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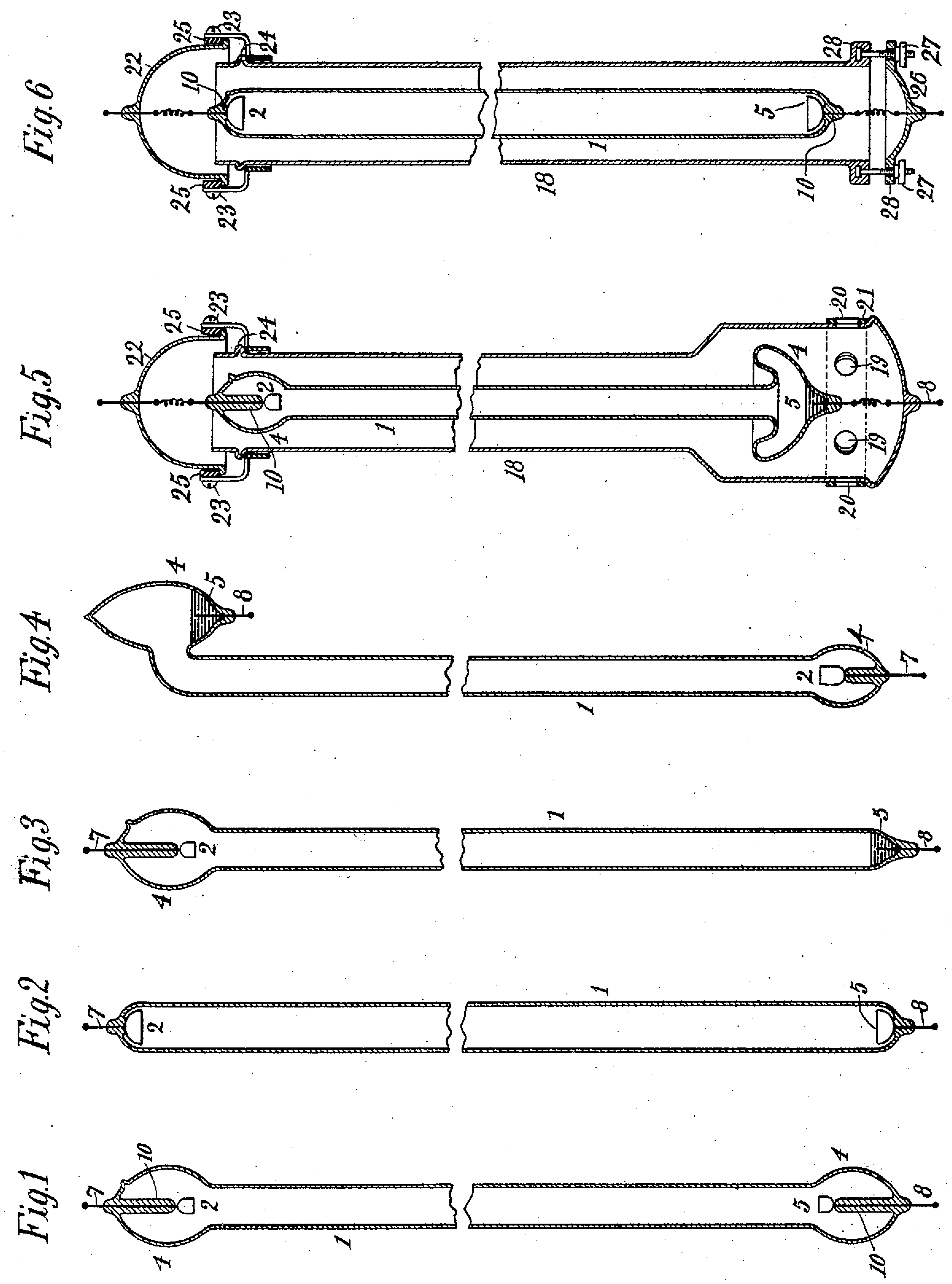
P. C. HEWITT.

APPARATUS FOR PRODUCING ELECTRIC LIGHT.

(Application filed Jan. 25, 1901.)

(No Model.)



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APPARATUS FOR PRODUCING ELECTRIC LIGHT.

SPECIFICATION forming part of Letters Patent No. 682,697, dated September 17, 1901.

Application filed January 25, 1901. Serial No. 44,649. (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 Apparatus for Producing Electric Light, of which the following is a specification.

My invention relates to an apparatus for producing light by means of electricity traversing a gas or vapor, the special object of the invention being to control the electrical conductivity or resistance of the gas or vapor by means which will be described in the present specification.

I have found that under 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 through the medium 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 so to 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, its efficiency in that respect being 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 as to render its naturally variable resistance controllable and stable, and thereby produce a highly efficient and commercially useful electric-lighting device.

I have found that the conductivity of a conducting gas or vapor increases as its density decreases up to a certain limit, beyond which decrease of density the conductivity diminishes with further attenuation of the gas or vapor. Starting from the condition of maximum conductivity, in other words, the resistance increases as the result of either an increase or a decrease of the vapor density. The first step toward controlling the density of the gas or vapor is taken when it is inclosed in a container of definite volume. When the gas or vapor has been so inclosed, the density of the conducting-path may then be varied by providing outside this path one or more chambers into which a portion of the gas or vapor can be made to pass or by the condensation or volatilization of suitable material held within the container. The total density is a function of the pressure (as determined by the limits given to the container through its length and radius) divided by the temperature. The density in any selected portion of the vapor inside the container depends upon the temperature of that portion as modified by the pressure affecting that portion. The effect of temperature in decreasing the density in a portion of the container by attenuating the vapor may be in part corrected by an increase in pressure.

In an operating-lamp the active agent which can be relied upon for producing the effects of light and heat is the current. In constructing an electric vapor-lamp designed for service as an efficient light-giving medium the object should be to provide means for so controlling the effects of the current as to make the lamp self-regulating, so that the heat developed by the current shall vary the density of the vapor, and incidentally the pressure, the whole being accomplished in such a manner that an increase of current-flow, and consequently of heat, shall produce an increased vapor resistance, thus cutting down the current and reëstablishing normal conditions. This may be accomplished by properly selecting the conducting medium and the length and radius of its container, thus determining the normal pressure of the vapor, and by providing a suitable heat-radiating capacity for the lamp not only through such careful selection of the length and radius of the container, but also through properly selecting the thickness of the walls, and in some instances providing one or more special cooling-chambers for assisting in the radiation of heat. Inasmuch as the radiation of heat takes place at the circumference the temperature of a vapor through which an electric current is flowing must necessarily vary throughout from circumference to center, being highest at the center and lowest at the circumference. Accordingly a vapor carrying current will have a varying density, decreasing along the radius from the circumference to the center. If now the density of the vapor in the container where no current is passing is at or below the density of maximum conductivity, the zone which nearest approaches the state of maximum conductivity when current is permitted to pass will be at the circumference, the vapor resistance increasing along the radius from the circumference to the center inversely as the density due to the attenuation caused by heat from the current. When the density of the vapor in the container is greater than the density of maximum conductivity, the vapor resistance will decrease along the radius of the conducting-column from the circumference to a point where the vapor is attenuated to the density of maximum conductivity, and from that point to the center the density will be below the state of maximum conductivity, and consequently the vapor will be of greater resistance toward the center.

If we adopt such a density of the contained gas or vapor that the zone of maximum conductivity or the zone nearest approaching that state is at the circumference of the vapor, we run the danger of exposing the substance of the container to injury from the effects of the current, and in practice I have found that it is not advisable to expose the container to this danger; but I have also found that with a vapor whose total normal density when no current is passing is at or below the condition of maximum conductivity I can select a radius sufficiently large to cause the accumulated vapor at the circumference, due to the heat developed when the current begins to flow, to have a resistance greater than that of maximum conductivity, whereby the condition mentioned in the preceding paragraph is attained, or I can select a radius large enough so that the heat generated by the current will not endanger the container. Thus it will be seen that the best available working condition for a lamp of this class is generally one in which the density is somewhat above the state of maximum conductivity. In this condition the zone of greatest conductivity is an annulus located along the radius between the center of the contained tube or chamber and the inner wall thereof. Bearing in mind that the conductivity of the gas or vapor is greatest at a given density or attenuation, the fact noted indicates that the stratum of gas or vapor between the inner surface of the wall and the so-called "conducting zone" is of greater density than that of maximum conductivity. The successful operation of a gas or vapor lamp appears to depend upon the proper control of the density of this outer stratum, thus determining the pressure of the said stratum upon the conducting zone and controlling the total conductivity of the lamp. The gas or vapor density in various parts of the container is governed by the temperature of the conducting medium, and this temperature may be regarded as the resultant of two factors or agents—first, heat generated by the current traversing the gas or vapor, and, second, the rate of heat radiation or heat emission therefrom per degree of difference of temperature. As in other electric lamps, the real controlling agent in a gas or vapor lamp constructed to be used at a constant voltage is primarily the resistance; but inasmuch as the resistance of a gas or vapor depends upon its density and as the density depends on what may be called the "resultant" temperature, due to the differential effects of the heat developed by the current and the heat radiated or emitted by the lamp, the controlling agent in a lamp of this class is practically the ratio of temperature of the gas or vapor as influenced by the pressure to the heat-dissipating capacity. If this temperature can be maintained definite at predetermined pressure, the ratio of density will be definite, and hence the conductivity or the resistance of the conducting medium will be definite with respect to a definite current. In lamps wherein a vapor is produced by the volatilization of a suitable substance contained within the tube or chamber the same law holds good, bearing in mind that the density may increase with the temperature, although in such cases the relation of the volatilizing or boiling point of the substance employed to the temperature at which it is intended to operate must be taken into consideration. In such lamps a properly-selected vapor temperature, maintained by the regulation of the heat emission, will accord approximately reliable self-regulation, the supply of fresh vapor to compensate for the condensation resulting from any cooling process being automatically responsive to the demands of operation. It follows that a lamp of this character in order to be stable should be so constructed that when the density of the gas or vapor has reached the point that is best suited for practical operation the rate of emission of heat from the lamp should be the same as the rate of development of heat caused by the passage of the current. In other words, the gas or vapor employed as the conducting medium should be confined in such a manner and with such surroundings that the thermal conditions inside the containing tube or chamber shall remain unchanged or shall correct themselves under varying conditions of imparted heat due to a varying flow of current at any given time. Should the heat-radiating capacity of the lamp be either too great or too small with respect to the current, the resultant temperature would cease to be a corrective factor, and the vapor density and lamp resistance would be unstable, and the lamp would cease to be self-corrective in its action.

In accordance with what has been suggested above self-regulation in lamps of this class may be attained by subjecting the gas or vapor path to such surrounding conditions as to secure the radiation or emission of heat at a predetermined rate, or means may be provided in addition to the regulation of the heat emission for supplying additional vapor, as from vaporizable material, to the conducting medium as the density of the vapor path tends to become too attenuated, and so have a tendency toward increasing the density due to increase of temperature by this means instead of decreasing density.

In the accompanying drawings I have illustrated several forms and arrangements of gas and vapor lamps adapted to serve for carrying out my invention.

In the drawings, Figure 1 is a section of a lamp adapted to contain a suitable gas the density of which will decrease with an increase of temperature. Fig. 2 is a similar view of a lamp in which the gas will maintain a constant total density. Fig. 3 represents in section a vapor-lamp containing a volatilizable substance and so arranged that the density will increase with an increase of temperature. Fig. 4 similarly represents a vapor-lamp wherein the density of the vapor varies in a prescribed manner with the temperature. Fig. 5 represents a vapor-lamp with variable vapor density, the same being surrounded by a transparent jacket provided with means for adjusting the amount of heat abstracted at a given time; and Fig. 6 is a similar view of a lamp with constant density surrounded by a transparent jacket with a variable draft to enable varying the temperature the lamp may attain.

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 pure 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. 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 will 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, thus bringing about a condition of variable density within the lamp due to the attenuation caused by the heat of 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. 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.

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 through giving to the enlargements 4 4 a definite containing and heat-radiating capacity, the enlarged portions 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 mesh 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.

The principles laid down in the present specification are embodied in 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, and 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 will be constructed of pure iron held in place by a supporting pillar of glass, through which the platinum leading-in wire passes. The negative electrode may be a puddle of mercury, as shown, and a platinum leading-in wire extending through the walls of the vessel will connect the mercury with the external circuit. Such a 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 75°.

The above is given merely as an illustrative lamp. By varying the proportions and dimensions the current consumed by the lamp may be varied from the above within wide limits, and the lamp may be made to adapt itself to the conditions of any circuit, and the lamp may be constructed to run on constant-voltage circuits of wide range of voltage.

The lamp may be started by any of the devices such as are described, for example, in my pending application, Serial No. 11,605, filed April 5, 1900.

The foregoing specification relates, primarily, to means for controlling the conductivity or resistance of a gas or vapor lamp by the means described, the object being to maintain a uniform resistance or conducting power under generally uniform conditions of outside temperature, as when a lamp of this sort is intended to give light in a confined space. It is possible, however, by varying the external temperature through such means as are illustrated, for example, in Figs. 5 and 6, or by any other simple means to produce the same conditions of stability under a constant lower temperature; but in that case the lamp resistance will be decreased while the current is increased as well as the candle-power of the lamp, the electromotive force remaining stationary. Having selected some lower outside temperature, thereby causing a more rapid radiation of the heat, the lamp will regulate itself in the manner hereinbefore described so long as the outside temperature remains at the lower degree. These principles furnish a means for increasing or decreasing the brilliancy of the light emitted by a lamp of this class without impairing its efficiency, as the watts consumed are varied by varying the actual resistance of the lamp itself, as will be readily understood.

In certain other applications filed by me April 5, 1900, Serial Nos. 11,605, 11,606, and 11,607, and Serial Nos. 44,647 and 44,648, filed January 25, 1901, claims are made to certain features which are disclosed herein.

I claim as my invention—

1. A gas or vapor lamp of the character described, consisting of electrodes, a gas or vapor path between them, and an inclosing chamber for said electrodes and gas or vapor path, consisting of a transparent wall, the exterior surface of said wall being so proportioned to the heat-developing capacity of the lamp, under normal operation, as to radiate heat at the proper rate to maintain such a density on the part of the gas or vapor path that the product of its resistance into the current flowing therethrough shall remain approximately constant.

2. In an electric lamp having a gas or vapor path rendered luminous by the conduction of current therethrough, an anode, a cathode, a conducting-path composed during the operation of the lamp of a conducting gas or vapor having definite dimensions and density with respect to the voltage and current employed, and an enlarged chamber surrounding the cathode, a portion of such enlarged chamber lying outside the conducting-path.

3. In an electric lamp having a gas or vapor path adapted to be rendered luminous by the passage of an electric current, an anode, a cathode, and a conducting-path composed, during the operation of the lamp, of a vapor having definite dimensions and density with respect to the voltage and current to be employed.

4. In an electric lamp having a gas or vapor path, a heat-radiating surface so proportioned to the resistance of the lamp and the current carried thereby at definite voltage, that the temperature of the lamp shall be maintained at such a point as to render the density of the vapor in the path of the current approximately constant.

5. In a vapor or gas lamp of the character described in which the gas or vapor path requires to be maintained at an approximately definite ratio of density, the combination of an inclosing chamber, and means for giving to that chamber such a heat-abstracting capacity that the heat abstracted will be equal to the heat generated by the current passing through the lamp at definite temperatures, substantially as described.

6. In a gas or vapor electric lamp, the combination with a vapor having a definite density and heat-absorbing capacity, of a container for the said vapor having a heat-radiating capacity equal to the heat-absorbing capacity of the vapor at a definite temperature for a definite amount of current, the density being predetermined with relation to the current to be employed so as to be made luminous thereby.

7. In a gas or vapor lamp of the character described the combination with a vapor having a definite heat-absorbing capacity of a container for said vapor, and means for varying at will the heat-radiating capacity of the container, and thereby varying the current consumed by the lamp.

8. As an article of manufacture, a lamp consisting of a tube or other suitable container holding a vapor or gas of comparatively low resistance, the density of the vapor or gas being approximately that of maximum conductivity for the electrical current passed, whereby it is adapted to pass a definite electric current.

9. As an article of manufacture, a lamp consisting of a tube or other suitable container, a volatile electrode therein provided with electrical connections for volatilizing the same to form a sole conductor of low resistance, the density of such conductor being approximately that of maximum conductivity for the

electrical current passed, whereby it is adapted to pass a definite electrical current.

10. In a light-producing device, a container, a gas or vapor in the container, fixed electrodes in the container and suitable electrical connections thereto, the vapor or gas acting as the sole path for the electric current and having a density approximately that of maximum conductivity for the electrical current passed, whereby it is adapted to pass a definite current of considerable quantity and low voltage between the electrodes, said gas or vapor being light-radiant on the passage thereof, the container inclosing a space lying outside the path of the electric current.

11. An electric lamp consisting of an inclosing chamber, a vapor or gas contained therein and capable of conducting currents, two electrodes located at or near the respective limits of the vapor or gas, said chamber having such dimensions as to render the heat-radiating capacity of the lamp commensurate with its heat-generating capacity when in operation.

12. An electric lamp consisting of an inclosing chamber, a vapor or gas contained therein and capable of conducting currents, two electrodes located at or near the respective limits of the vapor or gas, said electrodes being substantially deprived of such matter as would offer a high resistance to the passage of electric current between themselves and the vapor or gas and said chamber having such dimensions as to render the heat-radiating capacity of the lamp commensurate with its heat-generating capacity when in operation.

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.

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