United States Patent

[11] 3,622,826

[72] Inventor **Martin Robert Royce**
Lancaster, Pa.

[21] Appl. No. **880,865**
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[45] Patented **Nov. 23, 1971**
[73] Assignee **RCA Corporation**

[54] **PHOSPHOR SCREEN COMPRISING TWO KINDS OF PARTICLES, EACH HAVING PHOSPHOR CORE AND PHOSPHOR COATING**
2 Claims, 6 Drawing Figs.

[52] **U.S. Cl.** ..... **313/92 PH,** 313/92 R
[51] **Int. Cl.** **H01j 29/18,** H01j 3/20
[50] **Field of Search** ..... 313/92 B, 70 C, 92

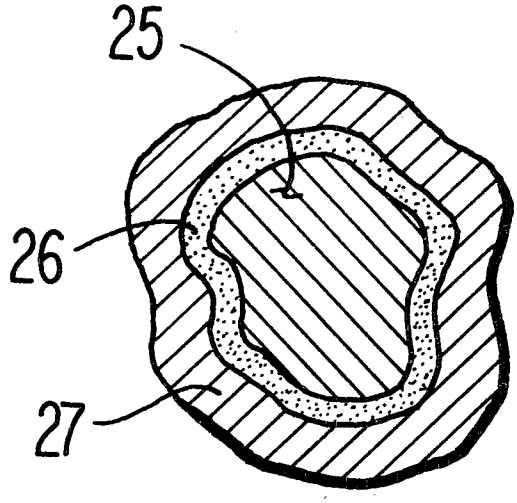
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3,371,153	2/1968	Matzen	313/92 X
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Primary Examiner—Robert Segal
Attorney—Glenn H. Bruestle

ABSTRACT: An electron tube having a penetration-type luminescdnt screen which includes phosphor particles of two different types. A builtup particle of the first type is comprised of a core of a first phosphor, a coating of an inert electron-absorbing layer, and an overcoating thereon of a third phosphor. A builtup particle of the second type is comprised of a core of a second phosphor, a coating of an inert electron-absorbing layer, and an overcoating thereon of the third phosphor.
At low operational voltages, the third phosphor (the overcoating) is excited to produce a colored emission to the viewer. At higher operational voltages, the first phosphor and the second phosphor (cores) of similar persistences are simultaneously excited to emit in different colors to produce a combined light of a white or off-white emission to the viewer. Thereby, the viewer may observe an information display in white or off-white and a related display in an easily distinguishable contrasting color such as red.



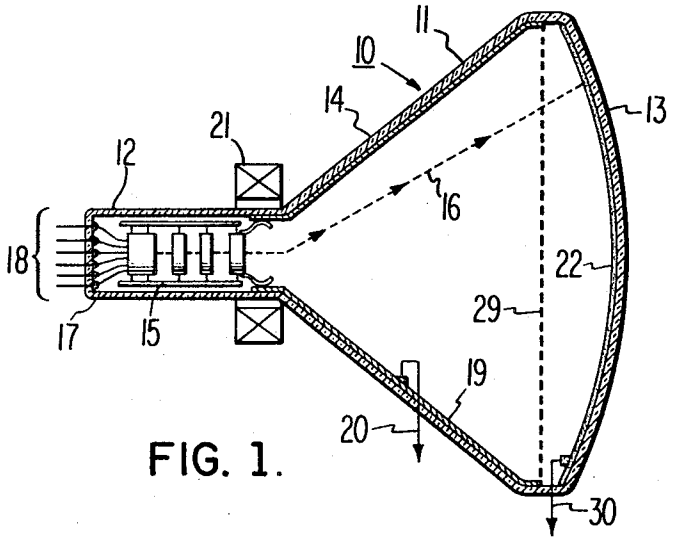


FIG. 1.

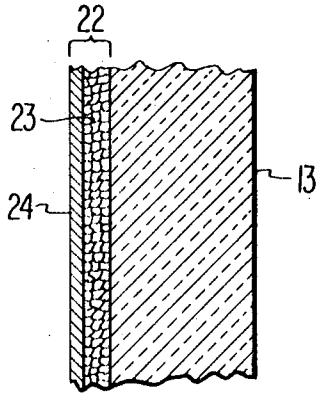


FIG. 2.

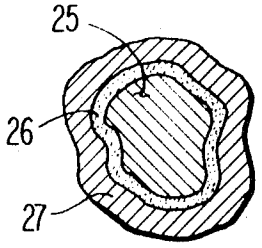


FIG. 3.

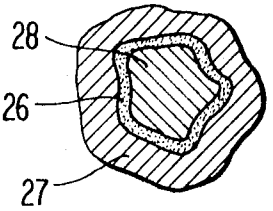


FIG. 4.

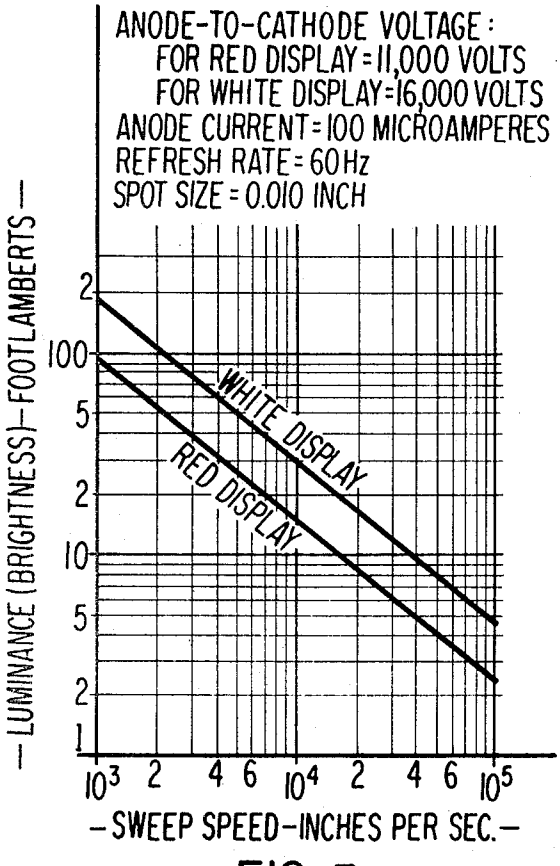


FIG. 5.

INVENTOR
Martin R. Royce
BY
ATTORNEY

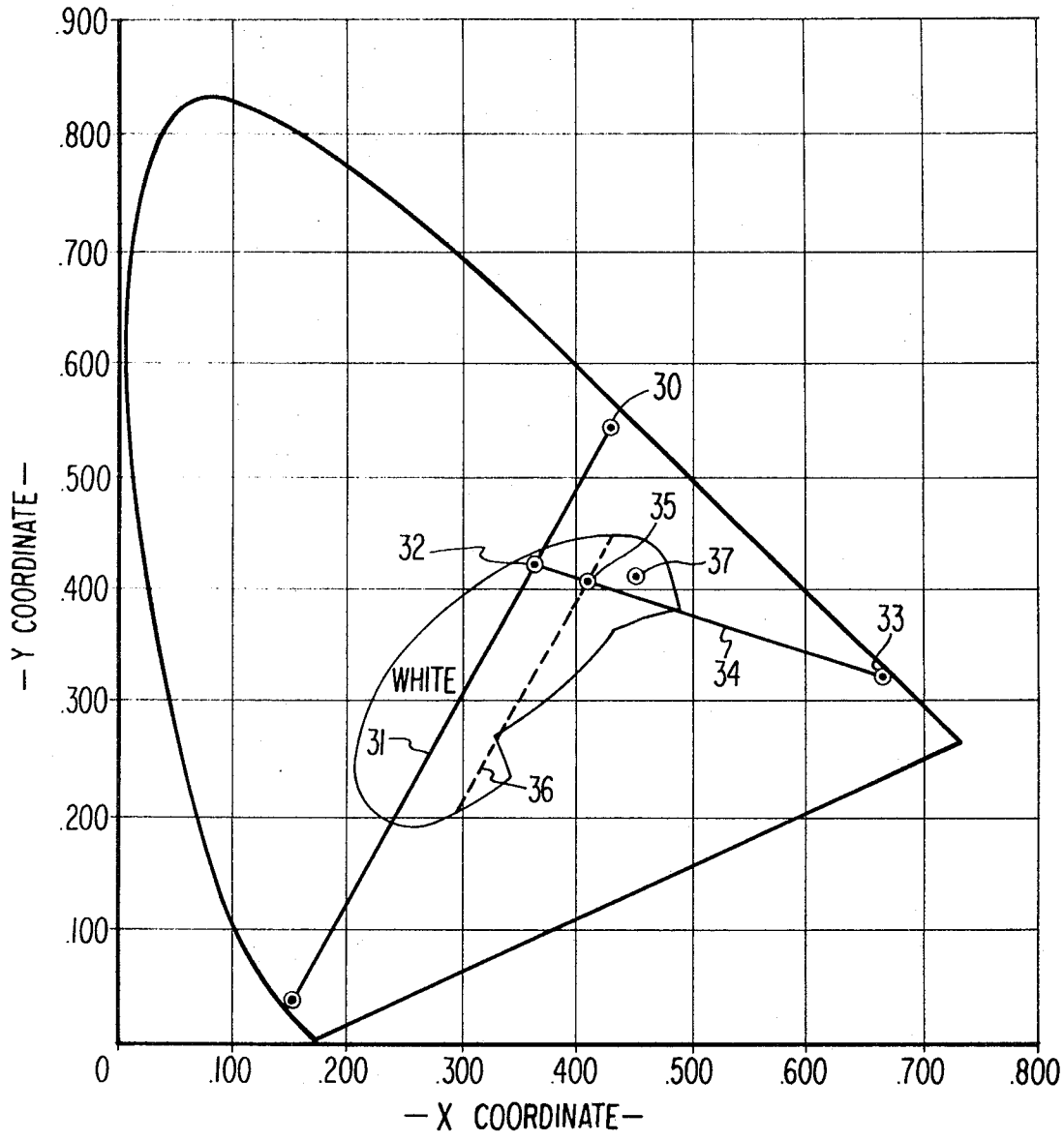


Fig. 6.

INVENTOR
Martin R. Royce
BY
Glenn H. Bruestle
ATTORNEY

PHOSPHOR SCREEN COMPRISING TWO KINDS OF PARTICLES, EACH HAVING PHOSPHOR CORE AND PHOSPHOR COATING

BACKGROUND OF THE INVENTION

The invention relates to a novel electron tube having a penetration-type luminescent screen which displays information in both white and a color depending on the applied voltages. Display tubes of this type may be used, for example, in computer data display terminals, military identification systems, stock market quotation displays, and so forth.

Some prior art multilayer penetration-type screens have been previously described, for example, in U.S. Pat. No. 3,204,143 to D. N. Pritchard. This patent describes color television picture tubes having penetration-type screens of both the extended layer type and the particle layer type known in the art as onion skin layers.

Another prior art penetration type screen is described in a U.S. Pat. application of A. E. Bishop filed July 15, 1968, Ser. No. 744,887. This application describes an electron tube having a multicolor, dual-persistence screen. A screen structure of this type relies on each phosphor having a different persistence characteristic to permit viewers to distinguish information according to colors and persistence of each color.

It is desirable that high-speed graphic display cathode ray tubes provide a continuous display of information in a white or off-white color and a relating display of information in a contrasting color. A display using a red emission contrasting with a white or off-white emission is desirable to instantly permit identifying a portion of a message as belonging to one of two categories.

SUMMARY OF THE INVENTION

The novel electron tube is comprised of an evacuated envelope, a luminescent screen therein, and means for exciting the screen with electrons. The screen is comprised of built up particles of at least two different types. Each of the built up particles of one type includes a base particle or core of a first phosphor which luminesces in one visual color. Each of the built up particles of the other type includes a base particle or core of a second phosphor which luminesces in another visual color. The first and second phosphors have approximately the same decay characteristics and, when simultaneously excited, the emissions add to produce a light mix output display which appears white or off-white to a viewer. Each of the cores of both particle types has an inert electron energy-absorbing coating and is overcoated with a third phosphor which when excited emits in still another color. The third phosphor may have approximately the same, a longer, or a shorter decay characteristic as the first and second phosphors.

The tube is operated at two voltage levels. At the low-voltage level, the third phosphor (the overcoating) is excited to produce a colored emission to the viewer. At the high-voltage level, the first and second phosphors (from the cores) are excited simultaneously to produce a white or off-white emission to the viewer. The use of a white emission in combination with a contrasting colored emission provides continuous viewing of two related displays of information. If the two emissions are red and white, for example, a continuous display of information can be viewed in white, and a related display of information can be viewed in red. Alternatively, a continuous display of information can be viewed in white and a display of information can be viewed only for special purposes in red, such as for a danger signal or for a variance from a prescribed program.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a longitudinal section of a novel cathode-ray tube incorporating the novel screen of the invention.

FIG. 2 is an enlarged broken-away section of the luminescent screen included in FIG. 1.

FIG. 3 is an idealized sectional view of the first type of built up phosphor particle used in the screen illustrated n FIGS. 1 and 2.

FIG. 4 is an idealized sectional view of the second type of built up phosphor particle used in the luminescent screen illustrated in FIGS. 1 and 2.

FIG. 5 is a graphical representation of the typical trace luminance characteristics of the white and red color displayed on the screen of the novel display tube illustrated in FIG. 1.

FIG. 6 is a typical color designation diagram illustrating how the emissions of the phosphors are chosen to obtain a specific red-to-white or off-white range of emission which can be viewed on the screen of the novel display tube shown in FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 illustrates a novel cathode-ray tube **10** comprised of an envelope **11** including a neck **12**, a faceplate **13** and an interconnecting funnel **14**. An electron gun **15** in the neck **12** is adapted to project a beam **16** of electrons toward the faceplate **13**. The neck **12** is closed at one end with a stem structure **17** through which a plurality of lead-in wires **18** are sealed. Suitable operating potential is supplied to the electron gun **15** through the lead in wires **18**. A conducting coating **19** is provided on the internal surface of the funnel **14** and serves as an accelerating electrode for the electron beam **16**. A suitable high-voltage potential is supplied to the conducting coating **19** through a terminal means sealed through the funnel **14** and schematically represented by arrow **20**. Means, such as a magnetic deflection yoke **21**, are provided for deflecting the electron beam **16** to scan a raster over the faceplate **13**.

A luminescent screen **22** is supported on the internal surface of the faceplate **13** in a position whereby the deflected electron beam **16** may excite the screen **22** to luminescence. FIG. 2 illustrates in more detail the luminescent screen **22** which is comprised of a single layer **23** of phosphor-coated phosphor particles. The layer **23** is characterized by having a thickness substantially greater than the size of the coated particles, thus resulting in a multiparticle thick layer **23** which is substantially free of perforations and voids. Because the particles are ordinarily small in size, the layer **23** is relatively thin. A light-reflective metallic layer **24** of, for example, aluminum, is supported on the phosphor layer **23**.

The layer **23** is comprised of a mixture of two different types of built up phosphor particles. The first type of built up phosphor particle, illustrated in FIG. **3**, includes a first core **25** of a medium-to-short-decay cathodoluminescent phosphor. The decay of luminescence is in the range of 1 millisecond to 1 micro second. The first core **25** may be, for example, a silver-activated zinc sulfide particle which exhibits a blue emission and a decay of about 35 microseconds. The first core **25** has a particle size in the range of 15 to 40 microns.

The first core **25** has an inert electron-absorbing coating **26** such as, for example, vermiculite, or a silica having the trade name Ludox, marked by E. I. du Pont de Nemours and Company, Wilmington, Del. The coating **26** may also be integral with the first core **25**, such as is obtained by diffusing cobalt into a surface region of the first core **25** which by subsequent treatment renders it nonluminescent. The coating **26** is approximately 0.1 to 1.0-micron thick. The preferred thickness is approximately 0.5 micron.

The first core **25** with coating **26** has an overcoating **27** of a short-to-medium-decay cathodoluminescent phosphor. The overcoating **27** may be, for example, a red-emitting manganese activated zinc magnesium cadmium silicate, europium-activated yttrium vanadate, or europium-activated yttrium oxysulfide. The overcoating **27** is approximately 0.1 to 1.0-micron thick and exhibits a decay of approximately 1 millisecond.

The second type of phosphor particle, illustrated in FIG. **4**, includes a second core **28** of a medium-to-short-decay cathodoluminescent phosphor. The decay of luminescence of the second core **28** is in the range of 1 millisecond to 1 microsecond and approximately the same as that of the first core **25**. The second core **28** may be, for example, a silver-activated zinc cadmium sulfide particle which exhibits a yellow

emission and a decay of about 35 microseconds. The second core **28** also has an inert electron-absorbing coating **26** and an overcoating **27** of the same phosphor of the overcoating of the first particle.

The luminescence decay characteristics of the first and second cores **25** and **28** should be very similar since their emission output provides a white light display to the human eye. If one of the first and second cores **25** or **28** has a longer persistence, then a residual image of an undesired color (nonwhite) may result. It is desirable that the luminescence decay of the first and second phosphor cores be within the range of 25 to 75 microseconds. The preferred decay range is 50 to 60 microseconds.

The luminescence decay characteristic of the overcoating **27** may be approximately the same as that of the first and second cores **25** and **28**. This will permit equal sequential scanning for both the overcoating and the cores and result in continuous image displays of both colors to the human eye. The luminescence decay characteristics of the overcoating **27** may also be longer or shorter than that of the cores **25** and **28**.

The tube **10** produces an electron beam **16** which may have electrons of different velocities. Means may be provided in the tube **10** for preventing raster size distortion. Such means may take the form of either a mesh **29** disposed traversely within the funnel **14** or other suitable means. Where the mesh **29** is used, it is connected to the conductive coating **19**, and the tube **10** is operated according to post-acceleration principles. A separate lead-in means as indicated schematically by arrow **30** may be provided for supplying suitable electrical potentials to the metallic layer **24** for the purpose of obtaining post-acceleration operation of this if so desired. However, the mesh electrode **29** and the separated lead-in wire **30** may be omitted entirely.

The concept of the operation of the novel tube may be described by reference to FIGS. **3** and **4**, which show idealized sectional views of the built-up particles of the two types. In the first type built-up particle (FIG. **3**), an overcoating **27** covers an electron-absorbing coating **26** and a first core **25** of a first phosphor. In the second type particle, the same overcoating **27** covers an electron-absorbing coating **26** and a second core **28** of a second phosphor. The phosphors of the first and second cores **25** and **28** are chosen only to add in color emission and produce a white or off-white color to the human eye. Since the two types of built-up particles are mixed to form the screen layer **23**, the first and second cores **25** and **28** are simultaneously excited by the high-voltage electrons producing a light mix output, and only a white or off-white color is observed by the human eye. Therefore, a signal from a computer having a high-speed scanning rate may be displayed in a continuous white or off-white pattern by the simultaneous emission from the first and second cores **25** and **28**. A stationary or moving reference mark or pattern may also be displayed in a second color, such as red, by the emission from the overcoating **27** without creating persistent images that could be confused with or obscure the signals from the aforesaid source having a high frame rate.

In making the screen **22**, the two types of built-up phosphor particles may be prepared together or separately. It is preferred to use a coating method described in U.S. Pat. NO. 3,275,466 to R.D.Kell. In one application of the Kell method, the first type of particle is prepared by soaking phosphor first cores **25** of the first type in a particle-absorbing liquid, such as an acidified gelatin solution. The soak is agitated to ensure particle liquid contact. The first cores **25** are then allowed to settle, and the excess liquid is poured off leaving an adsorbent film on the first cores **25**. The film coated first cores **25** are then washed in water one or more times. Next, the inert electron- absorbing layer **26** is laid down on the first cores **25** by a similar soaking procedure. A suitable material such as submicron-size vermiculite particles dispersed in water is put in the soak along with the gelatin filmed first cores **25**. The materials in the soak are agitated to coat the phosphor first cores **25** with an inert coating **26**. The first cores **25** are then allowed to settle and the excess inert material is poured off. The film-coated first cores **25** are then washed in water. Additional applications of absorbent film and inert electron-absorbing material may be laid down to increase the coating **26** thickness.

Another method of applying the inert layer is described in U.S. Pat. No. 3,294,569 to P. J. Messineo et al. This patent describes a method of diffusing an integral inert layer of cobalt sulfide into the outer portion of the phosphor core.

When the inert electron-absorbing coating **26** is sufficiently thick, the phosphor overcoating **27** is applied. An absorbent film is applied to the coated particles as described above. The film-coated first cores **25** are soaked in a water suspension of submicron-size particles of the third phosphor. The first cores **25** are agitated in the suspension whereby the submicron particles of the overcoating **27** are deposited on and overcoat the first cores **25**. The overcoated filmed first cores **25** are then decanted from the remaining suspension and washed with water. These latter steps may be repeated to increase the thickness of the phosphor overcoating **27** on the coated core **25**. When the overcoating **27** is sufficiently thick, the particles are washed and stored in water.

After the final application of the third phosphor, the overcoating **27** may be given a final treatment to improve the adherence thereof. This may be done by washing the overcoated first cores **25** with a solution of formaldehyde, chrome alum, or potassium silicate.

The foregoing steps are repeated using core particles **28** of the second phosphor in place of core particles **25** of the first phosphor to prepare the built-up phosphor particles of the second type.

Quantities of the built-up particles of the first and second types are blended in the desired proportions by mixing to form an aqueous suspension. The suspension is then used to deposit the phosphor layer **23**, as by a slurry coating process or by a settling process.

The layer **23** of built-up phosphor particles is filmed and a metallic layer of aluminum **24** applied, as by vapor deposition, in a manner known in the art. Then, the entire screen structure including the aluminum layer **24** is heated, whereby the volatile materials are removed.

Some specific combinations of commercially available phosphors which may be used to practice the invention are:

1. for the first cores **25**: RCA–33–z–20D
2. for the second cores **28**: RCA–33–Z–250
3. for the overcoating **27**: RCA–33Y–253A

These phosphors are marketed by RCA Corporation, Harrison, N. J. The specific phosphor combination used in the screen structure **22** of the novel display tube is a proportion of about 37.6 grams of the first type particle and about 100 grams of the second type particle. Approximately 6 to 7 grams of the third phosphor of the overcoating **27** are used with the 100 grams of the first core **25** or the second core **28** to make either the first or second type built-up particle.

In FIG. **5**, the average brightness of the center of a single trace is related to the scan sweep speed for the novel display cathode-ray tube. FIG. **5** shows the relationship in brightness between the red and the white display and the scan rate. The scan is refreshed at 60 Hz. providing a red display at approximately 11 kv. anode voltage and a white display at approximately 16 kv. anode voltage. The novel display cathode-ray tube is sequentially scanned for red and white over the complete tube display providing a continuous two-color display to a viewer.

FIG. **6** describes the range of red to white emission obtainable from preferred embodiment of the novel cathode-ray tube. The emission of the phosphor used for the first core **25** is shown by the point **29**, the emission of the phosphor used for the second core **28** is shown by the point **30**, and the emission of the phosphor used for the overcoating **27** is shown by the point **33**. The tube produces data either in red at a dominant wavelength of 6070 angstroms, or in white which is similar to the C.I.E. Illuminant "A" **37**. The tube may also be operated

to display any given color between the red emission **33** and the white or off-white emission **32**, as described by the locus **34** of the mixture of the two colors, by control of applied anode voltage.

One method of selecting a particular red-to-white range of color emission is to first select the proportions of the first and second type built-up particle to determine the white emission by simultaneous excitation of the first and second cores **25** and **28**. The theoretical white-emission range obtainable from the first and second cores **25** and **28** is shown in FIG. **6** by the portion of the locus **31** of the mixture of the emissions in the white area. The white emission as used in this specification includes the white and off-white emissions described by the elliptical area labeled "white" in FIG. **6**. In the specific embodiment used in the novel cathode-ray display tube a proportion of about 37.6 grams of the first type particle and about 100 grams of the second type particle theoretically provides a white emission shown by the point **32** in FIG. **6**.

After the white emission **32** is determined, the theoretical red-to-white emission is described by the locus **34** between the red emission **33** and the white emission **32**. The theoretical white emission **32** is usually not obtained in the novel display tube since the high-voltage electrons in exciting the first and second cores **25** and **28** also slightly excite the overcoating **27**. The slight emission from the overcoating produces an actual white emission **35** displaced from the theoretical white emission **32** toward the red. The extent of the displacement is affected by the difference between the high and low voltages and the effectiveness of the inert coating **26**. Since the simultaneous emission by the high-voltage beam also includes a small amount of emission from he overcoating **27**, the theoretical white emission **32** can be outside the white area shown in FIG. **6**. It is only necessary that the viewed white emission **35** be within the white area shown in FIG. **6**.

Other ranges of red-to-white emissions can be obtained in the novel cathode-ray display tube. The selection of different proportions of the first and second type built-up particles will move the theoretical white along the locus **31** of possible whites within the white area shown in FIG. **6**. The theoretical range of red to white occurs along the locus **34**. The actual white **35** for each possible range of red to white will occur on the locus **34** of theoretical red to whites displaced by the amount of emission from the overcoating as approximately illustrated by the locus **36** of whites obtainable.

Although the locus **31** of theoretical whites occurs between the emission **30** from the first core **25** (yellow) and the emission **29** from the second core **28** (blue), it can occur between any two phosphor color combinations that are displaced opposed over the white area of FIG. **6** such as, for example, phosphors having an orange emission and a cyan emission. The first and second phosphors used for the first and second cores **25** and **28** can also have a red and cyan emission. The colored emission from the overcoatings **27** can also be any contrasting color providing other color ranges such as blue-to-white and green-to-white by varying the third phosphor. A contrasting color as used in this specification is a saturated or near-saturated red, orange, blue or green color.

I claim:

1. An electron tube comprised of an evacuated envelope, a luminescent screen therein, and means for exciting said screen with electrons within said envelope, said screen being comprised of particles of at least two different types,

each of the particles of a first cathodo-luminescent type being comprised of a base particle of a first phosphor consisting of silver-activated zinc sulfide which luminesces with a persistence P_1 in the range of 25 to 75 microseconds in a first color blue upon excitation with electrons, and inert electron-absorbing coating on said base particles, and an overcoating thereon of a third cathodo luminescent phosphor selected from the group consisting of a red-emitting manganese-activated zinc magnesium cadmium silicate europium activated yttrium vanadate, and europium-activated yttrium oxysulfide which luminesces with a persistence P_3 in the range of 25 to 75 microseconds in a third color red upon excitation with electrons,

each of the particles of a second type being comprised of a base particle of a second cathodo luminescent phosphor consisting of silver-activated zinc cadmium sulfide which luminesces with a persistence P_2 in the range of 25 to 75 microseconds in a second color yellow upon excitation with electrons, an inert electron absorbing coating on said base particle, and an overcoating thereon of said third phosphor which luminesces with a persistence P_3 in said third color upon excitation with electrons,

said persistences P_1 and P_2 being about equal,

and the simultaneous excitation of said first and second phosphors in said screen producing an emission that appears white of off-white to the viewer.

2. The tube defined in claim **1** wherein.

P_1 is about 35 mircroseconds

P_2 is about 35 microseconds

P_3 is about 1 millisecond

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,622,826 Dated November 23, 1971

Inventor(s) Martin Robert Royce

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Abstract, lines 1 and 2	change "luminescdnt" to --luminescent--
Column 1, line 31	after "message" insert --or a given message--
Column 4, line 54	after "with" cancel --the--
Column 6, line 16	cancel "cathodo-luminescent"
Column 6, line 17	after "first" add --cathodoluminescent--

Signed and sealed this 13th day of June 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

ORM PO-1050 (10-69)

USCOMM-DC 60376-P69
* U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334