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Rehkopf et al.

[11] **3,858,081**

[45] **Dec. 31, 1974**

[54] **CATHODE RAY TUBE SCREEN STRUCTURE UTILIZING ADJUVANT EXCITATION**

[75] Inventors: **Charles H. Rehkopf; Kenneth Speigel,** both of Seneca Falls, N.Y.

[73] Assignee: **GTE Sylvania Incorporated,** Stamford, Conn.

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[52] **U.S. Cl.** **313/467,** 313/470

[51] **Int. Cl.** .. **H01j 29/20,** H01j 29/32, H01j 29/28, H01j 29/30

[58] **Field of Search** .... 313/92 B, 92 PD, 92 F, 313/92 PF

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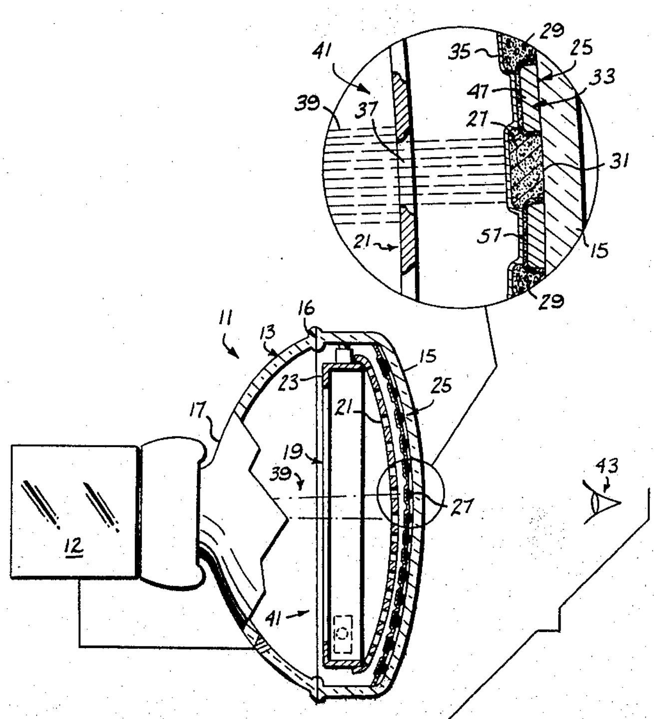
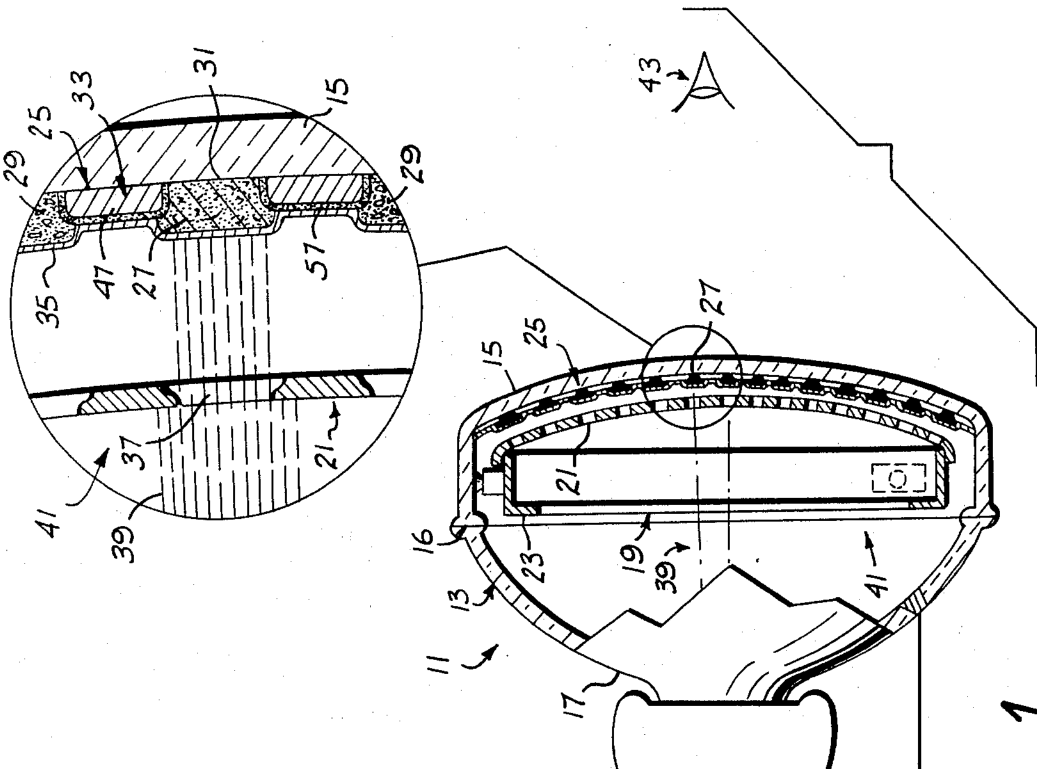
Primary Examiner—Robert Segal
Attorney, Agent, or Firm—Norman J. O'Malley; Frederick H. Rinn; Cyril A. Krenzer

[57] **ABSTRACT**

A multiplex screen structure is provided for a color cathode ray tube whereof the window areas of a webbing structure are smaller than the apertures of a spatially related pattern member. The screen structure comprises a first apertured webbing of defined window areas of a substantially opaque electrical conductive material formed by photo-processing on the inner surface of the tube viewing panel. A second apertured webbing of an electron responsive uv emitting phosphor material is electrophoretically superposed over the first webbing to provide a duo-webbing whereof the apertures are in alignment. The electrophoretic deposition of the second webbing, while effecting a very narrow mat-like encompassment within the perimeter of each aperture in the first webbing, primarily provides a source of uv energy for adjuvantly exciting and luminously enhancing of at least one of the electron responsive phosphor elements comprising the screen pattern overlaying the window areas.

4 Claims, 6 Drawing Figures





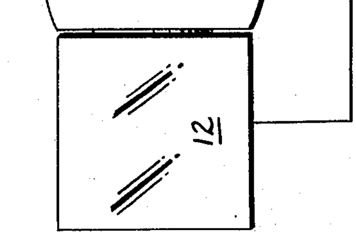


Fig. 1

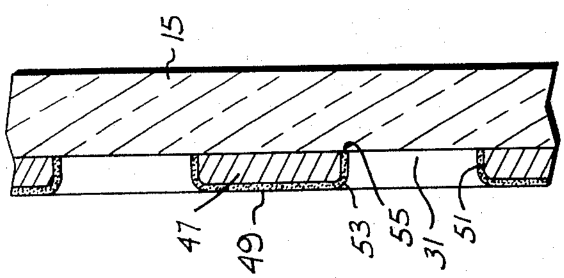


Fig. 3

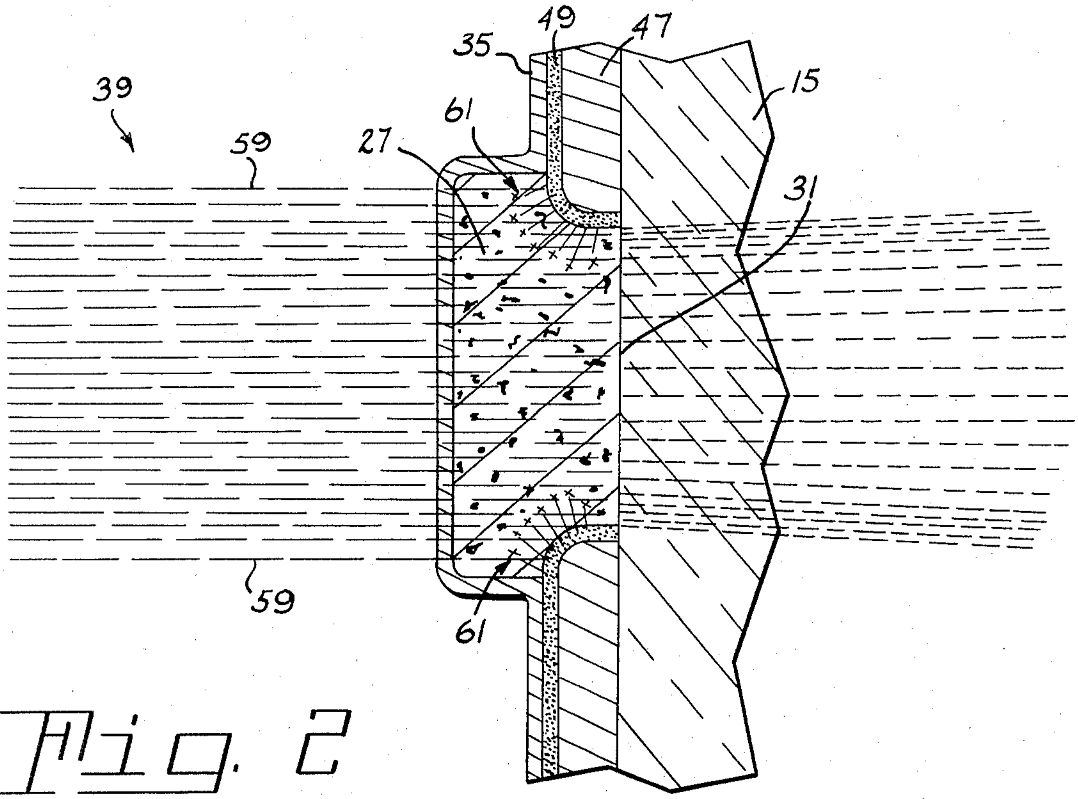

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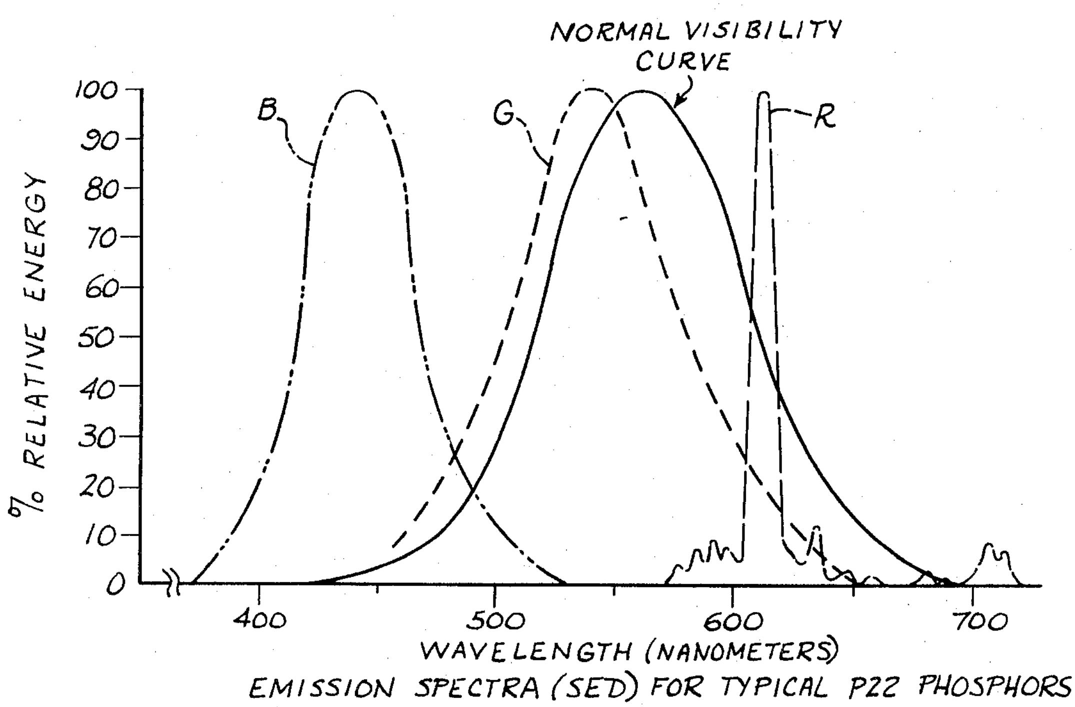
Fig. 2


NORMAL VISIBILITY CURVE
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% RELATIVE ENERGY
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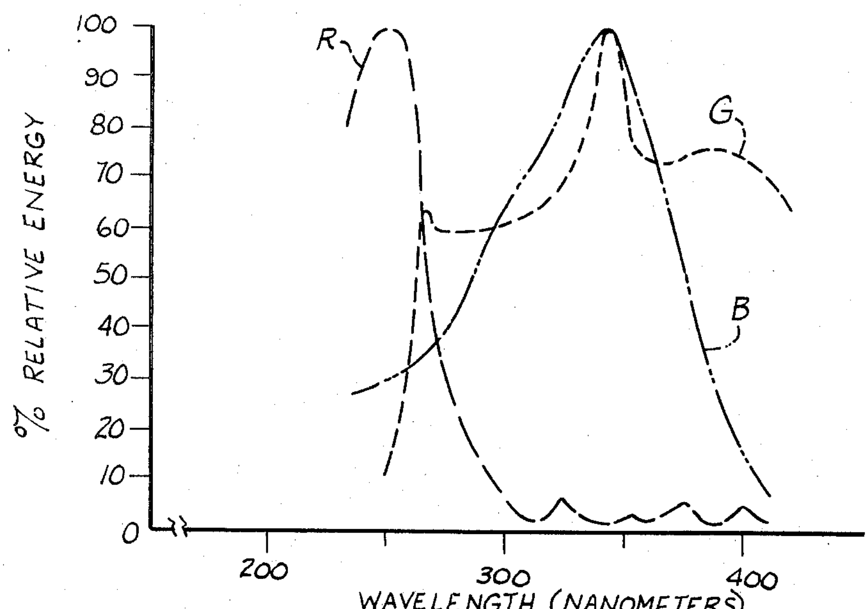
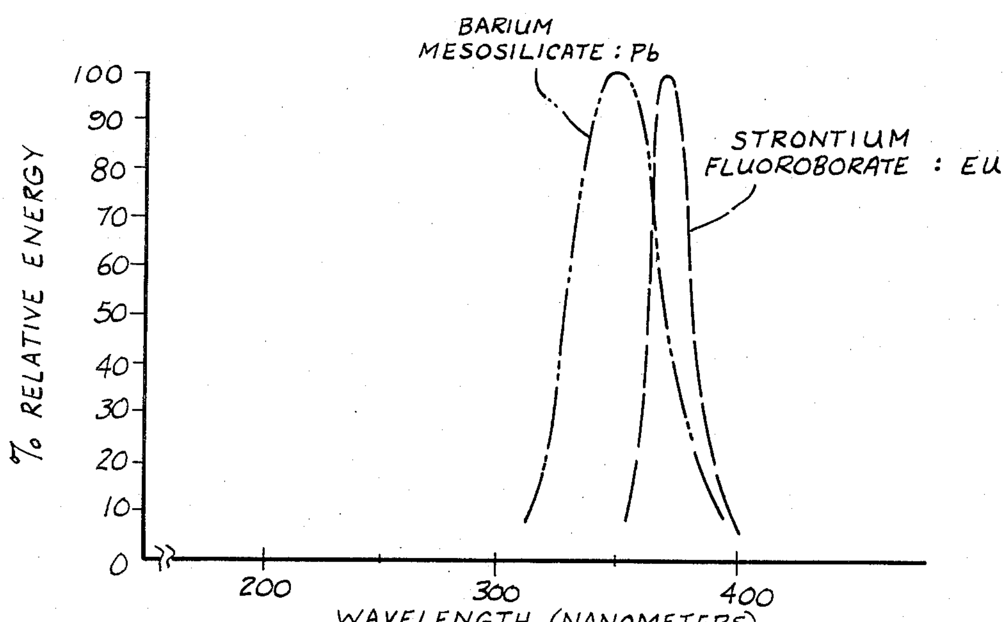
WAVELENGTH (NANOMETERS)
EMISSION SPECTRA (SED) FOR TYPICAL P22 PHOSPHORS

Fig. 4



EXCITATION SPECTRA FOR TYPICAL P22 PHOSPHORS

Fig. 5



EMISSION SPECTRA FOR EXEMPLA OF UV EMITTING PHOSPHORS

Fig. 6

CATHODE RAY TUBE SCREEN STRUCTURE UTILIZING ADJUVANT EXCITATION

CROSS-REFERENCE TO RELATED APPLICATION

This application contains matter disclosed but not claimed in two related United Stated patent applications filed concurrently herewith and assigned to the assignee of the present invention. These related applications are: Ser. No. 357,942,; and Ser. No. 357,941.

BACKGROUND OF THE INVENTION

This invention relates to a color cathode ray tube and more particularly to the multiplex screen structure disposed over the viewing panel thereof.

Cathode ray tubes, utilized to present multi-color display imagery for color television and the like, usually have patterned multi-element screen structures comprised of repetitive groupings of related phosphor materials of which dot-like areas are a common deposition.

A conventional tube construction employs an apertured pattern member posititioned in spaced relationship with the patterned screen, which in a post deflection type of tube, functions as an electrode in the finished tube, and is commonly utilized in the prior deposition of the patterned elements of the screen on the inner surface of the glass viewing panel. In the common shadow mask tube construction, the multi-element screen pattern is likewise formed by using a spatially positioned apertured pattern member. In both types of tubes, each of the openings in the pattern member being of a substantially round, elongated or rectangular shaping, is related to a specific grouping of phosphor elements in a spaced manner to enable selected electron beams transversing the apertures to impinge the proper pattern elements therebeneath. Normally the individual phosphor elements of the screen pattern are separated from one another by relatively small interstitial spacings which enhance color purity by reducing the possibility of adjacent color-emitting phosphor elements being excited by a specific electron beam.

It has been found that contrast in color screen imagery can be improved by filling the interstitial spacing between the phosphor elements with an opaque light-absorbing material. Primarily, the inculsion of this fill-in material enhances contrast by preventing ambient light from being reflected by the unexcited areas of the screen and the aluminum backing on the screen in the interstitial areas not covered by phosphor elements. Thus, by incorporating such material, each phosphor element is defined by a substantially non-translucent encompassment which collectively comprise a multi-opening pattern in the form of a windowed webbing having a lace-like array of opaque inter-connecting interstices. Such web-like screen structures have been fabricated, either before or after phosphor screening, by several known processes wherein photo-deposition techniques constitute a fundamental part. An example of one type of web-forming procedure is disclosed in Ser. No. 41,535 by R. L. Bergamo et al., filed May 28, 1970, and assigned to the assignee of this invention.

It has been found that further improvement can be realized from a mask-screen relationship wherein the respective phosphor covered windows of the opaque

webbing in the finished multiplex screen are substantially equal to or slightly smaller than the apertures in the related pattern member. This aperture-to-window relationship is referenced in the art as a "window-limited" screen. In this type of screen construction, when a phosphor dot of round, ovate or elongated shaping is impinged by an electron beam, that is "sized" by an aperture in the pattern member, the excited phosphor area completely fills the associated window area with a luminescent hue.

Usually each phosphor area of the color screen pattern and the electron beam impingement thereon are of areas larger than that of the associated window in the opaque webbing. Thus, there is "extra" phosphor material and "extra" electron excitement energy that is masked from the viewew and/or absorbed by the opaque webbing at each phosphor site. The definitive windows in the opaque webbing, while beneficially improving contrast and color purity, tend to reduce luminescent brightness by blocking out and absorbing the peripheral luminance of the formed dot areas. This is particularly noticeable in those screen pattern elements that are composed of phosphors that are least bright in luminescent color emission.

OBJECTS AND SUMMARY OF THE INVENTION

It is an object of the invention to reduce the aforementioned disadvantages by providing a windowed color screen structure having means therein to improve the luminescent brightness of the excited imagery emanating therefrom. Another object is to improve the operational and output efficiencies of a color CRT windowed multiplex screen structure.

These and other objects and advantages are achieved in one aaspect of the invention by the provision of a color cathode ray tube multiplex screen structure comprising a first apertured webbing of an opaque electrically conductive material formed by photo-processing on the inner surface of the tube viewing panel. A second apertured webbing of an electron responsive *uv* emitting phosphor material is electrophoretically superposed on the first webbing to provide a duo-webbing structure with the apertures thereof being in alignment. The electrophoretic deposition of the phosphor comprising the second webbing, while effecting a very narrow mat-like encompassment within the delineating perimeter of each of the first webbing apertures, primarily provides a source of discrete *uv* energy upon electron excitation. This *uv* radiation is of a wavelength to adjuvantly excite at least one of the phosphor elements comprising the respectively patterned color screen structure. The phosphor response resultant from adjuvant *uv* excitent energy in addition to normal cathodoluminescence increases the total luminescence from the respective phosphor elements thereby providing display imagery of enhanced brightness.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an illustration of a color cathode ray tube in an operable environment and partially in section showing the relationship of the apertured pattern member to the associated multiplex screen structure disposed on the glass viewing panel of the tube;

FIG. 2 is an enlarged section of a fragment of the screen structure illustrating the invention;

FIG. 3 is an enlarged sectional portion of a partially completed screen structure;

FIG. 4 is a comparison of emission spectra for typical color CRT phosphors;

FIG. 5 is a comparison of excitation spectra for typical color CRT phosphors; and

FIG. 6 is a presentation of emission spectra for exemplar of ultra-violet emitting phosphors.

DESCRIPTION OF THE PREFERRED EMBODIMENT

For a better understanding of the present invention, together with other and further objects, advantages and capabilities thereof, reference is made to the following specification and appended claims in connection with the aforedescribed drawings.

While the ensuing description is primarily directed to an exemplary window-limited shadow mask-screen assembly, the concept in the screen structure is likewise applicable for tubes employing a focus mask-screen structure.

With reference to the drawings, FIG. **1** illustrates a shadow mask type of color cathode ray tube **11** in an operating environment designated diagrammatically as **12.** The encommpassing envelope **13** includes a glass viewing panel **15** which is bonded along the sealing edge **16** thereof to the funnel portion **17** of the envelope. Within the panel there is positioned a pattern member or mask **19** which comprises a domed metallic multi-apertured portion **21** which is joined to a strengthening perimetrical frame **23.** Disposed on the inner surface of the viewing panel **15** is a patterned multiplex screen structure **25** comprised of repetitive groupings of two or more elemental cathodoluminescent areas of different phosphor materials **27** and **29** overlaid on the discretely formed window areas **31** of the non-light-transmissive interstitial webbing portion **33** of the screen structure **25** as will be described later herein. A reflective aluminum film **35** covers the back of the screen structure and extends onto the peripheral sidewall region of the panel. Spaced rearward from the screen structure **25** is the metallic apertured pattern member **21** wherein a representative aperture **37** is dimensioned larger than the related window area **31.** An exemplary electron beam **39,** emanating within the tube, from a source not shown, is directed toward the mask-screen assembly **41.** Upon striking the apertured pattern member **21,** a portion of the beam that is "sized" by the aperture **37,** traverses therethrough, impinges a related phosphor area **27** therebeneath and substantially excites the whole of the respective phosphor area to a state of luminescence. Since each of the excited phosphor area in this "window-limited" screen structure is as large as or preferably larger than its associated window area **31,** the total area of each window comprising the visible screen pattern is fully luminous. The resultant display in an operating tube is clearly discernible by the viewer **43.**

In referring to the multiplex screen structure **25** in greater detail, the first apertured webbing **47** as illustrated in FIGS. **1, 2** and **3** is disposed by a plural-step process on the inner surface of the glass viewing panel **15.** For example, a thin uniform layer of a substantially clear polyvinyl alcohol (PVA) solution photosensitized with a chromate material, such a potassium or ammonium bi or dichromate, is applied to the inner surface of the panel by known techniques in the art. The apertured pattern member **19** is then positioned within the panel and the PVA coating exposed by beaming substantially actinic radiation, from predeterminately located sources, through the multiple openings in the mask to photo-polymerize discrete portions of the panel coating in the areas subsequently occupied by the screen pattern phosphor elements. Upon removal of the apertured member from the panel, the exposed coating is developed by rinsing with water to remove the unexposed PVA, thereby providing a web pattern of substantially bare glass defining the interstitial spacings between the substantially clear polymerized pattern elements. These polymerized dot-like elements subsequently become window areas in the opaque interstitial webbing of the subsquently formed color screen structure, such as taught in the previously mentioned web-forming procedure disclosed in U.S. Pat. application Ser. No. 41,535 by R. L. Bergamo et al.

The patterned panel is then overcoated with a uniform layer of a substantially opaque electrically conductive material, for example a carbon containing substance, such as a colloidal suspension of graphite, which, upon drying, is treated with a degrading agent such as hydrogen peroxide. This treatment effects an effervescence and degradation of the coated screen pattern element area of light-polymerized material and loosens the associated graphite thereon. The degradation materials and loosened graphite coating are thence removed by pressurized water thereby providing the first apertured webbing **47** which is both opaque and electrically conductive.

A second apertured webbing **49** of an electron responsive ultraviolet emissive phosphor material having a uv energy spectral emission distribution that at least appreciably coincides with the excitation spectrum of at least one of the to-be-described pattern phosphor elements, is superposed on the opaque first webbing by electrophoretic means to provide a uniform coating thereover. Thus, a source of discrete uv radiation is provided within the screen structure to promote adjuvant excitation for at least a portion of the luminescent screen. In the electrophoretic deposition of the second webbing, the second coating phosphor material, in addition to overlaying the opaque first webbing material, is adherent to the defining peripheries **51** of the first webbing apertures. This peripheral adherence provides a slight fill-in or very narrow mat-like encompassment **53** within the delineating perimeter of each of the apertures of the first webbing to define a multiplicity of clear slightly reduced-in-size windows **31** that are in the order of 0.4 to 0.6 mils smaller than the first webbing apertures. The inner defining edge **55** of each window encompassment is substantially contiguous with the interior glass surface of the viewing panel **15.**

The application of the uv emissive webbing over the first apertured webbing priorly formed on the cathode ray tube viewing panel, is facilitated by an improved electrophoretic coating apparatus as fully disclosed in U.S. patent application Ser. No. 357,941, filed May 7, 1973, now U.S. Pat. No. 3,830,722, granted Aug. 20, 1974, by C. H. Rehkopf et al., assigned to the assignee of the present invention and filed concurrently herewith.

The discrete *uv* emissive second webbing material is completely compatible with the internal components of the tube, and may be of a number of phosphors that are electrophoretically applicable. Therefore, the examples presented later in this specification are not to be considered limiting. In general, the applicable *uv* emitting phosphors are normally substantially white-body materials and therefore provide the added advantage of reflectivity which tends to further enhance the visible luminescent emission output of the subsequently disposed electron excitable phosphor elements of the patterned screen.

After deposition of the second webbing, a patterned color screen is discretely disposed thereover by one of several known processes. Usually, the screen is in the form of a spaced-apart multitude of at least two repetitive phosphor elements, **27** and **29**, that are carefully overlaid on the second apertured webbing **49** in a manner that each window **31** in the webbng structure has a phosphor element disposed therein and thereover. The multiplex screen structure **25** is completed by applying a thin metallic reflecting film over the array of the respective spaced-apart phosphor elements **27** and **29** and the interstitial areas **57** of the second webbing exposed therebetween.

To describe the novel features of the multiplex screen structure in greater detail, reference is directed to the figures. The screen detailed in FIG. **1** is comprised of at least two and usually three conjunctive phosphor elements that are disposed in a repetitive pattern, such conventionally being red, green and blue color-emitting phosphors.

A typical three-color dot-type **P-22** phosphor cathodolum-inescent screen, may be comprised, for example, of a red-emitter R of europium activated yttrium oxide, a green-emitter G of copper activated zinc-cadmium sulfide, and a blue-emitter B of silver activated zinc sulfide. The spectral emission distribution curves SED for these three respective phosphors, R, G and B are delineated in FIG. **4** where also is noted the normal visibility curve to which the human eye is responsive. The normal eye, through brain control, has the ability to utilize the primary colors, "R", "G" and "B" to match almost every other color, but the eye reacts differently to each of these primaries. As noted from the visibility curve, the eye perceives green to be the brightest followed by red and blue. Unfortunately, in the CRT color screen combination, the green-emitting phosphors are sometimes deficient in the desired level of brightness or luminance.

Many of the cathodoluminescent phosphors employed in CRT screening, in addition to electron excitation, also respond to excitation spectra of varaious wavelengths of *uv* radiant energy. For example, FIG. **5** delineates the distributions of excitation spectra for the **P22** "R", "G" and "B" cathodoluminescent phosphors noted in FIG. **4**. As shown, the red-emitter R is responsive to *uv* energy radiation in the wavelength range from substantially 225 to 300 nanometers, the green-emitter G from about 250 to 400 nanometers, and the blue-emitter B from approximately 250 to 400 nanometers. Thus, the level of luminescent brightness resultant from electron excitation can be augmented by supplying additional or adjuvant excitation in the form of radiant energy of discrete *uv* wavelengths.

The spectral emission disributions of two examples of near or long wave *uv* phosphors are presented in FIG. **6.** The neat or long wave *uv* emitters are those which provide radiation substantially within the wavelength range of about 320 to 400 nanometers. With reference thereto, when europium activated strontium fluoroborate is electron excited, *uv* radiation in the range of about 360 to 400 nanometers is emitted. Another phosphor, lead activated barium mesosilicate, upon electron excitation, emits uv radiation of substantially 310 to 380 nanometers. Thus, adjuvant excitation means for one or more of the pattern phosphor elements is incorporable in the multiplex screen by including therein one or more appropriate uv emitting phosphors such a those aforementioned. Preferably, the uv emitters so employed should have an emission spectrum differing from the transmission wavelength of the glass composition comprising the viewing panel **15.** The persistence or duration of phosphorescence of these *uv* emitters preferably should not exceed that of the pattern phosphor material associated therewith. Many of the *uv* phosphors of this type have persistence characteristics not substantially exceeding 80 microseconds, while numerous of the **P22** type of pattern phosphors exhibit persistences ranging from about 100 microseconds and above.

By way of illustration, reference is directed to FIGS. **1, 2** and **3** wherein the pattern element **27** is a green-emitting G phosphor such as copper activated zinc-cadmium sulfide. The second apertured webbing **49** is a thin coating of substantially 0.2 to 0.3 mils thickness of electrophoretically disposed strontium fluoroborate: E*u* which has a peak emission of around 370 nanometers. During tube operation, the electron beam **39** penetrates the backing aluminum film **35** and impinges the phosphor element **27** which is of a larger area than the window **31.** Since the area of the electron beam is also normally larger than the window, the peripheral energy of the beam, upon exciting and traversing the phosphor hidden by the first window webbing **47,** impinges the *uv* emitting phosphor comprising the second webbing **49.** The resultant *uv* emission **61** adjuvantly excites the neighboring phosphor particles in the element **27** thereby increasing the luminance emanating therefrom. As the long wave *uv* emitting phosphors have a much lower efficiency than the visibly emitting pattern phosphors, the relatively low level *uv* emission therefrom is substantially completely absorbed by the adjacent phosphor material. Very little, if any, *uv* energy is radiated outward from the viewing panel.

Approximately 30 percent of the phosphor dot area **27,** extending peripherally beyond the window opening **31,** is covered with *uv* emitting material, which in conjunction with its white body reflectivity and the reflectivity of the aluminum backing **35** makes possible the achievement of a brightness increase in the order of 5 to 8 percent or possibly higher.

Thus there is provided an example of windowed color CRT screen structure including emission means therein to improve the brightness of the excited luminous output emanating from at least one phosphor element of the repetitive screen pattern. It is within keeping of the concept to include mixtures of appropriate wavelength *uv* emitters to furnish adjuvant excitation for more than one pattern element of the multiplex screen structure.

While there has been shown and described what is at present cconsidered the preferred embodiment of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the scope of the invention as defined by the appended claims.

What is claim is:

1. A color cathode ray tube comprising:

an enclosing envelope having a glass receiving panel;

a multiplex screen structure disposed on the interior surface of said receiving panel and including: a first apertured webbing of a substantially opaque electrical conductive material formed contiguous to the inner surface of said panel; a second apertured webbing formed of an electron-responsive ultraviolet emissive phosphor material superposed in said first apertured webbing being in alignment to provide a multitude of defined windows therethrough; said ultraviolet emissive phosphor material being selected from the group consisting essentially of europium-activated strontium fluoroborate and lead-activated barium mesosilicate; a patterened array of at least two repetitive phosphor elements disposed in a contiguous manner over the window areas of said second apertured webbing, each of said phosphor elements being of a size larger than the related window area, said pattern of phosphor elements being of materials responsive to excitation by both electron and ultraviolet energy and differing from the phosphor material comprising said second webbing, the ultraviolet emissive phosphor of said second webbing providing adjuvant excitation energy to at least one of said related phosphor elements during tube operation to increase the luminescent brightness thereof, and a metallic reflecting film applied as a backing over said pattern of spaced-apart phosphor elements;

an apertured pattern member oriented in spaced relationship to said multiplex screen structure; and

at least one source of electron energy positioned within said envelope in a manner to beam electrons through said pattern member to impinge discrete portions of said multiplex screen structure therebeyond.

2. A color cathode ray tube according to claim **1** wherein said second webbing *uv* phosphor material has an emission spectrum in substantially the long wave *uv* range.

3. A color cathode ray tube according to claim **1** wherein said *uv* phosphor material has a persistence not exceeding that of the pattern phosphor material associated therewith.

4. A color cathode ray tube according to claim **1** wherein the thickness of said second apertured webbing of uv phosphor material is in the range of substantially 0.2 to 0.3 mils.

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