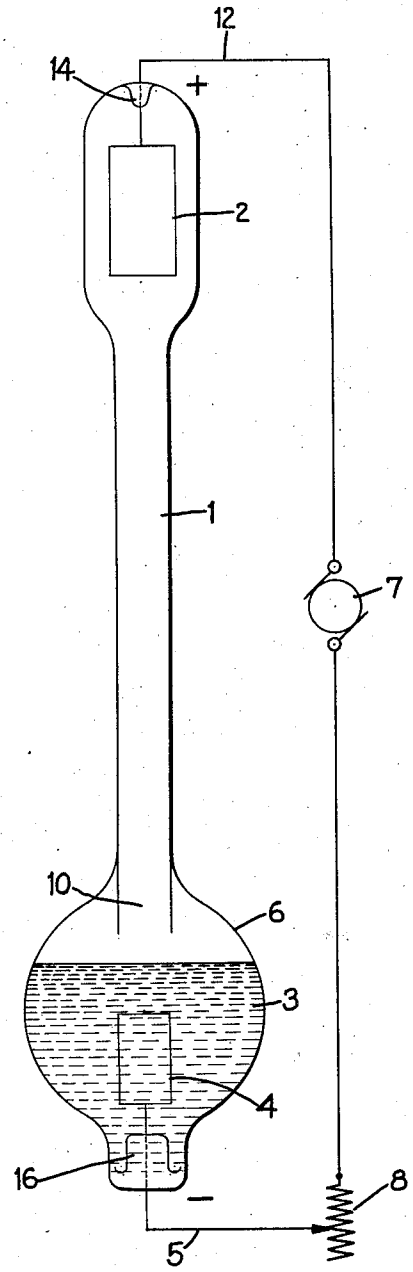
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WHITE LIGHT

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WHITE LIGHT

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The present invention is a continuation in part of my copending application, Serial No. 373,916, filed June 26, 1929.

The invention relates to luminous tubes which emit a light which does not distort the natural colors. It is well known that a neon luminous tube which emits the characteristic orange and red colors is rich in red rays and is lacking in blue rays, with the result that the natural colors are distorted and do not appear to the eye in their true colors. The disadvantage of neon luminous tubes for illuminating purposes is therefore obvious.

It is an object of this invention to supply red rays to the light emitted by helium tubes so that the colors of the spectrum are not distorted.

Another object is to include a rare gas with the helium which will emit a light having a characteristic color ray which is lacking or not particularly intense in the helium color.

It has been found that, in order to secure a light from a luminous tube which does not distort the natural colors of objects viewed thereby, by including the rare gas neon with the gas helium in a tube, and rendering the gaseous contents of the tube luminous by the passage of an electric current, the gaseous contents will emit a light which does not distort or materially distort the natural colors. It is to be understood, however, that when reference is made to helium or neon gas in the application, a gas is meant which emits the characteristic helium and neon colors when luminous regardless of whether it contains other gases mixed therewith, so long as the characteristic colors of these gases are not masked.

The helium and neon within the tube become luminous upon operation of the tube and each gas emits its characteristic color and the proportions of the gases are so selected that the characteristic color emitted by one gas blends with the characteristic color emitted by the other and the spectrum of each gas is visible in the light, or to express the result secured in a different manner, the light emitted by the tube has a permanent spectrum of each gas.

The luminous tube described herein may be used with a hot cathode or alkali electrode and may be operated on a low voltage direct current or, by the provision of double anodes, may be operated on low voltage alternating current.

By including krypton, xenon or argon with the helium and neon, a gaseous mixture is obtained which has a lower voltage gradient than a mixture of neon and helium alone, and results in a more efficient tube. The percentage of one of these gases added may be approximately one half of one per cent which is not sufficient to effect the nature of the light emitted by the tube but materially effects the voltage gradient or efficiency of the tube. The term low potential gas will be herein defined to mean one of the gases, argon, krypton or xenon, as distinguished from the other rare gases, and the term low potential gas as used in the claims is to be taken as having this meaning.

The present invention provides a new and improved white light. This term has a special meaning which has been hereinabove described and relates to a light which has a rich and well proportioned spectrum approaching that of sunlight.

The invention provides a new and improved gaseous discharge device adapted to emit white light and further adapted to operate at low voltages such as are commercially obtainable from ordinary electrical supply circuits.

The invention provides a new and improved combination of process and apparatus features including a combination of a mixture of gases adapted to yield a white light, particularly one in which the components are carefully adjusted and in which the proportion of the said components is suitably maintained with an alkali cathode as, for example, a cathode comprising a pool containing an alkali metal or mixture of alkali metals as, for example, potassium, cæsium, lithium, sodium, rubidium.

With a given voltage available, the efficiency of the device may be expressed in terms of the length of the tube of a given diameter which can be satisfactorily oper-

ated, since the amount of light is, in such a case, proportional to the length of positive column, and the length of the latter and of the tube as a whole depend upon the potential drop through the tube.

The present invention comprises a combination of a mixture of gases adapted to yield a new and improved white light with the following features in combination and sub-combination, viz:

1. Controlled and adjusted current densities.

2. Controlled and adjusted gas composition in which the proportion of neon is correlated with the current density to yield white light of the desired quality.

3. The use of a low potential gas, or gases, in carefully adjusted proportions.

4. A cathode comprising a pool of alkali metal.

5. An adjustment and control of the total pressure of the gas filling, including that of the vapor of the alkali metal and that of the helium and neon, and the correlation of this adjusted and controlled total pressure, including the partial pressure of the neon and helium, with the alkali cathode and with the diameter of the tube.

It has been found that by operating at relatively high current densities, the potential fall through the positive column is reduced thereby and according to the present invention, the current density is adjusted to a suitable range of value as from 0.15 to 0.60 amperes per square centimeter of cross-section of the positive column. It is highly desirable to correlate the percentage of neon in the gas mixture with the particular current density employed inasmuch as with increased current densities there is a tendency toward a disturbance of the balance between the proportion of the current carried by the helium and the neon at lower current densities, with a consequent disturbance in the character of the spectrum of the mixed gases of such a nature that the intensity of the neon light decreases and that of the helium increases. To offset this change and to maintain the desired spectrum composition of the light emitted by the mixed gases, the proportion of neon is increased as the current density is increased so that corresponding to the range of current densities specified above, the range of percentage of neon may vary as, for example, from 2 to 9 per cent. A typical gas mixture adapted to yield white light having a well proportioned spectrum at a current density in the neighborhood of 0.4 amperes per square centimeter of cross-section of the positive column may be represented by helium 92.25 per cent, neon 7.25 per cent and argon 0.50 per cent. As the current density decreases below the value specified, the per cent of neon should decrease, and conversely as the current density increases above the value specified the per cent of neon should increase. This careful adjustment of the relationship between the current density and the per cent of neon in the neon-helium mixture is highly desirable in order to maintain the well balanced character of the spectrum of the light emitted by the mixed gases so that the proportion of the various colors in the said spectrum will closely approach the proportion of the same colors in sunlight or other true white light.

Regarding the use of a low potential gas as hereinabove mentioned, it has already been pointed out that this term means one of the rare gases, argon, krypton or xenon. It has been found that such gases as herein specified, are of assistance in lowering the potential gradient of the gas and the invention comprises the use of one or more of these gases in combination with the other features. Care must be taken, however, that the per cent of this low potential gas does not exceed certain values in order to avoid reducing the intensity of the light. These gases, namely, argon, krypton and xenon, have a low potential gradient as compared with helium and neon, and tend to carry the current to the exclusion of the latter, and since the intensity of the light emitted by argon, krypton and xenon is relatively low, the result of using such low potential gases in too large a proportion is to reduce the intensity of the light emitted by the tube. For example, if the percentage of argon in the typical mixture hereinabove described goes much above that specified therein, namely, 0.50 per cent, the intensity of the light is considerably reduced. In the case of krypton, a similar effect is observed when the amount thereof exceeds approximately 0.30 per cent, and in the case of xenon it is undesirable to use more than about 0.15 per cent. Krypton and xenon are, therefore, distinguished in their properties in this connection from argon and from each other, since the proportion of krypton or xenon should be maintained at a lower value than is the case where argon is employed.

Regarding the control and adjustment of the total pressure of the gaseous contents of the tube and the partial pressure of the rare gases therein, it has been found that the potential gradient and therefore the efficiency of the tube, when employed in connection with a constant or predetermined potential such as 220 volts, varies with the pressure of the rare gas or gases in a tube of a given diameter and the present invention provides in combination with the other features, the maintenance of those ranges of pressure of the rare gases which contribute a maximum efficiency in terms of tube length. Under the influence of the heat developed during operation of the tube, a vaporization of alkali metal occurs. The total pressure in the

tube then becomes the sum of the pressure of the rare gases and that of the alkali metal vapor. In order, therefore, to preserve the total pressure at that value or range of values which corresponds to a minimum potential gradient, the partial pressure of the rare gas is adjusted to compensate for the presence of the vapor of the alkali metal. For example, in a tube having an outside diameter of 30 millimeters and an inside diameter of 27 millimeters, the pressure of the rare gases may vary from 0.3 to 1.5 millimeters as measured in the usual way in terms of mercury, and in a typical case it may be 0.75 millimeters. If, on the other hand, the outside diameter of the tube were 11 millimeters and the inside diameter 8 millimeters, the range of partial pressure of the rare gas filling should be about 5 to 7 millimeters. Unless adjustment of the pressure of the rare gas to make allowance for the generation of alkali vapor is made, the tube or lamp may be extinguished during operation due to the building up of the total pressure by alkali vapor, particularly where the lamp is to be operated at maximum efficiency, that is to say, where the length of the tube and the positive column of the given diameter is the maximum that can be operated from the source of predetermined potential.

The invention will be described in greater detail with reference to the accompanying drawing which illustrates one embodiment of the apparatus of the invention and of means for the practice of the process thereof. It is intended and will be understood, that the invention is illustrated by, and not limited to such illustration.

The generator 7 supplies current at a predetermined potential, such as 220 volts, through the resistance 8 which may be variable to the gaseous discharge device including the anode 2, the positive column 1, the alkali pool 3 constituting the cathode, and the metallic contact 4 which may be copper, nickel, iron, and the like. Lead-in wires 5 and 12 are connected respectively with the member 4 and the anode 2 through the usual glass seals or press members 14 and 16. The device is shown as adapted to be operated with direct current. In the event that alternating current is employed double anodes can be used operating in conjunction with the cathode. The tube 1 may have an outside diameter of 30 millimeters and inside diameter of 27 millimeters, and the shortest distance between the anode 2 and the surface of the alkali pool 3 may be 16 inches. By adjusting the resistance 8, a current density of 0.15 to 0.60 amperes per square centimeter of cross-section of positive column may be supplied. For example, the current density may be 0.40 amperes per square centimeter corresponding to a current of 2.25 amperes. At this current density, the gas composition may consist of helium 92.25 per cent, neon 7.25 per cent and argon 0.50 per cent, and will yield a white light having a well proportioned spectrum approaching that of sunlight. The partial pressure of the rare gases should be within a range of 0.3 to 1.5 millimeters, as for example, 0.75 millimeters in order to compensate for the building up of the total pressure of the gaseous contents of the tube by the formation of alkali vapor. By suitable correlation of the features herein described, including current density, proportion of helium and neon, the use of low potential gas, the adjustment of the pressure of the rare gases, and the use of a cathode comprising an alkali metal as shown, a light having a well proportioned spectrum approaching that of sunlight may be obtained at a high efficiency, the latter being expressed in terms of tube length of a given diameter such as 25 to 30 millimeters capable of operation from a source of current of predetermined potential, and as herein shown the length of the positive column between the electrodes may be approximately 16 inches for a tube of the dimensions specified.

The cathode 3 may comprise any of the metals of the alkali group such as potassium, cæsium, or the like, or mixtures thereof contained in the bulb portion 6. There is a tendency for the alkali metal to creep up along the inside surface of the member 6 of the tube 1 and to cause blackening thereof. To prevent this undesirable phenomenon a trap member 10 is provided.

The advantages of the invention have been set forth in some detail and the preferred embodiments have been described. It is to be understood, however, that various changes may be made without departing from the invention or sacrificing any of the advantages enumerated, or any other advantageous results which may be obtained by an application of the principles and the facts set forth.

What is claimed is:

1. A gaseous discharge luminous tube device comprising in combination an envelope, an anode, a cathode comprising a pool of alkali metal, a gas mixture comprising helium and neon, the said device being adapted to operate at a current density of 0.15 to 0.60 amperes per square centimeter of tube cross-section and the gas mixture containing neon in proportion of 3 to 9 per cent.

2. A gaseous discharge luminous tube device comprising in combination an envelope, an anode comprising a pool of alkali metal, and a gas filling comprising helium and neon, the proportion of neon being from about 2 to 9 per cent, the pressure of said gas filling being from 0.3 to 1.5 millimeters.

3. The method of operating a gaseous discharge luminous tube device which comprises passing a discharge through a mix-

ture of helium and neon, the pressure of which is from 0.3 to 1.5 millimeters, the proportion of neon being from 3 per cent to 9 per cent, between an anode and a cathode comprising a pool of alkali metal and maintaining the current density of the discharge between 0.15 and 0.60 amperes per square centimeter of tube cross-section.

4. The method of operating a gaseous discharge luminous tube device which comprises passing a discharge through a mixture of helium, neon and a low potential gas, the pressure of such gases being from 0.3 to 1.5 millimeters, the proportion of the neon being from 3 per cent to 9 per cent, between an anode and a cathode comprising a pool of alkali metal and maintaining the current density of the discharge between 0.15 and 0.60 amperes per square centimeter of tube cross-section.

5. A high efficiency positive column gas discharge light comprising in combination an envelope, an anode, a cathode comprising a reservoir of alkali metal, means to supply discharge current density of the order of 0.15 to 0.60 amperes per square centimeter of positive column cross section and a gas filling comprising helium and neon blended together to produce a composite light in which the proportion of neon is within the range of 2.0 to 9.0 per cent in which the characteristic helium and neon spectral lines of maximum intensity are both clearly effective in the composite light at current densities of the order described, the partial pressure of the helium and neon at ordinary room temperature being within the range which, augmented by the pressure of alkali metal vapor during operation, corresponds to an optimum low potential gradient of the positive column, this range being from about 0.3 to 1.5 millimeters for tubes having an internal diameter of the order of 27 millimeters to about 5 to 7 millimeters for tubes having an internal diameter of the order of 8 millimeters, the gas filling also containing a low potential gas the proportion of which is within the range that materially lowers the potential gradient of the gas mixture as a whole without detracting from the color and intensity of the helium neon blended light, the range being not greater than about 0.5 per cent.

In testimony whereof I affix my signature.

LEO L. BECK.