No. 654,277. Patented July 24, 1900.

H. PIEPER, FILS.

ELECTRIC ARC LAMP.

(Application filed Dec. 28, 1897.)

(No Model.) 2 Sheets—Sheet 1.

Fig. 2.

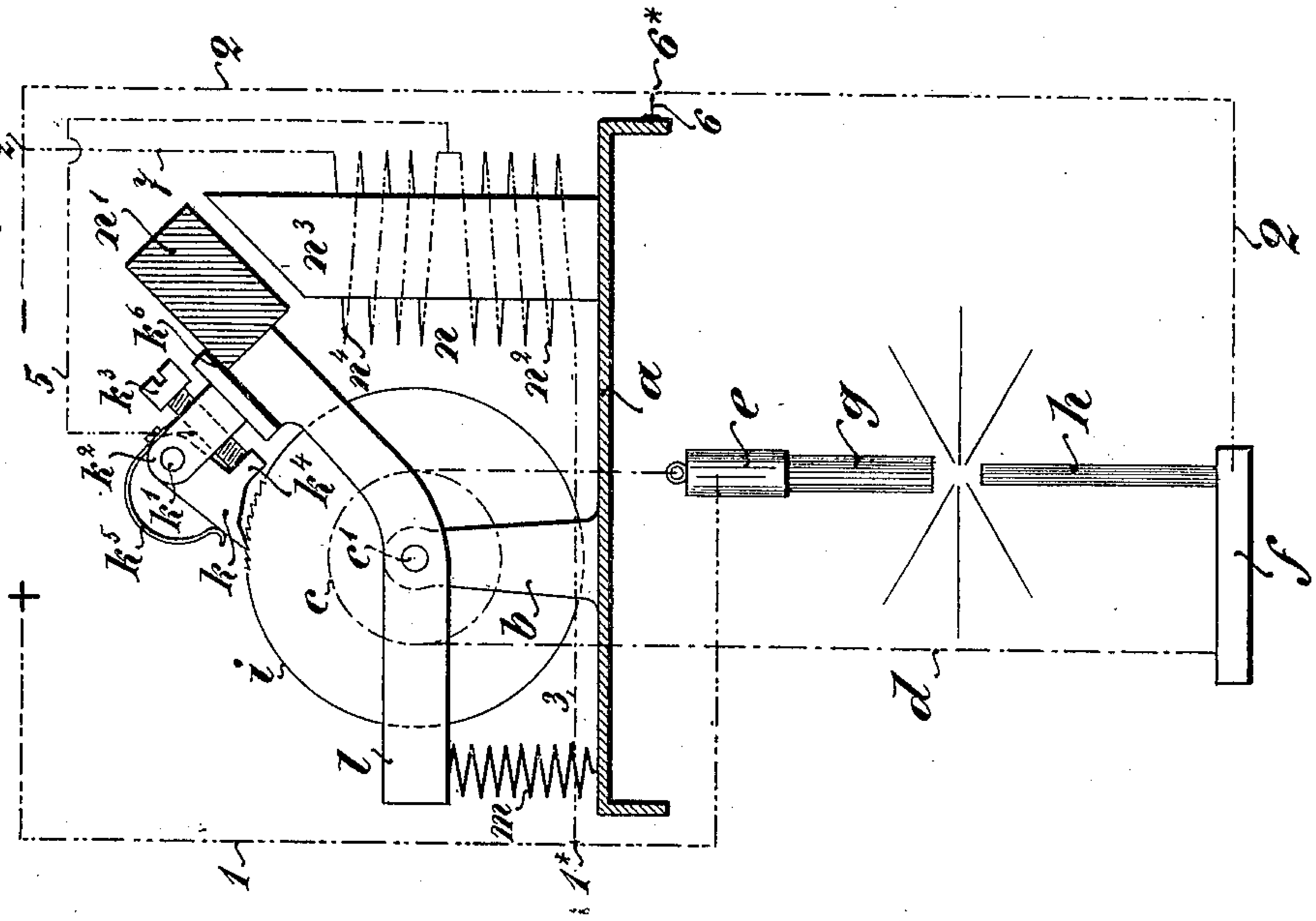
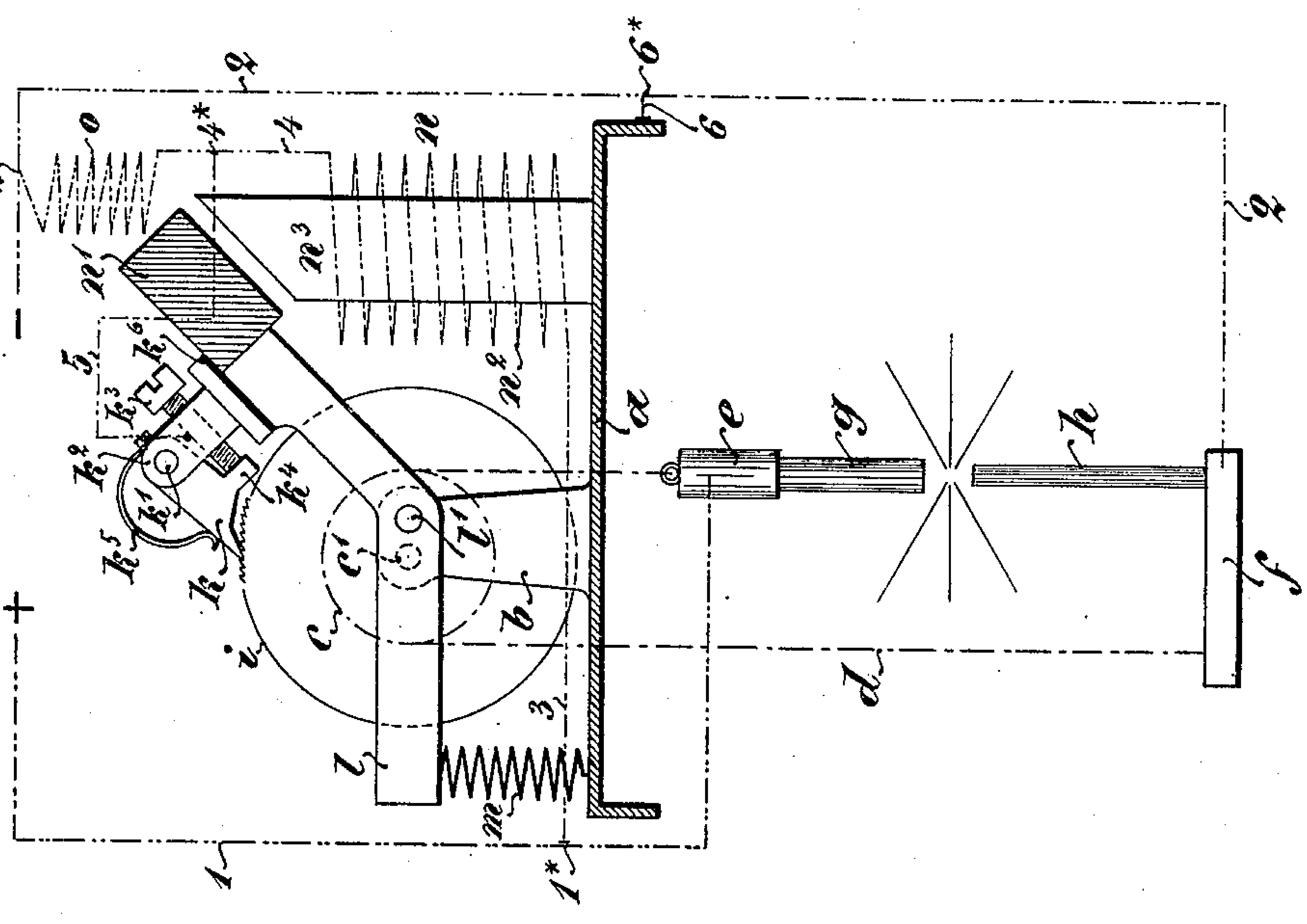


Fig. 1.



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Henri Pieper fils
by Marcellus Bailey
his attorney.

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

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Fig. 4.

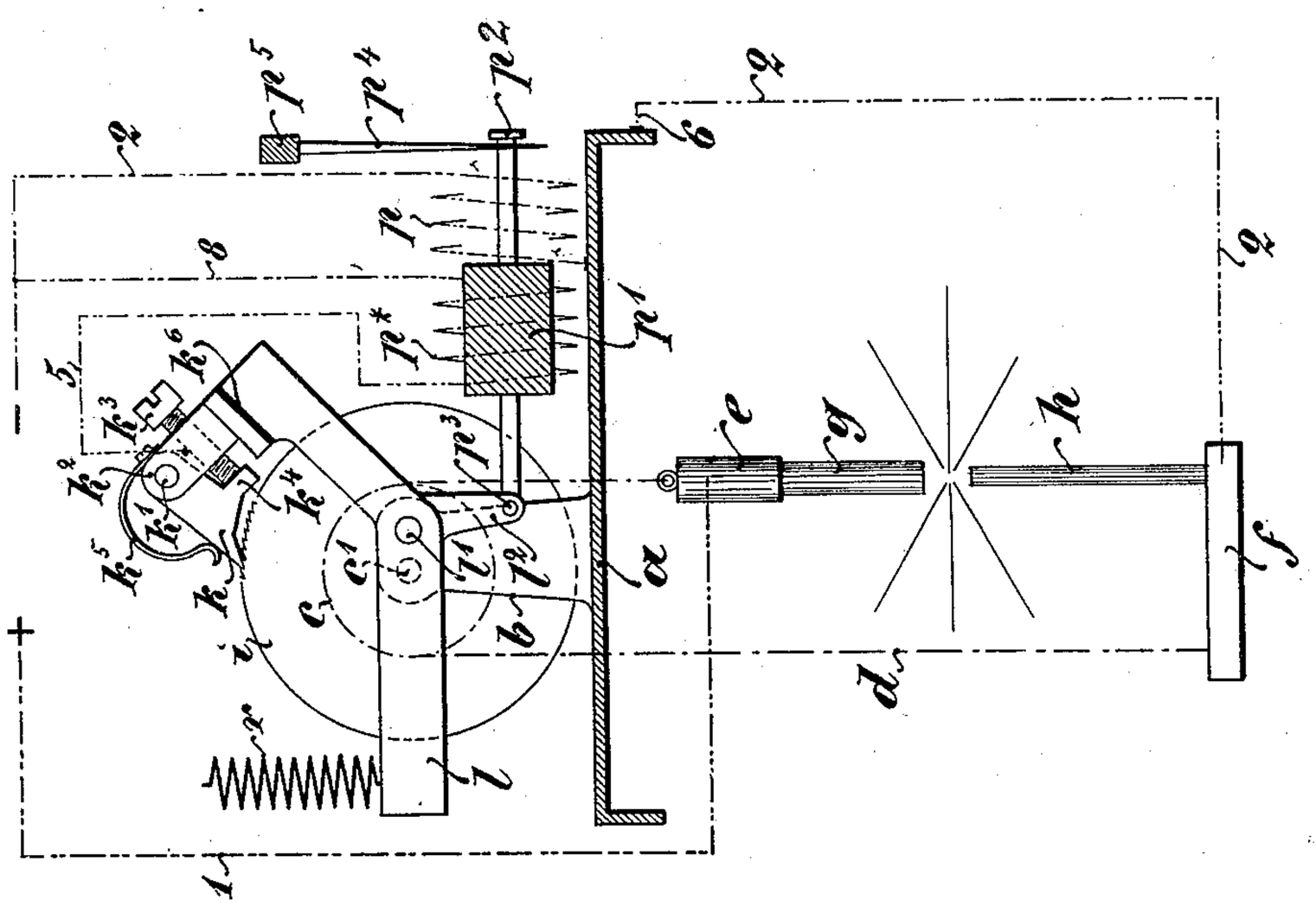
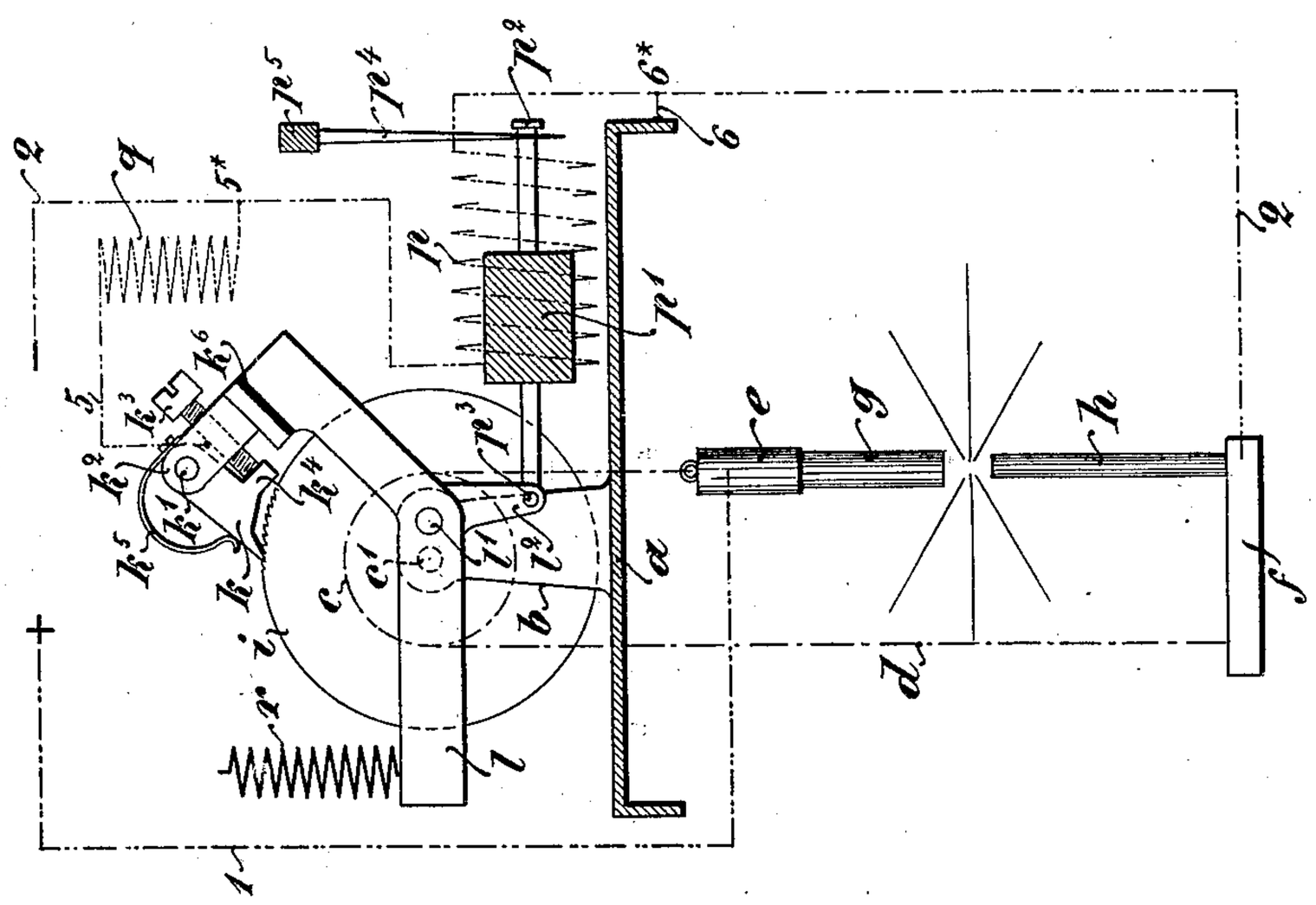


Fig. 3.



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UNITED STATES PATENT OFFICE.

HENRI PIEPER, FILS, OF LIEGE, BELGIUM.

ELECTRIC-ARC LAMP.

SPECIFICATION forming part of Letters Patent No. 654,277, dated July 24, 1900.

Application filed December 28, 1897. Serial No. 663,825. (No model.)

To all whom it may concern:

Be it known that I, HENRI PIEPER, Fils, a subject of the King of Belgium, residing at Liege, in the Kingdom of Belgium, have invented a new and useful Regulator for Electric-Arc Lamps, (for which I have obtained patents in Belgium, dated December 17, 1895; in Austria, No. 3,575, dated September 16, 1896; in Hungary, No. 7,348, dated February 19, 1896; in Great Britain, No. 11,230, dated May 22, 1896, and in France, No. 257,248, dated June 15, 1896,) of which the following is a specification.

The present invention relates to electric-arc lamps in which the regulation of the arc is automatically effected in such a manner that a catching member for a running member fixed to the holder of the upper carbon, which is movable vertically, is subjected to the simultaneously but oppositely acting forces of a spring or weight and the core of an electromagnet or solenoid, the force of said core being varied by the variations which occur in the length of the arc. According as one or the other of the two forces overcomes the other one the catching member will either be engaged with the running member or withdrawn. The withdrawal allows the upper carbon to descend by its own weight to approach the lower carbon, which is either retained in a fixed position or caused to ascend by being connected with the upper one through a cord or chain passing around a pulley or through a rack-and-pinion connection or other known means.

My aim is to so organize the regulating apparatus that the regulation is caused to begin the very moment the normal length of arc is altered, to continue, if required, by a series of as minute steps as possible, and to discontinue the very moment the normal length of arc is reëstablished, so that the regulation may be said to perform in a practically-continuous manner.

In order to obtain the result aimed at, the present invention essentially consists in combining with the usual electric connections of the regulating-coil a shunt, placing the catching and running members of the regulating apparatus in that shunt as coöperating contact-pieces for opening and closing the same, and providing means for so altering the force of the regulating-coil by the opening of the said shunt as will be required for at once causing the catching member to be reëngaged into the running member to relock the upper carbon, and thereby reclose the shunt. It is easily to be understood that by this arrangement I am enabled to avail myself of the catching member for the direct administration of the regulating-current without sparking being caused to take place between the contact-pieces. As this suppression of the sparking allows the course or lifting of the catching member to be reduced to such a minimum distance as will just suffice for clearing the running member, the relocking of the upper carbon can be effected without shock instantaneously. Moreover, a rack or a toothed wheel can be used as the running member in order to render the steps uniform without interfering with the minuteness of the steps, since the practically-imperceptible interval between break and make of the contact allows the teeth to be as fine as possible.

The invention can be made use of in lamps the regulating-coil of which is placed in a shunt to the arc as well as in lamps in which said coil is placed in the arc-circuit proper.

For altering or modifying the force of the regulating-coil I may use a resistance-coil or an additional magnetizing-coil and apply the same so as to exert a strengthening or a weakening influence upon the regulating-coil without departing from the spirit of the present invention, as one of said means is only an equivalent for the other in consideration of the like effect, which is the instantaneous relocking of the upper carbon.

In order that my invention may be fully understood, I will proceed to describe the same in a more detailed manner, reference being made to the accompanying drawings, which illustrate some modes of carrying out my invention.

The type of arc-lamps taken as an example is the well-known one in which the carbon-holders, of which the upper one is heavier than the lower one, are attached to the ends of a cord or chain passing around a pulley, with which is combined a ratchet-wheel retained by a pawl as long as the arc is of normal length, so that when the pawl is withdrawn the upper carbon becomes active as a

weight and turns the pulley whereby the carbons are fed toward each other.

Figure 1 is a diagram of a lamp of which the regulating-coil, being the coil of an electromagnet, is placed in a shunt to the arc, the force of the magnet being reduced through the medium of a resistance-coil which is inserted between the regulating-coil and the negative lamp-terminal by the break of contact between the ratchet-wheel and pawl. Fig. 2 is a diagram of a lamp of like description, the reduction of the force of the regulating-coil being produced by a reversely-wound coil on the electromagnet-core. Fig. 3 is a diagram of a lamp of which the regulating-coil, being a solenoid-coil, is placed in series with the arc, the force of the regulating-coil being strengthened by the withdrawal of the pawl from the ratchet-wheel allowing the full current to act as a magnetizing-current. Fig. 4 is a diagram of a lamp of like description, the force of the solenoid-coil being strengthened by the break of contact cutting out a reversely-wound additional coil on the core.

In all the figures like parts are denoted by like characters.

With reference to Fig. 1, a is the usual base-plate for supporting the regulating apparatus and other appliances. b is one of a pair of bearings secured to the base-plate, in which is mounted the pulley c, supporting the cord or chain d, to the ends of which are attached the carbon-holders e and f, with the carbons g and h. Fixed to the spindle c' of pulley c or to the latter is a ratchet-wheel i, having very fine teeth. The pawl k, coöperating with said wheel, is pivotally mounted at k' in a little post k^2, secured to the upper face of the upwardly-inclined right-hand arm of a bent lever l, which is pivoted at its elbow in the bearing b at l'. The left-hand arm of lever l is fixed to the upper end of a spiral spring m, fixed with its lower end to the base-plate and tending to engage the pawl into the ratchet-wheel. To the end of the right-hand arm of lever l is secured the armature n' of an electromagnet n. n^2 indicates the coil, and n^3 the core of this electromagnet. The core n^3 has its upper end beveled in accordance with the inclination of armature n'. The pawl k is well insulated from both the lever and the armature, as indicated by the thick line k^6. The distance between the working edge of the pawl and the teeth of the ratchet-wheel is adjustable by means of a fine-threaded screw k^3, having its nut in the post k^2 and projecting through the latter so as to form a butt for the tailpiece k^4 of the pawl, the latter being held against said butt by a spring k^5, fixed to the post k^2. The arc-circuit of the lamp is as follows: from the positive terminal through conductor l to the upper-carbon holder e, and from the lower-carbon holder f through conductor 2 to the negative terminal. The usual shunt is from conductor 1 through conductor 3, branched off at $1^\times$, electromagnet-coil n^2, conductor 4, and resistance-coil o to a point $2^\times$ of conductor 2. The additional shunt is from conductor 2 at a point $6^\times$, through conductor 6, base-plate a, and bearing b to ratchet-wheel i, and from pawl k through conductor 5 to a point $4^\times$ of conductor 4. Supposing the lamp be burning with the pawl engaged into the ratchet-wheel, then the regulating-current flows from $1^\times$ through conductor 3, coil n^2 of electromagnet n, conductor 4, conductor 5, pawl k, ratchet-wheel i, bearing b, base-plate a, and conductor 6 to conductor 2. If the current is cut off, the electromagnet becomes demagnetized and the spring m pulls down the left-hand arm of lever l, so that pawl k turns the wheel i to the left, and thereby moves the carbons apart from each other. The parts remain in this position until current is admitted anew. When current is admitted, it cannot take its way through the carbons, but is caused to pass through conductor 3, electromagnet-coil n^2, conductor 4, conductor 5, pawl k, ratchet-wheel i, bearing b, base-plate a, and conductor 6 to conductor 2, and out through the negative terminal, with the effect of strongly magnetizing the core n^3, which suddenly attracts the armature n' against the pull of spring m, and thereby at once pulls down the right-hand arm of lever l, with the effect of withdrawing the pawl from the ratchet-wheel, so that the current passes from electromagnet-coil n^2 through resistance-coil o to conductor 2, and the ratchet-wheel turns to the right under the pull of the upper carbon acting as a weight and the carbons approach each other. At this moment the weakening effect of resistance o is, however, not sufficient for allowing the spring m to overcome the magnetic attraction and to replace the pawl into the ratchet-wheel, but the carbons will move closely together and make contact with each other. This contact has the effect of fully diverting the current from the regulating-coil n^2, the whole current passing directly from conductor 1 through the carbons to the conductor 2. The electromagnet becomes consequently demagnetized and the spring m at once pulls down the lever-arm, so that the pawl engages with the ratchet-wheel, turning the same to the left, whereby the carbons are moved apart from each other with formation of the arc and reëstablishing the circuit through the electromagnet. This moving apart of the carbons continues until the magnetization of the core n^3 has become so strong as to balance the pull of spring m. The arc has then its normal length. When the arc grows beyond its normal length by the burning away of the carbons, more current is allowed to flow through the electromagnet, whereby the same is caused to attract the armature, with the effect of withdrawing the pawl from the ratchet-wheel, so that the carbons are allowed to approach each other. The very moment, however, the contact is broken between the pawl and the ratchet-

wheel the current is caused to take its way through the resistance-coil *o*, connected in series with the electromagnet-coil n^2, whereby the magnetization of the electromagnet-core is so much reduced that the spring *m* can at once reëngage the pawl into the ratchet-wheel, thereby locking the carbon and reëstablishing the shunt around the resistance-coil. Should this first regulation not suffice for restoring the normal length of arc, and consequently the normal magnetization of core n^2, then the reclosure of contact *i k* will allow the electromagnet to again attract the armature with the same result as before, and so on until reëstablishment of the normal length of arc is obtained.

Break and make of the contact between the pawl and the ratchet-wheel follow each other so rapidly that the ratchet-wheel is allowed to turn by one tooth only.

If from any cause, as by the accumulation of particles of the upper carbon upon the lower one, the length of arc should become too short, this would have the effect of diverting more current from the contact *k i*, so that the attraction of the electromagnet would be reduced, and consequently the spring *m* allowed to move the carbons apart by turning the ratchet-wheel to the left until reëstablishment of the normal length of arc is obtained and the magnetization so strengthened as to balance the spring.

It will easily be understood by any electrician that the simultaneity of the break of contact *k i* and the continuation of the current-passage through the coil *o*, as well as that of the make of said contact and the shunting of the resistance *o*, prevents any sparking from taking place between the pawl and the teeth of the ratchet-wheel, and thus constitutes a safeguard against the burning away of those parts; that, moreover, owing to the suppression of said sparking the distance the pawl has to be lifted away from the ratchet-wheel can be made such a minimum distance as is just sufficient for releasing the ratchet-wheel, and that consequently the relocking of the latter can take place without shock so rapidly that said wheel is allowed only to turn by the width of one tooth.

The lamp represented in Fig. 2, which is in all other regards alike to the lamp shown in Fig. 1, differs from the latter in that instead of employing a resistance-coil, such as *o*, Fig. 1, for weakening the magnetization of electromagnet *n* the latter is provided with an additional reversely-wound coil n^4 of less windings than the magnetizing-coil n^2 proper, with which it is connected in series, the point of connection being in electric communication with pawl *k* through conductor 5. When with this arrangement the pawl *k* is engaged in the ratchet-wheel *i*, current passes from conductor 1 through conductor 3, electromagnet-coil n^2, conductor 5, pawl *k*, ratchet-wheel *i*, bearing *b*, base-plate *a*, and conductor 6 to conductor 2. When the pawl is withdrawn, the current passes from coil n^2 through coil n^4 and conductor 7 to conductor 2. As coil n^4 is reversely wound it at once reduces the magnetization produced by coil n^2, whereby spring *m* is allowed at once to reengage the pawl in the ratchet-wheel.

In Fig. 3 a lamp is shown the regulating-coil of which is placed in series with the arc. In this lamp a solenoid-coil *p*, with a movable core *p'*, is used instead of an electromagnet. The core *p'* is fixed upon a sliding rod p^2, the left-hand end of which is articulated in p^3 to a rigid arm l^2 of lever *l*. The right-hand end of rod p^2 is supported and guided in the lower end of a depending flat spring p^4, fixed with its upper end at p^5. As mentioned, the coil *p* is in series connection with the arc—that is to say, it is placed in or forms a part of the conductor 2. At a point $5^{\times}$ behind the coil electrical communication is established between the conductor 2 and the pawl *k* through a conductor 5, in which is placed a resistance-coil *q*. The ratchet-wheel *i* is in electric communication with the conductor 2 at a point 6* in advance of coil *p'* through bearing *b*, base-plate *a*, and conductor 6. The left-hand end of lever *l* is in this lamp fixed to the lower end of a spiral spring *r*, tending to withdraw the pawl *k* from the ratchet-wheel *i*. From this it results that when the lamp is without current the pawl is withdrawn, so that the carbons make contact with each other. When current is admitted to the lamp, it passes from the positive terminal through conductor 1, carbons *g h*, conductor 2, solenoid-coil *p*, and conductor 2 to the negative terminal and the core *p'* is at once drawn to the right, whereby the lever *l* is so turned that the pawl *k* engages with the ratchet-wheel *i* and turns the same to the left, so that the carbons are moved apart from each other with formation of the arc and part of the current allowed to flow from conductor 2 through conductor 6, base-plate *a*, bearing *b*, ratchet-wheel *i*, pawl *k*, conductor 5, and resistance-coil *q* back to conductor 2. In the beginning the amount of current thus diverted from the coil *p* is not sufficient for so weakening the force of the latter as is necessary for allowing the spring *r* to withdraw the pawl from the ratchet-wheel, so that the carbons continue to move apart until the arc is of normal length. During the establishment of the normal arc-length the diversion of current from the coil *p* augments, and consequently the attractive force of the latter decreases accordingly, and the moment the normal arc-length is arrived at said attractive force has become so reduced that it is balanced by the spring *r*. When the arc grows beyond its normal length by the consumption of the carbons, the flow of current through coil *p* will be reduced accordingly, so that the spring *r* overcomes the attractive force of coil *p* and withdraws the pawl from the ratchet-wheel, whereby the carbons are caused to approach each other. Now the moment the pawl is lifted the shunt

is opened, and consequently the whole current allowed to pass through coil p, with the effect of increasing its attraction, so that the pawl k is at once reëngaged into the ratchet-wheel, relocking the carbons and reclosing the shunt. Should this regulation not suffice, then the make of contact $k\ i$ will at once so weaken the force of coil p that it will be overcome by the spring r and the pawl lifted anew, with the result of allowing the carbons to approach by a further step and breaking the contact $k\ i$, the latter having the effect of strengthening at once the force of coil p' and relocking thereby the ratchet-wheel, and so on until the normal length of arc will be reestablished. Should the arc become too short, then the force of coil p will be so strengthened as to overcome the pull of spring r, and consequently to turn the ratchet-wheel to the left.

In Fig. 4, which represents a lamp of the same type as the one shown in Fig. 3, the arrangement is somewhat different in that the weakening of the force of coil p is brought about by the action of a reversely-wound additional coil p^* for the core p', said coil $p^\times$ exerting a weaker attraction than the coil p. The connections of the coils are as follows: from conductor 2 through conductor 6, base-plate a, coil p to conductor 2 and the negative terminal, from base-plate a through bearing b to ratchet-wheel i, and from pawl k through conductor 5, reversely-wound coil $p^\times$, conductor 8 to the negative terminal. When the current is cut off from the lamp, the pawl k is lifted and the carbons are close together. When current is admitted, all of the same passes through coil p, with the effect of at once engaging the pawl into the ratchet-wheel, moving the carbons apart from each other and forming the arc, all as described with reference to Fig. 3. When the pawl is engaged in the ratchet-wheel, part of the current will flow from base-plate a through bearing b, ratchet-wheel i, pawl k, and reversely-wound coil $p^\times$. However, this flow of current will not be sufficient for reducing the force of coil p to such an amount that the spring r could withdraw the pawl. Consequently the carbons will continue to move apart until the surplus of force of coil p is balanced by the spring r. When the arc grows beyond its normal length, less current will flow through the coils $p\ p^\times$ and the spring r thereby be allowed to lift the pawl, which results in causing the carbons to move together and cutting out the reducing-coil $p^\times$, whereby the force of coil p is so increased as to enable it to at once reëngage the pawl in the ratchet-wheel, thereby relocking the carbons and reclosing the circuit of coil $p^\times$, so that should this regulation not suffice the spring r can at once become active anew, and so on until the normal length of arc is obtained.

What I claim, and desire to secure by Letters Patent of the United States, is—

1. In an electric-arc lamp, the combination with a movable upper carbon, a lower carbon, the circuit connections for the carbons, a coil for controlling the movable carbon, of a shunt for the regulating-current, a ratchet-wheel having finely-divided teeth, and connected with the movable carbon, a pawl controlled by the oppositely-acting forces of a spring and the said coil for releasing, feeding back and relocking the said ratchet-wheel, and means whereby the break of said shunt has the effect of modifying the force of said coil, substantially as and for the purposes hereinbefore set forth.

2. In an electric-arc lamp, the combination with a movable upper carbon, a lower carbon, circuit connections for the carbons, and a coil for controlling the movable carbon of a shunt for regulating the current, a ratchet-wheel having finely-divided teeth, and connected with the movable carbon, and a pawl mounted on the upwardly-inclined arm of a bent lever pivoted at its elbow controlled by the oppositely-acting forces of a spring and the said coil for releasing, feeding back and relocking the said ratchet-wheel, substantially as and for the purposes hereinbefore set forth.

In testimony whereof I have hereunto set my hand in the presence of two subscribing witnesses.

HENRI PIEPER, Fils.

Witnesses:

L. Pauchenne, Jr.,

M. Preud'homme.