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Gallaro

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[54] **DUAL PERSISTENCE SCREEN FOR A CATHODE RAY TUBE**

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[52] **U.S. Cl.** ....**313/92,** 313/92 B, 313/92 PF
[51] **Int. Cl.** **H01j 29/18**
[58] **Field of Search** ....313/92, 92 B, 92 PF

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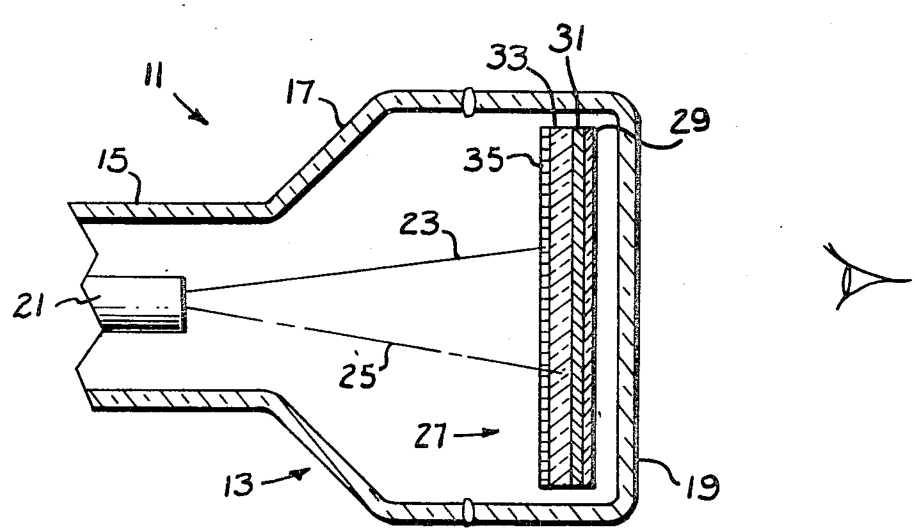
[57] **ABSTRACT**

A plural-layer dual persistence screen is incorporated in a CRT having defined low and high velocity electron beams. A first layer of an optically excited long persistence phosphor is formed on a supporting surface. A second layer of electron responsive material is laid thereover to provide the aforementioned optical excitation. Each particle of the second layer is peripherally modified to effect a barrier therearound to limit excitation of the unmodified interior to energy of the high velocity beam. The second screen layer has a thickness to absorb the electron energy impinged thereon. A third layer of short persistence electron responsive phosphor is disposed over the second layer to be impinged and excited by the low velocity beam.

10 Claims, 3 Drawing Figures



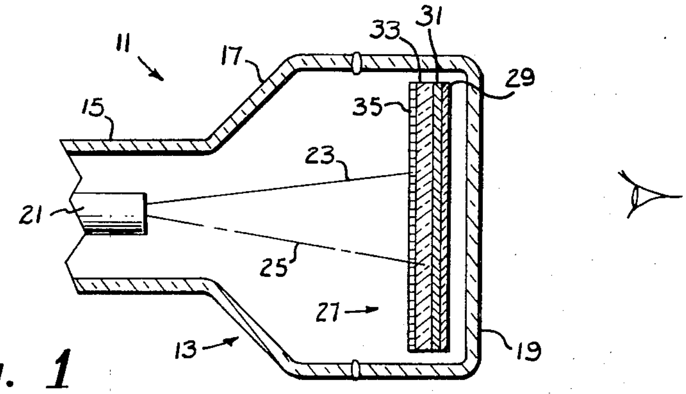


Fig. 1

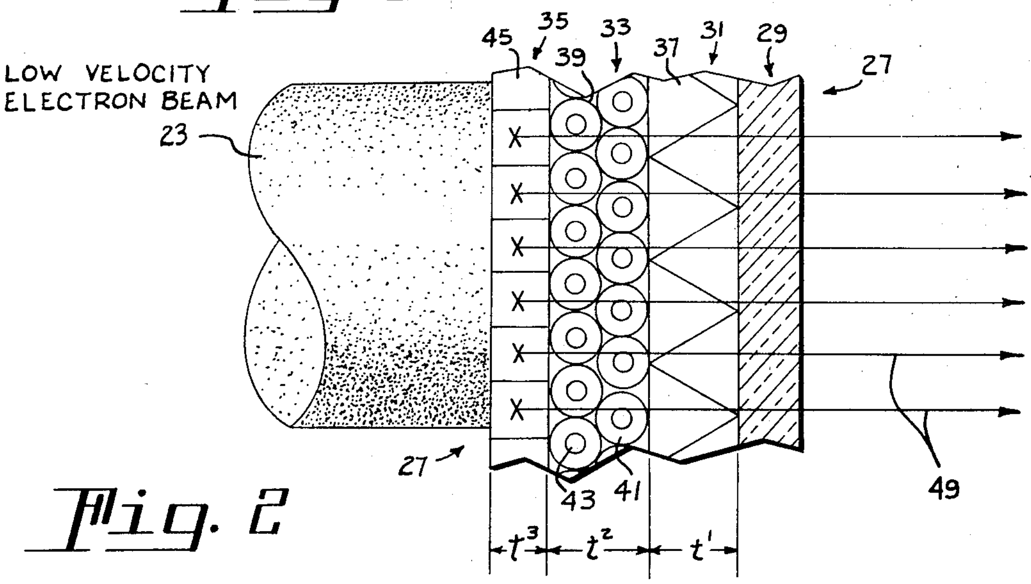


Fig. 2

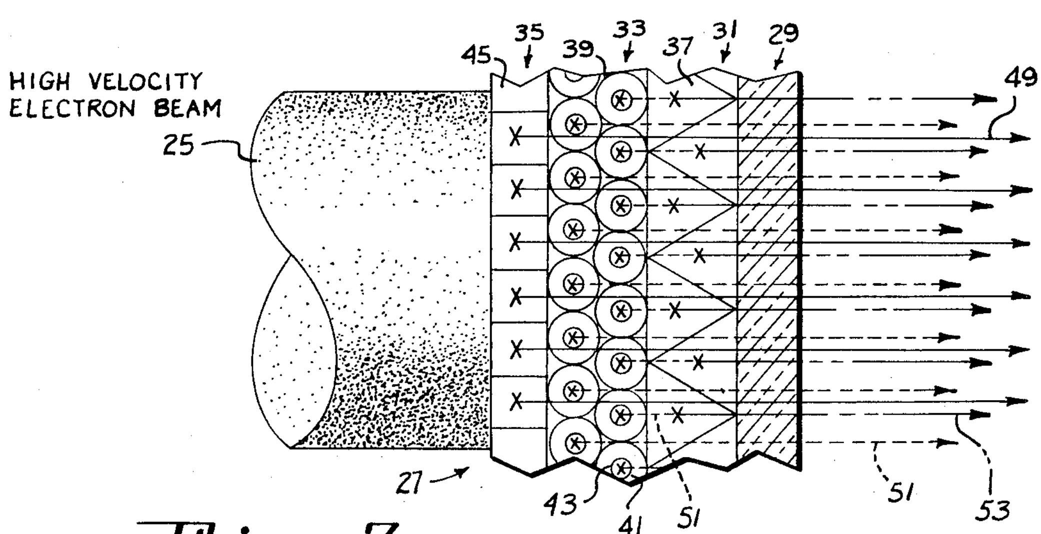


Fig. 3

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DUAL PERSISTENCE SCREEN FOR A CATHODE RAY TUBE

BACKGROUND OF THE INVENTION

This invention relates to a cathode ray tube display screen and more particularly to a screen structure exhibiting dual persistence. Cathode ray tubes utilizing dual persistence imagery are advantageous for displaying comparative information. For example, in radar applications it is often desirable to display, on a common raster, long persistence information, such as slow refresh position indication, along with substantially short or medium-short persistence information, such as alpha-numeric or vector data, that is frequently updated or refreshed. When information of different refresh rates is applied to beam penetration type screens employing plural phosphors having differing persistences, it is desirable to avoid smearing of the short persistence display by the simultaneous excitation of the long persistence phosphor.

In certain types of beam penetration type tubes, dual persistence is obtained by coating a long persistence phosphor component with a layer of a short persistence phosphor. The principle of operation involves the use of velocity modulation or electron beam penetration wherein a low voltage beam excites only the short persistence phosphor, while a high voltage beam excites both materials resulting in a phosphorescence of long persistence. A disadvantage of such a screen is the fact that the selective adsorption technique of coating particles does not always provide the uniformity of thickness to effect maintenance of the desired energy threshold during excitation.

By another technique, the long persistence phosphor particles are physically coated with a surface barrier layer of an inert material such as silica or aluminum oxide. This is usually accomplished by a vapor phase reaction in which the phosphor particles are agitated in a reaction chamber in the presence of a bubbling carrier gas saturated with a vapor such as ethyl orthosilicate or aluminum chloride. The resulting barrier coating is not always of uniform thickness which presents an undesired variable energy threshold for determining the penetration of the exciting electron beam.

The poisoning of the long persistence screen components with additives such as iron, cobalt, or nickel to control excitation has been found to be more detrimental to the phosphorescence characteristic than to the material's fluorescence. Thus, it is deemed inefficient to incorporate poisoned long persistence phosphors in dual persistence screens.

OBJECTS AND SUMMARY OF THE INVENTION

It is an object of the invention to reduce the aforementioned disadvantages and to provide an improved dual persistence screen for a cathode ray tube. Another object is to provide a cathode ray tube employing a dual persistence display screen having improved brightness and a longer persistence characteristic.

The foregoing objects are achieved in one aspect of the invention by providing a layered type of cathode ray tube screen in a tube environment having defined low and high velocity electron beams. A layer of a first phosphor material responsive to optical excitation and exhibiting a phosphorescence of substantially long persistence is disposed on the screen supporting surface. A second phosphor layer of an electron responsive material is disposed over the first phosphor layer to provide the optical excitation for the first phosphor material. Each of the particles making up the second layer is peripherally modified to provide an integral peripheral non-excitable portion. This modification effects an electron energy absorbing barrier of predetermined depth to provide an energy threshold limiting the excitation of the unmodified interior of the particle to the energy of the high velocity electron beam. The second layer is of a thickness to substantially totally absorb the energy of the high velocity beam. A third phosphor layer, responsive to both high and low velocity electron excitation and having a phosphorescence of substantially short persistence, is disposed over the second phosphor layer to complete the triple layer screen structure.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a cross-sectional view partially illustrating a cathode ray tube and an embodiment of the screen structure of the invention;

FIG. **2** is an enlarged cross-sectional portion of the screen shown in FIG. **1** diagrammatically illustrating screen excitation by a low velocity electron beam; and

FIG. **3** is an illustration similar to FIG. **2** diagrammatically showing screen excitation resultant from high velocity electron beam impingement.

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.

In this specification, "persistence" of a phosphor is defined as the period of duration of after-glow or phosphorescence after the cessation of excitation. In broadly defining persistence, a long persistence is considered to be in excess of about 100 milliseconds, a medium persistence from about 1 millisecond to 100 milliseconds, and a short persistence less than about 1 millisecond.

With reference to the drawings, there is shown in FIG. **1** a cathode ray tube **11** having an envelope **13** comprising neck, funnel and face panel portions **15**, **17**, and **19** respectively. Within the neck portion **15** there is oriented electron gun means **21** from which emanates defined low and high velocity electron beams **23** and **25**. These respective beams are directed to impinge upon the layered cascade type screen structure **27** which is formed to exhibit image displays of different persistences as later described. The construction of the layered screen **27** is applicable to cathode ray tubes of various sizes. Certain physical aspects of the screen structure are directly related to the tube anode voltages or electron beam velocities employed. For example, the high and low beam velocities **23** and **25** employed in the described embodiment are substantially 6 and 12KV respectively. The layered screen **27** can be formed on the inner surface of the face portion **19** of the tube or on a separate substantially transparent substrate **29**, such as glass, positioned within the tube envelope **13** relative to the face portion **19**.

The plural-layer screen 29 comprises a first layer 31 which is disposed on the surface of the support medium 29. This is overlaid successively by the second and third screen layers, 33 and 35, of different phosphor materials.

In greater detail, with particular reference to FIGS. 2 and 3, the transparent support medium 29 is of a thickness to withstand processing temperatures without warping or deforming. Upon this substrate, a first screen layer 31 in the form of a coating of an optically excited phosphor 37, that exhibits a phosphorescence having long persistence, is disposed by a conventional technique such as settling. Examples of suitable long persistence first layer phosphor materials are those such as (Zn,Cd)S:Cu which is classified as P–7 yellow by the Joint Electron Devices Engineering Council (JEDEC) and exhibits a phosphorescent emission in substantially the yellow-green wavelength region of the electromagnetic spectrum. Another suitable material is ZnS:Cu which is JEDEC classified as P–2 and likewise has a yellow-green phosphorescent emission. While the P–7 yellow and P–2 phosphors are also electron excitable, they produce markedly longer phosphorescent persistence when optically excited and such mode of excitation is utilized in the screen structure of the invention. It has been found that a phosphor particle size within the range of substantially 8–30 microns, as measured by a Fisher Sub-Sieve Sizer (F.S.S.S.), is suitable for forming the first layer, with the preferred size being within the range of substantially 12–18 microns to achieve the desired resolution and persistence. The screening density of the first layer is within the range of substantially 7.0 to 11.0 mg/cm^2. to provide a thickness t' that is uniform and continuous.

A second phosphor layer 33, of electron responsive material 39, is uniformly disposed, such as by settling, over the first layer 31 to provide the necessary optical excitation for the first layer phosphor material 37. This second layer phosphor material 39 is selectively treated, prior to screen forming, in a manner that the peripheral structural portion 41 of each phosphor particle is altered to a predetermined depth to be non-responsive to electron excitation. This discrete peripheral modification 41 forms an integral energy absorbing electron barrier on each particle that prevents electron beams of under a certain energy level from penetrating the particle and exciting the interior or unmodified portion 43. The second layer 33, per se, is of a thickness t^2 adjusted to substantially totally absorb the energy of the high velocity beam 25 so that electron energy does not penetrate to the first screen layer 31.

In greater detail, the treated second layer phosphor material 39 may be, for example, blue-emitting ZnS:Ag which is JEDEC classified as P–22 blue and has a short persistence. Another suitable phosphor can be P–7 blue which is also a ZnS:Ag material having short persistence. To provide efficient optical excitation, the luminescent emission of the second phosphor material 39 should have a peak wavelength of spectral energy emission of a value less than that of the optically excited first layer material. For example, a P–22 blue having a peak wavelength of spectral energy emission of approximately 460 nm provides efficient optical excitation energy for a P–7 yellow first layer phosphor having a peak wavelength of spectral energy emission of approximately 550 nm. The peak wavelength of the second layer material is also less than that exhibited by the third layer material. As previously mentioned, the peripheral portion of each phosphor particle 39 in the second screen layer 33 has a peripheral energy absorbing region 41 or integral barrier that is non-excitable or non-responsive to electron energy. This modification is accomplished by carefully diffusing a selected metallic material into the surface structure of each particle. Metals suitable for such incorporation may include one or more of the group comprising cobalt, iron, or nickel, the application of which may be in the form of nitrates, chlorides, or sulfates. The depth of the metallic diffusion in each particle is predetermined to establish an energy threshold to block the low velocity beam 23 thereby limiting excitation of the active or unmodified core portion 43 to the energy of the high velocity beam 25. It has been found that sulfide materials activated with small amounts of silver or copper are particularly adaptable to such modification. The basics of the technique for peripherally modifying the phosphor material are disclosed in U.S. Pat. application Ser. No. 707,511 by Anthony V. Gallaro and assigned to the assignee of the present invention.

The particle size of the second layer material 39 is within the range of substantially 5 to 15 microns (F.S.S.S.), wherein the preferable range is from substantially 6 to 10 microns. As aforementioned, the thickness t^2 of the second layer 33 is determined by the energy of the high voltage beam. For example, to effectively absorb a high velocity beam, such as 12KV, the screening density is in the range of substantially 8.0 to 12.0 mg/cm^2. Thus, this second screen layer functions as a selective switch barring the passage of electron energy and providing discrete optical energy.

A third phosphor layer 35 of a different electron responsive material 45 is uniformly applied over the second phosphor layer 33. This third phosphor material is a highly efficient, thinly settled, short persistence component that is responsive to both low 23 and high 25 velocity electron excitation. The third layer phosphor material 45 has a peak wavelength of spectral energy emission that is greater than that exhibited by the second layer phosphor 39 and at least equal to that exhibited by the first layer material 37. Being thus defined, the luminescent energy of the third layer will not optically excite the material of the first layer.

Examples of suitable third layer phosphors 45 are the efficient P–22 RE red emitting materials, such as YVO_4:Eu, Y_2O_3:Eu, Gd_2O_3:Eu, and Y_2O_2S:Eu. These phosphors exhibit peak wavelengths of spectral energy emissions that are in excess of 600 nm. The particle size of the third layer material is within the range of substantially 5.0 to 20.0 microns (F.S.S.S.), with the preferable range being in the 8.0 to 10.0 micron region. Being efficient, the third screen layer 35 is desirably thin and as such does not substantially attenuate the high velocity beam. The screening density of the third layer 35 is in the range of substantially 1.0 to 3.0 mg/cm^2 to achieve the desired screen layer thickness t^3.

Operationally, the aforedescribed multi-layered screen provides an image display exhibiting dual persistence characteristics. The low energy electron beam 23 is beamed to impinge the screen 27 whereupon the electron responsive phosphor particles 45 comprising the third layer 35 are excited to luminescence. While the excited phosphor emits light in all directions, for purposes of clarity only the light rays **49** projecting outwardly from the screen are shown in the figures. The impinging low energy electron beam **23** is absorbed by the treated non-responsive peripheral portion **41** of each of the phosphor particles **39** comprising the second layer **33**. Thus, under low velocity beam **23** excitation only the spectral emission of the third phosphor material **45** is evidenced, which in this instance is a red emission **49** of short persistence.

When the high velocity electron beam **25** is beamed to impinge the screen **27**, both the third and second phosphor layers, **35** and **33**, are excited to luminescence. The high velocity beam **25** has sufficient energy to penetrate the peripheral energy absorbing barrier **41** on the treated second layer phosphor **39** and excite the unmodified interior portion **43** thereof to produce light rays **51** of the spectral emission of the second phosphor material **39** which in this instance is a blue emission **51** having a shorter wavelength than the third layer red emission **49**. This second layer emission **51**, which includes luminescence of both fluorescence and phosphorescence, provides the optical energy for exciting the first layer phosphor material **37** to produce the long persistence spectral emission **53** having a wavelength longer than that of the second layer spectral emission **51**. When P–7 material is utilized in the first screen layer **31**, the spectral emission **53** therefrom is substantially of a yellow-green hue.

In employing a tube having this dual persistence screen structure, information requiring frequent updating is applied by the low velocity beam **23** on the third screen layer **35** and is evidenced in the display by red emission **49**. The slow refresh information is applied to the screen by the high velocity beam **25**. As aforementioned, the high velocity beam excites both red and blue emission **49** and **51** in the third and second screen layers respectively, but since the persistence of the third and second phosphors are of markedly short duration they do not detract from the much longer persistence display effected by the optically excited first phosphor **37**.

If additional brightness of the luminescent display is desired, a thin reflective aluminum film, not shown, can be applied over the third screen layer by a conventional procedure. The density of this aluminizing film should be of a thickness not detrimentally impeditive to the electron beams passing therethrough.

Thus, there is provided a plural-layer screen wherein the cooperative functions of each layer are optimized to produce an efficient and improved dual persistence display exhibiting enhanced brightness and a desirably long persistence characteristic.

While there have been shown and described what are at present considered the preferred embodiments 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 claimed is:

1. A cathode ray tube for presenting a color display of differing persistence comprising:

an envelope having a viewing area with a screen supporting surface related thereto;

electron gun means oriented within said envelope and structured to generate and project defined low and high velocity electron beams to impinge said screen supporting surface; and

a layered type dual persistence image display screen formed on said screen supporting surface, said screen comprising a first phosphor layer disposed directly on said supporting surface, said first phosphor layer being formed of a first phosphor material responsive to optical excitation and exhibiting a phosphorescence of substantially long persistence; a second phosphor layer uniformly disposed over said first layer, said second phosphor layer being formed of a second phosphor material to furnish said optical excitation for said first phosphor material, said second phosphor being an electron responsive material whereof each phosphor particle has a modified peripheral non-excitable portion in the form of an integral electron energy absorbing barrier of predetermined depth to effect an energy threshold surrounding the unmodified core of the particle and limiting the excitation thereof to said high velocity electron beam, said second phosphor layer being disposed to a thickness sufficient to substantially totally absorb the energy of said high velocity electron beam; and a third phosphor layer uniformly applied over said second phosphor layer, and being of a thickness less than that of said second layer, said third phosphor material being responsive to both low and high velocity electron excitation and exhibiting a phosphorescence of substantially short persistence, said third phosphor material having a peak wavelength of spectral energy emission at least equalling that of the phosphor material of said first screen layer.

2. A cathode ray tube according to claim **1** wherein said second layer is of a thickness greater than that of either said first and third layers.

3. A cathode ray tube according to claim **1** wherein said first layer is of a phosphor material having a persistence resulting from optical excitation that is longer than the persistences exhibited by the electron excited phosphor in said second and third screen layers.

4. A cathode ray tube according to claim **1** wherein said second layer has a peak wavelength of spectral energy emission that is less than that exhibited by either of said first and third layers, and wherein said third layer has a peak wavelength of spectral energy emission that is greater than that exhibited by said second layer and at least equal to that exhibited by said first layer.

5. A cathode ray tube according to claim **1** wherein the spectral energy emission of said first phosphor material is substantially in the yellow-green wavelength region, and wherein that of said second phosphor material is substantially in the blue wavelength region, and wherein that of said third phosphor material is substantially in the red wavelength region.

6. A cathode ray tube according to claim **1** wherein said optically excited first layer phosphor exhibits a substantially yellow-green phosphorescence of long persistence being at least one material selected from the group consisting of (Zn,Cd)S:Cu P–7 yellow, and ZnS:Cu P–2; and wherein said electron excited second layer of substantially blue-emitting phosphor is of substantially short persistence being at least one material selected from the group consisting of ZnS:Ag P-22 blue, and ZnS:Ag P-7 blue, said integral energy absorbing barrier on each second layer particle being formed of at least one metallic material selected from the group consisting of cobalt, iron, and nickel; and wherein said electron excited third layer substantially red-emitting high efficiency phosphor is of substantially short persistence being at least one P-22 RE material selected from the group consisting of YVO_4:Eu, Y_2O_3:Eu, Gd_2O_3:Eu, and Y_2O_2S:Eu.

7. A dual persistence image display screen for use in an electron discharge device having electron beams of high and low velocities, said screen comprising:

a first screen layer disposed on a screen supporting surface, said first layer being formed of a first phosphor material responsive to optical excitation and exhibiting a phosphorescence of substantially long persistence;

a second screen layer disposed over said first layer and formed of a second phosphor material to provide optical excitation for said first phosphor material, said second layer phosphor being an electron responsive material whereof each phosphor particle has a modified peripheral non-excitable portion in the form of an integral electron energy absorbing barrier of predetermined depth to effect an energy threshold surrounding the unmodified core of the particle and limiting the excitation thereof to said high velocity electron beam, said second screen layer being of a thickness to substantially totally absorb the energy of said high velocity electron beam; and

a third screen layer uniformly disposed over said second screen layer and being of a thickness less than that of said second screen layer, said third screen layer being formed of a third phosphor material responsive to both high and low velocity electron beam excitation and exhibiting a phosphorescence of substantially short persistence, said third phosphor material having a peak wavelength of spectral energy emission of a value at least equalling that of the phosphor of said first screen layer.

8. An image display screen according to claim 7 wherein said first layer is of a phosphor material having a persistence resulting from optical excitation that is longer than the persistences exhibited by the electron excited phosphors in said second and third screen layers.

9. An image display screen according to claim 7 wherein said optically excited first layer phosphor exhibits a substantially yellow-green phosphorescence of long persistence being at least one material selected from the group consisting of (Zn,Cd)S:Cu P-7 yellow and ZnS:Cu P-2; and wherein said electron excited second layer of substantially blue-emitting phosphor is of substantially short persistence being at least one material selected from the group consisting of ZnS:Ag P-22 blue, and ZnS:Ag P-7 blue, said integral energy absorbing barrier on each second layer particle being formed of at least one metallic material selected from the group consisting of cobalt, iron, and nickel; and wherein said electron excited third layer substantially red-emitting high efficiency phosphor is of substantially short persistence being at least one P-22 RE material selected from the group consisting of YVO_4:Eu, Y_2O_3:Eu, Gd_2O_3:Eu and Y_2O_2S:Eu.

10. A long persistence image display screen for use in an electron discharge device, said screen comprising:

a first screen layer of an optically excited phosphor material exhibiting a phosphorescence of substantially long persistence; and

a second screen layer of an electron excitable phosphor disposed directly on said first screen layer to furnish said optical excitation for said first layer, each particle of said second layer phosphor material being modified peripherally to effect a non-excitable encasement therearound in the form of an integral electron energy absorbing barrier of predetermined depth and energy threshold, said second layer having a thickness to substantially totally absorb the electron energy impinging thereon.

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