C. P. STEINMETZ.

ELECTRIC LIGHTING.

APPLICATION FILED APR. 30, 1902.

1,011,088. Patented Dec. 5, 1911.

Fig. 2.

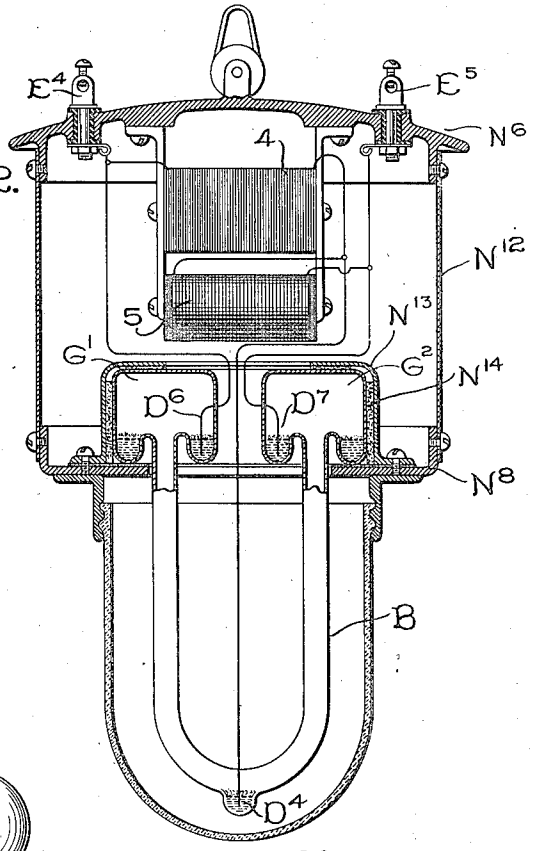


Fig. 4

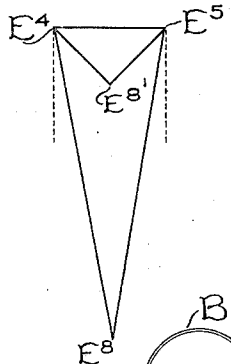


Fig. 1.

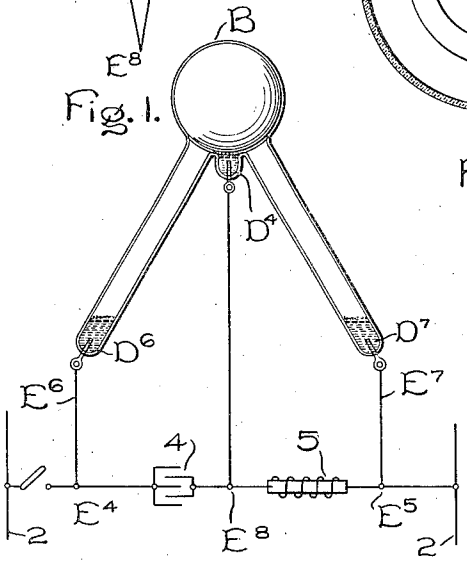
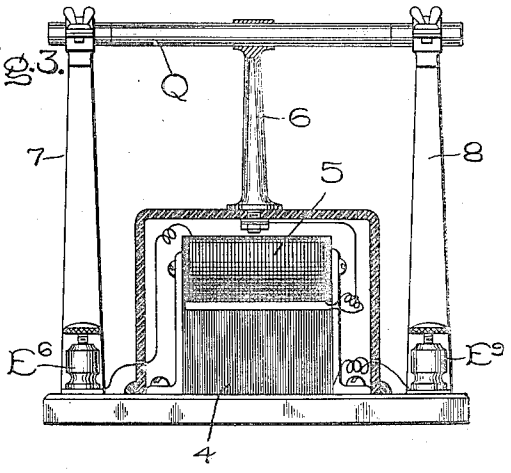


Fig. 3.



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UNITED STATES PATENT OFFICE.

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ELECTRIC LIGHTING.

1,011,088. Specification of Letters Patent. Patented Dec. 5, 1911.

Original application filed April 25, 1900, Serial No. 14,224. Divided and this application filed April 30, 1902. Serial No. 105,305.

To all whom it may concern:

Be it known that I, CHARLES P. STEINMETZ, a citizen of the United States, residing at Schenectady, in the county of Schenectady and State of New York, have invented certain new and useful Improvements in Electric Lighting, (division of my prior application, Serial No. 14,224, filed April 25, 1900,) of which the following is a specification.

It is well known that there are in existence various devices for transforming the energy of electric current into light, which are superior in efficiency to the ordinary incandescent lamp of commerce, but are objectionable in that they require, for one reason or another, extremely high potentials in starting as compared with the potentials necessary to maintain them in operation. One lamp of this class is that in which the light-giving body is composed of what is sometimes called a conductor of the second class, or, as I prefer to call it, a pyro-electrolytic conductor, usually taking the form of a rod of oxid of magnesium or other metal oxid, or compound of metallic oxids. A lamp of this type may be designed to run successfully on a single-phase alternating circuit of 100 volts, but requires for its starting a potential which may rise to 500 or 1000 volts, or higher. By using as light-giving body a mixture of initially conducting and non-conducting substances, as a mixture of ferrite and chromite of iron, Fe_3O_4 and Cr_2FeO_4, as set forth and claimed in my application Ser. No. 41,350, filed Dec. 28, 1900, this voltage may be reduced, but even with this improvement a starting device is advantageous. Another lamp, possessing to a certain extent the same characteristics, is that described in my pending application, Ser. No. 7265, in which light is formed by the passage of an arc between electrodes vaporizable at low temperature, which electrodes frequently take the form of bodies of mercury. In some of the forms shown in said application the mercury electrodes are inclosed in a glass vessel, from which the air has been exhausted to such an extent as to reduce the voltage necessary to strike across and start the arc, but even with the most favorable adjustment of the vacuum I find it difficult to start such lamps in multiple on ordinary constant-potential circuits without the addition of some extraneous starting device, although they are well adapted for use in connection with constant-current circuits.

I have, in the above-mentioned application, shown certain other lamps possessing the same general characteristics but arranged to start by relative movement between two electrodes, and such lamps are very suitable for certain classes of work. For certain other purposes, however, I find it better to dispense with the movement between the electrodes and to start the lamps by subjecting them to a very high potential. This is, as has been stated, extremely easy in connection with series circuits, alternating or direct, but difficult in connection with commercial low-tension, multiple arc or constant potential circuits.

My present invention aims to provide a simple and convenient means for starting, on ordinary constant-potential alternating circuits, any lamps which require higher voltage at starting than during the running condition, whether of the type described or of other types.

In the drawings attached to this specification, which represent various modifications of my invention, Figure 1 is a view of a lamp of the general character described in my application, Ser. No. 7265, provided with my improved starting device; Fig. 2 is a cross-section of a lamp based on the general principle of the lamp of Fig. 1, but provided with certain improvements; Fig. 3 is a view of an electrolytic lamp to which my present invention has been applied; and Fig. 4 is an illustrative diagram.

Referring more particularly to Fig. 1, E^4, E^5, are terminals between which is maintained a substantially-constant alternating electromotive force, as by connection to the mains 2—2. From these terminals wires lead to the terminals E^6, E^7, of the lamp B, which lamp consists of two glass tubes joined to a central chamber, as shown, with conducting points fused into the glass at E^6, E^7. A third terminal, entering a depression or cup D^4, is provided as shown. The lower ends of the tubes D^6, D^7, and the cup D^4 are filled with mercury, or other suitable substance, as set forth in my application above referred to, and the surface of the mercury is in each case covered with a thin layer of a color-modifying substance such as a mix-

ture of anhydrous halogen salts of earth metals, as iodids of lithium and sodium, and some neutral or dilutant substance, as calcium fluorid. Two impedances of different power factor, a condenser 4 and a self-induction 5, are connected in series between the terminals E^4, E^5, and a connection is made from a common point E^8 between the condenser and the self-induction to the central electrode D^4. With the parts arranged as follows, let us suppose that the switch is closed and that alternating current at a potential, for example, of 100 volts be allowed to pass to the terminals, the vacuum in the lamp being supposed to be such as to produce the minimum dielectric strength, as for example, 1 mm. on the ordinary mercury gage. Under these circumstances the voltage E^4, E^5, will form the base of a triangle, Fig. 4, of which the voltages E^4, E^8 and E^8, E^5, are the sides, and if the ohmic resistance of the self-induction coil 5, and the energy lost in the condenser 4, are comparatively small, the voltages E^4, E^8, and E^8, E^5, may each of them be very many times the magnitude of the resultant voltages E^4, E^5. In the theoretrical extreme case the voltage across E^4, E^8 would lag the voltage E^4, E^5 by 90 degrees, and the voltage E^5, E^8, would lead the voltage E^4, E^5, by 90 degrees, as shown in Fig. 4 in dotted lines, so that the phase triangle would be one of infinite altitude, and the voltages E^4, E^8, would be infinite. In practice this condition cannot occur, but these voltages may be ten times the impressed voltage, or even higher. This being the case, it will be seen that that portion of the tube between the left-hand terminal D^6 and the central terminal D^4 will be exposed to the total voltage across the condenser 4, while the right-hand portion of the tube will be exposed to the total voltage across the self-induction 5, so that although the total voltage across the tube may be only 100, yet the voltage across each half of the tube may exceed 1000. This high voltage will cause the air, hydrogen, or other rarefied gas in one or both sides of the tube to break down, and an arc will be started from the left-hand terminal D^6 to the central terminal D^4, or from the central terminal D^4 to the right-hand terminal D^7, or both. If only one arc starts at first, the other will tend to be started, even on lower potential, since the whole tube is warmed and filled with conducting vapors. This arc is formed of a column of mercury vapor evaporated from the terminals, and mixed with this mercury vapor are the halogen salts above mentioned, as, for example, lithium iodid. The mercury arc gives a bright light at high efficiency, and the lithium adds to the light the red line which is wanting. The lithium would attack the glass envelop and destroy it, but for the fact that it exists in the ionized state, constantly ready to combine with the free iodin, and thus incapable of combining with the silicious substances forming the walls of the tube. The result is that a continuous strong light, which may be white or of any other desired color according to the nature and quantity of the amount of color-modifying substances introduced, issues continuously from the tube.

The arc gradually warms the mercury until it reaches a temperature nearer the boiling point, when the voltage necessary to maintain the arc becomes very greatly reduced and the current flow for a given voltage correspondingly increases, but as fast as current is taken on the left-hand side of the tube, for example, a resistance is introduced in multiple with the condenser, and as fast as current is taken on the right-hand side of the lamp a resistance is interposed in multiple with the self-induction. The effect of resistance in multiple with a self-induction or condenser is to decrease its reactive effect, which causes the triangle of phases to collapse, as it were, as indicated in Fig. 4 by the triangle E^4 E^5 E^8. But if for any cause the arc should be extinguished on either side of the tube, as might happen, for example, if a very sudden draft of air should cool one of the electrodes, the phase triangle would extend, the voltage would rise, and the lamp would automatically start itself again. The current is then forced to flow through the lamp under all conditions and automatically regulated.

It will be seen that my improved starting device is perfectly automatic and instantaneous in its action, and that it does not require any moving parts or hand regulation. The relative values of the reactance of the condenser and self-induction should be adjusted in accordance with the well-known formula to produce a resonant condition, though accuracy in this respect is not absolutely essential. No series resistance or other steadying device is necessary, and the efficiency is very high.

Referring now more particularly to Fig. 2, it will be seen that the tube B appears in a U-shape, with a central terminal D^4 at the lower part and two condensing chambers G^1, G^2, containing the electrodes D^6, D^7, which electrodes are annular in shape, as well shown in the drawing. The tube B is supported on a base plate N^8, which in turn is carried by the external casing N^{12}, provided with terminals E^4, E^5. The tube B is held in place by a protecting plate N^{13} with an asbestos washer N^{14} interposed. A condenser 4 and a self-induction coil 5 are suspended from the cap N^6, and are connected according to the scheme of connections shown in Fig. 1.

The operation of this lamp will be readily understood from what has preceded, and

further description is, therefore, unnecessary.

Having thus described the operation of my invention as applied to the lamp shown in my application Ser. No. 7265, I will now proceed to describe its application to the pyro-electrolytic lamp shown in Fig. 3. In this figure Q is a rod formed of metallic oxids, either pure or mixed, as is well understood in the art. This rod is carried by a central support 6, and by side supports 7 and 8. The side support 7 is connected to the terminal E^6, and the side support 8 is connected to the terminal E^9. The condenser 4 and the self-induction coil 5 are connected in series, and from the common point is taken a lead to the central post 6. Obviously, the lamp may be suspended in an inverted position, and supplied with a glass globe, as shown in Fig. 2, if so desired. In starting, the rod does not take any substantial amount of current, owing to its very high resistance, but the voltages across the condenser and self-induction rise to a considerable value, as above explained, until finally current is forced through the rod. This action may be aided by external heat, if it is so desired. As soon as current begins to flow through the rod the phase triangle collapses and the voltages are reduced, as shown in Fig. 4. In this form of lamp, as in the other above described, it is possible for one side to start first, and to reduce the voltage on the other side. If the rod be long and thick one side only will burn, and the single lamp thus formed is within my present invention, but by making the rod fairly short and thick the active side will be caused to heat the inactive side, whereby the whole lamp will be started.

It is not essential to have the condenser and self-induction coil in circuit after the lamp starts, but the same impedance combination may be used to start a number of lamps successively. I prefer however to leave the condenser in circuit, on account of its steadying effect.

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

1. The method of operating an electric lamp having electrodes affording a plurality of paths for current flow, which consists in deriving from a source of alternating current a plurality of voltages out of phase with each other and impressing these voltages upon respectively different paths in said lamp, these voltages coöperating to produce flow of current in the lamp.

2. The method of operating an electric lamp having electrodes affording a plurality of paths for current flow, which consists in impressing on at least two of the electrodes the potentials of the mains of a source of alternating current and upon another electrode a potential intermediate in value, whereby coöperating currents flow in the lamp between said electrodes.

3. The method of starting and operating an electric apparatus of comparatively high resistance at starting, which consists of exposing separate portions of the apparatus to voltages of which the aggregate numerically exceeds the voltage of the system from which the apparatus is fed and reducing such voltage as the current taken by the apparatus increases.

4. The method of supplying energy to a translating device of comparatively high resistance at starting, which consists in supplying separate portions of the device respectively with the individual voltages of impedances of different power factor connected in series.

5. The method of supplying energy from an alternating current source to an electric lamp having coöperating electrodes affording a plurality of paths for current flow, which consists in exposing said paths to the action of voltages dependent upon the interaction of impedances of different power factor, the resonant voltages being automatically reduced when said lamp takes current.

6. The method of starting an electric arc lamp having coöperating electrodes affording a plurality of paths for current flow, which consists in exposing said paths to the action of an abnormally high voltage dependent upon the interaction of impedances of different power factor supplied with alternating current, the resonant voltages being automatically reduced when said lamp takes current.

In witness whereof I have hereunto set my hand this 28th day of April, 1902.

CHARLES P. STEINMETZ.

Witnesses:
BENJAMIN B. HULL,
HELEN ORFORD.