July 29, 1924. 1,503,085

E. J. BLAKE

REGULATOR

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Fig. 2.

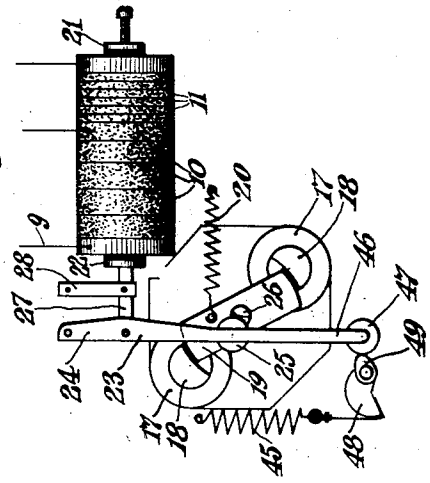

Fig. 1.

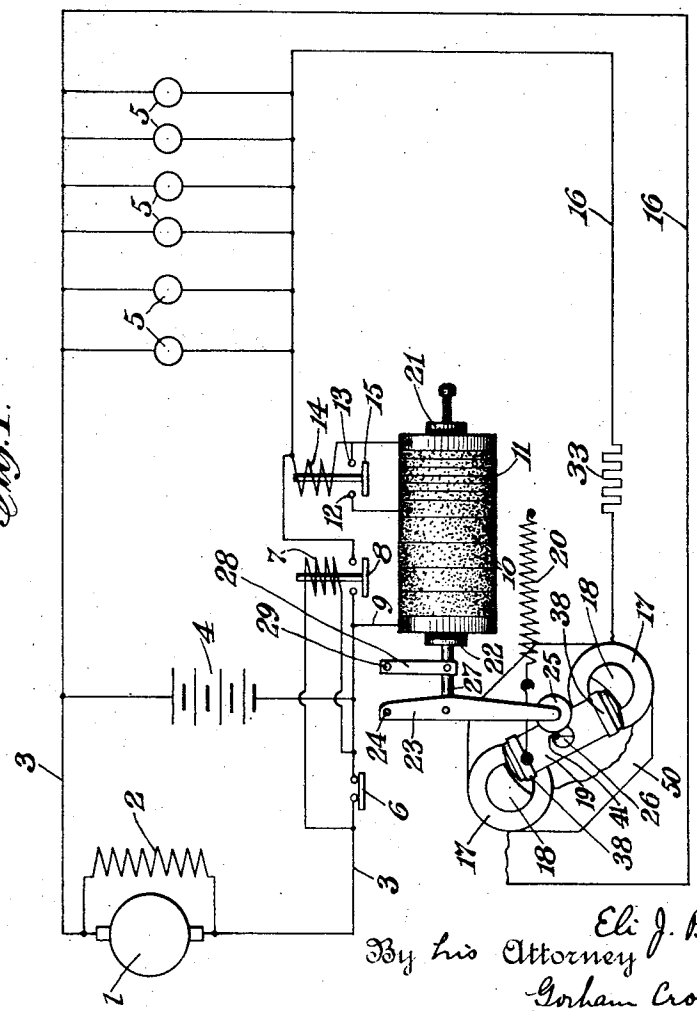

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Fig. 3

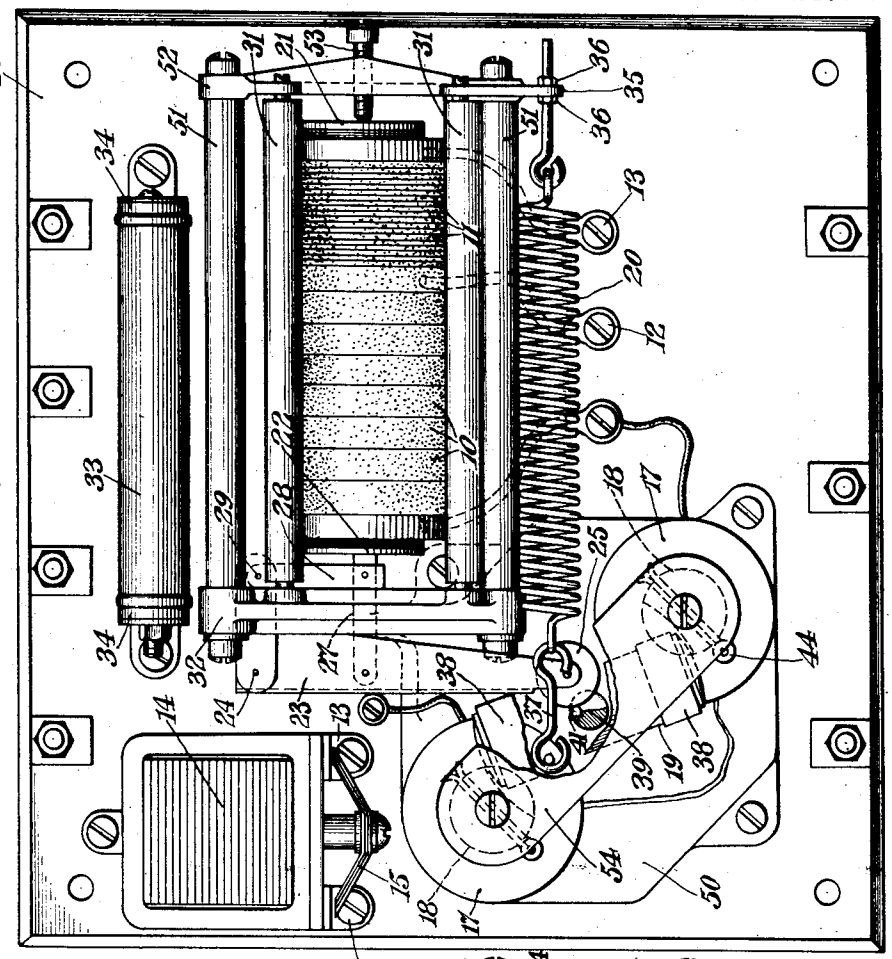
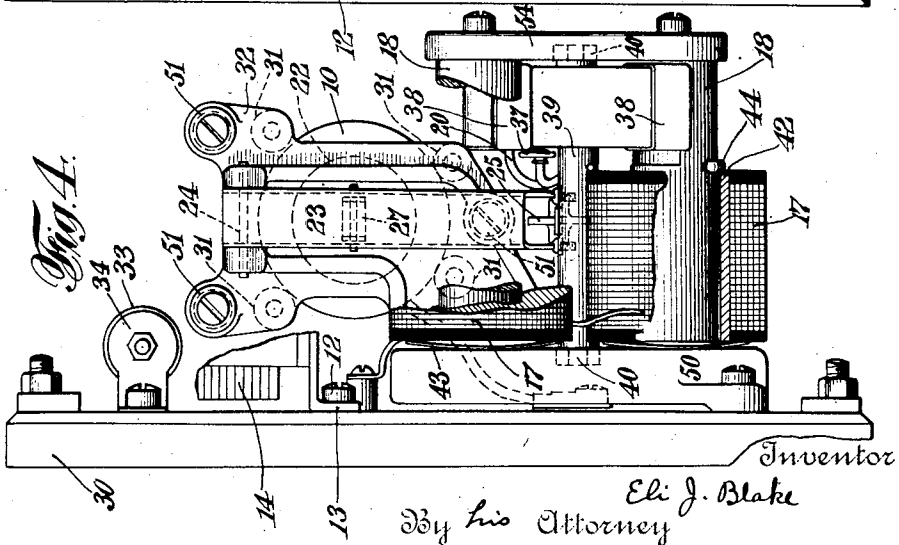


Fig. 4.



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By his Attorney
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Patented July 29, 1924. 1,503,085

UNITED STATES PATENT OFFICE.

ELI J. BLAKE, OF BUFFALO, NEW YORK, ASSIGNOR TO GOULD COUPLER COMPANY, A CORPORATION OF NEW YORK.

REGULATOR.

Application filed October 9, 1920. Serial No. 415,800.

To all whom it may concern:

Be it known that I, ELI J. BLAKE, a citizen of the United States, and resident of Buffalo, in the county of Erie and State of New York, have invented certain new and useful Improvements in Regulators, of which the following is a specification.

My invention relates to a regulator of the voltage type and is particularly useful as a lamp regulator on systems receiving a variable voltage, although the regulator may be used in other similar places, and some of the principles involved may be used in different kinds of regulators.

The preferred resistance element used in my regulator is of the carbon pile type, and in the following description reference will be made to the element as a carbon pile although as to some features of my invention other types of resistance element might be employed.

The objects of the invention are to obtain a heavy compression on the carbon pile with magnets of moderate size, consuming a moderate amount of energy; to obtain stability of operation without the use of the usual dash-pots; to provide a compact apparatus with a wider range of carbon pile resistance while substantially avoiding the effects of heating when the current through the pile is high.

A better understanding of these and other advantages of my invention will be had from the following description, taken in conjunction with the accompanying drawings, forming a part thereof, and in which

Fig. 1 shows a diagrammatical view of a car lighting system with my regulator connected in to regulate the lamp voltage,

Fig. 2 illustrates a modified form of the regulator,

Fig. 3 is a front elevation of the complete regulator on a vertical disposed panel, and

Fig. 4 is an end elevation of the regulator with some of the parts broken away.

In Fig. 1 a generator 1, having the usual field coil 2, supplies energy to mains 3. A battery 4 is connected across the mains and lamps 5 are also connected across the generator and battery. The main switch 6 is of the usual type and is illustrated diagrammatically because it forms no part of this invention and it is well known in the art as one which closes when the generator produces a predetermined voltage and automatically opens when the voltage of the generator falls below the predetermined amount. Connected across the contacts of the switch 6 is a coil 7 which, when operating, closes contacts between the battery and the lamps by means of the switch member 8. The switch 8 is always open when the switch 6 is closed, because when the switch 6 is closed the coil 7, which operates the switch 8, is short-circuited. Connected in the main 3 by a conductor 9 is a carbon pile having one portion made up of a series of comparatively thick carbon discs 10 and another portion of relatively thin carbon discs 11. One contact 12 is connected to an intermediate point on the pile and preferably to the last thick disc 10, and the contact 13 is connected to the carbon disc at the end of the pile opposite the connection of the conductor 9. Connected in series with the carbon pile is a coil 14 which when energized to a predetermined point, operates a switch member 15, which connects the contacts 12 and 13 together.

Connected across the lamp circuit by means of conductor 16 are two solenoids 17 having fixed pole pieces 18. An armature 19 is pivotally mounted midway between the poles of the magnets 17 on an axis parallel with the magnet axes. This armature is urged in a clockwise direction, as shown in Fig. 1, by a spring 20, and in a counter-clockwise direction by the electromagnets 17 when they are energized. The two ends of the armature are alike so that the armature is balanced between the poles of the magnet. The carbon pile is anchored at one end by means of an abutment 21 and the other end is operated upon by a head 22. This head 22 is actuated by a lever 23, pivoted at 24. The other end of the lever 23 is provided with a roller 25 which is engaged by a cam 26, actuated by the armature 19. The head 22 is pivotally connected to the lever 23 by a stem 27, which is supported in the position shown in Fig. 1 by a link 28, which is pivoted at 29 so that upon the movement of lever 23, a corresponding movement will be imparted to the link 28, and the head 22 will be maintained in a vertical position at all points of movement.

The details of construction of the regulator are shown in Figs. 3 and 4 and comprise a panel 30, usually of slate or other material similar thereto, which carries the

other parts. 50 is an iron frame mounted upon the panel constituting the support for the various parts of the regulator proper. The carbon pile is supported from this frame as follows: Integral with this frame 50 is the bracket 32, to which are suitably secured three rods 51 which at their outer ends are secured to and support the yoke 52. Extending between the bracket 32 and the yoke 52 are rods carrying four porcelain tubes 31, upon which the carbon pile is supported. The abutment 21 at one end of the pile is engaged by a set-screw 53 passing through the yoke 52. The three rods 51 are preferably made of a material whose thermal expansion is approximately equal to the thermal expansion of the pile itself, so that the working position of the right hand end of the pile varies with its temperature. Aluminum, which has a high co-efficient of expansion, is a suitable material for these rods 51.

Connected in series with the magnets 17 is a temperature compensating resistance 33, which is carried by the base plate by means of clips 34 screwed to the base. The spring 20 has one end fastened in a member 35, which is fastened to the yoke 52 and is adjustable by means of nuts 36, so that the tension thereon may be regulated. The spring 20 is connected to the armature 19 by means of a link 37. The armature 19 is provided at its ends with damping bands 38, which are for the purpose of producing a gradual movement, thus aiding in the elimination of dash-pots.

The armature 19 is mounted upon a shaft 39, the ends of which are carried by ball-bearings 40, supported respectively upon the frame 50 and a non-magnetic bridge 54 which ties the magnets 17 together. A recess is cut in the shaft 39 and a pin 41 is screwed into the edge of the recess and constitutes a cam which operates the roller 25 on the lever 23. The magnets 17 are wound upon heavy copper sleeves 42 and rest against spring washers 43, which prevent vibration and are retained by cotter-pins 44 at the outer ends. These sleeves 42 also aid materially in the damping effect on the armature.

In Fig. 2 is shown a modified construction of the means for operating the carbon pile. Several of the parts of this arrangement are the same as that shown in Fig. 1. In addition thereto, there is shown a second spring 45, which acts with varying leverage upon a wheel 47 in an extension 46 of the lever 23, the variation of the leverage being produced by a cam 48 and a cam 49. The cam surfaces 48 and 49 are so designed that the maximum resultant force from the spring 45 is applied to the wheel 47 at the maximum point of compression of the carbon pile, so that the force necessary to change the resistance of the pile is a constant one, regardless of the length of the pile. As the pile shortens, the compression between the discs increases so that a greater change of force is necessary to produce a given resistance change in the carbon pile than is necessary when the carbon pile was not so heavily compressed; and it is the object of the arrangement above described to automatically off-set the increase of resistance to compression of the carbon pile so that a given change in voltage on the circuit to be controlled will produce the same effect whether the carbon pile is lightly or heavily compressed. In the arrangement of Fig. 2 the spring 20 serves merely as a standard of torque to be attained by the magnet 17 corresponding to a definite voltage adjustment. Thus the carbon pile and the spring 45, acting through the cams 48 and 49, constitute a balance system like a counterweighted window sash. The magnets 17 and spring 20 determine the position of the former system but are not required to expend power upon it except in overcoming friction. In the arrangement shown in Fig. 1, the single spring 20 supplies two component proportions of torque; a roughly constant component is used to balance the torque of the magnet and the other component varies with varying positions of the armature and serves to compress the pile, because in the direction of compression, the effective radius through which the spring acts gradually increases approximately with the increase to resistance to compression.

The operation of the system as shown in Fig. 1 is as follows:

When the generator has attained a speed sufficient to give a predetermined voltage, the main switch 6 closes and the switch 8 opens, putting the carbon pile in series between the battery and the lamps. The voltage at the lamps will be maintained constant by the variation of resistance of the carbon pile, effected by the magnet 17 of the regulator.

The switch 15 will remain open until the lamp load has reached a predetermined value when the lamp current passing through the coil 14 will close switch 15 and thereby short-circuit the thin discs 11 of the carbon pile. When the current is heavy, less resistance is needed in the carbon pile to develop the necessary voltage drop across the pile, so that the relatively few contacting surfaces between the thicker discs 10 of the pile will be sufficient to give the necessary voltage drop, while the large radiating surfaces of these discs takes care of the greater heat developed at this time. Whenever the lamp load drops below a predetermined value, switch 15 opens and the thin discs 11 are put again into use in series

with the discs 10, so that a higher resistance and a greater number of contacting surfaces may be employed under circumstances where the heating of the pile is insufficient to require the use of thicker discs throughout, but where a higher resistance in the pile is required to produce the same voltage at the lamps.

When for any reason the generator slows down so that its voltage drops below that of the battery 4, the main switch 6 will open, whereupon the magnet 7 will attract the armature and close the switch 8 which short-circuits the entire carbon pile and puts the battery directly across the lamps. The operation of the device in Fig. 2 is specifically the same as that of Fig. 1.

I have been enabled to dispense with the dash-pot, ordinarily found necessary in regulators of this type, because of various contributing features of construction, including the reduction of momentum and inertia due to the relative lightness of the moving parts resulting from the character of the magnet employed, the construction whereby the magnet cannot open the pile and start a hunting action, and the provision of the electrical damping means described. Many modifications may be made in the apparatus shown to carry out the principles above set forth, and, therefore, I do not desire to be limited to the exact details shown, but have shown and described apparatus in detail merely as an example of one form of means for carrying out the principles of the invention.

It should be noted that in the preferred type of construction the cores or pole pieces 18 are parallel to the axis of the armature and have pole faces formed integrally on their outer ends which are substantially concentric with the axis of the armature, these cores being of uniform cross section cut away at the ends to form the pole faces. These cores project from a magnetic base, namely, the frame 50 which acts as a magnetic base therefor, and the pole faces are so formed in the ends thereof that the electro-magnet coils may be applied and removed over the pole faces. The advantages of the construction described include the possibility of using a small air gap with correspondingly small exciting current, adaptability for constant torque throughout the movement of the armature or a desired variation of torque, easy maintenance of the air gap with little friction and balanced magnetic and mechanical forces. These advantages are of peculiar utility in the device herein described.

It should be noted that the preferred construction described herein, by which it has been possible to do away with the necessity of using dash pots, includes the use of a number of features, all of which coact, in the preferred construction, to obtain the best effect. These features comprise, first, constructing the armature as a quick acting member, having very small inertia in proportion to the forces acting on it so that it will have relatively small momentum during its necessary regulating motions in service. Accordingly, the armature is more readily able to follow changing conditions, and is less likely to be thrown into a state of continued oscillation. Second, slow-acting magnetic circuits, which may be produced by the heavy copper sleeves on the cores referred to, or by the damping bands 38, and preferably by both. Sleeves 42 act as short circuited secondary windings about the magnet cores, bands 38 having a similar effect. In the event of any disturbance tending to set up an oscillation of the armature, the resulting pulsation of magnetic flux through the cores induces relatively large currents in the short circuited sleeves and bands, with the result that the oscillations are quickly damped out. The sleeves 42 must have sufficient conductance to accomplish the desired purpose. Such a construction restricts the magnetic changes to a speed which can be followed by the quick acting armature with very little tendency on the part of the latter to overswing. More generally speaking, the moving mechanism and the magnetic or electric circuits should be given widely dissimilar characteristics as regards rapidity of action, whereby the production of cumulative oscillations is minimized. It should be noted, in this connection, that a "vibrator" in an electric bell or the like, is only operative when the time characteristics of the clapper and the circuits are reasonably commensurate.

Another feature contributing to the insurance of stability of operation, without the use of dash pots, consists in avoidance of any discontinuity in the resistance variation of the carbon pile. In some other regulators it has been customary to connect the mechanism to the terminal carbons in such a manner that over travel of the mechanism may result in an actual open circuit through the pile. The result at the point of just making or breaking contact is similar to the action of an electric bell or buzzer; that is when the circuit is broken the magnets are de-energized and the mechanism returns to a position of contact. The pull exerted by the magnets is then once more sufficient to cause the circuit to open and vibration may result. In the present regulator the mechanical connections are such that the carbons may be completely relieved of external pressure but cannot be drawn out of contact. In the present construction there is no mechanical connection whereby head 22 may be drawn out of contact with the pile.

It should also be noted that the electric circuits provided by copper sleeves 42 and bands 38 are designed to rapidly dissipate by the currents induced therein the energy of such movements of the moving parts as occur, before overswing can occur. The sleeves and dampers thus have two functions, the retardation of magnetic changes and the dissipation of the energy of such movements as do occur, to prevent overthrow, i. e., render the mechanism deadbeat. A further feature contributing to the result desired consists in the mechanical balance of the parts which has been provided for to avoid oscillation which might be introduced by mechanical jarring actions.

In regard to the construction which has been described whereby the abutment 21 at one end of the carbon pile is in effect supported in its position against the pile by the rods 51 formed of material having a like thermal expansion to that of the pile, it should be noted that the intention is to maintain the position of the pile unchanged at all times in relation to the members 22 and 23. I desire to avoid change of position of the carbon pile, due to thermal expansion because of the fact that the regulator is constructed to balance the pressure of the carbons in all positions of the armature so that any considerable change of position of the carbon pile for a given pressure would disturb the state of balance. It may be noted that the total expansion of the supporting rods and of the carbons of the pile, each at its own temperature increase, should be the same. The temperature rise is actually less in the rods than in the carbons, and accordingly the rods should have a somewhat higher coefficient of expansion (i. e., expansion per degree of temperature rise) than the carbons, in order that the total thermal expansion of the rods and carbons should be equalized.

Having described my invention what I now claim as new and desire to secure by Letters Patent is:

1. In a regulator the combination of a carbon pile, two electro-magnets having parallel cores, an armature, pivoted on an axis between said cores and parallel thereto, pole faces formed on said cores substantially concentric with the axis of said armature, a lever for operating said pile, and a roller operatively interposed between the armature and said lever whereby movement of the armature operates the lever to vary the resistance of said pile.

2. In a regulator, a carbon pile, a magnet having opposing pole faces and an armature pivotally mounted between them at its center of gravity and attracted at each end by one of said poles, closed electric circuits affected responsively to the movement of said armature for damping said movement, and means for causing the movement of said magnet to vary the compression of said pile.

3. In a regulator, the combination of a carbon pile, two electromagnets having parallel pole pieces, the windings of said magnets being wound upon heavy copper sleeves, and an armature pivoted between said pole pieces and attracted at each end by one of said pole pieces, said armature having closed electric circuits about its end portions, affected responsively to the movement of said armature for damping said movement, and means for causing the movement of said armature to vary the compression of said pile.

4. In a regulator, the combination of a carbon pile, two electromagnets having parallel pole pieces, the windings of said magnets being wound upon heavy copper sleeves, and an armature pivoted at its center of gravity between said pole pieces and attracted at each end by one of said pole pieces, said armature having closed electric circuits about its end portions affected responsively to the movement of said armature for damping said movement, and said armature being designed to have small inertia in proportion to the forces acting thereon, and means detached from but engaging the armature and operating upon the carbon pile.

5. In a regulator, the combination of a carbon pile, two electromagnets having parallel pole pieces, and an armature pivoted at its center of gravity between said pole pieces and attracted at each end by one of said pole pieces, said armature being designed to have small inertia in proportion to the forces acting thereon, and having magnetic electric means thereon for damping the movement of said armature, a lever operating upon one end of said pile means on said armature, detached from but engaging said lever, to operate the same, and a spring acting upon said armature in opposition to said electromagnets.

6. In a regulator, the combination of a carbon pile, two electromagnets having parallel pole pieces, and an armature pivoted at its center of gravity between said pole pieces and attracted at each end by one of said pole pieces, said armature being designed to have small inertia in proportion to the forces acting thereon, and having a sluggish magnetic circuit, and closed electric circuit means for damping movement of the armature, and means, comprising a member detached from but engaging the armature, for varying the compression of said pile.

7. In a regulator, a carbon pile, a magnet having opposing pole faces and an armature

pivotally mounted between them at its center of gravity and attracted at each end by one of said poles, closed electric circuits affected responsively to the movement of said armature for damping said movement, a spring acting upon the armature in opposition to the magnet, and means detached from but engaging the armature and operating upon the carbon pile.

8. In a regulator the combination of a carbon pile, an electromagnet having oppositely disposed pole faces, an armature pivoted substantially at its center of gravity on an axis between said pole faces and adapted to swing into and out of alignment therewith, means whereby movement of said armature varies the resistance of said pile, and electromagnetic means damping the mechanism to an extent to prevent overthrow of the armature and render the mechanism dead beat.

9. In a regulator the combination of a carbon pile, an electromagnet having oppositely disposed pole faces, an armature pivoted between said faces and adapted to swing into and out of alignment therewith, means whereby movement of the armature varies the resistance of the pile and electrically conducting damping bands on the armature on opposite sides of its axis substantially preventing overthrow of the armature and whereby the mechanism is rendered substantially dead beat by electromagnetic means.

10. In a regulator for an electrical circuit combination of a compressible carbon pile the opposition to compression of which increases as the pile is compressed, means exerting a substantially constant component of force acting to compress said pile, a variable component of force for assisting said constant component of force and increasing in its value as the opposition to compression increases, and substantially offsetting said increase of opposition and a variable force dependent upon the condition of the circuit to be regulated for opposing the constant component of force and its assisting variable force.

11. In a regulator for controlling a circuit, the combination of a compressible resistance element, means tending to compress the element, means assisting in the compression of said element, the said assistance varying automatically as the opposition to compression varies and means controlled by the controlled circuit for opposing the joint action of the other two means.

12. In a regulator for controlling a circuit, the combination of a carbon pile, a spring acting to compress said pile, a spring acting through a varying leverage to assist the first spring, the assistance varying as the opposition to compression varies and acting to offset said varying opposition and a magnetic member actuated by the controlled circuit for opposing the resultant force of said springs.

13. In a regulator the combination of a carbon pile anchored at one end, a pivoted lever operating on the other end of the pile, a spring operating on the free end of said lever through a varying leverage dependent upon the degree of compression of said pile, a magnetic member acting on said lever to release the pressure of the pile and a spring acting in opposition to said magnetic member.

14. In a regulator the combination of a compressible variable resistance, a member acting on one end of said resistance to vary the compression thereof, two parallel links supporting said member and electro-magnetic means operating said member.

15. In a regulator, the combination of a carbon pile, a magnetic base, a pair of parallel pole pieces projecting from said base, and having faces so formed in the ends thereof that coils may be applied and removed over the same, electromagnet coils so applied, an armature pivoted between said pole faces to rotate between the same, one end attracted to one pole face and the other end to the other face, and means for causing the movement of said armature to vary the compression of the pile.

16. In a regulator the combination of a carbon pile, an electro-magnet and its armature and mechanical connections between the armature and the pile whereby variations in the strength of the electromagnet vary the pressure on the pile, a spring operating on one part of said mechanical connections to apply pressure to said pile, and a spring operating on another part of said connection and tending to move the armature in a direction to permit the first spring to apply pressure to said pile, said parts being operatively separated when the strength of the magnet decreases to a predetermined value whereby the pressing on the pile is determined by the first spring independently of the second spring.

17. In a regulator the combination of a carbon pile, an electromagnetically controlled lever operating on one end of the pile, a frame for supporting said pile and lever, expansible members fixed to said frame adjacent said operating end of the pile and extending parallel to the pile toward the opposite end thereof, and an abutment for said opposite end of the pile carried by said expansible members adjacent said opposite end of the pile whereby expansion of said pile due to heat is substantially compensated for by expansion of said expansible members which move the abutment with respect to said frame, and means for adjust-

ing said abutment toward and from the pile and with respect to said expansible members.

18. In a regulator, the combination of a carbon pile, means providing a magnetic circuit, comprising a base, a pair of projecting parallel cores with arcuate pole faces at their outer ends, and an armature arranged to swing between said pole faces in a plane parallel to said base, exciting and damping windings surrounding the magnetic circuit, a spring tending to displace the armature from alignment in the magnetic circuit, and means for causing the movement of said armature to vary the compression of the pile.

19. In a regulator, the combination of a carbon pile, means providing a magnetic circuit, comprising a base, a pair of projecting parallel cores with arcuate pole faces at their outer ends, and an armature arranged to swing between said pole faces, exciting and damping windings surrounding the magnetic circuit, a spring tending to displace the armature from alignment in the magnetic circuit, and means detached from but engaging the armature and operating upon the pile.

20. In a regulator, the combination of a carbon pile, an abutment for one end thereof, a movable abutment engaging the opposite end thereof, said first abutment being arranged to expand and contract in substantially the same manner as said pile, with thermal changes thereof, a lever actuating said movable abutment, an electromagnet and a torsion armature for controlling the movement of said lever.

21. In a regulator, the combination of a carbon pile, an abutment for one end thereof, a movable abutment engaging the opposite end thereof, said first abutment being arranged to expand and contract in substantially the same manner as said pile, with thermal changes thereof, mechanism actuating said movable abutment, including a swinging armature and connections between the same and said abutment, and an electromagnet for said armature, and means acting on said armature to balance the pressure of the carbon pile in all positions of the armature.

Signed at Depew, in the county of Erie and State of New York this 7th day of October A. D. 1920.

ELI J. BLAKE.