(No Model.) 2 Sheets—Sheet 1.

E. P. HOPKINS.

ELECTRIC ARC LAMP.

No. 573,464. Patented Dec. 22, 1896.

Fig. 2.

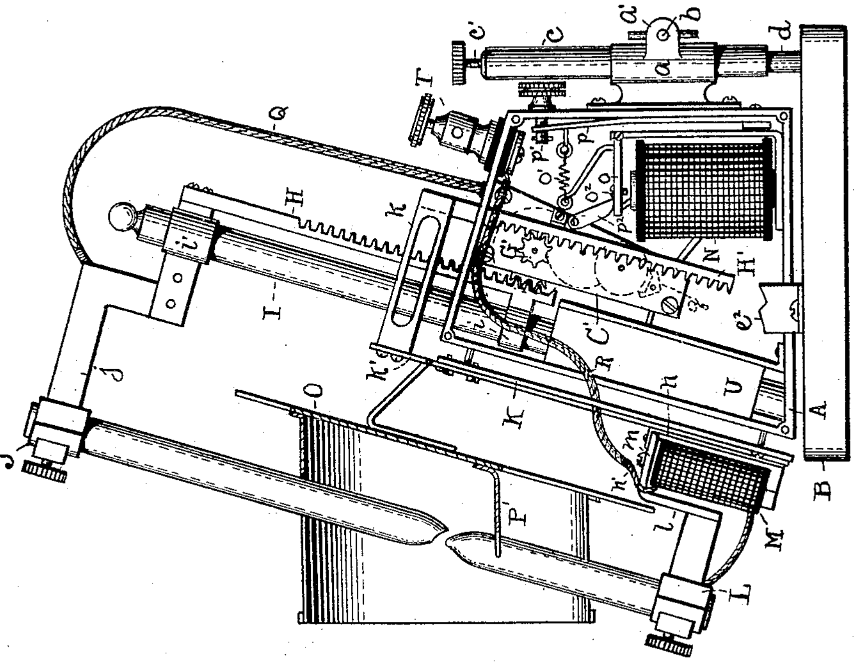
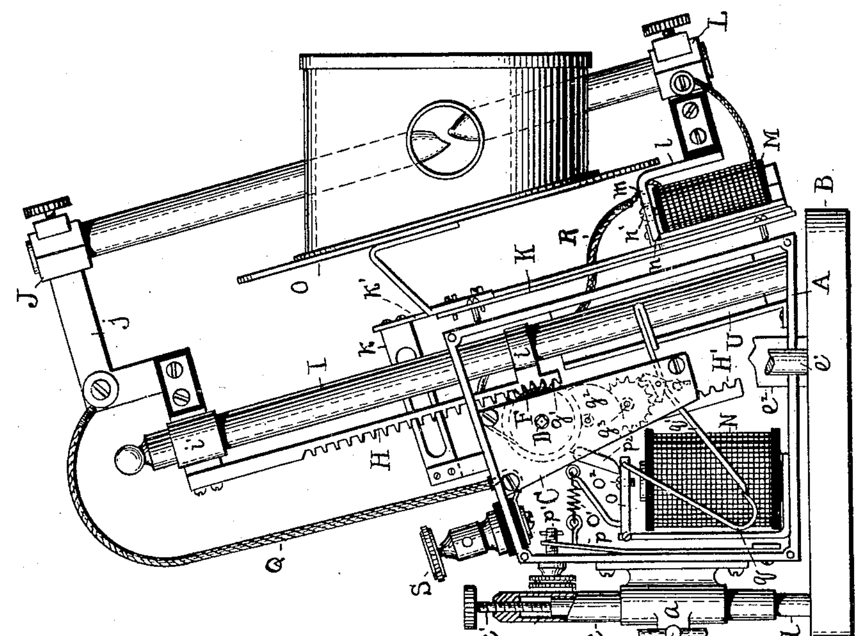


Fig. 1.



Witnesses
Norris A. Clark.
John R. Taylor.

Inventor
Edward Powell Hopkins,
By his Attorneys
Dyer & Driscall.

(No Model.)

2 Sheets—Sheet 2.

E. P. HOPKINS.

ELECTRIC ARC LAMP.

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Fig. 3.

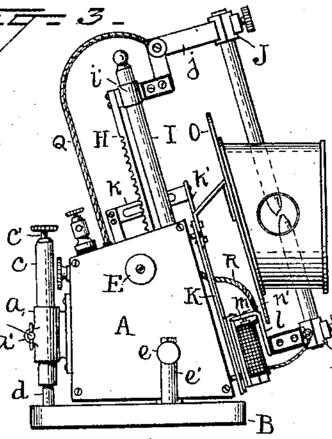


Fig. 4.

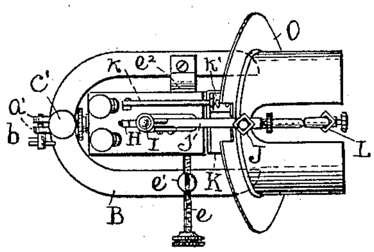


Fig. 5.

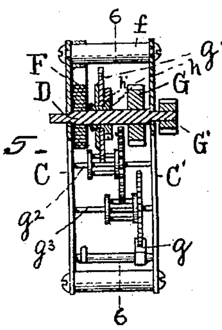


Fig. 7.

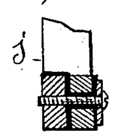


Fig. 8.

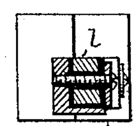


Fig. 6.

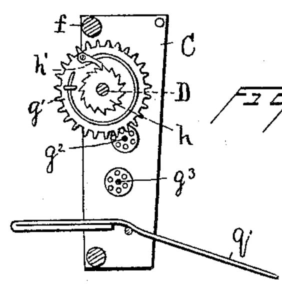
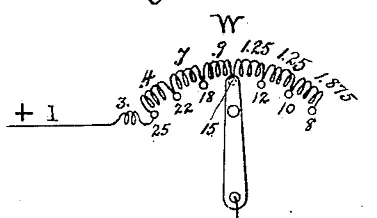
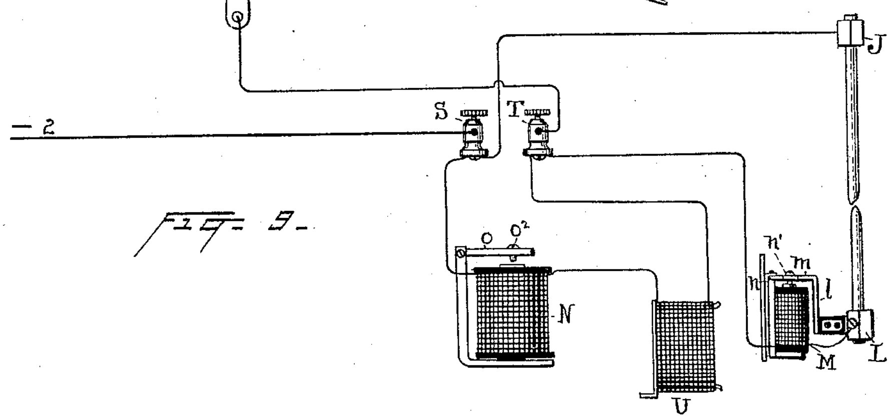


Fig. 9.

Witnesses
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John R. Taylor.

Inventor
Edward Powell Hopkins
By his Attorneys
Dyer & Driscoll.

UNITED STATES PATENT OFFICE.

EDWARD POWELL HOPKINS, OF NEW YORK, N. Y.

ELECTRIC-ARC LAMP.

SPECIFICATION forming part of Letters Patent No. 573,464, dated December 22, 1896.

Application filed June 13, 1894. Serial No. 514,372. (No model.)

To all whom it may concern:

Be it known that I, EDWARD POWELL HOPKINS, a British subject, residing in New York city, in the county and State of New York, have invented a certain new and useful Improvement in Electric-Arc Lamps, of which the following is a specification.

The object I have in view is to produce a small, compact, and light focusing electric-arc lamp, especially adapted for lantern projections, photography, and like purposes, which will give an absolutely steady light, can be used in any position, and the light of which may be increased or decreased at will without changing the regulation of the lamp itself, enabling the projection of dissolving effects with a stereopticon and adapting the lamp for stage-lighting and similar purposes. The regulation of my lamp is dependent upon a peculiar action of the electric arc hereinafter described, first observed by me or at least first utilized by me for this purpose.

My invention consists in the several devices and combinations more fully hereinafter explained, and pointed out by the claims.

In the accompanying drawings, forming a part hereof, Figure 1 is a side view of the lamp with the side plates of its inclosing case removed. Fig. 2 is a similar view from the other side of the lamp, the light-shield being in section. Fig. 3 is a side view of the lamp on a smaller scale with the side plate of the inclosing case in position. Fig. 4 is a top view of the lamp on the same scale as Fig. 3. Fig. 5 is a vertical section through the parts mounted on the main shaft of the driving-clockwork with the other wheels of the train in elevation. Fig. 6 is a vertical section on the line 6 6 in Fig. 5. Figs. 7 and 8 are sections showing the method of insulating the carbon-holders from their supports, and Fig. 9 is a diagram illustrating the circuit connections of the lamp.

The operative parts of the lamp are inclosed within or mounted upon a quadrangular box A of metal composed of a quadrangular frame and two side plates secured thereto by screws. For projection purposes, for which the lamp is especially designed, the box A is adjustably mounted upon a U-shaped stand B. For this purpose to the rear of the box A is secured, by a substantial foot, a split clamping-sleeve *a*, having on opposite sides of the split lugs *a'*, through which passes a screw *b* for operating the clamp by means of a suitable thumb-piece. The clamping-sleeve *a* slides upon a tube *c*, which is mounted on a post *d*, rising from the stand B. The upper end of the tube *c* is screw-threaded and receives a screw *c'*, which bears against the upper end of the post *d*. These parts give a vertical adjustment to the lamp, the clamp *a* being for the purpose of giving a proximate and quick vertical adjustment by moving the clamp up and down on the rod *d*, while the screw *c'* enables an exact adjustment to be secured. The lamp, being carried by the tube *c*, turns freely upon the post *d* to obtain a lateral adjustment, which lateral adjustment is produced by a screw *e*, passing through a post *e'*, rising from one side of the U-shaped stand and bearing against one side plate of the box, while from the other side of the U-shaped stand rises a leaf-spring e^2, which presses inwardly against the face-plate on that side of the box. By turning the screw *e* forward the box is pushed sidewise against the pressure of the spring, while by turning the screw backward the spring causes the box to follow the screw.

The carbons in my lamp are fed together positively, without regard to the position of the lamp, by a spring-motor having a fixed position and operated by a clock-spring having considerable initial tension. The clock-movement is carried by two plates C C', which are inclosed within the box and supported from its top. The clock-movement comprises a main shaft D, which projects beyond the plate C and has a squared end, on which is mounted a winding-wheel E, located outside of the box and having a hub extending through the face-plate C of the box for engaging with the main shaft. Upon this main shaft is secured the inner end of the driving-spring F, the outer end of this spring being attached to the stationary stud *f*. Upon the other end of the shaft D, on opposite sides of the plate C', are secured two pinions G G', engaging with racks H H' for feeding the carbons. The pinion G, which feeds the positive carbon, is larger than the pinion G', which feeds the negative carbon, the difference in size being proportional to the difference in the burning rate of the positive and negative carbons, *i.*

e., 1.66 to 1. This proportion is secured by making the pinion G one with twenty teeth and the pinion G′ one with twelve teeth. The pinions G G′ being fixed to the shaft D, the turning of that shaft by the winding-wheel E to wind up the spring will also turn the pinions G G′ and will move the racks H H′ in the direction of separating the carbon-holders. The reverse movement of the shaft D, under the effect of the spring F, will move the racks H H′ in the direction of feeding the carbons together.

To retard the feeding movement, the shaft D is connected by wheels and pinions with an escapement g, which is operated as the shaft D is turned by the unwinding of the spring F, but is not operated by the reverse movement of the shaft. To accomplish this, there is mounted loosely on the shaft D a gear-wheel g', engaging with a pinion on the shaft g^2, which shaft is provided with a gear-wheel engaging with a pinion on the shaft g^3, which latter shaft carries the scape-wheel. A ratchet-wheel h, fixed to the shaft D, is engaged by a spring-pawl h', carried by the gear-wheel g'. The pawl and ratchet permit the turning of the shaft D to wind up the spring F and move the racks H H′ for separating the carbon-holders without operating the escapement. The rack-bar H is supported at its ends by guide-collars i i', sliding on a round rod I, which extends from the bottom of the box through and above the top of the box. The collar i engages with the rod I within the box and the collar i' with the upper portion of the rod I above the box. The positive-carbon holder J is connected by an L-shaped arm j with the collar i', the parts being insulated, preferably with mica, as illustrated in Fig. 7. The rack-bar H is guided not only by the rod I, but also by the opening through the top of the box A, with which it makes an accurate fit. The rack H′, by means of which the negative carbon is fed, passes through and accurately fits a hole in the top of the box A. At its upper end it is rigidly connected by a cross-piece k with a vertical slide k', which is guided upon the face of a supporting-plate K, mounted upon studs and thimbles secured to the front of the box A, but separated therefrom by an air-space.

The slide k' carries at its lower end the negative-carbon holder L, which is mounted upon an L-shaped projection l, depending from the armature m of the series-wound striking-magnet M and insulated therefrom, as illustrated in Fig. 8. This magnet is preferably one having a winding only upon one leg of the magnet, and having the armature m pivoted upon the other leg of the magnet by means of a piece n of spring-brass, the play of the armature being regulated by a screw n', which passes through a slot in the armature and enters the other pole-piece, the head of the screw limiting the backward movement of the armature.

To regulate and control the feeding movement of the carbons, there is provided within the box an electromagnet N, having a high-resistance winding whose armature o is pivoted upon one leg of the magnet and is retracted by a spring o', whose tension is adjusted by a spring p engaging with a screw p', projecting through the rear of the box and having a milled head outside of the box for turning it. The forward movement of the armature o is regulated by a screw o^2 passing through the armature and striking the pole of the magnet, while the retraction of the armature is limited by a stop p^2, secured by a screw to the plate C′. The armature o carries a catch-arm q, which engages, when the armature is retracted, with the tail q' of the escapement-verge g, arresting the movement of the escapement and locking the train. When the armature o is attracted by the magnet N, the escapement is released and the train of wheels is run by the spring F feeding the carbons together. Upon the plate K is mounted the light-shield O, separated therefrom by an air-space and provided with a forwardly-projecting tubular shield, which is slotted at the top and at the bottom to permit the movement of the carbon and carbon-holders. Within the shield O and projecting horizontally forward from its back plate below the center of the shield, and hence below the arc, is an iron or steel plate P, which is cut out so as to partially encircle the negative carbon, which plate performs the double function of intercepting the passage of light downwardly through the slotted bottom of the shield and, by the magnetizing effect of the electric current, draws the arc inwardly and prevents it from flaming up on the face of the positive carbon. It also prevents the rising current of air from blowing directly on the arc.

Flexible cords Q and R extend from the binding-posts S and T through the top and front of the box, and are connected with the positive and negative carbon holders for conveying the electric current to them and through the coils of the striking-magnet M. The magnet N is located in another circuit between the binding-posts S and T, which circuit includes, preferably, an additional resistance U, which may, however, be omitted if the magnet N is made large enough and wound with a sufficient length of wire to give the amount of resistance required to prevent an excessive flow of current through the magnet-coils and a consequent burning out of such coils.

In general the operation of my lamp is effected by the initial separation of the carbons by the series magnet M (which separation causes the formation or striking of the arc) and by the subsequent feeding of the carbons together by the shunt-magnet N. The negative-carbon holder projects somewhat beyond the positive-carbon holder, so that the axis of the negative carbon is somewhat in advance of that of the positive carbon. The effect of this is to cause the formation of the crater of the arc in an oblique position on the forward side of the positive carbon and facing to the front, so that the light will be largely projected forward, and this effect is aided by arranging the carbons in an inclined position, as illustrated. The negative-carbon holder, being mounted upon a pivot, is moved by the striking-magnet in an arc of a circle, and the point of the negative carbon is therefore moved laterally and downwardly away from the positive carbon, following the lateral course which the arc takes in passing from one carbon to the other. The front of the lamp is effectively protected from the heat of the arc, first, by the light-shield O, and, second, by the front plate K. Since both of the racks enter the movement-box at the top and pass through openings which they fit closely, that box is made largely dustproof, and is also made more convenient for the mounting of the lamp.

Many advantages arise from the details of construction of my lamp, which it is not necessary to call attention to in detail.

The principle of regulation of my electric-arc lamp is based upon the fact observed by me from numerous experiments that the quantity of current or amperes flowing through the arc may be varied between quite wide limits without varying substantially the difference of potential at the arc itself—*i. e.*, that the difference of potential at the arc is independent of the quantity of current, or substantially so. If the arc acted like an ordinary resistance, the voltage would have to be increased in direct proportion to the amperes, according to Ohm's law, and if a difference of potential of forty-five volts was required to produce a flow of ten amperes, to increase the current to twenty amperes would require ninety volts, assuming that the resistance remained the same. The apparent resistance, however, I have found does not remain the same, but decreases with the increased current flow, and in some cases I have found that by increasing the current the difference of potential at the carbons is actually lessened. The phenomenon is explained, I think, on the theory that with a small current a greater percentage of the heat produced at the arc is conducted away by the carbons themselves than with a larger current, thus permitting with the larger current the formation of a proportionately larger amount of the conducting carbon vapor which exists in the arc.

In operating my lamp it is preferably connected with a constant-potential circuit 1 2 through an adjustable resistance W, as illustrated in Fig. 9. Assuming the voltage of the circuit 1 2 to be one hundred and twenty volts and the magnet N to be adjusted to maintain approximately forty-five volts at the arc, I have found that by adjusting the resistance W the current passing through the arc can be increased or decreased without changing the difference of potential at the arc itself or requiring any adjustment of the regulating-magnet N. The amount of current flowing through the lamp I have found to be almost exactly that which would be produced under Ohm's law by dividing the voltage found by deducting the constant voltage of the arc from the entire voltage by the number of ohms of the resistance W at the time in circuit. In other words, if the magnet N is adjusted to maintain an arc of forty-five volts, and considering the voltage of the circuit 1 2 to be one hundred and twenty volts, the difference between the two voltages will be seventy-five volts and the current flowing through the arc will be equal in amperes to seventy-five volts divided by the number of ohms of the resistance W which are in circuit.

In Fig. 9 I have given the resistance in ohms of the several sections of the resistance W above that resistance in the figure, and below the resistance the number of amperes are marked at the several contact-points. Thus if the arm of the rheostat is thrown to the first contact at the left of the resistance there will be three ohms in circuit and the current will be twenty-five amperes. If moved one point to the right, the resistance of W in the circuit will be 3.4 ohms and the current flowing through the arc will be twenty-two amperes, and so on. The effect of varying the current in the lamp is to vary the length of the arc, a shorter arc being produced for a smaller current; and this is an exceedingly desirable feature of my lamp, since it enables the brilliancy of the light to be varied for the production of dissolving effects for the stereopticon and for stage-lighting and like purposes by simply adjusting the resistance W.

What I claim is—

1. In an arc-lamp, the combination with the carbon-holders, of a spring clock-train, having an initial tension and mounted in a frame having a fixed position, said clock-train acting to positively feed the carbons together, a regulating-electromagnet for controlling the feeding movement, located in a constantly-closed shunt-circuit around the arc and blocking the clock-movement in the retracted position of its armature, and an electromagnet located in series with the arc and acting to separate the carbons to form the arc independently of the feeding mechanism, whereby varying quantities of current may be passed through the lamp without affecting the regulation thereof, substantially as set forth.

2. In a focusing arc-lamp, the combination with the carbon-holders, of a spring clock-train, having an initial tension and mounted in a frame having a fixed position, said clock-train being connected with the two carbon-holders and acting to feed such carbon-holders positively together with a proper relative rate of movement, a regulating-electromagnet for controlling the feeding movement, located

in a constantly-closed shunt-circuit around the arc and blocking the clock-movement in the retracted position of its armature, and an electromagnet located in series with the arc and acting to separate the carbons to form the arc independently of the feeding mechanism, whereby varying quantities of current may be passed through the lamp without affecting the regulation thereof, substantially as set forth.

3. In an arc-lamp, the combination with the two carbon-holders and operating-racks, of pinions of different sizes engaging said racks and fixed to the same shaft, a driving-spring having an initial tension connected with said shaft, an escapement-train connected with said shaft through a pawl and ratchet so as to retard the shaft when driven by the spring and acting to feed the carbons together, and an electromagnet located in a shunt around the arc, the armature of said magnet locking the escapement in its retracted position, whereby varying quantities of current may be passed through the lamp without affecting the regulation thereof, substantially as set forth.

4. In an arc-lamp, the combination with the two carbon-holders and operating-racks, of pinions of different sizes engaging said racks and fixed to the same shaft, a driving-spring having an initial tension connected with said shaft, an escapement-train connected with said shaft through a pawl and ratchet so as to retard the shaft when driven by the spring and acting to feed the carbons together, an electromagnet located in a shunt around the arc, the armature of said magnet locking the escapement in its retracted position, and a striking-magnet in series with the arc, whereby varying quantities of current may be passed through the lamp without affecting the regulation thereof, substantially as set forth.

5. In an arc-lamp, the combination with the positive-carbon holder having a sliding movement, of the negative-carbon holder arranged in advance of the positive-carbon holder so as to produce the crater of the arc on the front side of the positive carbon, a pivoted support upon which the negative-carbon holder is mounted, and a magnet in series with the arc moving said support on its pivot for striking the arc, the point of the negative carbon being thereby moved in an arc of a circle laterally away from the positive carbon, substantially as set forth.

6. In an arc-lamp, the combination of the positive and negative carbon holders, and a feeding mechanism feeding them together at a rate proportional to the burning rate of the carbons, a slide carried by the front of the lamp-case upon which the negative-carbon holder is movably mounted, and a striking-magnet also carried by said slide for moving the negative-carbon holder independent of the slide, substantially as set forth.

7. In a focusing arc-lamp, the combination with the positive and negative carbons and the slotted light-shield O, of the plate P projecting forward from the back plate of the light-shield above its lower slots and partially encircling the negative carbon, substantially as set forth.

8. In an arc-lamp, the combination with the movement-case A and the carbon-holders, of the light-shield O and front plate K for protecting the movement from the heat of the arc by means of the two air-spaces located respectively between the movement-case and the plate K, and between said plate and the light-shield O, substantially as set forth.

9. In an arc-lamp, the combination with the case A and the feeding-motor and controlling-magnet inclosed thereby, of the racks H, H′ passing through the top of the case, carbon-holders J, L, connected with said racks, guide-rod I, and guide-plate K, substantially as set forth.

10. In an arc-lamp, the combination with the case A inclosing and supporting the mechanism of the lamp, of the tubular clamp *a*, tube *c*, screw *c*′ and post *d* for supporting the lamp and providing for its vertical adjustment, substantially as set forth.

11. In an arc-lamp, the combination with the case A inclosing and supporting the mechanism of the lamp and mounted upon a vertically-adjustable pivoted support, of the screw *e* and spring e^2 for adjusting the lamp laterally, substantially as set forth.

In testimony that I claim the foregoing as my invention I have signed my name, in presence of two witnesses, this 5th day of June, 1894.

EDWARD POWELL HOPKINS.

Witnesses:
D. McFarlan Moore,
Peter P. Pope.