(No Model.) 2 Sheets—Sheet 1.

E. THOMSON.

ELECTRIC CURRENT REGULATOR.

No. 271,948. Patented Feb. 6, 1883.

Fig. 1.

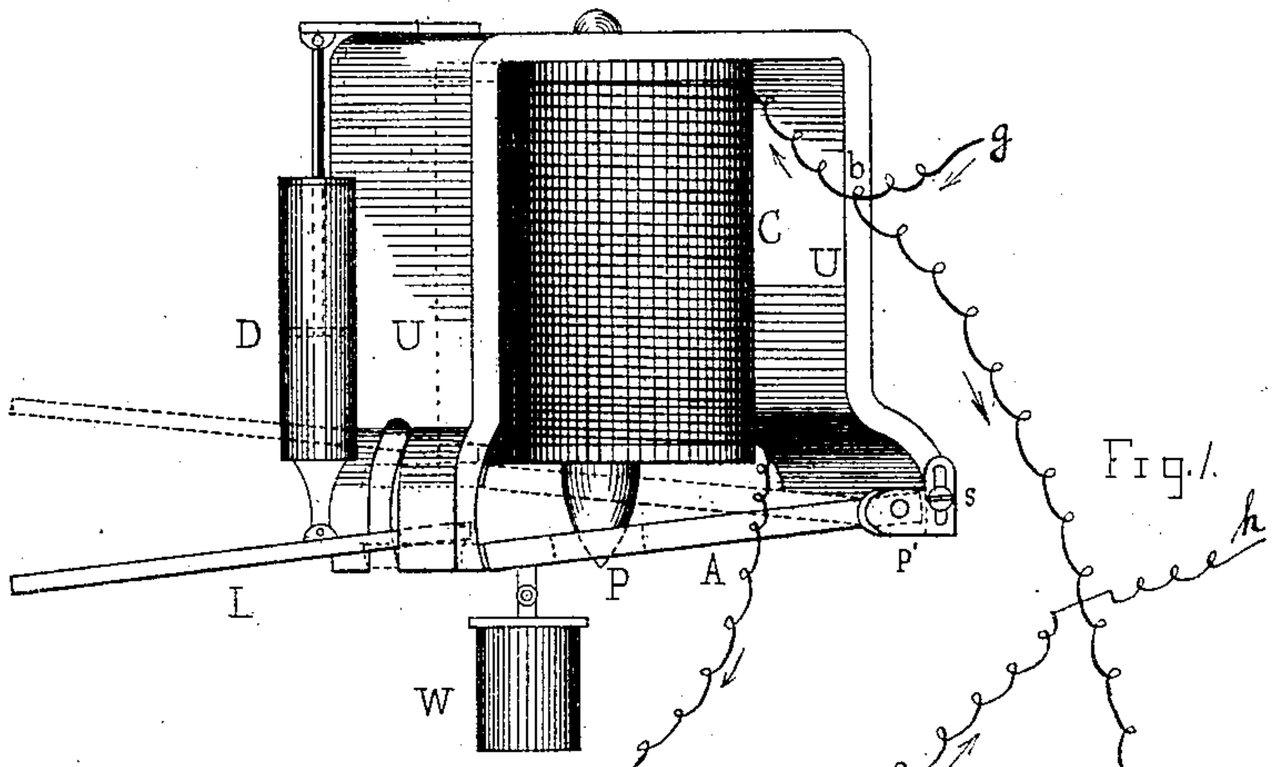
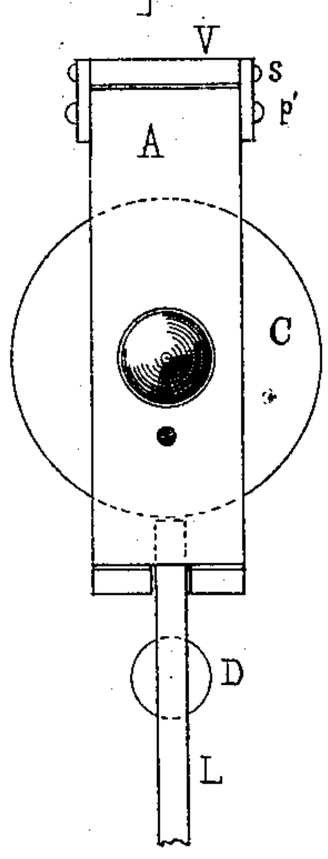


Fig. 2.



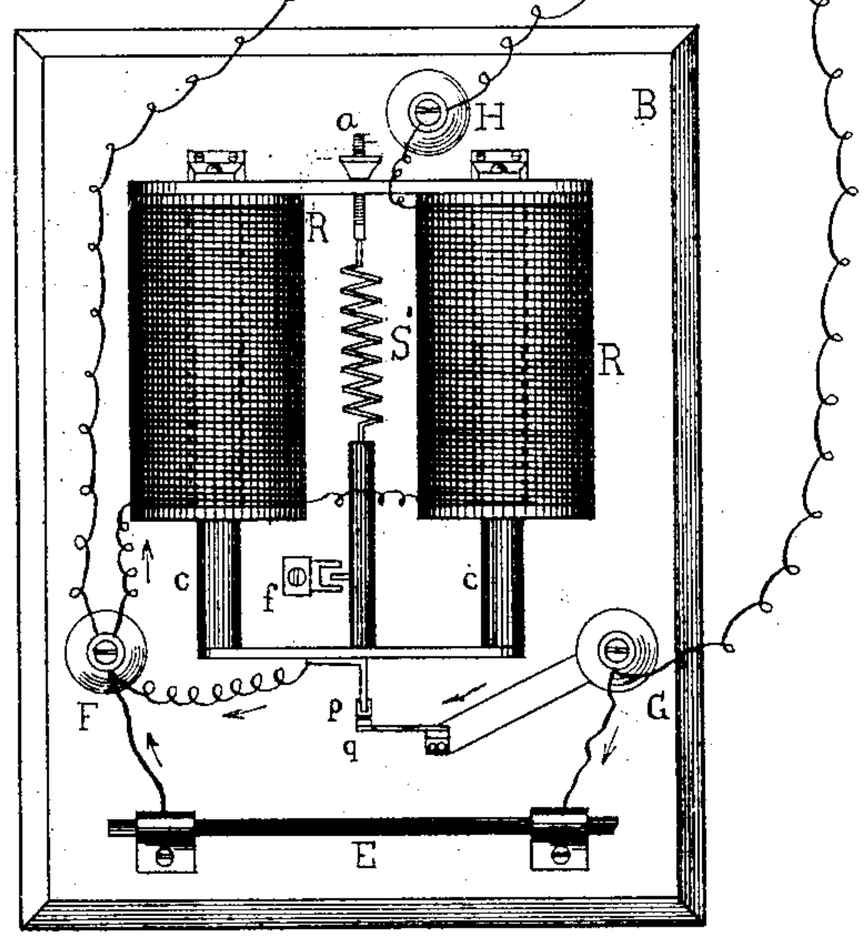
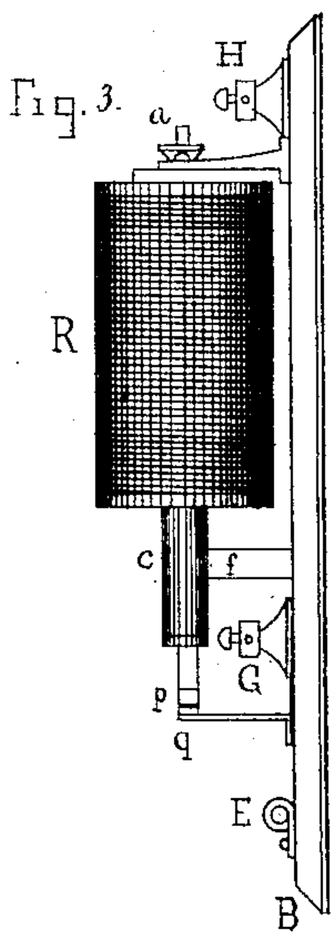


Fig. 3.



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(No Model.) 2 Sheets—Sheet 2.

E. THOMSON.

ELECTRIC CURRENT REGULATOR.

No. 271,948. Patented Feb. 6, 1883.

Fig. 4.

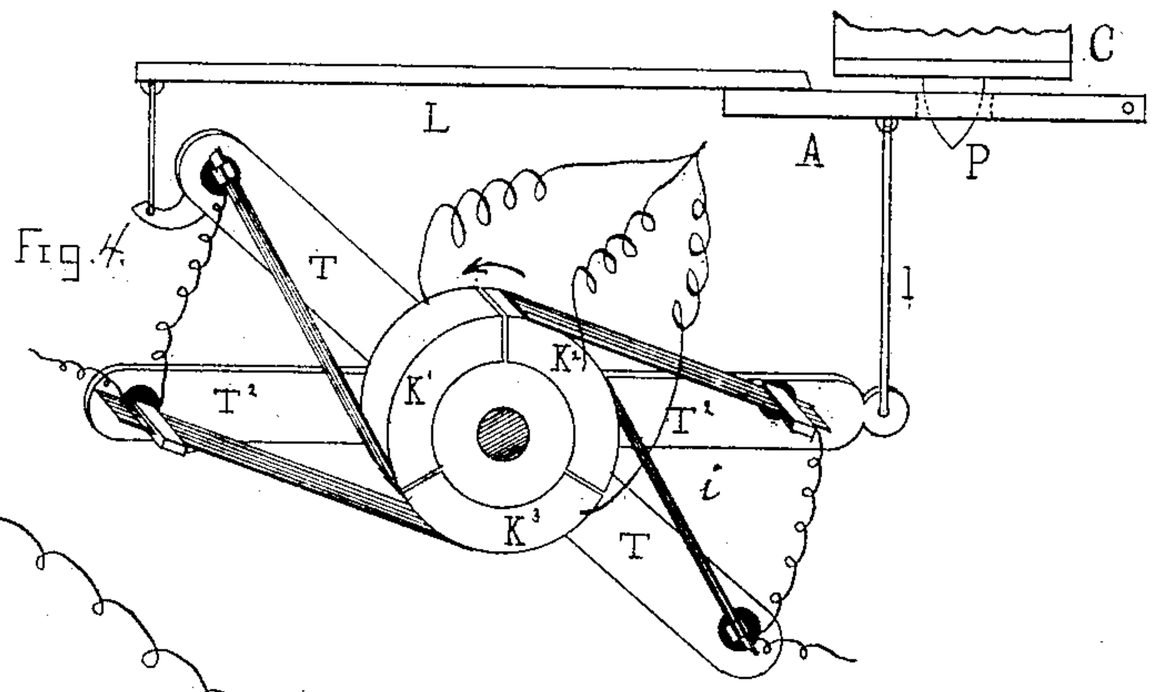


Fig. 5.

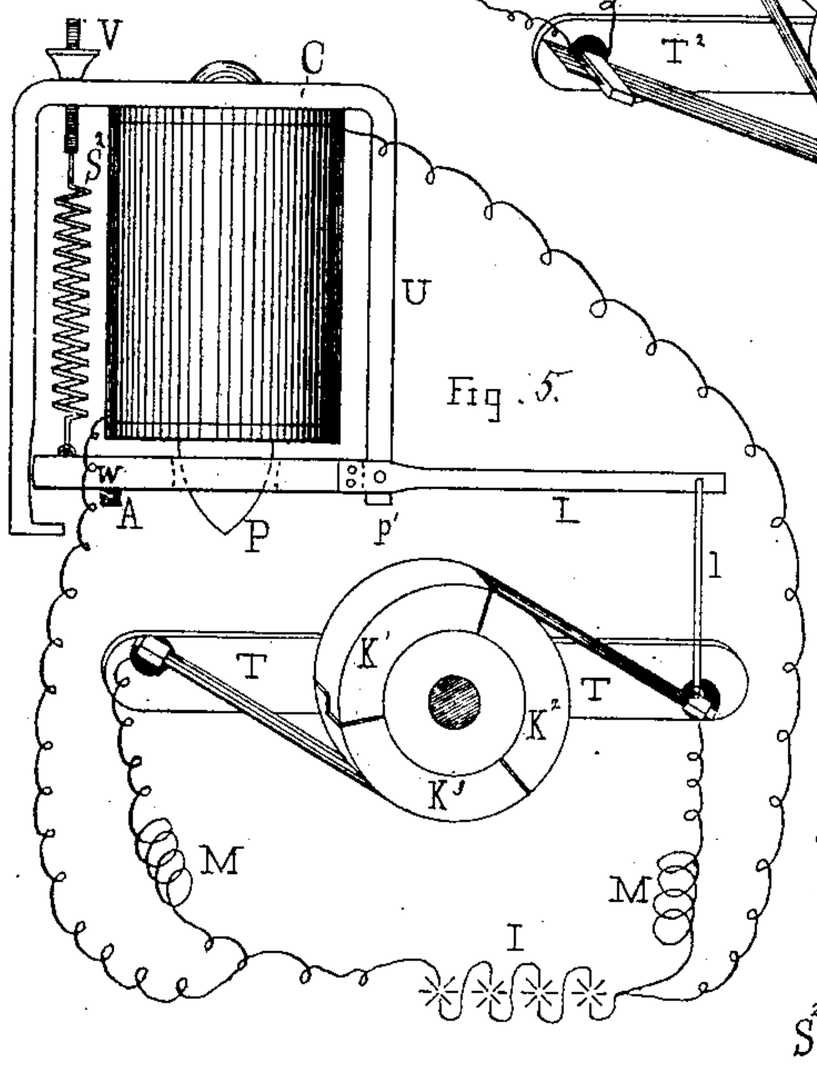
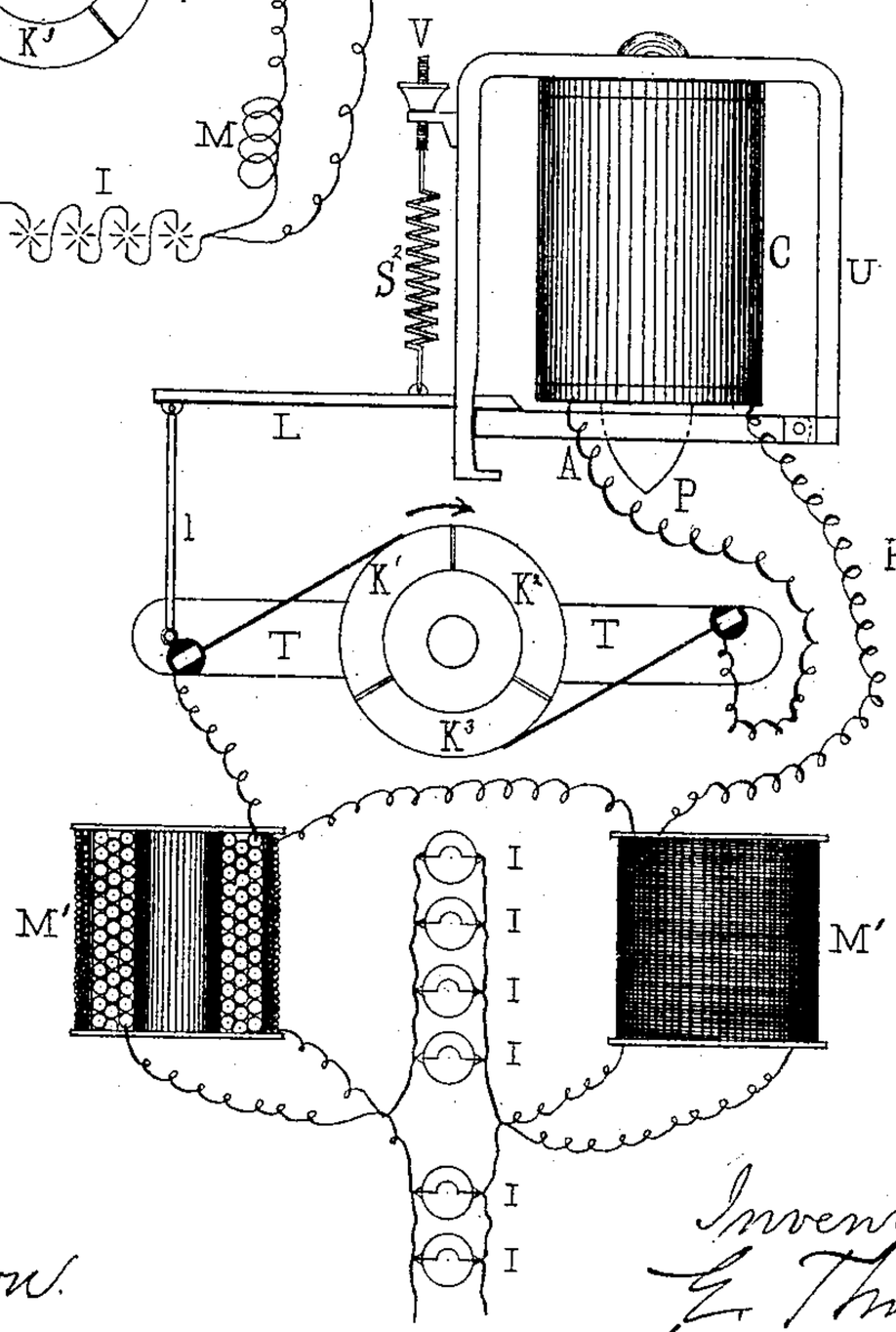


Fig. 6.



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Thos. Dorney

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UNITED STATES PATENT OFFICE.

ELIHU THOMSON, OF NEW BRITAIN, CONNECTICUT, ASSIGNOR TO THE AMERICAN ELECTRIC COMPANY, OF SAME PLACE.

ELECTRIC-CURRENT REGULATOR.

SPECIFICATION forming part of Letters Patent No. 271,948, dated February 6, 1883.

Application filed June 26, 1882. (No model.)

To all whom it may concern:

Be it known that I, ELIHU THOMSON, a citizen of the United States, and a resident of New Britain, in the county of Hartford and State of Connecticut, have invented certain new and useful Improvements in Electric-Current Regulators, of which the following is a specification.

My improvements relate particularly to regulators operated by an electric current, and serving to move or adjust the position of the commutator-brushes of a dynamo-electric machine.

My present invention is applicable to generators in which a change of electro-motive force developed is consequent on a changed position of the commutator-brush.

It consists in the combination, with the shifting brushes, of an electro-magnet formed to give a constant attraction upon its armature in any position of use when a constant current circulates on its coils.

I also apply my invention to special construction of generators, as hereinafter indicated.

Figure 1 is a front and side view of one form of my regulator, the movable lever L of which is connected to the commutator-brushes or other device by which the current is regulated. Fig. 2 is a bottom view of the upper magnet, Fig. 1. Fig. 3 is a side view of the lower magnet seen in Fig. 1. Fig. 4 shows the application of my regulator to the adjustment of two pairs of commutator-brushes. Fig. 5 shows my regulator-magnet arranged to be operated by a derived current or circuit around the lamps or resistances I. Fig. 6 shows my regulator as combined with a special construction of self-adjusting generator.

In Fig. 1, U U is a horseshoe or U-shaped piece of iron carrying an electro-magnet core and coil, C, attached to its center. The pole of this core, P, is paraboloidal or tapered, and enters a perforation in an armature, A, pivoted at p' on an adjustable slotted piece, S, as shown, secured to one leg of the horseshoe. By this means the relative position of the armature-supports to the frame U may be modified so as to obtain an attraction upon the armature A practically uniform in various positions of said armature with the same current. The armature A is nearly sufficient in length to join the extremities of the horseshoe U U. An arm, L, fastened to the armature A, serves to amplify its movement. A dash-pot, D, is provided, as shown, to check any too sudden movements of the armature. The end of the armature A to which the bar L is attached moves parallel to a curved pole-face formed upon the frame U, as shown. By this disposition the pivots p' are relieved of unnecessary strain, since the ends of the armature approach closely to both legs of the frame U U. The arm L passes out through a slot in the leg U, as shown. An adjustable weight, W, consisting in the present instance of a circular box for containing varying amounts of shot, is provided and tends to withdraw the armature A from the magnet-pole P.

It is not necessary here to describe the relations of the pole P and perforate armature A, as similar constructions are described and figured by me in prior applications for Letters Patent and prior Letters Patent. It is sufficient to say that the increased attraction due to a nearer approach of the armature to the body of the core P is counterbalanced by the opposite attraction of that portion of the core projecting through the armature, so that whatever the position of the armature the pull of the magnet is the same for a constant current circulating through its coil C. Let the coil C be included in an electric circuit to be controlled and the lever L attached to a moving commutator, means of varying resistance, or the like, and the armature A in any position within the limits of its movement will respond to changes in the current in coil C, and may be used to counteract said change, in accordance with principles at present well understood in the art and set forth in United States Letters Patent No. 238,315. In certain cases, however, it is desirable that a more delicate action be secured. This I accomplish by a construction of contact-breaking magnet controlling the admission of current to the regulator-magnet coil C. In this latter case the current to be kept constant, or a part thereof, is caused to traverse the coils of the contact-maker. B, Fig. 1, is a board by which are supported a

pair of coils, R R, provided with a double axial core of iron, *c c*, hung upon a spring, S, adjustable by a device shown at *a*, and movable between the limits of forked stop *f*, as shown. A contact, *p*, borne by the cores, touches a second contact, *q*, fixed to the base B. The contacts *p* and *q* are respectively connected to the posts F and G. A carbon rod or other resistance, E, is provided as a shunt around said contacts *p q*. The current to be regulated enters at *g*, branches at *b*, through C, and to post G, branches again at G, through the contacts *p q*, when closed, and the resistance E, and reunites at the post F, which receives also the branch that passed through the coil C, then passes from F, through the axial coils R R, and out at the post H, joining the circuit at *h*. When the parts are disposed as shown the coil C is cut out or short-circuited by the contacts *p q*, because the current circulating through the coils R R is insufficient to open contact at *p q* by attracting the cores *c c*. When, however, the current through R R or the circuit-current increases so as to be able to open the contact *p q*, the coil C conveys all the current except that which is diverted through the resistance E. The resistance E prevents spark at the opening of the contacts *p q*. The increased current in C thereupon attracts the armature A and shifts the commutator-brushes or operates an adjustable resistance or other suitable device, so as to diminish the current in the general circuit and restore it to normal. At the same time the contact at *p q* is restored, the current in the coils R R being then not strong enough to hold the cores *c c* suspended.

In actual practice the operation does not involve a series of defined makes and breaks of circuit at *p q*, but there is a rapid and delicate trembling of the contacts, and the condition is one rather of partial contact between them, the extent or nature of which contact varies with the current strength in R R. As a consequence the armature A is constantly attracted, but with a force dependent upon the condition of contact at *p q*, and the consequent extent to which the current is diverted from the coil C.

Fig. 3 shows a side view of the axial-magnet contact-breaker, similar parts being designated by similar letters of reference. Fig. 2 is a bottom view of the regulator-magnet and armature, where similar letters to those in Fig. 1 are used.

The foregoing devices are improvements in the regulating apparatus described in Figs. 2 and 3 of Patent No. 238,315, to Thomson and Houston, dated March 1, 1881. The same parts may be applied in a variety of ways to control the strength of an electric current.

In Fig. 4 the coil C, armature A, and arm L are shown in connection with a commutator so constructed as to vary the collecting extent of its positive and negative brushes simultaneously with the adjustment of the same to compensate for variations in the line-resistance. The positive and negative collecting-brushes are constructed, as in prior machines patented to me, of two or more springs or plates resting on the commutator-cylinder, so as to cover a considerable space upon the same. The space so covered or embraced by the compound collecting-brush thus formed by two or more single springs or brushes may be termed the collecting extent or space of the brush. In former constructions of commutator the collecting extent has usually been constant with the backward and forward movement of the collecting-brush, and said collecting extent could only be adjusted or varied by setting one or both of the two extreme springs forming the collecting-brush by hand. In the present arrangement an adjustment forward of the collecting-brush automatically increases its collecting extent, while an adjustment backward decreases the same.

In the accompanying drawings the forward and rear springs of the positive and negative collecting-brushes are shown as mounted on independent rocker-arms T T^2, both of which are suitably connected with the armature A or arm L, so that motion will be imparted to both in such a direction or at such a relative rate that when the armature is drawn toward the magnet to adjust the collecting-brush forward the distance between the forward and rear springs forming said brush will lengthen, thus increasing the collecting extent of the brush.

The two springs upon the one side of the commutator, and mounted on the two rocker-arms, are electrically connected, as usual, to form the positive collector, while the two upon the opposite side form the negative collector. The springs or brushes upon the arm T^2 are the forward springs or brushes, and are so arranged as to be adjusted forward in the direction of movement of the commutator. The rear pair of springs, mounted on arm T, I shall herein term the "supplemental springs or brushes." In the present arrangement the collecting extent of each positive and negative brush is increased by moving the rear or supplemental springs or brushes of the positive and negative compound collecting-brushes rearwardly simultaneously with the forward movement of the forward spring or brush. The inverse movement is produced by connecting the arms T T^2 at opposite ends to the arm L and armature A.

The construction should be such that the angle between the rear and forward portions of the positive and negative collecting-brushes may be varied from sixty degrees to ninety degrees. The three-segment commutator K' K^2 K^3 is substantially the same as is shown in my prior patents, and the slots between the segments are substantially straight and parallel to the revolving shaft upon which they are mounted. The three armature-coils are connected to the segments and to each other in the manner described in my prior patents.

The above construction of commutator collecting-brushes I find valuable for obtaining a steady current for electric arcs, and may be

applied to other forms of machine with beneficial effect. I find that approximately with my three-coil machine the relative rate of movement of the rear and forward portions of each collecting-brush should be as one to four, and the connections are shown to give this result—that is, the arm T^2 will move, say, five degrees forward, while the arm T will move in the same time twenty degrees backward. It is evident that the form of the contact springs or surfaces bearing on the commutator is not material to the invention, and that the collecting extent of the positive and negative collecting-brushes may be automatically varied by other mechanical arrangements in place of those described.

In Fig. 5 a modified use of my regulator-magnet is shown. The magnet-coil C is traversed by a current derived from the light-circuit I, and is therefore made of high resistance. Its armature A is loaded by a weight attached at W, partly counterpoised by a spring, S^2, regulable by a device shown at V. The lever L is attached by suitable means to the rocking support T T of the commutator-brushes of a dynamo-electric machine bearing on commutator-segments $K' K^2 K^3$. M M represent the field-magnet coils of the machine. The purpose and action are similar to the preceding device. Let the resistance I be increased or diminished within certain limits. The variations in the attractive energy of the coil C consequent thereon will move the brushes T T so as to compensate therefor. The spring S^2 is adjusted so that when the resistance I is at its maximum the armature A will be in its upper position, and the link *l* is of such length that the brushes T T will at this moment bear on segments at their maximum of electro-motive force.

Fig. 6 shows the regulator adapted to use with resistances run in multiple arc I I, &c.—for example, incandescent lights. The parts of the regulator and commutator of a generator are the same as in preceding figures, and are lettered similarly. In addition, M′ M′ indicate the field-magnets of the generator, each of which is wound with two coils—one placed in the main circuit and the other in a derived circuit around the resistances I I I, &c.—both acting to magnetize the field-magnets in the same way. These two coils are constructed to have a definite magnetizing effect with relation to one another, so as to produce an automatic regulation of the field-magnet strength and electro-motive force or current strength in accordance with changes in the resistance in the main circuit, as I have set forth in another application for patent; but as this forms no part of my present invention it need not be herein particularly described.

The coil C of the regulator is placed in the main circuit at any convenient point. The spring S^2 is set by the adjustment V, so that when the main current is at its maximum or the resistance I I, &c., combined at the minimum, the armature A shall be in its most elevated position, and the brushes T T bear upon the commutator where no spark is produced. Now, if the resistance I I I, &c., combined be increased by removing some of the lamps I I from the multiple-arc group, the main current is thus weakened, and the regulator C releases its armature A, which descends, at the same time readjusting the brushes T T backward to avoid spark at the commutator and sustain the electro-motive force of the generator. The slots between the segments $K' K^2$ are presumed to be inclined or broken, so that the segments themselves overlap about thirty degrees. This is the case also in the arrangement shown in Fig. 5, and is seen in said figure between the segments K′ and K^3 of the commutator.

I do not in this present application claim the regulation of the current produced by a dynamo-electric machine by a movement of its commutator-brushes, as that is the subject of prior Letters Patent; but my present invention is for improved construction and application of the same.

I make herein no broad claim to the peculiar form of U-magnet and armature, Fig. 1, independently of its combination with current-regulating mechanism, as I design making said magnet the subject of a separate application, in which it will be claimed *per se* and broadly.

What I claim as my invention is—

1. In a current-regulator for a dynamo-electric machine, the combination, with the regulating mechanism, of a controlling electro-magnet having a paraboloidal or tapered pole, and an armature overlapping the tapered portion of the pole and moving in proximity to said tapered portion in substantially the direction of the magnetic axis of the core.

2. The combination, with the U-frame, of the coil C, its core connected to the center of the frame, and a movable armature suspended between the extremities of the frame and current-regulating devices actuated by said armature.

3. The combination, with the U-frame, of the coil C and its core, connected to the center of the frame, an armature pivoted from one extremity of the frame, and moving with its free end past a curved pole-face formed upon the other extremity, and current-regulating devices controlled by said armature.

4. The combination of the U-frame, the coil C and core, the perforated armature A, pivoted from one extremity of the U-frame, and moving with its free end past a curved pole-face formed upon the other extremity, and current-regulating devices controlled by said armature.

5. In an electric-current regulator, the combination, with a regulator electro-magnet, of a shunt-circuit including a circuit-breaker, a resistance in a derived circuit around said circuit-breaker, and a controlling electro-magnet in the main regulated circuit beyond the circuit-breaker and the regulator electro-magnet.

6. In an electric-current regulator, the combination of the controlling axial electro-magnet R R *c c*, spring S, contacts *p q* in circuit with

said magnet, and resistance E in a derived circuit around said contacts.

7. The combination of the axial controlling electro-magnet R R *c c*, contacts *p q* in circuit therewith, resistance E in a derived circuit around said contact, regulator electro-magnet coil C, connected to frame U U, and in a second derived circuit to the contact-points *p q*, tapered pole P, and perforated armature-lever A L.

8. The combination, in a current-regulator, of a single commutator-cylinder, two pairs of oppositely and differentially moving brushes, and an operating electro-magnet, substantially as and for the purpose described.

9. The combination, in a current-regulator, of the armature-lever A L, separate pairs of commutator-brushes, connected to said lever at different points, and a revolving commutator, upon which said brushes bear.

10. The combination of the armature-lever A L, rocker-arms T T^2, each carrying a separate set of commutator-brushes, a commutator-cylinder, K′ K^2 K^3, and connecting-links *l*, attached to the armature-lever and to the rocker-arms at opposite sides of their fulcrum, so as to move them in opposite directions.

11. The combination, with the positive and negative collecting-brushes for a dynamo-electric machine, of means for increasing their collecting extent simultaneously with their forward adjustment.

12. The combination, with a compound positive or negative collecting-brush for the commutator of a dynamo-electric machine, of means for increasing the collecting extent of said brush rearwardly simultaneously with a forward movement of the forward portion thereof, substantially as and for the purpose described.

13. In a compound commutator collecting-brush, the combination, with a forward adjustable spring, of an auxiliary rear spring, and means for moving the latter backward simultaneously with the forward movement of the former.

14. In an automatic current-regulating apparatus, the combination of a derived circuit around the working-resistances, a regulator-magnet coil in said derived circuit, and mechanism operated thereby for adjusting the position of the commutator-brushes of the machine supplying current to the working-resistances.

Signed at New Britain, in the county of Hartford and State of Connecticut, this 22d day of June, A D. 1882.

ELIHU THOMSON.

Witnesses:
E. WILBUR RICE,
CHAS. M. MOREY.