontal position and thus keep the platinum contacts i i' clear of the screws $j\ j'$ on both sides. This being the case, a current passes from the exciter by wire c', binding-post f^2, and wire y^3 to the common terminal of coil first and coil second on the lower end of spool Q, thence it passes through coil second in a direction the same as the hands of a watch, as viewed from the top of the spool, thence by wire x' and wire x^4 to the outside end of coil second on the upper end of spool Q. Through this coil it passes in a right-hand direction, as viewed from above, then out at the common terminal of coils first and second on the upper end of spool Q, thence by wire y^4, binding-post f^3, and wire c^2 to the other terminal of the exciter. No current can pass through coil first on either end of the spool, because the circuit of these two coils is open at the platinum contacts, as before mentioned. Under these circumstances while a current is flowing, as described, through only one coil at each end of the spool Q there is practically no force exerted on the core T to move it one way or another, and it remains indifferently in any position throughout its range of movement. In other words, it remains stationary, although both coils are maintaining its magnetization at the maximum point with a south polarity at the top end and north polarity at the bottom end; but now in the second place suppose the voltage of the generator by reason of increase of speed has risen to a higher value. This causes a greater current in the primary X', which in turn induces a stronger current in the secondary X^2 and through the circuit of the coil A. The coil A then acts with greater force on the core L, lifting it and destroying the balance of the lever H. The contact end of this lever moves down and makes contact with the screw j'. Currents then flow through three coils—viz., coil second at the lower end and coils first and second at the upper end of spool Q—by the following course: from one terminal of the exciter through wire c', binding-post f^2, wire y^3, to the common terminal of coils first and second on lower end of spool Q, thence through coil second to wire x'. Here it divides, and a portion goes, as before, through wire x^4 and in a right-hand direction through coil second on the upper end of spool Q to the common terminal of coils first and second on that end, and the other equal portion passes through wire x', stud G, lever H, contact i', screw j', stud K', wire x^2, through coil first on upper end of spool Q in a left-hand direction to the common terminal of coils first and second on that end. Here the two portions reunite and pass by wire y^4, binding-post f^3, and wire c^2 to the other terminal of the exciter. The result of this distribution of the current is that coils first and second at the upper end of Q neutralize each other and coil second on the lower end alone excites magnetization in the core T and exerts its force upon it and pulls it downward and the lever N is moved and the brush o moves upward along the contact-segments, and thereby increases the quantity of resistance in the field-magnet circuit of the generator. The rapidity of the movement of T is checked by the dash-pot below it, and when enough resistance is turned into circuit the voltage again becomes normal and the lever H is again balanced and electrical contact with j' is broken, leaving only coil second at each end of Q in action as at first and the core T in a fixed position. Now, in the third place, suppose the voltage of the generator falls to a lower value by reason of diminished speed. Then the transformer-currents become weaker, the coil A loses some of its force, and the core L being less strongly pulled upward the lever H is again unbalanced and contact is made with screw j. Under these circumstances current will flow in three of the coils—viz., coils first and second on the lower end of Q and coil second on the upper end of Q. The course of the current is as follows: from one terminal of the exciter by wire c', binding-post f^2, and wire y^3 to the common terminal of coils first and second on lower end of Q. Here it divides, and one portion goes through coil second on that end to wire X' and the other equal portion goes through coil first on that end, thence by wire x^3, stud K, screw j, contact i, lever H, and stud G to wire x', where the two portions reunite and pass by wire x^4 to the outside end of coil second, thence through that coil to the common terminal of coils first and second on the upper end of Q, thence by wire y^4, binding-post f^3, and wire c^2 to the other terminal of the exciter. The result of this distribution of current is that coils first and second on the lower end of Q neutralize each other, while coil second on the upper end of Q alone excites magnetization in the core T and pulls it upward. The lever N is moved thereby, and the brush o is brought downward along the segments and reduces the amount of resistance in the field-magnet circuit of the generator until the voltage is again brought up to the normal, when the lever H will again become balanced and electrical contact with screw j be broken. Coil second on each end of Q will then be the only ones in action and the core T will remain fixed, as before.

It will be observed that in either of the cases above described when the contact is broken the result of the current thus broken is not to destroy the magnetization of the core T, but, on the contrary, it increases when the circuit is broken because of the fact that coil second on one end charges T in the same direction as coil second on the other end does, and when both these coils act together their magnetizing effect is greater than when either one is neutralized, as is the case when a contact is established either with j or j'.

Now it is well known that the spark occurring when the circuit through an ordinary solenoid is broken is due to the rapid fall of magnetism, inducing in the wire an extra current at the instant of rupture, whereas in my present arrangement the magnetism does not fall in the least when the contact is ruptured, and consequently very little or no spark occurs at the instant of rupture, and the contacts are thereby protected from the injury that usually occurs to them after a short period of use and renders their action uncertain and unreliable. When an alternating voltage is maintained at the terminals of a coil of wire like the coil A, it is well known that the current resulting from that voltage is much less than it would be if the same direct voltage were maintained at its terminals, owing to the effect of self-induction in the coil, and, furthermore, if the two terminals of this coil were attached directly to an ordinary alternating source without any other resistance in circuit with it the self-induction or choking action of the coil would be the chief factor in determining the quantity of current that would flow, whereas if it were connected to a direct-current source the chief factor in determining the quantity of current that would flow would be the ohmic resistance of the coil; but since the choking action of a coil is less when the frequency of alternation is less, and since a diminution of speed of an alternating generator causes not only a lower voltage, but also a lower frequency, it often happens that the choking action of a coil like A, when connected without other resistance to the transformer, will diminish enough, so that even a considerably lower voltage will still maintain the same quantity of current in the coil, and consequently the same force on the core L, and the lever H would then remain balanced in spite of the lower voltage, and, again, if the speed of the generator gets too high the voltage and also the frequency become high and the choking action of the coil may thereby be so increased as to keep the current practically the same and the lever H will remain balanced in spite of the increase in voltage. To obviate this difficulty and to render the force of the coil A on its core more nearly independent of the frequency and dependent on the voltage, the non-inductive resistance is put in circuit with it, and it is found expedient in practice to make the ohmic value of this resistance as much as twenty times as great as that of the coil itself. This arrangement adapts the apparatus for use on any frequency of alternating current and also for direct current.

In applying this apparatus to a direct-current generator the two binding-posts f and f' are connected, respectively, to the two binding-posts f^2 and f^3, and these latter to the terminals of the dynamo and the binding-posts f^4 and f^5 are connected into the field-magnet circuit of the generator in the usual manner of field-rheostats. It will be seen that the action of my apparatus, as above described, is to maintain a constant voltage at the terminals of the generator; but in practice it is sometimes desirable to maintain the constant voltage not at the terminals of the generator, but at a distant point in the line-wires that are connected to the terminals of the generator. When there is considerable current being supplied to the lines by the generator, the loss of voltage in the lines may be considerable, and it is therefore often desirable to raise the voltage at the generator a little in proportion to the load on the lines. To accomplish this automatically with my device, I have found it feasible to supplement the coil A with a few turns of coarse wire placed on the outside of it and connected directly into the main circuit of the generator that leads to the line-wires, so that the current may flow through the supplementary coil in a direction the reverse of that in the coil A, thus neutralizing a small portion of the force of coil A on the core L and necessitating a higher voltage to balance the lever H when the lines are loaded heavily. This arrangement is known as a "compound" winding, and is frequently applied to the coils of electric motors and dynamos to affect the degree of magnetic excitation with changes of load. In the present instance it operates to weaken the force of the core L as the load increases, and thereby calls for higher voltage at the terminals of the generator to overcome the loss in the line-wires.

The non-inductive resistance that has been described is one of the well-known forms; but any other form of non-inductive resistance may be substituted for it in circuit with the coil A. Incandescent electric lamps, for instance, make an excellent non-inductive resistance, and I have found it desirable in some cases to use them instead of German-silver resistances.

What I claim as new, and desire to secure by Letters Patent of the United States, is—

1. The combination of a solenoid having a movable iron core, and composed of four distinct coils of wire arranged to oppose each other and to balance each other's magnetic and mechanical action on said core and to thereby neutralize each other's effects whenever an even number of them is in action and to pull the said core one way or the other when an odd number of them is in action, a set of electrical contacts arranged to open and close the electrical circuit through one of said coils and so unbalance the opposing forces and thereby to cause the movement of the core, and a rheostat whose arm is arranged to be operated by the movement of said core substantially as shown and described.

2. In combination with a dynamo having suitable exciting-coils on its field-magnet, a coil of wire connected in a circuit whose terminals are at the two terminals of the dynamo, two pairs of electrical contacts arranged to be opened and closed with an increase or diminution of the magnetic force of said coil, a rheostat connected in circuit with the exciting-coils of said field-magnet, and a differential solenoid having a movable iron

core arranged to operate the arm of said rheostat, said solenoid being composed of four distinct coils connected oppositely in electrical circuits so as to exert opposing forces on said core, the circuits of one of said coils being arranged to include one pair of said contacts and the circuit of the other coil being arranged to include the other pair of said contacts, substantially as and for the purposes specified.

3. The combination of a coil of wire A having a movable iron core L operatively connected to two pairs of electrical contacts and arranged to close one pair of contacts at the end of its range of movement in one direction and to close the other pair of contacts at the end of its range of movement in the other direction, a differential solenoid having a movable iron core, and composed of four distinct coils connected oppositely in electrical circuits so as to exert opposing forces on said core, the circuit of one of said coils being arranged to include one pair of said contacts and the circuit of the other one of said coils being arranged to include the other pair of said contacts, and a rheostat whose arm and slider are operatively connected with the core of said differential solenoid substantially as shown and described.

4. In combination with a dynamo having suitable exciting-coils on its field-magnet, a coil of wire and a non-inductive resistance connected in a circuit whose ends are the terminals of said dynamo, a movable iron core placed in the axis of said coil, two pairs of electrical contacts operatively connected to said core so that one pair of contacts is closed at each extreme of the movement of said core, a differential solenoid having a movable iron core, and composed of coils connected oppositely in electrical circuits and arranged to exert opposing and balancing forces on said core under normal conditions, the circuit of one of said coils being arranged to include one pair of said contacts and the circuit of the other one of said coils being arranged to include the other pair of said contacts, a rheostat connected in the field-circuit of said dynamo and having its arm and slider operatively connected to the core of said differential solenoid, and a dash-pot having a piston *s* in which are holes *y* *y'*, arranged to be closed more or less tightly by a nut *w* mounted on the piston-rod *u* substantially as shown and described.

WM. H. CHAPMAN.

Witnesses:
WILLIAM J. KNOWLTON,
HIRAM KNOWLTON.