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PATENT SPECIFICATION

(11) 1 549 082

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- (21) Application No. 30026/77 / (22) Filed 18 July 1977 /
(31) Convention Application No. 51/085 074
(32) Filed 19 July 1976 in /
(33) Japan (JP)
(44) Complete Specification published 25 July 1979
(51) INT CL¹ C09K 11/30, 11/18; H01J 29/20
(52) Index at acceptance
C4S 43Y 708 713 716 723 729 72Y 739 73Y 747 74Y 763 779
78Y
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(54) GREEN-EMITTING PHOSPHORESCENT COMPOSITION

(71) We, HITACHI LIMITED, a Japanese Company, of 1—5—1, Marunouchi, Chiyoda-ku, Tokyo, Japan, and DAI NIPPON TORYO CO. LTD., a Japanese Company, of 6—1—24, Nishikujo, Konohane-ku, Osaka, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a green-emitting phosphorescent composition and a cathode ray tube for color television using the same as a green-emitting phosphor component, and more particularly to a green-emitting phosphorescent composition of a mixture of a copper and aluminium-activated zinc sulfide phosphor and a gold and aluminium-activated zinc sulfide phosphor used as a green-emitting phosphor component for the fluorescent screen of a color television cathode ray tube and also to a color television cathode ray tube using the same.

The phosphorescent screen of a color television cathode ray tube is comprised of a number of dots or stripes of green-, blue- and red-emitting phosphor components and presents various colors of light when excited by an electron beam. In the conventional color television cathode ray tubes, there have been used a copper and aluminium-activated zinc cadmium sulfide phosphor $[(Zn,Cd)S:Cu,Al]$ as a green-emitting phosphor component, a silver-activated zinc sulfide phosphor $(ZnS:Ag)$ or a silver and aluminium-activated zinc sulfide phosphor $(ZnS:Ag,Al)$ as a blue-emitting phosphor component, and a europium-activated yttrium oxysulfide phosphor $(Y_2O_3S:Eu)$ or a europium-activated yttrium oxide phosphor $(Y_2O_3:Eu)$ or a europium-activated yttrium vanadate phosphor $(YVO_4:Eu)$ as a red-emitting phosphor component.

As shown in the above description, cadmium is an essential element for the phosphorescent screen of a color television cathode ray tube. However, cadmium is a highly noxious metal, and accordingly requires a great care in handling the same in the process of coating the phosphorescent screen in the cathode ray tube. Further, the cathode ray tube using cadmium in its phosphorescent screen requires a great care in handling the same when it is broken or destroyed. In addition, since the allowable concentration of cadmium in a waste liquid is severely limited by anti-pollution laws, large scale equipment is needed to treat the waste materials. Thus, it is economically very disadvantageous to use cadmium in the phosphorescent screen.

Under the above-described circumstances, it has been known to use a copper and aluminium-activated zinc sulfide phosphor $(ZnS:Cu,Al)$ of cubic structure instead of the copper and aluminium-activated zinc cadmium sulfide phosphor $(Zn,Cd)S:Cu,Al$. However, the copper and aluminium-activated phosphor $(ZnS:Cu,Al)$ of cubic structure (hereinafter referred to simply as "cubic $ZnS:Cu,Al$ phosphor") lowers the white light luminance. The luminance of the color cathode ray tube, namely the brightness, is generally evaluated by the white light luminance represented by the luminance of a white point ($x=0.281, y=0.311$) in the JEDEC (Joint Election Device Engineering Councils) standard. In the conventional copper and aluminium-activated zinc cadmium sulfide used as a green-emitting phosphor component in the conventional color television cathode ray tube, the spectrum of the emitted light can easily be made to be on the long wavelength side of green by increasing the amount of cadmium which constitutes the host material of the phosphor. Actually, in the conventional color television cathode ray tube, a copper and aluminium-activated zinc cadmium sulfide

phosphor (Zn,Cd)S:Cu,Al which emits green light biased to yellow is used, and accordingly it has been possible to make the share of the exciting current for the green-emitting phosphor component, which contributes most to the increase in the white luminance, large. On the other hand, in the cubic ZnS:Cu,Al phosphor which does not contain cadmium, the green light emitted is biased to the short wavelength side and it is very difficult to shift the color of the emitted light to the yellow side beyond the color point of ($x=0.300$, $y=6.30$) in the CIE standard chromaticity diagram. Therefore, when this phosphor is used as the green-emitting phosphor component, the share of the exciting current for the red-emitting phosphor component, which does not contribute to a great extent to the increase in the white luminance, is inevitably made very large in comparison with the conventional (Zn,Cd)S:Cu,Al phosphor. Consequently, the white luminance is lowered about 10%.

In view of the above-described state of the art, it is desired to provide a green-emitting phosphor for a color television cathode ray tube which does not contain noxious cadmium, emits light of the wavelength biased to the long wavelength side more than the cubic ZnS:Cu,Al phosphor, and results in increase in the white luminance in comparison with the case wherein the cubic ZnS:Cu,Al phosphor is used.

In accordance with the present invention, a gold and aluminium-activated zinc sulfide phosphor of cubic structure (hereinafter referred to simply as "cubic ZnS: Au,Al phosphor") which emits yellow light is mixed with a cubic ZnS:Cu,Al phosphor to shift the spectrum of emission of the latter phosphor to the long wavelength side, namely to the yellow side, whereby the share of the exciting current for the red-emitting phosphor component which does not contribute to the increase in the white luminance is lowered in a color television cathode ray tube using said mixture of the phosphors as the green-emitting phosphor component and the white luminance of the cathode ray is increased.

In other words, the green-emitting phosphorescent composition for a cathode ray tube for color television in accordance with the present invention is a mixture of phosphors of a cubic ZnS:Cu,Al phosphor and a cubic ZnS:Au,Al phosphor and is characterized in that the x -value and y -value in the CIE standard chromaticity diagram of the color emitted when excited by an electron beam are within the ranges of $0.300 < x < 0.360$ and $0.575 < y < 0.635$, respectively.

The color television cathode ray tube in accordance with the present invention is characterized in that the phosphorescent screen thereof uses the above described mixture of phosphors as a green-emitting phosphor component, a ZnS:Ag phosphor activated by 10^{-3} to 10^{-2} g/g of Ag or a ZnS:Ag,Al phosphor activated by 10^{-3} to 10^{-2} g/g of Ag and Al, respectively, as a blue-emitting phosphor component, and a Y_2O_3 :Eu phosphor, a Y_2O :Eu phosphor or a YVO_4 :Eu phosphor activated by 10^{-2} to 1.5×10^{-1} g/g of Eu, respectively, as a red-emitting phosphor component.

The accompanying drawing is a graphical representation showing the color points of the conventionally known cubic ZnS:Cu,Al phosphor used as a green-emitting phosphor component in the conventional color television cathode ray tube, the green-emitting phosphor, the blue-emitting phosphor and the red-emitting phosphor used in the color television cathode ray tube in accordance with the present invention in the CIE standard chromaticity diagram.

The cubic ZnS:Cu,Al phosphor constituting the mixed green-emitting phosphor of the present invention is prepared by adding, as activators, a suitable amount of copper compounds such as copper sulfate ($CuSO_4 \cdot 5H_2O$) and copper nitrate ($Cu(NO_3)_2 \cdot 6H_2O$) and a suitable amount of aluminium compounds such as aluminium sulfate [$Al_2(SO_4)_3 \cdot 18H_2O$] and aluminium nitrate [$Al(NO_3)_3 \cdot 9H_2O$] to a reagent zinc sulfide, and normally adding further thereto a proper amount of flux such as alkaline metal halide and alkaline earth metal halide, and then firing the mixture at a temperature of $750^\circ C$ to $1030^\circ C$ in a reducing atmosphere which is generally used in manufacturing sulfide phosphors such as a hydrogen sulfide atmosphere or a sulfiding atmosphere containing carbon disulfide. From the viewpoint of luminance and emitted color, the preferable amounts of the activators Cu and Al are $10^{-6} g$ to $3 \times 10^{-4} g$ and $5 \times 10^{-6} g$ to $3 \times 10^{-3} g$ per gram of the host material ZnS, respectively. The x -value and y -value of the color point in the CIE standard chromaticity diagram of the light emitted by the cubic ZnS:Cu,Al prepared as described above and containing the activators in amounts within the above described preferable range are $0.280 < x < 0.300$ and $0.620 < y < 0.640$.

On the other hand, the yellow-emitting cubic ZnS:Au,Al which is another component constituting the mixed green-emitting phosphor of the present invention is prepared by adding, as activators a suitable amount of gold compounds such as gold chloride acid ($HAuCl_4 \cdot 2H_2O$) and suitable amount of aluminium compounds such

as aluminium sulfate $[Al_2(SO_4)_3 \cdot 18H_2O]$ and aluminium nitrate $[Al(NO_3)_3 \cdot 9H_2O]$ to a reagent zinc sulfide, and normally adding further thereto a proper amount of flux such as alkaline metal halide and alkaline earth metal halide, and then firing the mixture at a temperature of 950°C to 1030°C in a reducing atmosphere which is generally used in manufacturing sulfide phosphors such as a hydrogen sulfide atmosphere or a sulfiding atmosphere containing carbon disulphide. From the viewpoint of luminance and emitted color, the preferable amounts of the activators Au and Al are 5×10^{-4} g to 10^{-2} g and 5×10^{-3} g to 10^{-2} g per gram of the host material ZnS, respectively. The x -value and y -value of the color point in the CIE standard chromaticity diagram of the light emitted by the cubic ZnS:Au,Al prepared as described above and containing the activators in amounts within the above described preferable range are $0.385 < x < 0.405$ and $0.550 < y < 0.570$.

The green-emitting phosphorescent composition of the present invention which has been referred to as a mixed green-emitting phosphor is prepared by mixing the above-described cubic ZnS:Cu,Al phosphor and the above-described cubic ZnS:Au,Al phosphor so that the x -value and y -value of the color point of the light emitted thereby when excited with an electron beam may be within the ranges of $0.300 < x < 0.360$ and $0.575 < y < 0.635$. When mixing the two phosphors, both the phosphors are preferred to contain the activators of the amount within the above described preferable ranges. When the x -value or y -value of the color point of the light emitted by the above phosphorescent composition is lower than the above described range, the emitted color is shifted to the short wavelength side, and accordingly the color television cathode ray tube using this composition as the green-emitting phosphor component does not give a sufficiently high white luminance. On the other hand, when the x -value or y -value of the color point of the light emitted is higher than the above described range, the emitted color is shifted to the long wavelength side and becomes yellowish, and accordingly the purity of green is degraded and the area of the color reproduction region becomes markedly narrow though the white luminance of the color television cathode ray tube using this composition as the green-emitting phosphor component gives a greatly enhanced white luminance.

The green-emitting phosphorescent composition in accordance with the present invention is characterized in that it contains no cadmium and the color point of the light emitted by the cubic ZnS:Cu,Al is properly shifted to the long wavelength side. In the CIE standard chromaticity diagram in the accompanying drawing, the color point G1 shows an example of the color of the light emitted by the cubic ZnS:Cu,Al, and the color points G2 to G5 show examples of the color of the light emitted by the green-emitting phosphorescent composition in accordance with the present invention. As shown by these color points, it is clear that the color of the light emitted by the phosphorescent composition of this invention is biased to the long wavelength side in comparison with the color of the light emitted by the cubic ZnS:Cu,Al. Since the phosphorescent composition of this invention emits color biased to the long wavelength side, the color television cathode ray tube using this composition as a green-emitting phosphor component gives an enhanced white luminance in comparison with the conventional color television cathode ray tube using the cubic ZnS:Cu,Al as the green-emitting phosphor component.

Now the color television cathode ray tube in accordance with the present invention will be described in detail.

As the green-emitting phosphor component used in the phosphorescent screen of the color television cathode ray tube of this invention, the above described green-emitting phosphorescent composition is used. As the blue- and red-emitting phosphor components are used the conventional phosphors. For instance as the blue-emitting phosphor may be used a ZnS:Ag phosphor or ZnS:Ag,Al phosphor, and as the red-emitting phosphor may be used a $Y_2O_3:S:Eu$ phosphor, a $Y_2O_3:Eu$ phosphor or a $YVO_4:Eu$ phosphor. The amount of Ag contained in the ZnS:Ag phosphor is within the range of 10^{-5} to 10^{-3} g/g and more preferably 5×10^{-5} to 3×10^{-4} g/g. The amount of Ag and Al contained in the ZnS:Ag,Al phosphor is within the range of 10^{-5} to 10^{-3} g/g respectively and more preferably 5×10^{-5} to 3×10^{-4} g/g. In the drawing, the color points B1 ($x=0.148$, $y=0.058$) and B2 ($x=0.155$, $y=0.040$) are indicative of the colors emitted by the ZnS:Ag phosphor activated by 2×10^{-4} g/g of Ag and the ZnS:Ag,Al phosphor activated by 2×10^{-4} g/g of Ag and Al, respectively. The amount of Eu contained in the above described red-emitting phosphors is within the range of 10^{-2} to 1.5×10^{-1} g/g and more preferably 5×10^{-2} to 6×10^{-2} g/g for $Y_2O_3:S:Eu$ and $Y_2O_3:Eu$ phosphors, and 7×10^{-2} to 8×10^{-2} g/g for $YVO_4:Eu$ phosphor. In the drawing, the color points R1 ($x=0.652$, $y=0.346$), R² ($x=0.642$,

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y=0.352) and R3 ($x=0.668$, $y=0.328$) are indicative of the colors emitted by the $Y_2O_3S:Eu$ phosphor activated by $5 \times 10^{-2}g/g$ of Eu , the $Y_2O_3:Eu$ phosphor activated by $5 \times 10^{-2}g/g$ of Eu , and the $YVO_4:Eu$ phosphor activated by $7 \times 10^{-2}g/g$ of Eu , respectively. The above three color-emitting phosphor components are applied on the face plate of the cathode ray tube in dots or stripes to form a phosphorescent screen thereon by a photoprinting method which is generally adopted to form a fluorescent screen in the conventional color television cathode ray tube.

The phosphorescent screen of the color television cathode ray tube in accordance with the present invention as described in detail hereinabove does not contain cadmium and emits green light which is desirably shifted to the long wavelength side, in comparison with the conventional color television cathode ray tube using the cubic $ZnS:Cu,Al$ phosphor as the green-emitting phosphor component, and gives a higher white luminance than the conventional tube as shown in the Examples which are given below. Further, in the color television cathode ray tube of this invention, the color of the light emitted by the green-emitting phosphorescent composition used therein can easily be selected over a wide range by varying the mixing ratio of the cubic $ZnS:Cu,Al$ phosphor to the cubic $ZnS:Au,Al$ phosphor. Therefore, it is easy to obtain a color television cathode ray tube having a desired color of green emission and a desired area of color reproducing region.

Now the present invention will be described in detail with reference to the following Examples.

Examples 1 to 4.

A cubic $ZnS:Cu,Al$ phosphor containing $1.3 \times 10^{-4}g$ of Cu and $10^{-4}g$ of Al per one gram of ZnS as activators was prepared. The color point of the emitted light of this phosphor was ($x=0.293$, $y=0.631$). A cubic $ZnS:Au,Al$ phosphor containing $1.4 \times 10^{-3}g$ of Au and $5 \times 10^{-3}g$ of Al as activators was prepared. The color point of the emitted light of this phosphor was ($x=0.395$, $y=0.560$). The luminance of the phosphor when excited by an electron beam of 20KV and $1\mu A/cm^2$ was 86% of that of said cubic $ZnS:Cu,Al$ phosphor.

The above cubic $ZnS:Cu,Al$ phosphor and cubic $ZnS:Au,Al$ phosphor were mixed in the mixing ratio of 9:1, 7:3, 13:12 and 2:3 by weight to make four kinds of green-emitting phosphorescent compositions of this invention. The color point and the white luminance (excited by a 20KV, $1\mu A/cm^2$ electron beam) of the cubic $ZnS:Cu,Al$ phosphor (Control) and the four kinds of the green-emitting phosphorescent compositions (Examples 1 to 4) are shown in Table I below. The color points thereof are also shown in the accompanying drawing. In Table 1, the white luminance is represented by relative values in which the white luminance of the cubic $ZnS:Cu,Al$ phosphor is set to be 100%.

TABLE I

Example	Mixing Weight Ratio [($ZnS:Cu,Al$ phosphor): ($ZnS:Au,Al$ phosphor)]	Color Point	White Luminance (%)
Control	$ZnS:Cu,Al$ phosphor only	$x = 0.293$ (G1) $y = 0.631$	100
1	9 : 1	$x = 0.305$ (G2) $y = 0.625$	98
2	7 : 3	$x = 0.333$ (G3) $y = 0.601$	96
3	13 : 12	$x = 0.352$ (G4) $y = 0.588$	92
4	2 : 3	$x = 0.358$ (G5) $y = 0.580$	90

As shown in the drawing and Table I, the white luminances of the green-emitting phosphorescent compositions of Examples 1 to 4 are lower than that of the cubic ZnS:Cu,Al phosphor, but the emitted color of the composition is biased to the long wavelength side in comparison with the conventional phosphor.

Then twenty-five samples consisting of five samples for each of five kinds of 20 inch color television cathode ray tubes using said five kinds of phosphorescent compositions and phosphor as shown in Table I, respectively, were prepared. In these samples, as the blue- and red-emitting phosphor components, a ZnS:Ag phosphor containing 2×10^{-4} g/g of Ag and $Y_2O_3S:Eu$ phosphor containing 5×10^{-2} g/g of Eu were used, respectively, and the three kinds of phosphor components were applied on the face plate of a cathode ray tube in dots. The mean value of the cathode current of the color television cathode ray tubes for each of the five kinds of tubes was measured. The measured mean values are shown in Table II below.

Table II shows the mean values of the cathode current for the five kinds of samples of the color television cathode ray tubes which were required to obtain a predetermined white luminance (170 radlux). In Table II, RIk, GIk and BIk show the cathode current required to excite the red, green and blue emitting phosphor components respectively in order to obtain the predetermined white luminance. ΣIk shows the total cathode current of these three cathode currents. The smaller are the respective Ik values, the higher is the relative luminance of the respective color of the tube; and the smaller is the ΣIk value, the higher is the relative white luminance.

TABLE II

Example Group	RIk	GIk	BIk	ΣIk
Control	48.9	39.0	28.4	116.3
1	45.0	39.5	27.5	112.0
2	39.5	41.9	27.9	109.3
3	36.4	44.2	28.5	109.1
4	32.9	46.0	30.0	108.9

As shown in Table II, the higher is the mixing weight ratio of the cubic ZnS: Au,Al phosphor to the cubic ZnS:Cu,Al phosphor, the higher is GIk namely the lower is the green luminance. However, as the mixing weight ratio increases, the value RIk is markedly lowered. For the groups based on Examples 1 to 4, RIk was lowered by 8%, 19%, 26% and 33%, respectively. Accordingly, ΣIk was lowered and the relative white luminance was increased by 3.8%, 6.4%, 6.6% and 6.8%, respectively.

In the above described Examples, a ZnS:Ag phosphor was used as the blue-emitting phosphor component, and a $Y_2O_3S:Eu$ phosphor was used as the red-emitting phosphor component. It was, however, confirmed that the similar results were obtained when a ZnS:Ag,Al phosphor was used instead of the ZnS:Ag phosphor and a $Y_2O_3:Eu$ phosphor or a $YVO_4:Eu$ phosphor was used instead of the $Y_2O_3S:Eu$ phosphor.

WHAT WE CLAIM IS:—

1. A green-emitting phosphorescent composition for a color television cathode ray tube, comprising a copper and aluminium-activated zinc sulfide phosphor and a gold and aluminium-activated zinc sulfide phosphor, both of cubic structure, the x-value and y-value in the CIE standard chromaticity diagram of the color emitted by said composition when excited by an electron beam being within the ranges of $0.300 < x < 0.360$ and $0.575 < y < 0.635$, respectively.

As shown in the drawing and Table I, the white luminances of the green-emitting phosphorescent compositions of Examples 1 to 4 are lower than that of the cubic ZnS:Cu,Al phosphor, but the emitted color of the composition is biased to the long wavelength side in comparison with the conventional phosphor.

Then twenty-five samples consisting of five samples for each of five kinds of 20 inch color television cathode ray tubes using said five kinds of phosphorescent compositions and phosphor as shown in Table I, respectively, were prepared. In these samples, as the blue- and red-emitting phosphor components, a ZnS:Ag phosphor containing 2×10^{-4} g/g of Ag and $Y_2O_3S:Eu$ phosphor containing 5×10^{-2} g/g of Eu were used, respectively, and the three kinds of phosphor components were applied on the face plate of a cathode ray tube in dots. The mean value of the cathode current of the color television cathode ray tubes for each of the five kinds of tubes was measured. The measured mean values are shown in Table II below.

Table II shows the mean values of the cathode current for the five kinds of samples of the color television cathode ray tubes which were required to obtain a predetermined white luminance (170 radlux). In Table II, R_{Ik}, G_{Ik} and B_{Ik} show the cathode current required to excite the red, green and blue emitting phosphor components respectively in order to obtain the predetermined white luminance. ΣI_k shows the total cathode current of these three cathode currents. The smaller are the respective I_k values, the higher is the relative luminance of the respective color of the tube; and the smaller is the ΣI_k value, the higher is the relative white luminance.

TABLE II

Example Group	R _{Ik}	G _{Ik}	B _{Ik}	ΣI_k
Control	48.9	39.0	28.4	116.3
1	45.0	39.5	27.5	112.0
2	39.5	41.9	27.9	109.3
3	36.4	44.2	28.5	109.1
4	32.9	46.0	30.0	108.9

As shown in Table II, the higher is the mixing weight ratio of the cubic ZnS: Au,Al phosphor to the cubic ZnS:Cu,Al phosphor, the higher is G_{Ik} namely the lower is the green luminance. However, as the mixing weight ratio increases, the value R_{Ik} is markedly lowered. For the groups based on Examples 1 to 4, R_{Ik} was lowered by 8%, 19%, 26% and 33%, respectively. Accordingly, ΣI_k was lowered and the relative white luminance was increased by 3.8%, 6.4%, 6.6% and 6.8%, respectively.

In the above described Examples, a ZnS:Ag phosphor was used as the blue-emitting phosphor component, and a $Y_2O_3S:Eu$ phosphor was used as the red-emitting phosphor component. It was, however, confirmed that the similar results were obtained when a ZnS:Ag,Al phosphor was used instead of the ZnS:Ag phosphor and a $Y_2O_3:Eu$ phosphor or a $YVO_4:Eu$ phosphor was used instead of the $Y_2O_3S:Eu$ phosphor.

WHAT WE CLAIM IS:—

1. A green-emitting phosphorescent composition for a color television cathode ray tube, comprising a copper and aluminium-activated zinc sulfide phosphor and a gold and aluminium-activated zinc sulfide phosphor, both of cubic structure, the x-value and y-value in the CIE standard chromaticity diagram of the color emitted by said composition when excited by an electron beam being within the ranges of $0.300 < x < 0.360$ and $0.575 < y < 0.635$, respectively.



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2. A composition according to claim 1 wherein the amounts of copper and aluminium contained in said copper and aluminium-activated zinc sulfide phosphor are 10^{-5} g to 3×10^{-4} g and 5×10^{-6} g to 3×10^{-3} g respectively per gram of the zinc sulfide host material, and the amounts of gold and aluminium contained in said gold and aluminium-activated zinc sulfide phosphor are 5×10^{-4} g to 10^{-2} g and 5×10^{-6} g to 10^{-2} g respectively per gram of the zinc sulfide host material. 5
3. A composition according to claim 1 substantially as hereinbefore described with reference to any of the Examples.
4. A cathode ray tube, for a color television, provided with a phosphorescent screen comprising a green-emitting phosphor, a blue-emitting phosphor and a red-emitting phosphor, said green-emitting phosphor being a composition according to claim 1, said blue-emitting phosphor being a silver-activated or silver and aluminium-activated zinc sulfide phosphor in which zinc sulfide is activated by 10^{-5} g to 10^{-3} g of silver or silver and aluminium respectively per gram of the zinc sulfide and said red-emitting phosphor being a europium-activated yttrium oxysulfide phosphor, a europium-activated yttrium oxide phosphor or a europium-activated yttrium vanadate phosphor each activated by 10^{-2} g to 1.5×10^{-1} g of europium per gram of the yttrium oxysulfide, yttrium oxide or yttrium vanadate, respectively. 10
5. A cathode ray tube according to claim 4 wherein said green-emitting phosphor is a composition according to claim 2, said blue-emitting phosphor is a silver-activated zinc sulphide phosphor activated by 5×10^{-5} g to 3×10^{-4} g of silver per gram of the zinc sulfide or a silver and aluminium-activated zinc sulfide phosphor activated by 5×10^{-5} g to 3×10^{-4} g of silver and aluminium per gram of the zinc sulfide and said red-emitting phosphor is a europium-activated yttrium oxysulfide phosphor activated by 5×10^{-2} g to 6×10^{-2} g of europium per gram of the yttrium oxysulfide, a europium-activated yttrium oxide phosphor activated by 5×10^{-2} g to 6×10^{-2} g of europium per gram of the yttrium oxide or a europium-activated yttrium vanadate phosphor activated by 7×10^{-2} g to 8×10^{-2} g of europium per gram of the yttrium vanadate. 15
6. A cathode ray tube according to claim 4 substantially as hereinbefore described with reference to any of the Examples. 20
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Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1979.
Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from
which copies may be obtained.