(No Model.)

2 Sheets—Sheet 1.

W. H. CHAPMAN.

ELECTRIC REGULATOR FOR DYNAMOS.

No. 589,073.

Patented Aug. 31, 1897.

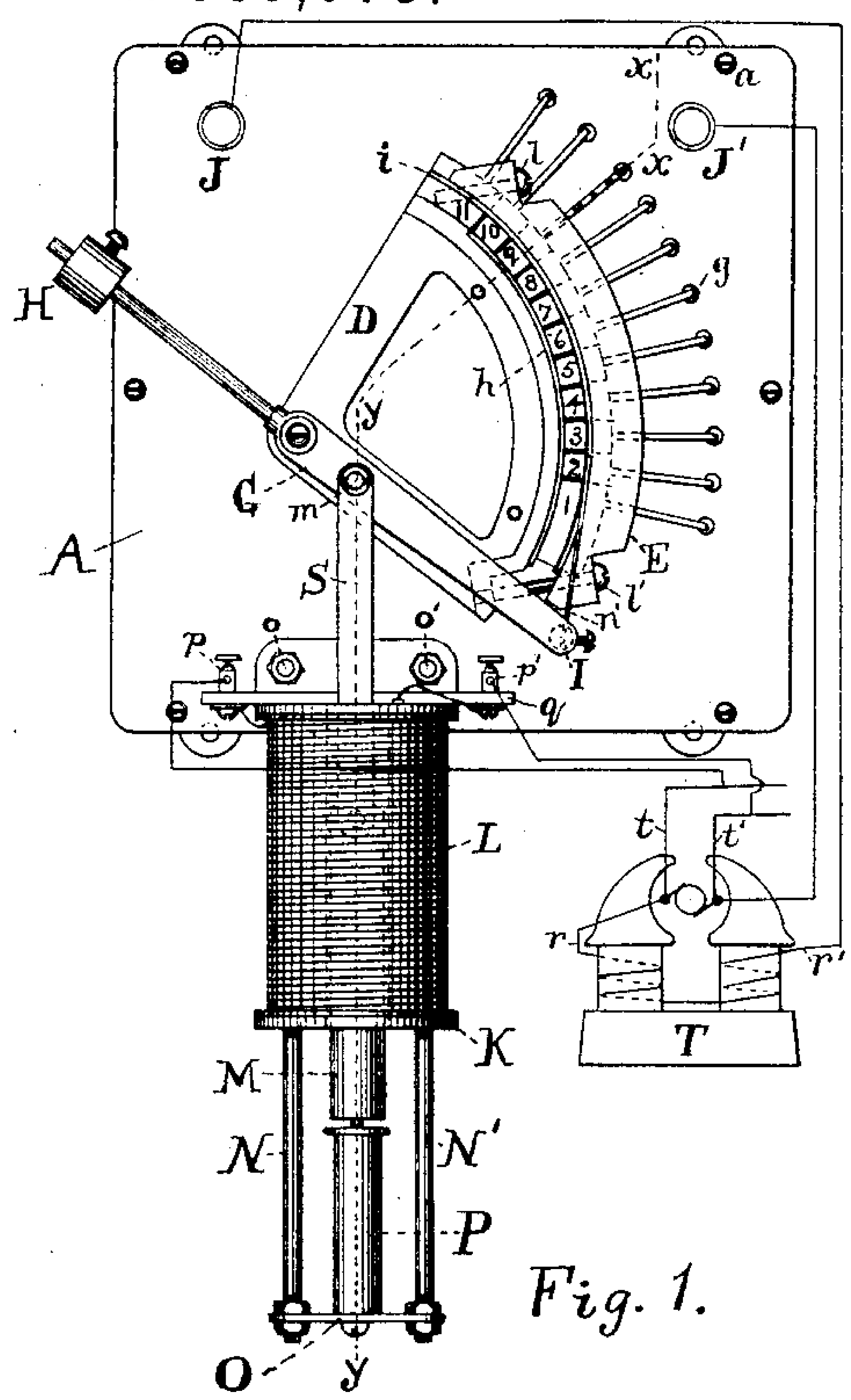

Fig. 1.

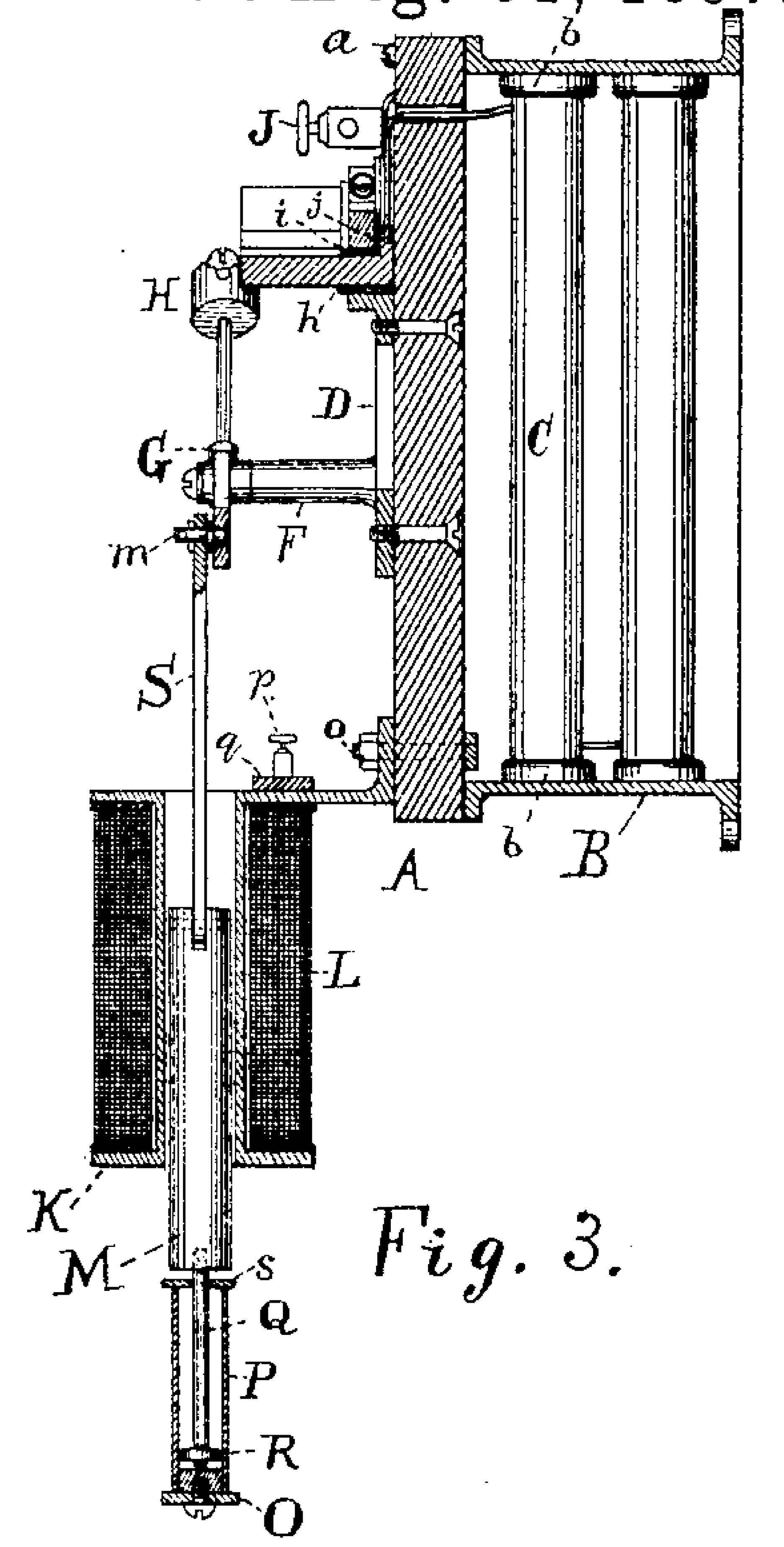

Fig. 3.

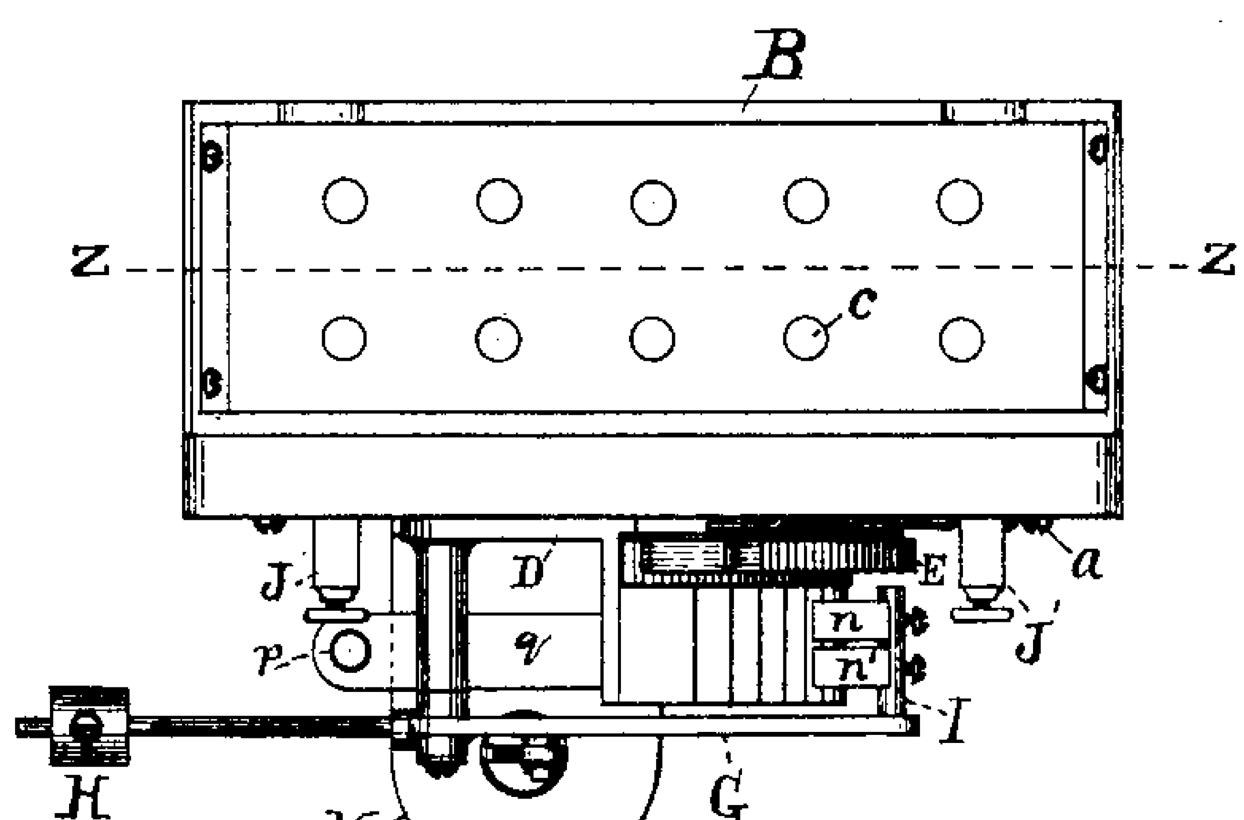

Fig. 2.

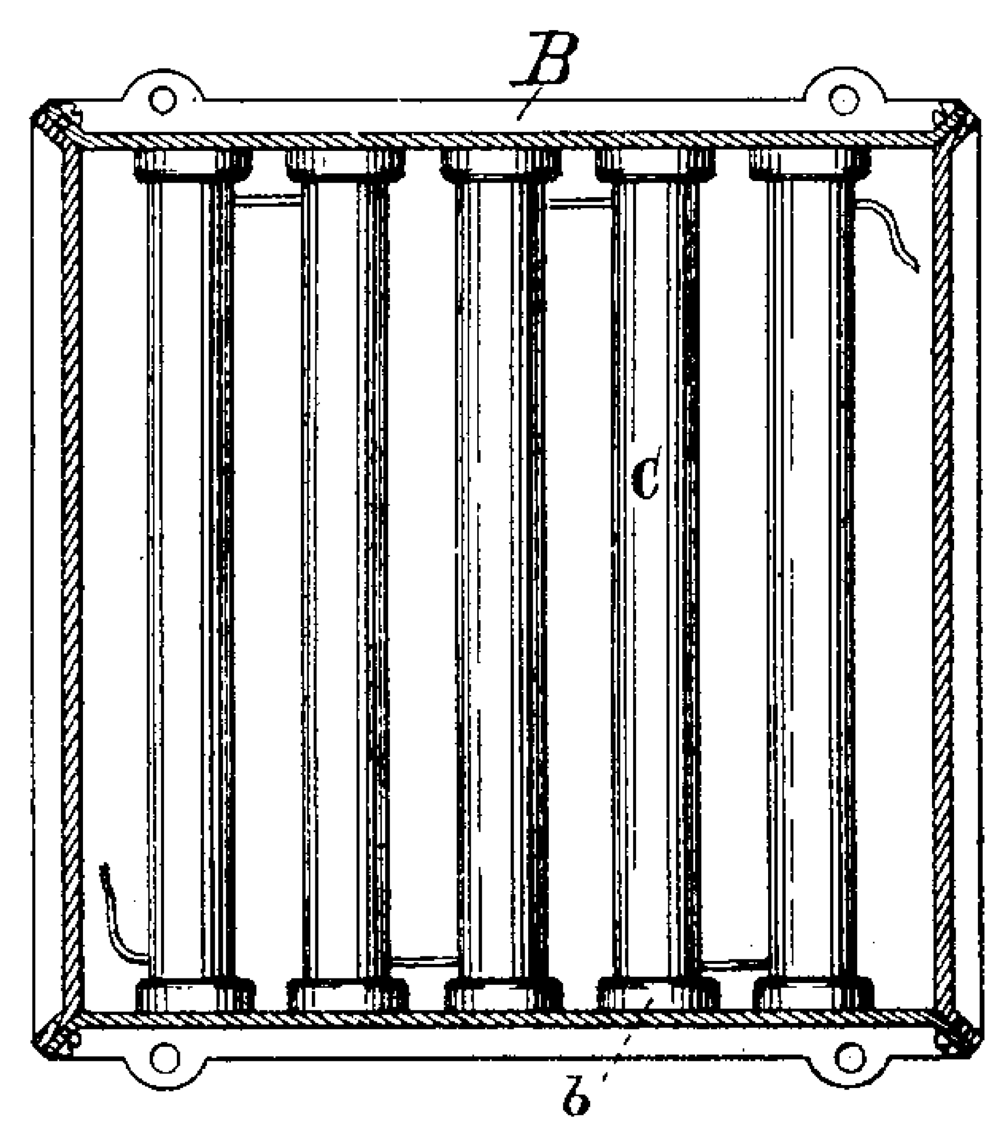

Fig. 5

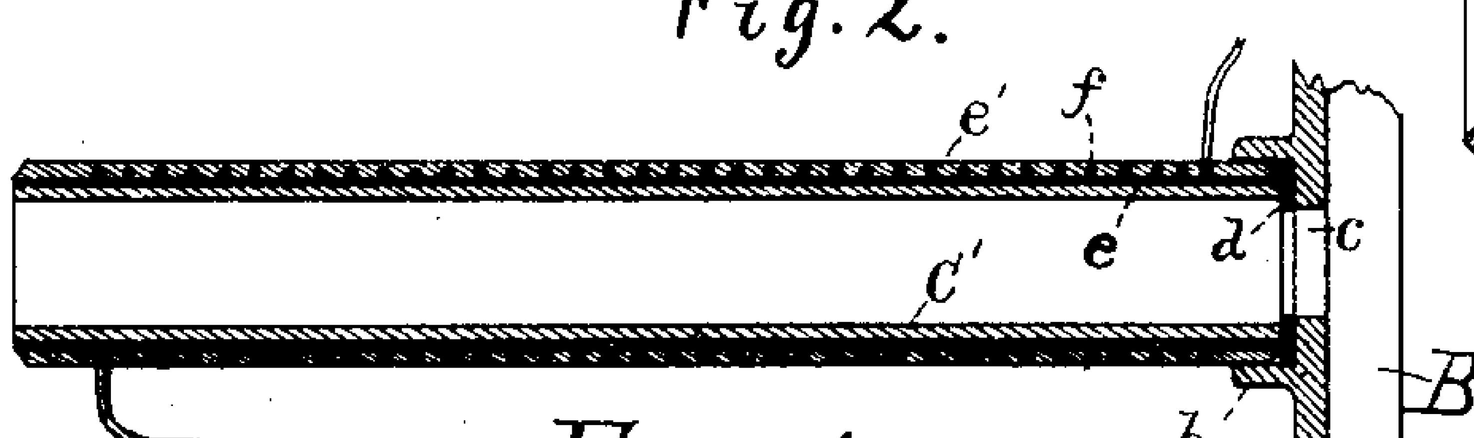

Fig. 4

Witnesses.

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(No Model.)

2 Sheets—Sheet 2.

W. H. CHAPMAN.

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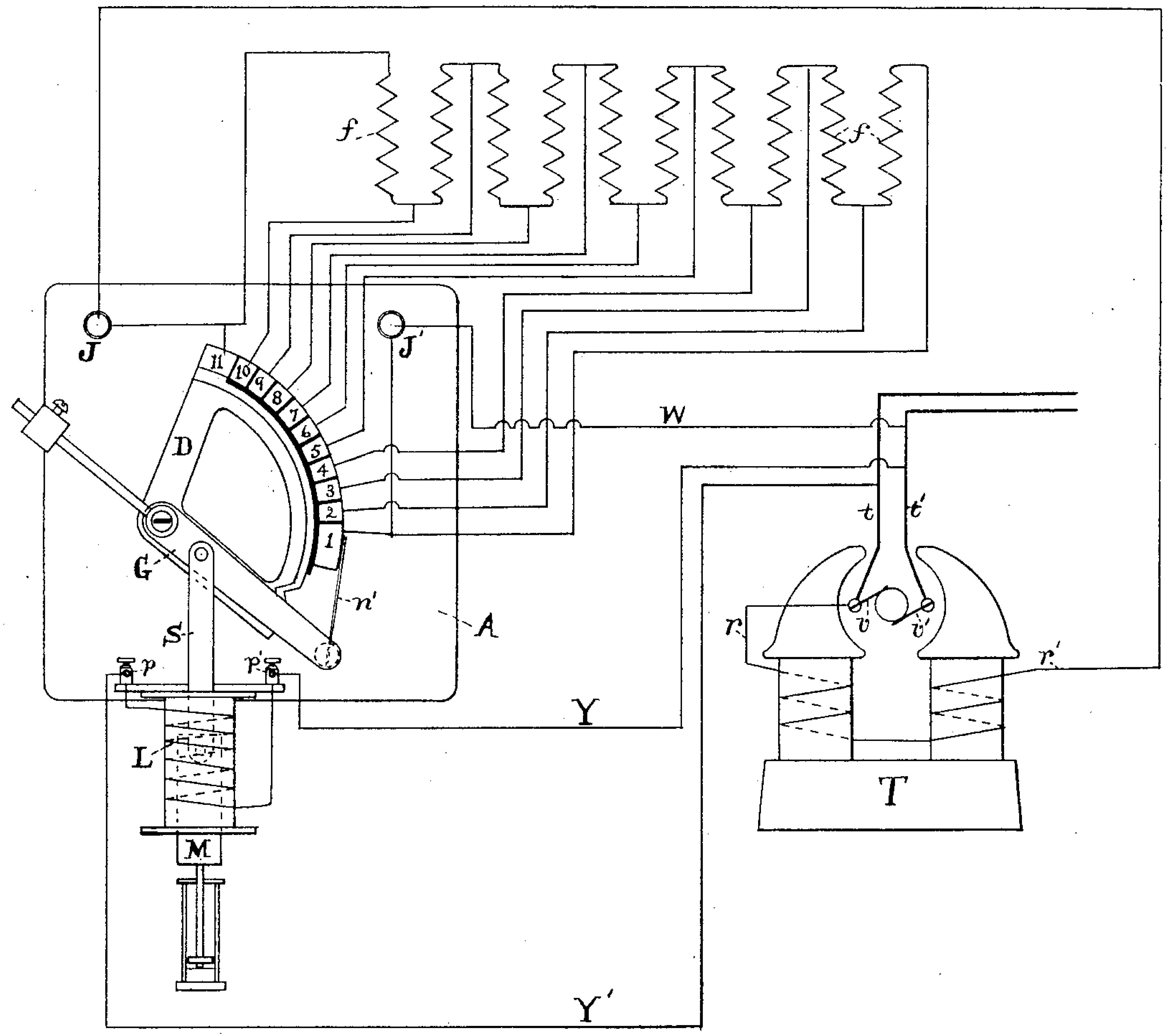

Fig. 6.

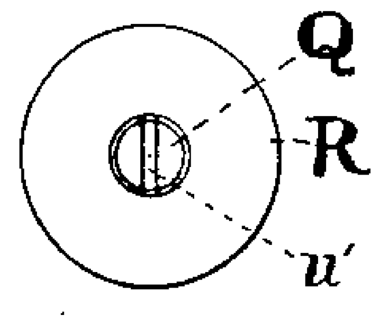

Fig. 7.

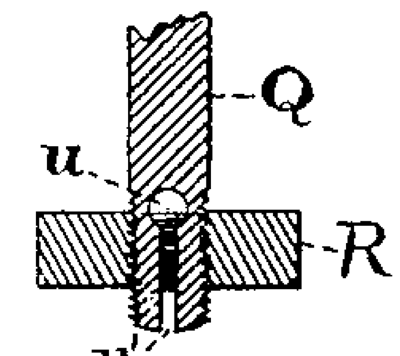

Fig. 8.

Witnesses.
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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. 589,073, dated August 31, 1897.

Application filed April 4, 1896. Serial No. 586,197. (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 Electric Regulator for Dynamos, of which the following is a specification.

My invention relates to dynamos that are designed for generating electrical currents for the operation of incandescent lamps or motors or other devices that require a constant potential or voltage to be maintained in the wires that supply them.

The object of my invention is to so regulate the strength of the field-magnet of the dynamo that the voltage may be kept constant in the wires leading from the dynamo in spite of changes of speed at which the dynamo may be driven. I attain my object by means of the mechanism shown in the accompanying drawings, in which—

Figure 1 is a front elevation of the regulator, together with a diagrammatic representation of a dynamo connected to it. Fig. 2 is a plan view of the regulator. Fig. 3 is a cross-section on the line $x\ x\ y\ y$ of Fig. 1. Fig. 4 is an enlarged cross-section of one of the resistance-coils and its supporting-tube and of a portion of the containing-box to show how the tube is held in place. Fig. 5 is a cross-section on the line $z\ z$ of Fig. 2. Fig. 6 is a diagram showing the connections of the various parts of the apparatus with each other and with the dynamo which it is intended to regulate. Fig. 7 is an end view of the piston R and rod Q, drawn to a larger scale. Fig. 8 is a vertical cross-section of the same.

Similar letters and figures refer to similar parts in the several views.

B is a cast-iron box which is made up of four separate pieces joined together at the corners, as shown in Fig. 5. The top and bottom pieces of this box each have a series of holes, as *c*, passing through them, and around each of these holes on the inside face is cast an annular projection, as *b*. Inside of the box B is a series of resistance-coils mounted on tubes or pipes, as C, each of which has its ends inclosed by the annular projections *b* on the box B, by which it is held in place at top and bottom. A reference to Fig. 4 will explain the arrangement in detail.

C′ is a piece of iron pipe which is covered with a layer of mica *e*. On this is wound the German-silver wire *f*, having its several convolutions separated a little from each other. After winding the wire onto the mica-covered pipe the whole surface is covered with asbestos cement *e*′, in which the wires are thus embedded and are retained rigidly in place after the cement has become hard. At each end of each pipe is a washer *d*, made of asbestos or mica. Each of the pipes is therefore thoroughly insulated electrically from the box B by the washer *d* and by the covering of mica *e* and by the coating of asbestos cement *e*′, extending to its ends, and the resistance-wires mounted on these pipes are insulated from the pipes themselves by the mica *e*. On the front of the box B is the slate slab A, secured thereto by screws, as at *a*.

All of the resistance-coils inside the box are connected together in series, and each point of junction of two coils with each other, as well as each of the two extremes of the whole series of coils, has a leading-wire connected to it which passes out through a corresponding hole in the slate slab A, as at *g*. On the face of the slate A is a series of metal segments 1 2 3 4, &c., corresponding in number to the number of leading-wires, and each one of the leading-wires is connected to its corresponding segment in the series.

The segments 1 2 3 4, &c., are all insulated from each other by strips of leatheroid or mica placed between them. D is a brass frame mounted on the face of the slate A. It has an outwardly-projecting hub or boss F, which is situated at the center of the circular arc formed by the segments 1 2 3 4, &c. The segments 1 2 3 4, &c., are insulated from the frame D by the fiber strip *h*, all except the last one, 11, which is cast in one piece with it and is thereby electrically connected to it. E is a sector of brass, which serves to clamp the segments 1 2 3 4, &c., firmly in position. It is secured to the frame D by means of the two clamping-screws *l l*′, which enter holes in the frame D threaded to receive them. The sector E is insulated from all the segments from 1 to 10, inclusive, by the fiber strips *i* and *j*.

On the hub F of the frame D is pivoted the lever G. One arm of the lever G has on it the weight H, adjustable radially to any desired distance from the center or fulcrum at F. The other arm of the lever G has at its extremity the stud I, projecting inwardly toward the slate A, and at a point nearer the center or fulcrum is secured the pin *m*, projecting outwardly. The stud I serves to support the copper strips or brushes *n n'*, which press on the surface of the segments 1 2 3 4, &c. Whenever the brushes *n n'* are in contact with any one of the segments, (from 1 to 10, inclusive,) that particular segment is placed in electrical connection with the last segment 11 through the brushes *n n'*, stud I, lever G, hub F, and frame D, on which segment 11 is cast, as above described. The brushes *n n'* therefore serve to short-circuit all the resistance-coils that are connected to segments situated between the last segment 11 and the particular segment with which the brushes *n n'* happen to be in contact.

J and J' are two binding-posts which form the terminals of the series of resistance-coils contained in the box B.

K is a spool made of brass and is secured to the face of the slate A by bolts *o o'*, passing through a foot projecting from the upper head of the spool, as seen in Figs. 1 and 3. The spool K is wound with several layers of fine insulated copper wire L, the two ends of which connect to the binding-posts *p p'*, which serve as its terminals. The binding-posts *p p'* are attached to the fiber strip *q*, which is attached to the upper head of the spool K. To the lower head of the spool K are secured the two rods N N', which project downward parallel to each other and parallel to the axis of the spool K.

O is a cross-bar secured to the lower ends of the rods N N'. At its center is attached the tube P, which is closed at its lower end.

Within the spool K is the cylindrical iron core M, which fits loosely inside the spool and is free to move lengthwise therein and is of a length equal to or greater than that of the spool.

Q is a brass rod attached to the lower end of the core M and extends downward in the line of the axis of said core into the tube P, where it has a piston R attached to it nearly at its extremity. The piston R is attached to the rod Q by being drilled and threaded to receive a corresponding thread on the rod, and the latter thread extends to some little distance from the end of the rod, so that the piston may be screwed on to a greater or less distance, as desired, and it is fitted so as to turn with some friction on the rod.

Referring to Figs. 7 and 8, at *u* there is a hole drilled through the rod Q, and a slot *u'* is cut lengthwise of the rod and extends from the end of the rod to the hole *u*. The thread on the rod Q is cut far enough to allow the piston to screw onto the point where it will entirely close the hole *u*. The tube P is normally filled with glycerin or other liquid, and the piston R is fitted rather loosely to the tube P, so that the glycerin may very slowly leak by it whenever any force is applied to move it up or down in the tube. The glycerin may also leak past the piston by way of the slot *u'* and hole *u* whenever the piston is screwed back so as to leave the hole open, and the amount of leakage may be regulated by setting the piston to close more or less of the hole *u*. On the top of the tube P is a cover *s*, that fits loosely on the rod Q and rests loosely on the top of the tube and serves simply to exclude dust and other foreign substances which would be likely to clog the piston and prevent the movement, which is expected to take place under very slight variation of force. When no electric current is passing through the coil L, the lower end of the rod Q rests on the bottom of the tube or cylinder P, and the rod is of such length that it then holds the core M with its upper end about two-thirds of the way through the spool K from the bottom toward the top.

S is a connecting-rod made of fiber. At its lower end it is pivoted to the upper end of the core M, and at its upper end it is pivoted to the lever G by the pin *m*. The connecting-rod S is made of such length that when the upper end of the core M is two-thirds of the way through the spool K from the bottom toward the top the brushes *n n'* will be in contact with segment 1. If now a current of electricity be sent through the coil L, the action, according to well-known principles, will be a tendency to raise the core M and to bring it to the position where the center of its length coincides with the center of length of the coil, and a sufficiently strong current may be sent through the coil L to cause it to lift the core M against the force of gravity and thus cause the movement of the connecting-rod S and lever G and of the brushes *n n'* along the segments 1 2 3 4, &c. The pin *m* is placed much nearer to the center or fulcrum of the lever G than are the brushes *n n'*, and so a short movement of the core M causes a comparatively wide movement of the brushes over the segments, and the position of the pin *m* on the lever G is such that the magnetic force of the coil L could impel the core M to go farther than it is actually required to go in producing the movement of the brushes *n n'* over the whole range of the segments.

For the accurate working of the device it is found best to arrange it so that the core M has to move but a short distance compared to its length. Experience has shown that when it is arranged to move through a space about equal to one-sixth of its length the force of its movement is almost exactly constant throughout this range, provided a constant voltage is maintained at the two terminals of the coil L. The weight H on the lever G partly counterbalances the weight of the core

M, and it is to be adjusted to such a distance from the center or fulcrum that its upward lift on the core M, combined with the magnetic uplift of the coil L on the core M, will be exactly balanced against the force of gravity when the desired voltage is being maintained at the terminals of the coil L. Under these circumstances the core M and the other moving parts attached thereto would remain indifferently in any position, but a very slight change in the voltage at the terminals of the coil L would destroy the balancing of the forces and determine a movement in one direction or the other. An increase of the voltage would cause an upward movement of the core, and a decrease of the voltage would cause a downward movement of the core.

In order to apply my invention to a dynamo to maintain its voltage constant, it is to be connected to the dynamo in the manner shown in Fig. 1 and also shown in the diagram, Fig. 6.

T is a dynamo having the ordinary well-known shunt-winding on its field-magnets.

t t' are the two main wires leading away from the dynamo to the lamps or motors or other devices that may be operated thereby. These two mains are in connection by wires Y Y' with the two terminals *p p'* of the coil L. One terminal, *r*, of the shunt-winding of the dynamo is connected to the brush *v*, and the other terminal, *r'*, of the shunt-winding is connected to the terminal J of the resistance-wires *f*. The other terminal J' of the resistance-wires *f* is connected by wire W to the main *t'*, and thence to the brush *v'* of the dynamo. The terminal J is in connection with segment 11 and the terminal J' with segment 1, as previously mentioned and as shown in the diagram. The current therefore that charges the field-magnets of the dynamo has to pass through a circuit containing more or less resistance, according to the position of the lever G and brushes *n n'*, for when the brushes *n n'* are on the bottom segment 1 it will be observed that there are two distinct courses for the charging-current to take, viz: One course is through all the resistance-wires and the other is through segment 11, frame D, lever G, stud I, brushes *n n'*, and segment 1 and binding-post J, connected therewith; but as this latter course is one of very low resistance it constitutes a "short circuit" of the resistance-wires, which practically removes all resistance from the circuit. If, however, the brushes *n n'* be on segment 11, the charging-current then has to pass through all of the resistance-wires. In all intermediate positions it is evident that the brushes *n n'* short-circuit whatever portion of the resistance-wires is connected to the segments situated between 11 and the particular segment with which the said brushes may happen to be in contact. As the brushes therefore are moved over the segments from 1 to 11 the resistance in circuit gradually increases from zero to the full amount, and a reverse movement from segment 11 to segment 1 diminishes the resistance from the full amount down to zero.

It is a well-known fact that an electrical resistance introduced into the field-magnet circuit of a dynamo reduces the energy of the field-magnet, and consequently reduces the voltage developed by the dynamo, and on this principle are constructed the well-known field-rheostats which are operated by hand and serve to adjust the voltage of the dynamo to the desired point whenever there are variations due to change of load or of the speed of the machine. These field-rheostats require the services of an attendant whenever they are operated, whereas my invention provides an automatic short-circuiting device for the resistances. Whenever there is a rise of voltage in the main supply-wires *t t'* of the dynamo this acts on the core M, as previously described, and raises it. The rapidity of the movement is checked by the piston R. The new position thus given to the brushes *n n'* causes an increase of the resistance in the field-magnet circuit, as above described, and a corresponding diminution of the charging force applied to the field-magnet, which tends to diminish the rise in voltage, and the movement of the core M upward will continue only until it has introduced enough resistance to render the voltage equal to its first value. It will then remain stationary until some other change occurs—as, for instance, diminution of speed or an increase of load. Then the resulting reduced voltage will cause the core M to move downward slowly until the movement has short-circuited enough of the resistance that was in circuit to check the drop of the voltage and bring it again to its normal value, and thus the apparatus is self-adjusting and keeps the voltage very nearly constant in spite of the variations of speed or of load on the dynamo. The range of adjustment is of course determined by the quantity of resistance-wire in the box. The more resistance-wire there is the wider may be the variations of speed that may be encountered and still maintain constant voltage. The accuracy of my apparatus, or, in other words, its ability to take notice of and to make adjustment for slight changes of voltage, is greatly enhanced by reducing the friction of the working parts to the minimum, and I have therefore devised the present arrangement of the segments and contact-brushes wherein the contact is made on a peripheral surface rather than on an end surface, as is common in rheostats operated by hand. The greater part of the friction in any rheostat is at the contact-surface. A flat end surface requires a greater pressure to secure a good contact than does a convex surface, and a flat end surface also requires a larger diameter of circle in order to secure a given amount of surface on each segment, and it is also found that a contact applied to a convex surface will clear itself better of any dirt or foreign substance that would tend to impair the contact of the metals with each other. These considerations have made it important for me to adopt the plan of peripheral contact described above and shown in the drawings. This form enables me to place a very large number of the contact-segments in a very small circle, thus adapting the apparatus to cover a very wide range and at the same time to be very sensitive to small changes of speed of the dynamo by reason of the small friction of the working parts.

In adapting my apparatus to various dynamos it is found necessary to adjust the amount of leakage past the piston R, so as to secure a greater or less retarding force. The dynamos built by different manufacturers vary widely in the degree of saturation of their field-magnets and consequently in the time that is required to produce a change in their strength when the charging-current is varied by means of a resistance. It is therefore necessary when attaching my apparatus to any dynamo to adjust the amount of leakage past the piston R, and this is done, as before explained, by screwing the piston along the rod Q so as to close the hole u more or less. This varies the retarding force of the piston to any degree needed. If the retarding force is too small, the movement of the core M and of the lever G and contact-brushes or sliders $n\ n'$ will take place so rapidly as to go beyond the segment at which the necessary resistance would be introduced to produce the required adjustment of the field, and might in fact go several segments beyond it before the field of the dynamo would change to the required degree, and then a reverse movement would take place of the core M and lever G and sliders $n\ n'$, which might then go too far the other way, thus producing a useless seesaw movement and a periodical wavering of the voltage above and below the desired point. On the other hand it is desirable to have any change of voltage corrected as quickly as the magnetic characteristics of the field-magnet will allow it to be, and it is therefore important not to make the retarding force of the piston too great. The required adjustment in any case is easily obtained by two or three trials.

I have adopted the improved construction of resistance-coils shown because it enables me to place coils of very high resistance in a small space and thus insures a wide range in apparatus of very compact form. In ordinary rheostats, where coils are stretched openly in air, the heat is radiated only from the surface of the wire itself, but in the present form the coil has the benefit of the whole surface of the pipe as a radiating-surface, and the pipes being placed vertically with both ends open the rise of temperature in them produces a draft of air that rapidly dissipates the heat, and this fact allows of the use of a comparatively fine wire of high resistance without danger of excessive heating. The coil L, which may be termed the "solenoid," is shown in the drawings as having its terminals connected by the wires Y Y′ to the two main wires leading from the terminals of the dynamo at a point near the dynamo.

It is not essential to make the connection near the dynamo, but connection may be made with the mains or with the branches from those mains at some more distant point, the connecting-wires Y Y′ being extended to that point, and since there is always more or less loss of voltage in the wires that lead from a dynamo to the devices for which it is supplying electrical currents it is often advantageous to make the connection for the solenoid at the distant point and thereby cause the dynamo to maintain a constant voltage at the point of consumption in spite of the loss in the line-wires.

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

In combination with a dynamo having a shunt-winding on its field-magnet a rheostat connected in circuit with said shunt-winding, a solenoid electrically connected with the terminals of said dynamo and having a movable iron core arranged and adapted by its magnetic force to operate the arm and slider of said rheostat—an adjustable retarding device consisting of a cylinder, a piston and piston-rod, said piston-rod being attached to said core at one end and at the other end being threaded to receive the piston and having a passage through it which the piston is arranged to close or open according as it is screwed to different positions along the rod, substantially as and for the purpose described.

WM. H. CHAPMAN.

Witnesses:
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A. C. BERRY.