C. F. BRUSH.
Electric-Lamp

No. 219,209. Patented Sept. 2, 1879.

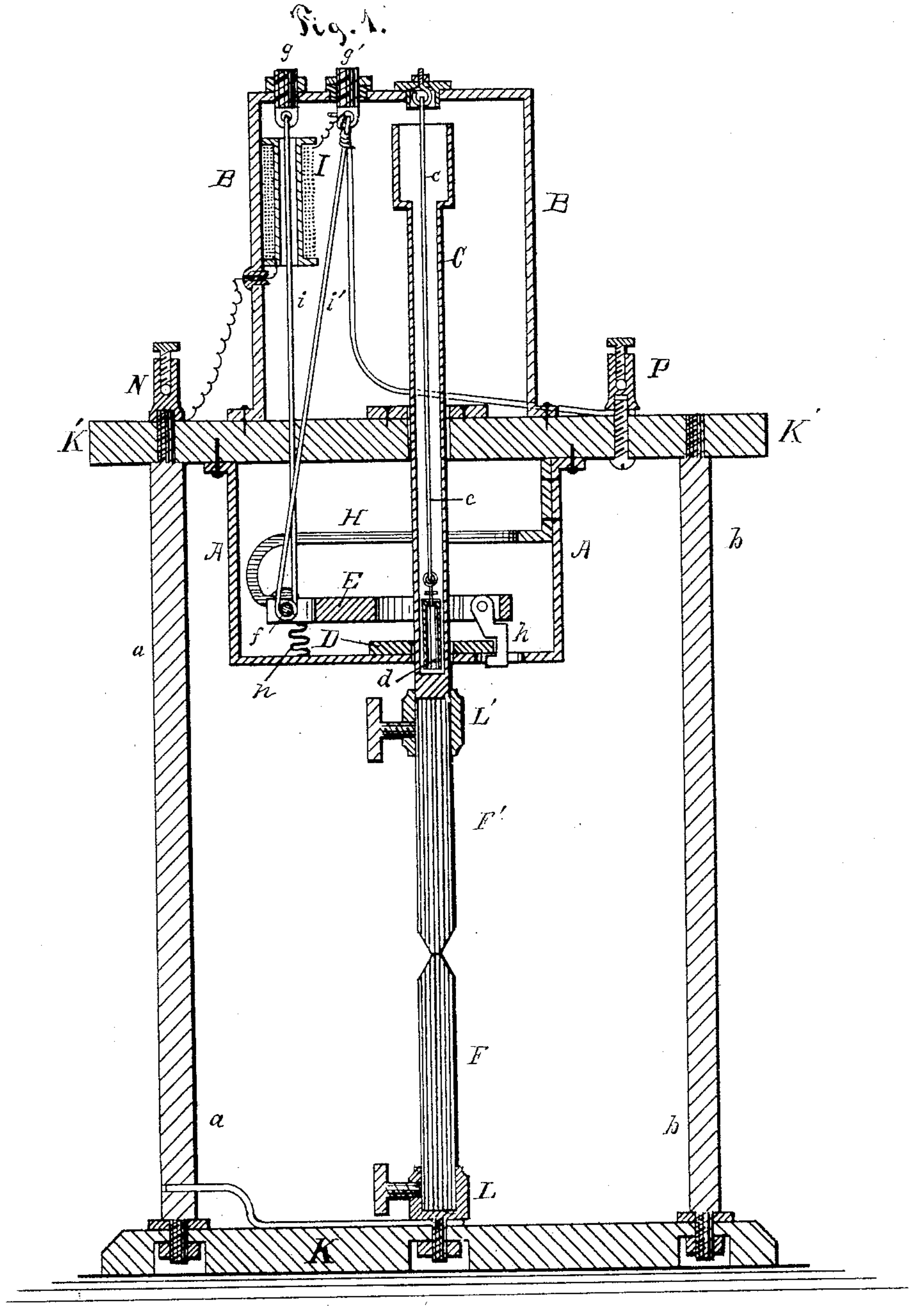

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Fig. 3'.

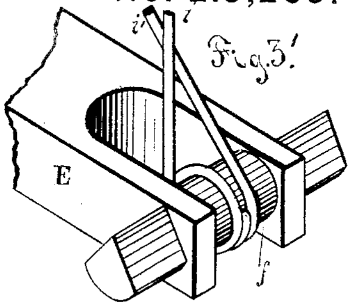

Fig. 3.

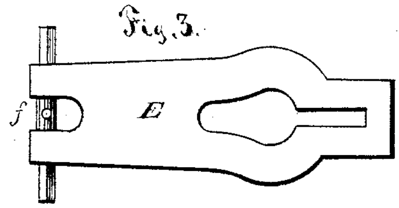

Fig. 2.

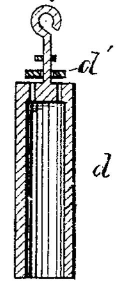

Fig. 4.

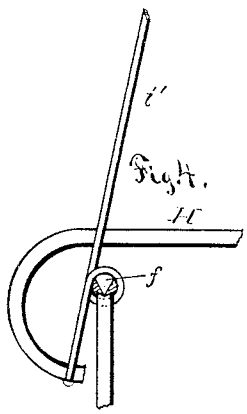

Fig. 5.

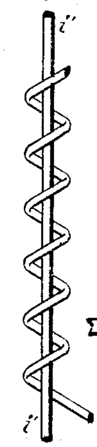

Fig. 7.

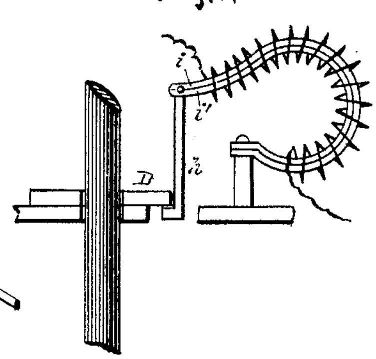

Fig. 6.

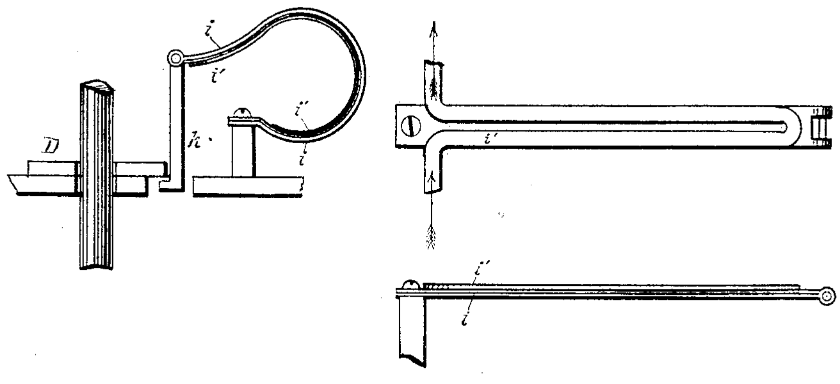

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Fig.10.

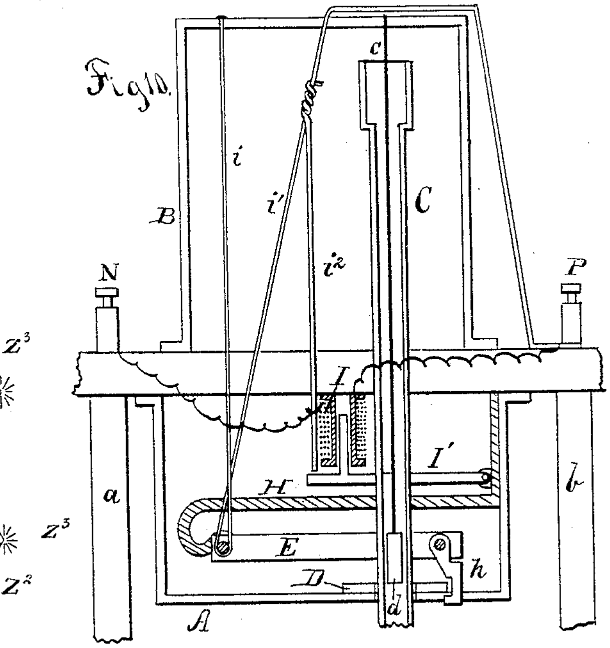


Fig.9.

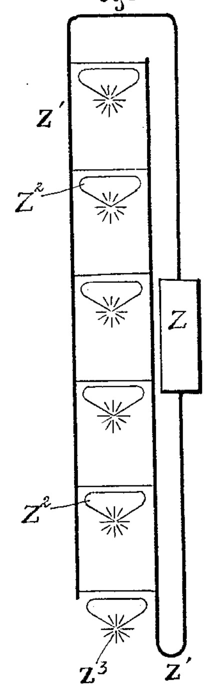


Fig.8.

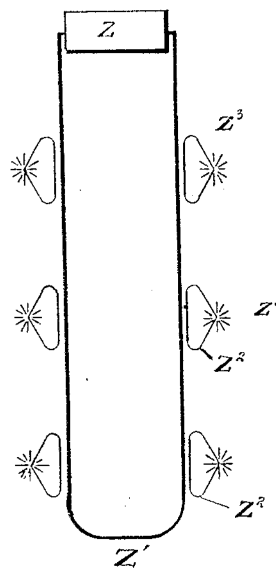
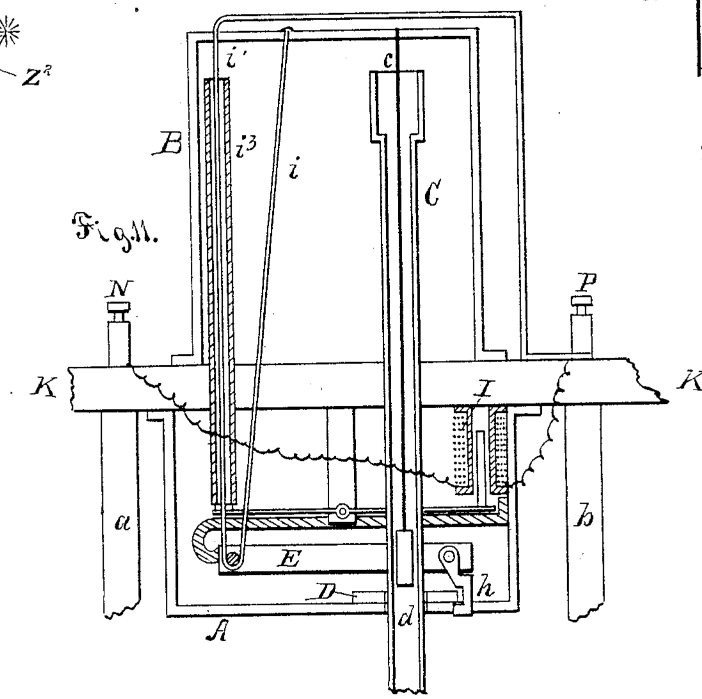


Fig.11.



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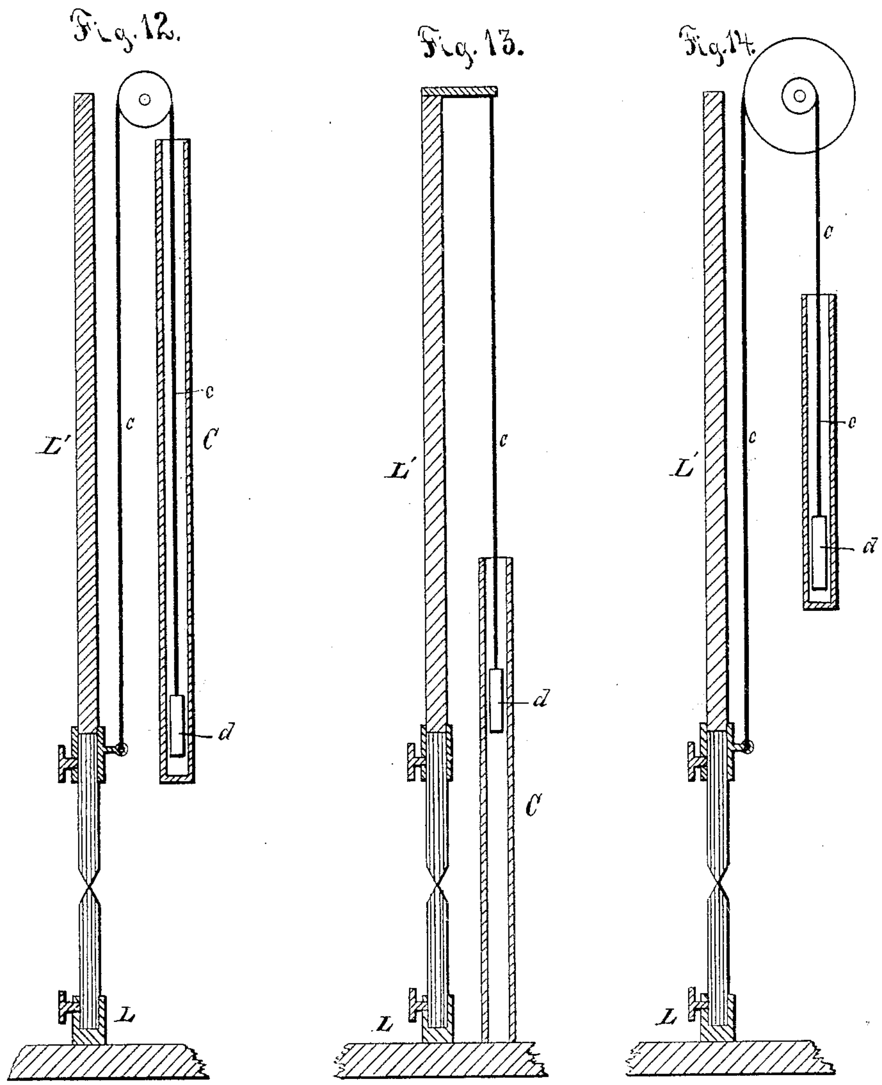

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UNITED STATES PATENT OFFICE.

CHARLES F. BRUSH, OF CLEVELAND, OHIO.

IMPROVEMENT IN ELECTRIC LAMPS.

Specification forming part of Letters Patent No. **219,209**, dated September 2, 1879; application filed May 16, 1879.

To all whom it may concern:

Be it known that I, CHARLES F. BRUSH, of Cleveland, in the county of Cuyahoga and State of Ohio, have invented certain new and useful Improvements in Electric Lamps; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it pertains to make and use it, reference being had to the accompanying drawings, which form part of this specification.

My invention relates to improvements in electric-light regulators; and it consists in the devices and appliances hereinafter set forth and claimed.

In the drawings, Figure 1 represents one form of my device as embodied in a lamp adapted for a to-and-fro current. Fig. 2 is a detached view, showing, in detail, my elongated plunger for use in the dash-pot, also showing its valvular construction. Fig. 3 is a detached plan view of the arm or lever E. Fig. 3′ is a perspective view of the same device. Fig. 4 shows a modified arrangement of the heating wire or bar i^1. Fig. 5 shows the wire i^1 surrounded by the heating-spiral. Fig. 6 represents, in three views—viz., side elevation and two developed views—a modified arrangement of the elements i i^1, in which my compensating principle is preserved. Fig. 7 shows a modification similar to Fig. 6, excepting that the compensating principle is not introduced. Figs. 8 and 9 are diagramatic representations, showing a system of several regulators having an induction apparatus and operated by a single current. Figs. 10 and 11 represent a lamp according to my invention adapted for use with a continuous current.

In Fig. 1, K is a base, of suitable material, to which are attached two metallic rods, *a b*, supporting a cross-piece of wood, K′. A carbon-holder, L, is attached to the base K, and carries the carbon F. This carbon-holder is electrically connected with the rod *a*, which latter carries a binding-post, N, at its upper end.

A B are metallic frames for supporting and containing the mechanism of the regulator, and are attached to the cross-piece K′. C is a tube of metal, closed at its lower end, and provided with a carbon-holder, L′, in which is placed the carbon F′. The upper end of the tube C is enlarged, as shown. The tube C moves up and down freely through two bearings, one in the frame A, and the other attached to the cross-piece K′, as shown. *d* is a piston, fitting freely in the tube C, and attached to the frame B by means of the rod or link *c*.

Fig. 2 shows the piston *d* enlarged. It is quite long, as compared with its diameter, is hollow the greater part of its length, and is provided at its upper end with several small openings, which are closed by a ring or washer fitting loosely on the rod which carries the piston. Thus the piston is provided with a valve opening upward.

In operation, the tube C, Fig. 1, is partly filled with glycerine or other suitable liquid, and then, with the piston *d*, forms a combined carbon-holder rod and dash-pot.

Owing to the valve *d′* in the piston *d*, the tube C may be pushed upward freely; but by the closing of this valve when a downward movement is commenced, the motion is greatly retarded, the rate of movement being determined by the rapidity of leakage of the glycerine past the piston *d*. This piston being made long, as before explained, renders the leakage very gradual, even when the piston does not fit very closely in the tube. Thus the descent of the tube C is very gradual, while its upward movement is free.

The valve *d′* in the piston *d* may be dispensed with, thus retarding both upward and downward movement of the tube C; but this is inconvenient when putting new carbons in the holder L′, and is otherwise objectionable.

If the rod C is forcibly drawn down for any reason, a vacuum will be formed under the piston *d*, and the glycerine above the piston might overflow the tube, were it not for the enlargement of the latter at its upper end. This enlargement affords a reservoir for holding the glycerine in the case, as above described.

E, Fig. 1, is an arm or lever, of metal, provided at one end with a cylindrical cross-piece, of steel or other suitable material, *f*, as shown in plan in Fig. 3. The projecting ends of this cross-piece are formed into blunt knife-edges, as shown.

A wire, i i^1, of suitable size, and preferably of soft steel, is passed through a small hole in the central part of the cross-piece or fulcrum *f*, and each half of the wire is then passed once or twice around the cylindrical portion of the cross-piece in opposite directions. The ends of this wire are then carried up and attached to the studs *g g'*, as shown in Fig. 1. These studs are threaded, and provided with nuts above the frame B, as shown. The stud *g'* is insulated from the frame B by means of a suitable bushing in the hole through which it passes, but is electrically connected with the binding-post P.

H is a very stiff spring, of steel or other metal, attached to the frame A, and split at its free end, so as to engage with and form a support for the knife-edges at the extremities of the fulcrum *f*. The wires *i* i^1, being sufficiently strained by means of the screw-studs *g g'*, hold the lever E firmly against the spring H, and in the position shown in the figure.

D is a ring-clamp or washer surrounding the tube C, and adapted to clamp and lift the latter when one side of the clamp is raised. *h* is a lifting-finger pivoted to the lever E, and adapted to lift the washer D when the free end of the lever E is raised. *n* is a flexible metallic connection between the lever E and frame A.

When the binding-posts P N are connected with a suitable source of electric current the path followed by said current will be as follows: From post P to stud *g'*, thence through wire i^1 to lever E, then through *n* or H, or both, to frame A, tube C, carbons F' F, and rod *a*, to post N.

Under these conditions the wire i^1 will become more or less heated by the passage of the current through it, and will expand accordingly, while the wire *i* remains as before. The cylindrical portion of the fulcrum *f*, being partially relieved of its support on one side, will be carried downward by the powerful spring H, the free end of the lever E will be raised, and with it the lifting-finger *h*, clamp D, tube C, and carbon F', thus establishing the electric light between the carbons.

The amount of separation between the carbons may be adjusted by varying the relative tension of the wires *i* i^1 by means of the screw-studs *g g'*.

As the carbons burn away the current will diminish, owing to the increased resistance of the voltaic arc; the wire i^1 will become less hot, and will accordingly contract. The free end of the lever E will descend, and the carbon F' will move downward until the increased current caused thereby expands the wire i^1 and checks the movement. When the clamp D reaches the frame A under it, it will allow the tube C to slide through it until the increased current, due to the approach of the carbons, causes the washer D to again clamp and retain the tube C.

It will now be seen why the dash-pot arrangement of the tube C is provided; for if this provision were not made the tube C, being once released by the clamp D, would force the carbons entirely together before the clamping device could have time to act. The slow downward movement of the tube C prevents this accident.

A notable feature of my invention, as above described, is the use of two wires, *i* i^1, of the same metal. This feature I style my "compensating device." It insures the normal working of the apparatus at all temperatures, since it is the difference in temperature between the wires *i* i^1, and not the actual temperature of i^1, which determines the working of the apparatus.

In practice, the wires *i* i^1 are from fifteen to twenty inches long, and a difference in temperature between them of 200° Fahrenheit is ordinarily sufficient to operate the device. In ordinary working the temperature of the whole apparatus gradually rises considerably, and, of course, the absolute temperature of the wire i^1 augments accordingly, and were it not for my compensating device the operation of the regulator would be seriously affected.

Fig. 4 shows one of several forms of device in which but one wire, i^1, is employed. This device will obviously perform all the functions described in connection with Fig. 1, except compensation for changes of general temperature.

The wires *i* i^1 may be replaced by thin ribbons of metal, and this is even desirable, so far as that portion which passes around the fulcrum *f* is concerned, on account of greater flexibility; or this part may be ribbon and the rest wire.

The wire i^1 may be surrounded by a long helix, through which the current passes, while being itself insulated from the current, and thus be heated indirectly by the latter. Fig. 5 shows such a modification.

Instead of employing wires *i* i^1, as in Fig. 1, I may use narrow sheets of metal connected rigidly together, side by side, and insulated from each other both thermally and electrically.

The pair may be used straight, curved, or coiled, as in Fig. 6, which shows this form of my invention. Here the expansion of the inner strip of metal, i^1, by the heat due to the passage of current through it, while the outer strip, *i*, remains unheated, operates to raise the lifting-finger *h*. This arrangement of parts evidently embodies my compensating device, and is a mere modified form thereef.

Fig. 7 shows a device similar to Fig. 6; but the strips of metal *i* i^2 are of different metals, expanding unequally on the application of heat. They are riveted or soldered together, the metal i^1 being the more expansible of the two, and are both heated either by the passage of current through them, or by the passage of current through a helix surrounding them, as shown in the figure.

The operation of the device is evident, but it lacks the compensating feature, which was retained in the device shown in Fig. 6.

My invention, so far as described, is equally useful with rapidly intermittent, alternating, or continuous currents; but it is especially adapted for alternating currents where magnet-regulators are not available.

When two or more regulators, such as I have described, are operated in a single circuit, conveying an alternating current, they will work irregularly, the same as other regulators of ordinary form with a continuous current. The reason for this irregularity of action is fully explained in Letters Patent No. 212,183, granted to me February 11, 1879.

In my present device I correct this irregularity of action by means of the adjusting-helix I, Fig. 1. The ultimate effect of this helix in my present device is the same as that of the adjusting-helix I, described in the Letters Patent above referred to; but its operation is entirely different.

The helix I, Fig. 1, is composed of many convolutions of fine wire, the ends of which are connected respectively with the binding-post N, and, through the stud g' and its connections, with the binding-post P. Thus the helix forms a constantly-closed circuit between the binding-posts P N. Two passages are thus afforded to the current through the regulator—one of comparatively low resistance through the carbons, &c., the other of comparatively high resistance through the helix I—the amount of current passing through each channel being inversely as its actual resistance; but the actual resistance of the helix I is much greater for rapidly-alternating currents than for continuous currents, owing to the inductive action of each convolution of the current on its neighbors in the former case. This disturbing element must be considered when calculating the dimensions of the helix.

The helix is wound on an insulating-spool, which very loosely surrounds the wire i, which, in this case, is made of iron or steel.

Now, when the regulator is operated by a rapidly-alternating electric current, magnetism of rapidly-alternating polarity will be induced in the wire i, which will thus become heated to a certain extent.

The number of convolutions of the helix I and its actual resistance are so arranged that the heat developed by the alternating magnetism in the wire i shall be less than the heat developed in the wire i^1 by the passage of the main current through it when the voltaic arc between the carbons is of normal length. Here, as formerly, the difference in temperature between the wires i i^1 determines the operation of the regulator.

Suppose, now, that the carbons burn away until they are more than their normal distance apart, the current will not be materially lessened when several regulators are in circuit, and the wire i^1 will maintain its temperature, thus holding the carbons apart; but, owing to the increased resistance of the voltaic arc, more current will be shunted through the helix I, the alternating magnetism of the wire i will be increased, and consequently its temperature. This is equivalent to a reduction of temperature in the wire i^1, and the carbon F′ is allowed to move downward. On the other hand, if the carbons approach too near together less current will pass through the helix, the wire i will become cooler, which is equivalent to an increase of temperature in the wire i^1, and the carbon will be separated. Thus, by means of the adjusting heating-helix I, any number of these regulators may be operated uniformly on a single suitable alternating current.

When a large number of regulators of any kind are operated directly by a single electric current, the danger of extinguishing all by breaking the circuit in any one is considerable; and in view of this fact I shall briefly, and in a general way, refer to a method for correcting this objectionable feature. It is my purpose, however, soon to apply for separate Letters Patent upon the system, or what may be termed the "inductive method," which I shall presently refer to, and therefore I do not waive, on account of what I shall now describe, any right to a subsequent application for patent upon such device or method. By combining my "expansion-regulator" (as I have styled the one above described) with a suitable form of dynamic induction apparatus, and using a rapidly-alternating current, I avoid this danger, since in this case the main circuit through which the current passes is unbroken under all circumstances.

Figs. 8 and 9 of the drawings show in a diagramatic manner a battery, or preferably a dynamo-electric machine, Z, designed to maintain a current through the circuit Z^1. It is commonly the practice to cut the circuit Z^1 and introduce into it one or more electric lamps, in such a manner that the current through said circuit Z^1 shall pass through and directly operate them. Instead of so doing, however, I propose, if desired, to operate the lamps by an induced current due to and generated by the current of the circuit Z^1.

I shall not here specify any particular electro-induction apparatus, reserving such a description for a proposed subsequent application, as above stated.

It is well known that when an electric current is started in one of two parallel and adjacent conductors an inverse current is induced in the other conductor, lasting only until the inducing-current has obtained its maximum strength; and that when the inducing-current is stopped or diminished a direct current is induced in the neighboring conductor. I propose to utilize these facts in the construction of my induction apparatus alluded to, whereby a current through the circuit Z^1 will set up an induced current in each circuit Z^2 of an electric lamp, Z^3, as diagramatically illustrated in Figs. 8 and 9. By such an arrangement and system as just intimated, and as suggested in Figs. 8 and 9 of the drawings, several lights might be operated upon a single circuit, and the removal or extinguishing of any one or more from any cause whatever would not materially affect the operation of any other lamp that might be operated by the current through the circuit Z^1.

Having now, for the purposes of the present specification, sufficiently alluded to the induction system suggested in Figs. 8 and 9 of the drawings, and having hereinbefore alluded to the fact that my invention is equally applicable to lamps employing a to-and-fro, a pulsating, or a constant current, I shall now briefly explain how my invention may be embodied in a lamp suitable for a continuous current operating more than one lamp; and for this purpose I have shown two forms of device in Figs. 10 and 11 of the drawings.

In Fig. 10 the wire i^1 is placed in the general circuit, and is made of sufficiently high resistance to be heated by the current operating the lamp, and the difference in temperature between the wires i i^1 and the consequent difference in expansion and length of said wires, as before pointed out, is the direct means whereby the lifter D is moved.

In the form of lamp shown in Fig. 10, I is an adjusting-helix, which is always in closed circuit, and the amount of current passing through it is always regulated by the resistance of the voltaic arc—that is, if the voltaic arc becomes too long, and thereby offers an abnormally great resistance, the current is increased through the helix I, and vice versa, as already explained in Fig. 1. This helix is made to attract an armature, I′, which is pivoted to the lamp and electrically connected with the general circuit.

i^2 is a branch wire from the wire i', and it is made to terminate just above the armature I^1 as it rests in its open-circuit position.

The operation of the device, as just described and shown in Fig. 10, will be as follows: The difference in tension between the wires i and i^1, due to the heating of the wire i^1 by the current operating the lamp, will act to raise the lifter D, as already specified, in the to-and-fro-current type of lamp. So long as the voltaic arc does not offer any abnormally great resistance, the parts will be substantially in the relative positions shown in the drawings, Fig. 10; but when, for any reason, it is necessary that the lamp should feed, or that the lifter D should descend, or the wire i^1 made cooler, such a necessity will result in a condition of things that will cause an increased current through the helix, sufficient to draw up the armature I′ until it comes into electrical contact with the branch wire i^2. This will greatly diminish the current passing through the wire i^1, and its heat will be consequently and correspondingly decreased, and this will result in a re-establishment of normal relation between the carbons and other parts to put the lamp again in proper operation. And now, the current having a sufficiently free passage through the carbons, the magnetism of the helix I will be so weakened that the armature I′ will be released, and break the circuit through the branch i^2, and now the current passing through the wire i^1 will again heat it. This operation is manifestly equivalent to cooling the wire i, as it is the relative temperatures of the wires i and i^1 that determine their relative tension, and, consequently, their lifting action upon the carbon-separating apparatus.

I have, in Fig. 10, shown how the wire i^1 may be cooled by automatically shunting its heating-current from it as necessary. This function or equivalent is susceptible of being performed in a variety of ways—as, for instance, by any arrangement such as the interposition between the armature I′ and branch wires i^2 of a variable resistance, governed by the condition of the voltaic arc and the resulting magnetism of the helix I; or the heat of the wire i^1 may be governed by purely mechanical contrivance, and one such arrangement is shown in Fig. 11, where the wire i^1 is surrounded by a tube.

The relative positions of the wires i i^1, Fig. 11, are modified as shown merely for convenience in locating and applying the tube i^3. This tube i^3, in the form shown in the drawings, is held stationary in the frame of the lamp, and is closed at its bottom by any suitable valve arrangement operated by a magnet-lever, which is moved by the attractive force of the helix I. Now, as the wire i^1 needs cooling for purposes before pointed out, the current through the helix I will be sufficient to draw up the magnet and open the valve at the bottom of the tube i^3, thus admitting air into said tube, and allowing the inclosed wire i^1 to cool, for when the tube i^3 is closed the loss of heat from the wire i^1 is greatly impeded, and a given amount of current will more rapidly and intensely heat it than though it were freely exposed to the air. Thus, by governing the circulation of air around the wire i^1 in any manner, its temperature may be controlled so as to insure a proper operation of the lifter D according to the varying conditions of the voltaic arc.

When the character of the current operating the lamp is such that the wire i^1, in order to be sufficiently heated, is too small to be of sufficient strength, one or more similar wires may be added to it, so connected with other parts of the apparatus that the current shall pass through them successively. Thus the strength of as many wires as may be necessary will be secured.

As respects the heating of the wires i or i^1, or their equivalent, I do not limit myself, as my invention consists in any appropriate method of accomplishing this heating, which might be accomplished by a shunt-current, either constant, pulsating, or alternating, or by the adjusting-helix, as shown, or by a variety of other methods; nor do I limit myself to any specific method of controlling the movement of the carbon rod or holder C by a dash-pot or equivalent contrivance. This may be effected by making the carbon-holder itself the cylinder of the dash-pot, as shown in Fig. 1 of the drawings; or, as shown in Figs. 12, 13, and 14, the carbon-holder may have a sufficiently slow and steady movement by any suitable connection with a dash-pot placed adjacent to it.

Fig. 12 of the drawings illustrates one method where a carbon or carbon-holder, L′, is connected with a dash-pot, C *d*, by a belt-and-pulley arrangement. Fig. 13 illustrates the same arrangement, where a pulley might be dispensed with; and Fig. 14 represents a belt-and-pulley connection between dash-pot and carbon, wherein a dash-pot of a shorter length than in the forms shown in Figs. 12 and 13 might be used.

What I claim is—

1. In combination with the wires i i^1, or their equivalent, an adjusting-helix, I, or its equivalent, through the influence of which the wires i i^1 are maintained at suitably different temperatures, substantially as and for the purposes described.

2. In an electric lamp wherein the carbon-moving apparatus is actuated by the expansive action of heat upon some portion of said apparatus, the wires i and i^1, or their equivalents, adapted, as required for the varying conditions for maintaining a continuous and steady light, to be differently heated, said difference of heating automatically caused and controlled substantially as and for the purposes described.

3. An electric lamp wherein the separation and government of the carbons are effected by reason of the difference in temperature between the wires i i^1, or their equivalent, substantially as and for the purposes described.

4. In an electric lamp, the combination, with a moving carbon or its holder, of a clamp constructed to grasp and move said carbon or carbon-holder, and, in connection with said clamp, suitable mechanism adapted to be set in motion or controlled by the expansive effect of heat generated by the electric current operating the lamp, substantially as shown.

5. In an electric lamp, the combination, with a moving carbon-holder, of a tube, C, said tube constituting the body or cylinder and a moving element of the dash-pot, substantially as shown.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

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