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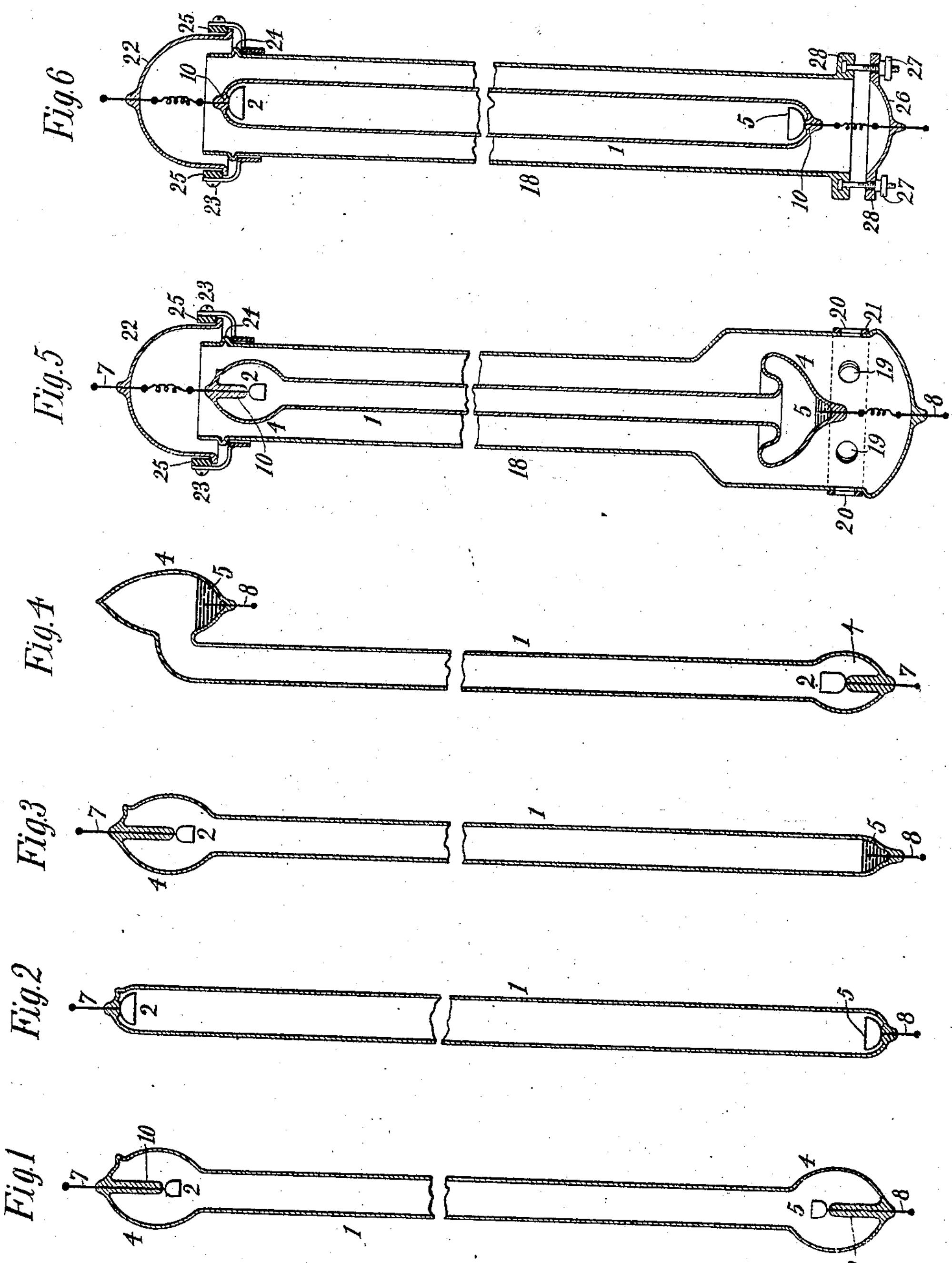
P. C. HEWITT.

METHOD OF PRODUCING LIGHT BY ELECTRICITY.

(Application filed Jan. 25, 1901.)

(No Model.)



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UNITED STATES PATENT OFFICE.

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METHOD OF PRODUCING LIGHT BY ELECTRICITY.

SPECIFICATION forming part of Letters Patent No. 682,696, dated September 17, 1901.

Application filed January 25, 1901. Serial No. 44,648. (No model.)

To all whom it may concern:

Be it known that I, PETER COOPER HEWITT, a citizen of the United States, and a resident of New York, in the county of New York and State of New York, have invented certain new and useful Improvements in Methods of Producing Light by Electricity, of which the following is a specification.

My invention relates to a method of controlling the electrical conductivity or resistance of a gas or vapor traversed by an electric current.

I have found that under the proper conditions a gas or vapor inclosed within a suitable vessel or container can be made to control the flow of current under the influence of a given difference of electrical potential by reason of its resistance. I have also found that the electrical resistance of a conducting gas or vapor bears a definite relation to the density of the gas or vapor. I have further found that it is possible to so control the density of an inclosed gas or vapor acted upon by an electric current as to maintain that density at a predetermined degree, rendering its conductivity sufficiently stable and suitable for service as a light-giving medium, and that the efficiency as such is exceedingly great.

My present invention aims to provide means for such control of the density of the gas or vapor which is acted upon by the current flowing so as to render its naturally variable resistance controllable and stable, and thereby produce a highly-efficient and commercially-useful electric-lighting device. To do this, I have found that the following elements enter into consideration, each having its own particular effect on the density and resistance.

I have found that the effect of electric current on a vapor or gas carrying current may be considered in portion as the effect of heat on the density of the vapor. Vapors or gases carrying current have a density of minimum resistance, and increase or decrease of said density increases the electrical resistance of the vapor. Increasing the temperature of a portion of an inclosed vapor or a vapor free to expand attenuates the vapor and lessens its density in that portion; but when the temperature of the whole vapor inclosed is raised or the vapor is not free to expand the density remains unchanged. When volatile material is present in the container at or near the temperature of volatilization and the temperature be raised, the density is increased, inasmuch as the vapor is not allowed to expand. The effect of current passing in a vapor being in portion that of heat, the temperature attained by the vapor is modified by the heat-radiating ability of the vapor. As the density may be varied by temperature, so may the resistance be varied.

I have found for the purposes of this invention that the electrical resistance of a vapor varies substantially inversely as the diameter of the circular area of the conducting-vapor and directly with the length. Also the resistance varies inversely with the current carried by the vapor, and, as above stated, directly or inversely with the vapor density, depending upon whether the vapor is at a greater or less density than the density of maximum conductivity, and the density may be made to vary directly or inversely with the temperature or remain constant. As the temperature to which a conducting body of vapor may rise is limited by the heating effect of the current and the rate at which the heat is radiated from the vapor, the temperature may be controlled through the ability of the surroundings to abstract heat from the vapor, and by this means the resistance may be controlled and be varied by varying the heat-abstracting capacity of the surroundings.

The effect of the current to vary the resistance of a conducting-vapor by reason of the current flowing may be counteracted by the density the vapor is allowed to attain. The current, as stated above, is also limited by limiting the cross-section of the conducting-vapor and also by the length of its path through the vapor. This is accomplished by means of the size and shape of the container. As the heat created by the current in a conducting-vapor is created throughout the vapor and this heat is given off from the circumference, the vapor column will attain the highest temperature at the center, and the density will vary from the center toward the circumference, the vapor being most attenuated at the center. If the outside vapor of the conducting-column be at a density greater than the density of maximum conductivity and the center below, then the zone of greatest conductivity will be in a circumference lying somewhere between the center and the circumference, as from this zone the resistance increases either way. By having the outside vapor or gas of the conducting-vapor at a density greater than that of maximum conductivity the wall of the container will be protected from the effects of the current by the vapor itself, and I avail myself of this feature when operating vapors or gases at high temperature. A lamp constructed on these principles will have its resistance decreased in proportion as the ability of the surroundings to abstract heat is increased, and if this capacity be made variable, as by movable draft-openings in an inclosing case, the light-giving quality of the lamp may be varied at will within wide limits by varying the draft without impairing the efficiency of the lamp.

In the accompanying drawings, Figures 1, 2, 3, 5, and 6 illustrate certain principles of the lamp, and Fig. 4 illustrates a complete lamp.

As an illustration of how the vapor density in a vapor carrying current may be made to decrease with the temperature due to the current, reference will be had to Fig. 1. In this figure the vapor is crowded from the central portions to the ends or enlargements outside the vapor path back of the electrodes by attenuation due to heat from the current, and this effect is limited by the relative size of these portions.

Fig. 2 illustrates a lamp of constant total density at all working temperatures.

Fig. 3 illustrates a lamp with volatile material in the lamp where the density of the vapor will increase with increase of temperature.

Fig. 4 illustrates a modification of Fig. 3, whereby the density may be made to vary in a prescribed manner with the temperature by providing an enlarged portion by means of which heat is abstracted and wherein condensation may take place, the enlarged portion lying outside of the conducting-vapor path.

Fig. 5 illustrates a modification of Figs. 3 and 4, whereby the total temperature inside the container, and therefore the vapor density in the container, may be varied from outside the lamp by varying the heat abstracted by the surroundings.

Fig. 6 illustrates a device whereby the temperature of the vapor may be varied without affecting the density.

The effect of any of the illustrated structures may be further modified by supplying a similar regulatable heat-abstracting capacity.

In Fig. 1 the main portion of the container is represented by a tube 1, within which are held two electrodes 2 and 5, of iron, the former of which may represent the anode and the latter the cathode. At each end of the tube 1 in this figure I have represented a bulb or enlargement 4, extending beyond the electrodes in such a manner that the gas contained in these bulbs will be mainly outside the conducting-path between the electrodes, thus providing space for gas to expand into and out of the path of the current. The contained gas may be a mercury vapor or nitrogen or other suitable gas. Conductors 7 and 8, of platinum, leading to the electrodes 2 and 5, respectively, are sealed through the glass and covered for a considerable distance inside the container with glass or other good heat-resisting non-conducting material. Generally the covering of such material may extend as far as the electrodes, as illustrated at 10 10. In the operation of this lamp a portion of the gas or vapor is forced into the bulbs or enlargements 4 4 out of the path of the current, thus bringing about a condition of variable density decreasing with increase of temperature within the portion of the lamp-carrying current due to heat generated by the current.

In Fig. 2 I illustrate a lamp of constant total density at all working temperatures. In this lamp the bulbs or enlargements are dispensed with, and practically all of the gas or vapor is in the conducting-path and subjected to the heating effect of the current. The gas or vapor may be a mercury vapor or nitrogen or other suitable gas.

The lamp illustrated in Fig. 3 has as its cathode some volatilizable material, as shown at 5. This material may be a puddle of mercury. In this form of lamp the density of the vapor will increase with the temperature, although the cooling-chamber 4 may serve to condense a portion of the vapor and so modify this effect within limits, according to its proportional size.

Fig. 4 illustrates a modification of the lamp shown in Fig. 3, whereby the density may be made to vary in a prescribed manner with the temperature though giving to the enlargements 4 a definite containing and heat-radiating capacity, the enlarged portion lying outside the conducting-vapor path.

In Fig. 5 I show a vapor-lamp containing a volatilizable material, the entire lamp being surrounded by a transparent jacket 18, closed at the bottom and having openings 19 19, with which similar openings 25 in an adjustable ring 21 are adapted to register when moved to the proper position. The jacket 18 is suspended from a cap 22, through which the leading-in wire 7 passes on its way to the electrode 2. The cap 22 may be secured to the wire 7 by any suitable means, as by the sealing of the wire into the cap. The connection between the cap and the jacket may be made by means of screws 23 23 passing through the cap and engaging with a bead or beads 24 on the jacket. Where the screws pass through the material of the cap, pieces of metal 25 25 may be secured to the cap in order to hold the screws, or a band or ring of metal may be secured to the cap for the same purpose. The upper end of the jacket 18 is open, and within limits any desired draft may be maintained between the lamp proper and the jacket through the regulation of the openings 19 by means of the ring 21.

Fig. 6 shows a similar draft-varying device in connection with a lamp similar to the one illustrated in Fig. 2. In this arrangement, however, the draft is regulated at the lower end by the adjustment in a vertical direction of a cap or end piece 26 through the medium of screw-bolts 27 27 passing through suitable flanges 28 28 on the lower end of the jacket 18 and on the cap or end piece 26, which may be used in connection with any form of lamp.

The principles laid down here are embodied in a practical form in a lamp in which the container is of glass having a bore three-quarters of an inch in diameter, the length between the electrodes being fifty-four inches, the chamber lying outside of the path of the current having a radiating-surface equal to a spherical area three inches in diameter, the positive electrode being constructed of pure iron held in place by a supporting pillar of glass, through which the platinum leading-in wire passes, and having as a negative electrode a puddle of mercury, as shown, also electrically connected through the walls of the vessel by means of a platinum wire. This lamp will run on a current of approximately one hundred and twenty volts and pass approximately four amperes when the surrounding temperature is that of an ordinary room—say seventy-five degrees—when exhausted so as to contain only the vapor emanating from the mercury constituting the negative electrode. When subjected to a lower temperature, the amperes increase without loss of efficiency in the lamp.

The successful operation of a lamp such as is described above is obtained by correlating the electrical resistance of the gas or vapor and the electrical energy, so that each is adjusted with respect to the other under relations which are expressed by the formula

$$\frac{V}{C} = R = \frac{l}{d} g,$$

in which V represents the voltage; C, the current; R, the electrical resistance; d, the diameter of cross-section of conducting gas or vapor; l, the length of current-path in vapor or gas, and g the electrical resistance factor for any particular vapor or gas, and where the electrical resistance factor is a function of the density of the vapor or gas and the resistance of the vapor or gas is understood to increase with increase or decrease of density from the density of maximum conductivity it is understood that the density will vary as if by reason of the temperature and pressure, and that the gas density may be varied by the passing current, as specified. In other words, the volts tend to vary directly with the length, inversely with the diameter, and inversely with the conductive factor of the gas, and also directly or inversely with the density of the gas, depending on whether the gas is above or below its density of maximum conductivity, the resistance tending to vary inversely with the current. A gas of definite condition and dimensions tends to require constant voltage to overcome its resistance, and the current passing then tends to vary the resistance inversely with the current passed. The object of this invention is to correct the variation in resistance due to current by varying the density of the vapor, and it has been shown in the various figures how the vapor density may be caused to vary by variations in the current.

The above is given merely as an illustrative lamp. By varying the proportions as indicated above the current consumed by the lamp may be varied within wide limits from this and lamps may be constructed to run on circuits of widely-different voltages.

These lamps may be started by any of the devices described in my pending applications—for example, Serial No. 11,605, filed April 5, 1900.

I claim as my invention—

1. The method of controlling the resistance of a lamp having a gas or vapor path, which consists in maintaining the density of the vapor or gas path approximately constant under a given voltage by varying the heat radiation of the lamp directly with variations in the current flowing.

2. The method of adapting a gas or vapor electric lamp to be operated by an approximately constant voltage, which consists in so correlating the vapor density and the heat-radiating capacity of the lamp that any increase of current and consequently of temperature in the vapor will be compensated for by the radiation of heat whereby the current will be cut down and normal conditions be restored.

3. The method of compensating for the increase of current due to a decrease of resistance in the operation of a gas or vapor electric lamp, which consists in creating a variable ratio between the heat absorbed by the vapor, due to the effects of current, and the heat radiated by the lamp.

4. The method of varying the luminous effect of a gas or vapor electric lamp, which consists in confining a gas or vapor in a suitable container, passing an electric current through it, and exposing the container to varying temperatures.

5. The method of correlating gas or vapor lamps containing a vapor or gas of definite variable resistance and having a definite length, for use upon circuits of different voltages, which consists in giving to the lamps a

cross-section whose diameter varies approximately inversely with the voltage with which they are to be used.

6. The method of constructing a lamp having as a conductor a gas or vapor of definite variable resistance, for use in connection with any desired voltage and current, which consists in giving to the lamp a length whose ratio to the diameter bears a direct relation to the ratio of the voltage with which it is to be used, to the current which it is to consume.

7. The method of correlating vapor or gas electrical resistance and electric energy for commercial use which consists in adjusting each with respect to the other as expressed by the formula

$$\frac{V}{C} = R = \frac{l}{d} g,$$

in which V represents the voltage, C the current, R the electrical resistance, d the diameter of cross-section of conducting vapor or gas, l the length of current path in vapor or gas, and g the electrical resistance factor for any particular vapor or gas; and where the electrical resistance is a function of the density of the vapor or gas and the resistance of the vapor or gas is understood to increase with increase or decrease of density from the density of maximum conductivity, and it is understood that the density will vary as if by reason of the temperature and pressure and that the density may be varied as specified.

Signed at New York, in the county of New York and State of New York, this 24th day of January, A. D. 1901.

PETER COOPER HEWITT.

Witnesses:

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