Jan. 8, 1946. N. C. BEESE 2,392,305

HIGH EFFICIENCY FLUORESCENT LAMP

Filed April 13, 1943

Fig. 1.

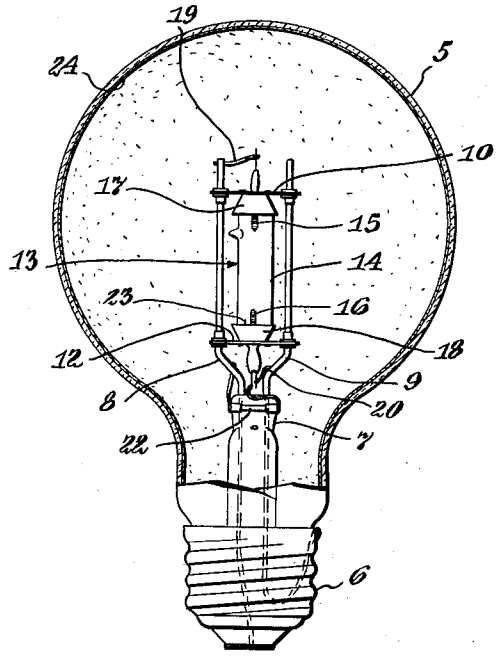


Fig. 2.

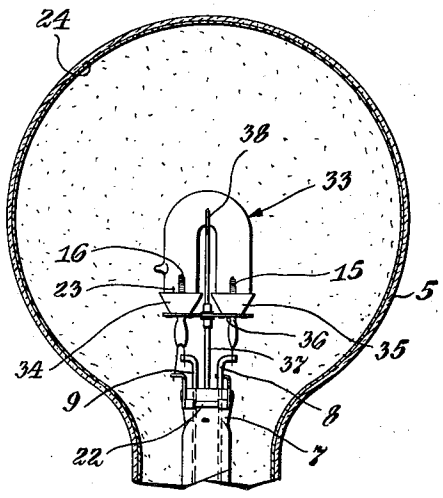
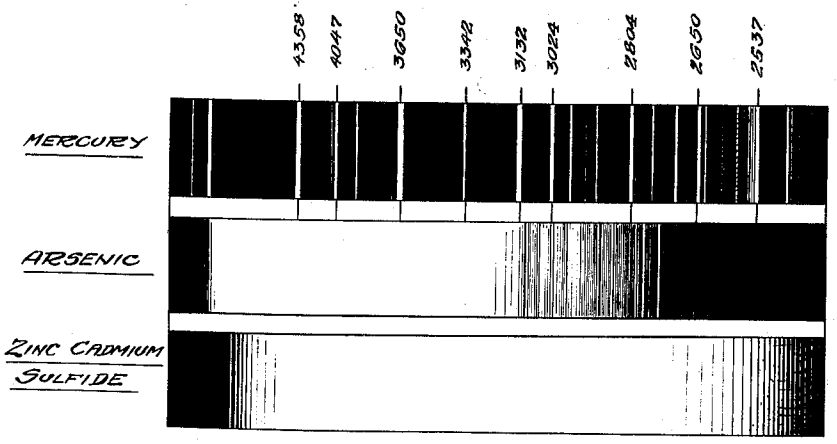


Fig. 3.



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HIGH EFFICIENCY FLUORESCENT LAMP

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4 Claims. (Cl. 176—122)

The present invention relates to gaseous electric discharge lamps and more particularly to what are known to the art as fluorescent lamps.

It has heretofore been customary to employ mercury vapor as the discharge supporting medium in lamps of this type and in order to convert the invisible ultra-violet resonance radiations of low pressure lamps into visible light, a coating of fluorescent material, commonly called phosphors, is applied to the surface of the lamp envelope. In cases where the lamp operates at high pressures and temperatures, such coating is applied to the wall of the outer container.

In the present commercial fluorescent lamps phosphors that are utilized are excited chiefly by the invisible mercury resonance radiations at 2537 Angstrom units. The color of the light emitted by such lamps is controlled by the mixture of phosphors applied as a coating to the wall of the envelope. There is, however, a certain amount of monochromatic yellow, green and blue visible light approximating five lumens per watt which comes through the coating directly from the mercury arc discharge and causes certain objects to appear somewhat unnatural.

Also, since present type fluorescent lamps operate most efficiently with a bulb temperature of about 45° C., envelopes of considerable surface area must be employed which precludes a source of high intrinsic brightness and makes such lamps difficult to adapt to general home lighting. Experimental data also indicates that under certain conditions there is practically a 100% quantum transfer efficiency in converting ultra-violet radiation into visible light by excitation of a phosphor. However, one quantum of mercury resonant radiation at 2537 Angstrom units converted into visible light at 5074 Angtsrom units involves a 50% energy loss, since the energy associated with each quantum is inversely proportional to its wavelength. Consequently, the same quantum of visible light at 5074 Angstrom units, if produced by one quantum of ultra-violet energy at 3650 Angstrom units, involves a loss of only about 25%. Hence an efficient source of visible light can be produced by the proper selection of a phosphor whose excitation response is as close to the near ultra-violet at about 4000 Angstrom units as possible. In contrast to the light emitted by a mercury vapor lamp, it has been found that the radiation from a lamp utilizing arsenic as the discharge supporting medium is exceptionally poor in visible light and substantially devoid of the objectionable and pronounced yellow, green and blue radiations present in a mercury vapor lamp.

Moreover, a high pressure arsenic lamp mounted inside a fluorescent glass outer envelope or within a clear or opal outer bulb coated with a suitable phosphor would not be as temperature-dependent as the present type commercial fluorescent lamps and can therefore be used over a much wider ambient temperature range. In addition, an arsenic lamp produces a continuous spectrum with its maximum radiant energy in the near ultra-violet region at about 3650 Angstrom units. Consequently, to utilize the high quantum transfer efficiency of the near ultra-violet arsenic spectrum, it is necessary only to select a suitable phosphor that is capable of absorbing these radiations and converting them efficiently into visible radiations.

The conventional phosphors used in present type commercial fluorescent lamps, such as silicates, tungstates, or borates, do not respond to the near ultra-violet radiations and hence are inert. However, the group of sulphide phosphors, such as zinc, cadmium, calcium and strontium, are highly activated by these near ultra-violet radiations. Certain minerals like Wernerite (commercial composition being principally a calcium-aluminum-silicate) are also very luminous when excited by near ultra-violet radiations. Morever, made synthetically, such material has all the advantages of the sulphides with the addition of much greater chemical stability and hence renders it readily adaptable for lamp phosphors.

Accordingly, while the utilization of an arsenic lamp is the primary source of invisible radiations in combination with a phosphor whose excitation response is in the region of maximum radiant energy from the lamp, a highly efficient source of visible light is produced since the visible light is almost entirely dependent upon the excitation of the phosphor coating and since, as above noted, the visible light, and particularly the monochromatic yellow, green and blue colors, is not present. On the other hand, a high pressure mercury lamp emits principally the monochromatic yellow, green and blue colors from the mercury arc, together with a relatively small contribution from the phosphor, which merely corrects slightly the light from the mercury lamp and amounts to only a few per cent of the total visible radiations.

It is accordingly the object of the present invention to provide a fluorescent lamp which is very efficient and of comparatively long commercial life.

Another object of the present invention is the provision of a fluorescent lamp wherein the discharge generates a continuous spectrum and a coating material is employed which has the peak of its response near the wavelength band from the discharge, thus producing a highly efficient lamp.

A further object of the present invention is the provision of a fluorescent lamp employing a discharge supporting medium generating a continuous spectrum and wherein a coating material is employed which exhibits no fatigue when excited by such continuous spectrum, thus prolonging the commercially useful life of the lamp.

Still further objects of the present invention will become obvious to those skilled in the art by reference to the accompanying drawing wherein:

Fig. 1 is an elevational view of an electric energy translation device in the form of a high pressure discharge lamp constructed in accordance with the present invention;

Fig. 2 is a fragmentary view similar to Fig. 1 but showing a modification which the lamp of the present invention may take, and

Fig. 3 is an illustration of the line spectrum produced by mercury vapor in comparison with the continuous spectrum produced by arsenic and also showing the spectral response of sulphide phosphors.

Referring now to the drawing in detail, the lamp as shown in Fig. 1 comprises an enclosing envelope 5 of suitable vitreous material, such as hard or soft glass pervious to visible light. Appropriately secured to the envelope is a base 6 of the usual type to enable the lamp to be screwed into a socket.

The envelope 5 is provided with a reentrant stem press 7 to which is hermetically sealed a pair of leading-in conductors 8 and 9 of suitable material and as shown are of rod-like form widening out immediately above the stem press and extending parallel to each other longitudinally of the enclosing envelope 5.

A pair of bridges 10 and 12 of suitable insulating material tie the leading-in conductors together for the purpose of forming a rigid mount for a discharge lamp 13. This lamp as shown is of the high pressure type and comprises an envelope 14 of vitreous material capable of withstanding high pressure and temperature and permeable to ultra-violet radiations such, for example, as quartz. Interiorly of the envelope 14, the customary electrodes 15 and 16 are provided for sustaining a discharge through the gaseous medium within the envelope. In addition, a pair of metallic shields 17 and 18 are carried by the bridges adjacent the supported ends of the lamp 13 for the purpose of conserving heat and preventing condensation of the gaseous medium within the envelope 14.

The lamp electrodes are connected to the leading-in conductors 8 and 9 by flexible connections 19 and 20 and for starting purposes an impedance device 22 is connected between the leading-in conductor 8 and the customary starting electrode 23, as shown. In order to make the lamp generate a continuous spectrum, arsenic is utilized as the ionizable medium for sustaining the discharge between the electrodes 15 and 16, which medium attains a pressure of approximately 3 atmospheres during operation. In addition, an inert gas, such as argon, neon or the like, or a mixture of such gases, at several millimeters pressure is employed in the lamp 13 to facilitate starting of the discharge.

By reference now to Fig. 3, it will be noted that a lamp utilizing arsenic for supporting the discharge results in the production of a band or continuous spectrum extending over a range from about 2800 Angstrom units through the longer wavelength near ultra-violet and visible region beyond 4350 Angstrom units. A comparison with the spectral distribution from a mercury vapor lamp, as shown immediately above the arsenic spectrogram of Fig. 3, indicates that throughout this same spectral range there are but relatively few radiation lines, whereas with arsenic the entire range is encompassed by the continuous spectrum with maximum radiant energy being in the near ultra-violet region at about 3650 Angstrom units.

An arsenic lamp is known to be a very poor generator of visible light even at high pressure. For example, a lamp operating at 90 watts gave only 250 lumens or about 2.8 lumens per watt. For the purpose of converting the near ultra-violet into visible light, the interior surface of the envelope 5 is provided with a coating 24. Experiments have shown that the sulphide group of phosphors are most suitable for this coating because they have a spectral response in the near ultra-violet just at the region where the arsenic lamp gives out its maximum radiant energy. Moreover, I have discovered that such sulphide group of phosphors exhibit no appreciable fatigue after a comparatively long useful life.

For these reasons the coating 24 comprises zinc sulphide, zinc cadmium sulphide, or a mixture of these or other sulphides, depending upon the color of visible light desired, which, as shown by the lower portion of Fig. 3, responds to wavelengths ranging from about 2500 Angstrom units with the peak of its response at about 3650 Angstrom units. Comparing this with the spectrogram of the arsenic discharge immediately above in Fig. 3, it will be noted that maximum energy therefrom likewise occurs at this region. This accordingly results in maximum excitation of the sulphide coating by a preponderance of radiations of a proper wavelength producing a very efficient lamp having a high intrinsic brilliance. Moreover, since this sulphide group of coatings evidences no fatigue under excitation, the efficiency of the lamp does not become impaired even after many hundred hours of operation. For best results the phosphor coating must be kept relatively cool, i. e., below about 150° C., and since the lamp 13 operates at a relatively high temperature, the outer envelope is provided as an isothermal surface sufficiently large as to maintain the coating within the above noted temperature range. This, for example, requires an outer envelope area of about 250 sq. cm. for a 100-watt lamp which is equivalent to a spherical envelope 3.5 inches in diameter or a prolate ellipsoid of 8 cm. minor axis and 12.5 cm. major axis. The outer envelope 5 may be highly evacuated or filled with nitrogen gas, care being taken to exclude moisture.

The modification as shown in Fig. 2 differs from that previously described merely in the configuration of the lamp and its structural support. As shown in this figure, the lamp 33 is of U-shaped configuration with its ends being supported by heat shields 34 and 35, the latter of which are secured to a single bridge 36. The reentrant press 7 in this modification is provided with a support rod 37 sealed thereto which forms a sup-

port for the bridge 36 and at the same time extends above the bridge, being provided with a bifurcated end 38 to form a cradle for the base portion of the lamp 33, thus increasing the rigidity of the support assembly. The leading-in conductors 8 and 9, although much shorter in length, connect to the respective electrodes 15 and 16 in the same manner as previously described in Fig. 1, except that no necessity exists for a flexible connection such as at 19 and 20 of Fig. 1. The impedance 22 is again connected to the starting electrode 23 and in all other respects this modification is identical to the structure of Fig. 1.

The advantage in this design is the elimination of supports in the path of the ultra-violet between the lamp 33 and the outer envelope 5, which otherwise shadows a small percentage of the emitted ultra-violet radiations as in Fig. 1. In addition, since the lamp 33 is U-shaped, its axis of curvature closely approximates that of the outer envelope 5, thereby tending to dispose the greater area of the coating 24 equi-distant from the emitting surface of the lamp 33 and increasing slightly the uniformity of excitation of the coating.

It thus becomes obvious to those skilled in the art that a highly efficient fluorescent lamp is herein provided wherein a continuous spectrum is produced by the discharge having its maximum radiant energy in the near ultra-violent region of the spectrum. Moreover, a coating is disposed in the path of the emitted near ultra-violet radiations which has a spectral response in the precise region where the lamp emits its maximum radiant energy, thereby producing a highly efficient fluorescent lamp.

Although several embodiments of the present invention have been shown and described, it is to be understood that still further modifications may be made without departing from the spirit and scope of the appended claims.

I claim:

1. A gaseous electric discharge lamp comprising a vitreous envelope pervious to ultra-violet radiations, electrodes therein for initiating and sustaining a discharge upon the application of a potential thereto, an ionizable medium in said envelope including arsenic for generating a continuous spectrum with its maximum radiant energy in the near ultra-violet region at approximately 3650 A. U., a container surrounding said discharge lamp, and a fluorescent coating on the surface of said container comprising a sulphide phosphor having its spectral response in the same region as the maximum radiant energy of the continuous arsenic spectrum from said lamp at approximately 4,000 A. U. and excitedby the latter to convert the invisible radiations and form a highly efficient source of visible radiations,

2. A gaseous electric discharge lamp comprising a vitreous envelope pervious to ultra-violet radiations, electrodes therein for initiating and sustaining a discharge upon the application of a potential thereto, an ionizable medium in said envelope including arsenic for generating a continuous spectrum with its maximum radiant energy in the near ultra-violet region at approximately 3650 A. U., a container surrounding said discharge lamp, a fluorescent coating on the surface of said container comprising a sulphide phosphor having its spectral response in the same region as the maximum radiant energy of the continuous arsenic spectrum from said lamp at approximating 4,000 A. U. and excited by the latter to convert the invisible radiations and form a highly efficient source of visible radiations, and said container constituting an isothermal surface of sufficient area to maintain the temperature of the fluorescent coating below about 150° C.

3. A gaseous electric discharge lamp comprising a vitreous envelope pervious to ultra-violet radiations, electrodes therein for initiating and sustaining a discharge upon the application of a potential thereto, an ionizable medium in said envelope including arsenic for generating a continuous spectrum with its maximum radiant energy in the near ultra-violet region at approximately 3650 A. U., a container surrounding said discharge lamp, and a fluorescent coating on the surface of said container comprising zinc sulphide having its spectral response in the same region as the maximum radiant energy of the continuous arsenic spectrum from said lamp at approximately 4,000 A. U. and excited by the latter to convert the invisible radiations and form a highly efficient source of visible radiations.

4. A gaseous electric discharge lamp comprising a vitreous envelope pervious to ultra-violet radiations, electrodes therein for initiating and sustaining a discharge upon the application of a potential thereto, an ionizable medium in said envelope including arsenic for generating a continuous spectrum with its maximum radiant energy in the near ultra-violet region at approximately 3650 A. U., a container surrounding said discharge lamp, and a fluorescent coating on the surface of said container comprising zinc cadmium sulphide having its spectral response in the same region as the maximum radiant energy of the continuous arsenic spectrum from said lamp at approximately 4,000 A. U. and excited by the latter to convert the invisible radiations and form a highly efficient source of visible radiations.

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