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ELECTRICAL GASEOUS DISCHARGE LAMP

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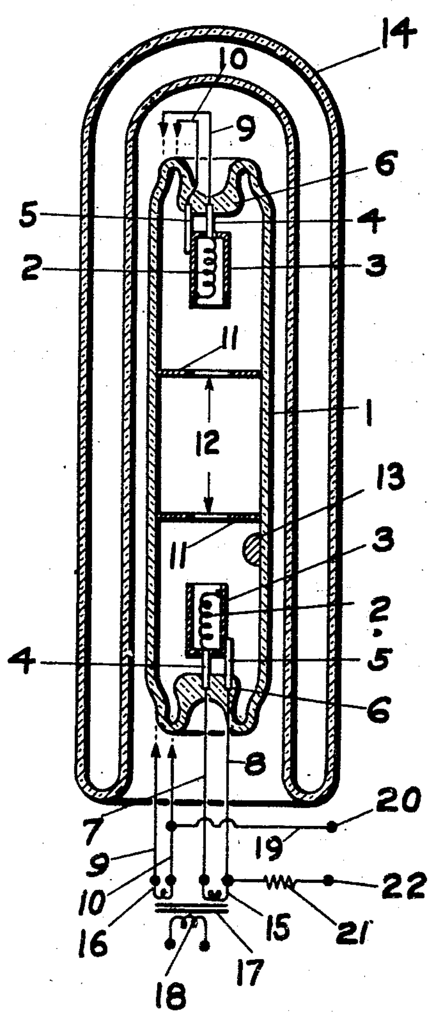

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ELECTRICAL GASEOUS DISCHARGE LAMP

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10 Claims. (Cl. 176—124)

This invention relates to an electrical gaseous discharge lamp of the type in which atoms of a material which has desirable spectral properties are introduced into a discharge space in which they are excited and caused to emit the desired radiation.

An object of this invention is to produce a lamp of high intensity and high efficiency.

Another object of this invention is to secure such high efficiency by producing a lamp in which the electronic temperature and the temperature of the gas in the discharge path are substantially of the same order of magnitude.

A further object is to secure the above results with moderate envelope temperatures and moderate current densities.

The foregoing and other objects of this invention will be best understood from the following description of an exemplification thereof, reference being had to the accompanying drawing in which the single figure is a cross section of a lamp structure and associated circuit embodying my invention.

In the usual electrical gaseous discharge, the electronic temperatures are relatively high as compared to the temperature of the gas in the discharge space. I have found that in the case of a relatively intense electrical gaseous discharge, the efficiency of the production of light can be greatly increased by lowering the electronic temperature and raising the temperature of the gas in the discharge space until these temperatures are of substantially the same order of magnitude.

The electronic temperature depends on various factors, such as the nature of the gaseous atmosphere in which the discharge takes place, the gas pressure and the current density in the discharge space. In general, the electronic temperature is likely to be less if the ionization voltage of the gas is less. As the gas pressure is increased, the electronic temperature tends to decrease. As the current density in the discharge space is increased, the electronic temperature tends to decrease.

In lamps made in accordance with my invention, I prefer to have the envelope temperature of a moderate value so that special cooling, such as water cooling, is not necessary. Further, I prefer that the current density in the discharge space should be likewise moderate, preferably of the order of one ampere per square centimeter. In lamps of this kind, electronic temperatures of the order contemplated by this invention may be secured with the vapor of caesium, rubidium, potassium or sodium, as the ionizable medium carrying the discharge. With moderate pressures of these vapors (e. g. below atmospheric pressure) and moderate current densities (e. g. one ampere per square centimeter) electronic temperatures of the order of several thousand degrees Kelvin may be secured with the above materials.

The temperature of the gaseous atmosphere in the discharge path is determined by a balance between the rate of energy input to said gas and the rate of escape of energy therefrom. The rate of energy input is determined by the watts per unit volume expended by the electric current flowing through the discharge space. With a predetermined value of current flow, the rate of energy input increases with the voltage drop per unit length of discharge path. This voltage drop per unit length depends on the ionization voltage of the gas carrying the discharge and usually rises as the pressure rises. The rate of loss of energy is determined by the rates of radiation loss and ionic loss and by the thermal conduction and convection. In a lamp, it is desirable to increase the radiation from the gas as much as possible. Therefore in order to retain energy within the gas so as to raise its temperature in accordance with this invention, the electrical losses should be made high and the thermal conduction and convection should be made as low as possible.

The gases recited above as carrying the discharge, viz. the vapor of caesium, rubidium, potassium and sodium, have relatively low ionization potentials and therefore tend to produce a relatively low voltage drop per unit length of discharge path in the lamp. As indicated above, it is desirable that the voltage drop per unit length be relatively high. In order to accomplish this, I add to the gaseous filling another component which raises the voltage drop. Such a component should have atoms which have a small molecular weight, such as helium and hydrogen, in order that electronic losses due to elastic collisions shall be relatively great. Helium and hydrogen, however, possess relatively high thermal conductivity. As indicated above, the thermal conductivity of the gas filling should be relatively low in order to inhibit escape of energy from the discharge space. In order to decrease the thermal conductivity I add a further component to the gaseous filling. Such further component should have a relatively large molecular weight and high ionization voltage, such as xenon, krypton, argon and neon.

The pressure of the low ionization voltage gas such as caesium vapor should be high enough to produce substantial ionization and substantial current flow in a relatively concentrated discharge path. Such pressures preferably are of the order of ten microns or greater. The pressure of the voltage drop-increasing gas, such as helium, should be sufficiently greater than that of the caesium so that a relatively large number of elastic collisions occur between electrons and atoms of helium as compared to the number of collisions occurring between caesium atoms and electrons. Thus, for example, the pressure of the helium may be of the order of ten times or greater than that of the caesium. In practice, I prefer to have the helium pressure much greater such as of the order of several centimeters of mercury. The pressure of the thermal conductivity-increasing gas such as xenon, should be such as to substantially decrease the molecular-free path of the helium. For this purpose, it preferably should be of the same order of magnitude or greater than that of the helium.

My invention may be incorporated in an arrangement as illustrated in the single figure of the drawing in which 1 represents a lamp envelope such as glass, preferably transparent to the radiations which are generated within it. A pair of hot filamentary cathodes 2—2 are disposed at opposite ends of the tube 1. These filaments may be made of some suitable material such as tungsten which emits electrons thermionically when raised to its operating temperature. It is also desirable to surround each filament 2 with a hollow metal member 3 which may be made of nickel. One end of each filament 2 is electrically connected to the member 3. The other ends of each filament 2 and each member 3 are electrically connected to and supported by conducting rods 4 and 5 respectively, sealed in a stem 6. The stems 6—6 are disposed at opposite ends of the envelope 1. A pair of lead-in conductors 7 and 8 are connected respectively to the rods 4 and 5 at one end of the envelope 1 and another pair of lead-in conductors 9 and 10 are connected to the rods 4 and 5 at the opposite end of the envelope 1. Intermediate the cathodes are disposed a number of baffles 11. These baffles are preferably made of thin, polished tungsten in the form of washers having central openings 12 through which the discharge may pass between the two cathodes. These baffles tend to cut down thermal eddy currents in the gas and further assist in concentrating the discharge along the central region of the envelope 1 where the gaseous atmosphere may be maintained at a higher temperature than that of the walls of the envelope 1. The envelope 1 contains a small amount of low ionization voltage material 13 such as caesium, rubidium, potassium or sodium. In addition, the envelope 1 contains either helium or hydrogen and one or more of the gases xenon, krypton, argon and neon at the pressure discussed above. In some instances it may be desirable to coat the envelope 1 on the inside with a glass resistant to the vapor of the low ionization voltage material.

In some instances it may be desirable to inhibit loss of energy from the walls of the envelope 1 so as to maintain said envelope at a sufficiently high temperature to keep the vapor pressure of the low ionization potential material at a desired value. For this purpose, the envelope 1 may be surrounded by a double-walled container 14. This may likewise be made of a suitable material such as glass which is transparent to the radiations emitted from the lamp. The double-walled member 14 may be hermetically sealed and the interior thereof evacuated. In this way heat is conserved and the envelope 1 may be maintained at the desired temperature which in the case of caesium may be of the order of 150° to 200° C. at the coolest part of the envelope 1.

In order to supply the filaments 2 with heating current, the lead-in conductors 7—8 and 9—10 may be connected to secondary windings 15 and 16 on a heating transformer 17 having a primary winding 18 connected to a suitable source of alternating current. A conductor 19 connects the lead-in conductor 10 to a terminal 20. The lead-in conductor 8 is connected through a stabilizing resistance 21 to another terminal 22. The terminals 20 and 22 may be connected to some suitable source of current which may be either direct or alternating. Where direct current is used, the positive electrode can be in the form of an unheated anode.

When the arrangement described above is energized, the filaments 2 are heated to a relatively high temperature and thermally ionize some of the caesium in their vicinity. Radiations also make a few caesium ions in the main discharge path. The discharge then starts between the two filaments 2—2. This discharge has a stringy appearance and is constricted along the central portion of the envelope 1 between the two cathodes. The baffles 11 keep the discharge from getting too close to the glass walls of the envelope 1. The helium raises the electrical resistance by increasing the electronic energy losses suffered in elastic collisions between electrons and helium atoms as described above. In this respect helium is atom for atom about thirty-two times as effective as xenon. The high electrical resistance thus produced leads to a relatively large energy input per unit length of discharge column. The xenon being a poor heat conductor, is still a poor heat conductor even when a large supply of helium is added so that even in the presence of helium, the gaseous mixture is not a good heat conductor. This is a result of two factors. First, the mean free path of the helium atoms is short due to the presence of the big xenon atoms. Second, collisions between helium and xenon atoms result in a poor rate of interchange of energy due to their great diversity of mass. During operation the current density in the discharge path should preferably be of the order of one to ten amperes per square centimeter of discharge path or greater.

Under the above conditions, the discharge column is very hot and luminous and contains an electronic atmosphere whose temperature is of the order of several thousand degrees Kelvin. The temperature of the gas in the restricted discharge column may likewise be of this order of magnitude. The resultant emitted light is a good approximation to white light. The efficiency is well above that of commonly known light sources. The light has little or no flicker on 60 cycles and as a load it introduces less line disturbance than most gaseous discharges.

Of course, it is to be understood that this invention is not limited to the particular details as described above, as many equivalents will suggest themselves to those skilled in the art. For example, in some instances the high atomic weight gas can be omitted, as where the geometry of the tube prevents excessive loss of heat from the discharge path. Various other variations will suggest themselves. It is accordingly desired that the appended claims be given a broad interpretation commensurate with the scope of this invention within the art.

What is claimed is:

1. A lamp comprising an envelope containing an atmosphere comprising caesium vapor, helium and xenon and means for producing an electrical discharge therein.

2. A lamp comprising an envelope containing an atmosphere comprising a material taken from the group caesium, rubidium, potassium and sodium at a pressure in the range extending upward from a pressure of the order of ten microns, a gas taken from the group hydrogen and helium at a pressure in the range extending upward from a pressure of the order of ten times the pressure of said material and an additional gas taken from the group xenon, krypton, argon and neon at a pressure in the range extending upward from a pressure of the order of the pressure of said first named gas, and means for producing an electrical discharge therein.

3. A lamp comprising an envelope containing an atmosphere comprising caesium vapor at a pressure in the range extending upward from a pressure of the order of ten microns, helium at a pressure in the range extending upward from a pressure of the order of ten times the pressure of said vapor, and xenon at a pressure in the range extending upward from a pressure of the order of the pressure of said helium, and means for producing an electrical discharge therein.

4. A lamp comprising an envelope containing an atmosphere comprising a vapor at substantial pressure of a material taken from the group caesium, rubidium, potassium and sodium, said pressure being sufficiently high to produce substantial ionization of said material in said atmosphere, a gas taken from the group hydrogen and helium, and an additional gas taken from the group xenon, krypton, argon and neon, and means for producing an electrical discharge path therein, the current density in said discharge path during normal operation being of the order of one to ten amperes per square centimeter.

5. A lamp comprising an envelope containing an atmosphere comprising a vapor at substantial pressure of a material taken from the group caesium, rubidium, potassium and sodium at a pressure in the range extending upward from a pressure of the order of ten microns, a gas taken from the group hydrogen and helium at a pressure in the range extending upward from a pressure of the order of ten times the pressure of said material, and an additional gas taken from the group xeon, krypton, argon and neon at a pressure in the range extending upward from a pressure of the order of the pressure of said first named gas, and means for producing an electrical discharge through a discharge path therein, the current density in said discharge path during normal operation being of the order of one to ten amperes per square centimeter.

6. A lamp comprising an envelope containing an atmosphere comprising a material taken from the group caesium, rubidium, potassium and sodium at a pressure in the range extending upward from a pressure of the order of ten microns and a gas taken from the group hydrogen and helium at a pressure in the range extending upward from a pressure of the order of ten times the pressure of said material, and means for producing an electrical discharge therein.

7. A lamp comprising an envelope containing an atmosphere comprising a vapor at substantial pressure of a material having an ionization potential of the order of about five volts or less and a gas having an atomic weight of the order of about four or less and means for producing an electrical discharge through a discharge path therein, the temperature of operation of the atmosphere in said discharge path being substantially of the order of the electronic temperature in said discharge path.

8. A lamp comprising an envelope containing an atmosphere comprising a vapor at substantial pressure of a material of relatively low ionization potential, a gas of relatively low atomic weight and a gas of relatively high atomic weight, said gases having substantially higher ionization potentials than said material, and means for producing an electrical discharge through a discharge path therein, the temperature of operation of the atmosphere in said discharge path being substantially of the order of the electronic temperature in said discharge path.

9. A lamp comprising an envelope containing an atmosphere comprising a vapor at substantial pressure of a material having an ionization potential of the order of about five volts or less, a gas having an atomic weight of the order of about four or less and a gas of a substantially higher atomic weight, said gases having substantially higher ionization potentials than said material, and means for producing an electrical discharge through a discharge path therein, the current density in said discharge path during normal operation being of the order of one to ten amperes per square centimeter, the temperature of operation of the atmosphere in said discharge path being substantially of the order of the electronic temperature in said discharge path.

10. A lamp comprising an envelope containing an atmosphere comprising a vapor at substantial pressure of a material taken from the group caesium, rubidium, potassium and sodium, said pressure being sufficiently high to produce substantial ionization of said material in said atmosphere, a gas taken from the group hydrogen and helium, and an additional gas taken from the group xenon, krypton, argon and neon, and means for producing an electrical discharge therein.

CHARLES G. SMITH.