March 19, 1940. C. G. FOUND 2,194,300

VAPOR LAMP AND METHOD OF OPERATION

Filed Sept. 24, 1937

Fig.1.

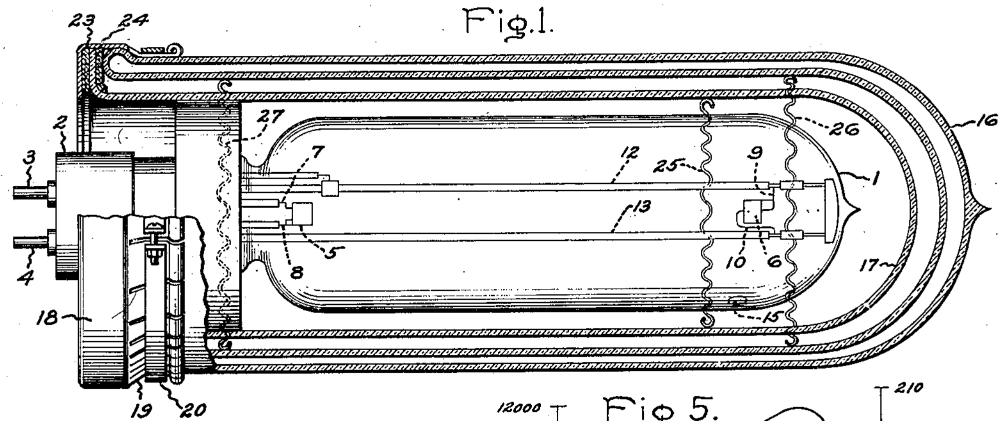


Fig.2.

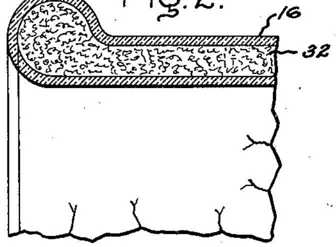


Fig. 5.

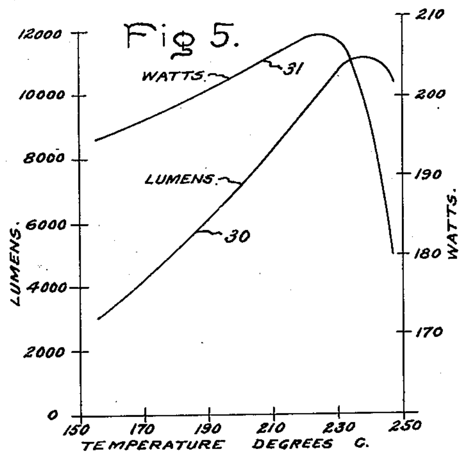


Fig. 3.

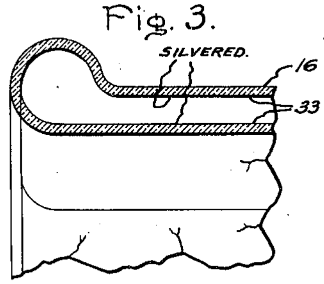


Fig. 6.

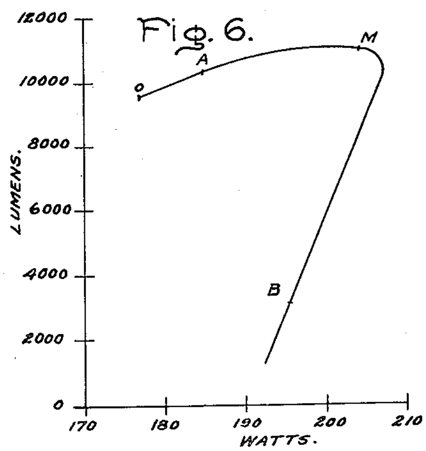
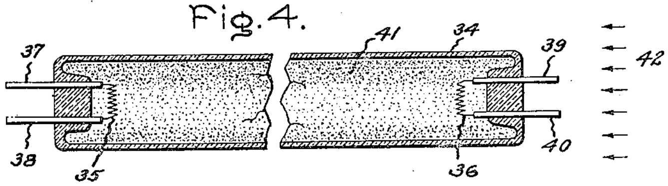


Fig.4.



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UNITED STATES PATENT OFFICE

2,194,300

VAPOR LAMP AND METHOD OF OPERATION

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4 Claims. (Cl. 176—124)

The present invention relates to vapor electric discharge lamps and, in particular, relates to the operation of such lamps under conditions involving variable ambient conditions, such as extreme cold, high winds, rain, snow and so forth.

The radiation output of vapor lamps varies considerably with ambient temperatures unless precautions are taken to avoid this variation. For example, if a sodium lamp is constructed to operate during the summer with a designed normal luminous output, it will be found during the winter when ambient temperatures are low and high winds are apt to be encountered, that the light output is materially reduced.

As described in Fonda and Young U. S. Patent No. 2,025,585, such lamps may be operated with a substantially constant luminous output over a wide range of ambient temperatures by maintaining the operating current at a critical value. However, it is not always possible to fix the operating current for vapor lamps at any desired value. For example, many lighting circuits are arranged to operate with fixed current values, thus making it impracticable to operate sodium, or other vapor lamps in accordance with the method of said Fonda and Young patent.

In accordance with my present invention this difficulty is overcome by suitably fixing the temperature of the lamp envelope under summer conditions at a value at which the energy consumed in the lamp is slightly less than maximum and such that changes in external heat dissipation will be compensated by corresponding changes in internal heat generation, thus resulting in approximately constant temperature for the lamp envelope. For example, the temperature of the lamp envelope is predetermined by providing more or less heat insulation, or by artificially cooling the envelope, or any other suitable way to correspond to a value at which stability is obtained under varying ambient conditions. My invention is particularly applicable to the control of resonance radiation devices and will be more fully explained in connection with the accompanying drawing. Its novel features will be pointed out with greater particularity in the accompanying claims.

Included among resonance radiation discharges are the sodium vapor discharge with its resonance radiation at 5890 Å., the mercury vapor discharge with its resonance radiation at 2537 Å., and the cadmium vapor discharge which emits resonance radiation at 3261 Å.

The drawing shows in Fig. 1 a side elevation, partly in section, of a sodium lamp with surrounding heat-conserving housings; Figs. 2 and 3 are fragmental views illustrating modifications; Fig. 4 is a longitudinal section of a low pressure lamp arranged to be artificially cooled; Figs. 5 and 6 are graphs illustrating respectively the relation of temperature and lamp characteristics and the relation of light output and energy consumption of typical lamps.

A sodium lamp is shown in Fig. 1 and comprises an elongated bulb or lamp envelope 1 having a base 2 which is provided with electric terminals 3, 4. Within the bulb, and at opposite ends, are provided electrodes 5, 6, each of which alternately functions as cathode and anode. These electrodes comprise a thermionic filamentary member (not shown) surrounded by and electrically-connected to a metal cylinder as indicated. The electrode 5 is supported by the current-conveying conductors 7, 8. The elecrode 6 is supported by current-conveying conductors 9, 10 which, in turn, are connected to suitably insulated conductors 12, 13 extending through the lamp interior from the base 2. The lamp envelope is exhausted of air and filled with a suitable gas, which is not condensable under ordinary conditions, such as neon or argon, at a pressure of one to several millimeters. For convenience, this gas will be referred to as a fixed gas. As indicated at 15, a charge of sodium, cadmium, zinc, or other easily vaporizable metal, having a lower ionization potential than the fixed gas, is introduced into the envelope. Devices containing such mixtures of fixed gas and vapor have operating characteristics (such as herein illustrated), which exhibit marked temperature sensitivity. The lamp envelope is supported inside a heat conserver which may consist only of a surrounding simple glass jacket or of double-walled evacuated glass jacket. The lamp which is illustrated is surrounded by both forms of heat conservers, namely, an outer double-walled vacuum jacket 16 and an inner single-walled, non-evacuated jacket 17, both jackets being supported on the base 2 by a ring 18 having an expansible flange 19. A flexible strap 20 is shown for binding the flange 19 on the jacket 16. Suitable gaskets 23, 24 are provided to cushion the ends of the jackets 16 and 17. A resilient spacer 25 is provided to cushion the free ends of the lamp bulb within the jacket 17 and the spacers 26, 27 are provided to cushion the jacket 17 within the outer vacuum jacket 16. The lamp here shown is in many respects similar to the lamp shown in De Groot

U. S. Patent No. 1,919,933, patented July 25, 1933.

When a lamp, such as described, is put into operation, the cathodes are heated to a thermionic-emitting temperature and current is caused to pass through the neon or other gas filling, by applying voltage across the main electrodes. It will be understood, of course, that if the lamp is to be operated with direct current, it need be provided with only one thermionic electrode, which operates as a cathode, the anode being unheated and of any suitable form. Initially, all the light is characteristic of the inert gas. As the discharge through the gas in the lamp continues, its temperature rises and the sodium, or whatever vaporizable metal is provided in the lamp, is progressively vaporized and takes part in the production of light. At low concentrations of the sodium, or other vapor, the light from the vapor is chiefly resonance radiation. When the vapor concentration exceeds a limiting value, the amount resonance radiation decreases and light corresponding to higher members of the spectrum becomes predominant.

As shown in Fig. 5, by the curve **30**, with constant operating current the output of resonance radiation by lamps of the type shown increases as the bulb temperature is increased, reaches a maximum and then with further increase of bulb temperature the radiation output decreases. In the particular case under consideration, the radiation output rises from about 3000 lumens at a bulb temperature of about 160° C. to about 11,000 lumens at about 240° C. When the bulb temperature is increased in any way (as by better heat insulation), the energy consumed in such a lamp with a fixed current increases to a maximum and then decreases. As shown by curve **31**, the energy in a typical lamp reaches a maximum of about 208 watts at about 225° C.

The relation of lumens (light output) to energy consumption (watts) for a given current is shown by the graph of Fig. 6. The greatest light output is obtained by so controlling the lamp container temperature that the energy consumption (watts) is maintained at approximately a maximum, for example, the value M on the graph of Fig. 6. However, should the container temperature even slightly decrease, for instance, because of a decrease of ambient temperature, or due to a change in wind or other external ambient thermal condition, then the energy consumption (watts) in the lamp will decrease and the temperature of the lamp will decrease in much greater measure than if the watts remained constant. This results in a large decrease in light output. For example, a decrease in ambient temperature to about −18° C. with a 15 mile per hour wind for the sodium lamp having characteristics shown in Fig. 6, the lumen output will decrease from the value M to the value B, that is, a decrease in light from about 11,000 to 3000 lumens and a decrease in energy from about 205 to 195 watts. If, however, the operating container temperature is determined by suitable heat insulation to be high enough under average conditions to cause the bulb temperature to rise about 10 to 15° C. and hence the watts consumed to be somewhat less than realizable maximum, ordinarily about 10 per cent, (corresponding to a value A on the graph Fig. 6), then the same change in external heat-dissipating conditions will result in only a small change of light output, ordinarily only a few per cent. A reduction of external temperature from the summer temperature is largely compensated for by an increase in internal heating due to increased energy consumption, so that changes in bulb temperatures are much less than if no compensation were provided. As the slope of the upper branch of the lumens-watts graph (Fig. 6) of a resonance radiation device is less than the slope of the lower branch, the result is that under such conditions the lumen output remains substantially constant.

The efficiency of light production is substantially constant over the range of lamp wattage values included between points O and M on the graph of Fig. 6. Although the lumen value decreases somewhat from M to O, the efficiency does not correspondingly decrease as the watt consumption also decreases.

As shown by the graph **31**, a bulb temperature of about 230° C. (or slightly higher) is accompanied by an energy consumption in the lamp of about 200 watts or slightly higher (point M of Fig. 6). If, by more effective heat insulation, the bulb temperature is raised about 15 to 20° C., that is to 240 or 245° C., then the lamp wattage is reduced, say to 180 or 185 watts. This decrease of 7.5 to 10 per cent in wattage corresponds to point A of Fig. 6 and, as explained in connection with Fig. 6, desired stability in lumen output over a wide range of external heat-dissipating conditions thus is obtained. Exposure to cold, high wind and even sleet or snow will result in little change in lumen output.

An increase in bulb temperature may be obtained in various ways. For example, as shown in Fig. 1, a higher bulb temperature may be obtained surrounding the lamp in addition to the usual vacuum flask with an inner auxiliary heat insulating chamber consisting of the single-walled flask **17**. The effective heat insulation of the vacuum flask **16** also may be improved by placing a heat-insulating, translucent material, such as glass wool, within the evacuated space, as shown in Fig. 2 at **32**. The heat insulation will be further improved by silvering a sector of the heat insulating flask through which light emission is not desired or from which the cutting off of light will result in no decrease in effective lighting obtained from the lamp. For example, as shown in Fig. 3, the two inner surfaces of the vacuum flask are silvered at **33**. The silvering may extend over an arc of about 90° at the part of the vacuum flask which is uppermost when the lamp outfit is operated above a road or areaway to be lighted.

In some cases the desired effect will entail artificial cooling in order to cause the lamp container to operate at a lower temperature. In Fig. 4 is shown a lamp consisting of a sealed envelope **34** which is provided at opposite ends with thermionic cathodes **35** and **36**, these cathodes being respectively connected to, and mounted upon, leading-in conductors **37**, **38** and **39**, **40**. In the discharge device of Fig. 4 a coating of fluorescent material is indicated by the stippling at **41**. This material will be excited to luminescence by ultraviolet radiation from a discharge within the container, particularly from the 2537 Å. wave length, when the vaporizable metal is mercury. In some cases this fluorescent coating may be omitted, for example, when the ultraviolet output is desired for use external to the tube. In such case an ultraviolet-transmitting glass, or fused silica, should be used. The envelope **34** may be charged with various attenuated gases, or vapors or mixtures thereof, for example, with about 4 millimeters of argon and a small amount, say about 10 cubic millimeters, of mercury.

The characteristics of such a device substantially correspond to the characteristics of a sodium lamp, as shown in Figs. 5 and 6, except for some differences of contour and the fact that the output of resonance radiation is in the ultraviolet instead of the luminous range.

By artificial cooling of the envelope, for example, by a current of air, as indicated at 42, the temperature of the envelope may be reduced to an optimum operating value of about 60 to 70° C., which will give a stable output of radiation over a range of variable external conditions.

The term lamp has been used herein to include not only devices emitting light in the visible range but also devices emitting invisible radiation, such as ultraviolet.

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

1. The combination of an electric lamp containing cooperating electrodes, an attenuated fixed gas and an easily vaporizable metal, means for supplying thereto a substantially constant current for the operation thereof, means for maintaining the heat-dissipating characteristics of said lamp at a value such that the lamp-operating temperature is higher than the temperature of realizable maximum radiation output and the energy consumption is about ten per cent less than the realizable maximum energy consumption whereby large variations in ambient dissipating conditions produce little change in radiation output.

2. The combination of an electric lamp containing cooperating thermionic cathodes, a charge of attenuated neon gas and sodium, means for supplying thereto a substantially constant current for the operation thereof, means for conserving the heat generated by said lamp to obtain a lamp operating temperature which is about 15 to 20° C. higher than the temperature of realizable maximum energy consumption whereby large variations in ambient heat-dissipating conditions produce little change in light output.

3. The method of operating a vapor electric dicharge lamp containing fixed gas and sodium, and having a luminous radiation output reaching a peak at a temperature above the maximum energy consumption of said lamp which comprises adjusting the energy input and the heat-dissipating characteristics of said lamp for a given operating current to result in an operating lamp temperature higher than the temperature of maximum energy consumption, at which operating temperature the energy input is materially less than the energy consumption corresponding to maximum radiation output whereby a wide range of external heat-dissipating conditions results in little change in luminous radiation.

4. The method of operating a vapor electric dicharge lamp containing a fixed gas and vaporizable metal which consists in adjusting the energy input and the heat-dissipating characteristics of said lamp for a given operating current to result in a lamp-operating temperature higher than the temperature of realizable maximum energy consumption, at which operating temperature the energy input is at least about 10 per cent less than the realizable maximum energy consumption whereby large changes in ambient heat-dissipating conditions result in little change in radiation output.

CLIFTON G. FOUND.