J. A. ORANGE.

ELECTRIC LAMP.

APPLICATION FILED SEPT. 12, 1914.

1,279,415. Patented Sept. 17, 1918.

Fig. 1.

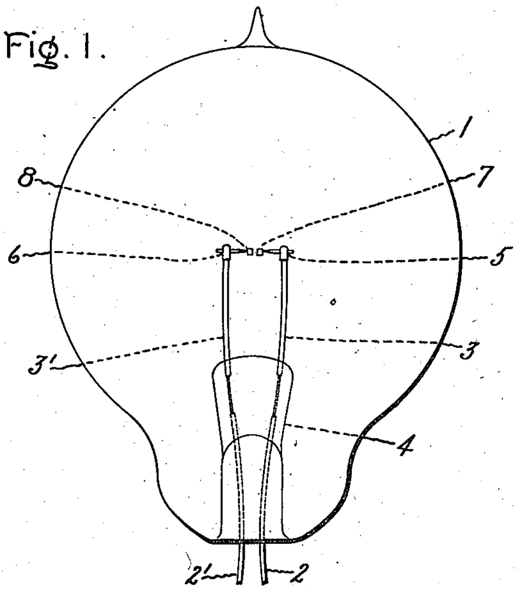


Fig. 3.

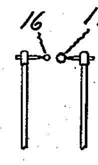
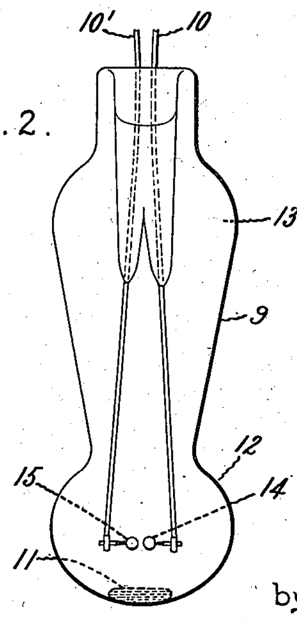


Fig. 2.



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UNITED STATES PATENT OFFICE.

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ELECTRIC LAMP.

1,279,415. Specification of Letters Patent. Patented Sept. 17, 1918.

Application filed September 12, 1914. Serial No. 861,381.

To all whom it may concern:

Be it known that I, JOHN A. ORANGE, a subject of the King of Great Britain, residing at Schenectady, county of Schenectady, State of New York, have invented certain new and useful Improvements in Electric Lamps, of which the following is a specification.

The present invention relates to electric lighting and comprises a lamp in which an arc is operated between electrodes of highly refractory metal, as, for example, tungsten, in a sealed envelop containing an indifferent gas or vapor.

The efficiency of an incandescent filament lamp increases with the temperature of the incandescent filament. However, the rate of evaporation of a refractory metal when operated at incandescence in a vacuum increases so rapidly with an increase of temperature that the operating temperature is limited to a value at which the evaporation will not be too rapid to give a useful length of life, and this is commonly a temperature corresponding to a light efficiency of about one watt per candle. An atmosphere of inert gas of relatively considerable pressure depresses the evaporation of a refractory metal, such as tungsten, to such extent that it has been found practicable to increase the operating temperature to a value at which a marked increase of efficiency could be secured under certain conditions in spite of the heat losses due to gas convection currents, as disclosed in Patent No. 1,246,118, granted to Dr. Irving Langmuir, on November 13, 1917. As the heat losses by convection are approximately independent of the diameter of the filament between certain limits and as the larger diameter filament with its greater surface area will radiate more light, it has been found that the increased efficiency could be most advantageously obtained in lamps of large energy consumption. In lamps of small current the convection heat losses are greater in proportion to the light emission, due to the decreased filament diameter, and in low voltage lamps the heat losses by conduction from the terminals constitute a formidable proportion of the energy losses. It, therefore, has not been found practicable to make incandescent lamps having a filament operating in a gaseous atmosphere below certain candle powers.

A gaseous atmosphere of relatively considerable pressure is efficacious not only to reduce evaporation of the metal at a high temperature, as in the filament lamp above described, but will also reduce the sputtering or electrical disintegration of the cathode due to an arc to such extent that a lamp of small candle power having a commercially useful life may be made in which electrodes of tungsten, or equivalent refractory metal, are maintained at intensive incandescence by means of an arc. In this manner electrodes having the shape of hemispheres, cubes, disk or similar bodies of concentrated mass and small surface area may be heated to a temperature of incandescence at which the efficiency of light production is about one-half watt per candle power or even greater, although these bodies could not be heated by heat developed due to their ohmic resistance alone without prohibitive loss of heat at the terminals.

The arc in addition to its function of heating its electrodes may contribute a portion of the light at high efficiency provided the inert gas is so chosen that the arc is luminous, for example, as is the case in mercury vapor, but preferably the arc gap is of the same order of magnitude as the electrodes, and hence usually the light from the arc represents only a small fraction of the light emitted by the lamp.

In order that the lamps may be operated at the high temperature at which the increased efficiency of light production would more than off-set the cooling effect of the gas, it is desirable that the current-carrying conductors for the electrodes should be made as small in cross section as is consistent with their function. The pressure of gas should be great enough to materially reduce the vaporization of the metal, preferably approaching the pressure of the atmosphere at the operating temperature.

In one aspect my new lamp is a combination arc and incandescent lamp containing a gaseous atmosphere, the electrodes being so proportioned that the advantages of a gaseous atmosphere at relatively considerable pressure in an incandescent lamp may be secured in lamps of very small rating.

In the accompanying drawings, Figure 1 illustrates my invention in a lamp employing an inert fixed gas, such as nitrogen or argon; Fig. 2 illustrates a lamp containing a body of mercury which during the operation of the device is vaporized at least in part, and surrounds the arcing electrodes; and Fig. 3 illustrates diagrammatically the electrodes of a lamp adapted for direct current operation.

The lamp as shown in Fig. 1 comprises as usual a transparent globe 1 consisting of glass or the like, provided in the usual manner with leading-in wires 2, 2′ sealed into a stem 4, and making connection to supporting conductors 3, 3′ consisting of nickel or tungsten. To the conductors are secured the terminals 5, 6 which separate the arcing electrodes 7, 8. The terminal wires 5, 6 may be joined to the conductors 3, 3′ in any convenient manner, as by sealing or by merely mechanically pinching the ends of the wires 3, 3′ around terminals 5, 6 while heated. The terminal wires 5, 6 should be made as small in diameter as consistent with their function of carrying the operating current of the lamp so as to reduce to a minimum the heat losses by conduction from the incandescent electrodes 7, 8. On the other hand the terminal wires 5, 6 should not be so small that they will operate at a high enough temperature to become softened and deformed. Preferably the terminal wires are reduced locally in section by etching or otherwise near the electrodes. For example, with electrodes of about 40 mils in diameter separated for a space of about 2 to 10 mils and designed to operate with a current input of about .6 to .8 amperes, the wires may have a diameter of about 20 mils, etched down to a neck of about 4 to 8 mils. Both the electrodes and the terminals preferably consist of ductile tungsten, but my invention is equally applicable to electrodes of non-ductile metal and also to refractory metals other than tungsten, for example, tantalum.

The bulb 1 contains a gas having a relatively low heat conductivity and being inert in respect to the electrodes when the latter are at incandescence, for example, nitrogen, argon, krypton, or other rare gases or mixtures of these may be used. The pressure of the gas may be varied and should preferably be so chosen that when it is heated to the operating temperature its pressure will approximate that of the atmosphere, but pressures up to two atmospheres when operating can be used without much danger of the globe bursting. As a general rule the gas pressures may vary from about one-fifth of an atmosphere upward and I have designated these pressures as relatively high gas pressures to distinguish over the very low gaseous pressures heretofore employed in lamps of the Geissler or Moore tube type. With a lamp operating with an input of about 30 to 50 watts and a globe of about three inches in diameter, the gas pressure when the bulb is cold is preferably about 600 m. m. of mercury. In some cases, however, the pressure may be as low as about 150 to 200 m. m. of mercury. The arc voltage varies with the character of the gas and the length of the gap but the voltage drop is in all cases relatively low. For example, in nitrogen at about atmospheric pressure the arc voltage with a gap of about 2 to 4 mils is about 40 volts.

The lamp shown in Fig. 2 is similar to that already described in connection with Fig. 1, but contains a quantity of mercury. The globe 9 may consist of low expansion borosilicate glass into which tungsten wires 10, 10′ are sealed, but the character of the glass and the seal, of course, may be chosen as required by the operating temperature and other conditions. In this case the bulb contains a quantity of mercury 11 as well as an inert gas, such as nitrogen or argon, at a relatively considerable pressure, for example, about 150 to 250 m. m. of mercury, but in some cases the gas filling other than mercury may be omitted. In that case some of the mercury preferably should be volatilized in the starting of the lamp. A lamp consuming about 50 watts may have a diameter of about ½″ at the arcing region constituted by the chamber 12 and a length of about 1½″.

When as preferred a gas filling is provided in addition to the mercury, an arc is first started between the electrodes 14, 15, by a high potential discharge or any other way. The heat of this arc quickly vaporizes some of the mercury and the relatively dense mercury vapor displaces the lighter gas around the electrodes so that very soon after the arc is started the nitrogen or argon is displaced by the mercury vapor to the chamber 13 constituted by the upper part of the bulb.

The arc between the electrodes 14, 15 operating in mercury vapor filling the chamber 12 is luminous and will contribute a part of light. I do not aim, however, to obtain any great proportion of the light from the arc, as my device is essentially an incandescent lamp heated by means of an arc, or, in other words, the energy consumed in the arc is substantially all utilized for heating the electrodes. In mercury vapor the arc voltage at about atmospheric pressure is about 10 to 20 volts with a current varying from 3.2 to .86 amperes.

The lamps shown in Figs. 1 and 2 have electrodes of substantially the same size and are adapted particularly for alternating current. As more heat is liberated at the anode than at the cathode, the anode 17 in a direct current lamp is preferably made larger than the cathode 16 as shown in Fig. 3.

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

1. An electric lamp comprising the combination of a sealed container, a gaseous filling

therein having a heat conductivity not substantially higher than nitrogen at a pressure greater than about 150 millimeters of mercury, tungsten electrodes therein having a shape and mass adapting the same for incandescence in said gas at a lighting efficiency materially higher than one watt per candle power, said electrodes being separated by a gap so short that the energy consumption of the arc is substantially all utilized for heating said electrodes, and refractory stems for said electrodes having a reduced section adjacent said electrode.

2. An electric lamp comprising the combination of a sealed envelop, a filling of inert gas of low heat conductivity therein at a pressure approximating the pressure of the atmosphere at the operating temperature of the lamp, electrodes of tungsten having a diameter of substantially about one millimeter in said envelop separated from each other by a gap of the order of magnitude of about one millimeter, and refractory current-carrying conductors therefor, having a section adjacent the electrodes reduced in diameter to conserve the heat generated at said electrodes.

3. An electric lamp comprising the combination of an envelop, tungsten electrodes of about the order of magnitude of about one millimeter, separated from each other by a gap of about the same order of magnitude as said electrodes, a filling of gas of low heat conductivity and indifferent with respect to said electrodes at a pressure approaching one atmosphere when at the operating temperature, terminal conductors having a section adjacent the electrodes reduced in diameter and substantially large enough only to carry without softening energy sufficient to maintain an arc adapted to heat said electrodes to incandescence.

4. An arc device comprising the combination of a sealed container, electrodes of refractory material therein proportioned to be operable at incandescence, current carrying conductors therefor having a section adjacent said electrodes reduced in diameter and a gaseous filling in said container having a heat conductivity not materially higher than nitrogen at a pressure sufficiently high to substantially suppress electrical disintegration of said electrodes during the operation of an arc therebetween.

5. An electric lamp comprising the combination of an envelop, a filling of inert gas, such as argon, therein at a pressure of about 150 to 200 mm. of mercury, tungsten electrodes having a diameter of about 40 mils separated by a space of about 2 to 10 mils and proportioned to be heated to incandescence by an arc operating between said electrodes, and current carrying conductors for said electrodes having a diameter of about 20 mils said conductors having a section adjacent the electrodes having a diameter of about 4 to 8 mils.

In witness whereof I have hereunto set my hand this 8th day of September, 1914.

JOHN A. ORANGE.

Witnesses:
HELEN ORFORD,
BENJ. H. WEISBROD.