No. 238,315. PATENTED MAR. 1, 1881.

E. THOMSON & E. J. HOUSTON.

CURRENT REGULATOR FOR DYNAMO ELECTRIC MACHINES.

NO MODEL. 2 SHEETS—SHEET 1.

FIG. 1.

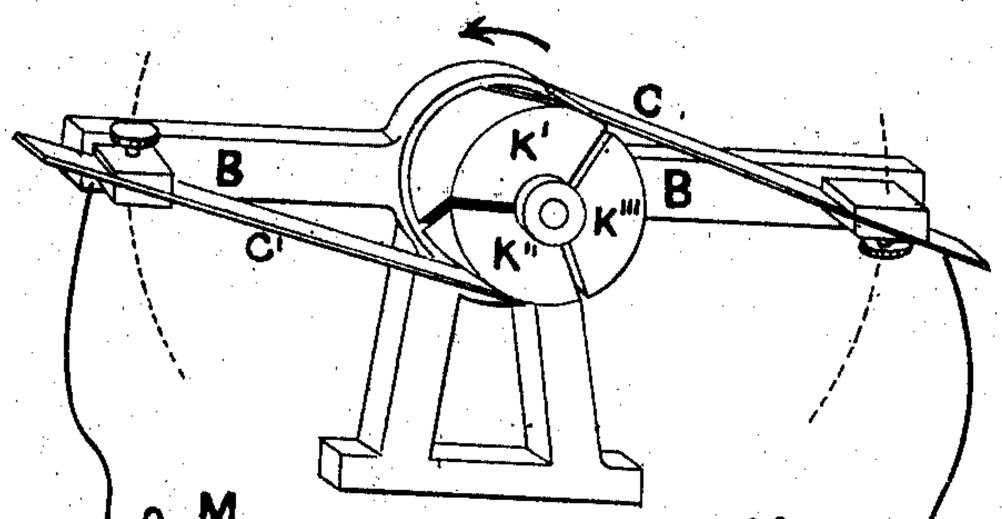



FIG. 2.

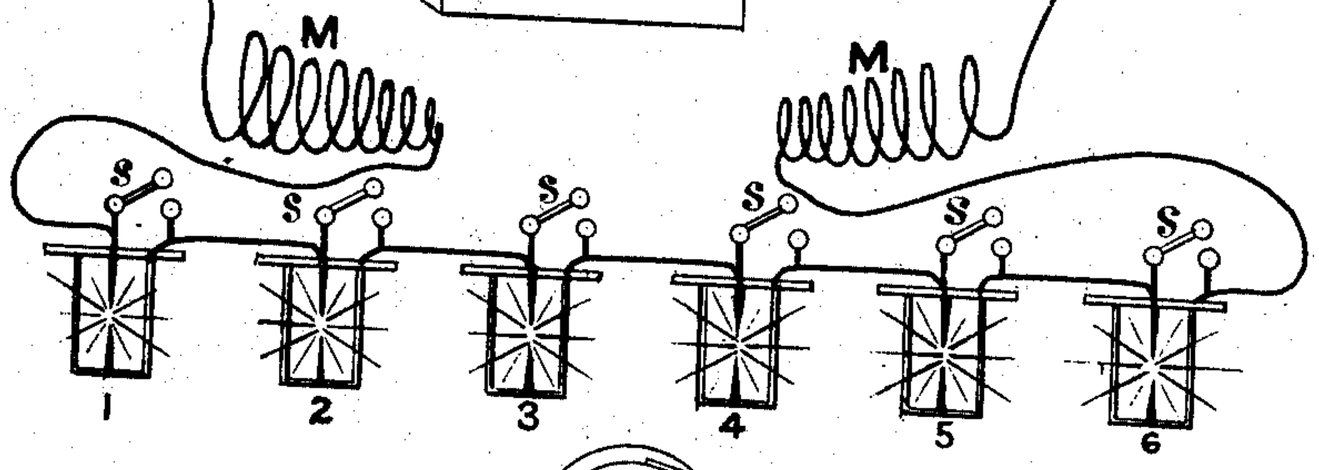
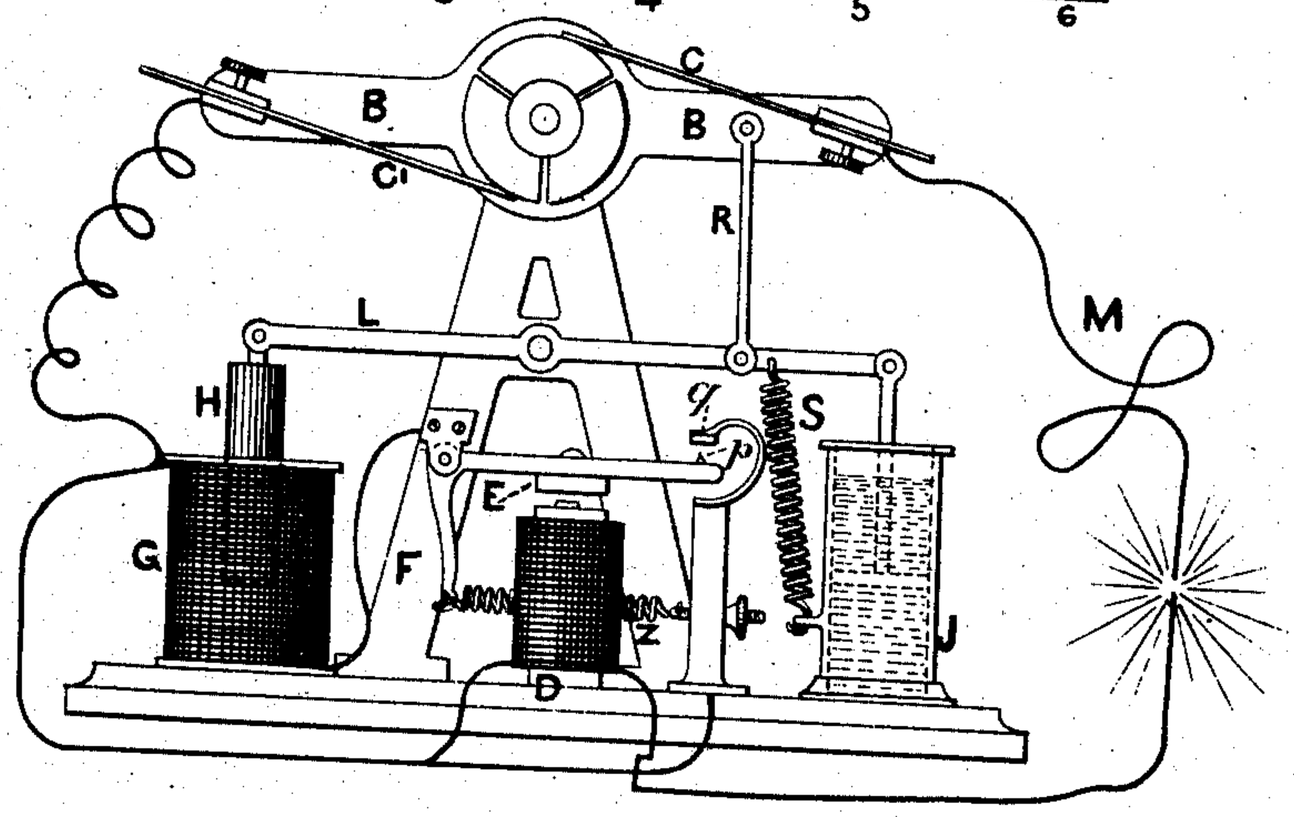
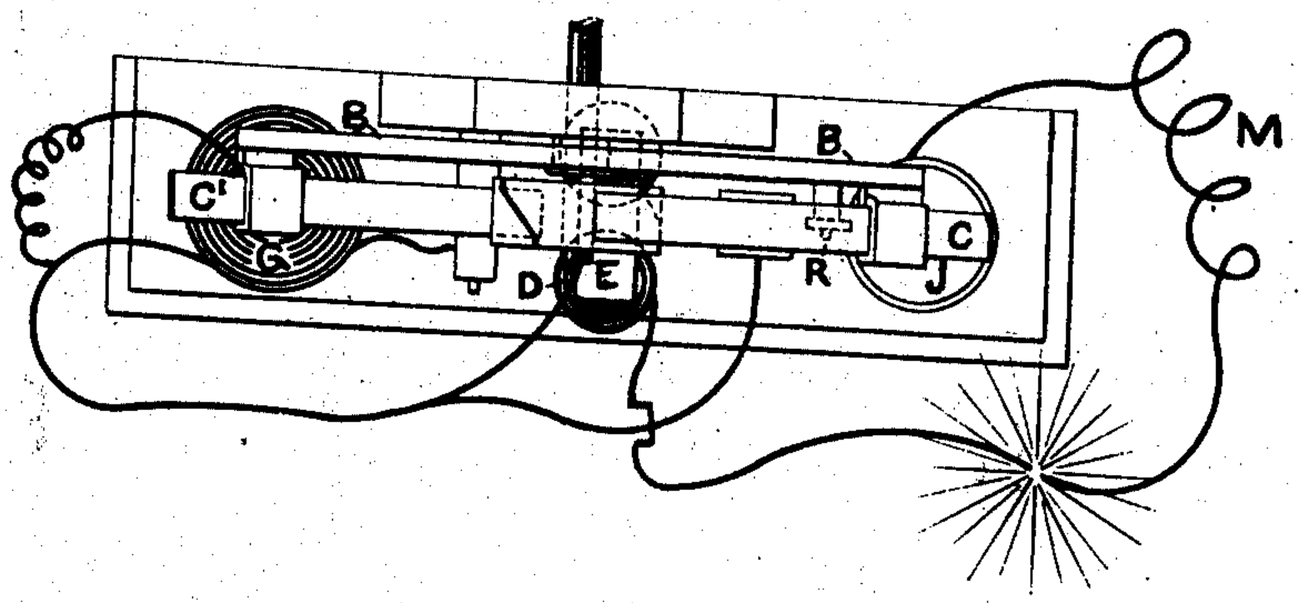



FIG. 3.

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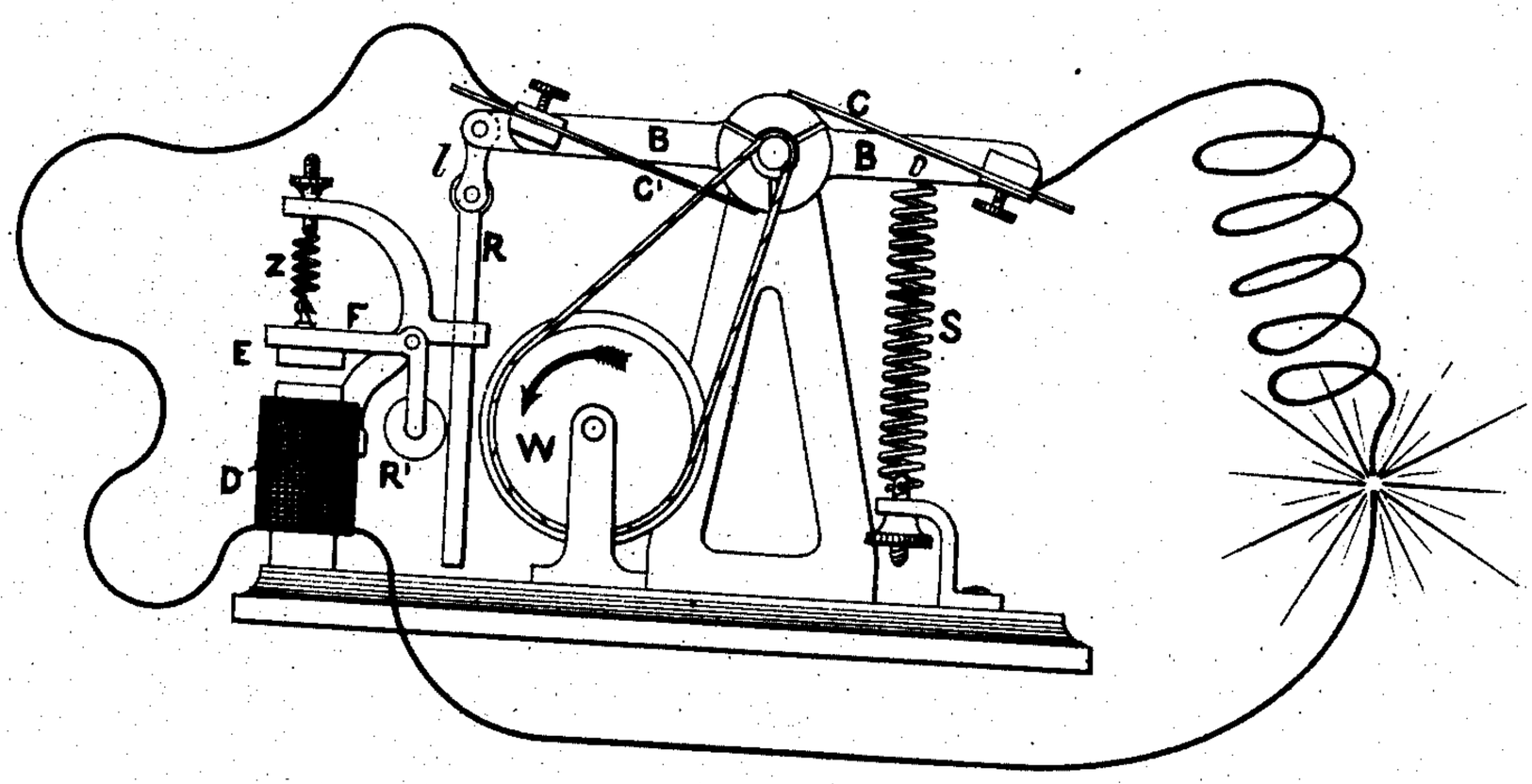
CURRENT REGULATOR FOR DYNAMO ELECTRIC MACHINES.

NO MODEL.

2 SHEETS—SHEET 2.

FIG. 5.

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# UNITED STATES PATENT OFFICE.

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## CURRENT-REGULATOR FOR DYNAMO-ELECTRIC MACHINES.

SPECIFICATION forming part of Letters Patent No. 238,315, dated March 1, 1881.

Application filed June 26, 1880. (No model.)

*To all whom it may concern:*

Be it known that we, ELIHU THOMSON and EDWIN J. HOUSTON, both of the city and county of Philadelphia, Pennsylvania, have jointly invented certain new and useful Improvements in the Regulation of Electric Currents Developed by a Dynamo-Electric Machine by a Movement of its Commutator-Brushes, of which the following is such a description as will enable those skilled in the art to make and use the same.

The object of our invention is to provide improved means for controlling automatically the strength of an electric current flowing over a circuit composed of a dynamo-electric machine and one or more electric lamps, or other appliances through which the current passes, and to obtain said control without the introduction of resistances as such, and without varying the speed or field of the dynamo-electric machine, and at the same time, if desired, to utilize the reaction principle for the magnetization of said dynamo-electric machine—or, in other words, to cause the current generated to pass through the field-magnet coils. We accomplish these results at the same time that the power expended to drive the dynamo-electric machine varies directly in accordance with the changed resistance of its circuit, being less as the resistance is less, and greater as the resistance is greater.

Let us suppose, for the purpose of elucidating the principles of our invention, a dynamo-electric machine running at a constant speed and having in its circuit twelve lamps of the arc type, the current from the machine passing successively through all the lamps and through the field-magnets of the machine. If the electrical resistance of the circuit remains uniform the current will remain uniform. Let now half of the lamps be removed from the circuit by switching around them in the ordinary manner. The resistance of the circuit being thus rendered much less than before, the current produced will be greatly increased, increasing the intensity of the light from the remaining six lamps, throwing a great strain upon the motive power, caused by the increased current due to the circuit being of small resistance and giving rise to heating of the wire coils of the machine and other disadvantages. If all the lamps but one be cut out of the circuit these disadvantageous effects are enormously intensified from the machine running on an almost short circuit. Yet, in practice, it is often desirable to reduce the light-giving capacity of a machine, so as either to diminish the amount of light given out in each lamp or to reduce the number of lamps in the circuit. The latter result has heretofore been accomplished by the introduction into the circuit, in place of the unused lamps, of equivalent resistances of iron wire, or the like, or by modifying the speed of the machine, or by changing the field-magnet circuit or the current traversing it. The first method, or that of resistance substitution, requires that the same power be expended whether all or but few of the lights be used. The second method is impracticable for continuous running, while the third involves special construction of the machine, or the use of apparatus which greatly complicates the working and requires frequent adjustment of the commutator to be made to avoid short-circuiting.

In the improved system of operation provided by our present invention we possess the ability to cut out lamp after lamp from circuit, and yet maintain a uniform current strength in the remaining lamps and economy of motive power proportional to the diminished resistance, while the normal light-giving power of each lamp not cut out is maintained, and an absence of heating or necessity for any other adjustments than those at the commutator of the machine obviated. These adjustments are preferably made automatic, for we find that with the commutator used by us, as herein specified, a proper adjustment of the commutator being effected when a certain resistance is in circuit, a similar adjustment will, when the resistance is changed, give the same current. In our system we have employed a dynamo-electric machine in which the commutator is constructed of three insulated segments of a ring connected to three armature-coils. The collecting-brushes applied to said commutator are supported so as to be movable around the commutator without changing the relative positions of the two collectors. This movement

of the collecting-brushes is well known in the art.

Figure 1 shows a commutator consisting of three insulated segments, K′, K″, and K‴, and supposedly attached to the armature-coils in accordance with our former inventions. Bearing upon the commutator-segments, and parallel and opposite to each other, are two strips of metal, C C′, for conducting off the current from the segments, and called "commutator collecting-brushes." The slot between or separating two segments, K′ K″, is made at an oblique angle, as shown. When the two ends of a slot are angularly displaced with respect to each other twenty to thirty degrees circumferentially around the commutator, a single pair of collecting-brushes are used, the planes of which are tangent to the circumference of the commutator at opposite points and parallel to each other, as before stated. These collecting-brushes are supported on a bar, B B, Fig. 1, moving concentrically with the center of the commutator, and enabling the collectors C C′ to be placed in different positions relatively to the commutator-segments while still remaining in the same positions relatively to each other. The ends of the bar B B describe the arcs shown in the dotted lines. The supposed direction of revolution of the commutator is shown by the arrow. The collectors C C′ are mounted so as to be insulated from each other, and the current discharged into said collectors from the armature-coils and segments K′, K″, and K‴, attached to them, passes from said collectors to the coils of field-magnets of the machine, (indicated by M M,) and thence also into the circuit of the lamps, six of which are indicated as 1, 2, 3, 4, 5, and 6. At each lamp is placed a switch, *s*, by which any of them may be shunted around or cut out of the circuit. When the six lamps are being used the collectors C C′ are adjusted to the proper position as to absence of spark and other irregularities, and to carry off the current of the normal working strength. Supposing now that three of the switches be closed, so as to remove half the number of lamps, a movement of the commutator-collectors C C′ forward in the direction of revolution of the commutator restores the current to its former working strength, and, even though all the lamps but one be switched from the circuit, we find that a similar movement may be given to the collectors, and that they may be set in such position as to discharge into the circuit a current of only the normal working strength. Any number of lamps in circuit may thus be put out of use and a position of the commutator-collectors found which will restore the normal current strength.

We are aware that in the operation of commutators of the Pacinotti type, such as the Gramme, Siemens, and the like, where the coils on the armature are numerous and connected in closed circuit end to end, a movement forward or backward of the commutator collecting-brushes around said commutator from the position of maximum effect, or the position when the commuator-segments that are simultaneously in contact with a collecting-brush, are of equal potential results in decreased current; but the variation of the current so obtained is attended with damaging short-circuiting of the coils of the armature—a fact well known in the operation of such commutators when the position of equal potential mentioned is not maintained. In our system short-circuiting of the armature-coils is prevented.

Where the amount of separation of the carbon electrodes or length of arc of the lamps used in our system varies with the current strength, increasing and decreasing therewith, we are enabled, simply by changing the position of the commutator collecting-brushes, to vary the amount of current passing through the lamps, and hence their light-giving power. In practice, therefore, by a simple movement of the commutator-collectors C C′, we are enabled to turn up or down the lights in the circuit. A motion in the direction of revolution, or in the direction of the arrow, Fig. 1, diminishes the current-producing power of the machine, while motion in the opposite direction increases it. These results are accomplished with a consumption of power depending on the electro-motive force of the current produced and without short-circuiting any of the armature-coils. We are not aware that these results, unattended by injurious effects, such as waste of power and short-circuiting, have ever before been realized.

The principle upon which our system is founded is substantially as follows: During revolution the commutator-segments have positions one hundred and eighty degrees from each other, of maximum positive and maximum negative polarity respectively. When the collectors C C′ are set for the normal current with the total number of lamps in circuit, the segments K′ K″ K‴ will break contact with the collectors C C′ shortly after passing their positions of maximum electro-motive force. On removing some of the lamps from the circuit the current is increased, but may be restored to its normal strength by placing the commutator-collectors C C′ in such position that segments are in contact with them when the electro-motive force is below its maximum, this being accomplished by moving the collectors forward in the direction of revolution. The ability to so vary the electro-motive force by a simple motion forward of the commutator-collectors in an armature-coil system with three branches results from the fact that for the major part of the revolution but two armature-coils and their corresponding segments, as K′ and K″, are in connection with said brushes, the electro-motive force of the current produced in the armature being, when both armature-coils—as those attached to K′ and K″, respectively—are acting in the same direction to produce current, the sum of their

electro-motive forces, and when they are acting oppositely to each other, as when the commutator-brushes are placed far forward in the direction of revolution, the difference of their electro-motive forces. In this latter case the segment, as K′, may leave the collecting-brush C, even after the armature-coil to one terminal of which said segment is attached has passed beyond the neutral point, the current in said coil being prevented from reversing at the neutral point by the superior electro-motive force of the other armature-coil with which, for the time, it is conjointly acting, as that armature-coil one terminal of which is attached to K″. The moments when all three segments and their corresponding armature-coils are simultaneously in direct contact with the collecting-brushes correspond to the times when either of the collecting-brushes C C′ is over a slot between any two segments. At this moment a transfer of the current takes place from the coil and segment, leaving the commutator-brush to the succeeding-coil and segment coming into contact therewith, which transfer is repeated at every slot in the commutator. This transfer occupies an appreciable time, and the current produced is due to the resultant action between the coils in their maximum position operating in conjunction with coils that have either passed or have not attained that position when in circuit with the collectors C C′.

We have hereinbefore described our method of regulating the strength of the current traversing the circuit by a movement of the commutator collecting-brushes, so that whatever be the number of lamps in the circuit, up to the maximum, the normal current strength may be obtained; but as in practice the lamps are generally at a distance from the dynamo-electric machine furnishing the current, and as the switching out of circuit of one or more of the lamps would necessitate an adjustment of the commutator-brushes, as before described, we prefer to effect said adjustment automatically and without the introduction of resistance-coils, and maintain, notwithstanding changes in the number of lamps used upon the circuit, a practically uniform current strength without requiring the attendance of the operator. We find in practice, moreover, that we obtain with this automatic regulation of the current strength an independence of speed-variations in the machine, it being only necessary to so adjust the speed of running that when the speed is at its lowest the machine shall yet be sufficient in power to maintain the number of lights placed in its circuits. We are therefore able to operate successfully under conditions of motive-power variations that have hitherto been recognized as fatal to steadiness of light obtained.

In United States Patent No. 223,659, January 20, 1880, before referred to, we have described a means of automatically adjusting the commutator-collectors of dynamo-electric machines, which method is adaptable to the present case of current regulation. When a single pair of commutator-collectors, C C′, are employed with an inclined or angularly-slotted commutator, as hereinbefore mentioned, the current of the machine is caused to traverse an electro-magnet, the variations in the power of which current and magnet either directly or indirectly serve to effect the adjustment of the commutator-collectors with or without centrifugal regulation in a similar way to that shown and described in Patent No. 223,659, before referred to. The regulation of the current strength is readily obtained by causing the main current of the machine, or a shunted portion thereof, to traverse an electro-magnetic controlling device, operating to throw into or out of action an electro-magnet or equivalent motor device, which, in turn, imparts motion to the commutator collecting-brushes. As in our former invention, already referred to, the motor device used may be adapted to move by the current, or by the motive power, or by suitable clock-work, or other mechanism adapted to be thrown in or out of action by an electro-magnet, and constitutes, as before, a minor feature of our present system. Our present method of operating, therefore, so far as it relates to automatic regulation, is based upon the same principles of operation as our previous invention; and it consists in an improved construction and mode of use of the apparatus employed in Patent No. 223,659.

In Fig. 2 the direct current of the machine is conveyed through the coils of the electro-magnet D, placed in the circuit of the machine at any convenient point. Its armature E is suitably supported so as to be movable to and from the electro-magnet, as by the lever F, and held away from the magnet by an adjustable spring, Z. Two contact-pieces, *p q*, are provided, adapted to be closed or opened by movements of the lever F, due to variations in the power of the electro-magnet D following changes in the current. The contact-pieces *p q* serve as a shunt of small resistance or short circuit around an electro-magnetic coil, G, provided with a movable core, H, suitably supported in the axis of the coil. The core H is hung upon a lever, L, connected by a rod, R, with the swinging bar B B of the commutator collecting-brushes, a dash-pot, J, being provided to prevent too sudden and violent motions of the lever. Variations in the magnetic pull of the coil G upon its iron core H, opposed by the action of spring S, or equivalent counterbalance-weight, imparts motions to said core, which motions are, in turn, imparted by the rod R to the supports of the commutator collecting-brushes C C′, thus varying their position with respect to the segments of the commutator.

The mode of operation is substantially as follows: The cutting out of one or more lamps from the circuit of the machine, or an increase in the speed of rotation of the latter, causes a corresponding increase in the current traversing

the circuit of which the coils of the electro-magnet D form a part, and a necessity for readjustment of the commutator-brushes to prevent a continued increased current and sparks at the commutator. The increased attraction upon the armature E, opposed by the spring Z, opens the contacts *p q*, diverting the current of the machine through the coil G, which, in attracting its core H, readjusts the collecting-brushes C C, thus bringing the current strength again to the normal, at which moment the armature E is released by the magnet D, and the contacts *p q* are again closed, and are ready to allow the same action to be repeated on a further increase of current strength. On the decrease in the current strength, due to any cause, the armature E not being attracted sufficiently to open the contacts *p q*, the current is diverted through them from the coil G, which, failing to attract its core H, a counteracting-spring, S, moves the commutator-collectors C C', so as to increase the current or raise it to the normal. A dash-pot, J, with oil or glycerine, prevents violent motions of the lever L, and during normal action a sufficient number of makes and breaks at the contacts *p q* occur to maintain the current at its proper strength, and the collectors C C' in their proper position to maintain that strength and avoid injurious burning. An automatic readjustment of position is thus made to follow every removal of a lamp from or introduction into the circuit.

Fig. 3 is a plan of the parts shown in Fig. 2, the parts visible in said plan being designated by similar letters to those in Fig. 2, as described.

In Fig. 2 the various parts are shown as occupying positions separate from one another; but in practice we sometimes combine the motor-coil G and core H, with the rod R, dash-pot J, and spring S, into a single compact device. This combined device forms the subject of a separate application for Letters Patent.

The magnet D and armature E, Fig. 2, instead of acting to open and close contacts *p q*, may serve to throw in or out of action a mechanical motor device by movements imparted to a friction-clutch or its equivalent. In this case the power which moves the commutator-collectors or brushes is obtained either directly from the rotary motion of the machine, or by clock-work or other suitable mechanism thrown in or out of action by variations in the strength of the current traversing the magnet D. As a type of this modified use of the controlling electro-magnet D we refer to Fig. 5. The coils of the electro-magnet D are, as before, placed in any convenient part of the circuit of the machine. The armature E is mounted upon a lever, F, suitably supported and free to move. The lever F bears a roller, R', against which hangs the rod R, attached to the swinging support B B of the commutators. Held by a spring, Z, away from the magnet D, the armature E is free to respond to variations of its attraction. The rod R is suitably guided and attached to B B by a double joint or link. A wheel or roller, W, rotated in the direction of the arrow by any suitable means, is placed at a small interval from the rod R, as shown, so that the rod R is almost a tangent thereto. A band of rubber preferably surrounds the edge of the wheel W. The remaining parts, S, B B, and C C', are as in Fig. 2, and serve the same functions.

The operation is essentially as follows: On an abnormal increase of the current strength the magnet D attracts its armature E, and so moves the lever F as to throw the rod R against the periphery of the rotating wheel W. The friction of the wheel W upon the rod R so produced results in a movement of the rod R and the parts to which it is attached against the elastic force of the spring S, resulting in a readjustment of the collectors C C', as hereinbefore described. A corresponding decrease in the current strength, and release of the armature E, the rod R being thrown out of frictional contact with the wheel W by the spring Z, is followed by a readjustment in the contrary direction by the action of the spring S. In practice, a position of equilibrium is soon attained between the counteracting influences, such as to maintain the current at a practically normal working strength.

We claim—

1. In a current-regulator for a dynamo-electric machine, the combination of a device responding to changes in the main or generated current, a shifting commutator for said machine, and mechanism controlled by said responsive device to shift the commutator to those positions where the current taken up by said commutator shall be constant.

2. In a current-regulator for a dynamo-electric machine, an electro-magnetic device acted upon by variations in the main or generated current, an adjustable or shifting commutator for the machine, and mechanism controlled by said electro-magnetic device to adjust the commutator to those positions where the main or generated current taken up by said commutator shall be constant.

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EDWIN J. HOUSTON.

Witnesses:
FREDK. F. CHRISTINE,
GEO. I. RICHE.

Correction in Letters Patent No. 238,315.

It is hereby certified that in Letters Patent No. 238,315, granted March 1, 1881, upon the application of Elihu Thomson and Edwin J. Houston, of Philadelphia, Pennsylvania, for an improvement in "Current Regulators for Dynamo-electric Machines," an error appears requiring correction as follows: The drawings forming a part of said patent should have been corrected, as directed by the patentees in an amendment and drawing duly filed before the issue of the patent, by erasing the short line showing connection of the electro-magnet D with line running to the brush C′ and connected instead to wire leading from magnet G; that with such correction, figures 2 and 3 of the drawings would have appeared as upon the sheet hereto attached marked 3; and that the drawings and the patent should be read as herein set forth to make the same conform to the record of the case in the Patent Office.

Signed, countersigned, and sealed this 9th day of October, A. D. 1883.

[SEAL.]

M. L. JOSLYN,
*Acting Secretary of the Interior.*

Countersigned:

E. M. MARBLE,
*Commissioner of Patents.*