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Kamiya et al.

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[54] **FLUORESCENT LAMP OF HIGH COLOR RENDERING**

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[30] **Foreign Application Priority Data**

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[51] **Int. Cl.** **C09k 1/28,** C09k 1/36, C09k 1/38

[58] **Field of Search** .... 252/301.4 R, 301.4 P, 252/301.5; 313/109

[56] **References Cited**

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[57] **ABSTRACT**

A low pressure mercury vapor fluorescent discharge lamp, having a color rendering value as high as 97 is obtainable by applying on the inner wall of the lamp a layer of a phosphor mixture comprising a basic magnesium arsenate phosphor containing 0.02 -0.2 gram-atom of manganese per 6 mols of magnesium oxide, magnesium tungstate, tin-activated strontium magnesium orthophosphate and antimony-and-manganese-activated calcium halophosphate.

3 Claims, 2 Drawing Figures

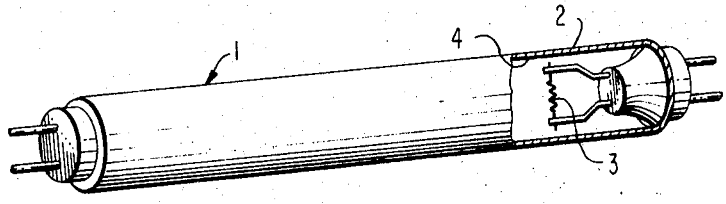

FIG 1

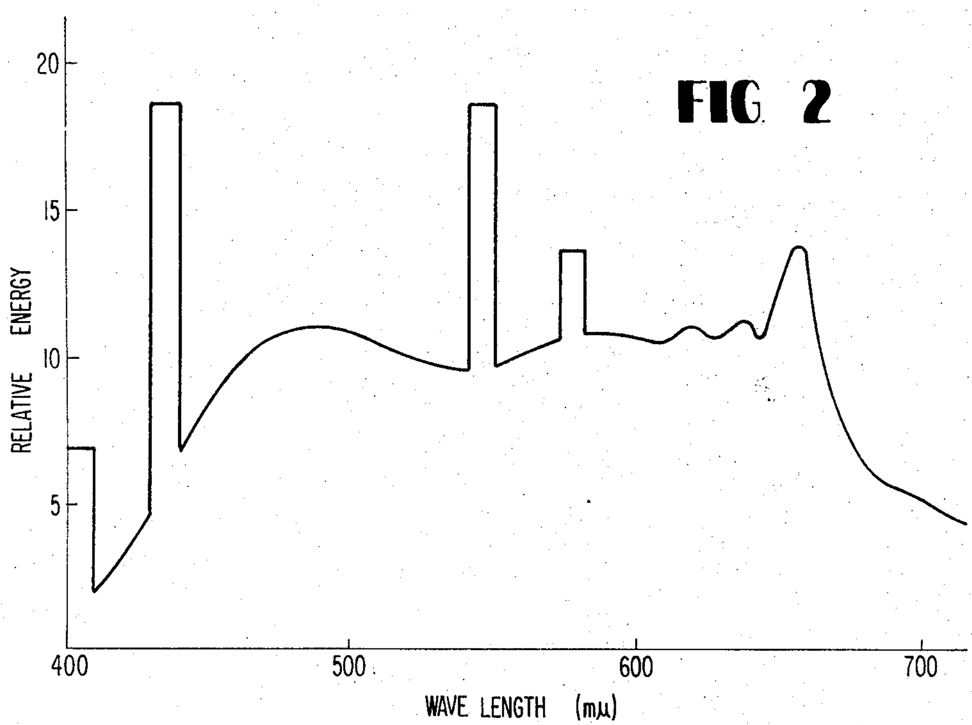

FIG 2

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FLUORESCENT LAMP OF HIGH COLOR RENDERING

BACKGROUND OF THE INVENTION

This invention relates to a fluorescent lamp having an improved color rendering.

In those applications where fluorescent lamps are used for illumination such as in a museum or in an art gallery or as a light source for inspecting color-printed matters, the color rendering is a very important requirement for the lamps.

A fluorescent lamp, in which a phosphor layer is formed on the inner tube wall by applying a phosphor slurry containing several kinds of phosphors blended together, has been developed in order to obtain an emission spectrum closely resembling the spectrum of natural daylight. The color rendering of the fluorescent lamp having blended phosphor as mentioned above is considerably improved as compared with standard type fluorescent lamps for general use. However, an average color rendering value Ra by a C.I.E. (Commission Internationale de l'Eclairage) test color method (defined in the publication: CIE COMMITTEE E-1.3.2 "Method of Measuring and Specifying Color Rendering Properties of Light Sources"— First edition, designated as CIE publication No. 13, 1965) for fluorescent lamps is around 90 to 92 for lamps having a color temperature of 5,000°K, which color temperature is believed to be very close to that of the natural daylight and is around 85 for lamps having color temperature of 3,000°K. These values, however, are insufficient for use as a light source for inspecting color-printed matters or the like.

As a method for increasing the color rendering, there is a method of applying two layers of phosphors. However, the application of two layers by this method naturally entails increased cost of manufacture. Thus, in order to attain a color rendering higher than 92, it is insufficient to change only the blending ratio of ordinary phosphors. It has been found that it is necessary to control the strong line spectrum emission of mercury in the fluorescent lamp. The color rendering of fluorescent lamps is chiefly lowered by an excessively strong emission of line spectrum having wavelength of 435.8 nanometer (10^{-9} meter). Accordingly, the forming of a light-absorbing layer on a phosphor screen for the purpose of absorbing, to some extent, the spectrum emission of mercury gas has been in practice already. Although this method enables the manufacture of fluorescent lamps with splendid color rendering, the complicated process of manufacture causes an increase in the manufacturing cost, and moreover, lowering of efficiency of the lamp is inevitable.

SUMMARY OF THE INVENTION

Advantageously this invention provides a new fluorescent lamp with high color rendering, which can be manufactured economically.

BRIEF DESCRIPTION OF THE DRAWING

The invention is described in greater detail in reference to the accompanying drawing, wherein:

FIG. **1** is a partly broken-away perspective view of a fluorescent lamp embodying the present invention; and

FIG. **2** is a spectrum distribution chart of light emission of the lamp of the embodiment shown in FIG. **1.**

DETAILED DESCRIPTION OF THE INVENTION

According to this invention, a fluorescent lamp of high color rendering can be made by applying a single layer of phosphor-containing phosphor powder of the kind or type which has strong absorption in the spectrum range of wavelength shorter than 450 nano-meter and has high reflectance in the spectrum range of wavelength longer than 450 nano-meter, in such a specified ratio that makes the emission from the outer tube wall of the fluorescent lamp resemble desired standard light source. For the above-mentioned phosphor powder having strong absorption in wavelength under 450 nano-meter and high reflectance in wavelength over 450 nano-meter, a basic magnesium arsenate phosphor containing a specified quantity of manganese is found to be suitable in accordance with this invention. Although the above-mentioned phosphor is of the same kind and is similar with those employed in conventional fluorescent lamps, an important aspect of the present invention lies in the selection of the quantity range of the manganese. Our research has revealed that absorption of light of wavelength around **450** nano-meter varies prominently depending on the quantity of manganese contained in the basic magnesium arsenate phosphor.

Thus it has been found that the ratio of light emission energy of wavelength under 450 nano-meter against the total light emission energy should be less than 16 percent in order to obtain high color rendering such as over 95. In order to attain such ratio in the light emission, the amount of manganese should be between 0.02 and 0.2 gram atom per 6 mols of magnesium oxide (M_gO) in a magnesium halosulph-arsenate phosphor. If this ratio of manganese exceeds 0.2 gram atom, even though the absorption of short-wavelength line-spectrum emission of mercury vapour is very strong, the emission of reddish light is insufficient. If the ratio of manganese is below 0.02 gram atom, the absorption is very low, necessitating the larger amount of the magnesium halosulph-arsenate phosphor for absorbing the line spectrum emission around 450 nano-meter and thereby causing unnecessary increase of reddish light and decrease of total light emission.

The following examples further illustrate the present invention.

EXAMPLE 1

In FIG. **1**, at each end of a glass lamp tube **2**, an electrode **3** is provided, and a small amount of mercury and inert gas is confined in the tube **2** at a low pressure such as 2.5 mm Hg. A single layer **4** of blended phosphor is formed on the inner wall of the lamp tube **2.** The phosphor layer is composed as follows:

1. Magnesium tungstate (Mg WO_4) phosphor	400 g.
2. Tin-activated strontium-magnesium ortho-phosphate [$(SrMg)_3$ $(PO_4)_2$: Sn] phosphor	250 g.
3. Antimony-and-manganese-activated calcium halophosphate [3 Ca_3 $(PO_4)_2$ CaFCl : Sb, Mn] phosphor	150 g.
4. Manganese-activated magnesium halosulpharsenate (6 MgO · As_2O_5 · O.35 $MgSO_4$ · 0.19 MgF_2: 0.04 Mn) phosphor containing 0.04 gram atom of manganese (Mn) per 6 mols of magnesium oxide (MgO)	65 g.

The above-mentioned four kinds of phosphors are blended to form one phosphor slurry. The slurry is prepared by blending one kilogram of the phosphors in the above-described proportions with 1,000 cc of butylacetate containing 1 weight percent nitro-cellulose in a ballmill for 5 hours. This slurry, accordingly to the conventional procedure for making fluorescent lamps, is applied on the inner wall of the tube **2** to form a layer. Then the layer is dried and baked to form a layer **4** of the blended phosphor of about 0.005 gram/cm^2. Then electrodes are fixed at both ends. The tube is exhausted and filled with argon and a drop of mercury. A fluorescent lamp is obtained by subsequent aging.

The fluorescent lamp thus manufactured performs the spectrum distribution shown by the diagram in FIG. **2** wherein "relative energy" refers to the light energy distribution per small specified ranges of wavelength. As can be seen from the diagram, the fluorescent lamp of the present invention has a desirably balanced spectrum distribution. Also this lamp attains a color rendering value as high as 97.

EXAMPLE 2

By following the procedure outlined in Example 1, another fluorescent lamp is formed having a phosphor layer of the following composition:

1. Mg WO_4 (Magnesium tungstate phosphor)	350 g.
2. $(SrMg)_3(PO_4)_2$: Sn(Tin-activated strontium-magnesium orthophosphate phosphor)	300 g.
3. 3 $Ca_3(PO_4)_2 \cdot CaFCl$: Sb,Mn (Antimony and manganese activated calcium halophosphate phosphor)	150 g.
4. 6 MgO · As_2O_5 · 0.35 $MgSO_4$ · 0.19 MgF_2:0.06 Mn (Manganese-activated magnesium halosulph-arsenate phosphor)	66.4 g.

The resulting fluorescent lamp has a color temperature of 4,200°K and average color rendering value of 97.

EXAMPLE 3

Still another lamp is formed by the procedure of Example 1 with a phosphor layer having the following composition:

1. $MgWO_4$ (Magnesium tungstate phosphor)	130 g.
2. $(SrMg)_3(PO_4)_2$: Sn (Tin-activated strontium-magnesium orthophosphate phosphor)	1200 g.
3. 3 $Ca_3(PO_4)_2 \cdot CaFCl$: Sb, Mn (Antimony-and manganese-activated calcium halophosphate phosphor)	150 g.
4. 6 MgO · A_2O_5 · 0.35 $MgSO_4$ · 0.19 MgF_2:0.15 Mn (Manganese-activated magnesium halosulph-arsenate phosphor	240.1 g.

The fluorescent lamp obtained shows a color temperature of 2,700°K and an average color rendering value of 92.

What is claimed is:

1. A low pressure fluorescent lamp comprising a glass tube containing a pair of spaced electrodes, a small amount of mercury and inert gas confined within said tube, and a layer of blended phosphor on the inside surface of said tube, wherein the phosphor layer contains in approximate proportions:

4 parts by weight of magnesium tungstate, 2.5 parts by weight of tin-activated strontium-magnesium orthophosphate, 1.5 parts by weight of antimony-and-manganese-activated calcium halophosphate, and 0.6 parts by weight of basic magnesium arsenate phosphor containing 0.04 gram atom of manganese per 6 mols of magnesium oxide.

2. A low pressure fluorescent lamp comprising a glass tube containing a pair of spaced electrodes, a small amount of mercury and inert gas confined within said tube, and a layer of blended phosphor on the inside surface of said tube, wherein the phosphor layer contains in approximate proportions:

3.5 parts by weight of magnesium tungstate, 3.0 parts by weight of tin-activated strontium-magnesium orthophosphate, 1.5 parts by weight of antimony-and-manganese-activated calcium halophosphate, and 0.6 parts by weight of basic magnesium arsenate phosphor containing 0.06 gram atoms of manganese per **6** mols of magnesium oxide.

3. A low pressure fluorescent lamp comprising a glass tube containing a pair of spaced electrodes, a small amount of mercury and inert gas confined within said tube, and a layer of blended phosphor on the inside surface of said tube, wherein the phosphor layer contains in approximate proportions:

1.3 parts by weight of magnesium tungstate, 12 parts by weight of tin-activated strontium-magnesium orthophosphate, 1.5 parts by weight of antimony-and-manganese-activated calcium halophosphate, and 2.4 parts by weight of basic magnesium arsenate phosphor containing 0.15 gram atom of manganese per **6** mols of magnesium oxide.

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