(No Model.) 2 Sheets—Sheet 1.

J. M. BRADFORD.

REGULATOR FOR DYNAMO ELECTRIC MACHINES.

No. 410,663. Patented Sept. 10, 1889.

Fig. 1.

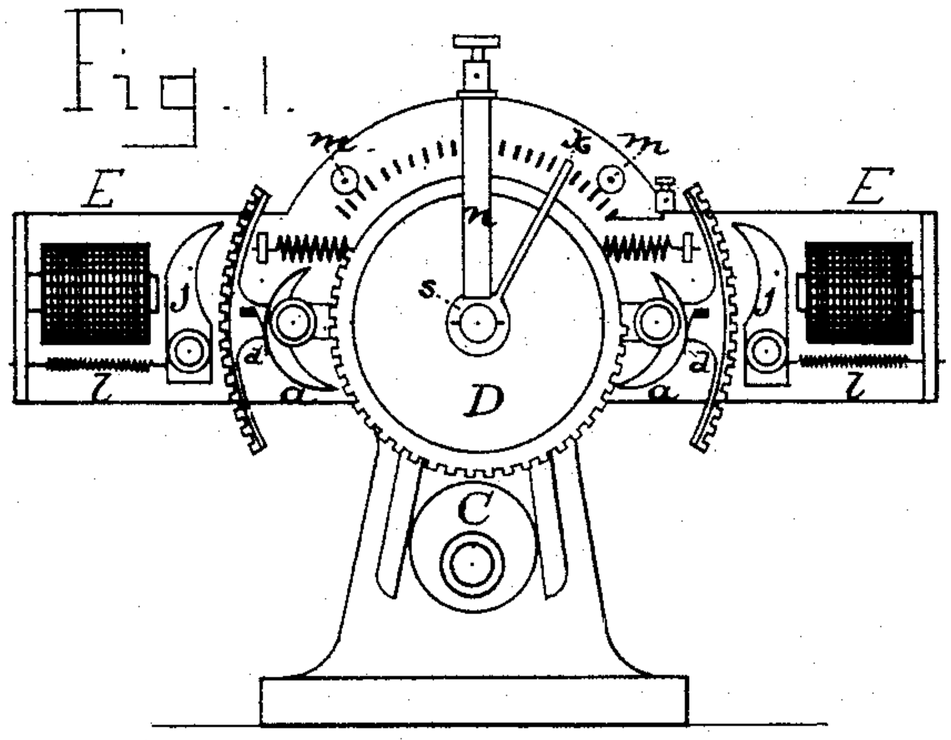


Fig. 2.

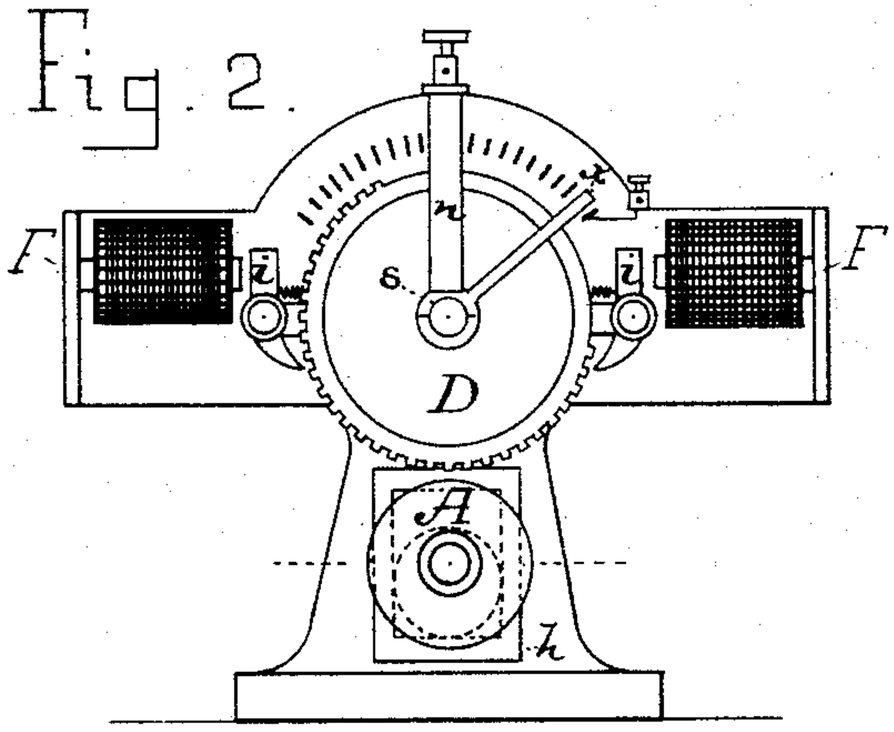


Fig. 3.

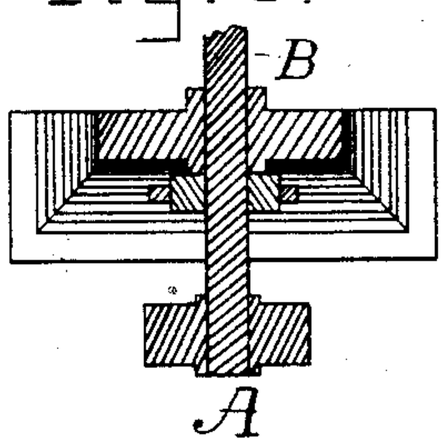


Fig. 4.

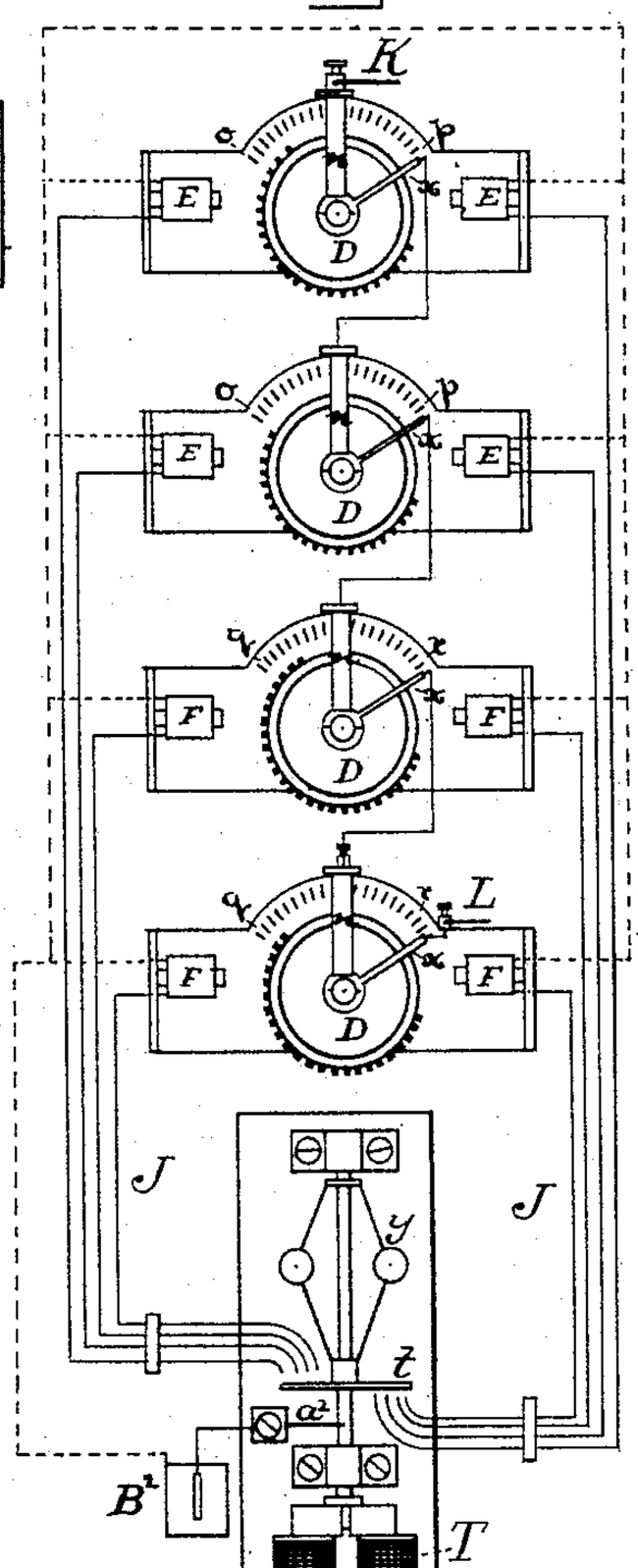
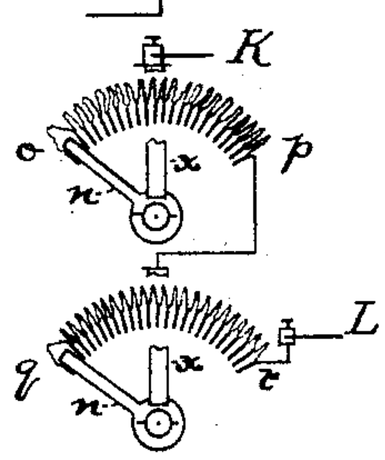


Fig. 5.



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(No Model.) 2 Sheets—Sheet 2.

J. M. BRADFORD.

REGULATOR FOR DYNAMO ELECTRIC MACHINES.

No. 410,663. Patented Sept. 10, 1889.

Fig. 6.

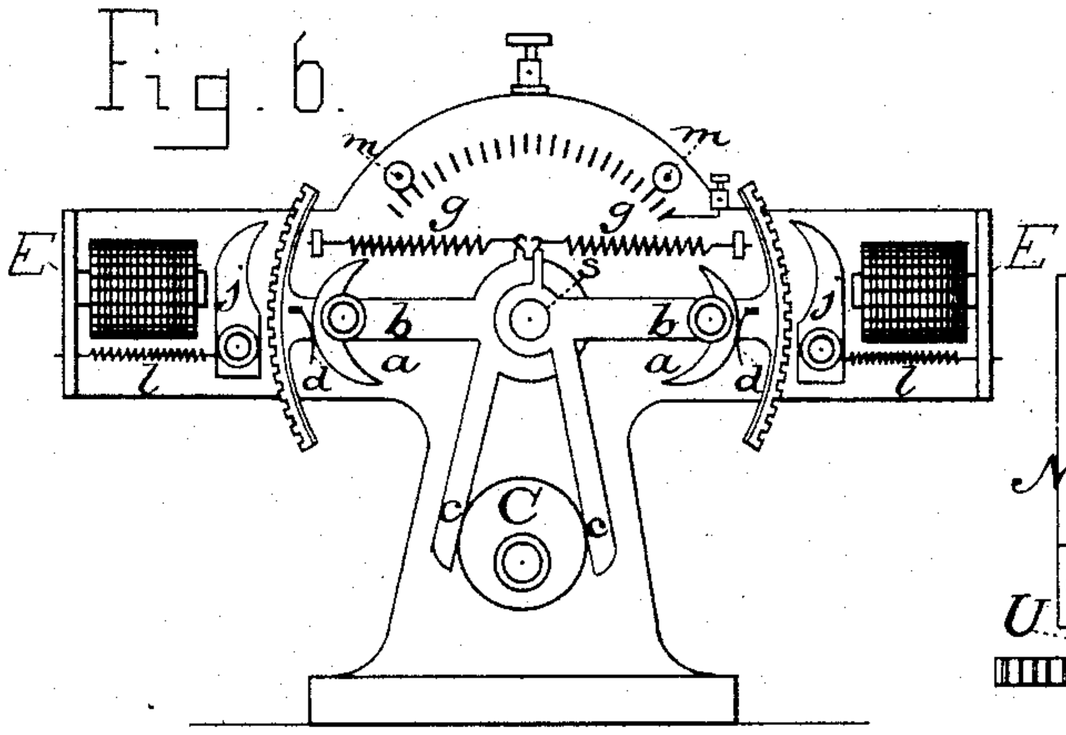


Fig. 8.

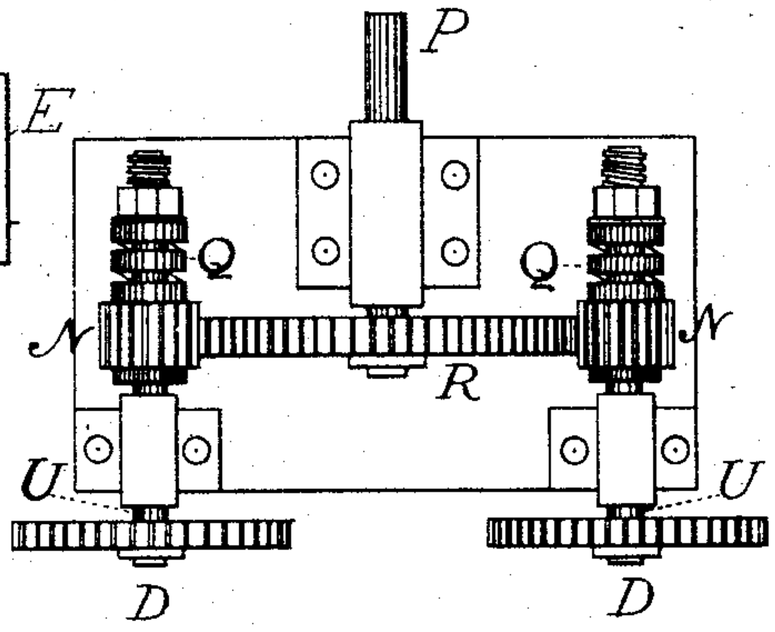


Fig. 7.

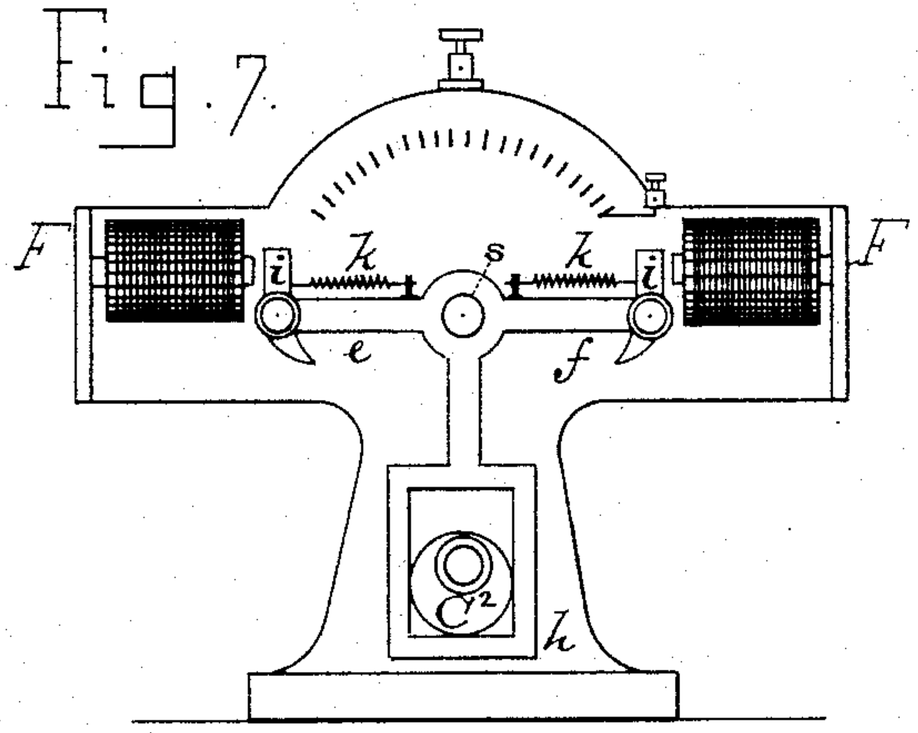


Fig. 9.

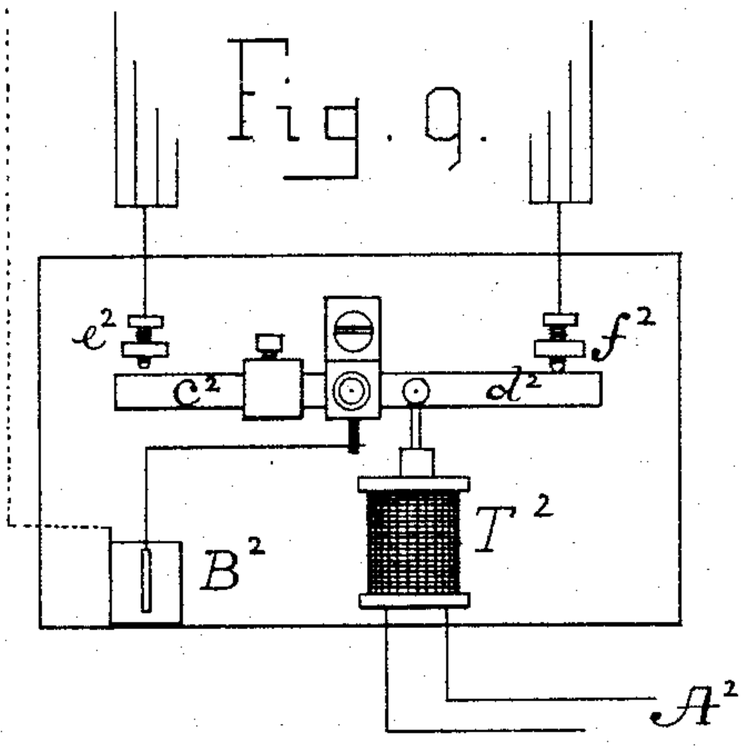
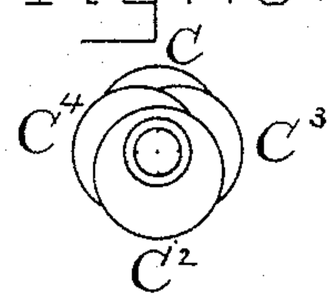


Fig. 10.



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UNITED STATES PATENT OFFICE.

JULIEN M. BRADFORD, OF PORTLAND, MAINE.

REGULATOR FOR DYNAMO-ELECTRIC MACHINES.

SPECIFICATION forming part of Letters Patent No. 410,663, dated September 10, 1889.

Application filed December 27, 1887. Serial No. 259,119. (No model.)

To all whom it may concern:

Be it known that I, JULIEN M. BRADFORD, a citizen of the United States, residing at Portland, in the county of Cumberland and State of Maine, have invented a new and useful Regulating Apparatus for Dynamo-Electric Machines, of which the following is a specification.

This apparatus is designed to maintain the line-current within narrow limits of any required degree of intensity by changing the generative power of the dynamo as often as may be necessary to secure this result. Moreover it acts automatically, changes in the action of the dynamo being primarily induced by the action of current-indicators included in and operated by incipient changes in the line-circuit.

To secure the different kinds of regulation for which this apparatus is intended, it may be used to increase or decrease the resistance offered to the passage of the current feeding the magnetic field of the dynamo, or it may be caused to regulate the dynamo by moving the commutator-brushes.

The salient features of this apparatus include—

First, the employment of a power to work the regulator which is entirely distinct and independent of the controlling-power, the former being obtained from some convenient motor and the latter being engendered by comparatively weak currents applied or withheld from action by current-indicators worked by incipient fluctuations of the line-current, such weak currents being used solely to apply the motive power, making the necessary compensating changes, and not being in any way directly instrumental in supplying force to effect this object.

Second, the use of a stop-motion regulating device controlled by incipient fluctuations of the line-current and operating in such a manner that a regulating movement may be quickly applied, and the point at which this movement is cut off will be dependent upon the duration of the fluctuation.

Third, the use of a reciprocating regulating device that will produce an accumulative or differential effect, according to the action of the line-current indicator, provided two or more of them work in combination and are moved by eccentrics so arranged on the driving-shaft that no two of the current-changers will commence and complete their upward and downward stroke at the same time. An accumulative effect is produced when the line-current indicator, Fig. 4 or 9, closes the circuits of one class only, either for increasing or diminishing the dynamo's action, thereby causing one or more strokes in a single direction to be applied. The differential effect is produced when the indicator closes circuits in quick succession for both increasing and diminishing the action of the dynamo, thereby causing opposite action at the same time, and a differential or intermediate result is ultimately obtained. The accumulative action increases the quickness of the regulator, and the differential action also contributes to the same result by allowing a coarser feed by the pawl without thereby disturbing the potential of the line-current. The extent of effective action within a given time by this arrangement last described is also in proportion to the duration of a fluctuation of intensity of the line-current, and the action of either regulating device is intended to anticipate or prevent strong fluctuation of that current.

Fourth, the use of two separate circuits, one for diminishing and the other for increasing the generative power of the dynamo, the operation of which being such that a continuance of the restraining-power of the regulator is not dependent upon the continuance of the fluctuation of the line-current that primarily caused it to be applied, the restraint being held fixedly at one point, increased, or diminished, according to the state of the line-current.

This apparatus is intended to combine extreme quickness with delicacy of regulation, and is designed for incandescent and arc light circuits, or for other systems of electric distribution.

Of the drawings illustrating this invention, Figure 1 is a front elevation showing the manner of moving the regulating-wheel D by the stop-motion regulating device. Fig. 2 is a front elevation showing the manner of moving the regulating-wheel D by the reciprocating regulating device. Fig. 3 is a section of Fig. 2. Fig. 4 is a front elevation showing

the electrical connections between the regulator and the line-current indicator. Fig. 5 is a diagram showing the path of the current feeding the magnetic field of the dynamo through the regulator. Fig. 6 is a front elevation of Fig. 1 with the regulating-wheel D removed. Fig. 7 is a front elevation of Fig. 2 with the driving-pulley A and the regulating-wheel D removed. Fig. 8 is a plan view showing the means by which the motion of a number of regulating-wheels may be concentrated upon one shaft. Fig. 9 is a front elevation showing a line-current indicator. Fig. 10 is a front elevation of four eccentrics, showing their inclination one to the other as fixed upon the driving-shaft.

In carrying out my invention the regulator may be placed near the dynamo to be controlled and set in motion by connecting pulley A, Figs. 2 and 3, to an available motor, such as the engine working the dynamo. This pulley is joined to the driving-shaft B, the length of which will depend upon the number of regulating-wheels used in any particular case. In Fig. 4 four regulating-wheels are shown, in which case the driving-shaft will carry four eccentrics C C^2 C^3 C^4, Fig. 10, which may be of different sizes or the same size, one being joined to the shaft under each regulating-wheel, and their inclination one to the other may be nearly as shown in the figure. In all cases a movement of the regulating-wheel D, Figs. 1 and 2, is an initial step in controlling the dynamo, and these wheels are moved by regulating devices of two kinds, one of which I call the "stop-motion regulating device" and the other the "reciprocating regulating device."

The regulating-wheels above mentioned have teeth, and in some cases a gap or space may be left uncovered by teeth as a means of limiting the movement of the wheels.

The stop-motion regulating device, Fig. 6, consists of the following parts: the levers *b c* and *b c*, springs *g* and *g*, pawls *a* and *a*, springs *d* and *d*, disengaging-pins *m* and *m*, stop-motion latches *j* and *j*, temporary magnets E and E, and the springs marked *l*. The two levers *b c* are independent of each other and may be moved freely on the stationary shaft *s*, which also supports the regulating-wheel *d* D. The upward motion of the levers is caused by the rotation of the eccentric C and the downward movement by the springs *g*. At each revolution of the eccentric C the levers *b c* are raised slightly to clear the ends of the latches *j*, so that there is a moment at each revolution of the eccentric when these latches may be pulled away from the toothed surface of the levers by a magnet E unimpeded by the friction resulting from the weight of a lever *b c* resting thereon. When a temporary magnet E is excited, the stop-motion latch nearest to it is drawn away from the toothed surface of the lever, causing it to fall and rise with each revolution of the eccentric and the pawl *d* joined to it to move the regulating-wheel D, Fig. 1, by the downward strokes, which are repeated, if one stroke is insufficient, until the magnet liberates the latch, thereby causing the spring *l* to draw it against the toothed surface of the lever, arresting its downward motion, it being next raised by the motion of the eccentric C to its extreme upward limit, the pawl *d* striking against the disengaging-pin *m*, thereby removing it from the teeth of the wheel D.

The levers *b c* are made quite light to lessen the momentum of their downward stroke, and the stop-motion latches may, if necessary, be cushioned beneath their metallic ends with rubber or other suitable substance, so that the effect of the slight impact may be reduced to a nominal figure.

The reciprocating regulating device, Fig. 7, consists of the following parts: a lever *e f h*, loosely supported on the stationary shaft *s*, pawls *i* and *i*, springs *k* and *k*, and the two temporary magnets F. The slotted end of the lever *e f h* incloses the eccentric C^2, the rotation of which imparts a vibrating motion to the lever and to the pawls *i*, which are held away from the regulating-wheel D, Fig. 2, by means of the springs *k;* but should an electric current excite a magnet F the pawl nearest to the excited magnet engages with the teeth of the wheel D, causing it to be moved at each downward stroke, the direction of motion being dependent upon whether a right or a left hand pawl acts upon the wheel.

If the dynamo is to be regulated by feeding the magnetic field with a current of variable intensity, the resistance-conductors and regulating-wheels may be repeated, as shown in Fig. 4.

The regulating devices used to move the regulating-wheels in a given combination will depend upon the kind of regulation wanted, and which combination will give the best results at the least expense must be determined by careful experiment. In some cases a combination of the stop-motion with the reciprocating regulating device may be used, thereby modifying the effect of one by that of the other and securing results not otherwise attainable by the use of one regulating device unaided by the other.

The feeding-current enters the regulator by way of the binding-post K, Fig. 4, thence to the contact-arm *x* by way of the metallic spring *n*, thence through more or less of the resistance-conductors, the ends of which lie between *o p* and *o p*, *q r* and *q r*, and finally leaving the regulator by way of the binding-post L. The strength of this current will therefore vary according to the position given to the arms *x* by the regulating-wheels to which they are attached, the arrangement being such that said feeding-current will be at its maximum when the arms are moved to their extreme limit to the right, as shown in Fig. 4, and at its minimum when at their extreme limit in the opposite direction, as shown in Fig. 5.

The motion of several regulating-wheels may also be concentrated for moving the commutator-brushes or a contact-arm, as last described. In this case the regulating-wheels D are rigidly joined to the shaft U, Fig. 8. Each shaft U carries a pinion N, each of which is held on the shaft by the springs Q. From this arrangement, when one or more of the regulating devices impart motion to the regulating-wheels D in a given direction, the wheel R is moved; but should the regulating devices act oppositely at the same time the pinions N slip on the shafts U, and the motion of the wheel R is stopped. By this arrangement energy of regulating action depends upon the diameter of the eccentrics actuating the regulating devices and the number of strokes communicated thereby within a given time to the regulating-wheels. Weak currents only are required to excite the electromagnets controlling the regulating devices, and strong currents can have no influence whatever in increasing the regulating energy of this apparatus.

When the apparatus regulates by moving the commutator-brushes, the eccentrics and regulating devices may be so proportioned that a single stroke will instantaneously move the regulating-wheel sufficiently to cause the line-current to change from the maximum to the minimum working limit, or the reverse, and this stroke can instantly be cut off at any intermediate point by the stop-motion latch or by differential action. In some cases one side of the eccentrics working the stop-motion regulating devices can be cut away, thereby forming a cam of such shape that the stop-motion devices will drop when liberated unimpeded by the eccentrics. A sufficient number of regulating devices in one combination insures capacity for instantaneous action with a low speed of the driving-shaft by which they are operated.

The shaft P, joined to the wheel R, would be connected directly or by means of suitable gearing to the commutator-brushes or contact-arm.

It has been stated that a movement of the regulating-wheels D was an initial step in regulating the line-current, that motion was imparted to these wheels by the regulating devices, and that the regulating devices were applied or withheld from action by the action or inaction of the temporary magnets forming a part of the regulating mechanism. It now remains to describe the source of the currents for exciting these magnets and the means by which said currents are applied or withheld from action.

A small battery B^2, Fig. 4, or a dynamo-electric machine may be used as a source of the above-mentioned currents, and several different forms of line-current indicators may be used to apply or withhold these currents from action. Fig. 4 shows a small electric engine T, which is worked by a part of the line-current entering by the wires A^2. This engine rotates a centrifugal governor y, causing the disk t to rise and fall with changes in the potential of the line-current. When the potential of the line-current is within the proper mean, the disk t is midway between the upper and lower ends of the wires J. Should the potential of the line-current increase or decline, a succession of circuits are completed through the above-mentioned wires, the current flowing from the battery through the spring a^2 to the disk t and back to the other pole of the battery by a wire, (indicated by the dotted line,) the arrangement being such that the circuits completed by a rise of the disk cause the resistance through which the dynamo's feeding-current passes to be increased, and a fall of this disk completes other circuits, causing an opposite result.

Instead of adjusting the apparatus so that the circuits will be closed in succession, as above described, the ends of the wires J, which in practice will consist of adjustable screws, may be so arranged that the circuits may be closed at once, as shown in Fig. 9, and although all the circuits for either increasing or diminishing the action of the dynamo may be closed at once the regulating devices will act in succession, because they rise and fall at different intervals, owing to the adjustment of the eccentrics which move them.

In the current-indicator shown in Fig. 9 the helix T^2 receives a current from the line-circuit, causing the lever c^2 d^2 to be moved more or less, according to the strength of the current. If the lever touches the screw e^2, all of the circuits for restraining the action of the dynamo are closed at once, and if the screw f^2 is touched the other circuits for producing an opposite result are closed, thereby causing a succession of changes to take place as the eccentrics move into the right position to cause this result.

Besides the above-described line-current indicators, one may be used in which a part of the line-current heats a conductor through which it passes, thereby causing expansion, which, with contraction, may be used to make and break circuits for the regulating devices.

Having described my invention, I claim as new and desire to secure by Letters Patent—

1. The combination, with a dynamo-electric machine, of two stop-motion regulating devices, electric circuits for controlling said regulating devices, a line-current indicator and two regulating-wheels for controlling the dynamo, and two eccentrics arranged on the driving-shaft for obtaining accumulative and differential action, substantially as described.

2. The combination, with a dynamo-electric machine, of two regulating devices, electric circuits for controlling said regulating devices, a line-current indicator, two contact-arms, a series of resistance-conductors, and two regulating-wheels for moving the contact-arms over the resistance-conductors, and two

eccentrics arranged on the driving-shaft for obtaining accumulative and differential action, substantially as set forth.

3. In a circuit-regulator arranged to variably increase or decrease the action of a dynamo-electric machine, and in which a strong increase or decrease of the line-current is not necessary to produce variable action, the combination of a line-current indicator, two or more regulating devices, and electric circuits for controlling said regulating devices, eccentrics for operating the regulating devices, and regulating-wheels for controlling the dynamo in such a manner that its generative power may remain stationary or be diminished or increased, substantially as set forth.

4. The combination, with a dynamo-electric machine, of two regulating devices, electric circuits for controlling the regulating devices, a line-current indicator and two regulating-wheels for controlling the dynamo, and two eccentrics arranged on the driving-shaft for obtaining accumulative and differential action, substantially as described.

5. The combination of an oscillating lever *b c*, spring *g*, pawl *a*, stop-motion latch *j*, temporary magnet E, spring *l*, and disengaging-pin *m* with the wheel D, for regulating a dynamo-electric machine, substantially as set forth.

6. The combination, with two or more regulating devices and a driving-shaft carrying eccentrics for actuating said regulating devices, of two or more regulating-wheels for transmitting the action of the regulating devices through intermediate gearing to a shaft regulating a dynamo-electric machine, substantially as described.

7. The combination, with two or more regulating devices and a driving-shaft carrying eccentrics for operating said regulating devices, of two or more regulating-wheels carrying pinions held thereto in such a manner that they may turn with said wheels when the regulating devices act in concert to concentrate action, accumulating according to the operation of regulating devices, and slip without turning with said wheels when the regulating devices act in opposition for concentrating differential action, substantially as described.

8. The combination of a driving-shaft, eccentrics on said shaft, two toothed levers, each carrying a pawl, the regulating-wheels, two stop-motion latches, each having an electro-magnet and a spring to actuate it, two circuits, and a line-current indicator, substantially as described.

9. The combination of one or more toothed regulating-wheels, each having an untoothed gap or space, one or more regulating devices to move the regulating-wheels to the right or left to an extent that will be limited by their untoothed spaces, electric circuits, and a line-current indicator, substantially as described.

10. The combination of a driving-shaft carrying eccentrics, levers oscillated by said shaft, pawls carried by said levers, regulating-wheels and gearing for controlling a dynamo-electric machine, and stop-motion latches actuated by electro-magnets through changes in the intensity of the line-current to cut off the stroke of said levers at different points, substantially as described.

JULIEN M. BRADFORD.

Witnesses:
H. M. BRADFORD,
A. T. NOYES.

Corrections in Letters Patent No. 410,663.

It is hereby certified that in Letters Patent No. 410,663, granted September 10, 1889, upon the application of Julien M. Bradford, of Portland, Maine, for an improvement in "Regulators for Dynamo-Electric Machines," errors appear in the printed specification requiring correction, as follows: In lines 54–55, page 1, the compound word "current-changers," should read *regulating devices*, and in line 5, page 3, the word "shaft" should read *shafts;* and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed, countersigned, and sealed this 8th day of October, A. D. 1889.

[SEAL.]

CYRUS BUSSEY,
Assistant Secretary of the Interior.

Countersigned:

ROBERT J. FISHER,
Acting Commissioner of Patents.