United States Patent [19]

Todd, Jr.

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[45] **Aug. 26, 1975**

[54] **METHOD OF AND APPARATUS FOR EXCITING LUMINESCENCE IN A CATHODE RAY TUBE HAVING AN IMAGE SCREEN COMPOSED OF A MATERIAL THAT IS BOTH CATHODOCHROMIC AND CATHODOLUMINESCENT**

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[73] Assignee: **Massachusetts Institute of Technology**, Cambridge, Mass.

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[21] Appl. No.: **457,112**

[52] **U.S. Cl.** ..... **313/398;** 313/465; 315/13 ST; 315/22

[51] **Int. Cl.**[2] **H01J 29/12;** H01J 29/50

[58] **Field of Search** ..... 313/397, 398, 463, 465; 178/7.5 D; 315/13 R, 13 ST, 22; 350/160 P

[56] **References Cited**

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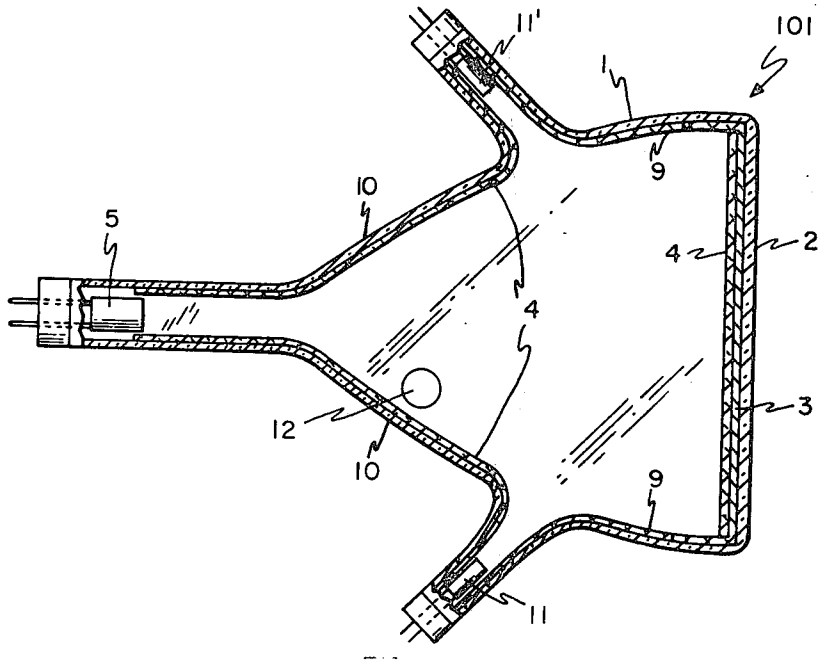
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[57] **ABSTRACT**

Method of and apparatus for exciting luminescence in a cathode ray tube (CRT) having an image screen that is both cathodochromic and cathodoluminescent, whereby an electron beam effects luminescence of the image screen as well as writing upon the screen. Writing is accomplished at a high level of beam exposure and luminescence is accomplished at a low level of exposure.

10 Claims, 3 Drawing Figures



PATENTED AUG 26 1975

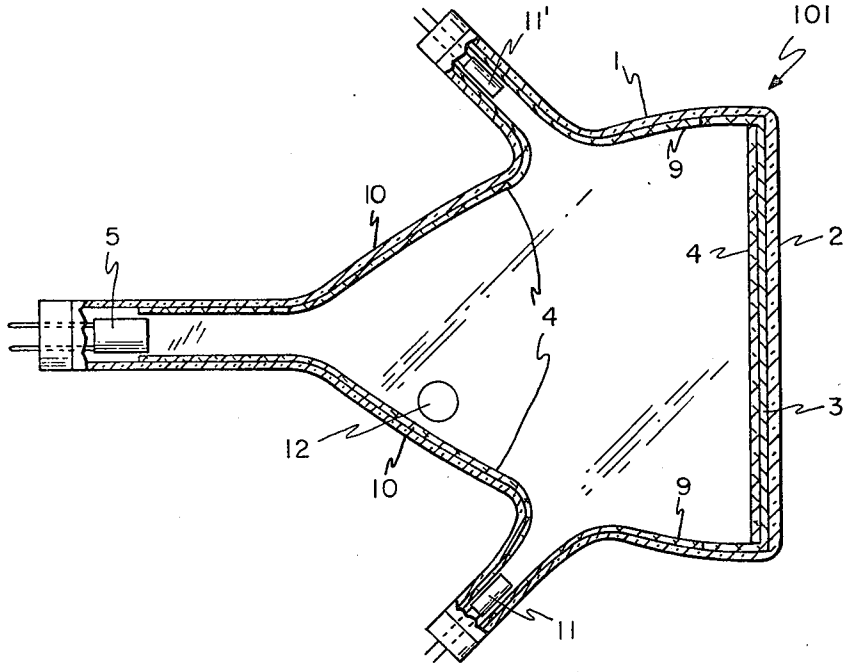


FIG. 1

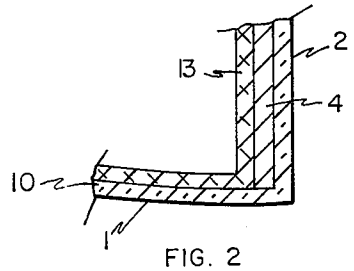


FIG. 2

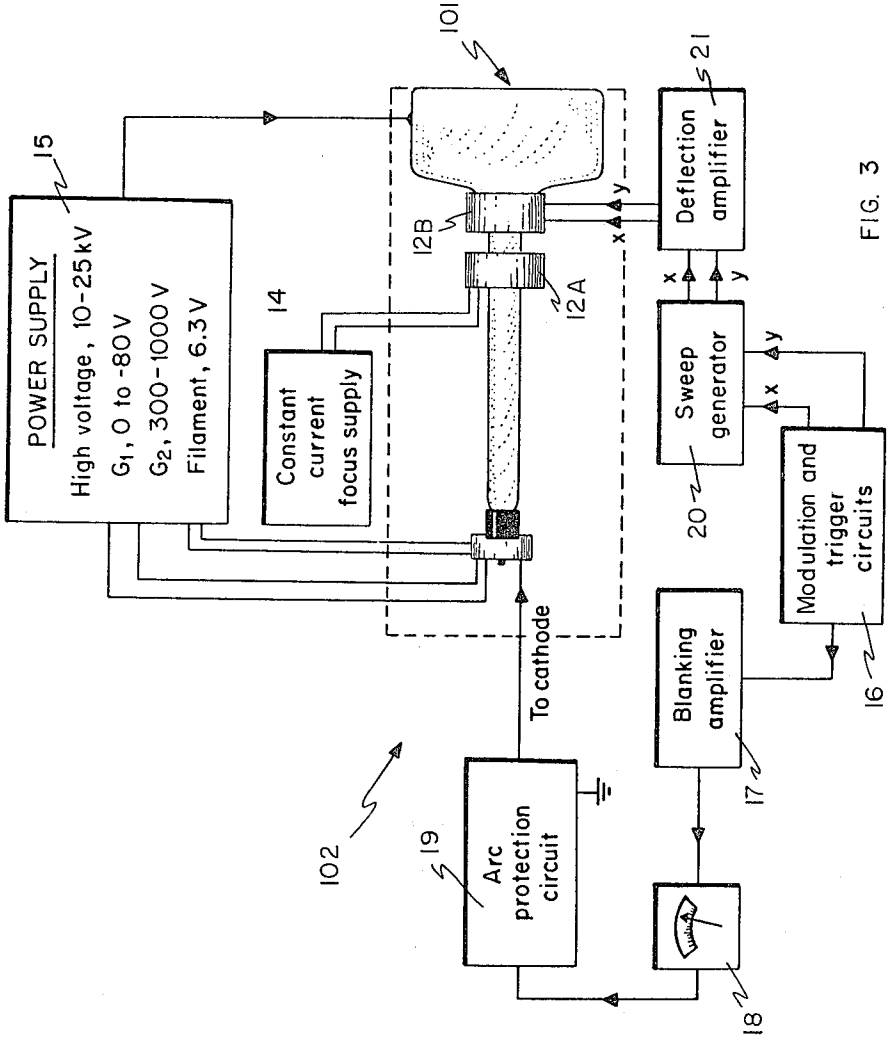

101
15
POWER SUPPLY
High voltage, 10-25 kV
G1, 0 to -80 V
G2, 300-1000 V
Filament, 6.3 V
14
Constant current focus supply
12B
12A
x
y
21
Deflection amplifier
x
y
Sweep generator
20
y
x
Modulation and trigger circuits
16
Blanking amplifier
17
To cathode
102
19
Arc protection circuit
18

FIG. 3

METHOD OF AND APPARATUS FOR EXCITING LUMINESCENCE IN A CATHODE RAY TUBE HAVING AN IMAGE SCREEN COMPOSED OF A MATERIAL THAT IS BOTH CATHODOCHROMIC AND CATHODOLUMINESCENT

The invention described herein was made in the course of or under a grant from the National Science Foundation, an agency of the United States Government.

The present invention relates to a cathode ray tube whose image screen is both cathodochromic and cathodoluminescent and, in particular, to a novel way to excite the cathdoluminescence.

Attention is called to the following related applications being filed herewith and hereby incorporated herein by reference: "Cathode Ray Tube Whose Image Screen Is Both Cathodochromic and Fluorescent and the Material for the Screen," Ser. No. **456,961,** filed Apr. **1, 1974** (Todd, Jr. et al.); "A Process for Preparing Cathodochromic Sodalite Having Enhanced Coloration Properties and a Cathode Ray Tube Employing the Same" Ser. No. **456,962,** filed Apr. **1, 1974;** (Todd, Jr. et al.); and "Cathode Ray Tube Employing Faceplate-Deposited Cathodochromic Material and Electron Beam Erase," Ser. No. **457,111,** filed Apr. **1, 1974** (Todd, Jr.). Attention is called also to the doctoral thesis of Lee T. Todd, Jr. (a copy of the thesis accompanies the application entitled "A Process for Preparing Cathodochromic Mixtures Having Enhanced Coloration Properties"), which thesis is hereby incorporated herein by reference; the work upon which the thesis is based was done by the inventor at M.I.T. The thesis contains an exhaustive list of references to prior work as well as detailed theoretical analysis, neither of which is repeated here. The following Letters Patent are made of record: U.S. Pat. Nos. **3,705,323** (Shidlovsky); **3,598,750** (Phillips); **2,752,521** (Ivey); **2,761,846** (Medved); **3,706,845** (Heyman et al.); **3,148,281** (Fyler).

Attention is called specifically to the application entitled "Cathode Ray Tube Whose Image Screen Is Both Cathodochromic And Fluorescent and the Material for the Screen" wherein there is disclosed a screen material that can be caused to lum inesce by the systems disclosed herein. The screen material there described is $Na_6Al_6(Ge_ySi_{1-y})_6\ O_{24}\ 2(1-z)NaX$, wherein X is chosen from the group consisting essentially of chlorine, bromine, OH and iodine and mixtures thereof, y varies from about **0.003** to **0.30,** and $0<z<1$. Whereas in the other application the mechanism for causing luminescence is ultraviolet radiation, in the present system both writing on the image screen of the cathode ray tube (CRT) and illumination of the screen in the fluorescent mode are effected by electron beams. The write function requires a high beam exposure and the luminescent function a lower beam exposure which repeatedly illuminates the screen.

Accordingly, an object of the present invention is to provide a novel system for effecting background fluorescent illumination of a cathode ray tube (CRT) image screen that is both cathodochromic and cathodoluminescent.

Another object of the present invention is to provide a CRT system in which the screen is both cathodochromic and cathodoluminescent and in which no ultraviolet shielding is necessary, as is required by other illumination schemes.

These are still further objects as discussed hereinafter.

The objects of the present invention are achieved by a cathodochromic cathode-ray tube (CRT) display system comprising a CRT and associated focusing, deflecting and modulating electronic circuits to control the electron beam. The CRT consists of an envelope with a faceplate, an image screen and electron beam producing means including one or more electron guns. The image screen is made of a material which is both cathodochromic and cathodoluminescent such as germanium-doped, sodalite, $Na_6Al_6(Ge_ySi_{1-y})_6\ O_{24}\cdot 2(1-z)NaX$, wherein X is Br, Cl, I, OH and mixtures thereof, y is the atomic percent of germanium and $0.003<y<0.30$, and z is the fraction of NaX vacancies. The electron guns are used to provide the functions of writing on the image screen and exciting the screen fluorescence. In operation, information is written on the image screen by a modulated electron beam which provides sufficient exposure for dark coloration of the screen material. In low ambient light, the information is read by illuminating the entire screen with electrons which are capable of exciting luminescence but are unable to cause significant coloration. Since the luminescence is greatly reduced in colored areas, a very high contrast image is achieved and appears as dark indicia on a bright green background.

The present method of fluorescence excitation offers at least two advantages over methods in which ultraviolet illumination of the image screen is employed as the excitation means. First, it is not necessary to provide viewer protection from harmful ultraviolet radiation and, second, the CRT fabrication can be much simpler and thus less expensive.

The invention is hereinafter discussed with reference to the accompanying drawing in which:

FIG. **1** is a side section viewing a cathode ray tube (CRT) having an image screen that is both cathodochromic and cathodoluminescent and having a transparent conductive coating on the faceplate of the CRT between said faceplate and the image screen thereof;

FIG. **2** is a partial section view of a modification of the CRT of FIG. **1** and shows a tube in which the image screen is sandwiched between an inside conductive coating and the faceplate of the CRT; and

FIG. **3** is a schematic circuit diagram in block diagram form showing a CRT and circuitry operable to perform the present teaching.

Turning now to FIG. **1,** the cathodochromic cathode ray tube (CRT) shown at **101** comprises a glass envelope **1** having a transparent faceplate **2** on the inner surface of which there is deposited a sandwich structure consisting of a transparent conductive layer **3** and a cathodochromic image screen **4.** The anode consists of the thin conductive layer **3** deposited directly upon the inner surface of the faceplate **2** and extending along the inner side walls of the envelope **1** to make electrical contact with an Aquadag (trademark of Acheson Colloids Company, a division of Acheson Industries, Inc., Port Huron, Mich.) or aluminum coating **9** which extends along the side walls **10** of the envelope to an electron gun **5.** The electron gun **5** acts to write upon the cathodochromic image screen **4** as well as to illuminate the screen in the fluorescent mode, when the display is to be viewed in low ambient light, as hereinafter discussed. An alternate method of illuminating the screen in the fluorescent mode is the use of one or more off-

axis electron flood guns **11** and **11'**, which flood the entire screen with electrons of sufficient energy to excite the cathodoluminescence. The image is viewed in high ambient light by transmitting viewing light, provided by a bulb **12**, through the screen toward the viewer.

The CRT anode, comprising the coatings **3** and **9** in FIG. **1** may be replaced by an all aluminum anode in some cases. FIG. **2** shows the screen structure in this case in which the image screen **4** is deposited directly on the faceplate **2** and between the faceplate and an aluminum coating **13.** The aluminum coating covers the entire back surface of the image screen and extends along the side walls **10** of the envelope. One advantage of the aluminum film is that it reflects all fluorescent light that is being emitted away from viewer back toward the viewer thus increasing the effective light output. In this case, the image is read under reflecting light in high ambient light conditions rather than transmitted light as shown in FIG. **1.**

The cathodochromic and luminescent screen material may be sensitized germanium doped, sodalite, $Na_6Al_6(Ge_ySi_{1-y})_6\ O_{24}\cdot 2(1-z)NaX$, wherein X is chosen from the group consisting essentially of Br, Cl, I, OH and mixtures thereof, $0.003<y<0.30$ and z is the fraction of NaX vacancies. (See the application entitled "Cathode Ray Tube Whose Image Screen is Both Cathodochromic and Fluorescent and the Material for the Screen.") The image screen thus comprises a material that has a coloration or F-center (i.e., the cathodochromic characteristic) as well as a luminescent or fluorescent center (i.e., the cathodoluminescent characteristic). As noted elsewhere herein, writing is effected by use of a high intensity electron beam which creates the coloration or F-center to produce dark indicia on the screen, the necessary contrast to enhance the indicia in low ambient light being provided by subjecting the image screen to a low intensity electron beam that excites the luminescent center. The screen coloration for the sensitized germanium doped sodalite just described is dark indicia with a bright green background. The image-screen material is such that the F-center absorption band occurs very close to the luminescent center emission band so that much of the fluorescence created within the colored portions of the image screen is reabsorbed to provide the high-contrast ratios discussed in said application Ser. No. **456,961.**

The block diagram cathodochromic CRT display system **102** shown in FIG. **3** implements the present inventive concepts. The cathodochromic CRT **101** (the flood-guns **11** and **11'** are omitted) is shown with a magnetic focusing coil **12A** and a deflection coil **12B.** In this case, focusing the electron beam is accomplished by passing a constant current provided by a constant current supply **14,** through the magnetic focusing coil **12A.** Focusing can also be accomplished electrostatically, as is known in the art. The electron beam is accelerated toward the image screen by a high voltage, usually **20** kv for writing, provided by a power supply **15** which also provides the appropriate voltage for the electron gun **5** in FIG. **1.** Information is written on the image screen by a combination of modulation and deflection of the electron beam. Modulation circuits **16** send a signal to a blanking amplifier **17** which, in turn, varies the cathode voltage and thus the intensity of the electron beam from zero to full scale, usually **500**μa for writing, as read on an ammeter **18.** These circuits are protected from internal CRT arcing by an arc protection circuit **19.** Trigger circuits in the element labeled **16** trigger a sweep generator **20** which provides the appropriate voltage signals for positioning the electron beam. These voltage signals are then transformed to current waveforms by a deflection amplifier **21** and the currents, one for each axis x and y, pass through the deflection coil **12B,** thus positioning the electron beam on the image screen. Deflection may also be accomplished electrostatically. For raster scan operation, the electron beam moves horizontally across the screen and vertically down the screen, such that the entire screen area is encompassed. As the beam sweeps, it is modulated on and off in such a manner to write the desired information. The sweep rate of the beam must be sufficiently slow to provide adequate exposure for dark coloration. Once information is written on the screen, the electron beam is again scanned, in a raster format, over the entire screen. In this case, the beam is not modulated, except possibly during retrace, and the sweep rate is sufficiently fast that little or no coloration occurs — this often requires reducing both the electron beam current and accelerating voltage below the values used for writing in addition to increasing the sweep rate. However, the exposure is such that cathodoluminescent emission does occur and, as the beam sweeps repeatedly over the screen, the image appears as dark indicia on a light background. If the screen material is $Na_6Al_6(Ge_ySi_{1-y})_6\ O_{24}\cdot 2(1-z)NaX$, wherein X is Br, Cl, I, OH and mixtures thereof, $0.003<y<0.30$, and $0<z<1$, the background emission is bright green at approximately **5250**A. If electron flood guns, **11** and/or **11'** in FIG. **1** are used to illuminate the screen to excite the cathodoluminescence, the information is again written on the screen as described above in relation to FIG. **3.** The information is viewed in low ambient light by placing the appropriate voltage on the electron flood guns such that the entire screen area is showered with electrons which are capable of exciting cathodoluminescence. This method allows the information to be read as it is being written whereas in the previous case this was not possible.

Modifications of the invention herein described will occur to persons skilled in the art and all such modifications are deemed to be within the spirit and scope of the invention as defined by the appended claims.

What is claimed is:

1. A cathode ray tube that comprises: an envelope having a faceplate; an image screen in said envelope, said image screen comprising a material that has a coloration or F-center as well as a luminescent or fluorescent center so that said material is cathodochromic and is also cathodoluminescent, the cathodochromic coloration lifetime being at least **1** month, the coloration or F-center absorption band of said material occurring very close to the emission band of the luminescent or fluorescent center; and means for producing an electron beam for writing on the image screen by exciting the coloration or F-center and for exciting the cathodoluminescence in the image screen by exciting the luminescent or fluorescent center.

2. A cathode ray tube as claimed in claim **1** in which the means for producing an electron beam includes an electron gun, an anode and beam focusing and deflection means and in which said deflection means is adapted to provide at least two different raster scan rates, the slower rate serving to write upon the image

screen and the faster rate serving to excite cathodoluminescence.

3. A cathode ray tube as claimed in claim 2 in which the faster scan rate repeats to expose the screen to the electron beam for an extended time period, such that the luminescence remains visible.

4. A cathode ray tube as claimed in claim 3 in which the fast scan rate is about 1/30 of a second per frame.

5. A cathode ray tube as claimed in claim 1 in which the means to produce an electron beam includes an electron gun, an anode and focusing and deflection means and which further includes means to change the electron beam intensity from one to the other of at least two intensity levels, the lower intensity level serving to excite cathodoluminescence and the high intensity level serving to write on the image screen.

6. A cathode ray tube as claimed in claim 1 in which the means to produce an electron beam includes a first electron gun that serves to write on the screen and a second electron gun to excite cathodoluminescence.

7. A cathode ray tube as claimed in claim 6 which includes at least two electron guns to excite cathodoluminescence.

8. A cathode ray tube as claimed in claim 7 in which the electron guns that excite cathodoluminescence are electron flood guns.

9. A cathode ray tube as claimed in claim 1 in which said material is $Na_6Al_6(Ge_ySi_{1-y})_6O_{24} \cdot 2(1-z)NaX$, wherein X is chosen from the group consisting essentially of chlorine, bromine, OH and iodine and mixtures thereof, y varies from about 0.003 to 0.30, and $0<z<1$.

10. A cathode ray tube having an image screen comprising a material that has a coloration or F-center as well as a luminescent or fluorescent center, so that the screen is both cathodochromic and cathodoluminescent, and having electron beam means both to write on the image screen by exciting the coloration or F-center and to excite cathodoluminescence in the image screen by exciting the luminescent or fluorescent center, the coloration or F-center absorption band of said material occurring very close to the emission band of the luminescent or fluorescent center so that much of the fluorescence created within the colored portions of the image screen is reabsorbed to enhance the contrast ratio of the image.

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