C. P. STEINMETZ.

ELECTRIC LIGHTING.

APPLICATION FILED APR. 21, 1900. RENEWED JULY 23, 1906.

942,472. Patented Dec. 7, 1909.

Fig. 1.

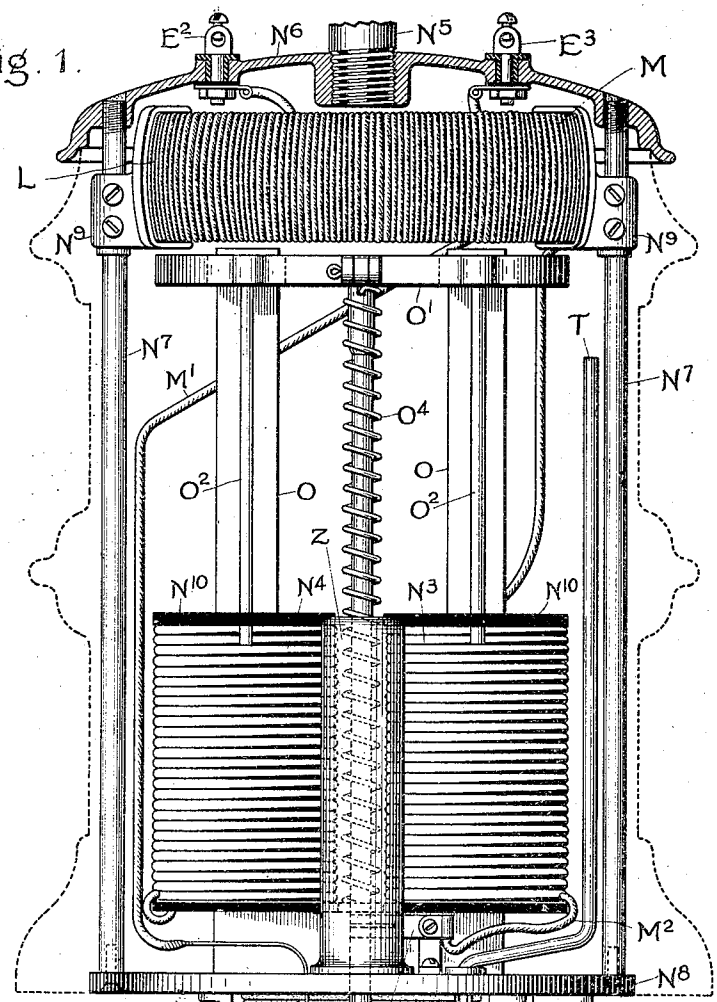
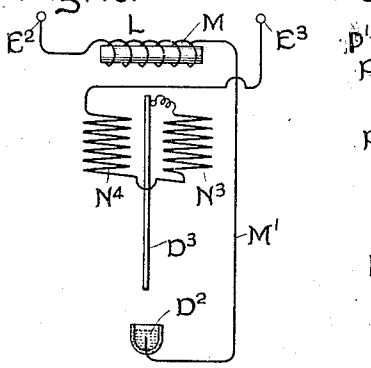


Fig. 2.



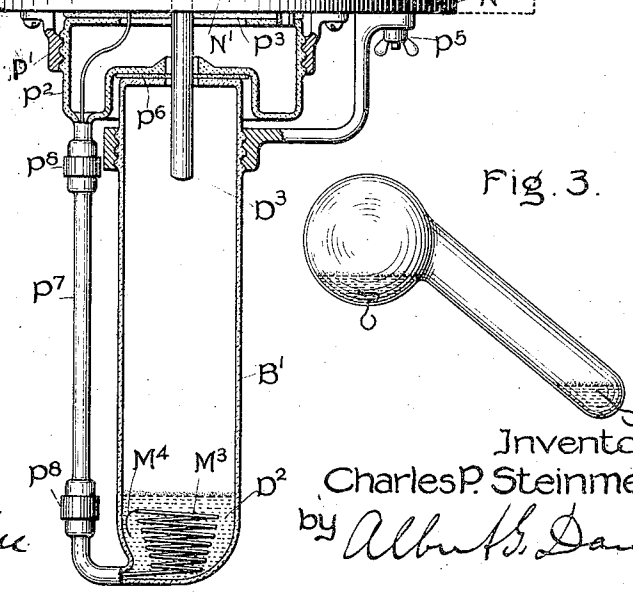


Fig. 3.

Witnesses:

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by Albert G. Davis.

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UNITED STATES PATENT OFFICE.

CHARLES P. STEINMETZ, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

ELECTRIC LIGHTING.

942,472. Specification of Letters Patent. Patented Dec. 7, 1909.

Application filed April 21, 1900, Serial No. 13,718. Renewed July 23, 1906. Serial No. 327,401.

To all whom it may concern:

Be it known that I, CHARLES P. STEINMETZ, a citizen of the United States, residing at Schenectady, county of Schenectady, State of New York, have invented certain new and useful Improvements in Electric Lighting, of which the following is a specification.

In a certain prior application for Letters Patent, Serial Number 7265, filed March 5, 1900, I have called attention to the fact that the light from an electric arc, excluding that portion of the light coming direct from the crater, is practically speaking, independent of the temperature, and dependent principally on the nature of the conducting vapor which forms the arc stream, as if the particles of the electrode carried into the arc stream were set into sympathetic vibration by the passage of current therethrough; and I have called attention to the fact that the efficiency of the arc lamp can be greatly increased by using as electrodes, or at least by using as one electrode, a substance which vaporizes at a comparatively low temperature, whereby the temperature of the arc stream, and therefore the radiation losses, may be greatly reduced, and more light may be obtained by the expenditure of a given amount of electrical energy. I have fully set forth in the said prior application the fact that the substance forming the arc stream must necessarily be such as to furnish conducting vapors, and that mercury is, among other substances, particularly well adapted for this purpose; since it volatilizes at low temperature, and furnishes, when used in the manner above described, a light of very considerable intensity, though the color of that light is not suitable for general application by reason of the marked absence of the longer light waves corresponding to the yellow, orange and red. In the said prior application I disclosed and claimed broadly a method of modifying the color of the arc from a terminal possessing the characteristics above set forth, by the addition to the arc stream of conducting vapors which, when exposed to the action of the current flowing through the arc stream, would give forth the light rays necessary either to complete the spectrum, or to modify it in such a manner as to cause any desired color to predominate. Further, I have shown, in the said application, that the mercury arc, owing to the poisonous nature of the fumes, and owing to its instability, must be more or less protected and must therefore be surrounded more or less completely by a glass or other transparent or translucent envelop, and that this envelop is attacked by the action of the various color-modifying substances, and should therefore be artificially protected. Such protection is broadly claimed in my above-mentioned application, and in that application there is described and claimed the method of protection, which consists of neutralizing the chemical activity of the color-modifying substances, as by causing them to exist in the arc in the ionized state, which may be accomplished by the addition of iodin or iodid of mercury, or better, by introducing the color-modifying substances in the state or condition of salts of one of the halogen group, preferably iodin. I find that the use of the halogens is of special value when the arc exists in a completely closed vessel in which they may be protected from the moisture of the atmosphere, but when the arc exists in a vessel which is not perfectly air tight, I find it better to make use of the alternative method which forms the subject of the present invention, as the halogen salts tend to absorb moisture, which interferes with their action and renders it irregular.

My present method utilizes the broad principle of introducing the color modifying substances, and of protecting them, and further utilizes the principle of introducing the substances to the arc in the ionized state, but differs from the specific embodiment more particularly set forth in the said application in that it protects the inclosure, not by absolutely preventing chemical action upon it, but by regulating the nature of such chemical action in such a manner as to prevent the transparency or translucency of the inclosure from being destroyed. This I may accomplish by introducing the color-modifying substances in the form of salts of silica acids, and particularly in the form of meta-silicates, such for example, as the meta-silica of lithium, SiO_3Li_2. The action of these silica salts is to dissociate in the temperature of the arc, whereupon the lithium, if lithium be used, is free to produce the color, while the silicic radical is also

free to attack the glass, the chemical activity of the radicals being more or less neutralized, each by the other owing to the fact that they exist in the ionized state, nevertheless, an exchange of bases takes place between the silicates and the hard glass used as an envelop, and there is continual chemical action on the inner surface of the envelop, a composition and decomposition of the glass, a tearing down at one place and a building up at another. But the various silica salts thus formed on the inner surface of the tube are transparent, or at least translucent, and the only effect is to give to the inside of the tube a frosted appearance, similar to that of the well-known frosted incandescent lamps. This action does not cut down the light to any serious extent, particularly in view of the very high efficiency of the lamp, and only serves to cause the tube to present the appearance of a solid source of uniform and agreeably-diffused light.

It is quite clear that I am not necessarily limited to silicates and to glass tubes, but that my invention includes generally the idea of modifying the color by introducing color-modifying substances in the state of salts of one of the general class of acids, as for example glass-forming acids, which form, or are capable of forming, the envelop in which the light-giving substance is contained. Other acids of this class are for instance boric acid etc.

In the drawing attached to this specification, Figure 1 is a general view of a lamp constructed in accordance with my present invention, and Fig. 2 is a diagram of circuits, while Fig. 3 is a view of a very simple form of lamp also embodying my invention.

Referring more particularly to Fig. 1, it will be seen that current enters by the terminal E^2 and thence passes to a regulating device L. As this particular lamp is intended for alternating current, this regulating device may well take the form of a reactive coil with a nearly closed magnetic circuit, such as is ordinarily employed in alternating arc lamps. The usual taps or connections may be provided for regulating the amount of this reactance in circuit. From this reactive coil, current passes by the wire M′ to the mercury electrode D^2, and thence through the arc in the tube B′ to the upper terminal D^3, which is preferably formed of iron or aluminum. From this terminal it passes by the collecting spring N′ through the wire M^2 to the solenoid coils N^3, N^4, and thence to the terminal E^3. It will be seen that these are the ordinary connections of an arc lamp to be operated in multiple arc on a single-phase alternating circuit. The terminal D^2 is formed, in the lamp illustrated, of mercury covered with meta-silicates, as above fully explained.

To describe the structure more in detail, it may be said that the support N^5 is screwed to a cap N^6, and that from this cap depend a plurality of rods N^7, N^7, fastened at their lower ends by screws as shown, or otherwise, to the lower plate of the lamp N^8. These rods also carry, by the clips N^9, N^9, the reactive coil L.

A U-shaped core O of laminated iron is fastened to the lower plate N^8, and the solenoids N^3, N^4, above referred to, are mounted respectively on the limbs of this core, and are so connected that they have a tendency to polarize in the same direction the magnetic circuit formed by the core. A repulsion device O′, which may consist of a solid casting of copper, aluminum, or other suitable material, is pierced with two holes in order that it may fit over the two limbs of the laminated piece O, and to this repulsion device are attached four guides O^2, O^2, two only of which are shown in the drawing, which work through suitable openings in the upper flange N^{10} of the spools of the solenoid cores N^3, N^4. The upper flange is expanded for this purpose, while the lower flange is of smaller diameter. The upper electrode D^3 is fastened to the repulsion device O′, and is so adjusted that the weight of the parts is sufficient, when no current is passing through the lamp, to compress the coil spring O^4, and to cause the lower end of the electrode to dip into the mercury at D^2.

Z is a dash-pot, serving to steady the lamp and to prevent "pumping".

It will be seen that the screw-ring P′ is attached to the lower plate of the lamp, and that into this ring is screwed the glass condensing chamber P^2. A suitable washer P^3, of felt or asbestos, is interposed between this condensing chamber and the lower plate. A second screw-ring is fastened to the lower plate of the lamp by the screw-clamp P^5, and into this ring is screwed the tube B′, with a second washer of felt or asbestos P^6. Considerable clearance is allowed between the electrode and the edge of the opening, in order to make it possible for the vapors to pass to the condensing chamber.

In order to carry current to the lower terminal of the lamp, and also in order to provide for the return to the lower terminal of the mercury vapors which may escape into the chamber P^2, I provide a glass tube P^7, which is connected by asbestos washers P^8 with an extension from the chamber P^2, and in a similar way is connected with an extension from the lower end of the tube B′. Through this tube I pass the wire M′; which at its lower portion is covered with an enamel insulation in order to protect it from the mercury vapors. I further prefer to coil this wire into a heating coil M^3, and to uncover the insulation only at the extremity M^4, whereby current will pass

through the heating coil M^3 and will tend to maintain the mercury at D^2 at a sufficiently high temperature.

The operation of this lamp is as follows: The current enters at the terminal E^2 and passes through the self-induction coil M, in the path above described, through the heating coil M^3 to the mercury electrode D^2. If we suppose the lamp to be just starting into action, it is clear that the weight of the repulsion device O′ will have compressed the spring O^4, so that the electrode D^3 will be in contact with the mercury D^2. Current will therefore pass through the solenoids N^3, N^4, and out to the terminal E^5. These solenoids will set up lines of force in the core O, and by virtue of the action set forth in a patent to Elihu Thomson, No. 363,186, the repulsion device O′ will tend to rise, carrying with it the electrode D^3. The lamp will, therefore, burn until the arc is broken by too great lengthening. This will not occur if the mercury is at a sufficiently high temperature, but if it does occur the electrode will fall and the action will be repeated. This may be repeated several times, but finally the mercury will be heated to a sufficiently high temperature, and the electrode D^3 will rise to the position shown in the drawing. The length of the resultant arc will obviously be regulated by the design of the solenoids N^3, N^4, the design of the reactance coil, the voltage of the circuit, the diameter of the tube B′, etc. An increase in the resistance of the arc will weaken the current, weaken the repulsive action, and cause the arc to be shortened. The tendency is toward constant current in the branch including the lamp, as in most commercial arc lamps. In this position the tube B′ will be filled with a brilliant glow of light, and the color of this light will be regulated by introducing the various substances above mentioned in the portion D^2. The vapors will tend to escape from the tube B′, but they are collected in the condensing chamber P^2, and pass back through the tube P^7. I find it much better to pass the condensed substance back outside the tube B′, than to allow it to trickle down the sides of this tube.

By variously regulating and adjusting the amount of color modifying substances introduced, and the character of said substances, and by mixing with the said substances some neutral diluting substance, as for example fluorid of calcium, I am able to produce any color or shade of light which I may desire, from pure white to a brilliant red, blue, green, etc. For example, if I desire to produce a white light I add mixtures of the meta-silicates of potassium or lithium and sodium, and when I find that the amount of these substances introduced into the arc is so great as to impart to the light too much red or yellow, I may reduce this tendency by the addition of calcium fluorid, as above set forth. Whatever the color-forming substances may be, they are carried into the arc, and though they may be dissociated, the acid radicals protect the glass from the metals, and though the acid radicals themselves may attack the glass, nevertheless, the glass is completely protected by the fact that the salts formed on the inside of the glass are transparent or translucent, and as the quantity of available bases is limited, there is always left enough free acid radicals to neutralize the metals. A modification of the lamp suitable for use with direct current is shown in my prior application referred to. The connections should be so adjusted that the mercury electrode is the one tending to become hotter, where there exists any tendency to a difference of temperature, or with direct current, but even with this provision the upper part of the tube may rise above the boiling point of mercury. This is another reason for preferring the silicate to the iodids with this type of lamp, as the silicates work better at a higher temperature than they do at a very low temperature.

It is important in non-exhausted lamps to provide some device for equalizing the pressure, but it is best not to allow mercury fumes to escape from the lamp. I am able to accomplish these objects by the tube T, which is inserted in an opening in the lower plate N^8, and registers with a round or crescent-shaped opening in the washer P^3, and with a corresponding opening or recess in the upper wall of the chamber P^2. This tube extends vertically upward, being bent around the lamp mechanism. It allows air to escape from or to reënter the chamber P^2, but the mercury vapors, which are very heavy, will not rise to the top, but will be condensed on the sides and will trickle back to the condensing chamber, and thence through the tube P^7 to the lower electrode D^2.

The lamp shown in Fig. 3 is of that class in which the arc exists between mercury or equivalent electrodes covered with silica salts, in a rarefied atmosphere of air, or preferably hydrogen, argon or helium, at say 1 mm. pressure. The arc is formed by exposing the lamp to high voltage, and the action will be readily understood by what has preceded. Such lamps are well adapted to constant current circuits.

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

1. The method of modifying the color of the light from an arc existing within a transparent or translucent envelop, which consists in introducing into the arc a color-modifying substance in the condition of a salt of one of the general class of acids forming, or capable of forming, the envelop.

2. The method which consists in causing

sympathetic light-giving oscillations in a transparent or translucent envelop, and continuously associating and dissociating the inner wall of the envelop without destroying its translucency.

3. The method which consists in causing sympathetic light-giving oscillations of conducting vapors in a transparent or translucent envelop, and continuously associating and dissociating the inner wall of the envelop without destroying its translucency.

4. The method of protecting a transparent or translucent substance in the presence of active chemicals, which consists in introducing said chemicals as salts of acids forming with the materials of the transparent substance a transparent or translucent substance.

5. The method of producing light which consists in generating an electric arc in a glass inclosure, and introducing to the arc metallic salts of silica acid radicals.

6. The method of generating light from electric energy, which consists in creating an electric arc in a glass inclosure between substances one of which, at least, vaporizes at low temperature, and introducing color-modifying metals as salts of glass-forming acids.

7. The combination in an arc lamp, of an envelop, a color modifying substance which may attack the envelop without destroying its translucency, and electrodes in said envelop.

8. In an arc lamp protected by a light transmitting envelop, a mercury electrode covered with a color-modifying substance existing as a salt of an acid which when united with the envelop will form a transparent or translucent product.

9. In a mercury arc lamp, a glass inclosure for the arc, and color-modifying means consisting of a metallic meta-silicate salt.

10. In a mercury arc lamp, a glass inclosure for the arc, and a color-modifying means consisting of one or more meta-silicates of alkaline metals.

11. In a mercury arc lamp, a glass inclosure for the arc, and a color-modifying means consisting of meta-silicate of alkaline metal mixed with a diluent substance.

12. In a mercury arc lamp, a glass inclosure for the arc, and a color-modifying means consisting of meta-silicate of alkaline metal mixed with a calcium fluorid.

13. In a mercury arc lamp, a hermetically sealed glass inclosure for the arc, electrodes one at least of which is liquid, and a color-modifying substance in said inclosure which may attack said inclosure without destroying its translucency.

In witness whereof I have hereunto set my hand this 18th day of April, 1900.

CHARLES P. STEINMETZ.

Witnesses:
BENJAMIN B. HULL,
ALEX F. MACDONALD.